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Papers on Mammalogy

Published in honor of
WILFRED HUDSON OSGOOD

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ZOOLOGICAL SERIES
FIELD MUSEUM OF NATURAL HISTORY
VOLUME 27
DECEMBER 8, 1941
PUBLICATION 511

Natural History Library

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WILFRED HUDSON OSGOOD

PAPERS ON MAMMALOGY

Published in honor of
WILFRED HUDSON OSGOOD

PRINTED IN THE UNITED STATES OF AMERICA
BY FIELD MUSEUM PRESS

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THE WORK OF WILFRED HUDSON OSGOOD

The Trustees and Scientific Staff of Field Museum of Natural History have felt that a volume composed of papers on mammalogical topics and dedicated to Wilfred Hudson Osgood would form a testimonial to him of their appreciation of his eminence as a museum zoologist. Papers have accordingly been invited from some of his colleagues, more particularly those of his own generation, and from the Field Museum Staff. Such a testimonial volume is the more appropriate in Field Museum's Zoological Series since this series for twenty years has borne the stamp of his editorship and thereby of his personality. This stamp, and the high level of editorial conscientiousness it denotes, is perhaps best known to the younger members of Dr. Osgood's staff. Their papers have gone through his hands, and the resulting improvements in the form of their scientific contributions reflect fundamental improvements in their very thinking.

It is not difficult to trace some of the environmental factors which made Wilfred H. Osgood a great museum zoologist. He grew up in a generation when private collections of birds and mammals still provided a great stimulus to outdoor natural history, and began his career with collecting and field observation. His connection with the "Biological Survey" began in the year 1897 while he was still an undergraduate at Stanford University. The idea of a true biological survey of the North American continent was a grand one. Building on the necessarily more scattered results of the early biological explorations of the west under the direction of Spencer Fullerton Baird, it was proposed under C. Hart Merriam's leadership to define the distributions of plants and animals in order to relate them to the underlying climatic and physiographic conditions. Thus there was current an understanding of some of the broad biological implications of taxonomic work, and there could scarcely have been a more satisfactory background for a career as a systematic zoologist.

The development of the "closet naturalist" type is one of the pitfalls of systematic zoology which has been largely avoided in America. Dr. Osgood's career, with its constant alternation of field observation and collecting on one hand and critical study of the resulting collections on the other, exemplifies the almost ideal correlation of studies in nature with studies in museum and laboratory toward which we strive. He began with collecting expeditions

in the Pacific northwest—to Alaska in 1899, to the Queen Charlotte Islands in 1900, to the base of the Alaska Peninsula again in 1902, and again to the interior of Alaska in 1903 and 1904. Reports on these several expeditions appeared in the “North American Fauna.” In the intervals between periods of field work he carried on studies of various groups of North American rodents, of which the most noteworthy were embodied in a comprehensive report on the white-footed mice (*Peromyscus*), published in 1909. This group of small rodents, ubiquitous in North America, required the study of an extraordinary wealth of material; it is gratifying to the systematic zoologist to find that it has supplied the basis for broadly ramifying studies of ecology and genetics that are still in progress.

The early part of his career, with its emphasis on North America and Alaska, came to an appropriate end with his studies and the published report on the Alaska fur seal (with other members of the Fur Seal Commission), in 1915.

Within his career in Field Museum, beginning in 1909, Dr. Osgood made himself the acknowledged authority on South American mammals, his authority being based on personal knowledge from repeated expeditions to South America, supplemented by that gained from collections from other Field Museum expeditions promoted by him, and by exhaustive studies both in the Museum’s laboratories and at the British Museum. Other notable expeditions for Field Museum took him to Abyssinia in 1926-27 and to Indo-China in 1936. The results of these successive expeditions, embodied in reports by Dr. Osgood on the collections made, have appeared in the long series of publications of Field Museum. It is gratifying to state that as Curator Emeritus he is enabled to devote his attention to the completion of his important larger work on the mammals of Chile and to the check list of South American mammals which is much desired by his colleagues.

Thus the background of Dr. Osgood’s career is a broad knowledge of the geography of the world, and a special knowledge of the geography of birds and mammals. This background has been invaluable to Field Museum in planning and carrying out the Museum’s program of exhibition, notably in its habitat groups. His essay on the modern trends of museum work in the *Encyclopaedia Britannica* Yearbook (1938) exhibits his interest in the more subjective and more specifically educational types of museum exhibition, toward which museums must turn as the available space for elaborate habitat groups is exhausted.

In his administrative relations within the Department of Zoology Dr. Osgood has been able to combine the respect and the friendship of his subordinates, to direct them, sometimes without their knowledge, and to give them a free hand in their respective divisions when this would best develop their capacities.

The great growth of Field Museum has coincided with Dr. Osgood's régime as Chief Curator of Zoology. This growth has been two-fold: in the direction of exhibition on one hand and in the development of the scientific collections and of the researches based on them on the other. No one in Field Museum's organization has played a more active or more effective part in this vital developmental period of the Museum than has Wilfred Hudson Osgood.

STANLEY FIELD

President, Field Museum of Natural History



PERSONAL APPRECIATION

Most of the zoologists who will receive and study this volume are personally acquainted with Dr. Wilfred H. Osgood, in whose honor it is published. It is to be hoped that others, who may not know him personally, will learn to know enough of him through his own publications to appreciate his well-rounded and all-inclusive interest in the field of zoology, which is so characteristic of him, and which so much impresses his associates in Field Museum.

Dr. Osgood's history may be read from his successive environments. After a childhood in New England, he moved to California at the age of twelve. Ten years were spent in California, the next twelve in Washington (and in his long expeditions to Alaska), and since 1909 he has been a member of our staff and thus a Chicagoan. His first interest was in birds, beginning when, as a child, he was a collector of birds' eggs. During a later short period of his life, he became a country school teacher during the interrupted course of his college years, and his principal recreation was the collection of birds and the study of living birds in their native haunts.

At Stanford University he became saturated in the traditions of the great Louis Agassiz by his association there with one of Agassiz' most brilliant pupils, David Starr Jordan. During his years at Stanford he was one of the organizers of the Cooper Ornithological Club of California, and became its first president—an accomplishment and honor the memory of which he still cherishes.

His professional career began with the United States Biological Survey and continued with that organization until he began his association with Field Museum. In the late nineties he made a trip to Alaska over White Pass and down the Yukon to Bering Sea, collecting and charting as he went. His ambition almost got the better of him in this particular trip, as his boat was so overloaded with specimens that it was swamped in the icy waters of the Yukon. It is fortunate for zoology that Dr. Osgood had become an able swimmer in his earlier years. This icy bath did not cool his enthusiasm for successive expeditions to Alaska.

On this eventful trip Dr. Osgood expressed the wish that he might traverse in a similar manner the other great rivers of the world. As the years passed, his hopes were realized to a great degree, for his research expeditions took him down the Amazon in 1912 and down the Nile in 1927. In the course of his twenty-two scien-

tific expeditions he has visited the mountains of Abyssinia and the jungles of Indo-China, although his principal interest has been in his repeated expeditions to South America. He has sought out birds and mammals in their native environment, has lived with them, and has observed their habits. Thus he has been able to bring back to the Museum specimens and information that contribute largely to the world's knowledge of his chosen fields of specialization.

While Dr. Osgood has long been a specialist in the field of mammalogy, his attainments in this field have not limited his interests or his breadth of view. Within Field Museum he is known especially as an able administrator, carrying the burdens of an executive without losing his ability to plan and finish research problems. His personality is a well-rounded one, as attested by his interest in golf and in hunting and fishing on one hand, and in amateur dramatics on the other.

Dr. Osgood's research and publication exhibit the variety of his interests. A glance at his bibliography of nearly two hundred titles reveals not only many contributions to the taxonomy and nomenclature of mammals and many faunistic reports, but outstanding works of other kinds. In the field of conservation and economic zoology, there is his notable report on the fur seals of the Pribilof Islands. In mammalian anatomy his monograph on the marsupial *Caenolestes* is a monumental contribution. The general reader who would have an accurate story of what happens on an expedition is referred to Dr. Osgood's "Artist and Naturalist in Ethiopia," in which his diary and that of the late Louis Agassiz Fuertes are compared on a day by day basis.

My own acquaintance with Dr. Osgood covers the past fifteen years, during which time it has been my privilege to witness at first hand and in his company the splendid development of the Department of Zoology, of which he was Chief Curator. In that time I have come to know him as a friend as well as a colleague, and have been fascinated with the story of his career. My appreciation of him prompts this brief sketch in the hope that others may learn to know him not only as the eminent scientist that he is, but also as a well-rounded and most likable personality, a warm friend, and a genial and co-operative co-worker.

CLIFFORD C. GREGG

Director, Field Museum of Natural History

PYGMY SPERM WHALE IN THE ATLANTIC

GLOVER M. ALLEN

Curator of Mammals, Museum of Comparative Zoology

Until recent years, specimens of the pygmy sperm whale (*Kogia breviceps*) have been so rarely obtained that Le Danois (1911), in recording two individuals stranded on the French coast, believed that they were respectively the eleventh and twelfth to be reported. Even that number, however, should have been reduced by one, for, in repeating the two records from Madras given by Owen (1866), Le Danois failed to notice that, through a misunderstanding, the two specimens originally reported were in fact one and the same. A few years later, Schulte (1917), in describing a skull newly obtained, listed a total of twenty-one specimens known up to that time, but overlooked several that had been recorded. His listing includes two jaws without locality, preserved in the Royal College of Surgeons and the Hunterian Museum, respectively (the second, however, from Australia, according to Van Beneden and Gervais). Still other individuals have since been taken and sundry papers have described details of the anatomy, so that at present the species is fairly well known and in spite of some half dozen names applied in the past to various individuals all are currently regarded as pertaining to but a single species.

On April 21, 1939, Dr. Thomas Barbour secured for the Museum of Comparative Zoology a specimen that had come ashore some ten miles south of Cape Henry, Virginia. With the assistance of Mr. and Mrs. William E. Schevill of the museum staff, the skeleton was saved. The specimen proved to be an adult female, containing a large fetus, which was preserved entire. Notes on these and some other specimens supplement our still meager knowledge of this species.

OCCURRENCE IN THE INDIAN AND PACIFIC OCEANS

Since Blainville's description of the original skull from the Cape of Good Hope, most of the specimens reported have come from the Indian and Pacific oceans, especially from the seas about Australia and New Zealand. Van Beneden and Gervais, in their "Ostéographie," describe and figure the type skull of Blainville's *Physeter breviceps* as well as the type skeleton of Krefft's *Euphysetes macleanii*, while on a later page of the same work they add a note

on a skeleton from Japan of which a supplementary plate is given. Another Japanese specimen, caught by fishermen off the east coast of Ishigaki Jima (an island between Formosa and the main Japanese group), was recently recorded by Hirasaka (1936), who in a later and more detailed account (1937) refers to no less than five other skulls obtained between 1913 and 1936 in the seas about Japan and recorded by Ogawa. Serène (1934) records a specimen stranded on the coast of Annam. Oliver (1922), reviewing the Cetacea of New Zealand, states that "at least eleven specimens have been cast ashore" on those coasts during the previous forty years. One of these is the type of *Euphysetes pottsii*, described by Haast (1874); one is from Napier (1892); four are from Wanganui Beach; four are from Cook Strait (Port Underwood, Lyall Bay, Wellington Harbour); and one is from Otago (Benham, 1901, 1902a). To these may be added what seems to be an unrecorded skeleton, No. 6927 Museum of Comparative Zoology, from Poverty Bay, North Island, New Zealand, purchased of H. A. Ward of Rochester, New York, in January, 1884, and now mounted and on exhibition. Its sex and the date of capture are unknown. Two synonyms of *Kogia breviceps* (*Euphysetes grayii* and *E. macleayii*) are based on Australian specimens from New South Wales; it has been once recorded from South Australia; and more recently Longman (1926) has reported it for the first time from Queensland on the basis of a weathered skull found on the beach near Corio Head.

In the Indian Ocean, Sir Walter Elliot secured a specimen near Madras (at Waltair) on which Sir Richard Owen (1866) founded his *Physeter simus*, a name now generally regarded as synonymous with *Kogia breviceps*. Due to various misunderstandings, later explained by Sir Walter (Owen, 1867), Owen supposed that the notes sent him referred to two specimens, a male and a female, instead of to the single female, an error which, in spite of its correction, persists in the literature. From Ceylon, the British Museum received a specimen in 1891 taken at Trincomalee, and Pearson (1920) has reported on a second specimen of unknown sex, stranded at Moratuwa on November 30, 1915, of which he gives a brief description, with figures of the exterior.

From Travancore, at the southwestern end of the Indian peninsula, Pillay mentions that in February, 1925, while he was at Trivandrum, he had an opportunity to observe a gravid female about ten feet long. It seems to have been associated with an immature animal. Other records are known from the East Indies, as that of

Weber (1923), based on a skull found by him at Lamar-arap on the island of Lomblam; and a specimen has been reported from Timor.

For the eastern Pacific I know of but two records: (1) A specimen of unknown sex, found by Grayson near Mazatlan, Mexico, in 1868, of which the incomplete lower jaw and a sketch of the exterior were sent by him to the United States National Museum and subsequently formed the basis of the supposed new species, *Kogia floweri* of Gill (1871); and (2) an imperfect cranium, No. 18489 Museum of Comparative Zoology, picked up on the beach at Independencia Bay, Peru, by Dr. Robert Cushman Murphy, in November, 1919. The specimen was found in several parts and is evidently not fully adult; however, it is interesting as occurring in the region of the cool Humboldt Current, though it may, of course, have washed in from a warmer area of the adjacent seas.

OCCURRENCE IN THE ATLANTIC OCEAN

In his summary list of twenty-one specimens of *Kogia*, Dr. Schulte (1917) includes mention of five from the Atlantic Ocean (Nos. 1, 15, 16, 18, 19) in addition to one in the collection of the United States National Museum figured by Elliot (1904) without number or locality, and two others previously unrecorded (Nos. 20, 21), making but eight in all. In 1923, Piers, in reporting on his Nova Scotia *Kogia*, gave further particulars of specimens in the United States National Museum overlooked by Schulte, as well as of one or two others. Since then a few additional instances have occurred so that it seems worth while to enumerate once more such Atlantic occurrences as are available, omitting the jaw from an unknown locality, in the Hunterian Museum, previously mentioned.

(1) The original specimen, a skull from the Cape of Good Hope, described by Blainville in 1838 and presumably still in the Muséum d'Histoire Naturelle at Paris. Elliot (1904, p. 46) has published a translation of Blainville's description, since the original is not to be had in most libraries.

(2) A "young female stranded on the rocks at Green Point, near Capetown," South Africa, in 1896, the skull of which is preserved in the South African Museum. W. L. Sclater (1901, p. 190), who records the specimen, presents a few measurements.

(3) A "much larger" individual, "probably a male," stranded at Knysna, South Africa, the skeleton of which is in the South African Museum. This locality might perhaps better be regarded as just within the bounds of the Indian Ocean.

(4) The male stranded about six kilometers from Roscoff, France, December 27, 1905, and reported by Delage (1906) as the first record for European waters and the most northerly known occurrence. Le Danois (1910, 1911) later published notes on the skeleton and soft parts.

(5) A male taken September 3, 1910, on the coast of Domino, Ile d'Oléron, in the Bay of Biscay, France, and recorded casually by Le Danois (1911).

(6) An adult female that came ashore dead at Noordwijk aan Zee, The Netherlands, on December 13, 1925, a still more northerly European record than No. 4. It was secured for the Rijks Museum at Leiden and was briefly reported upon by Van Oort (1926).

The remaining Atlantic records are all from the eastern coast of North America:

(7) A female stranded at Spring Lake, Monmouth County, New Jersey, and received in the flesh by the United States National Museum on April 27, 1883. This specimen was figured by Goode (1884, pl. 2) under the name *Kogia goodei* True, so that the name has technical status, and the type is given as No. 13738 United States National Museum. True (1884), in his "Catalogue of the Aquatic Mammals Exhibited by the United States National Museum" at the International Fisheries Exhibition in London in 1883, again refers to the specimen by the new name and adds a second record, No. 8. No further description was published, however.

(8) A lower jaw and a photograph, in the United States National Museum, of an individual from Jupiter Inlet, Florida, credited to M. E. Spencer.

(9) A male, seven feet ten inches long, secured at Kitty Hawk, North Carolina, January 5, 1885, and listed as accession 15560 United States National Museum (Piers, 1923).

(10) A female from Barnegat City, Atlantic County, New Jersey, taken October 24, 1885, and said by Rhoads (1903) to be No. 15222 United States National Museum.

(11) A male from Loveladies Island, Atlantic County, New Jersey, secured on October 25, 1885, and listed by Rhoads (1903) as No. 15223 United States National Museum. The occurrence of these two specimens at about the same time and in the same locality, suggests that they may have been associated, as a pair.

(12) A male, washed ashore during a storm, at Dam Neck Mills, south of Virginia Beach, Virginia, in February, 1887, and secured

by the United States National Museum (accession 22559), according to Piers (1923, p. 97).

(13) A male from Atlantic City, New Jersey, secured in April, 1888, now No. 22893 United States National Museum (fide Rhoads, 1903).

(14) A male from Corson's Inlet, Cape May County, New Jersey, taken February 18, 1894, and said to be preserved in the Wistar Institute Museum, Philadelphia (Rhoads, 1903).

(15) A male from Ocean City, Cape May County, New Jersey, secured November 2, 1899; it was driven into a small cove by fishermen and killed. According to Rhoads (1903) it weighed about 700 pounds and is preserved in the Wistar Institute Museum, No. 3700.

(16) An immature individual, sex unrecorded, obtained by Frank Wood at New Bedford, Massachusetts, about 1910. It was about eight feet long. Mr. Wood sent it to the American Museum of Natural History, where its skeleton is No. 34867.

(17) A male, killed at Nahant, Massachusetts, October 30, 1910. The skeleton and a cast of the exterior were secured by the Boston Society of Natural History.

(18) A large female, stranded at Long Beach, Long Island, New York, on February 28, 1914, and secured for the American Museum of Natural History by Dr. Roy C. Andrews. An account of the specimen (No. 36595 American Museum of Natural History), the external characters, muscles, and peripheral nerves was published by Schulte and Smith (1918), with a description of some of the anatomical features of the new-born calf accompanying it, by Kernan and Schulte (1918).

(19) A "nearly adult female," found dead under the ice in Herring Cove, outer part of Halifax Harbor, Nova Scotia, on January 17, 1920, by men clearing ice floes from about the wharves. An account of the specimen was published by Piers (1923), who supposes that the whale, "on coming into the small inlet, had got under the ice, and, not happening to retrace its way, had drowned beneath the strong covering, as it was unable to reach the surface to breathe." The skull is preserved at the Nova Scotian Institute of Science at Halifax.

(20) A specimen from South Beach, Staten Island, New York, secured March 1, 1920, by the American Museum of Natural History, as reported by Piers (1923, p. 97).

(21) A partially decomposed individual, about nine feet long, washed ashore, November 1, 1929, on "the north side of the Long Island Fill, near the mouth of the Savannah River, . . . only a hundred yards across the line, in South Carolina." No injury was apparent, nor was the sex determined. The skull was later secured and sent to the Charleston Museum (Tomkins, 1934).

(22) A male, harpooned and killed on May 7, 1932, some 200 yards offshore, opposite the Oregon Inlet Life Saving Station, North Carolina, by Dr. Cecil K. Drinker, Louis Agassiz Shaw, and L. Freni. The skull and some parts of the skeleton were later retrieved by Dr. Drinker and presented to the Museum of Comparative Zoology. The specimen (No. 32159 Museum of Comparative Zoology) has not hitherto been recorded.

(23) In the issue of "Natural History" for January, 1940, McBride (1940, p. 27) contributes an article including a photographic figure of a live *Kogia* which had washed ashore in a storm near Marineland, Florida. It was at once transferred bodily to the large aquarium conveniently at hand, but soon after succumbed. Its further disposition is unrecorded.

(24) The adult female containing a large fetus, earlier mentioned, secured by Dr. Thomas Barbour and the Schevills some ten miles south of Cape Henry, Virginia, on April 21, 1939. The skeleton is preserved in the Museum of Comparative Zoology (No. 40838). I am indebted to Mr. and Mrs. Schevill for generously permitting me to make use of the notes and measurements they made at the time.

(25) An immature male washed ashore at the same time with the female (No. 24) but not collected. It was thought to have been a yearling calf still following the mother, which at that time was again pregnant. Both the specimens were more or less "cut up" and Dr. Barbour surmises that they had gotten in among a flotilla of torpedo boats that a few hours previously had passed out of the Virginia Capes and had been damaged by the propellers of the boats.

(26) Dr. Barbour permits me to record that in April, 1940, almost a year to a day following the above occurrence, and at the same place, he found another dead one, killed in the same way, doubtless through having become fouled with the propeller blades of one of a flotilla of torpedo boats that had passed out from the Capes a short time before.

So far as this summary of records may signify, *Kogia* is relatively rare in European waters with but three records from the French and Dutch coasts, and none at all for British waters in spite of many years of intensive effort to gather notes and specimens of cetaceans (Harmer, 1927). This is in contrast to twenty or more instances from eastern North America, from Florida to Nova Scotia. Similarly, in the western Pacific Ocean there are many records from the seas about New Zealand and eastern Australia to the East Indies, French Indo-China, and Japan, as well as others for the northern Indian Ocean, whereas for the eastern Pacific there are but two, one each for Lower California and Peru. No doubt the lack of records for the South Atlantic, except for the Cape of Good Hope region, and for the eastern Pacific, except as just noted, is in part due to the lack of interested observers. Nevertheless the distribution of the cases now reported probably indicates that the pygmy sperm whale does favor certain areas of sea where conditions of food and water temperature are optimum. These areas are perhaps those of such major ocean currents as the Agulhas of the Cape region, the Gulf Stream in the western North Atlantic and the Japanese Current of the western North Pacific.

What significance may be attached to the fact that most of the North Atlantic records are for the cooler months of the year is uncertain. Possibly it may reflect the habits of the food species. The dates for five of the twenty-six records are not known; of the remaining cases, one occurred in September, three in October, two in November, two in December (Europe), three in January, three in February, one in March, five in April, and one in early May.

A factor in the stranding of this whale is perhaps also the nature of the shore where the animal is passing. The gradually shelving, sandy coast of New Jersey southward may be more favorable for this than a coast where the inshore waters are deep or the shores rocky. The definite American records arranged by states indicate this, namely, from south to north: Florida, two; South Carolina, one; North Carolina, two; Virginia, four; New Jersey, six; New York, two; Massachusetts, two; Nova Scotia, one.

Apparently *Kogia* is a rather slow-moving, lethargic, non-social species, as may be indicated by the few available notes. Dr. Cecil K. Drinker, who took part in the capture of the male near Oregon Inlet, May 7, 1932, writes that while going north in a motorboat about 200 yards offshore, he and his companions saw what they took to be a single porpoise, "going down the coast, moving very

steadily in a straight line. A harpoon gun was gotten ready and also a hand harpoon. It was unnecessary to use the gun since we easily came directly alongside. When first struck by the harpoon, the whale ran vigorously and directly away from the boat. This placed so much strain on the line as to draw the swordfish dart then in use. Almost immediately the whale headed south again on its original route, and again the boat was easily brought alongside. At the second trial the animal was securely fastened and after fifteen or twenty minutes was brought in and killed with a dart from the harpoon gun. The vigor of the whale was, in our opinion, much less than that displayed by a porpoise of anything like the same size. We estimated the weight as between four and five hundred pounds." Of the October male, killed at Nahant, Massachusetts, in 1910, I was told by its captor that when first seen it was swimming at the surface about 200 yards offshore. When pursued and shot at, it leaped partly out of the water. Another, on the New Jersey coast, was driven by fishermen into a small cove and killed. In at least two instances, individuals have been found washed ashore and still living, as in the case of the one at Marineland, Florida, and a second on the coast of Annam. Estimates of the weight of dead individuals vary from 400 to 700 pounds.

SIZE

The male of the sperm whale is considerably larger than the female; in *Kogia*, however, no such contrast appears and it is usually stated in the literature that the sexes are of equal size. Unfortunately, for a large part of the reported specimens either the sex or the total length or both are omitted. The tabulation on page 25 gives most of the instances in which these factors are recorded. These averages show that males slightly exceed females in size when full grown. The largest recorded male is 3,351 mm. (11 feet) and the largest female 3,200 (10 feet 6 inches). Omitting this last from the average as possibly unusual or erroneous, as well as the small (immature) female from Capetown, gives a similar average of 2,451 mm. The Cape Henry specimen was fully adult, as indicated by the well-ossified mesethmoid and complete union of all epiphyses. Taking into account the females with fetuses, total lengths recorded are:

Locality	Total length mm.	Date	Reference
Waltair, near Madras.....	2,184	Feb. 28	Owen, 1866, 1867
Spring Lake, New Jersey.....	2,591	April 27	Rhoads, 1903
Cape Henry, Virginia.....	2,210	April 21	Present paper
Noordwijk aan Zee, The Netherlands.	2,950	Dec. 13	Van Oort, 1926
Travancore, India.....	3,048	Feb.	Pillay, 1926

The largest of these five definitely breeding females is thus about 3,048, the smallest 2,184, with an average of about 2,596 mm., which is only slightly larger than the average of eight in the following table. It is quite likely that some of the published dimensions are merely estimates.

MEASUREMENTS OF KOGIA

Males

Locality	Total length mm.	Reference
New Zealand	2,667	Benham, 1902a, b
Ile d'Oléron, France	3,300	Le Danois, 1911
Corson's Inlet, New Jersey	3,048	Rhoads, 1903
Ocean City, New Jersey	3,351	Rhoads, 1903
Nahant, Massachusetts	3,200	Unpublished
Oregon Inlet, North Carolina	2,743	Unpublished
Roscoff, France	2,250	Le Danois, 1911
Kitty Hawk, North Carolina	2,388 or 2,743	Piers, 1923

Average of 8 males..... 2,868 or 2,912 (the total length of the last specimen is said by Piers to have been 7 feet 10 inches, but by the "American Naturalist" [1885] in a contemporary record, 9 feet).

Females

Locality	Total length mm.	Reference
Near Capetown, Africa	1,752 (imm.)	Sclater, 1901
New Zealand	2,184	Haast, 1874
Madras, India	2,184	Owen, 1866, 1867
Halifax, Nova Scotia	2,591	Piers, 1923
Spring Lake, New Jersey	2,591	Rhoads, 1903
Barnegat City, New Jersey	3,200	Rhoads, 1903
Noordwijk aan Zee, The Netherlands	2,950	Van Oort, 1926
Cape Henry, Virginia	2,210	Unpublished

Average of 8 females..... 2,457

BREEDING AND YOUNG

From the data at hand very little may be deduced as to the times of breeding or the length of the gestation period. Possibly the two individuals stranded on the New Jersey coast in October, 1885, the male on the twenty-fifth at Loveladies Island, the female on the twenty-fourth at Barnegat City, may have been a mated pair. The five pregnant females listed above were taken between December 13 (Holland) and the latter part of April. The female taken at Long Beach, New York, on February 28, was accompanied by a newly born young, only 1,097 mm. long; while the one taken on April 21 at Cape Henry, Virginia, containing a large fetus, was accompanied by a younger animal, some five feet long, probably a yearling born in the previous season and still suckling, for the adult was lactating abundantly. What seems to have been a pre-

cisely similar case is that reported by Pillay (1926) from Travancore, India, of a gravid female "about ten feet long" that he had an opportunity to observe in February, 1925, at Trivandrum. He adds, "There was another one of the same species which was immature," implying that it was a yearling accompanying the female parent.

Possibly, then, mating may take place in late summer, and the young are born in the following spring, after a gestation period of some nine months, as in certain other whales. Evidently the single calf stays with the mother during its first year.

EXTERIOR AND SKELETON

The Cape Henry specimen and its fetus offer a few points of interest. The external form with obtusely pointed head, the small, narrow mouth on the ventral side, the asymmetrical crescentic blowhole, the low falcate dorsal fin, the slightly tapering pectoral limb, and the tail with a median notch between the flukes, have been often described.

In a ventral view of the head, the fore part of the snout is seen to project considerably beyond the tip of the jaw, whence it slopes upward and forward to a blunt point. Since in the skull the tip of the lower jaw slightly exceeds the rostrum, it is clear that the front of the snout forms with the spermaceti organ a pad, which possibly acts as a bumper or shock absorber in head-on contacts, for the eyes are placed so far at the sides of the head that they seem hardly capable of forward vision and there are no vibrissae to give notice of solid objects in the path. Without some such protection the delicate bones of the rostrum and mandible might easily be fractured. Indeed, it seems likely that the condition described by Benham (1902a), in which there were two "premaxillary nodules" or small separate bones at the tip of the snout, may have been a result of some accidental breakage.

In naval architecture, it is said that a favorable angle for the bow of a boat going through water is about 35° on each side of the median axis, in connection no doubt with moderate speed. It is at least interesting to find that this angle in the Cape Henry specimen, as measured from a photograph taken by Mrs. Schevill, was about 37° . This corresponds essentially with the measurement of the inter-ramal angle of the jaw as measured from the skeleton, namely, 70° (twice the angle formed with the median line).



FIG. 1. Fetus of *Kogia breviceps* from the Cape Henry female, showing the row of four bristles in front of the eye, the asymmetrical blowhole, falcate dorsal fin, and (enlarged) a lower view of the throat showing the five inter-ranal grooves. Drawing by E. N. Fischer.

Hair.—No trace of hair was noted in the adult or in other recorded specimens. It is therefore interesting to find that the fetus shows four short, tapering bristles placed in an oblique row in front of each eye (fig. 1). Schulte and Smith (1918), in describing the new-born young from Long Beach, Long Island, state that although no hairs were discovered they nevertheless found the bases of four hairs in a similarly oblique row in the specimen. Probably these remaining hairs are shed before or soon after birth.

Throat grooves.—In none of the accounts of this whale is there any mention of throat grooves. In the Cape Henry fetus, however,

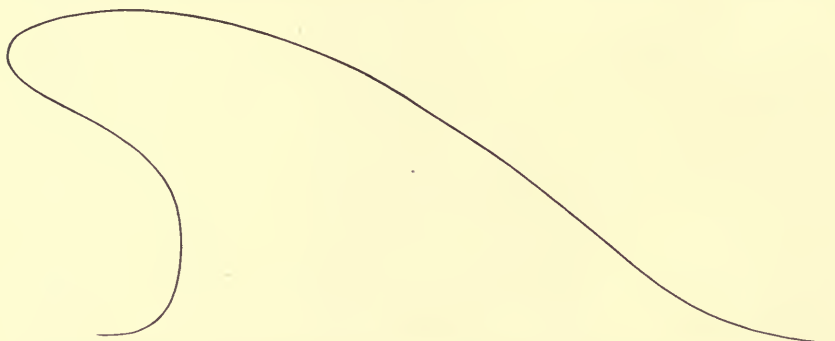


FIG. 2. Tracing of the outline of the dorsal fin of the Cape Henry female. $\times \frac{1}{3}$.

there are five well-marked grooves on the throat, beginning just back of the angle of the mouth and extending a short distance back on the inter-ramal region. Of these, the median one is the longest, 35 mm., the next outer one about 5 mm. shorter, and the external one on each side the shortest, about 23 mm. The two on either side of the midline diverge slightly forward, while the two outermost ones curve slightly outward. In the adult these shallow grooves are probably not evident enough to attract attention and are easily passed by; yet they are dimly visible in photographs I have of the adults from Cape Henry and from Oregon Inlet. In the sperm whale (*Physeter*) as well as in the beaked whales, two are present, one on each side, while in a young *Ziphius* from New Zealand, Scott and Parker have described three on each side. These grooves may indicate a certain relationship with the beaked and sperm whales.

External measurements.—Few series of measurements of *Kogia* are published. It may therefore be worth while to add the principal dimensions of the Cape Henry adult female and those of an adult

male from Nahant, Massachusetts, hitherto unpublished. The former were taken by the Schevills, the latter by myself.

	Female mm.	Male mm.
Total length, snout to notch of flukes.....	2,210	3,200
Snout to anterior corner of eye.....	290	330
Snout to anterior point of blowhole.....	195	344
Snout to pectoral limb.....	650	680
Snout to anterior edge of dorsal fin.....	1,050	1,735
Anus to median caudal notch.....	700	1,030
Right fluke from tip to notch of tail.....	350	438
Height of dorsal fin at tip.....	145	76
Length of base of dorsal fin.....	260	140
Length of pectoral limb from insertion.....	350	495
Greatest width of pectoral limb.....	130	165

Apart from the generally greater dimensions of the adult male as compared with the adult female, the only striking difference is in the very much smaller dorsal fin, which in the male is low and narrow, while in the female it is of nearly twice the size (fig. 2). This also comes out in a comparison of photographs of the two

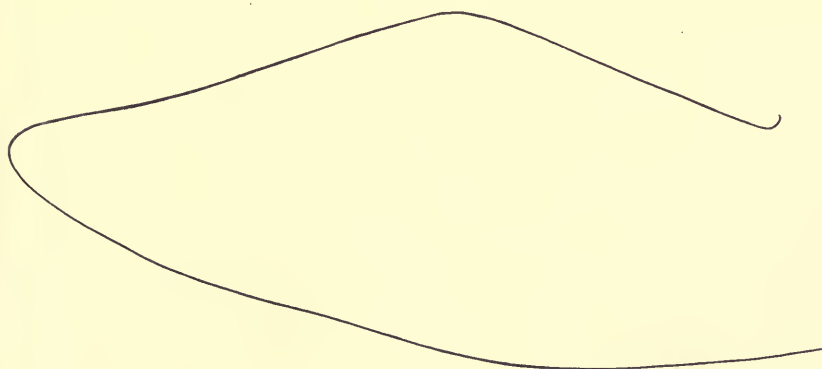


FIG. 3. Tracing of the outline of the pectoral limb of the Cape Henry female. $\times \frac{1}{3}$.

animals. Again, in the case of the adult female secured by Sir Walter Elliot on the coast of Madras, Owen (1866) states that the height of the dorsal fin, "vertically at its back part, where the apex curves back a little beyond the basal attachment," was 7 inches (177 mm.), and the base some 10 inches (253 mm.) long, figures that agree approximately with those for the Cape Henry female. Whether or not this is a normal sexual difference or merely individual variation, future observations may show.

Skull and teeth.—The extremely spongy texture of the bones of the cranium and the almost paper-thinness of the mandibles are

rather remarkable, perhaps degenerate characters. In contrast to the Delphinidae, also, is the structure of the pterygoids, which appear to be thick and solid, rather than thin and folded over exteriorly to unite with a wing-like process of the palatine bone. The

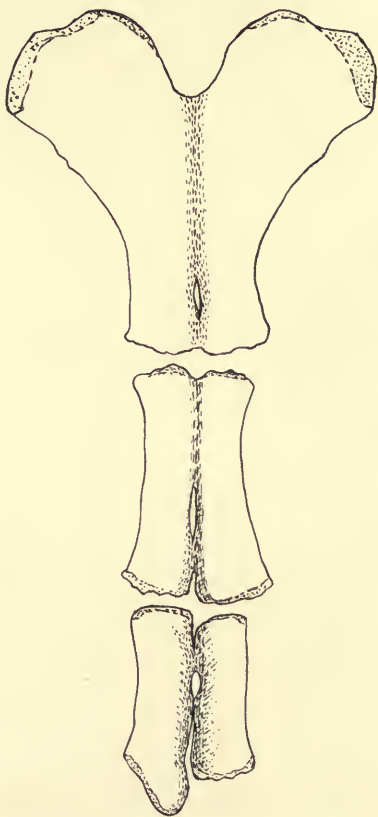


FIG. 4. Sternum of the Cape Henry female from above, to show the paired origin of the sternebrae.

symphysis of the mandible in the Cape Henry female is imperfectly ossified but would be about 40 mm. long.

In the upper jaw, a shallow and continuous alveolar groove extends from the front of the maxillary back for some 60 mm. on each side, but is not continued forward on to the premaxillary. There are four very small spicular teeth present, two on each side at the front of this groove. In the lower jaw the teeth are much larger and set in separate sockets, ten on the right side, eleven on

the left, giving the formula $\overset{2}{I_0} - \overset{2}{I_1} = 25$. The posterior teeth especially are long and backwardly directed; their roots are slightly roughened with minute ridges or points of dentine. In other recorded specimens, the number of teeth has varied from none to one or two on each side above, and from nine to fourteen on a side below. Piers (1923) and Le Danois (1911) both report none above and fourteen on each side below; for the Madras specimen Owen (1866) gives one above and nine below on each side. Obviously, however, the minute upper teeth are easily overlooked or lost. Benham (1902a), who was able to macerate his (New Zealand) specimen very carefully, found the number to be $\overset{2}{I_3} - \overset{2}{I_3} = 30$, which is probably close to an average condition.

Vertebrae and ribs.—There is a slight individual variation in the number of ribs, vertebrae of different groups, and chevron bones. Moreover, unless great care is used in preparation, the small terminal vertebrae are easily lost, so that the number of caudals recorded for most of the specimens is liable to slight error.

The seven cervical vertebrae in *Kogia* are apparently always fused into a single mass, and so thin are the middle bones that their individuality is largely lost and their exit openings for the corresponding spinal nerves merge together. The first and second vertebrae, however, are indicated by their respective nerve passages, and the seventh also seems distinct. Indeed, in the Poverty Bay (New Zealand) skeleton in the Museum of Comparative Zoology, the low neural arch of the last is distinct completely from that of the sixth. It would be interesting to see if in the embryo the several bones showed their individual boundaries, and which spinal nerves had a common exit.

The number of rib-bearing vertebrae following varies from twelve to fourteen. Twelve were present in the Roscoff specimen, in Haast's type of "*Euphysetes pottsi*" from New Zealand, and according to Oliver (1922) in two other New Zealand specimens, as well as in the Poverty Bay (New Zealand) skeleton in the Museum of Comparative Zoology. Thirteen ribs were found in the Cape Henry female, in the specimen from The Netherlands, one from New Zealand (Benham, 1902a), one from Ceylon (Pearson, 1920), and one from Japan (Hirasaka, 1937). In only one case, that of the type of "*Euphysetes grayii*" from New South Wales, have fourteen ribs been reported. In the Cape Henry skeleton the first nine ribs have a double articulation; the others articulate by the tuberculum alone.

In this, too, there is some variation, for Haast reports that six of twelve have a single articulation.

The lumbar vertebrae are nine in the Cape Henry skeleton and in four others for which the number is recorded, while eleven are said to be present in the type of "*Euphysetes grayii*" and in the specimen from The Netherlands (Van Oort, 1926). Here again some uncertainty may be caused in the determination of the first caudal, which I have regarded as the one on the posterior ventral border of which are the articular facets for the first chevron bones.

The caudals, counting from the first to have a chevron, are twenty-seven in the Cape Henry specimen, making a total of fifty-six vertebrae. This is two more than were found by Pearson (1920) or Van Oort (1926). Benham (1902a) found only twenty-three. Undoubtedly, in some of the other cases reported, the last few are lost, since they are very small. The anterior zygapophyses disappear after the thirty-fifth vertebra in the Cape Henry specimen; on the forty-fifth the neural canal is open at the summit and disappears with the forty-seventh.

Sternum.—As in *Physeter* the sternum consists of three sections, the first of which is broadly expanded in front and tapers to a narrow stem posteriorly. The two following pieces are long and narrow. The bilateral origin of the sternebrae is evident, since the last section in the Cape Henry specimen (fig. 4) consists of two narrow pieces united at only one point, while the two sections anterior to it have each a median gutter with a small slit-like opening in the posterior part where ossification is incomplete. Benham (1902a) was the first to figure and describe this structure adequately. It was somewhat different in shape from that of our specimen, with the broad anterior section less deeply emarginate in front, and the last section definitely of two separate bony rods. Very likely, as commonly in cetaceans, this wide variation in form of the sternum is a mark of degeneration in the structure.

Pelvic bones.—Apparently pelvic bones are lacking or at least unossified in *Kogia*. In roughing out the skeleton of the Cape Henry specimen, the Schevills sought carefully for them and made many sections through the region where they should have been but failed to find any. Benham, likewise, in preparing his Otago specimen, looked very carefully for pelvic bones, even following out the muscles of the penis to which they should give attachment, but felt quite certain that none was present. Van Oort (1926) states again that no pelvic bones were present in the adult female stranded

at Noordwijk aan Zee, The Netherlands, the skeleton of which was carefully prepared for the Leiden Museum. The testimony of these investigators seems conclusive, that these bones are at least usually absent, so that one may suppose their place is taken by cartilage or a tendinous fascia. Evidently, as suggested by Benham (1902a), the four small objects figured by Wall (1887) as the pelvic bones of "*Euphysetes grayii*" pertained to some other animal, for they bear not the remotest semblance to the usual rod-like pelvic vestiges of Cetacea. They were sifted out of the sand in which the whale had been buried for cleaning.

PARASITES

In the Cape Henry specimen the Schevills made no search for parasites, but the calf accompanying the adult had a *Penella* about five inches long attached in the skin and blubber near the base of the caudal peduncle, and trailing behind. The only other records of parasites in this species include nematode worms and two peculiar cestodes in the intestine (Delage, 1906), in the case of the Roscoff specimen, and quantities of nematodes in the stomach and cestodes in the skin (muscles) of the back in the one from Kitty Hawk, North Carolina.

FOOD

Very little is recorded of the stomach contents of specimens of *Kogia* that have been collected. The curiously overshot jaw and the nearly complete loss of teeth in the upper jaw imply a diet on something other than fish, in fact, crabs and cephalopods. The stomach of the specimen reported from Noordwijk aan Zee, The Netherlands, by Van Oort, held a mass of carapaces and appendages of the green crab, *Carcinides maenas*, as well as the beak of a cephalopod, apparently *Sepia officinalis*; that of the Roscoff (France) animal held a large number of squid beaks, in addition to many nematodes and two curious cestodes as parasites in the intestine; finally, the Kitty Hawk, North Carolina, whale is said to have contained beaks and eyes of cuttlefish as well as a great quantity of nematodes (Amer. Nat., 1877). The stomach of one examined by Haast in New Zealand was empty.

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MAMMALS COLLECTED BY THE VERNAY- CUTTING BURMA EXPEDITION

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INTRODUCTION

The Vernay-Cutting Burma Expedition, 1938-39, worked in northeastern Burma and had as major projects the collection of representative series of mammals, birds, and plants. The expedition was financed by Mr. Arthur S. Vernay and Mr. C. Suydam Cutting, Trustees of the American Museum of Natural History, both of whom accompanied the party into the field.

Mr. Frank Kingdon Ward, the well-known plant explorer and collector, who has had a wide field experience in Burma, had charge of the botanical activities of the expedition. Mr. J. K. Stanford, formerly District Commissioner at Myitkyina, Burma, and a field student of the birds of Burma, took over the ornithological work. The collecting and study of the mammals were in charge of the author.

The staff of skinners and field assistants included Mr. J. Gabriel, lent to the expedition by the Prince of Wales Museum of Bombay, Mr. W. H. Stubbs, on leave from the Burma Excise Department, and Maung E. Thaung, a Karen, from the office of the Forest Botanist, Maymyo, Burma. These were the individuals most helpful in the preparation of mammal specimens. Mr. Gabriel, as the one with the most experience, was placed in charge of the skinning.

I received material assistance in collecting mammals from the other members of the expedition. Messrs. Vernay and Ward set out trap lines in some of the camps, and Mr. Stanford shot any small mammals encountered while hunting birds. He also conducted a successful hunt for a bear reported by the natives.

The members of the expedition arrived in Burma at different times. Stanford and Ward left railhead at Myitkyina on November 15, 1938, and proceeded up country to organize base camps and provide transport and other facilities for the party, which would assemble in December. I arrived in Rangoon on November 29 and was joined there by Vernay and Cutting on December 9. The three of us met Stanford at Myitkyina on the twelfth, transported our supplies and equipment across the Irrawaddy to Waingmaw,

and were ready to begin field work on the morning of the thirteenth. Ward was collecting at Laukhaung, where we joined forces on December 20. At this place traps were set out for the first time but only a short line could be placed, the region was unpromising, and no specimens were caught.

The first part of the journey was primarily concerned with getting to the base camp, and mammal collecting was desultory in consequence. Birds could be collected while on the march, and such mammals as squirrels and bats were shot whenever opportunity offered. Adequate trap lines could not be established at one-night stands. The skinners occupied most of their time in camp with the birds shot during the day. The ecology of the foothills was of a character very discouraging to a small-mammal collector; there was very little ground cover, no signs of burrows or runways, ants gathered on the baited traps, and not one trap in fifty was visited by a mammal. As soon as higher elevations brought us into cooler environments the results of short trap lines put out at the end of a day's march began to be interesting.

At the Pyepat Ridge we stopped over a day in order to collect in the first of the good mountain forest, about 6,500 feet elevation, and short stops were also made at Htawgaw and at Hkamkawn, but otherwise the time spent in reaching Gangfang on January 1, 1939, was engaged in a series of daily marches which were kept short to save the pack mules. Mammal collecting did not begin in earnest until then, when all of the equipment was unpacked, the skinners were settled in quarters where they had some conveniences for their work, and the locality could be given more than a casual inspection in passing.

We had a large pack train of mules, over fifty, to move us and our supplies from Myitkyina to Gangfang. Some supplies had already been moved up to Gangfang before our arrival. A smaller number of mules was used for later moves, such as the trip to Hpimaw and to the Panwa Pass district, but for transport to Imaw Bum, to the Chimeli region, and to inaccessible localities where trails were steep and poor, the natives served as packers. We formed a large party and fortunately for us the natives were eager to work; we had no difficulty in securing the requisite number of packers. All told, there were 110 individuals in camp on the trip to Imaw Bum.

We were also fortunate in having good weather conditions for most of the time we were in the field. This part of Burma has a

wet and a dry season and the work was planned to avoid that period of the year when the monsoons bring on heavy precipitation and make collecting difficult. Although this region has an annual rainfall of anything from 65 inches to over 100 and perhaps as high as 200 in some places, most of the precipitation is concentrated within the period from May to November. Statistics have not been compiled for most of the mountainous area of northeastern Burma but charts for regions to the south show that there may be no rain whatsoever for several months at a time during the dry interval of the year. In the hills brief showers are more apt to break up such a long sequence of dry days. We had no rain of any consequence from the start of the travel in Burma, December 10, until February 14, when a cloudy, stormy period of four days gave us a hint of what we might expect when the wet season set in. Snow, at elevations of 10,000 feet and over, may fall while the valleys are dry, and we expected snow at our higher collecting stations.

Three days of bad weather, with rain falling much of the time, drove us from a leaky camp on the Hpaw-Saulang road, a collecting site that was well worth a longer stay. But the total number of days lost because of bad weather, for the period of December to the middle of April, was relatively small. We escaped the plague of leeches which appear with the advent of the seasonal rains and make digression from the trails an ordeal.

Rest houses are mentioned frequently in this report and, lest one should get the impression that northeastern Burma is much better settled, or "civilized," than it is, a word of explanation is in order. The character of the government rest houses in northeastern Burma varies with the locality. On the roads most frequently used and at the stopping places near Myitkyina, the "bungalows," as they are often called, are well-built structures, with windows, stoves, tight floors, bathing facilities, and shelters for the servants and for the mules. A caretaker, in residence, looks after the station. As one passes deeper into the back country many of these conveniences gradually drop out, and at such places as Hpawte or Changyinku, seldom visited by outsiders, the government shelter is a native-built, grass-thatched hut, with cane sides, a puncheon floor, no windows, an open fire on a square of earth in the center of the room with the smoke free to follow its fancy, and perhaps not a nail used anywhere. Such rest houses proved to be dry, nevertheless, and we were always glad to use them, supplemented by tents when the five of us were together. On trails which do not have

travel of sufficient importance to justify them the government maintains no shelters of any type.

The principal collecting sites in chronological sequence and the itinerary in that connection are as follows:

At Gangfang the entire party worked together from January 1 to 6. On January 6, Vernay, Cutting, and Ward went on a side trip for taken into the district near Sadulaw, returning January 10. Stanford left Gangfang on January 6 to hunt bear near Hpawshi, returning January 9. We remained as a party, then, until January 14, when we all started for the camp built for us by natives on the northern slopes of Imaw Bum.

We required three days on the trail to reach this camp, where we collected from January 16 to 24. On that day we split forces, Vernay, Cutting, and Ward to travel north, west, and south about the foothill flanks of Imaw Bum, eventually coming back into the main mule road at Htawgaw and thence to Gangfang once more. They arrived at the base camp on February 10.

Stanford and I returned over the trail we had used coming in and established a camp on the headwaters of the Nyetmaw River, January 24. We collected here until the morning of January 31 and then made a short march to the camp above Tsonma. On February 1 we were back in Gangfang.

After reorganizing for the next move, Stanford and I left Gangfang February 4 and on the afternoon of February 5 we were in the camp on the Chimeli road. Collecting here occupied us until February 12 and we returned to Gangfang to join the other members of the expedition on February 13.

Several days of overcast skies and intermittent heavy rains kept us from leaving Gangfang as promptly as we desired and we were fearful lest the transportation of specimens would prove a difficult problem if the rains should continue as daily occurrences. Vernay undertook to move all specimens and non-essential equipment to dry storage at Htawgaw, and left Gangfang during an all-day rain on February 18. The rest of us left Gangfang for the last time on February 19, with all of the baggage our transport could handle. We proceeded to the Hpimaw site, arriving February 20 and working there until the morning of February 27. Vernay joined us there on February 24.

The entire party moved from Hpimaw, by the usual short daily marches, to Hkamkawn and collected there from February 28 to March 3, when they arrived in Htawgaw. This place was now the

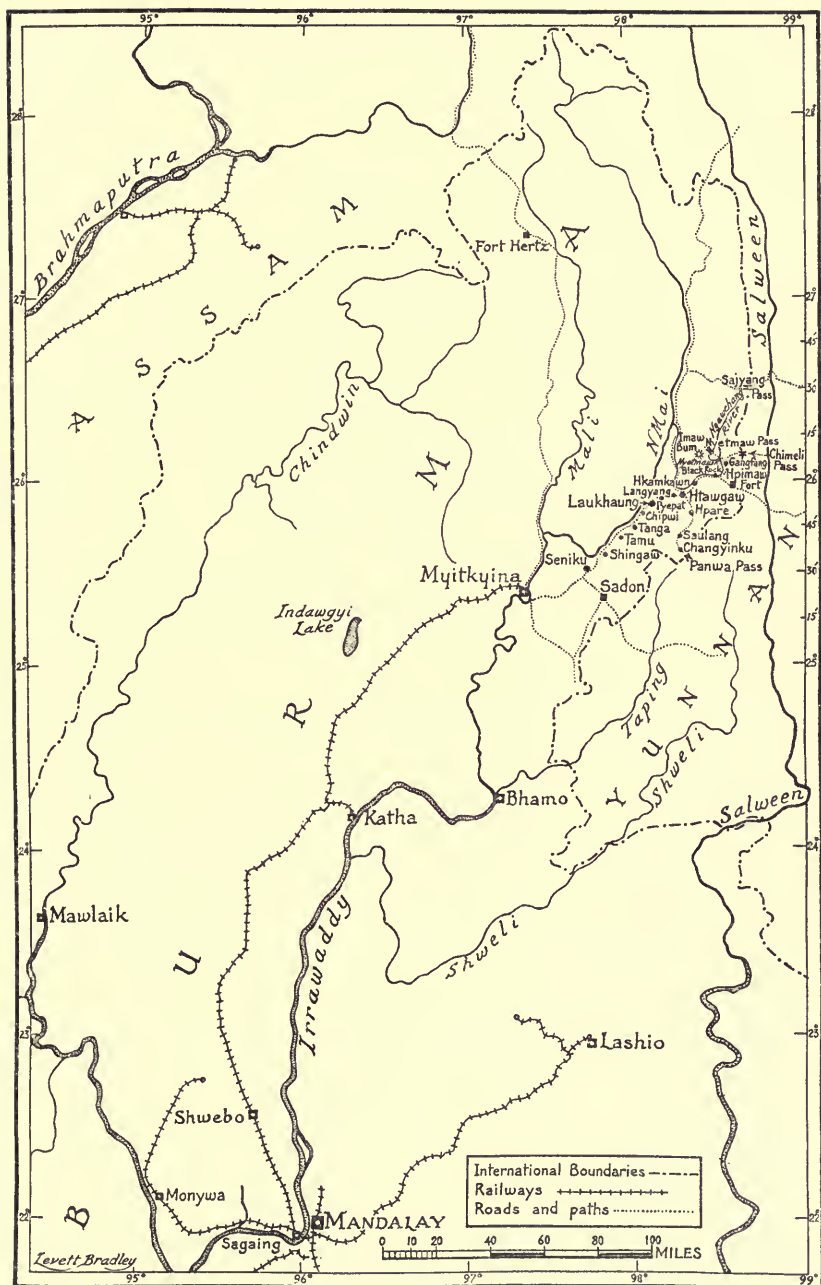


FIG. 5. Map showing principal collecting sites of Vernay-Cutting Burma Expedition.

base of operations and the interval from March 3 to March 6 was occupied in providing transport for such loads as were to go to the railroad at Myitkyina, outfitting for another side trip, and doing some collecting about Htawgaw.

On March 6 the expedition left Htawgaw for the Panwa District. The night of March 6 was spent at Luksuk, of March 7 at Hpare, and of March 8 at Saulang; at mid-day of March 9 we reached Changyinku, a short distance from the Panwa Pass. Ward and Stanford had remained at Htawgaw to attend to botanical and ornithological matters for a day or two but by March 12 all of the personnel were together once more. However, this condition was of brief duration, for about noon of March 12 Vernay and Cutting left the party to return to Rangoon and the United States. Thereafter, Ward, Stanford, and I constituted the expedition.

The three of us remained at Changyinku until the morning of March 16, when we started back for Htawgaw. On March 17 we established the camp near the Hpare-Saulang Chet, or Pass, where we found one of our best collecting sites. Stormy weather drove us from our inadequate shelter and after two days of almost continuous rain we left on March 20 for Hpare.

Collecting about Hpare was my program from March 20 to 28. Ward and Stanford made a short trip, during this period, to a camp near the Hpare Pass, March 23 to 27. On March 28 the three of us returned to Htawgaw, making the usual two-day march in one. This concluded our exploration of new collecting areas but we took advantage of favorable localities, such as the Pyepat Ridge, to add to our collections as we made the return to Myitkyina. We left Htawgaw for the last time on March 31. I arrived in Myitkyina on April 11, having left Ward and Stanford at Seniku that morning and they reached Myitkyina on April 12.

On the return from the high country, mammal trapping ceased after we left Laukhaung. At this place only one specimen was trapped in three nights, and the hot lowlands were not a collecting proposition that gave much return on a rapid transit basis. Anything that might be trapped had to be skinned at once, but the party had to be on the move early in the morning to avoid the heat of the day.

An unusually high percentage of the time spent by the expedition after leaving the railroad had to be devoted to travel, getting to places and returning to a base. While some of this time might be used to collect birds, many of these days were non-productive as

far as mammals were concerned. Carefully placed trap lines with a reasonably large number of traps were out on such a small part of the total time spent in the field that the size of the mammal collection, 1,034 specimens, may be taken as a significant index to the truly rich mammal fauna of these mountains.

The place names used in this paper for the origin of specimens and localities that are mentioned in other connections are catalogued below. In addition to our principal collecting stations, the list includes localities such as the rest houses where the expedition made only a one-night stay, and the small native communities or villages from which specimens were brought to us.

The spelling of place names in northeastern Burma is very confusing. The English spelling is based upon the phonetics of the native name and several spellings may be encountered for the same place. The "Kakhyen Hills" of Anderson, Yunnan Expeditions, 1878, I assume to be the "Kachin" or "Cachin" Hills of current literature; all three are attempts to reproduce the same name as pronounced by a Chinghpaw native. Our base camp was recorded as "Gangfang" on the labels of the specimens, but on some maps it is spelled "Kangfang"; "Hkamkawn" on our labels also appears variously as "Gamhkawn" and as "Kham Kham" (this latter on the sheet of regulations hanging in the rest house). Names of rivers take the ending "kha" on maps if the Burmese influence is predominant, "kyaung" if Chinese. Thus the Hpawte River may be written Hpawte Kha or Hpawte Kyaung.

The term "road" is used for the main highways in northeastern Burma, at least where there are government rest houses at the regular intervals. Except for a short distance out of Myitkyina, where it is possible to drive an automobile, these highways are not "roads" in the ordinary sense. They are mule trails, and usually too narrow, in the mountains especially, to allow the passage of an ordinary wheeled vehicle. Most of them are well laid out, follow easy grades, and have a good surface. No labor has been spared to make them very good highways for mules and pedestrians. The highways which do not have rest houses may not be as well planned or in such good order. Some of them, such as the one from Gangfang across the Nyetmaw Pass around the flank of Imaw Bum, have steep pitches and poor footing and are particularly troublesome when snow and ice occur.

Black Rock.—A rest house on the road from Htawgaw to Gangfang located a short distance west of the junction of the Moku

River and the Ngawchang River, altitude about 4,600 feet. Black Rock is in a narrow river valley which is cultivated at intervals. Where cultivation has not removed the forest, it consists of uniformly open pine and alder association with deciduous oaks. In some of the ravines there are thickets of subtropic jungle where dense green foliage persists in winter. The prevailing type of forest is characterized in winter by bare limbs (except for the pine) and the ground littered with fallen leaves.

The only collecting at Black Rock was done in transit as it was a one-night stop both going and returning.

Changyinku.—A small native village on a well-traveled mule trail across the Panwa Pass into Yunnan. It is about three and a half miles from the pass and the elevation is approximately 7,000 feet. The district is a wide, open valley drained by the headwaters of the Chipwi River and has been rather extensively cleared for cultivation and for grazing. Ecologically it is very distinct from all other collecting stations visited by the expedition. There is a small rest house on the trail and the expedition made this its headquarters from March 9 to 16.

Forest occurs in pockets throughout the Changyinku district but is nowhere very extensive. To the eastward rises the divide which is the height of land between the Shweli drainage in Yunnan and the N'mai River in Burma. Along the ridges working up to the divide, forest is much more dense than in the open valley and in some places appears to be of a pure climax type. A conspicuous feature of the valley is a species of tree rhododendron, *Rhododendron delavayi*, with large scarlet flowers in bloom at the time of our visit. The region is well watered and some of the meadows are boggy. Along these small watercourses dense thickets of shrubbery and some large trees may be found. In such places the best trapping was encountered, although, in general, the trapping at Changyinku was rather disappointing. A species of deciduous oak grows in groves here and there throughout the valley and the low hills, but there is very little ground cover under the oaks and apparently a very poor population of small mammals. The valley is rather densely populated for this section of northeastern Burma. Where the fields have not been plowed and put into crops there is an abundance of open meadow and a tall bracken occurs plentifully. The Panwa Pass itself is low, only 7,684 feet, and on the Yunnan side of the divide there is a preponderance of pine forest.

Changyinku experiences many earthquakes, for it is not far from an epicenter and quakes may be experienced several times each day, often accompanied by a rumble like distant thunder.

Chimeli.—A camp on the mule trail about two miles in a direct line from Chimeli Pass, which crosses the divide at 12,664 feet. Stanford and I collected from February 5 to 12 from a camp constructed by our natives at the side of the trail. This was one of the best collecting stations for small mammals, but we were handicapped somewhat by snow and bad weather, which interfered with our freedom of action. There is very little travel over this trail in midwinter and the upper stretches are probably impassable for a mule when there is a foot or two of snow over the rocky intervals. Our camp was located at about 10,300 feet but the trail climbs rapidly at this place and collecting covered an interval of perhaps 500 feet above and below this elevation.

There is no burning of the forest or other interference by the natives with the ecology this near to the Chimeli Pass. The gorges and ridges are heavily clothed with substantial forest and there are few natural openings, aside from slopes too rocky to support trees. Conifers are represented by fir, which is the most common evergreen, and by hemlock. At the higher elevations, heading the ravines, the coniferous forest is predominant. At the lower levels there are oaks, both deciduous and evergreen, and rhododendrons. Bamboo thickets are common and at 10,000 feet and lower the canes are of substantial size. A smaller variety of bamboo goes considerably higher in elevation. There are a number of different shrubs and small trees making up the undergrowth, such as *Rhododendron* (several species), *Buddleia*, *Berberis*, *Hydrangea*, *Gaultheria*, and various ericaceous species. The plant associations are definitely palearctic in their relationships.

The minimum temperature recorded at this camp was 21° F. During the day the temperature in the shade ran from 48° to 60° F., with sun temperatures as high as 90° F.

Chipwi.—A government "bungalow" or rest house on the main road up the valley of the N'mai River; altitude 764 feet. The only collecting done here was on the one-night stops going and returning. The valley is rather open at this point and the vegetation is characteristic of the hot lowlands. Heavy forest, which might almost be described as tropical jungle, occurs in favored localities along the road, but for the most part the vegetation is confined to shrubbery and scattered forest not to be described as jungle.

There are caves two or three miles from Chipwi to the east of the mule road and these were visited by Stanford the day we left Chipwi, April 7, on our return to Myitkyina.

Gangfang.—Spelled on some maps as “Kangfang.” The government bungalow at Gangfang is situated at the junction of the Ngawchang and the Hpawte rivers. This was the principal base-camp of the expedition and considerable collecting was done at this point. The party operated out of here for Imaw Bum, the Nyetmaw River, and the Chimeli camp. The name is applied, in a loose sense, to an agricultural district along the river valley and some maps have two villages of this name, the one on the east and the other on the west bank. The one used by the expedition is the trading post and located at the precise junction of the two rivers. The altitude on the map is 5,403 feet.

The river valley at Gangfang is moderately open and most of the primeval forest in the valley itself has been burned off by natives in order to secure fields for cultivation. There are a few groves of sizable trees here and there along the river and up some of the tributary ravines, but undisturbed climax forest can not be reached until one has climbed some distance out of the valley.

All of our mammal collecting was done within a radius of a mile or two from the trading post and within the confines of the valleys and ravines.

The region is quite well watered and nearly every ravine of any size carries a small stream along which vegetation is usually fairly heavy. The cultivated fields are terraced for rice paddies, but where forest has been removed and the slopes are not used for active cultivation there are thickets and low shrubbery and a dense stand of bracken. Temperatures in January dropped as low as 26° F. at night and most nights it was cold enough to form thin ice. The days averaged fairly clear and often a brisk wind came up about noon and blew all afternoon.

A number of specimens were brought in to us at Gangfang by natives who came from small villages or communities nearby. These specimens were labeled “Gangfang” when nothing more definite could be learned although often it was possible, upon inquiry, to assign a locality more precise than Gangfang and yet discernible on a map.

Gangfang was the limit of our mule transport and our moves north and east of this place utilized native packers. These people dress rather lightly for the colder weather encountered at elevations from 9,000 feet up and they were obviously uncomfortable, especially

at night, in our upper camps. Owing to the rapid ascent from the river valley, it was possible to reach regions with snow and a real winter in a single day's travel from Gangfang.

We occupied Gangfang from January 1 to 14, February 1 to 4, and February 13 to 19.

Gawlam.—A native community between Tangtung and Gangfang, about a mile and a half from the former. The source of some native-collected material. Altitude about 5,200 feet.

Hkamkawn.—Also spelled "Gamhkawn" and "Kham Kham." Altitude on map 4,080 feet. A sizable agricultural village in the valley of the Ngawchang River near the junction of the Munglang River. This is on the main road from Htawgaw to Hpimaw, one day's march northeast of Htawgaw. There is a government bungalow at Hkamkawn and the expedition collected there on the way up to the base camp from December 27 to 30, and on the return from February 28 to March 3.

The valley of the Ngawchang River in the vicinity of Hkamkawn is moderately open in profile and a compromise between the narrow mountain gorge and the broad valley of the lower foothills. Most of the original forest has been burned off to clear land for agriculture and many of the slopes are terraced for cultivation of rice. Pines and alders occur where the natives have not destroyed the trees.

The fauna of this region has relationships both with the mammals of the temperate mountain zone and with the hot, dry lowlands. Plant life takes an early start and on the last day of February we found new leaves on the trees and shrubs and peach trees in bloom.

Hpare.—Altitude on map 5,864 feet. A village in the valley of the Hkaingshang River. This valley has, for the most part, been denuded of the original vegetation and is occupied by a relatively large population of natives. The village of Hpare is larger than most of the mountain villages we encountered. It is situated on one of the main mule-roads to the Chinese frontier which one may cross at either Hpare Pass or Panwa Pass. There is a government rest house at Hpare.

Collecting was done at Hpare from March 7 to 8 and from March 20 to 28.

The main valley at Hpare is fed by a number of tributary ravines each of which carries water, and up these one may encounter forests of good-sized trees. The climax forest begins on the upper flanks of the ridges hemming the valley. Second growth in the deforested

valley takes the form of low shrubbery, brambles, and dense stands of bracken. Magnolias, rhododendrons, cherries, and alders are common features along the valley.

Traps were scattered out in each of the several types of environment and the least number of specimens was secured in the nearest undisturbed primeval forest, which appeared to have great possibilities but proved to be surprisingly poor as a collecting site. This forest was densely undergrown, dark and damp; it was the home of Lady Amherst pheasant, one of which was seen while I was running traps.

Minimum temperature recorded, 40° F.; maximum sun temperature, 90° F.

Hpare-Saulang Road.—A camp on the mule road from Hpare to Saulang a short distance south of the highest pass, which is about 8,400 feet in altitude. The camp was at an approximate elevation of 8,200 feet, and traps were set out both up and down the trail. This was a very interesting collecting site for the small mammals but unfortunately we encountered so much rain that our tenting facilities were inadequate, more especially for the numerous retinue of natives who were trying to keep dry under leaf-thatched shelters, and camp was moved on March 20, having been set up on March 17.

The trail from Hpare to Saulang crosses an elevated ridge, after a long climb out of the valley of the Hkaingshang River, and then starts an equally long descent toward the headwaters of the Chipwi River. The camp was located to explore this ridge, which was covered with splendid climax forest undisturbed by the hand of man. A predominant feature of this forest is the magnificent tree rhododendron, *Rhododendron sino-grande*. Hemlocks and oaks also occur. The undergrowth in this forest is not very dense and one can move about with more freedom than is usually the case in these mountain forests. Heavy growths of ferns and mosses cover the ground, fallen logs, and rocks, and, with such an abundance of cover, conditions favor the presence of small mammals. As usual, the smaller ravines all carry water.

Trapping the first night at this place, before the rain set in, yielded a very heavy catch. I was hunting along the trail with a headlight that evening; one trap had a specimen as I looked at it on the way down the trail and another one when I returned. However, with the advent of the rains the number of specimens caught fell off very sharply and seemingly the inclement weather discouraged activities of the small mammals.

This region, in common with Saulang and Changyinku, experiences many earthquakes, some of them with amplitude sufficient to break dead limbs from the trees. We noted as many as fifteen or more separate tremors on the most active days, and at least four or five on quiet days.

Hpare Pass.—A camp occupied by Ward and Stanford from March 23 to 27, at about 8,500 feet altitude, a short distance before reaching the pass itself. The Hpare Pass is about four miles south of the Lagwi Pass and about five miles southeast of Hpare; I believe it is not used by travelers into Yunnan as often as the Lagwi and the Panwa passes.

This camp was described to me as being in climax forest and a desirable collecting site, although inferior, according to Ward, to the Hpare-Saulang camp.

Hpawshi.—A native community about two miles, on the map, southeast of Gangfang; altitude 6,297 feet, with high surrounding ridges and considerable climax forest.

Hpawte.—Also "Pawahku" and "Bawahku" on maps; altitude about 7,500 feet. Stanford and I stopped overnight at the rest house in this village on February 4, en route to the Chimeli camp, and on February 12, as we returned to Gangfang. I set out trap lines on both occasions.

This is an agricultural community, with natives scattered along the valley of the Hpawte River, and a fair-sized village. Forest has been removed from most of the valley and up quite a distance on many of the slopes which confine the valley. Tall bracken, occasional shrubbery, and tangled brambles have come in as second growth. At this place shrews seemed very abundant in the bracken and tall grass.

Hpimaw.—A community, indicated on some maps as a large village in the main river valley (headwaters of the Moku River), an abandoned military post much higher in elevation than the village, and two small outlying villages situated back in the hills. There is a rest house on the site of the former Hpimaw Fort and the expedition stayed there from February 20 to 27. The altitude at the rest house is about 7,500 feet but the fort is located along the narrow crest of a ridge and slopes are steep. Past the fort a good mule trail follows the ridges back to the Hpimaw Pass where it crosses the divide, at 10,388 feet, into Yunnan.

Most of the open valley, from the main village of Hpimaw downstream practically to the junction of the Moku River with the Ngawchang River, has been stripped of forest and we saw more intensive agriculture here than anywhere else in northeastern Burma. The natives have burned off the primeval forest along most of the ridges even higher than the site of the fort. Eventually, as one follows the trail (almost southeast) toward the Salween Divide, climbing steadily, splendid, undisturbed climax forest is entered. Strips of this forest run down ridges and ravines like fingers, in some instances, but the continuous stand of large trees begins at about 9,000 feet and thereafter extends unbroken to the upper slopes of the divide, many of which are rocky and bare. At this time of year the peaks are well whitened with snow and deep drifts lie in the dark woods. Clouds are seldom out of the sky, rain falls frequently, and the forest has little in it that is dry.

Prominent plant species in this forest include hemlock, conspicuous from 9,000 feet and up; oaks; many species of *Rhododendron*, both tree and shrubby forms; *Gaultheria*; *Vaccinium*; and broad-leaf evergreen trees unknown to me.

Hpinlawkha.—The Hpinlaw River, a small stream cutting the main mule road from Hkamkawn to Black Rock, about midway between these two rest houses. This is in the Ngawchang River valley at an altitude of about 4,200 feet. Vernay, Cutting, and Ward camped here on February 8. The region is in mixed pine, alder, and oak forest.

Htawgaw.—An important locality for northeastern Burma because it is a post of the military police, has a telegraph station, a post office, native stores, a mission school, and serves as a clearing house for all the activity in the back country. It is located along the crest of a ridge lying between the Ngawchang and Hkaingshang rivers and the altitude at the rest house is 6,025 feet. The native village comprises a fair number of houses and in addition are the more substantial structures put up by the Burma Government. Most of the terrain is sloping and the community is perched wherever there is enough level ground available.

The expedition was in Htawgaw from December 24 to 27, March 3 to 6, and March 28 to 31. Vernay, Cutting, and Ward also passed through Htawgaw at other times.

Forest has been removed from most of the accessible slopes of the Htawgaw Ridge, at least those with a western exposure. Pines

are a conspicuous part of such forest as remains on the ridge, but down in the adjacent river valleys broad-leaf trees prevail. Second growth about Htawgaw is characterized by heavy stands of tall bracken, shrubbery such as *Buddleia* and *Luculia*, and brambles. On the northern slopes, extending down into the fork where the rivers meet, the clearing operations have not been so extensive and forest is continuous enough to be used by bands of gibbons.

When we reached Htawgaw at the end of March we found the sky darkened by the smoke of several large fires. This was near the end of the dry season and the proper time to fire the dried-out slashings. This practice of deliberately burning off square miles of steep mountain sides for the sake of cultivating a small percentage of the cleared areas is ruinous of the primeval ecology. The impress of this exploitation exists as deep scars upon the terrain and each year these grow broader as new fires are set and deepen as erosion attacks the openings of the previous years.

Imaw Bum.—One of the highest mountain masses in the north-eastern corner of Burma, the elevation for the peak being 13,369 feet. It lies within a deep loop of the Ngawchang River, at about 23° 10' N. Lat. and 98° 30' E. Long. It is about seven miles in a straight line on the map from Gangfang to where we had our base camp on this mountain, but it required three days of travel to get there.

Our camp consisted of a large, thatched shelter, put up for us by natives who went up some days in advance, with several small shelters, and our tents. The spot selected was below the Nyetmaw Pass, on the bank of the Chaungmaw River which drains Imaw Bum to the north, and at about 9,000 feet altitude. We worked out of this camp from January 16 to 24. Snow was on the upper ridges and we found it impractical to attempt a camp nearer the summit of the mountain.

Even in this relatively remote region we discovered that fires had swept away large patches of forest along the valley of the Chaungmaw River. Thickets of bamboo have replaced the primeval forest of fir, larch, hemlock, rhododendron, oaks and other broad-leaf trees, and bamboo is now the dominant plant in many places. During our stay fires were started, not a great distance down the stream bed, and burned day and night, sections of bamboo exploding like gun-fire. The smoke interfered with our work and the natives attempted to put out the fire but with no lasting effect.

The river bed was heavily ice-bound; temperatures dropped as low as 8° F. at night and did not exceed 69° F. when the sun was

shining. Smaller tributaries of the main stream, coming out of the steep lateral ravines, were flowing freely and proved to be the best trapping sites. On some nights the traps did very poorly and the activity of the small mammals seemed to have a rhythm, perhaps associated with the weather.

Kumaw=*Ku-maw*.—On the Ngawchang River at an altitude of 2,000 feet. Visited February 2 by Vernay, Cutting, and Ward on their circuit about Imaw Bum.

Langyang.—A rest house on the main road from Laukhaung to Htawgaw, in a small agricultural community. It is one march from Htawgaw, well above the Ngawchang River; altitude about 4,600 feet. The expedition had only two one-night stops at Langyang. As is so often the case along the mule road, this region is alternate clearings and patches of undisturbed forest, but most of the climax ecology has been destroyed near Langyang itself.

Laukhaung.—Also spelled "Lauhkaung" and "Laukkaung." A post of the military police, a center of activity for the foothill region, and a fair-sized agricultural community with a native village, one day's march from Chipwi on the N'mai River. Altitude 4,366 feet for Fort Laukhaung on the map and about 4,000 feet for the rest house at Rukchang, where we stopped.

This region has been burned off, the second growth is uninteresting, and mammal collecting was poor. Traps were set out on December 20 on our way up-country, and from April 4 to 6 on our return.

Luksuk.—A rest house one day's march from Htawgaw, on the road to Hpare. In the valley of the Hkaingshang River; altitude about 5,200 feet. Traps set out the night of March 6, in region of second growth and a few patches of original forest missed in burning. More cleared areas than otherwise along the river in this general region, but not a very large native population.

Ngawchang River.—Altitude 1,800 feet. A camp of Vernay, Cutting, and Ward, January 30 and 31, on their trip about the western foothills of Imaw Bum.

Nyetmaw River Camp.—A temporary camp—tents—on the upper waters of the Nyetmaw River, on the east flank of Imaw Bum; altitude about 8,500 feet. This was on the trail over the Nyetmaw Pass, altitude 10,221 feet, about an hour's walk below the pass. Stanford and I worked from this camp from January 24 to 31 and found this region to be one of the best collecting sites visited. Tem-

peratures dropped as low as 27° F. at night and went as high as 91° F. in the sun.

The Nyetmaw River at this point is a small mountain brook, easily crossed without wetting one's feet, and the hills rise steeply back from the river. Splendid climax forest extends in an unbroken stand for here the natives have not yet brought fire. The common trees include oaks (several species, deciduous and evergreen), *Rhododendron magnificum* (a large tree reaching a height of fifty feet and a diameter of a foot or more), a red-barked birch, a *Heptapleurum*, and a number of broad-leaf evergreen trees. Up on the ridges hemlock occurs and everywhere bamboo springs up where a fallen tree provides an opening. The undergrowth is not especially heavy but there is an abundance of ground cover. Shrubs include a number of species of *Rhododendron*, a *Berberis*, *Gaultheria*, *Vaccinium*, and other plants with palearctic affinities. In occasional openings where sunshine could strike through, a primrose, *Primula whitei*, was in bloom. Ample evidence of spring was to be seen although the calendar told us that it was midwinter.

Everywhere the ground was damp; moss and ferns grew along the watercourses and about fallen logs and stones. In most places the forest canopy kept the ground well shaded and only where the bare limbs of deciduous trees predominated could one see much sky.

Pyepat.—A government bungalow or rest house on the principal mule road one day's march northeast from the Laukhaung military post. Altitude 6,300 feet.

The rest house is situated on the narrow top of a small ridge; there is no native village in this locality and no structures other than those erected for the convenience of travelers.

The Pyepat Ridge is a long divide rising from the confluence of the N'mai and Ngawchang rivers, about twenty-five miles due north of the rest house. It continues to the south and southeast and finally reaches the height of land forming the boundary between Burma and Yunnan. It is not clear from the map just how low the crest of the ridge may drop before its eventual consolidation with the main divide with its elevations of 10,000 feet and more, but in general the Pyepat Ridge holds up to 7,000 to 8,000 feet. It seems a fair assumption that the ecology of the ridge is closely associated with the wet mountain environment which characterizes the main mountain masses of northeastern Burma. Pyepat Ridge is interesting as a long, narrow intrusion of temperate flora and fauna into the tropical ecology found in the two river valleys.

Coming up from Laukhaung in the morning of December 21, we left an altitude of 4,000 feet, the open hillsides dry and hot, the facies of the environment with a pronounced tropical character. After a continuous climb of six or seven miles we reached the pass, about 7,400 feet, and arrived on the eastern slopes of the ridge. There was an abrupt change. In the shady portions of the trail, crystals of frost were in the ground. Splendid climax forest of temperate affinities stretched in an unbroken mass as far as we could see. Under the trees the ground was damp, the banks along the trail were covered with dense masses of ferns, mosses, and begonias, with an occasional *Primula*, several species of orchids, seedling rhododendrons, gentians, and a host of other plants. The forest trees included many species but among the commonest were oaks, laurels, and rhododendrons.

The slopes of the Pyepat Ridge fall away sharply both to the east and the west and the only means of covering any distance is to stay on the mule trail. Once off the trail it is necessary to cut a way through vegetation, and footing is very precarious. Down the slopes to the west the forest follows some of the ravines and better-watered slopes, although the character of the species composing it changes as one enters the warmer zone. On the eastern slopes the forest spreads in a sheet to reach the valley of the Ngawchang River, about three miles from the rest house and perhaps 2,000 to 2,500 feet lower, where the mule trail crosses it. Along the valley of this small mountain stream the forest has assumed many tropical features but here it is humid tropics and not the semi-arid tropics of the west slope. Precipitation appears to be much heavier on the east face of the Pyepat Ridge than on the west.

We collected from the Pyepat rest house from December 21 to 23 and from April 1 to 4.

Rawngaw=*Rawng-aw*.—Vernay, Cutting, and Ward stopped from January 27 to 29 at this Maru village, 4,200 feet altitude, on their trip around the northern and western periphery of Imaw Bum. This village is located not far from the lower Ngawchang River, between five and six miles from its juncture with the N'mai River.

Sadulaw.—A native community about a mile to the westward of Vijawlaw; about four miles on the map, from Gangfang, in a northeasterly direction. Altitude about 6,600 feet and with high surrounding ridges carrying climax forest.

Saulang.—Also spelled "Sukiang." A rest house on the mule road from Hpare, one day's march, to the Panwa Pass. Altitude

about 6,500 feet. Two nights, March 8 and 16, were spent at this station. Very little native population near this spot, which is primarily for the convenience of travelers.

The rest house is located in the valley of a small tributary of the upper Chipwi River. Very little, if any, climax forest in this general region. The bare slopes back toward the Hpare-Saulang Pass were colorful with the purple blossoms of a primrose, *Primula denticulata*, in great drifts. Undisturbed forest runs down some of the ravines but much of the shrubbery along the river's course is second growth. Rain at Saulang the night of March 8 was snow on the slopes above at 8,500 to 9,000 feet. On March 16 I found peaches and a wild cherry, *Prunus puddum*, in full bloom, and heard frogs calling.

Trapping was poor about the rest house and not much better in a damper, more promising environment along the river.

Seniku.—A regular stopping place, with a government bungalow, on the mule road up the valley of the N'mai River. Altitude 1,150 feet. Only one-night stops made here, December 15 and April 10. This region is in the hot lowland zone; stands of large forest trees are intermittent. It is possible for an automobile to reach Seniku and I returned from here to Waingmaw, across the Irrawaddy from Myitkyina, in about two hours. It had required three days with our mule train to reach Seniku in December.

Shingaw.—A rest house, one day's march northeast from Seniku, and still in the open, hot valley of the N'mai River. Altitude 750 feet. Stopped here only for the night on December 16 and April 9. Forest occurs in undisturbed areas and is definitely tropical in character. Second growth is tangled and uninteresting.

Tamu.—A rest house in the N'mai River valley a day's march from Shingaw to the south and from Tanga to the north, on the well-traveled mule road to Laukhaung. Altitude 724 feet. Stopped here the nights of December 18 and April 7. In the semi-arid tropic zone with pretty fair jungle in some of the ravines, but with many open, monotonous stretches of trail.

Tanga.—A rest house, at 900 feet altitude, in the valley of the N'mai River, a day's march south of Chipwi. In the tropical zone with fair jungle in some of the ravines. Stopped here December 17 and April 8, overnight.

Tangtung.—A rest house, a day's march south of Gangfang, in the valley of the Ngawchang River. Altitude 5,077 feet. Stopped

here overnight on December 31 and February 19. A small native community is located here and much of the original forest has been removed. Wet ravines and precipitous slopes still retain thickets and groves of interesting ecology. The influence of the nearby high mountains is shown in the amount of water in the ravines, the temperate characteristics of most of the flora, and the lower temperatures.

Tsonma.—A small native village at 6,046 feet elevation on the ridge which rises from the junction of the Nyetmaw River with the Ngawchang. On the map this distance from Gangfang west to Tsonma is little more than a mile, but it is several times that by the trail which climbs two ridges and descends into two ravines to get there, requiring several hours of arduous travel. The expedition camped near Tsonma on January 14, en route to Imaw Bum, and Stanford and I camped on the ridge above Tsonma on January 31, returning to Gangfang. On specimens this station is recorded as "Above Tsonma." The altitude by barometer is about 8,300 feet.

This camp, of January 31, was just below the high point of the trail, on the east slope of a long ridge which is a prominent feature to the northwest. This is probably the same ridge later crossed at the Nyetmaw Pass and one of the ribs of Imaw Bum itself. The forest on the east side of this ridge is quite different from that on the west side and the upper valley of the Nyetmaw River, where we had just collected at approximately the same altitude. The Tsonma slope is heavily forested, the trees large, close together, and with very little undergrowth. The predominant species are oaks, one of them *Quercus imbricata*, and on the lower fringes of the forest, before we came on to the areas burned off by the natives, the leafless deciduous oaks looked like a dead forest. Higher up the presence of broad-leaf evergreen trees takes away from the lifeless appearance of these woods. The mountain slopes are quite steep, the trail descends abruptly, and one can not wander at random through the forest.

Vijawlaw.—A native community about five miles northeast of Gangfang, up a tributary of the Hpawte River. Altitude about 6,600 feet and back country up to 11,300 feet, with undisturbed climax forest.

The operations of our expedition were greatly facilitated by the fullest co-operation of various officials in the Burma government and grateful acknowledgment is hereby given. The admission of much equipment and supplies into the country, the transportation of this by rail and mules to Gangfang and thence by man power



GANGFANG

A trading post, the base camp of the expedition and site of much collecting



NGAWCHANG RIVER WITH GANGFANG IN BACKGROUND

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required planning and assistance from a number of individuals in Burma and everyone was most helpful. Especial thanks are due to Mr. R. E. McGuire, I.C.S., the Deputy Commissioner of Myitkyina, and to Mr. J. W. McGuinness, Burma Frontier Service, the Assistant Superintendent of Laukhaung, for their assistance in an official capacity, and to the Rev. L. R. Dudrow, Baptist Kachin Mission, for help with native personnel.

Professor F. J. Meggitt, of the University of Rangoon, met me when my steamer docked, early in the morning, tendered me the full hospitality of his quarters on the campus, and did everything in his power to assist the plans of the expedition and to make my sojourn in Rangoon a pleasant one. His help and his friendship were an expedition asset. To recall by name the other residents of Rangoon who gave freely of their time and advice would make a list too long to include in this report, but their assistance is no less appreciated because un-itemized.

I wish to express my appreciation of the co-operation I have received, in studying this collection, from Field Museum of Natural History. The loan of critical material for comparison and the comments of Dr. Wilfred H. Osgood, in correspondence on moot points, have been very helpful in guiding me to decisions.

Finally, I desire to acknowledge the extensive assistance given me by Mr. T. D. Carter, Assistant Curator in the Department of Mammalogy of the American Museum, who has studied this collection with me, made provisional identifications, laid out the literature, and in many ways taken over the time-consuming details involved in handling a collection of this size. His field experiences in western Szechwan and in Indo-China and study of the mammals he collected there have made his opinions on the Burma mammals very useful to me.

Throughout the study of the mammals collected by the expedition, Dr. G. M. Allen's monumental monograph, "The Mammals of China and Mongolia," has been of great assistance. The full descriptions, the distributional maps and the listing of specimens examined have all been very helpful. Many of the mammals in this part of Burma are identical with or have their closest relationships with the fauna of Yunnan, or of other parts of China covered by the report. The Chinese mammals in the American Museum have been identified by Allen and are available for comparison. Furthermore, Allen inspected types and other specimens in the British Museum, so that many elements of uncertainty with regard to our material

have been removed. The American Museum collections have but a very meager representation of the small mammals west of Burma. No museum in America has an adequate collection of the mammals of India and this material is greatly needed. There are many questions of identification and distribution which can not be solved until such a collection is available.

Under the discussions of the various species I have commented somewhat upon the association factors observed, the nature of the flora, the probable relationships to a palearctic or an oriental fauna, and topics which should, perhaps, receive some attention, considering the collection as a whole.

Most of the specimens collected were taken at mountain elevations, from regions of temperate winter conditions, and from well-watered localities. That part of our itinerary which lies within the hot tropics, the dry or semi-arid tropics in this case, was traversed as rapidly as possible and the collections received a very small increment there; consequently the affinities of most of the mammals collected are with the palearctic fauna, with the mammals of China, Tibet, and mountainous India, with groups that have a distribution in both the eastern and western hemispheres north of the tropics. Many of the dominant plant species in the mountains where we collected would look equally at home in North America, if one left off the spectacles of specific focus, and the same remark holds true for such mammals as the voles, the shrews, and the pikas.

One of the noteworthy features of this mountain collection is the large representation of shrews of two distinct subfamilies and of many genera. The shrews and the shrew moles would sometimes make up half or more of the catch from a long trap line. One or more varieties of shrews could be confidently expected whenever one set traps in the type of environment they prefer. Shrews were taken from the streams, from subterranean burrows, and running at large over the ground. Apparently this region has a particularly large representation of the Soricidae and I have never had experience with so many varieties on a single expedition.

***Neotetracus sinensis cuttingi* subsp. nov. CUTTING'S
INSECTIVORE.**

Type from Hpimaw road, above Hpimaw fort, northeastern Burma. Altitude 9,000 feet. No. 115,503 American Museum of Natural History. Adult male. Collected February 23, 1939, by H. E. Anthony. The type is a skin and skull in good condition, with the trunk preserved in alcohol.

General characters.—Closely resembling *Neotetracus sinensis sinensis* in size and general appearance but noticeably darker along the dorsal region and under parts more buffy.

Description.—Color above, mixed cream color and black, the dark predominating; three types of hairs, black, cream color, and cream tipped with black, combine to produce a brownish olive tone with almost a greenish cast in some lights; bases of hairs blackish; an ill-defined blackish dorsal band extends from crown to base of tail; hands and feet light brown, the latter with a band or streak of cream-colored hairs from ankle to tip of second and third toes; ears dark brown, thinly haired; tail above, light brown, below, cream-colored; under parts uniformly washed with cream color over blackish base.

Skull with slender nasals, premaxillae extending well up on superior face of rostrum and with long, pointed posterior extension between maxillae and nasals; braincase moderately rounded; zygomatic flaring; palate with some fenestration posteriorly, but openings small; upper toothrow long, first incisor well developed, the highest in the row, incisors three in number; canine small; premolars three, the last molariform; first two molars large, subequal, last molar about one-third as large; lower toothrow with same number of teeth as above; first incisor elongate, subspatulate; last premolar high and pointed; last molar about half as large as preceding molar.

Measurements.—Taken in the flesh: total length 175; length of head and body 114; tail vertebrae 61; hind foot 25. Skull: greatest length 32; basal length 29; length of nasals 10; palatal length 18; zygomatic breadth 17.5; mastoid breadth 13; breadth across upper molars 9.8; length of upper toothrow 16.4; length of lower toothrow 15.3.

Specimens collected.—25: Changyinku, 4; Hpape Pass, 2; Hpimaw road, 17 and 2 in alcohol.

The specimens in the series of twenty-three skins of this new form are consistently darker above and more buffy below than in the good series of *N. s. sinensis* available for comparison. These latter were collected by Andrews and Heller (American Museum Asiatic Expeditions) in Yunnan at no very great distance from Hpimaw. The Burmese animals may be readily separated on the basis of color alone.

The series of *N. s. cuttingi* has also been compared with three specimens of *N. s. fulvescens* from Tonkin, lent by Field Museum. The Tonkin skins, collected November 29 to December 29, are in

the winter pelage as are those from Burma, February and March. The former show no trace of a median dark stripe above and this would seem to be the best character of separation. They also show a tendency to be a warmer brown in general color of upper parts and less warmly colored on under parts, but these characters are more the impressions of the series than a skin to skin comparison; they are average differences.

There appears to be considerable individual variation in the length and topography of the rostrum as displayed by the specimens of *Neotetracus* at hand. Some specimens have rather short nasals and the premaxillae are pinched off between the nasals and maxillae without any marked posterior prolongation; in such cases the maxillae make contact with the nasals. Other skulls have longer nasals and the premaxillae extend posteriorly as narrow, pointed slips and make contact with the frontals; the maxillae do not meet the nasals. Examples selected to show the extremes of this variation look to be different species but both the Chinese and the Burma animals display this variation, and in several degrees, so that taxonomic significance can not be given it. There seems to be no correlation with sex or locality, and the variation can best be interpreted as individual.

Neotetracus was collected by the Vernay-Cutting Burma Expedition only at stations close to the Burma-Yunnan frontier. It was trapped in cool, damp forest at elevations of 7,000 to 9,000 feet and more. It was first trapped along the upper stretches of the Hpimaw road, about two miles above the old fort, where forest becomes continuous and winter snows occur. Here it was fairly common in runways and burrows along the moss- and fern-covered banks edging the trail and under logs, rocks, or any other good cover. Rodents, shrews, and shrew moles used these same runways, and signs of the presence of pikas were noted; it is impossible to say that *Neotetracus* made the runways, but it seems to be an actively ranging mammal and goes everywhere over the ground. This particular environment was damp and dark, with an abundance of ground cover. At Changyinku there is very little primeval forest, probably none, left standing in the floor of the valley but there are a few pockets of vegetation, shrubbery, and small trees, in some of the short ravines that carry water, which afford dark, damp cover. *Neotetracus* was taken sparingly in such places. One specimen was trapped in a much more open situation, among bracken and rank grass fringing a small stream in the open valley.

This insectivore is named for Mr. C. Suydam Cutting, a co-leader of the expedition, and a generous supporter of many expeditions.

***Tupaia belangeri chinensis* J. Anderson. CHINESE TREE SHREW.**

Tupaia chinensis J. Anderson, Anat. and Zool. Researches Western Yunnan, p. 129, 1879.

Specimens collected.—12: Gangfang, 6; Hpimaw, 1; Htawgaw, 1; Laukhaung-Pyepat, 1; Ngawchang River, 1; Tamu, 1; Tangtung, 1.

These specimens were collected from an area not far removed from Ponsee, Kakhyen Hills (Kachin Hills of Burma), where Anderson took his first specimen of *chinensis*. They agree in all particulars with a series of *chinensis* from Yunnan collected by Andrews and Heller.

We encountered this genus only in the foothills and the drier environments which penetrate the higher altitudes by way of the river valleys. As we were hunting along the trails on our way to and from main mountain ranges, tree shrews were noted sparingly in the open stretches where shrubbery and sparse forest afforded cover, and in the occasional patches of heavier forest in ravines and areas not cleared for cultivation. The highest elevation recorded is 7,600 feet at old Fort Hpimaw. At this place all the primeval forest had been burned off some years ago and the open valley of the Ngawchang River provides an excellent highway for the invasion of lowland forms.

Our failure to collect a tree shrew in the damp, high-altitude forests does not provide positive proof that it does not occur there. This animal resembles a squirrel so closely that it is well to have a specimen in hand to be certain of the identity. Our experience with this insectivore below the temperate forest zone inclines me to the belief, however, that its distribution to the northward terminates with the closing-up of the main river valleys.

Tree shrews were seen in the trees and on the ground. When alarmed they seemed to prefer leaving a tree and seeking escape through the ground cover. At Htawgaw, altitude 6,000 feet, I shot one in the lower branches of a pine tree. At Gangfang, two were caught in traps set on the ground. One of these had been devoured or carried away and only the fore part of the skull remained in the trap. Another tree shrew was suspected as being responsible for this but when the same trap caught a weasel the next day this animal also had to be considered as a possibility.

Rhynchonax andersoni andersoni Thomas. ANDERSON'S SHREW MOLE.

Rhynchonax andersoni Thomas, Abstract No. 100, Proc. Zool. Soc. Lond., p. 49, 1911.

Specimens collected.—46: Hpare-Saulang road, 11; Hpimaw road, 4; Imaw Bum, 9; Nyetmaw River, 11 (including 1 alcoholic); road to Chimeli Pass, 11.

There is available for comparison with these specimens a series of over eighty *a. andersoni* collected in western Szechwan by the Sage West China Expedition and nine *a. atronates* Allen, including the type, collected in Yunnan by the Asiatic Zoological Expedition. The large series from Szechwan was taken north of Omei Shan, the type locality of *andersoni*, but near enough for geographic proximity to be a significant factor. A wide range of coloration is shown by these specimens from Szechwan, some of which are so dark as to be practically melanistic. Darker color is given as one of the characters of *atronates* Allen (1923, p. 2), but there are individuals in this Szechwan series considerably darker than any in the much smaller series of *atronates*. The size of the third upper premolar, described as "less reduced" in *atronates*, appears to be a rather intangible diagnostic character, for the differences in size of this tooth in specimens from Szechwan, Yunnan, and Burma are too slight to be measured. Incidentally, this third upper premolar, which is referred to by several authors as a "minute upper premolar," is large enough to be readily noted by the unaided eye and, it seems to me, scarcely qualifies as "minute," in a relative sense. The third upper premolar is very much smaller than the fourth, considerably smaller than the second but approximately equal to the first.

The Burma series shows quite a range of variation in color and if one had only extremes to compare there would be ample justification for considering them as separate subspecies. Selected specimens from the dark, damp forest along the Nyetmaw River, 8,500 feet altitude, are much darker in color, have glossier pelage, and more naked tails than shrew moles taken in more open forest along the road to Chimeli Pass, 10,000 feet altitude. In view of the variation shown by the large series of *andersoni* from Szechwan and the presence of some intermediates between the extremes of the Burma series, I can find no satisfactory basis for proposing new names and fall back upon the one name for the lot, *andersoni andersoni*. I consider *atronates* to be a synonym of *andersoni* not only on the basis of the characters shown but on geographical grounds, since

the range of *atronates* appears to be midway of the range of *andersoni* (as I am now extending it) and not isolated from it by virtue of special conditions such as altitude.

We found the shrew mole fairly common in the mountain forests. It was not taken in forests below 7,500 feet altitude, although at some of the lower collecting stations we found an abundance of shrews. On Imaw Bum, where *Rhynchonax* was first encountered, it was trapped under logs and rocks in the same traps that took *Eothenomys* and *Apodemus*. There was no evidence that the animal's activities were subterranean or mole-like. My only previous experience with shrew moles was with *Neurotrichus gibbsii* of western Oregon, which I never caught on the surface but in underground workings and that but rarely. It was a surprise, therefore, to find the Burma shrew mole apparently as free-ranging and as active over most environments as shrews and small rodents.

Our upper camps were all near to dark, damp, mossy banks and ravines where ferns and other low vegetation provided good cover for small mammals. Such spots usually yielded a good sample of the small fauna of the region, and shrew moles seemed to be more abundant in such places. Often they were caught in surface runways, presumably those of meadow mice; some at the margins of clear mountain brooks, in traps set among rocks. Occasionally a specimen was caught in a comparatively dry spot, a ridge-top, for example, but generally the best places were such as most shrews prefer.

Shrew moles come readily to bait and they run across traps set in runways. They are active in some degree during the day but most active after sundown.

Scaptonyx fusicaudatus affinis Thomas. THOMAS'S LONG-TAILED MOLE.

Scaptonyx fusicaudatus affinis Thomas, Ann. Mag. Nat. Hist., (8), 9, p. 514, 1912.

Specimens collected.—1: Nyetnaw River.

The American Museum has for comparison with this specimen one skin and skull of *S. fusicaudatus fusicaudatus* from Szechwan and two skins and skulls of *S. f. affinis* from Yunnan. The Szechwan mole is larger than the one from Burma and has noticeably shorter, crisper pelage, but the Yunnan specimens show closer accord, although there are some differences which might justify describing the Burma mole as new if only there were more specimens to rule out individual variation. These differences include smaller size and

proportionally longer tail for the Burma skin, and the size and relative proportions of the upper premolars are not identical with the Yunnan skulls. These latter characters, however, are indicated as having questionable diagnostic value because even our scanty representation of the genus suggests variation in the pattern of one jaw as compared with the other side in the same skull. This variation is in the size and prominence of the second upper premolar, as compared to the third. In the two specimens of *affinis* from Yunnan wear or injury has reduced a second upper premolar in each skull so that it is smaller than its mate on the other side. The unaltered second upper premolars in these skulls are not so large as this same tooth in the Burma specimen, but whether this might be used as a basis for separation must wait, for decision, upon the accumulation of more material.

The Nyetmaw River specimen was caught, during the day, in a mouse trap set across an open burrow. My field notes give the following:

"January 28. Mole taken in trap set on damp hillside just above floor of the little river valley. Had been digging for mole runways and scooped out a shallow depression, cutting rather a poor-looking runway that might have been *Eothenomys* except that the digging was not easy at this spot. Do not know whether mole tripped the trap in passing or was interested in the bait. Something had cut a gash in the side of the animal.

"Have not seen any fresh mole 'earths' or any evidence of the presence of moles except the many small runways opening to the surface on every hillside or mossy bank and which are used by *Eothenomys*, *Apodemus*, and shrews. Probably many of these are made originally by moles. Digging must be difficult because of roots, rocks, and shallow soil. In some places soil is frozen and moles may not be making fresh runways until the rains start."

Parascaptor leucurus Blyth. WHITE-TAILED SHREW.

Talpa leucura Blyth, Journ. Asiatic Soc. Bengal, 19, p. 215, 1850.

Specimens collected.—3: Gangfang, 1, in alcohol; Hpare, 1; Pyepat, 1.

So far as I am aware, these specimens are the only representatives of this species in any American museum and hence there is no comparative material at hand.¹ However, the characters, as given in

¹Field Museum has one specimen from Adung Valley, Kachin Province, Burma.—Ed.



SALWEEN DIVIDE

Viewed from ridge above Imaw Bum camp



NEAR CHIMELI PASS

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the literature, are so distinctive that there is little difficulty in identifying our material. Furthermore, Gerrit S. Miller, Jr. (1940, p. 442) in a very timely paper on moles from southeastern Asia, gives an excellent synopsis and had these three specimens for examination.

I saw evidence of the presence of moles in several of our collecting localities and spent considerable time in attempting to catch them. At Gangfang, for example, their workings were visible as ridges in most of the cultivated areas, in terraced rice paddies, and in the sand and loose earth along the river. These moles are small and none of my traps were effective in the small burrows. Most of the time the burrows where traps were set would not be visited by moles and when an active runway was located the trap was invariably sprung or plugged by earth pushed ahead of the animal. The only specimen trapped was caught near the Pyepat rest house in a trap set in a damp ravine, placed under a log, on the surface of the ground, for shrews or small rodents.

The mole recorded from Gangfang was bought from the natives who caught it somewhere in that general district, the exact locality unknown because the specimens changed hands several times before reaching me. It was on the verge of decomposition and was preserved entire in alcohol. The specimen labeled from Hpare was also collected by a native and brought in from outside, probably from a higher elevation.

At Hpare the natives had done so well collecting *Nectogale* for the expedition that I had hopes they could bring in moles if particularly urged to do so. I observed one man patiently tearing up a mole labyrinth but it was a futile proceeding because some of the burrows turned under large rocks and thick roots.

***Sorex cylindricauda gomphus* G. M. Allen. ALLEN'S STRIPED-BACK SHREW.**

Sorex bedfordiae gomphus Allen, Amer. Mus. Nov., 100, p. 3, 1923.

Specimens collected.—37: Gangfang, 1, in alcohol; Hpare-Saulang road, 5; Hpare Pass, 2; Hpimaw, 2, in alcohol; Hpimaw road, 2; Imaw Bum, 10; Nyetmaw River, 7; road to Chimeli Pass, 7 and 1 in alcohol.

The shrews in this series are all quite dark and a fair match in color for the type specimen of *gomphus* which was taken at Mucheng, Salween drainage, western Yunnan, 7,000 feet altitude, about 170 miles almost due south of where we collected. Typical *cylindricauda*

ranges throughout western Szechwan and has been recorded in north-western Yunnan. The Burma animals, therefore, bridge over the gap between the two races, which seem to be only slightly differentiated.

Sorex c. gomphus has been represented heretofore by the type specimen alone. This skin has a very short tail, only 39 mm. in length, and the Burma specimens average about 50 mm. in tail length. The color of the latter animals is a rich dark brown appreciably darker than the color of *c. cylindricauda* from western Szechwan (49 specimens compared) and northwestern Yunnan (7 specimens compared). The dark dorsal stripe is not as conspicuous on the Burma shrews, in some cases indistinguishable, because the contrast with the color of the upper parts is not as great. In some of the large series from Szechwan the stripe is wanting and hence may not be considered as an invariably constant character. To judge from the material available, *S. c. gomphus* is characterized primarily by slightly darker color. Possibly more material from near the type locality will show that it has a slightly shorter tail than *c. cylindricauda* but this character needs more than one specimen to substantiate it.

Shrews are a predominant part of the small mammal fauna in all of the cooler, damper spots from about 5,000 feet altitude up to tree limit in northeastern Burma, to judge from our experience. Because of the superficial resemblance of many different shrews and the difficulty of examining dentition at the skinning table, it was not easy in the field to tell just what one was trapping and to co-ordinate field notes as readily as for easily distinguished specimens. As many as three varieties of shrews might come in the bag from one night's trapping, and in order to carry through data on habitat preferences it would be necessary to keep individual specimens segregated from the trap to the catalogue. As regards any marked restriction to particular environmental associations, the only shrews with obvious limiting requirements were the specialized water shrews. All others seemed to be satisfied with a generalized ecological pattern and the same trap might take several distinct groups of shrews over a period of a few days.

***Soriculus leucops* Horsfield. INDIAN LONG-TAILED SHREW.**

Sorex leucops "Hodgson" Horsfield, Ann. Mag. Nat. Hist., (2), 16, p. 111, 1855.

Soriculus macrurus Blanford, Fauna Brit. Ind., Mamm., p. 231, 1888.

Specimens collected.—49: Gangfang, 9; Hpare-Saulang road, 14; Hpawte, 3 and 1 in alcohol; Hpimaw road, 4; Imaw Bum, 2; Nyet-maw River, 8 and 2 in alcohol; road to Chimeli Pass, 3; Vijawlaw, 3.

The skins of this large series do not vary much in coloration. They are a dark gray, which does not, it seems to me, agree very well with the "blackish-brown" used by Horsfield in describing *leucops* and Blanford in describing *macrurus*. And yet, our animals must represent the same long-tailed shrew which Thomas (1921, p. 499) reports from Imaw Bum as *macrurus* Blanford. Thomas (1912, p. 132) described a "slaty grey" shrew, *Soriculus irene*, which would be a good name for our animals were it not for the fact that he later (1921, p. 500) doubts the value of his own name and goes back to *macrurus*. Allen (1938, p. 99) makes *irene* a synonym of *macrurus* and it is difficult to reconcile Allen's description of *macrurus* as a "pale gray" shrew with the color given by Blanford.

Because Thomas had comparative material and could use specimens instead of interpreting some one's description of a color, I follow him in dropping *irene* from consideration and going back to an older name. According to Osgood (1932, p. 250), *leucops* of Horsfield should be used instead of *macrurus* of Blanford. Allen (1938, p. 100) concurs in these words: "Osgood is probably correct in using *Soriculus leucops* Horsfield (who credits the name to Hodgson) in place of *S. macrurus*." I take *leucops* then, despite the implication that this name was used for a darker animal, and pass by *irene* with its apparent applicability because this seems the most conservative course to follow.

This gray, long-tailed shrew was usually to be found in damp situations, or near streams, where moss, rotting leaves, and plenty of ground cover made good hunting territory for these insectivores. Most of the specimens were trapped in forested localities although those taken at Hpawte came from an agricultural district where primeval forest had been burned off and the uncultivated areas were overgrown with bracken, brambles, and low shrubbery.

***Soriculus caudatus* Horsfield. HODGSON'S BROWN-TOOTHED SHREW.**

Sorex caudatus Horsfield, Cat. Mamm., Mus. East India Co., p. 135, 1851.

Specimens collected.—34: Black Rock, 1; Gangfang, 17; Hkam-kawn, 1; Hpaw, 2; Hpaw Pass, 3; Hpimaw, 1; Hpinlawkha, 2; Htawgaw, 3; Tangtung, 4.

I am provisionally identifying these thirty-four specimens as *caudatus*, although I have a strong suspicion that they are at least subspecifically distinct from the animal known to Horsfield. The habitat of *caudatus* is given as "Sikim and Darjeling, Upper India,"

and it is unlikely that a *Soriculus* can range from Nepal to north-eastern Burma without showing at least subspecific differentiation. I am handicapped by a lack of comparative material. Although I have been fortunate enough to secure three specimens of *caudatus*, taken in Sikkim, by loan from Field Museum, I have no specimens of *baileyi*, described from the Mishmi Hills by Thomas (1914, p. 683), a form which should be considered. Thomas mentions only the type, which has an imperfect skull, and some of the characters he mentions fit the Burma series very well, especially the color pattern. However, the latter do not appear to be quite as large as the type of *baileyi* (which may prove to be about maximum); the tail length averages about 65 mm. against 76, and the skull measurements fall a little short of those given in the description.

Thomas makes a special point of the size of the anterior unicuspid of *baileyi*, larger than in any other member of the genus. This tooth in the Burma series is so nearly the same size of that in the three skulls of *caudatus* from Sikkim that one might consider them identical. The skins of the Sikkim *caudatus* are a fair match in color although as a series the Burma specimens are a cooler tone, less brown, but selected specimens seem indistinguishable. The dark under parts, only slightly lighter in tone than the back, help to separate *caudatus* from *leucops*, a somewhat grayer and longer-tailed shrew.

Our specimens of *caudatus* were taken mostly at intermediate elevations, 4,000 to 6,000 feet altitude, with one from as high as 9,500 feet. Thomas has recorded this species from Imaw Bum (1921, p. 499) but we did not take any there, although the catch of other shrews was large.

***Soriculus sacratus umbrinus* G. M. Allen. ALLEN'S UMBER SHREW.**

Soriculus caudatus umbrinus Allen, Amer. Mus. Nov., 100, p. 5, 1923.

Specimens collected.—38: Changyinku, 5; Gangfang, 4; Hpare, 9; Hpare-Saulang road, 1; Hpawte, 5; Hpimaw, 5; road to Chimeli Pass, 1; Saulang, 2; Tangtung, 2; above Tsonma, 2; Vijawlaw, 2.

The shrews of the above-listed series are small, dark animals with comparatively short tails, a short hind foot, and dentition of the *caudatus* pattern. Selected individuals match very well with the type and four topotypes of *umbrinus*, which was described as a subspecies of *caudatus*, but the series as a whole exhibits considerable variation in size of the hind foot and color of the under side of the

tail. The length of the hind foot varies from 10 to 13 mm., the under side of the tail is dark in most instances but paler and approaching, perhaps, the condition seen in *sacratu*s, "glossy whitish" (Thomas, 1911, p. 165), in a few cases. The term "glossy" implies reflections from the fine hairs covering the tail, and if this is the case less actual white need be present to give an impression of whiteness. The point to be made in this connection is that these specimens from Burma, except for the "glossy whitish" under side to the tail, fit reasonably well into the description of *sacratu*s.

The position of *umbrinus* is complicated by the fact that I have a substantial overlap in range of what I am calling *caudatus* and *umbrinu*s. There do not appear to be specimens with characters intermediate between the two groups although the relationship is so close, in dental characters, that one's first inclination is to call *umbrinus* a subspecies of *caudatus*, as Allen has done. The principal difference is one of size; a slight color distinction exists but is of minor significance. The two series can be separated on the basis of size alone, and there is no specimen which causes much doubt as to the group to which it belongs.

It may be violating implied relationship, and over-emphasizing the tenet that two subspecies do not occur in the same locality, to remove *umbrinus* from subspecific affinity with *caudatus*. I have considered the possibility that these two shrews may have different habitat preferences and thus remain separated in the same locality. This is a point upon which I do not have very definite proof. We trapped many shrews of many groups and often it was difficult, in the field, to note the differences that become obvious when skulls are cleaned and the material examined properly. Many sizes, shades of color, and proportions of tail and hind foot might be taken in a single night's catch. The outstanding differences could be correlated with any significant ecological data but the more subtle distinctions might be misjudged as individual variation. However, as I have stated elsewhere, there did not seem to be any noticeable shrew habitat differentiations in a given locality. Any damp, dark spot, or any environment with good ground cover, seemed to yield a representation of all of the terrestrial shrews of that locality. The same trap might take several varieties of shrews over a short period of time.

I am reluctant to list *umbrinus* as a full species, a course which has this to commend it, that *umbrinus* is left alone until such time as more material and further study of the shrews with *caudatus* dentition give a better understanding of true relationships. I have

linked *umbrinus* with *sacratulus* because the affinity between these two appears to be close; they do not, as far as is known at present, occur in the same place, and the material available suggests intermediates between the two.

The series of *umbrinus* was collected mostly at intermediate elevations. The greatest number came from elevations of 5,000 to 8,000 feet, and from regions where most of the original forest had been burned. Trapping was in overgrown localities in ravines, or in patches of forest spared in the general clean-up for agriculture.

***Soriculus radulus* Thomas. LARGE-CLAWED SHREW.**

Soriculus radulus Thomas, Journ. Bombay Nat. Hist. Soc., 28, p. 429, 1922.

Specimens collected.—1: purchased from a native at Gangfang.

This shrew is noteworthy for its strong, elongated claws, especially well developed on the forefeet. The feet themselves are broader and more robust than the feet of *S. caudatus* and suggest that the animal is actively fossorial in habit. The identity of this single specimen has been a troublesome problem because the collections of the American Museum have nothing like it for comparison. The cranial characters place its relationships with the genus *Soriculus*, the dental formula agreeing, but the stout feet, long claws, and short tail are quite unlike *S. caudatus* or *S. leucops*, for example.

A specimen of *S. nigrescens pahari* from Sikkim, borrowed from Field Museum, is like the Burma specimen in foot characters but differs in the size of the second upper unicuspid and in the posterior extension of the first lower incisor. The skull of the specimen of *nigrescens pahari* is that of an old individual, the teeth greatly worn, but it shows that this species has the second upper unicuspid larger than the first, the reverse being true in the Burma skull, and the first lower incisor extends under the first unicuspid and midway of the second. The Burma skull has the first lower incisor terminating approximately at the posterior plane of the first unicuspid.

In the original description Thomas points out the size differences of the second and third upper incisors of *nigrescens* and *radulus* and in this respect and in the characters of feet, tail, color, and measurements the Burma specimen agrees well with *radulus*. The dentition of our specimen shows only the faintest tip of pigment on the first incisor; otherwise it is everywhere white.

The upper surfaces of the fore and hind feet are thinly haired and scaled in a manner suggestive of *Anourosorex squamipes*.

Unfortunately we did not trap this interesting species and I can not contribute any field notes on habitat or behavior. At the time it was brought in by the natives its peculiar characteristics escaped attention, for on superficial examination it would pass for a bob-tailed *Soriculus caudatus*, a rather common shrew. Although it was delivered at Gangfang and labeled with that locality, it may have been captured anywhere in that general vicinity.

The developed claws and large feet suggesting fossorial adaptation may indicate that the animal spends most of its time in burrows, and hence is difficult to trap, but against this argument is the large series of shrew moles, with even more specialized fossorial adaptation, taken where no burrows were in evidence.

Chodsigoa smithii parca G. M. Allen. ALLEN'S LONG-TAILED SHREW.

Chodsigoa smithii parca Allen, Amer. Mus. Nov., **100**, p. 6, 1923.

Specimens collected.—7: Gangfang, 1; Laukhaung, 1; Pyepat, 1; Rawngaw, 4.

These specimens agree reasonably well with the type series from western Yunnan. The Burma skins have large hind feet, 18–20 mm. in length as against 17.5 for the type, but one of the type series has a hind foot 19 mm. long.

The localities where this shrew was taken are at the lower limit of our collecting range, 4,000 to 6,300 feet altitude, and we did not encounter the animal in the dense forest of the main mountain ranges. I should judge that it is more properly a denizen of the foothills and that its place is taken by other species of *Chodsigoa* or *Soriculus* once the more open river valleys are passed. It is worthy of comment that it was trapped at Gangfang in the same small radius where *Soriculus leucops*, almost identical in color and proportions but noticeably smaller, was caught.

Chodsigoa smithii furva subsp. nov. DUSKY LONG-TAILED SHREW.

Type from Imaw Bum, northern Burma. Altitude 9,000 feet. No. 114,620 American Museum of Natural History. Adult male. Collected January 21, 1939, by H. E. Anthony. The type is a skin and skull in good condition.

General characters.—Resembling *Chodsigoa smithii smithii* but with blacker, longer pelage, darker ears, and darker tail; molariform teeth of upper jaw less deeply emarginate posteriorly.

Description.—Color above, between fuscous black and sooty black, pelage plumbeous black at base, tips of hairs grayer and glossy to give general effect not quite black; color below only slightly lighter than above; ears blackish brown; tail chaetura drab above and below; hands and feet pale, soiled whitish.

Skull like that of *C. s. smithii* but first pair of incisors with posterior portions more nearly parallel; viewed from below the space between these teeth in *furva* is slightly lyriform, in *smithii* it is almost circular because of inwardly curved posterior portions; upper molariform teeth with posterior margins deeply indentate but not to a degree equaling that condition in *smithii*; anterior teeth faintly pigmented, molars lacking pigment.

Measurements.—Taken in the flesh: total length 158; tail vertebrae 87; hind foot 18. Skull, greatest length 21; interorbital constriction 5.1; width of braincase 9.5; height of braincase 5.5; length of palate 9.5; width across molars 5.8; length of upper toothrow 9.0; length of lower toothrow 8.2.

The type was the only specimen of *furva* taken and I have hesitated to describe a new subspecies on the basis of a single example. However, it differs so obviously in color from a specimen of *C. s. smithii*, taken in Shensi, that it does not seem to belong with typical *smithii*. It differs in much the same way from *smithii parca*, collected at lower altitudes in northern Burma.

According to my field journal, this shrew was trapped "in a damp, oozy spot under log and rocks next to small mountain stream." Except for somewhat darker color and larger size, *Chodsigoa s. furva* bears a close superficial resemblance to *Soriculus leucops*, a long-tailed shrew, which was also taken at the Imaw Bum camp.

Blarinella quadraticauda wardi Thomas. WARD'S SHORT-TAILED SHREW.

Blarinella wardi Thomas, Ann. Mag. Nat. Hist., (8), 15, p. 336, 1915.

Specimens collected.—27: Changyinku, 2; Gangfang, 1; Hpore, 2; Hpore-Saulang road, 5; Hpawte, 2; Hpimaw, 1; Hpimaw road, 3; Imaw Bum, 3; Luksuk, 1; Nyetmaw River, 1; Pyepat, 1; road to Chimeli Pass, 4; Tangtung, 1.

The type locality of *wardi* is Hpimaw, altitude 8,000 feet. Hpimaw Fort, abandoned at the time of our visit, is located on a ridge which climbs steadily back toward the Salween Divide and is the map location to correspond with the type locality. On these steep slopes a short distance may mean a decided change in elevation

and there is a considerable ecological difference between the open river valley and the heavy forest running up onto the divide. Our series includes a topotype of *wardi* from approximately the same place as Ward collected in 1914, and two others from a thousand feet higher on the road; the rest are from cool forest or temperate foothills at 5,000 up to 10,000 feet altitude.

There is very little variation in external characters shown by these twenty-seven skins and the only differences in the skulls may be attributed to age and wear of dentition.

This shrew was trapped in the usual damp, cool, overgrown localities one expects to find associated with these small creatures.

***Crocidura dracula dracula* Thomas. WHITE-TIPPED SHREW.**

Crocidura dracula Thomas, Ann. Mag. Nat. Hist., (8), 9, p. 686, 1912.

Specimens collected.—12: Htawgaw, 1; Hkamkawn, 7; Kumaw, 1; Ngawchang River, altitude 1,800 feet, 3.

The skins of this series average somewhat darker in color and a trifle smaller than those of a large series of *d. dracula* from Yunnan. The differences do not appear to be of an order justifying description of a new subspecies, but they do indicate that one may expect a considerable degree of variation in these characters.

This shrew appears to be restricted to the river valleys and foothills where hot, dry weather shows an obvious effect upon the environment. It was not taken in the regions of cool, frosty nights, although it is recorded from Yunnan at elevations up to 8,000 feet. At elevations approaching 6,000 feet and above in northeastern Burma, our traps took plenty of shrews but we found *dracula* was replaced by other groups.

***Crocidura indochinensis* Robinson and Kloss. INDO-CHINESE SHREW.**

Crocidura indochinensis Robinson and Kloss, Ann. Mag. Nat. Hist., (9), 9, p. 88, 1922.

Specimens collected.—11: Changyinku, 1; Gangfang, 5; Hpare, 1; Hpawte, 1; Rawngaw, 1; Pyepat, 1; Tangtung, 1.

These small dark shrews can not be identified with either *vorax* or *rapax*, small species found in western Yunnan, for the latter are much lighter in color, browner. The specimens available for comparison are in winter pelage; hence the difference can not be attributed to season. Being unable to match this series satisfactorily with anything in the nearby west China fauna, and believing that

indochinensis described from Annam, some 1,200 miles distant, could be ruled out of consideration, I had written a tentative description for a new form. As a double check against adding a new name to an already overloaded list, I compared my description with that of Robinson and Kloss. I find that the Burma shrews agree so closely with the description of *indochinensis* that I am identifying them as that species. The type of *indochinensis* came from the Langbian Plateau, altitude 5,000 feet, and the matter of altitude accords well with that of our specimens, which were collected at 4,000 to 7,000 feet. Because the more immediate relationships of the mammals collected in the mountains of northeastern Burma are predominantly with the Indian and west China faunas I had not expected this link with the Annam fauna.

Robinson and Kloss compared their type of *indochinensis* with that of *fuliginosa* Blyth, a larger, browner shrew. I have not seen specimens of *fuliginosa* but the characters as given by Blanford (1888, p. 242), except for color and slightly longer tail, are very like those of the Burma series. Perhaps more material will prove that *indochinensis* is the eastern representative of *fuliginosa*.

If I am correct in my identification, and if it is not premature to base conclusions upon the rather inadequate representation of Asiatic *Crocidura* at hand for examination, I shall support Allen's suggestion (1938, p. 137) that *vorax* may eventually stand in a subspecific relationship to *indochinensis* as will *rapax*, if it does not prove to be a synonym of *vorax*. Possibly all of these will prove to be races of *fuliginosa*. Our specimen from Changyinku, on the very border of Yunnan, is noticeably browner than the other specimens, although somewhat darker than *vorax*. It may be an intermediate between *indochinensis* and *vorax*. There are no differences in dental characters between skulls of *indochinensis* from Burma and those of *vorax* from Yunnan, which could not be included in a subspecific relationship.

Crocidura indochinensis was not trapped in the high mountains but seemed to be a denizen of the intermediate altitudes. Its dark color suggests that it will not be found in the dry, more open reaches of the lower valleys, that it belongs in the well-watered regions where cover is fairly heavy.

Anourosorex squamipes Milne-Edwards. CHINESE SHORT-TAILED SHREW.

Anourosorex squamipes Milne-Edwards, Rech. Mamm., p. 264, 1868-74.

Specimens collected.—7: Hpimaw, 1; Htawgaw, 1; Pyepat, 2; Rawngaw, 2; Tangtung, 1.

These specimens show no great differences when compared with specimens from western China. According to Osgood (1932, p. 247), this species ranges over an extensive area without differentiating to a degree which can be consistently defined subspecifically.

This shrew did not appear to be common at any of the camps where we collected. Those taken were trapped under rocks and in dark, damp spots likely to be frequented by shrews. One or two were trapped in runways along fern- and moss-covered banks. This species was either local in its distribution or else spends most of its time in subterranean passages or we should have secured a greater number. Shrews of other genera were trapped in abundance everywhere above the dry lowlands and special efforts were made for more *Anourosorex*, once the first specimen was taken in a locality. None were found at an elevation above 7,700 feet, although there are records for western China up to 10,000 feet altitude. The lowest altitude at which we trapped specimens is 4,200 feet.

Chimarrogale himalayica himalayica Gray. HIMALAYAN
WATER SHREW.

Crossopus himalayicus Gray, Ann. Mag. Nat. Hist., (1), 10, p. 26 1, 1842

Specimens collected.—2: Pyepat.

These two specimens have brownish gray under parts which merge gradually into the much darker color of the sides. There is no distinct line of demarcation between the two areas.

Special efforts were made to secure water shrews, but these creatures are either rare, perhaps local in distribution, or else not particularly attracted by any bait that is offered them. I suspect the latter reason is the best explanation for their scarcity in museums. The bait most often used in Burma was the combination of peanut butter, bacon, rolled oats, and raisins. This proved to be very attractive to shrews (other than the specialized water shrews) and shrew moles.

Influenced by experience with the fish-eating rats of South America which do not come readily to bait, I set traps along the Burmese brooks wherever I encountered waterfalls or obstacles which might force the shrew to a detour along the bank. The first specimen of *himalayica* stepped into a set of this character where a small stream came down the steep hillside near the Pyepat rest house. A waterfall made a deep pool in heavy woods, and traps were placed in the most obvious paths likely to be followed by an animal climbing up over the rocky ledge.

This specimen was taken on December 23, on our way up country, and a second specimen was caught at the same spot when we returned through Pyepat on April 2. This species was not encountered elsewhere and is probably replaced in the higher country to the north by *C. styani*.

Chimarrogale styani De Winton and Styan. STYAN'S WATER SHREW.

Chimarrogale styani De Winton and Styan, Proc. Zool. Soc. Lond., p. 574, 1899.

Specimens collected.—4: Gangfang, 2; Imaw Bum, 1; road to Chimeli Pass, 1.

These specimens have lighter-colored under parts than those of *C. h. himalayica* and there is a well-defined line of demarcation between under parts and sides. Otherwise there seems to be no great difference between the two forms of water shrews.

The type specimen of *styani* came from northwestern Szechwan and the second known specimen was reported by Thomas (1915, p. 335) from the mountains in the north of Upper Burma. Mr. F. Kingdon Ward, who collected the Burma specimen, reports (1921, p. 757) that it was taken by hand, in the daytime, in a stream on Imaw Bum, 11,000 feet altitude.

Although I have followed current practice and call *styani* a full species, I suspect it could be designated as a subspecies of *himalayica* and come closer to indicating the true relationships between the two shrews. We did not take large enough series to establish definitely that both do not occur in the same locality. This state of affairs is suggested by the distribution of the six specimens representing both *styani* and *himalayica*, but more material is needed to prove this point.

Styan's shrew was taken in three different localities and is doubtless to be found along most of the cool, mountain brooks in that part of Burma where we collected. It was a red-letter day when one was found in the traps although likely spots were plentifully sprinkled with traps and no opportunity was missed to run a special line for this species alone.

On every occasion but one the animals were captured at the margins of pools or otherwise at the water's edge. The exception was a shrew trapped forty or fifty feet from the Ngawchang River at Gangfang. This specimen was brought in by my native assistant who ran part of the traps that morning, through a misunderstanding,

while I was busy elsewhere. Later, I had him show me the spot where the water shrew was caught and he was very definite and insistent when I expressed doubt that the animal was so far from water. The Ngawchang is a sizable stream, too large in most places to wade, and during high water its banks extend back into the shrubbery and scattered forest. At this place the high-water mark was a low bank, the earth held by a tangle of roots, and with sand running down to the stream. The locality was dry, not the environment favored by shrews where damp earth and rotting leaves make good hunting for insects. The only interest a water shrew could have had in such a spot would seem to be a nest burrow in the bank or under the roots.

***Nectogale elegans* Milne-Edwards. TIBETAN WATER SHREW.**

Nectogale elegans Milne-Edwards, Compt. Rend. Acad. Sci. Paris, **70**, p. 341, 1870.

Specimens collected.—19: Hpare, 14, and 2 in alcohol; Lagwi, 1, and 2 in alcohol.

After a careful study of this series and comparisons with the characters given in the literature—no comparative material of this rare shrew is available—I find nothing which might distinguish the Burma animal from the one in Szechwan. Perhaps this apparent lack of differentiation is the result of the special environment in which this shrew lives. Practically all of its time is spent in mountain streams, which would tend to offset any local influences such as are correlated with differentiation found among small, terrestrial mammals. Mountain brooks are very much the same in Burma and in Szechwan. However, the terrestrial (or subterranean) *Anourosorex* ranges over much of this same territory in western China and Burma and shows a comparable lack of subspecific differentiation.

Our series of this water shrew was collected from several streams in the Htawgaw-Hpare district. In every case the specimens were brought in by natives who reported upon the locality where the capture was made. Although traps were set for water shrews in every region where streams were encountered, and specimens of two species of water shrews of the related genus *Chimarrogale* were taken, *Nectogale* would not take a bait or cross a set.

The natives took them by hand in a rather interesting fashion which involved damming off a portion of the stream. This operation required much time and hard work and I saw the process through to the end on several occasions, but unfortunately these happened to be the very times when no shrews were encountered in the drained

watercourse and I did not actually witness a capture. I was paying a rupee for each specimen brought into camp and this was sufficient inducement for native men and boys to comb the streams for miles around.

Nectogale frequents the fast-flowing streams and probably leaves the water only when forced to do so. The streams have log jams, boulder piles and other similar obstructions which provide recesses for home burrows entered directly from the water. Although some of the brooks hunted for this shrew were small enough to be crossed by leaping from rock to rock, most of the watercourses were of a size to be crossed only where bridges were built for the roads.

In working a stream the natives selected a stretch where the channel divided or tended to divide the water into two main bodies. At the head of this run a dam was thrown across one of the forks, diverting the flow. Boulders and logs formed the bulk of the dam but finally twigs, leaves, and sod were employed to cut the stream to a mere trickle back of the dam and all of the water went down the unobstructed branch. At the foot of the drained fork, where the stream bed swung back into the flowing branch, sometimes several hundred feet downstream, a small dam directed the scanty flow through one or two gaps, and elongated wicker baskets, probably built as fish traps, were placed in these gaps. Nothing could swim or drift down into the full stream without passing into one of the baskets.

Just back of the dam at the head, a bundle of aconite roots was laid across a stone and pounded with a club. A milky juice ran into the stream, now reduced to a series of pools joined by shallows, and slowly worked down. The effect of the poison was obvious, small fish and aquatic insects coming to the top in distress. The natives hunted over the full length of the drained branch, turning over boulders and logs where these could be moved and thrusting long, slender poles into nooks and crevices which could not be opened up. The shrews are sometimes seized in the hand, or they may be recovered from the basket at the foot. The natives saved the small fish as they appeared and it was doubtless the experience gained in fishing which made them so adept at capturing *Nectogale*. They showed very little skill in catching moles, for example, although the mole runs were common and the men wanted to earn money. The natives were familiar with the habits of *Nectogale* and not with those of the mole.

I was told that this shrew could be seen in the daytime.

Rhinolophus rouxi sinicus Andersen. ANDERSEN'S LEAF-NOSED BAT.

Rhinolophus rouxi sinicus Andersen, Proc. Zool. Soc. Lond., 2, p. 98, 1905.

Specimen collected.—1: Vijawlaw, in alcohol.

This is a very poor specimen, badly mutilated, and the skull has been removed for study. The head skin is so torn that it is difficult to discern the facial characters, but they seem to agree with those ascribed to *sinicus*.

Hipposideros armiger armiger Hodgson. GREAT HIMALAYAN LEAF-NOSED BAT.

Rhinolophus armiger Hodgson, Journ. Asiatic Soc. Bengal, 4, p. 699, 1835.

Specimens collected.—6: Black Rock, 1; Chipwi, 3, and 1 in alcohol; Tanga, 1.

These large bats display all the characters of typical *armiger* but the series shows considerable variation in color with the extremes representing what may be two color phases. One phase has the hairs on the back tipped with warm brown, followed by a broad zone of much lighter brown, and with a narrow basal band nearly as dark as the tip. The other phase is darker, the tips of the hairs approximating clove-brown, the broad subterminal zone dirty whitish, and the dark base, on those regions where it exists, much the same color as the tip.

This species was encountered only in the lowlands and the foothills, our records 1,000 to 4,750 feet altitude. It was a fairly conspicuous bat, coming forth about sundown, and if one were hunting for specimens it would be noticed as occurring in a region. It is not easy to collect, however, because it flies rather low and one can not catch it against the sky. It is a rapid flier and its large size identifies it readily. At the camps in the higher country, Gang-fang for example, where many evenings were spent in watching for bats, it was not encountered.

There is an extensive cave two or three miles from Chipwi, and Stanford visited it on our return to Myitkyina; *armiger* was one of three species of bats which he collected there.

Hipposideros larvatus grandis Allen. ALLEN'S HORSESHOE BAT.

Hipposideros larvatus grandis Allen, Rec. Indian Mus., 38, p. 345, 1936.

Specimens collected.—2: Chipwi, 1 skin and skull, 1 in alcohol.

These specimens agree in size, coloration, and facial and dental characters with *grandis*, a larger subspecies of *larvatus*. Dr. G. H. H.

Tate, who has in press a review of the genus *Hipposideros*, has called to my attention the applicability of *leptophylla* Dobson. The type locality of *leptophylla* is the Khasi Hills, Assam, and Allen had specimens from there which he called *grandis*. Basing his opinion on the literature and on a considerable number of specimens of the genus seen in various museums, Tate suggests that further study of Dobson's type may result in making *grandis* a synonym of *leptophylla*.

This bat was found only in the caves near Chipwi, in the warm lowlands (altitude approximately 1,000 feet).

***Triaenops wheeleri* Osgood. WHEELER'S TRIDENT BAT.**

Triaenops wheeleri Osgood, Field Mus. Nat. Hist., Zool. Ser., 18, No. 10, p. 224, 1932.

Specimens collected.—7: Chipwi, 6 skins and skulls, 1 in alcohol.

These specimens agree closely with Osgood's type description, and with a specimen collected at Chapa, Tonkin, and obtained by exchange with Field Museum. In his remarks, given in the type description (p. 226), Osgood states that the reference of *wheeleri* to the genus *Triaenops* is somewhat provisional.

The genotype is *Triaenops persicus*, which has quite different facial characters (figured by Dobson, 1878, pl. 8) from those shown by *wheeleri*. An alcoholic specimen of *wheeleri* permits much better study of the facial structure than does a dry study skin and in all essential details the complex pattern of the face and nasal appendages seems a much closer match to *Phyllorhina stoliczкана*, figure 5 on Dobson's plate, first described as *Asellia stoliczкана* (Dobson, 1871, 40, p. 106, and 1871a, p. 263).

Asellia stoliczкана came from Penang and the name apparently has dropped out of recent literature. Dr. G. H. H. Tate has in the press, as this is written, a paper discussing the relationships of the genera of hipposiderine bats, and he has called to my attention the possibility that *wheeleri* might be a synonym of *stoliczкана* or at least congeneric with it. He believes that *stoliczкана* does not belong in the genus *Triaenops*. Peters (1871, p. 513) describes *Phyllorhina trifida* from Burma, and Dobson (1876, p. 61) places *trifida* in synonymy with *stoliczкана*.

In the description by Dobson of *stoliczкана* and by Peters of *trifida*, it is apparent that many of the characters shown by our Burma series are clearly outlined. Their specimens were taken very close to the region known to be occupied by *wheeleri* and until these old names are adequately resolved there must be doubt as to the

validity of *wheeleri* as a good species. If it is a valid species there is still the question of its inclusion in the genus *Triaenops*.

A skull of *Triaenops persicus* from Aden, Arabia, kindly lent by the United States National Museum, shows, when compared with a skull of *wheeleri*, quite a difference in the size, shape, and location of the vertical expansion of the zygoma and in the inflation of the rostrum.

Because of the scarcity of material representing the several old names involved in the solution of this discussion, and in view of the more comprehensive review being made by my colleague, Dr. Tate, I have retained the name used by Dr. Osgood, *Triaenops wheeleri*, as the course causing the least confusion at this time.

Pipistrellus affinis(?) Dobson. CHOCOLATE BAT.

Vesperugo (Pipistrellus) affinis Dobson, Proc. Asiatic Soc. Bengal, p. 213, 1871.

Specimens collected.—1: Changyinku.

This specimen is provisionally identified as *affinis*, the type locality for which was given by Dobson as "Bhamaw, Yunan," which I take to be Bhamo, Burma, of today.

The Changyinku skin is very dark, almost black above, and perhaps does not entirely agree with Dobson's "chocolate brown," but the length of forearm, 39 mm., is a good match for 1.55 inches given for the type. I have considered *raptor* Thomas (1904, p. 388) as a possible name for this specimen. Checking against the description I find about the same degree of conformity as for *affinis*. But the type locality of *affinis* is only about a hundred miles from where our specimen was taken; the type locality of *raptor* is Tonkin, about four times as far away.

In the absence of any comparative material, this identification must be taken as somewhat of a guess, but one which seems to accord fairly well with literature and with geographic distribution.

Pipistrellus circumdatus Temminck. BLACK BAT.

Vespertilio circumdatus Temminck, Monog. Mamm., 2, p. 214, 1835-41.

Specimens collected.—1: Pyepat rest house.

This is a very well-characterized species with dead black pelage, tipped on upper parts with rich, glossy chestnut-brown and on lower parts with grayish.

The type specimen came from Java and the species has been reported from southern India. Dr. Tate examined, measured the

type specimen, and took photographs of the type skull, when visiting the Leiden Museum. He records the forearm measurement as 43 mm., and the Burma specimen has a forearm of 41.5. It is not unlikely that the Burma bat represents a race of *circumdatus* distinct from that found in Java, but in the absence of sufficient material to establish characters the present identification must suffice.

This specimen was shot at twilight by J. K. Stanford on the trail just at the Pyepat rest house. The rest house is perched on a very small clearing and the trail is cut into a steep hillside. The retrieving of any bat shot from the trail involves a great element of luck, and it was an exceptionally fortunate circumstance that this very rare bat fell where it could be recovered.

Pipistrellus coromandrus tramatus Thomas. TONKIN
PIPISTRELLE.

Pipistrellus coromandrus tramatus Thomas, Proc. Zool. Soc. Lond., p. 144, 1928.

Specimens collected.—1: Shingaw.

The characters of this specimen agree with those given in the type description.

This bat lives in the warm lowlands and foothills and was not encountered in the mountains. Our only specimen is the one shot at dusk near the rest house at Shingaw, altitude about 750 feet.

Miniopterus schreibersii fuliginosus Hodgson. HODGSON'S
LONG-WINGED BAT.

Vespertilio fuliginosa Hodgson, Journ. Asiatic Soc. Bengal, 4, p. 700, 1835.

Specimens collected.—3: Chipwi, 2, in alcohol; Gangfang, 1 skin and skull.

The selection of a subspecific name for these bats presents a problem incapable of satisfactory solution with the inadequate material at hand for comparison. As a group, the known races of *schreibersii* have a very extensive range and the characters of separation, chiefly size and color difference, are not of an order to permit ready identification from literature alone. The American Museum has specimens, from China, of *s. chinensis* and *s. parvipes* for comparison, but the Burma specimens can be matched about as well in the one race as in the other; furthermore, one specimen of *chinensis* agrees rather closely with selected specimens of *parvipes*. *M. s. fuliginosus* is a much older name than either *M. s. chinensis* or *M. s. parvipes*, and the type locality of Nepal, bearing a significant geographic relationship to northeastern Burma, calls for some weighing

against the more remote type localities in Hopei (*chinensis*) and Fukien (*parvipes*).

The Gangfang specimen is very dark and it is to be noted that dark specimens of *schreibersii* may turn up in company with much browner individuals. This is the case in our series of *s. parvipes* from Fukien. Howell (1929, p. 20) cites an extremely dark specimen which he includes in a series from Fukien identified as *s. parvipes*. Allen (1938, p. 266) states that "specimens from India, representing *M. fuliginosus*, are not very different from those of eastern China, but lack the warm russet tint to the otherwise somber pelage," and this characterization is a fairly good fit for the Burmese specimens.

Since identification, under these circumstances, is only provisional at best, I have chosen the oldest name.

This bat was shot at dusk while it was hunting insects. Although two specimens were secured thus at Chipwi, none were encountered in the caves near this place.

Murina cyclotis Dobson. ROUND-EARED, TUBE-NOSED BAT.

Murina cyclotis Dobson, Proc. Asiatic Soc. Bengal, p. 210, 1872.

Specimens collected.—1: Gangfang.

This specimen is not very brightly ferruginous in color of upper parts, to conform with Dobson's description, but otherwise agrees with the characters given for *cyclotis*. The tips of the long hairs are nearer Brussels brown and only sparsely cover the color below, which is much darker. The long hairs clothing the base of the interfemoral membrane, on the upper side, have a touch of brighter color which suggests ferruginous.

This is a rare species in museum collections and we found it to be so in the field. The single specimen secured was shot at dusk while flying near the rest house at Gangfang.

Macaca mulatta Zimmermann. RHESUS MACAQUE.

Cercopithecus mulatta Zimmermann, Geog. Gesch. Mensch., 2, p. 195, 1780.

Specimens collected.—1: shot along the road from Tanga to Shingaw.

This specimen of a widely ranging race presents no unusual features.

Rhesus macaques were not observed anywhere except in the warm forests of the river valleys and lower foothills. Even here they

appeared to be uncommon at the time we were traveling in these regions.

Hylobates hoolock Harlan. HOOLOCK GIBBON.

Simia hoolock Harlan, Trans. Amer. Phil. Soc., n.s., 4, p. 52, pl. 2, 1834.

Specimens collected.—2: purchased in flesh from native at Htaw-gaw, 1; Pyepat, 1.

These two specimens represent a pair, a black male and a yellowish brown female.

Gibbons were fairly abundant from elevations of about 5,000 feet up to 8,000 feet or more. They were much oftener heard than seen, their resonant halloos carrying for several miles. They occur in regions where the pine is a dominant forest tree as well as in locations where the broad-leaf trees seemed to offer more in the way of a food supply. Apparently they work up onto the higher ridges very early in the spring for we heard them above Fort Hpimaw late in February while there was still much snow in the pass. At this time they must have been at 8,000 to 9,000 feet elevation. We did not see or hear them in the warm zone forests of the lower foothills.

On the Pyepat Ridge I had a good opportunity to observe a small band at close range. In most cases, gibbons were encountered under circumstances where it was impossible for a man to travel under the trees without a great disturbance. This was especially true on the precipitous mountain slopes where progress off the trail became almost an acrobatic feat. My notes for Pyepat, on April 2, are as follows:

"Heard gibbons calling from several quarters this morning and got very close to a band just above the trail, not over a mile from the rest house. The animals undoubtedly saw me and gave a single loud alarm call when I came around a bend in the trail. After a moment they went on with their calling to distant bands and whooped it up in fine fashion. Some of them deliberately came closer to the trail to have a better look at us (I was accompanied by a native) and the band of 8 to 12(?) lingered in the vicinity, shaking branches and occasionally scolding amongst themselves in harsh, rasping tones. While the predominant call in the chorus was a two-note whoop, there was a single, high-pitched voice that differed greatly from the others. Do not know whether this was the voice of a youngster or whether it was a definite one-note call made by one of the adults as a variant, perhaps with a significance, from the regular call.

"These apes were brachiating and threw themselves fair distances but nothing remarkable. Perhaps if they had been alarmed they would have put on a better show. I preferred to watch them and did not make a very serious effort to shoot one, although I was approaching the stage where I was about to collect a good adult. I gave a call, an attempted imitation, and at once the band became silent. They did not rush away from the spot but rather quit calling and moving. I saw two or three after I called but could not see them well enough to discover whether the band was sneaking away or hiding."

***Ailurus fulgens styani* Thomas. SMALL PANDA.**

Ailurus fulgens styani Thomas, Ann. Mag. Nat. Hist., (7), 10, p. 251, 1902.

Specimens collected.—2: native skins, without skulls, said to have come from Sakkauk, north flank of Imaw Bum.

There is considerable difference in color shown by these two skins, both of which are strikingly marked. One has the back predominantly reddish chestnut; the other is paler, the back yellowish brown.

***Euarctos thibetanus thibetanus* G. Cuvier. TIBETAN BLACK BEAR.**

Ursus thibetanus G. Cuvier, Ossements Foss., 4, p. 325, 1823.

Specimens collected.—1: skin and skeleton, from the Hpawshi River, altitude 7,400 feet.

A good specimen of the Tibetan black bear was collected by Stanford, who made a side trip from Gangfang up the ravine of a small river, the Hpawshi, after scouts had reported the presence of bears.

The skin shows the characteristic color pattern of *thibetanus*, with a small cream-colored crescent across the base of the throat and a small spot on the chin. The stomach of the bear was filled with finely crushed acorns.

The natives told us that the Hpawshi district was good territory for bears and on several occasions these animals were said to be observed in other regions, but we saw little sign of their presence about any of our collecting stations and their distribution must be rather local.

***Canis* sp.? WOLF.**

I believe that a small to medium-sized wolf occurs in the uplands of northeastern Burma. No specimens were secured although we

offered the natives an attractive price and I hunted both day and night for it at Hpare, the locality where one was actually seen.

On the day we walked up to Hpare, along the fairly open river valley that includes this district, a large dog-like animal was discovered by the natives, who tried to point it out on the distant hillside. It was too inconspicuous, and too far off, for me to catch it before it passed into cover. The natives called it a jungle dog; that is, a wild dog as contrasted with a domestic dog.

Late the afternoon of this same day, about three miles farther up the valley, I ran across what may have been the same animal. It came out of a thicket situated in a small boggy hollow and was about 40 or 50 yards away. I was near enough to the native houses and clearings to suspect that I had frightened a domestic dog feeding on the carcass of a cow or a mule. I did not shoot on first glance and I never had another opportunity. The beast cut back through the low bushes and then emerged on a long, grassy slope, running, and too far for a shotgun.

The animal was the size of a large dog but not as large as our North American wolf. It was very light-colored, the general tone a dirty gray, washed with tawny, a rather striking and unusual color unlike that of any dog seen in Burma. It had a very full and bushy tail. There was an old and very smelly carcass of some large animal in the little ravine and this had attracted the attention of the wolf.

When I returned to the rest house at Hpare I pressed an inquiry into the presence of wolves and was assured that the villagers saw them about occasionally but never killed one because there were no good guns in Hpare. My native gun-bearer and trap boy (not with me when I saw the wolf), who was reared in this same village and by this time had learned enough of our strange ways and interests to be extremely useful, was able to get me fairly precise information. He now explained, through an interpreter of course, that the animal we had encountered that morning as we came up the valley was a wolf, not a dog run wild but a part of the native fauna.

I went back to the boggy ravine that night with a headlight and hunted there again at sunrise, as well as on many subsequent occasions, but I did not see the wolf again.

***Mustela altaica kathiah* Hodgson. YELLOW-BELLIED WEASEL.**

Mustela (Putorius) kathiah Hodgson, Journ. Asiatic Soc. Bengal, 4, p. 702, 1835.

Specimens collected.—2: Gangfang, 1; Gawlam, 1 (skin only, purchased from native).

These two weasels agree in size and pattern of coloration with specimens collected in western China.

The one specimen trapped by the expedition was caught in a rat trap set in a thicket of shrubbery along a small ravine. The trap was placed on a rocky ledge so narrow that the weasel entered the trap squarely and was struck across the back; the animal was too large to have been held by the trap unless the back or skull had been broken. The same trap had caught a *Tupaia* previously, which was devoured and only part of the head left; perhaps the weasel was responsible.

***Mustela sibirica moupinensis* Milne-Edwards. MOUPING WEASEL.**

Putorius moupinensis Milne-Edwards, Nouv. Arch. Mus. d'Hist. Nat. Paris, 7, Bull., p. 92, 1871.

Mustela hamptoni Thomas, Journ. Bombay Nat. Hist. Soc., 27, p. 500, 1921.

Specimens collected.—4: Gangfang, 1 (skin only, brought in by native); Imaw Bum, 1; Nyetmaw River, 2.

These specimens agree fairly well with descriptions of *moupinensis* in literature and with specimens collected in Yunnan and Szechwan. Our animal from Imaw Bum, as well as the two from the Nyetmaw River, may be considered as topotypes of *hamptoni* which Thomas compared principally with *subhemachalana* when he described it, but later (1922, p. 395) admitted should have been compared with *moupinensis*. The inference is that he might still (in 1922) have considered his *hamptoni* as a distinct form, but I can see no significant differences between our Burma specimens and those from western China. The extent of the black on the tip of the tail is a very variable character and the three skins taken by the expedition and known to be in winter pelage all show some blackish tipping. The greatest amount, however, is only about an inch and a half in extent; the others have a scant inch.

This large weasel appeared to be not uncommon on the flanks of Imaw Bum. Ward caught one in a rat trap, baited with a mixture of rolled oats, bits of bacon, raisins, and peanut butter, set near the ice-bound course of the Chaungmaw River. The wire bow of the trap held the weasel by the neck and it had not been killed by the blow. Inasmuch as this weasel is such a large and powerful species, it is rather surprising that a rat trap was able to hold it.

The second specimen I took in a No. 0 steel trap set along the Nyetmaw River, at a spot where some animal, presumably this weasel, had been robbing the mouse and rat traps. The trap was baited with meat. This animal was alive and fought fiercely, proving very tenacious of life. It was drowned in a pool but required very long immersion. It emptied its scent glands and smelled abominably. Another specimen was shot near camp early the same day.

Lutra sp.? OTTER.

Specimens collected.—None.

Two otter were seen the afternoon of December 17 along the N'mai River near the rest house at Tanga, altitude 900 feet.

The river is quite wide at this place, a deep, large stream, and the animals were on the other side where we could not stalk them. They came running down the bank of the river to where a small trickle of water entered it from the side. After pausing a moment on the sand bank they entered the stream and swam down the river. Cutting shot at them with a .22 caliber rifle but the distance was well over one hundred yards and they were not hit. The animals were aware of something unusual but could not understand what it was; they were not alarmed. They swam downstream a short distance, climbed out onto a large rock and looked about in obvious curiosity. A bullet struck the rock and the otters squealed with excitement. They soon concluded that the rock was not the best place for them and went on about their business, down the river.

Paguma larvata intrudens Wroughton. SOUTHERN MASKED PALM CIVET.

Paguma larvata intrudens Wroughton, Journ. Bombay Nat. Hist. Soc., 19, p. 793, 1910.

Specimens collected.—1: Gangfang (skin and skull, brought in by natives).

The type locality for this civet is Myitkyina, no great distance from Gangfang, and our specimen agrees fairly well with the description and with specimens taken in western Szechwan and Yunnan.

Prionodon pardicolor Hodgson. SPOTTED LINSANG or SPOTTED TIGER CIVET.

Prionodon pardicator (sic) Hodgson, Calcutta Journ. Nat. Hist., 2, p. 57, pl. 1, figs. 3, 6, 1842.

Specimens collected.—1: Hpawshi (native skin, no skull).

This skin was not a very good one and the fur had slipped in some places.

Felis (Prionailurus) bengalensis bengalensis Kerr. LEOPARD CAT or TIGER CAT.

Felis bengalensis Kerr, Anim. King., 1, Mamm., p. 151, 1792.

Specimens collected.—1: Htawgaw (native skin, no skull).

The native who brought in this specimen said that the cat was killed about the village of Htawgaw and that this animal sometimes bothered their chickens.

Felis tigris subsp.? TIGER.

Specimens collected.—None.

Presence of the tiger was noted at only two places visited by the expedition. At Laukhaung, on our return from the higher mountain section, on April 4, Stanford and I were told by Captain Parks, who was in command of the Post, that two of his Sepoys had wounded a tiger the day before. They were watching at a waterhole and crippled the animal when he came toward the machan. The waterhole was said to be a salt lick. The animal was reported to be badly wounded and known to be lurking in the trees and shrubbery not far from where it was shot.

Early in the morning of April 5, Parks, Stanford, and I tried to hunt the tiger down. By this time the account of the wounded tiger had been retold so often, through interpreters and by several individuals, that it was difficult to distinguish between fact and fancy. A careful search of the terrain, which was not at all favorable to a quiet stalk of a sulking tiger, failed to disclose the pools of blood or other proof of a badly wounded animal which had featured the stories. There seemed little doubt that the soldiers had seen a tiger, shot at it and perhaps hurt it somewhat, but great doubt that the animal was wounded so badly that we stood any chance of walking up to it. We gave up the attempt and returned to the rest house.

At Tanga, on April 8, I saw the skin of a tiger killed there by a native who trapped it at the carcass of a sambar.

Callosciurus quinquestriatus quinquestriatus J. Anderson.
ANDERSON'S BELLY-BANDED SQUIRREL.

Sciurus quinquestriatus J. Anderson, Proc. Zool. Soc. Lond., p. 142, 1871.

Specimens collected.—1: road between Nomoyoung and Seniku, altitude about 1,000 feet.

This specimen is much warmer in color, a bright chestnut, than *C. q. beebei*. Probably the brighter coloration is correlated with the dryer character of the forest encountered at the lower elevations. There is a long, dry season in this part of Burma and the valleys and foothills lack the influence of cool nights, mists, and low clouds which make the mountain forests denser and darker.

***Callosciurus quinquestriatus beebei* J. A. Allen. BEEBE'S
BELLY-BANDED SQUIRREL.**

Sciurus beebei Allen, Bull. Amer. Mus. Nat. Hist., 30, p. 338, 1911.

Callosciurus quinquestriatus imarius Thomas, Ann. Mag. Nat. Hist., (9), 17, p. 640, 1926.

Specimens collected.—22: Chipwi-Laukhaung road, 2; Gangfang, 1; Hkamkawn, 1; Htawgaw, 3; Hpimaw, 1; Laukhaung, 3; Pyepat, 3; Pyepat-Langyang road, 2; Tamu-Chipwi road, 3; Tamu-Tanga road, 2; Tsonma, 1.

The type of *C. q. beebei* was labeled as coming from Sarawak, at the time it was described by Allen. Among other specimens in the same collection, made by the Kuser-Beebe Pheasant Expedition, is a squirrel of the *vittatus* group labeled as collected in the Sansi Gorge, Burma-Yunnan frontier. It is obvious that the labels of these two specimens in some way became transposed and that the type locality of *beebei* is on the Burma-Yunnan frontier. The geographical distribution of these two groups of squirrels is such that the transposition of labels is the only way to account for the two specimens being so far from where they belong. In this same collection are two other squirrels, these representing *C. q. quinquestriatus*, taken also in Burma.

This apparent discrepancy between the characters given for *beebei* in the type description and the type locality, where none of the *quinquestriatus* group can be logically expected, has been noted by Ellerman (1940, p. 373). He lists *beebei* as a synonym of *q. quinquestriatus* and states that Sarawak as a locality is erroneous.

I can see very little significant difference between squirrels collected as listed above. While there is some individual variation in color, the light stripes on the under parts range from white to buffy or almost ochraceous, and there is a uniformity in general appearance; all must belong to the same race. Some of this material was taken not very far from the type locality of *C. q. imarius* and is indistinguishable from the type of *C. q. beebei*, which has priority by fifteen years.

These squirrels were shy and comparatively scarce, considering the number of persons in our party who were watching for them. They were seen more frequently in the forests of the foothills and more were shot along the trails as we traveled from Myitkyina to our base camp at Gangfang than out of the collecting stations in the heavier forests of the main range. Despite the fact that squirrels are more readily seen in the more open type of forest often encountered at the elevations of 1,000 to 5,000 feet, I believe that they actually are more numerous there, and had we been stopping to collect intensively at some of our one-night rest houses a much larger series would have been secured. In the climax forests of oak, conifers, rhododendrons, and bamboo, squirrels were most difficult to see.

This squirrel has a scolding call which is best described as a squall. One that I shot at Pyepat uttered a hoarse bark, a single note, not a chirr. It seems to spend most of its time up in trees; at least we did not often note it at the ground level.

***Dremomys lokriah bhotia* Wroughton. · LONG-SNOURED BHUTAN SQUIRREL.**

Dremomys lokriah bhotia Wroughton, Journ. Bombay Nat. Hist. Soc., 24, p. 426, 1916.

Specimens collected.—2: Imaw Bum, 1; Nyetmaw River, 1.

These two squirrels have a rich ochraceous band running the length of the under parts from chin to base of tail and obviously belong in the *lokriah* group. Just which race of *lokriah* should be used here is not so clear. The type locality of *bhotia* is eastern Sikkim, and on geographical grounds one might expect the squirrel from eastern Burma to show some differentiation. Another race, *garonum* Thomas, has been described from the Garo Hills, Assam, but is said to have the wash on the under parts "orange-buff" (Ridgway), which is rather too pale to fit our specimens. Unfortunately, the American Museum has for comparison no specimens whatsoever of this section of *Dremomys*.

It is possible that these two animals represent an undescribed race, but in view of the lack of comparative material and the fairly close agreement with the few characters given in the description of *bhotia* it seems the wisest course to use this name.

I have given Wroughton as the describer of *D. l. bhotia* but it may be argued that Thomas is the author of the name. In the same volume of the Journal, cited above, on page 417, Thomas

begins a synopsis of the British Indian forms of *Dremomys* and on page 418 gives the characters for "*D. l. bhotia*." It would seem that this first use of the name, with enough characters to identify it, should establish Thomas as the author. Nevertheless, Wroughton, on page 426, under the heading "*Dremomys lokriah bhotia*, sp. n." gives a full description and designates a type specimen. Ellerman (1940, p. 381) lists "*Dremomys lokriah bhotia*, Thomas" and cites the reference on page 426 of the Journal, which is in Wroughton's paper.

Both of the localities where this squirrel was encountered are characterized by damp, high altitude (8,500 to 9,500 feet) forest.

***Dremomys pernyi imus* Thomas. LONG-SNOURED BURMA
SQUIRREL.**

Dremomys pernyi imus Thomas, Ann. Mag. Nat. Hist., (9), 10, p. 402, 1922.

Specimens collected.—2: Gangfang (purchased from native, not known to have been collected at Gangfang), 1; above Tsonma, 1.

No specimens of *imus* are available for comparison but the American Museum has specimens of *howelli* from Yunnan and these are very much like the Burma material. Thomas, l.c., states that *imus* is "a large mountain race of *D. p. howelli*," and the type came from the west flank of Imaw Bum, Burma. Our two specimens were collected at no great distance from Imaw Bum, the Tsonma animal being from a ridge that runs into the eastern flank of Imaw Bum.

If it is permissible to judge from the rather scanty material in the American Museum representing several races of *D. pernyi*, and from the rather close resemblance of these two specimens of *imus* (which are almost topotypical) to the specimens of *howelli* taken in Yunnan, I should characterize some of these subspecies as very weakly differentiated. In the paper describing *D. p. imus*, Thomas also describes *D. p. howelli* and the latter has page priority. I use *imus* for our squirrels, primarily because of two considerations. The skull of one of them measures 56.5 mm. in greatest length (as against 53 mm. given for *howelli*). The proximity to the type locality is one of the few definite bits of data not dependent on a personal analysis of rather intangible characters.

Squirrels of the genus *Dremomys* appeared to be even rarer than *Callosciurus*. The two genera occur together, at least in part of the forest where we collected. At a one-night camp above Tsonma, altitude about 8,300 feet, Stanford shot a specimen of each genus when he was hunting a short distance. He reported that he heard two squirrels barking, with a noise he compared to that of a pack of hounds.

Their voices had great power and resonance. Although both genera were represented by specimens he brought in, it is believed his description applied to *Dremomys*, for the usual calls I heard made by *Callosciurus* had no remarkable carrying power. Judging from our rather limited contact with *Dremomys*, specimens collected by us only on Imaw Bum, the Nyetmaw River, and adjacent Tsonma camp, these squirrels prefer dense, dark woods and spend a good deal of their time down on the ground.

***Tamiops macclellandi macclellandi* Horsfield. STRIPED
HIMALAYAN SQUIRREL.**

Sciurus macclellandii Horsfield, Proc. Zool. Soc. Lond., pt. 7, p. 152, 1839.

Specimens collected.—2: Laukhaung-Pyepat road, 1; Seniku-Shingaw road, 1.

The type locality for *m. macclellandi* is given as Assam without any more specific designation within that area. According to the map of distribution of *Tamiops* given by Allen (1940, p. 669), the region where we collected in Burma is marked to indicate *m. barbei* Blyth. Allen identified specimens from Yunnan, close to the Burma border, as *m. barbei* and six of these are available for comparison. The Burma specimens differ slightly from the Yunnan ones in having paler under parts, but otherwise would fit reasonably well into the same series. There are only three well-marked, dark, dorsal stripes shown by the Burma *Tamiops*, collected in November and December; the color of the sides passes directly into the creamy lateral stripes without noticeable black edging.

The type of *m. barbei* came from Yé, Tenasserim, which is at least twice as far from northeastern Burma as any probable locality within the area of "Assam" as given for *m. macclellandi*. The relationships of most of the mammals in the foothills and mountains of this corner of Burma tie up better with the Assam fauna than with that of Tenasserim. No specimens of typical *m. macclellandi* are in the American Museum to afford a comparison but the designation of these specimens in question as this race seems to be a better choice than calling them *m. barbei*.

The specimen collected along the road from Laukhaung to Pyepat was taken in fairly cool forest (5,400 feet elevation) which is part of a mountain environment best classified as subtropic to temperate. The other specimen, Seniku-Shingaw road, comes from a lower elevation, between 1,000 and 2,000 feet, from foothills in the midst of definitely tropical ecology.

***Tamiops monticolus spencei* Thomas. SPENCE'S STRIPED SQUIRREL.**

Tamiops spencei Thomas, Journ. Bombay Nat. Hist. Soc., 27, p. 503, 1921.

Specimens collected.—4: Imaw Bum, 2; road to Chimeli Pass, 2.

The type locality of *spencei* is given as northern "Kachin Province, N. Burma, at 28° 22' N. 97° 40' E.," apparently the Namkiu Mountains. This is no great distance from the mountain ranges whence came our four specimens. They agree quite well with the type description in warm coloration (inclining toward dull rufous), dorsal stripes not as conspicuous as in other forms of the genus, and the long pelage which one might expect in the cool, damp forests of 9,000 to 10,000 feet elevation.

These skins bear considerable resemblance to specimens from Mucheng, Yunnan, identified by Allen (1940, p. 676) as *T. s. swinhoei* and compared by Osgood (1932, p. 295) to *spencei*. The latter noted the resemblance of the Mucheng specimens to *spencei* as described. Our Burmese squirrels are not quite as clearly striped as the Mucheng animals and are a shade darker in general coloration because of the suppression of the outside pair of light stripes.

Squirrels of the genus *Tamiops* were only rarely noted by our party and but six specimens, representing two species, were collected. Two which I shot appeared to be rather indifferent to the presence of man, and my first impression was that these animals would be easy to collect whenever encountered. This idea was revised on the basis of later experience; I was not so confident that one could be collected once it was known to be in a locality. Whether this scarcity of specimens is due to a conscious shyness and secretiveness or to a naturally protective coloration and quiet demeanor can not be determined from my few observations.

At the camp on Imaw Bum I shot one out of a leafless apple tree after Ward and I had stalked it for several minutes. It was calling in a fine, wiry note which we thought to be that of a small bird, and I was not expecting to see a squirrel. The call lacked directional quality and the animal, so closely matching the dark bark of the tree, was very difficult to locate. It did not move or pay any attention to our disturbance of the shrubbery below it. A similar call-note was heard near the camp on the Nyetmaw River and I was convinced that it was made by *Tamiops*, but a long search, on several occasions, met with no success.

Near the camp close to the Chimeli Pass I had waited very quietly, late one afternoon, in the hope of getting a shot at a tufted

deer which had been jumped at this spot two days before. I was in a dark patch of forest and nothing had moved for more than an hour. A *Tamiops* came into sight, moving over logs and on the ground, the first time I had noted one at the ground level. It slipped along like a shadow and when it stopped moving blended into the background so completely as virtually to disappear. Eventually I shot it as it was climbing about the base of a clump of large bamboo. I realized from watching this squirrel that I might have passed by it a dozen times without seeing it had not the circumstance of movement first caught my attention.

There were a few crab-apple trees scattered along the river valley on Imaw Bum and the small, shriveled fruit lay on the ground. Rodents cut up these apples to get at the seeds and *Tamiops* undoubtedly has apple seed on its menu for two specimens were collected in apple trees.

***Pteromys (Hylopetes) alboniger orinus* G. M. Allen. BLACK-AND-WHITE FLYING SQUIRREL.**

Pteromys (Hylopetes) alboniger orinus Allen, Mamm. China and Mongolia, pt. 2, p. 723, 1940.

Specimens collected.—4: Gangfang (brought in by native hunters, and Gangfang as a locality needs some reservation).

These specimens agree quite closely with material from Yunnan, where the type was collected by Joseph Rock.

Despite night hunting with a headlight wherever the presence of forest led me to expect flying squirrels, I saw no specimens of *Pteromys*. Those we secured were bought from natives who presumably obtained them from some of the stands of primeval forest only a relatively short distance from the village of Gangfang. Three of these were brought in fresh, in the flesh, and good skins and skulls were obtained. The fourth was a flat skin and lacked a skull. The abundance of oaks in the forest, with a plentiful supply of acorns, would seem to provide a congenial habitat for these squirrels, but the difficulty in locating specimens indicates either a local distribution or very inconspicuous habits.

***Belomys pearsoni pearsoni* Gray. PEARSON'S FLYING SQUIRREL.**

Sciuropterus pearsonii Gray, Ann. Mag. Nat. Hist., (1), 10, p. 263, 1842.

Specimens collected.—3: Gangfang (about three miles above), 2; near Hpawshi, 1.

Three specimens of a rare flying squirrel, of the genus *Belomys*, were brought in to us by natives. One was in the flesh and was saved as a skin and skull, the other two had been skinned and the skulls were not available. The men reported that they had secured the animals as noted above.

I have had for comparison the type of *B. pearsoni blandus* and a specimen of *B. p. pearsoni* from Sikkim (both lent by Field Museum), as well as a specimen from Assam, and two specimens from Indo-China (Legendre Indo-China Expedition). This material represents a wide geographical range and there are some color and size differences, but with so few specimens it is difficult to evaluate these characters. Some of the animals have skulls with unworn molars, the crowns sharp, and the mature topography of the skull yet to be achieved; the Burma skull has well-worn molars. Although the Burma specimens do not agree in every respect with the Sikkim specimen, they are so close that I believe they are the same subspecies.

Taking Ellerman's list of named forms (1940, p. 277), there are four subspecies of *pearsoni* which call for consideration; the only other subspecies in the list, *kaleensis*, is from North Formosa and can be ruled out on geographical grounds.

Belomys pearsoni pearsoni; type locality, Sikkim

Belomys pearsoni blandus; type locality, Tongking

Belomys pearsoni villosus; type locality, Upper Assam

Belomys pearsoni trichotis; type locality, Manipur

Both Upper Assam and Manipur are fairly near to northeastern Burma and perhaps our specimens should be called either *villosus* or *trichotis*. There is nothing in Blyth's description of *villosus* (1847, p. 866) which will not fit *pearsoni*. The color of the hair on the chest of *trichotis* is given by Thomas (1908, p. 7) as white to the base, a condition matched by the two Legendre Expedition squirrels from Indo-China (which should be *blandus* on a geographical basis) and approximated by a specimen from Assam.

Eight specimens is not enough to permit one to pass considered judgment upon how many of these subspecies of *pearsoni* are based upon characters of taxonomic value, although I suspect that four distinct races, ranging from Sikkim to Tonkin, are probably too many.

Various authors, in giving the characters of the genus *Belomys*, describe the ear as large, which is a statement requiring qualification. It is not a large ear, although it may be large as compared with the ear of *Pteromyscus* (see key in Thomas, 1908, p. 4), no specimens of which have been examined by me. It seems that a more useful comparison would be with a flying squirrel much better represented

in museums, *Pteromys* for example, and in this case one would describe the ear of *Belomys* as small.

***Petaurista clarkei* Thomas. CLARKE'S FLYING SQUIRREL.**

Petaurista clarkei Thomas, Ann. Mag. Nat. Hist., (9), 10, p. 396, 1922.

Specimens collected.—3 (skins only): Htawgaw, 1 (brought in by native hunters); 2, no locality, probably not far from Htawgaw (bought from natives).

These three specimens agree, in all essentials, with the type description. Two of them have under parts washed with warm buffy; the third is only slightly buffy below, almost white, except for the edges of the lateral membranes.

This species was not encountered in the flesh by any of the party. It does not seem to be as plentiful as the other form of *Petaurista* brought in by the native hunters. The type series of five, collected by Forrest in the Mekong Valley, were all shot in pine forest, and those brought to us could also have been living in pines, a common tree about Htawgaw and several of our lower camps.

***Petaurista yunanensis* J. Anderson. ANDERSON'S FLYING SQUIRREL.**

Pteromys yunanensis J. Anderson, Ann. Mag. Nat. Hist., (4), 16, p. 282, 1875.

Specimens collected.—12: Black Rock, 3 skins with skulls (purchased from natives); Gangfang, 2 skins with skulls, 1 skin only (all from natives); Gawlam, 2 skins only (from natives); Laukhaung, 2 skins only (from natives); Nyetmaw River, 1 skin with skull; no locality, 1 skin only (from natives).

These handsome squirrels agree, in all particulars, with descriptions of *yunanensis* given in literature, and with material collected in Yunnan. The series does not show very much variation in color of upper parts, but below the color varies from all white to white with brownish wash down the mid-line.

Only one specimen of this big flying squirrel was personally collected by our party; all the others were purchased from natives. Some of the natives brought them in as flat, or as stuffed skins, and there are no skulls to go with these specimens. A few were brought in as freshly killed animals and complete specimens could be saved in such a case. The localities given for the native material do not adequately designate the sources of these skins, merely the location of the expedition at the time of purchase. It may be assumed,

however, that most of the specimens originated at no very great distance from the spot of delivery.

The one specimen shot was collected at the camp on the Nyetmaw River, altitude 8,600 feet. I secured this early one evening, hunting with a headlight. The animal was in mixed forest, oaks predominating, well above the ground and its eyes glowed brilliantly, a soft yellowish red. Although this forest was hunted thoroughly on several subsequent evenings, no other squirrels were seen.

***Eothenomys melanogaster cachinus* Thomas. CACHIN MEADOW MOUSE.**

Microtus (Eothenomys) cachinus Thomas, Journ. Bombay Nat. Hist. Soc., 27, p. 504, 1921.

Specimens collected.—109: Hpare-Saulang road, 10; Hpimaw road, 18; Imaw Bum, 22; Nyetmaw River, 9; road to Chimeli Pass, 50.

The type locality of *E. m. cachinus* is Imaw Bum, altitude 9,000 feet. Our expedition had its base camp on the flanks of Imaw Bum, at an elevation of 9,000 feet, and hence the series of twenty-two specimens from there are topotypical *cachinus*. It is fortunate that the entire series of this meadow mouse can be considered in relation to topotypes for considerable individual variation occurs and some of the characters given prominence in literature break down when many specimens are involved.

The literature indicates that several forms of *Eothenomys* occur in this northeastern corner of Burma; others have been reported in western China and could be expected in Burma. Some of the Chinese mice are available for comparison. The written descriptions are seldom sufficiently descriptive and exclusive to afford a satisfactory basis for identification of these plain-colored mice.

Despite the monotonous identity in external appearance when these mice were examined in the field, I had rather expected that two or more species, if not subgenera, would be discovered when the mountain collections were studied at the museum. The chief basis for this expectation was the observation that some of the mice had five and some six plantar tubercles. This difference now appears to have no significance. Howell (1924, p. 1014) has shown that the number of plantar tubercles and exact molar patterns are not to be considered as constant formulae for meadow mice in California, and I suspect that this is true for Burma.

In literature the pattern of the third upper molar is given great diagnostic value. The crown of this tooth in *cachinus* should have,

according to authors, four inner and four outer salient angles. In our series I find this often to be the case but I also note that the last loop of M^3 may range in development from an important feature in the molar topography, with sharply salient angles, through progressive reductions in size, past the stage with angles much shortened, to the final pattern where a straight side, either inner or outer, wipes out the salient completely.

This meadow mouse is a common resident in all the mountain environments visited by the expedition. The altitudinal range covered by our records is from 7,500 to 10,500 feet. It occurs in a variety of situations but seems to prefer banks or slopes which may be easily tunneled. Here its burrows open to the surface at frequent intervals and there are numerous surface runways. The banks along the trails are a favorite site, because moss, ferns, grass, and low vegetation give some ground cover and here the workings of a colony may be noted extending for long distances. I did not see very extensive surface runways through rank grass in mountain meadows, such as those made by many of our North American voles. In a meadow near the Imaw Bum camp there were a fair number of such runways but only a few mice seemed to be using them and most of our specimens at this place came from the banks of small streams.

This mouse was also trapped under rocks and logs but usually there were some signs of tunnels or runways nearby. These animals move about during the day but become most active about sundown and at night.

***Eothenomys melanogaster libonotus* Hinton. PÈRE DAVID'S VOLE.**

Eothenomys melanogaster libonotus Hinton, Ann. Mag. Nat. Hist., (9), 11, p. 151, 1923.

Specimens examined.—115: Changyinku, 14; Gangfang, 55; Hkamkawn, 2; Hpawte, 21; Hpawte, 7; Hpimaw road, 1; Hpinlawkha, 4; Htawgaw, 2; Langyang, 1; Luksuk, 2; Pyepat, 2; Tangtung, 4.

The name *libonotus* has been selected for these mice only after a process of elimination which has removed from consideration all of the comparative material of the genus in this museum, with none of which they agree. No specimens of *libonotus* are available but the characters as given in the original description come close enough to make *libonotus* the first choice from the literature. The type locality, Dreyi, Mishmi Hills, Assam, altitude 5,140 feet, is not

greatly removed, either geographically or ecologically, from the region in Burma where our specimens were collected.

The last upper molar is extremely variable, in crown pattern, in this series from Burma, and the differences do not seem to be co-ordinated with age or locality. The typical pattern for this tooth, to follow the original description of *libonotus*, should be three salient angles on both inner and outer faces. This is true of many of our specimens but a number show four salients on the inner face, a few have four on the outer face, others have four on both inner and outer faces. Occasionally a skull has the last upper molar on one side with a 3-3 pattern, its mate on the other side with a 3-4 pattern. Most of the variation in this tooth is confined to the last loop, which ranges from small and simple to elongated and complex.

The rather small ears, almost hidden in the fur of the surrounding parts, the short sleek fur of the body, and the short tail, give this meadow mouse an appearance suggestive of the species of *Chilotus* and *Pitymys*. The first specimens taken were caught in mole runways, which had been opened up to place traps flush with the floor of the tunnel. The position of the mice in the traps showed that they were using these subterranean highways and the circumstances recalled those under which I had trapped *Microtus (Chilotus) oregoni* in mole runways about Portland, Oregon. Later, specimens were caught in traps set on the surface of the ground, in spots where suitable cover made an environment attractive to meadow mice. I believe, however, that the suggestive external appearance of this mouse, indicating specialization for subterranean habits, was confirmed by our field experience and that more of its activities take place underground than is the case with *Eothenomys cachinus*.

This round-headed, short-tailed meadow mouse was not caught in the heavy forest of our upper altitude collecting sites. Its apparent range is in the intermediate foothills (not of the dry lowlands), where it may be found in grassy meadows, about cultivations, or in the occasional stand of trees and shrubbery along the streams. The highest altitude recorded is 9,000 feet. One specimen was trapped in a mole runway at old Fort Hpimaw, in open terrain.

This mouse is both diurnal and nocturnal in habit. Breeding activity must be at very low ebb for these prolific mammals during the winter season, for very few immature or half-grown specimens were taken in the traps.

Rhizomys sinensis wardi Thomas. WARD'S BAMBOO RAT.

Rhizomys wardi Thomas, Journ. Bombay Nat. Hist. Soc., 27, p. 504, 1921.

Specimens collected.—7: Gangfang, 4 (brought in by natives); Imaw Bum, 1, skin and skeleton, 2 (brought in by natives).

The specimens from Imaw Bum are virtually topotypes, for Ward secured the type on the west flank of Imaw Bum, at an elevation of 9,000 feet. The specimens brought in to us at Gangfang came from nearby forest and probably within a radius of no more than fifteen miles from Imaw Bum at the outside.

Bamboo rats seem to occur throughout the forested mountain slopes where we collected, but they are difficult to trap and all but one of our specimens were secured by purchase from natives. Even the one that was actually caught by us was trapped by my native trap-boy and gun-bearer who used his own methods after steel traps failed. Not infrequently one can hear a bamboo rat cutting bamboo underground and the brittle snapping of the tough fibers under the powerful incisors is audible for a surprising distance. Usually the burrows of these rats are to be found about clumps and thickets of bamboo, and I doubt if they feed on much of anything else. On the slopes of Imaw Bum we dug out a nest at well above 10,000 feet elevation. The nest was a grass-lined cavity and pieces of freshly cut bamboo, bamboo twigs and leaves, and droppings were in the burrow at this point.

An occupied burrow was located at about 9,000 feet in the valley of the Chaungmaw River where we camped on the northeastern flank of Imaw Bum, and my native boy showed me the approved technique for trapping the animal. With the help of two Lisus, my boy set about exploring the course of the burrow with sharp bamboo stakes. Probing from above, the stake broke into the burrow and revealed its presence. The home territory of a bamboo rat includes several burrows and only one or two of these may be in active use. Each time a burrow was opened the boy thrust in an arm, took a sample of the débris from the bottom and felt, at arm's length, for any turn or change in direction. The débris, made up of droppings, short lengths of bamboo, chips, etc., indicated by its appearance whether it was old or freshly made.

An old burrow might be ripped up in following its course, or, if it went under a clump of bamboo or tree roots, the probe would search for emergence on the other side. It was not long before sections of green, freshly cut bamboo were found, some of them thick pieces two inches in diameter. The marks of the incisor teeth reminded me of the work of a beaver. Soon the nest itself was located, a mass of leaves with fragments of bamboo and a great deal of a

white, granular substance like fine sawdust. This may have been from cuttings or disintegrated droppings. From this point the main runway pitched under the roots of a large tree and the men could dig no farther so gave up the idea that the rat could be captured by excavation. At this time No. 0 Newhouse traps were set flush with the floor of the burrow and stakes planted to force the rat across the set. That night the rat plugged all the burrows that had been opened, forcing fresh earth up from below, and sprung the two traps with plugs of dirt.

My boy then set one of his own snares, making elaborate preparations which involved framing the entrance to the main burrow with firmly driven stakes so that the rat had to follow the course intended for it. Two stout bamboos were bent over to spring the snare and it was held in position by a toggle working against a bamboo splint. One end of this splint was firmly anchored to the floor of the burrow and then passed squarely across the passageway. The rat meeting this obstruction promptly cuts it to get it out of his way. The snare itself was a slender strip split from the hard outside shell of a green bamboo and passed for a brief period above a small fire to make it pliable. The snare passed through an opening in the roof of the burrow and the running noose filled the burrow. When jerked upward by the bent bamboos the closing loop would pull the rat up tight against the roof of the burrow and hold him there. Indeed, I calculated that the power of the bent bamboo should be almost sufficient to cut the animal in two and wondered why so much energy was required. Apparently the natives believe in using plenty of force in their traps.

After the snare was set in place the loose débris removed previously from the burrow was scattered back in place, the mouth of the burrow was restored with damp earth, stakes were placed across the opening made to get into the tunnel, and the leaves and loose earth piled about to shut out all light. The snare had been rubbed with earth to color it and great pains taken to avoid arousing the suspicion of the rat. The occupant of the burrow sprung the snare that night and may have been within the noose, but the violent jerk of the released bamboos snapped the slender noose and we secured no specimen. Neither the boy nor the rat was discouraged by this episode and eventually, after four days and nights of trapping, the bamboo rat reached the skinning table.

I believe that the natives eat these rats and are accustomed to digging them out or trapping them when in need of food.

Apodemus sylvaticus orestes Thomas. CHINESE WOOD MOUSE.

Apodemus speciosus orestes Thomas, Abstract No. 100, Proc. Zool. Soc. Lond., p. 49, 1911.

Specimens collected.—209: Black Rock, 1; Changyinku, 16; Chimeli road, 16; Gangfang, 55; Hpare, 21; Hpare Pass camp, 4; Hpare-Saulang road, 8; Hpimaw, 8; Hpimaw road, 13; Hpawte, 4; Hpinlawkha, 1; Htawgaw, 7; Imaw Bum, 19; Luksuk, 2; Nyetmaw River, 23; Saulang, 7; Tangtung, 2; Tsonma, 2.

This large series displays considerable variation and it is possible that more than one form is represented. The variation, in size and coloration, does not appear to exceed the limits which define *orestes* but when extreme examples are compared one gains the impression that more than a single race, or perhaps species, is involved. Unfortunately, the very large individuals invariably have the dentition so worn that nothing definite can be learned of the molar patterns. Also the intermediate examples seem to bridge over any apparent gaps between the extremes. The localities represented cover a sufficient spread of ecologies to warrant the expectation that more than one form of *Apodemus* would be found.

This mouse was usually the commonest small rodent in each environment collected. It was found among the bracken, tall grass, and shrubbery of the foothills and continued through the forest up to elevations of 10,500 feet or more. I detected no marked habitat preference. Specimens were caught along streams, among rocks, on damp moss-covered forest floor, and in dry, exposed situations. My notes record the fact that *Apodemus* was comparatively rare along the upper Hpimaw road where the environment appeared to be favorable. At this place *Neotetracus* was common and may possibly prey upon this mouse.

Micromys minutus erythrotis Blyth. BLYTH'S HARVEST MOUSE.

Mus erythrotis Blyth, Journ. Asiatic Soc. Bengal, 24, p. 721, 1855.

Specimens collected.—17: Gangfang, 7; Hpare, 7; Hpawte, 1; Hpimaw, 1; Htawgaw, 1.

I have used *erythrotis* for these mice, following Osgood (1932, p. 318) who cites this as "the oldest name for any Asiatic *Micromys*," rather than Allen (1940, p. 963) who identifies Yunnan specimens as *pygmaeus* of Milne-Edwards. The Burma specimens appear to be identical with Yunnan material. Blyth's type came from the Khasi Hills of Assam, Milne-Edwards based *pygmaeus* upon specimens from central Szechwan, and our mice were taken about midway

between these two localities. But Allen (l.c., p. 964) states that "it is still to be shown that the Chinese specimens are really different from *M. minutus erythrotis* . . ." and under these circumstances the older name should be given preference.

Harvest mice were found only on open hillsides, among low shrubbery, bracken, and tall grass. They were not caught in the dense, primeval forests although each of the localities where specimens were trapped had formerly been a forested area. The present open terrain is a secondary condition and harvest mice must have found their way into it in comparatively recent times.

Leggada cookii meator G. M. Allen. ALLEN'S SPINY MOUSE.

Leggada cookii meator G. M. Allen, Amer. Mus. Nov., 270, p. 6, 1927.

Specimens collected.—12: Black Rock, 1; Gangfang, 10; Langyang, 1.

These mice match reasonably well with the series of *meator* from Yunnan from which the type specimen was selected. Several of the Gangfang specimens are quite dark, almost black, and most of the Burma animals have spinous hairs mixed with the predominating soft, normal pelage.

This mouse, of a group variously known as jungle mice or spiny mice, was encountered only in open terrain where shrubbery had taken the place formerly occupied by forest. The localities listed can be reached up river valleys which afford avenues of penetration from the warmer lowlands. Andrews and Heller took *meator* at elevations up to 8,000 feet, but we caught none at similar mountain camps on the western face of the Salween Divide.

Rattus rattus sladeni J. Anderson. SLADEN'S ROOF RAT.

Mus sladeni J. Anderson, Anat. and Zool. Researches Western Yunnan, p. 305, 1879.

Specimens collected.—1: Htawgaw, altitude 5,600 feet.

This specimen agrees well with Yunnan specimens of *sladeni*. Anderson gives the type locality as Ponsee, in the Kakhyen Hills, on the Burmese border of Yunnan. It is near or on the Taping River, has an altitude of 3,500 feet, and is not very far from the region worked by our expedition. On modern maps Kakhyen is spelled Kachin.

Anderson states that this rat appears to live in houses and also in trees. It must be rare in northeastern Burma for only the single specimen was encountered. It was trapped on the brushy hillside not far from the rest house at Htawgaw.



IMAW BUM FROM THE TRAIL
Between Tsonma and Nyetmaw Pass



LOOKING WEST FROM TRAIL, GANGFANG TO HPAWTE
Imaw Bum in background

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Rattus nitidus Hodgson. HODGSON'S GRAY-BELLIED RAT.

Mus nitidus Hodgson, Ann. Mag. Nat. Hist., (1), 15, p. 267, 1845.

Specimens collected.—13: Gangfang, 11; Htawgaw, 1; Rawngaw, 1.

This small series of rather dark-colored rats checks fairly closely with specimens from Yunnan and also agrees with the data given by various authors. It is not clear just which race of *nitidus* should be used for these specimens. The type description of *n. nitidus* was based upon specimens taken in Nepal, and later authors have given *nitidus* a very extensive range. Several eastern races have been described, one of them, *n. obsoletus* Hinton, from the Chin Hills of Burma. On geographical grounds, perhaps *obsoletus* should be applicable to our specimens but Allen (1940, p. 1002) doubts the distinctness of this race. This conclusion finds me in a receptive mood because the material of this genus now in the American Museum amply demonstrates the variability of many of the characters used to establish these subspecies and, in some cases, even species.

With specimens of some of these questionable races on hand for comparison, I find it difficult, in some instances, to share the faith of the describer who enumerates exclusive characters. And if one lacks specimens for comparison, it is well-nigh impossible to satisfactorily allocate fresh material upon the basis of a written description. A competent reviser, with ample material, may be able to save some of the names that appear to have uncertain status today, but too much emphasis seems to be given to trivial differences which do not hold up for a large series of specimens. These reflections are not directed particularly toward the validity of *R. n. obsoletus*, which may prove, in the final analysis, to be one of the races to survive. This reaction has been induced by searching for flitting characters in the genus *Rattus*, characters which are absent when needed and turn up when the prescription states otherwise. These things happen in series of specimens which should all be of one race but which show composite characters to drag into consideration one or more other races. This hunt has been in a field fertile in names and leaves one almost ready to put the list in a hat, draw out as many as needed, and pass on to something more worth while.

Rattus fulvescens fulvescens Gray. GRAY'S SPINY-HAIRED RAT.

Mus fulvescens Gray, Cat. Mamm. Nepal and Thibet, 1st ed., p. 18, 1846.

Specimens collected.—4: Gangfang, 3; Ngawchang River, altitude 1,800 feet, 1.

This spiny-haired rat, with warm brown to ochraceous pelage, was rarely encountered. In its most highly colored phase it is a handsome form and easily distinguished from the other *Rattus* of the same size. All of our specimens are in the winter pelage but there is considerable variation in the development of the spiny hairs. The spiniest, as well as the richest-colored example, is the one taken at an elevation of 1,800 feet, in an open river valley with temperatures much higher than at Gangfang, the source of the other specimens, where ice formed overnight. One of these Gangfang rats, a small animal not yet of mature dimensions, has no spines; the other two are moderately spinous.

These animals were found in the more open, shrubby environment of the lower foothills. Perhaps they do not range much higher than 5,000 feet elevation in northern Burma or, if they do, they are comparatively rare. Good series of *confucianus*, *andersoni*, and *ninus* were collected throughout the expedition and presumably more *fulvescens* would have been trapped had it ranged in the same territory.

***Rattus confucianus confucianus* Milne-Edwards. SULPHUR-BELLIED RAT.**

Mus confucianus Milne-Edwards, Nouv. Arch. Mus. d'Hist. Nat. Paris, 7, Bull., p. 93, 1871.

Specimens collected.—33: Changyinku, 4; Gangfang, 14; Hpare, 1; Hpare-Saulang road, 1; Hpimaw fort, 3; Hpimaw road, 4; Hpawte, 1; Hpinlawkha, 1; Imaw Bum, 1; Saulang, 3.

A series of fifty-six specimens collected by the expedition appears to represent *R. c. confucianus* and *R. andersoni*, but it is not a simple matter to break the lot up into the two groups. In general, *andersoni* is noticeably larger than *confucianus*, with longer and heavier hind foot, larger skull, and longer and heavier tooththrows. There are no color differences that hold when many specimens are compared.

These two forms, if indeed there are two, have overlapping ranges and both were taken in the same trap line. Examples typifying the two extremes are readily sorted out, but the intermediate specimens are puzzling. The individuals listed above as *confucianus* include some of these intermediates which appear to fall just short of the characters which might justify calling them *andersoni*. Osgood (1932, p. 306) had difficulty in arriving at a satisfactory allocation of a large series of *confucianus*, concluding with the observation that the group would not be thoroughly understood until some competent

reviser had studied more material than was then available. The specimens under discussion confirm the soundness of his conclusion.

For comparison I have had a large series of *confucianus* collected in Yunnan.

The habits of this rat are the same as those of *andersoni*, as far as I can judge from the results of trapping.

Rattus andersoni Thomas. ANDERSON'S RAT.

Epimys andersoni Thomas, Abstract No. 90, Proc. Zool. Soc. Lond., p. 4, 1911.

Specimens collected.—23: Changyinku, 1; Gangfang, 5; Hpare, 3; Hpare Pass, 1; Nyetmaw River, 2; Pyepat, 3; Tangtung, 1; Tsonma, 5; Vijawlaw, 2.

As stated in the discussion of *R. c. confucianus*, the differences between this rat and *andersoni* do not appear to be well defined. I have been unable to apply Allen's diagnosis (1940, p. 1032) with much success, about the only exclusive character being the heavier dentition of *andersoni*. Selected examples of *confucianus* closely approach *andersoni* even in size of teeth, and quite parallel it in color of under parts and topography of skull.

To judge from the number of specimens of these two rats collected, both are fairly common in northeastern Burma. They were trapped in thickets of shrubbery, in forest, along the banks of streams and among the rocks.

Rattus eha ninus Thomas. SMOKY-BELLIED RAT.

Rattus eha ninus Thomas, Ann. Mag. Nat. Hist., (9), 10, p. 404, 1922.

Specimens collected.—23: Chimeli road, altitude 10,000 feet, 11; Hpimaw road, altitude 9,000 feet, 2; Imaw Bum, 7; Nyetmaw River, altitude 8,600 feet, 3.

This long-tailed rat, with dark, slender hind feet and pelage of under parts slate-colored at base, is the only medium-sized species of *Rattus* collected by the expedition which can be readily assembled in a homogeneous series. The other forms of *Rattus* of comparable size, the *confucianus-andersoni-fulvescens* assortment, require considerable juggling to arrange in series which give full consideration to all the characters, both those which are obvious and those which are ascribed but fail to hold for any but exceptional specimens. Lest this statement be interpreted to indicate that the range of individual variation of *ninus* is narrow, it should be pointed out that our series displays considerable variation in lengths of tails, of skulls, and

amount of white on under parts. These differences are not sufficient to obscure the many similarities which establish the relationship.

Rattus e. ninus was taken only at the higher elevations, in a temperate zone ecology. The specimens were caught along the banks of streams, about rocky outcroppings, and, in some instances, in well-marked runways on the forest floor. Traps set on logs, well above the ground, caught this rat at the Nyetmaw River camp where the climax forest of oak, rhododendrons, birch, magnolia, etc., provided an ideal environment for a mammal with the arboreal propensities which are attributed to several of these long-tailed species of *Rattus*.

Both at Imaw Bum and on the Hpimaw road, *ninus* was taken on snow-covered terrain. Dark, damp forest seems to be its favorite habitat.

***Rattus edwardsi gigas* Satunin. SATUNIN'S GIANT RAT.**

Mus gigas Satunin, Ann. Mus. Zool. Acad. Imp. Sci. St. Pétersbourg, 7, p. 562, 1902.

Specimens collected.—1: Hpare.

R. e. gigas is easily distinguished from *R. b. bowersii* on the basis of color and skull topography. The warm brown pelage and small, audital bullae of the former are noticeably different from the cool grayish pelage and inflated bullae of the latter. *R. listeri garonum* described by Thomas (1923, p. 27), type locality Garo Hills, Assam, requires consideration because it is one of the *edwardsi* group and geographically it could range into northeastern Burma. The Assam rat, however, is slightly smaller and measurements of both skull and hind foot associate the Burma specimen with *gigas*.

Only one specimen of this large, brown rat was taken. It was trapped on the bank of a fair-sized mountain brook running through heavy forest, elevation about 6,000 feet above sea level. Additional traps were put out in this area in the hopes of catching more specimens but with no success.

This animal is seemingly rarer than *R. b. bowersii* in the regions where we collected, for the natives brought us none as contrasted with eight specimens of the latter species.

***Rattus bowersii bowersii* J. Anderson. BOWERS' GIANT RAT.**

Mus bowersii J. Anderson, Anat. and Zool. Researches Western Yunnan, p. 304, pl. 17, 1879.

Specimens collected.—8: Gangfang, 2; Hpawshi, 1; Ngawchang River, altitude 1,800 feet, 5.

The colored plate of *bowersii*, given by Anderson in the type description, shows a rat of warm brown coloration, rather unlike anything in the series here identified as *bowersii*. The type was collected about 1868 and was preserved in alcohol. Kloss, who examined the type in the Indian Museum and comments on it (1917, p. 5), writes of the faded color, and perhaps considerable color change had taken place between the time of capture and the execution of the color plate. Certainly there is little about this plate to suggest the characterization of later authors who write of the members of the *bowersii* group as being "large rats of a silvery or brownish-grey colour minutely flecked with white" (Bonhote, 1903, p. 32), or "large iron-grey rats forming the 'bowersi group' of Bonhote" (Thomas, 1916, p. 409). "Iron-grey" is a good description of the general color effect of the large rats collected by the Vernay-Cutting Expedition. One is forced to conclude that the color plate is not to be trusted.

There are no specimens of adult *bowersii* available for comparison. Specimens collected by Andrews and Heller in western Yunnan, and identified as *bowersii* by Allen (1940, p. 1044) are noticeably smaller and browner than the specimens I here designate as *bowersii*. A large, grizzled rat in the American Museum from "northwestern Fukien" which Allen (1926, p. 16) states "is practically a topotype" of *latouchei* is virtually indistinguishable from these Burmese specimens. Unfortunately, the Fukien specimen lacks a skull. The validity of *latouchei*, which has been treated as a subspecies of *bowersii* by several authors, does not need to enter into consideration because the older name, *bowersii*, must be used in any event. The type locality of *bowersii*, Kakhyen Hills, is very near our localities.

All of the specimens of *bowersii* obtained by our expedition were purchased from natives who brought the rats into camp from localities near at hand. One was caught near Gangfang and the native took me to the spot where I examined the burrow and the deadfall set there. The burrow was on a hillside covered with low scrub, so thick that one would have to step almost into the hole to discover it. Although this district was probably forested many years ago, the climax ecology has been destroyed by clearings and fires, and the tangle of low shrubbery, bracken, and herbaceous vegetation which has taken possession of the low hills is radically different from undisturbed regions at the heads of the ravines. If *bowersii* is a forest-dwelling rat, as some authors have described it, the Gangfang capture indicates that it may also occur several miles from large trees.

The rat had dug a large burrow laterally into the hillside and the native had built a little palisade of twigs which compelled the animal to pass under a small log poised as a deadfall by an ingenious system of rattans, levers, and a treadle. The man told me that he had found no other burrows on this particular hillside and he did not catch more than the one rat in several nights of trapping. The Kachins are accustomed to trap small mammals and are very clever at using the materials close at hand, especially bamboo, which supplies them with long, pliable strips twisted into cordage.

Vernaya gen. nov.

Description.—A small, long-tailed mouse closely related to *Vandeleuria* and *Chiropodomys* and, to some degree, combining characters of these two genera of climbing mice. In external appearance very much like *Vandeleuria* in color pattern, character of pelage, and long, non-tufted tail, but noticeably different in respect to development of digits on fore and hind feet. With exception of pollex, all digits of *Vernaya* carry typical, pointed claws; pollex vestigial and carrying small, flattened nail visible under magnification but not easily distinguished by the naked eye.

Skull with short rostrum and moderately inflated braincase; a shallow but conspicuous longitudinal concavity extending from interorbital region well along the nasals; incisive foramina long, narrow, reaching about to plane of first molars; molars small, first two resembling those of *Chiropodomys* in crown pattern, with three well-developed, longitudinal series of tubercles, last molar much smaller, roughly semicircular in cross section, crown about as broad as long, in contrast with the last molar of *Chiropodomys* which is distinctly longer in the axis of the toothrow; incisors without longitudinal grooves.

Genotype.—*Vernaya fulva* G. M. Allen, represented by a specimen, No. 43989, American Museum of Natural History, collected at Yinpankai, Yunnan.

The genus is named for Mr. Arthur S. Vernay, who has given his full support to so many expeditions for the American Museum and whose interest in the fauna and flora of Burma led to the field work which is the basis of this report.

Remarks.—Two specimens of climbing mice taken by the Vernay-Cutting Burma Expedition proved so difficult to identify that it became necessary to go over the scanty material available for comparison rather critically in order to reconcile apparent discrep-

ancies between published accounts and the characters exhibited by the specimens.

A specimen of this group of small, long-tailed climbing mice, collected by Andrews and Heller in Yunnan in 1916, and now in the American Museum, was described as *Chiropodomys fulvus* by Allen (1927, p. 11). One of the characters cited was the presence of flat nails on the pollex and hallux. This is not actually the case for the hallux because it has a short, but pointed claw, not as compressed laterally as the claws on the other digits but, nevertheless, not to be confused with the broad, flat nails to be found on the hallux of true *Chiropodomys* and true *Vandeleuria*.

Allen later (1940, p. 1048) reported this particular specimen as *Vandeleuria dumeticola*, listing his *Chiropodomys fulvus* as a synonym of *V. dumeticola*. But I am unable to detect any grooves on the incisors and there are other characters which, as I am pointing out, argue against calling *fulva* a *Vandeleuria*.

The two specimens from Burma seem to be so similar to *fulva* that they should be considered identical with it, and thus there are three specimens available to establish the characters of the new genus. Thanks to the co-operation of Field Museum, I have had the opportunity to examine the type specimen of *Vandeleuria dumeticola scandens* Osgood and have also had the benefits of Dr. Osgood's comments on our three specimens, which were mailed to him for examination and comparison. He, too, is unable to see, in the type of *fulva*, the characters which would place it, without question, either in *Chiropodomys* or in *Vandeleuria*.

The American Museum has sufficient material of *Chiropodomys*, several species, to fully demonstrate that *fulva* does not belong in that genus. Apart from the characters of the nails and claws, the structures of the skulls are quite different. The *Chiropodomys* skull shows much greater inflation of the braincase, relatively shorter and broader incisive foramina, and a better-developed last molar. *Chiropodomys* gives evidence, in several respects, of being a more highly specialized climber than *Vernaya*.

The only representatives of *Vandeleuria* that I have seen are the type and topotype (skull broken) of *V. d. scandens* and a third specimen of *scandens* collected by the Legendre Indo-China Expedition of the American Museum. These have grooved incisors, nails on more digits than is the case in *Vernaya*, and show a molar pattern that is very distinct from the new genus. The incisive foramina of *Vandeleuria* are shorter and more open than in *Vernaya*.

More material of *Vandeleuria* is badly needed in order to dispose of all the names used in literature and to work out a more satisfactory geographical distribution. Some of the older descriptions are brief and inadequate, but the one point on which most agree is the presence of longitudinal grooves down the anterior face of the upper incisors.

Vernaya fulva G. M. Allen. VERNAY'S CLIMBING MOUSE.

Chiropodomys fulvus Allen, Amer. Mus. Nov., 270, p. 11, 1927.

Vandeleuria fulva Allen, Mamm. China and Mongolia, p. 1048, 1940.

Specimens collected.—2: Hpawte, 1; Hpimaw, 1.

The first specimen of *Vernaya fulva* (a female) secured by our expedition was trapped on an open hillside, covered by thickets of low shrubbery and a heavy growth of bracken. The trap line was set along a line of low cliffs and rocky outcrops. Because this mouse was noted to be different from *Micromys*, rather similar in size and coloration, which had been caught in similar environment earlier in the trip, a special effort was made to capture more when we returned via this one-night stop at Hpawte. None were caught the second night and, unfortunately, I was not aware at the time that the specimen was one of the specialized climbing mice. Upon casual inspection the peculiarities of the hands and feet are not apparent and a lens is required to perceive the presence of the tiny, flattened nails. In the dry specimens it is especially difficult to get these details because there is so little differentiation in color between nail and shrunken epidermis, and the forefeet can not be twisted

	<i>Vandeleuria</i>	<i>Chiropodomys</i>	<i>Vernaya</i>
Nails	1st and 5th digits both fore and hind feet	1st digit fore and hind feet	1st digit forefoot only
Tail	moderately long, thinly haired	moderately long, penicillate	very long, well haired, not definitely penicillate
Incisive foramina	relatively short and broad	relatively short and broad	long and relatively narrow
Longitudinal concavity, interorbital-nasal region	well indicated	well indicated	noticeably developed
Incisors	longitudinally grooved	not grooved	not grooved
First and second upper molars	resembling <i>Rattus</i> pattern	more complex than <i>Rattus</i> , outer row of tubercles well developed	resembling <i>Chiropodomys</i> pattern
Third upper molar	reduced, sub-circular in cross section	reduced, greatest dimension in axis of tooththrow	reduced, greatest dimension transverse to axis



LOOKING EASTWARD FROM HPIMAW FORT TOWARD SALWEEN DIVIDE
Slopes show native clearings at base and climax forest at higher elevations



NATIVE DEADFALL SET FOR LARGE RAT, *Rattus bowersii*
Gangfang

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out for clear vision except at the risk of breaking off a leg. Perhaps a fresh specimen would reveal the foot structure in a more satisfactory manner.

The other specimen, trapped at the former military post of Hpi-maw, is a male. The trap line was set just below the crest of a ridge on slopes from which the original forest had long been removed and its place taken by bracken and low shrubbery, tangled and difficult to penetrate in places.

Hystrix (Acanthion) subcristata subcristata Swinhoe. SUBCRESTED PORCUPINE.

Hystrix subcristata Swinhoe, Proc. Zool. Soc. Lond., p. 638, 1870.

Specimens collected.—2: Gangfang, 1 skull; Hpimaw, 1 immature.

The only porcupines secured or seen were two brought in to camp by natives. An adult had been so chewed up by dogs that only the skull was worth saving. An immature animal was brought in alive, but this specimen is so young as to have little value for comparison.

Ochotona osgoodi sp. nov. OSGOOD'S PIKA.

Type from Nyetmaw River, northeastern Burma. Altitude 8,600 feet. No. 115,464 American Museum of Natural History. Adult male. Collected January 28, 1939, by H. E. Anthony. The type is a skin and skull in good condition.

General characters.—Probably most like *forresti* which it resembles in coloration, enlarged front claws, and subtriangular palatine foramina, but differs in smaller body size, less black on soles of feet and larger auditory bullae.

Description.—Back mixed brown and black, nape grizzled, head lightly washed with brown; ears only faintly edged with white; fore and hind feet above, grayish; below heavily washed with buffy; soles of fore and hind feet moderately furred, mixed whitish and fuscous in color; terminal pads of toes not hidden by hair, conspicuous.

Skull slightly convex in superior profile; palatine foramina restricted anteriorly and almost in contact with vomer, gradually expanded posteriorly, pattern of entire opening subtriangular; bullae large, well inflated.

Measurements.—Taken in the flesh, measurements of type of *forresti* in parentheses: total length 169 (185); tail vertebrae from skinned carcass 14; hind foot, c.u. 33, s.u. 28.5 (from dried skin), (27). Greatest length of skull 39.4 (39); condylo-incisive length 37

(37); zygomatic breadth 19.3 (19.4); nasals 13 by 5.5 (12.6 by 6); interorbital breadth 4.2 (5); breadth of braincase 15.8 (15.8); palatal foramina 9.5 by 4 (9.6 by 3.3); length of bullae 9.7 (9); upper tooth-series (alveoli) 7.3 (7.3).

This pika is named for Dr. Wilfred H. Osgood of Field Museum of Natural History, whose publications on mammals have done so much to bring order out of taxonomic confusion. His report on the "Mammals of the Kelley-Roosevelts and Delacour Asiatic Expeditions" has been a constant guide in the preparation of this paper.

I have searched the literature carefully and examined all available comparative material in the attempt to discover a name applicable to these three specimens. Thomas (1921, p. 505) records *Ochotona roylei* from Imaw Bum, 9,000 feet altitude, and our Nyetmaw River specimen comes from the east flank of Imaw Bum. *O. roylei* has a reddish head and shoulders, at least in the summer pelage, and it seems to be a larger animal. Our specimens are in winter pelage, show no trace of reddish on head and shoulders, and it is difficult to imagine a seasonal change which would make them match two specimens of *roylei* in the American Museum from Kashmir. Material is lacking to afford the basis for any categorical statement on the degree of redness shown by winter pelages of *roylei* but the evidence at hand seems sufficient to establish the fact that the Nyetmaw pika is not *roylei* or any race of it.

The only other name to be considered is *forresti*, described from the Likiang Range of Yunnan about a hundred miles distant. A specimen identified by Allen (1938, p. 548), "A skin supposed to be this [*forresti*] from the type locality," is in the American Museum. The specimen is a skin and badly broken skull of what appears to be a sub-adult individual. The palatine foramina flare posteriorly and on this character I judge the specimen to belong to the *thibetana* group. *O. forresti* is contrasted with *thibetana* by Thomas (1923a, p. 662) as follows: "Palatine foramina only slightly and evenly expanded behind, quite without the conspicuous posterior broadening found in *thibetana*." The Likiang specimen does have rather blackish soles, agreeing in this respect with *forresti*, but the claws of the forefeet are not developed as in *forresti* or in *osgoodi*. My basis for distinguishing between *forresti* and *osgoodi*, therefore, has to be the characters as given in the type description of *forresti*, and adequate material may show that *osgoodi* is a race of *forresti*.

Examination of the Asiatic pikas in the American Museum indicates that the shape of the palatine foramina and the characters

of the feet may be useful criteria for separating the several groups; at least they have been sufficient to justify elimination of the *thibetana* group from consideration in describing *osgoodi*.

My experience with the genus *Ochotona*, prior to the Burma Expedition, was with the American species which live in loose rock piles, in open, exposed situations. The capture of three pikas in Burma, in dark, damp forest environment, has directed my attention to the development of the claws and hairiness of the sole as a feature of possible special significance. Collectors have commented briefly on the occurrence of Asiatic pikas in forests or in grassy situations but I have noted nothing on the foot differences, if any, of the pikas living in these different environments. From my own observations, not quite as limited as the small series indicates, I believe the forest-dwelling pika of Burma is much more of a burrowing animal than his rock-dwelling relatives. Runways and burrows were found in fair numbers and the large front claws and reduced hairiness of the sole (due to wear) suggest that the feet are used to move soil. I have compared the feet of the Nyetmaw pika with those of a rock-dwelling North American pika (*O. p. lemmhi* from Idaho), of about the same size. The Burma pika, collected in late January, is in full winter pelage, the Idaho pika, taken in late August, is in worn summer pelage. The soles of the feet of the Burma animal are less densely haired, especially about the claws, the claws are longer and sharper, and the pads at the base of the toes are noticeably smaller. The pad of the Idaho pika is a large, black, subcircular structure useful on a sloping rock surface; the pad of the Burma pika is about half the size, whitish in color and of doubtful gripping value.

There is a similar contrast between the feet of *O. pallasii* ("a true rock-living species." Allen, 1938, p. 528) and those of *O. dauurica* ("found burrowing in the patches of grass and weeds in the valley bottoms." Allen, l.c., p. 552). Skins of each, collected in August, show a well-furred sole, with subcircular, heavily pigmented (black) toe pads for *pallasii*, and less brushy soles, narrower, less-pigmented pads, and sharper claws for *dauurica*. I have not attempted to carry out this inspection of feet and correlation with known habitat preference for all the Asiatic pikas in the collection, and I do not know how many exceptions might be discovered. In some cases the habitat preference for a series of specimens is not definitely known.

Notes taken on the occurrence and behavior of this pika are extracted from my field journal as follows:

"January 28, Nyetmaw River.—Caught in damp, dark woods at mouth of hole running back under rocks, on a hillside a few feet above the little river valley. Wet leaves covered the rocks, and traps were set in this spot in hopes of getting a mole. I had been digging wherever soil was loose enough, trying to locate mole runways. Pulled leaves away and saw this well-worn hole running back under rocks. Set a regular rat trap. Pika was caught squarely across body. No obvious signs of *Ochotona* found in this place. Environment not at all the type where one could find a North American pika.

"January 29.—Traps set about this place baited with piece of fresh onion—five Schuyler traps—caught nothing last night. One of them sprung but no hair in trap.

"January 28.—Obvious signs of *Ochotona*, characteristic round droppings found in forest at base of tree, up a dry valley—no running water but woods fairly damp, not far from camp, altitude perhaps 8,800 feet.

"Droppings also found about rocks, a low cliff on a hillside at about 9,200 feet. This place a better prospect for pika, but no slide rock, not much sunshine. Runways of a character suited to *Ochotona* all over the hillside. A little dried vegetation apparently stored in a cavity low down in a dry spot but no typical "hay piles." This vegetation looked like short lengths of grass but may have been fine stems of something else.

"No droppings seen high up on ridge which we climbed to 10,600 feet.

"February 9, Chimeli Camp (altitude about 10,000 to 10,500 feet).—One caught in mouse trap set in runway along bank above trail; runway similar to hundreds seen in similar situations along these mountain trails. Size of runway, and hole where runway passed through parts of bank, about right for *Ochotona*, but I have caught voles, rats, *Apodemus*, and shrews in such runways and have not suspected *Ochotona* as a possibility. Rather open, exposed bank.

"Have seen droppings, almost certainly of *Ochotona*, along other banks here, but rat traps set there have caught nothing. Suspect my combination bait is not attractive to *Ochotona* because of bacon content.

"Animal caught last night had tripped trap in passing and was struck squarely across middle of back.

"Have tried baits of boiled rice on ten rat traps set where droppings have been seen. Suspect I might catch many *Ochotona* here if I knew a good bait.

"February 10.—The fresh snow on the trail last night gave me a few clues this morning as to the movements of *Ochotona*. Tracks that I think were made by pikas were noted in several places, both up and down the trail. Two types of tracks were seen, one suggestive of a rabbit. This was in deep snow and the animal had progressed by hops, the hind feet farther apart and over-reaching the forefeet. In lighter snow the animal had walked or scampered and the tracks were not bunched. Tracks started and ended at holes under logs, rocks, or in banks. Up the trail a series of tracks ran for many feet, in and out of cover. From places visited by tracks I deduce that pikas are feeding on dry and green herbaceous perennials. Found old cuttings to indicate this.

"February 11, Chimeli Camp.—*Ochotona*. A pika, caught where I saw tracks in the snow yesterday, confirms my identification. This animal tripped the trap in passing and did not touch the bait. Loose patch of fur on the rump may have been dislodged by another pika passing later, at any rate quite a patch of bare skin was exposed, not cut as by a shrew or mouse."

In addition to the stations where specimens were actually taken, observations confirmed the presence of the pika at Hpare Pass (one seen by Stanford) and along the upper Hpimaw road at elevations of 9,000 feet or more. Here burrows, with cut vegetation pulled into them, and tracks in the snow (indistinct because snow was melting) were pretty good evidence of pikas but none could be coaxed into traps during the brief period they were set.

Sus scrofa subsp.? WILD BOAR.

Specimens collected.—None.

The wild boar is recorded on the basis of one animal seen on the mule road to Hpimaw Pass, altitude about 8,700 feet, by Stanford, on January 27. He reported that the animal was in the bracken when discovered and bounded off down hill like a stag, heading for the bamboo thickets. The forest at this point was open oak and rhododendron. The natives (Lashis) with Stanford told him that the "hill-pig" was not common but that it reached a large size. At Hpawshi, in January, natives identified tracks as those of this animal. At the Nyetmaw River camp, also in January, I saw where some animal had been rooting in a muddy spot near the small mountain stream. The natives said this was the work of the wild boar. The abundance of several species of oaks in these mountain forests probably provides a supply of acceptable food in the form of acorns.

Elaphodus cephalophus cephalophus Milne-Edwards. TUFTED DEER.

Elaphodus cephalophus Milne-Edwards, in David, Nouv. Arch. Mus. d'Hist. Nat. Paris, 7, Bull., p. 9, 1871.

Specimens collected.—3: Pawahku, 1 male, skin and skeleton; Sadulaw, 1 female, skin and skeleton, 1 embryo in alcohol.

These dark tufted deer are indistinguishable from a series collected in western China for which the name *cephalophus* is applicable. From the evidence on hand, northeastern Burma may be the western limit of the range.

In newspaper accounts of the proposed field work in Burma, before the expedition left the States, some mention was made of a "black barking deer," never taken in Burma, and an especial object to be sought. Apparently this statement derived in some way from the fact that there is a true barking deer, so-called black, *Muntiacus crinifrons* Selater, of which only three specimens have been recorded (these from Chekiang, China) and that a Chinese name for the tufted deer can be translated as "black muntjac." There was no likelihood that the very local *Muntiacus crinifrons* would be encountered in Burma, over 1,000 miles removed from the known records. When I saw the first specimen of the tufted deer I could readily understand how natural a thing it would be for the layman to call it a "black barking deer." Size, color, and general appearance all make the name seem appropriate although it is not a barking deer (*Muntiacus*) at all.

The tufted deer has been taken before in northeastern Burma. Captain E. Maxwell West (1925, p. 1080) gives an account of a hunt "within a day's march" of Htawgaw which brought him a specimen of what he called Michie's tufted deer. Michie's variety of tufted deer is the race confined to southeastern China and the Burma animal is not *michianus* but the race discovered in Szechwan by Père David.

Our specimens were purchased from the natives who brought them in the flesh, making it possible to save complete material.

I saw an animal near our camp on the Chimeli road but was hunting with a shotgun and loads too light for deer. My native boy and I were coming up the mule trail through primeval forest, interspersed with small openings and at an elevation approximating 10,000 feet. The time was late in the afternoon. The deer was in an opening near the trail and quite close before I saw it. It bounded off into cover at once. I did not see any horns but was

impressed by the dark color and by the white underside of the tail, which was very conspicuous. The tail was carried high, very much like that of our Virginia deer, flopping with each leap.

I believe this deer is to be found in most of the high, damp forest of the main mountain ridges of northeastern Burma. The second one brought to us was said to have been trapped not far from the Chimeli Pass section and the men carried it for three days to deliver it to us at the Imaw Bum camp.

Muntiacus muntjak vaginalis Boddaert. LARGE INDIAN MUNTJAC or BARKING DEER.

Cervus vaginalis Boddaert, Elenchus Animalium, 1, p. 136, 1785.

Specimens collected.—6: Changyinku, 1; Gangfang, 1; Hpare, 1, skin and skeleton; Hpawshi, 1, skin and skeleton; Rawngaw, 1; Tangtung, 1, juvenile.

This muntjac is the common small deer of the foothills and lower mountains. Its characteristic barking call was heard mornings and evenings at a number of stations where no specimens were secured. The highest camp where this animal was noted was the one on the Nyetmaw River, 8,500 feet. Here one approached the camp fires about eight o'clock one evening and barked its curiosity, but managed to keep out of sight when I searched for it with a flashlight.

I was able to collect only one specimen personally, the one from Changyinku, although I had a very good look at one on the Hpimaw road when I had no gun with me. This was at an elevation of about 8,500 feet on the lower fringe of forest which climbed into snow at 10,000 feet and higher. This particular animal was a female and detected my presence very quickly. When she bounded away the tail was carried conspicuously, the white underside rising above the back.

The Changyinku muntjac, a male, was jumped from a dense growth of tall bracken and probably would not have been discovered had not the white underside of the tail caught my attention as the deer dodged into a ravine filled with shrubbery. The animal did not go far and with the help of a native to drive it past an opening we were able to shoot it. The natives sometimes hunt the barking deer with dogs and shoot the quarry with their cross-bows.

Rusa unicolor subsp.? SAMBAR.

Specimens collected.—None.

No evidence of the presence of the sambar was noted at our collecting stations, with the exception of the Hpare Pass, altitude

8,500 to 10,000 feet. At this place, visited briefly by Stanford and Ward, the natives saw one animal and Stanford picked up cast antlers of two individuals.

Capricornis sumatraensis milne-edwardsi David. MILNE-EDWARDS' SEROW.

Capricornis milne-edwardsi David, Nouv. Arch. Mus. d'Hist. Nat. Paris, 5, Bull., p. 10, 1869.

Specimens collected.—2: Hpawshi, 1 skin and skull; Ngawchang River, 1,800 feet altitude, 1 skeleton only, brought in by natives.

The specimen recorded from Hpawshi is a large adult male and it was killed by natives who skinned the animal themselves. We were camped near the Chimeli Pass when a messenger brought us word that the natives had killed a large "mountain goat" on a snow mountain about six miles from Vijawlaw. The animal was too heavy and the travel too difficult to attempt to bring it down in the flesh. Instructions for skinning were given and the natives were told to have the specimen ready when we returned through Hpawte. When the skin and skull arrived, Joseph, the head skinner, catalogued it as taken at Hpawshi, presumably on the basis of what the hunters told him. Since I could not understand any of the several native languages spoken in camp, the data on material derived from natives was once, and perhaps twice, translated before I received it.

In the case of this serow the two different localities reported to me are so close together that either one fits the environmental requirements equally well. The matter is mentioned only as an illustration of the difficulty of securing precise localities for native-collected material.

The skeleton acquired at the camp on the Ngawchang River was bought from natives who had carried it in from a distance, perhaps from the western flank of Imaw Bum. It is that of a sub-adult male.

In comparing these two specimens with serows collected in China, I have examined the type specimen and topotypical material of *C. s. montinus* G. M. Allen. The adult male from Hpawshi approaches *montinus* in some characters. The depth of the postpalatal notches, which is one of the features to separate *montinus* from *milne-edwardsi*, is so different in the two skulls from Burma that I suspect that age has much to do with it.

Budorcas taxicolor taxicolor Hodgson. TAKIN.

Budorcas taxicolor Hodgson, Journ. Asiatic Soc. Bengal, p. 65, 1850.

Specimens collected.—1 pair horns, no definite locality.

The expedition made an effort to collect specimens of takin and natives were sent out to search for the animals or signs of their presence. The takin is known to occur in the high country where we were working but it does not seem to be very abundant and it is very local in distribution. The scouts reported fresh signs in the vicinity of Sadulaw, and Vernay and Cutting took four days to explore these prospects. They required a day to reach this place and another to return but the short stay near Sadulaw convinced them of the futility of looking for takin in heavy forest.

The tracks showed that a few animals were feeding on the steep slopes near Sadulaw where heavy forest and dense bamboo made travel slow and stalking particularly difficult. One could not penetrate this growth without making considerable noise, and the range of vision was very limited. A takin could not be seen unless one met it at close quarters and the odds were greatly against such an event.

The best places to secure specimens are the open ridges at the higher elevations where it is possible to scan a wide expanse with binoculars. In winter these places may be covered with snow and the takin are in the mixed bamboo and forest lower down, well hidden from sight.

In response to the reward offered for reports on the presence of takin or for specimens, the natives brought in an overstuffed skin, slung from a pole. They said the animal was killed across the border on the Yunnan side and they had come over the Chimeli Pass. Unfortunately the skin had not been properly prepared, the feet and ears were not skinned out, and the hair was too loose for the specimen to have any value.

From what we learned the two most likely places for takin visited by us are the upper slopes of Imaw Bum and the high ridges in the vicinity of Chimeli Pass.

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CRANIAL AND DENTAL CHARACTERS OF SOME SOUTH AMERICAN CERVIDAE

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Although there have been several valuable contributions to the knowledge of the characters of skulls and teeth in the family Cervidae, it is evident that our knowledge of these characters is still far from satisfactory, especially as concerns the South American forms. In distinguishing genera of deer it is customary to give preference to form of antlers, which really are a part of the skull, but subject to individual and age variation, besides being present in males only. Brooke, in his well-known paper on the classification of these ruminants (1878), described some interesting details of the skull structure, but only the more superficial features. Moreover, in many instances, characters given generic value by this author are not present in some of the species included in the genera established. The same may be said of Rutimeyer's treatise on the same subject (1881). More recently, Knottnerus Meyer (1907) has contributed a very elaborate monograph on the lacrimal bone of ungulates, in which the structure of this bone is extensively discussed for the different types of deer. This author, by giving too much importance to a single part of the skull, reaches misleading conclusions when he attempts to derive taxonomic categories from his work. For instance, according to his views, the Virginia deer, *Odocoileus*, and the pampas deer, *Ozotoceros*, both of them telemetacarpal and having the choanae divided by the vomer, should be considered as representing subgenera of the genus *Dama*, the typical species of which is the European fallow deer, that is to say, a plesiometacarpal species with undivided posterior nasal aperture.

Blainville's magnificent "Ostéographie," unfortunately unfinished because of his death, contains neither text nor figures of Cervidae, and Hue, in his more recent "Musée ostéologique," has figured the European species only, without any reference to neotropical forms.

The taxonomic importance of the differences in the incisiform teeth of deer has recently been pointed out by Pocock (1935), but the observations of this distinguished British zoologist have a limited value from the standpoint of the naturalists of the Americas, as they are exclusively based on Eurasiatic species.

The paucity of literature containing detailed descriptions of cranial and dental features of this family is particularly felt by the paleontologist attempting a comparative study of remains of extinct deer. Some years ago, in the course of a revision of the material of fossil Cervidae in the La Plata Museum, it became necessary for me to investigate the skull characters of the living species of South American deer with branched antlers, and I found, as was to be expected, that there were a number of rather constant details characterizing genera besides the general size and form of antlers. The material on which those observations were based being somewhat limited, I have supplemented it by taking notes on every skull that has since become available. In the present paper I intend to bring out the results of this research, describing those details of the skull and the teeth which, in my opinion, may prove of systematic value. The specimens examined were exclusively adult male skulls, belonging to the four genera of deer with complex antlers living in the New World south of Panama. Chronologically enumerated, these genera are the following:

Hippocamelus Leuckart, 1816.

Genotype.—*Hippocamelus dubius* Leuckart, 1816=*Equus bisulcus* Molina, 1782. Two species, both from South America, are recognized in this genus. Huemul.

Odocoileus Rafinesque, 1832.

Genotype.—*Odocoileus spelaeus* Rafinesque, 1832=*Cervus virginianus* Boddaert, 1785. Represented in the northern half of South America by several forms, all of them considered by Lydekker (1915) to be subspecies of the typical North American species, and by other authors as specifically distinct. The Virginia deer.

Blastocerus Wagner, 1844.

Genotype.—*Cervus paludosus* Desmarest, 1822=*C. dichotomus* Illiger, 1815. The genus contains only this species. The marsh deer.

Ozotoceros Ameghino, 1891.

Genotype.—*Blastocerus campestris* Gray=*Cervus bezoarticus* Linnaeus, 1758, the only species of the genus. The pampas deer.

I have examined seventeen skulls of *Ozotoceros bezoarticus*, fourteen of *Hippocamelus bisulcus*, and nine of *Blastocerus dichotomus*. As for the genus *Odocoileus*, I have had no opportunity of studying material of South American origin beyond two excellent

photographs of the tropical form commonly known as *O. gymnotis* (the true name of which must very likely be *O. campestris*)¹ but I have seen also four skulls of North American members of the *virginianus* group. I must express my heartiest thanks to Dr. E. J. MacDonagh for allowing me access to the splendid series of skulls in the Department of Vertebrate Zoology at La Plata Museum, and to Dr. J. Yepes, of the Argentine Museum of Natural Science at Buenos Aires, for permitting me to study the material in the collection under his charge. *Hippocamelus*, *Odocoileus*, *Blastocerus*, and *Ozotoceros* are closely allied genera, and they constitute, with the brockets (*Mazama*), a very natural group of Cervidae for which the subfamily name Odocoileinae,² applied by Pocock, seems quite appropriate. All of them are telemetacarpal deer, with the posterior nares mesially divided by the vomer, the ectocuneiform and naviculocuboid bones of the tarsus separated, and the prepuce placed immediately before the scrotum. They show considerable differences in the form of the antlers. These are not very divergent in *Hippocamelus* and normally form a simple fork. In the other three genera the antlers are broadly lyrate, *Odocoileus* being peculiar in the position of the brow-tine, which is internal, constituting the so-called basal snag. *Blastocerus* and *Ozotoceros* have an anterior brow-tine, but in the former it is bifurcate, while in *Ozotoceros* a forked brow-tine is found only as an abnormality. Corresponding with these differences, and independent of either local or individual variation, many distinctive features may be seen in the skull and in the incisiform teeth. A discussion of these characters follows.

Rostrum.—The rostral part of the skull in *Hippocamelus*, or at all events in *H. bisulcus*, appears to be heavier than in the other genera, this being a combined effect from convex upper outline and

¹ *Cervus campestris* Cuvier, 1817, was primarily based on the antlers of an *Odocoileus* from Brazil figured by Daubenton and on a similar specimen, without locality, "qui se trouvait dans le cabinet de Tenon." These specimens were mentioned by Cuvier and he described the species as having "bois courbés en avant" and with "un andouiller à la face interne, s'élevant obliquement." These characters are never seen in any deer except *Odocoileus*, and, in fact, when the same author figured the animal in the "Histoire naturelle des mammifères," he gave the portrait of an *Odocoileus*, apparently the same species later named *Cervus gymnotis* by Wiegmann. Unfortunately, Azara's guazu-ti was erroneously thought by Cuvier to be the same animal, and due to this confusion the name *campestris* has been frequently used for the guazu-ti or pampas deer. That Cuvier, himself, was not very sure about this identity seems to be shown in his second description of *Cervus campestris* after recording the *Odocoileus* form of its antlers: "Nous avons cru reconnaître l'espèce qui se caractérise par ces sortes de bois le cerf décrit par d'Azara sous le nom de Gouazouti." (The italics are mine.)

² The alteration of this term to Odocoilenae, as used by Frick in his "Horned Ruminants of North America," is untenable, both for etymological reasons and from the nomenclatural standpoint (see Article 4 of the International Rules).

comparatively short premaxillae. In *Odocoileus*, *Blastocerus*, and *Ozotoceros* the nasals are rather variable in form, sometimes having slightly concave lateral borders and sometimes almost straight and parallel. Near the hinder part, where they contribute to form the upper rim of the preorbital vacuities, these bones become more or less expanded, and their posterior ends are slightly separated, a small process of the frontals extending wedgewise between them. On the contrary, in all the specimens of *Hippocamelus* that I have seen the form of the nasals is very constant, their borders being practically straight for more than the anterior half and the posterior

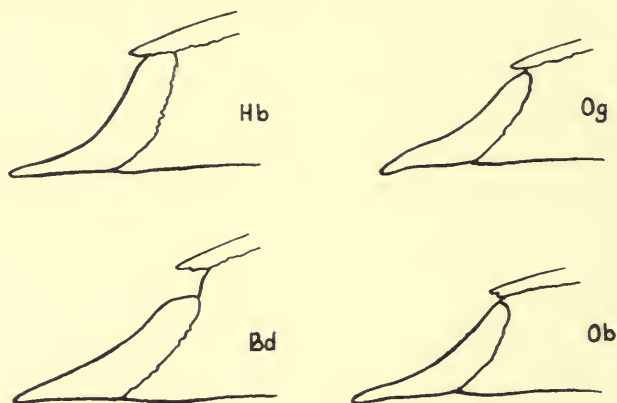


FIG. 6. Side view of anterior part of rostrum in *Hippocamelus bisulcus*, *Odocoileus gymnotis*, *Blastocerus dichotomus*, and *Ozotoceros bezoarticus*. $\times 3/8$.

part appearing as a narrow hexagon, with an angle at the apex, where the two bones do not allow for the intrusion of any frontal process. About the middle of their length the nasals are somewhat pinched and from this the slightly convex upper contour results. A similar pinching of the nasals is sometimes observed in the other genera but only in old specimens.

In all the genera, except *Hippocamelus*, the narial aperture is high and narrow in the front view, this being to some extent an effect of the great length of the premaxillae. The distance from the tip of the nasals to the gnathion is about twice the breadth of the aperture. In *Hippocamelus* this aperture is almost square, and the premaxillae are rather short, the distance from nasals to gnathion being only one and one-half times the breadth of the cavity.

The difference in the relation between the premaxilla and the nasal has been frequently regarded as of taxonomic value in the

deer. As a matter of fact, in *Odocoileus*, as well as in *Ozotoceros*, the upper or nasal branch of the premaxilla sometimes touches the nasal bone in a small point, but more frequently these bones are slightly separated one from another, the space between them being occupied by a small, pointed projection of the maxilla. In all the skulls of *Blastocerus dichotomus* that I have examined, the nasal branch of the premaxilla does not reach the nasal bone, a gap of 6 to 10 mm. existing between them, whereas in *Hippocamelus bisulcus* the premaxilla is broadly in contact with the nasal. This character, however, may be of specific rather than generic significance as, according to Gray (1872, p. 88) and Philippi (1894, p. 14), *Hippocamelus antisensis* has the premaxilla separated from the nasal. In contradiction with this, Garrod (1877, p. 14) asserts that in *antisensis* the relative position of these bones is exactly the same as in *bisulcus*, but it appears that, at the time when Garrod wrote, the two species of *Hippocamelus* were frequently confounded. I have never examined a skull of a male *antisensis*, but in a semi-adult female of this species in the La Plata Museum the relative position of premaxilla and nasal is like that of *Ozotoceros*, and in accord with Gray's and Philippi's statements.

Orbital region.—A very striking difference between *Blastocerus* and *Ozotoceros* lies in the relative sizes of the orbit and the lacrimal bone. In the marsh deer the antero-posterior diameter of the orbital fossa is constantly rather less than the distance from its anterior rim to the more anterior point of the lacrimal, while in the pampas deer this distance is constantly shorter than the orbital diameter. In all but two of the *Hippocamelus* skulls examined by me the relative measurements were like those of *Ozotoceros*, both the lacrimal and the orbit being, however, slightly smaller in proportion to the size of the skull. The two exceptional specimens had these measurements equal. *Odocoileus* resembles the huemul in this respect. In comparing the orbital diameter with the basal length, I have found an average orbital index of 14 for *Blastocerus*, 16 for *Hippocamelus* and *Odocoileus*, and 18 for *Ozotoceros*.

In all the four genera the lacrimal pit occupies almost the entire exposed part of the lacrimal bone, but in *Ozotoceros* and *Odocoileus* it is rather shallow, with a rounder upper border, the marsh deer and the huemul having, on the contrary, a very deep lacrimal fossa with prominent upper rim.

The size of the preorbital vacuity is also an excellent feature distinguishing *Ozotoceros* from *Blastocerus*. In the pampas deer this

cavity is never longer, and is frequently shorter than the antero-posterior diameter of the orbit and, moreover, the frontal bone enters it to form its upper border in a larger proportion than the nasal bone. On the other hand, *Blastocerus dichotomus* has a very large vacuity, always longer than the orbit and with the upper border formed by the nasal in a greater part than by the frontal. *Odocoileus* resembles the marsh deer in this. In *Hippocamelus* the vacuities

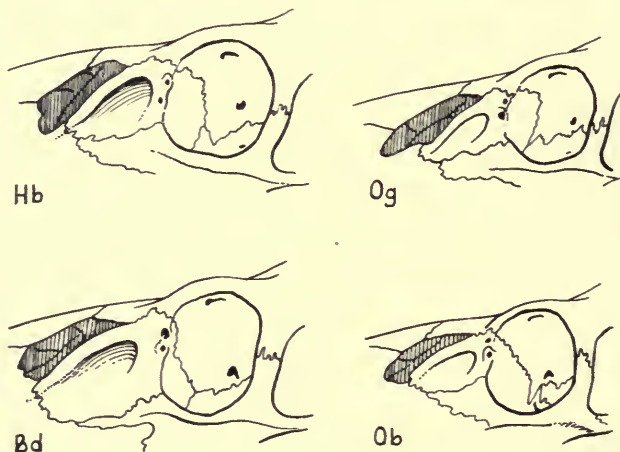


FIG. 7. Orbital region in *Hippocamelus bisulcus*, *Odocoileus gymnotis*, *Blastocerus dichotomus*, and *Ozotoceros bezoarticus*. $\times 1/3$.

are short, as in *Ozotoceros*, but the upper rim is formed more by the nasal than by the frontal.

Cranial roof.—In all the genera here discussed, excepting *Hippocamelus*, the frontals present a narrow median point advancing between the nasals. According to Philippi, this occurs also in *Hippocamelus antisensis*. As stated above, I have not studied any male skull of this species, but the female mentioned is quite similar to *H. bisulcus* in this respect.

The frontal processes constituting the pedicels of the antlers are in *Odocoileus*, when seen from front, very divergent, their inner borders forming an angle of 65° to 70° . The divergence of the pedicels is not so great in *Blastocerus* and *Ozotoceros*, the angle of deviation being in these genera, on the average, 45° . In *Hippocamelus*, in which the antlers tend to be parallel, the angle is only about 25° .

Ozotoceros differs from the other genera in having the parietal ridges less concave in the part included between the metopic and parieto-occipital sutures, so that the space limited laterally by them

is in this genus rather less constricted in its middle than in *Blastocerus*, *Odocoileus*, or *Hippocamelus*. Moreover, in the pampas deer each parietal ends anteriorly in a point, the metopic suture appearing as an advancing angle. In the marsh deer, in *Odocoileus*, and in *Hippocamelus* this suture frequently has the same aspect in young skulls, but in every adult specimen used in connection with this paper it tends to form a transverse and almost straight line between the antler pedicels and a little before them, as figured by Cowan (1936, p. 166) for *Odocoileus hemionus columbianus*. An "almost straight line" refers only to the position of the suture, as this is really very complexly indented in all the adult skulls of the four genera.

Occiput.—In the marsh deer the posterior outline of the braincase, when seen from the side, is strongly concave, both the lambdoidal region and the condyles projecting much more backwards than in the other deer here studied. *Odocoileus* has a lambdoidal edge rather prominent in old adult specimens, but never so much as in *Blastocerus*.

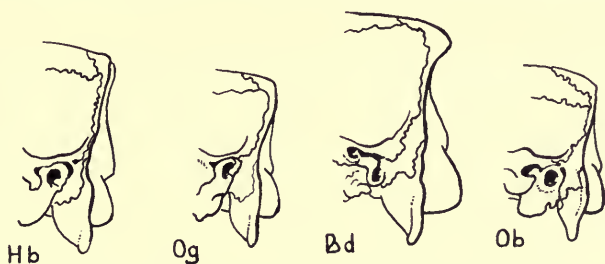


FIG. 8. Side view of occiput in *Hippocamelus bisulcus*, *Odocoileus gymnotis*, *Blastocerus dichotomus*, and *Ozotoceros bezoarticus*. $\times 1/3$.

As a combined result from the projection of the condyles and from the fact that the paroccipital processes are very near the glenoid fossae, each condyle in *Blastocerus* is entirely visible in a side view of the skull. In the other genera, when the skull is seen from the side, only the posterior half of the condyle appears behind the paroccipital process.

Some years ago (1929, p. 55) I stated that *Blastocerus* was different from *Ozotoceros* in having broader and shorter paroccipital processes. As a matter of fact, the examination of a series of skulls shows that there is in both genera a good deal of variation in this point. A more constant difference may be found by viewing the skulls from behind and comparing the distance between the two processes. In *Blastocerus* these are nearer one to another than in the pampas deer, the separation between the points being about twice the

length of the anterior rim of the process. In *Ozotoceros* there is a greater separation. *Hippocamelus* resembles the pampas deer in this respect, while *Odocoileus* is more like *Blastocerus*.

Basiscranial and otic region.—The foramina in the basicranium present some noteworthy differences. For instance, the foramen ovale, narrow and elongated in *Ozotoceros*, has a more rounded outline in the other genera. It is generally rather small as compared with the foramen rotundum, but in *Hippocamelus* both foramina

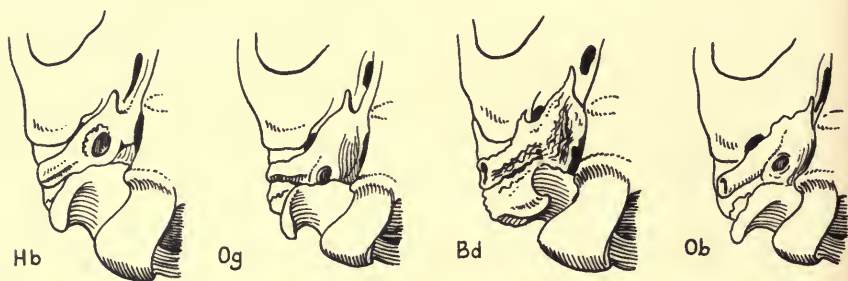


FIG. 9. Bullar region in *Hippocamelus bisulcus*, *Odocoileus gymnotis*, *Blastocerus dichotomus*, and *Ozotoceros bezoarticus*. $\times 2/5$.

are about equal in size. This genus has also a large and almost round sphenopalatine foramen, while in *Odocoileus* and *Blastocerus* this foramen is more oval in form and of medium size, and in *Ozotoceros* it is high and narrow.

The auditory bulla in *Odocoileus* is more inflated than in the other genera. In *Ozotoceros* it has a very smooth meatal tube, with hardly a suggestion of the ridge frequently present along its under surface in Cervidae. The depression for the tympanohyal in the same genus is rather deep, appearing as a well-defined pit. *Hippocamelus* has a slight indication of a ridge in the under side of the meatal duct, and the pit for the tympanohyal in this genus is markedly deeper than in the pampas deer. The bulla of *Blastocerus* is quite different from those of the other genera, being much less inflated, its meatal tube rugose and with a well-marked ridge, and the tympanohyal depression shallow and open posteriorly.

Mandible.—*Hippocamelus bisulcus* possesses a very peculiar mandible with the lower border almost straight from the posterior part of the symphysis to a point below the last molar, and the posterior ascending part of the ramus comparatively narrow, the anterior and posterior borders being almost parallel and the last becoming deeply concave above the angle. In *Odocoileus*, *Blastocerus*,

and *Ozotoceros* the lower profile of the ramus is evenly convex under the entire cheek-series, and the ascending part has a less concave posterior border, this and the anterior border diverging downwards markedly. *Blastocerus* has a more remarkably curved, sickle-shaped coronoid process than the other genera.

I cannot say if the differences in the form of the mandible I have recorded for the huemul are of generic or only of specific importance. The only specimen of *Hippocamelus antisensis* at my disposition resembles the other genera very much in the characters of the mandible, but it is an immature female (skeleton with upper epiphysis of humerus and femur not yet united to the shaft), this suggesting a difference dependent on age. In a semi-adult *H. bisulcus*, however, the mandible is not very different from that of the adult specimens.

Teeth.—Many years before the publication of Pocock's paper upon the incisiform teeth of Eurasiatic Cervidae, Brooke (1878,

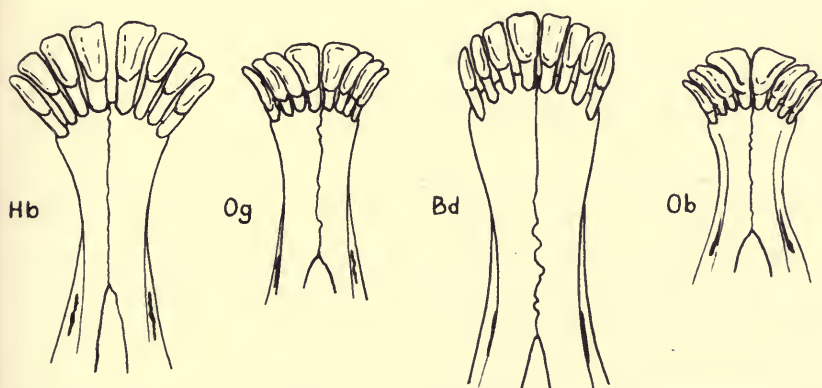


FIG. 10. Incisiform teeth in *Hippocamelus bisulcus*, *Odocoileus gymnotis*, *Blastocerus dichotomus*, and *Ozotoceros bezoarticus*. $\times 3/4$.

pp. 922, 923) called attention to the characters of the same teeth in *Furcifer* (= *Hippocamelus*) and *Blastocerus*. He ascribed exactly the same features to both genera, as he said that the former has "central incisors very slightly spatulate," and defined *Blastocerus* as possessing "central incisors very slightly spatulate and exceeding the pair next to them but slightly in size." My own observations upon fourteen mandibles of *Hippocamelus bisulcus* agree entirely with this description, the form of the teeth being somewhat like those of *Alces alces* as figured by Pocock, although the central

incisors have a slightly wider edge, in which character they approach those of *Cervus elaphus*. Brooke included under *Blastocerus* both the marsh deer and the pampas deer but, as a matter of fact, the dental characters he described are those of *Blastocerus dichotomus* only. The incisor teeth of the pampas deer are quite different, this being one of the characters justifying generic separation. In the marsh deer the teeth resemble those of *Alces* still more than do those of *Hippocamelus*, while in *Ozotoceros bezoarticus* the incisor teeth are very like those of *Axis* and *Dama*. The first incisor in this species has an almost triangular form, and its cutting edge is as wide as those of the three remaining teeth together, or even wider, the canine being especially noteworthy for its narrow crown. *Odocoileus*, or at least the *virginianus* group, approaches the pampas deer in this, but the difference of width between the central incisors and the other teeth is not so remarkable. In the photographs of South American specimens I have seen the dental features appear to be very much as in the figures of *Ussa* and *Melanaxis* published by Pocock.

The presence of upper canines in the male has been frequently recorded as one of the distinctive characters both of *Hippocamelus* and *Blastocerus* (Gray, 1872, p. 89; Burmeister, 1879, p. 88), and the same character has been used by Wiegmann (1833, p. 954) to split the pampas deer into two species. My own observations do not bear out these statements. In fact, I have never found upper canines in any specimen of the genera here discussed, with the sole exception of the immature female of *Hippocamelus antisensis* mentioned above, in which a very small canine is seen in the right maxilla. If the age of this example is borne in mind, we must admit the possibility that this tooth is a relic of the milk dentition.

The cheek-teeth in the four genera are subject to a great amount of variation, especially as to the form and size of the upper and lower second premolars. I have been quite unable to find any constant distinctive character in the material examined. Small accessory interlobular pillars may be present in one or another of the true molars, sometimes appearing on one side only, but they are more frequently wholly absent. I have observed them in an example of *Odocoileus*, in two of *Blastocerus*, and in two also of *Ozotoceros*, one of the last being a female and therefore a specimen not included in the material used in preparing this paper.

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THE ARTERIES OF THE FOREARM IN CARNIVORES

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INTRODUCTION

This study forms a part of a general plan for a survey of the anatomy of the Carnivora, which is being made in connection with a comprehensive study of the giant panda (*Ailuropoda*). No system is generally regarded as less promising of return on time invested in comparative morphological study than is the circulatory system. This is attributed to a supposed failure of the blood vessels to adhere

to any but the most general patterns in their ramifications. The atmosphere of frustration, and even of disgust, that often emanates from the more ambitious comparative studies of the circulatory system is readily understood by anyone who is familiar with the time and patience required for a single satisfactory dissection.

The arteries of the foreleg in the Carnivora fissipedia have not gone without attention in the past, although nothing has been added to our knowledge of them for more than a third of a century. Disregarding the two familiar domestic carnivores, the dog and the cat, the papers cited in the list of references appended to this study contain descriptions of these vessels in 32 individuals, representing 24 species. No fewer than 16 of these are in Zuckerkandl's monumental treatise alone. Yet, despite the acknowledged competence of their several authors, these investigations failed to yield any significant results as far as the Carnivora are concerned. There are several factors that make this sterility more apparent than real. Each of the investigators concerned was under the domination of the philosophy of Gegenbaur, and hence regarded the Carnivora merely as a convenient way station on a main line leading from the monotremes to man—a concept that is scarcely conducive to a proper evaluation of the carnivores. In the second place, in common with the medical fraternity in general, few had more than the slightest notion of taxonomic philosophy. When their descriptions are rearranged in the sequence indicated by mutual relationships certain suggestive similarities and differences begin to appear. In the third place, critical examination of these studies reveals that by modern standards they are superficial and incomplete to an extraordinary degree. Finally, Reighard and Jennings' description of these vessels in the domestic cat is quite inadequate, and Ellenberger and Baum's description of the domestic dog is found to be complete and accurate only after it has been made intelligible by comparing it with an actual dissection—a situation caused by their peculiar nomenclature and very inadequate illustrations.

Despite the fact that the arteries of the foreleg have been studied more extensively than the vessels of any other region in the Carnivora, the factors enumerated above indicate that they may have been condemned, as not warranting further study, without a fair trial. Moreover, a great deal of time and effort has been expended on the arteries in the study of the giant panda now under way by the author, and the resulting data would be essentially meaningless if the arteries are devoid of comparative significance. To that extent,

then, the present study was a "test case," in a circumscribed region, of the value of the arterial pattern in providing clues to phylogenetic relationship.

MATERIAL AND ACKNOWLEDGMENTS

Most of the material studied consisted of animals from the zoo of the Chicago Zoological Society, which had been turned over to the Museum for study following their deaths. Grateful acknowledgment is hereby made to the Society for this wealth of material, without which this study would have been quite impossible. The domestic dog and cats dissected were provided by the General Biological Supply House, of Chicago, and thanks are also due that organization for the excellent embalming and injection performed on several specimens by their preparator, Mr. Arnold Blaufuss. The American Museum of Natural History, through Mr. H. C. Raven, loaned three civets and a hyena for dissection, and this study would have been much less complete without these critically important animals. One of the two lesser pandas dissected was lent by the United States National Museum. Finally, much of the credit for this study is due my able assistant, Miss Elizabeth Story, who in addition to spending many tedious hours dissecting is also responsible for the drawings on the following pages.

In the present state of our knowledge of vessel patterns, it seems best to follow the style used by Zuckerkandl in describing the vessels. Each of the arteries, whether it appears to be of comparative importance or not, is described briefly. Considerable care has been taken to keep the descriptions uniform throughout.

It was found that one of the most serious shortcomings of previous work was in the matter of illustration, which was either entirely lacking or much limited in value because muscle outlines hid extensive areas of the circulation. The semi-diagrammatic type of drawing used in this paper was adopted after considerable discussion. It is believed that these illustrations give a clearer conception of the inter-relations of the vessels than can be achieved by any other means.

The data on the 35 specimens dissected are as follows. Unless otherwise noted the animals were adult.

ARCTOIDEA

Canidae

<i>Canis familiaris</i> ♀ (mongrel terrier).....	Both forelegs	Latex injection
<i>Canis nubilus</i> ♀ (Wisconsin).....	Right foreleg	Uninjected
<i>Nyctereutes procyonoides</i> ♀ (Zoo).....	Right foreleg	Latex injection
<i>Vulpes fulva</i> ♂ (Indiana).....	Left foreleg	Uninjected

<i>Procyonidae</i>		
<i>Bassariscus astutus</i> ♂ (California).....	Right foreleg	Gelatine injection
<i>Nasua narica</i> ♀ juv. (British Honduras)....	Both forelegs	Uninjected
<i>Procyon lotor</i> ♀ (Zoo).....	Right foreleg	Starch injection
<i>Procyon lotor</i> ♂ (Zoo).....	Right foreleg	Uninjected
<i>Potos flavus</i> ♂ (Zoo).....	Both forelegs	Starch injection
<i>Potos flavus</i> ♂ (British Honduras).....	Right foreleg	Uninjected
<i>Ailuridae</i>		
<i>Ailurus fulgens</i> ♀ (Zoo).....	Both forelegs	Starch injection
<i>Ailurus fulgens</i> ♀ (Zoo).....	Right foreleg	Uninjected
<i>Ailuropoda melanoleuca</i> ♂ (Zoo).....	Both forelegs	Starch injection
<i>Ursidae</i>		
<i>Euarctos americanus</i> half-grown (Zoo).....	Both forelegs	Starch injection
<i>Euarctos americanus</i> half-grown (Zoo).....	Right foreleg	Starch injection
<i>Ursus middendorffi</i> newborn (Zoo).....	Both forelegs	Starch injection
<i>Ursus middendorffi</i> newborn (Zoo).....	Both forelegs	Starch injection
MUSTELOIDEA ¹		
<i>Mustelidae</i>		
<i>Mustela putorius</i> ♀ (Zoo).....	Both forelegs	Starch injection
<i>Mustela noveboracensis</i> ♀ (Chicago).....	Right foreleg	Gelatine injection
<i>Tayra barbara</i> ♂ (Peru).....	Both forelegs	Uninjected
<i>Taxidea taxus</i> ♂ (Zoo).....	Both forelegs	Starch injection
<i>Mephitis mesomelas</i> ♂ (Zoo).....	Both forelegs	Starch injection
AELUROIDEA		
<i>Viverridae</i>		
<i>Arctictis binturong</i> newborn (Zoo).....	Right foreleg	Uninjected
<i>Paradoxurus hermaphroditus</i>	Right foreleg	Uninjected
(Wettar, East Indies)		
<i>Nandinia binotata</i> newborn (Zoo).....	Right foreleg	Uninjected
<i>Genetta</i> sp. juv. ♂ (Belgian Congo).....	Right foreleg	Uninjected
<i>Herpestidae</i>		
<i>Herpestes ichneumon</i> ♀.....	Right foreleg	Uninjected
(Cape Province, South Africa)		
<i>Hyaenidae</i>		
<i>Hyaena striata</i> (Zoo).....	Right foreleg	Uninjected
<i>Felidae</i>		
<i>Felis domestica</i> (3 specimens).....		Latex injection
<i>Felis chaus</i> ♂ (Zoo).....	Right foreleg	Latex injection
<i>Lynx lynx</i> ♂ (Zoo).....	Right foreleg	Starch injection
<i>Panthera leo</i> ♀ (Zoo).....	Right foreleg	Uninjected
<i>Acinonyx jubata</i> (Zoo).....	Right foreleg	Uninjected

There are 25 genera represented in this list, which is slightly less than one-fourth of the approximately 106 genera of living Carnivora. The mustelids and civets are most poorly represented, and this is further aggravated by the great diversity of structure within

¹ This superfamily was recently erected by Gregory and Hellman (Proc. Amer. Phil. Soc., 81, p. 314, 1939) on the basis of fossil evidence.

these two groups. On the other hand, the representation of the procyonids, pandas, and bears is practically complete.

ARTERIES OF THE FOREARM IN CARNIVORES GENERAL CONSIDERATIONS

A. brachialis:

The brachial artery is that section of the trunk vessel of the foreleg that is situated between the origin of the subscapular trunk in the shoulder and the origin of the interosseae in the forearm. Throughout its length it is associated with the median nerve. Only the distal part of the vessel is of interest here.

Typically there are two pairs of small vessels arising from the brachial in the cubital region. These are the ulnar and radial collaterals, which usually arise immediately above the elbow; and the ulnar and radial recurrences, which usually arise immediately below the joint. These vessels have been disregarded in the present study.

Of fundamental importance in connection with the brachial is its relation to the entepicondylar foramen. When it is present,¹ this foramen invariably transmits the median nerve. The brachial artery may or may not accompany the nerve through the foramen, and this relation appears to be very constant indeed within any given group. The German literature contains an enormous amount of speculation on the question of how the artery could relinquish its course through the foramen, but this academic question is of no interest here.

A. radialis superficialis:

Collateralis radialis superior Ellenberger and Baum, 1891; Reighard and Jennings, 1901, 1935.

Radialis superficialis Schwalbe, 1895.

Brachialis superficialis inferior Müller, 1904.

Brachialis anterior Göppert, 1905.

Brachialis superficialis + radialis superficialis + dorsalis manus superficialis Zuckerkandl, 1907.

Collateralis radialis proximalis Bradley, 1935.

The superficial radial artery is a slender subcutaneous vessel, situated external to the deep fascia of the forearm, that arises from the brachial above the elbow. It then passes across the fossa cubiti

¹ The entepicondylar foramen is absent only in the Canidae, the Ursidae, and the skunks among the Mustelidae. It is often absent or poorly developed in hyenas.

onto the radial side of the dorsum of the forearm. Shortly beyond its origin, usually in the fossa cubiti, the vessel divides into a relatively strong dorsal ramus and a weak volar ramus.

The volar ramus is often no more than a muscular branch that terminates in the flexor muscles of the forearm. In other cases it may send a slender anastomotic twig down to the medianoradialis. It does not accompany a nerve.

The dorsal ramus accompanies the medial ramus of the superficial radial nerve down to the back of the hand, where it is the most important element contributing to the superficial dorsal arch. Shortly beyond its origin the dorsal ramus gives off a recurrent twig to the flexor muscles of the upper arm. In the less primitive forms this twig receives the terminus of the descending circumflex humeral, which in primitive carnivores enters the main trunk of the dorsal ramus farther distad. In most carnivores the dorsal ramus divides into a pair of collateral branches, which reunite at the carpus. In some (e.g. Canidae, Mustelidae, and all Aeluroidea) the weaker of the collateral branches remains on the volar surface of the forearm, accompanying N. cutaneus antibrachii lateralis down to the carpus, where it winds around onto the dorsum. In others both collateral branches remain on the dorsum, where they flank the cephalic vein.

A. mediana communis:

Antibrachialis Ellenberger and Baum, 1891.

Mediana (part) Schwalbe, 1895; Müller, 1904; Göppert, 1905.

Radialis (part) Reighard and Jennings, 1901, 1935.

Mediana communis Zuckerkandl, 1907.

Mediana Bradley, 1935.

The common median artery is the direct continuation of the brachial beyond the origin of the interosseae. It accompanies the median nerve, and terminates by dividing into the proper median and medianoradial arteries. This division takes place near the middle of the forearm in most carnivores, but may vary from the proximal third (dogs, hyena) to the distal third or lower (bears and pandas).

A. mediana propria:

Ulnaris Ellenberger and Baum, 1891; Bradley, 1935.

Mediana (part) Schwalbe, 1895; Müller, 1904; Göppert, 1905.

Unnamed branch of radialis Reighard and Jennings, 1901, 1935.

Mediana propria Zuckerkandl, 1907.

The proper median artery continues the course of the common median, beside the median nerve, beyond the origin of the medianoradialis. It accompanies the nerve onto the palm, where it forms the radial end of the superficial volar arch. The proper median is usually chiefly instrumental in forming this arch, the caliber of the vessels contributing the ulnar end of the arch often being relatively insignificant.

The caliber of the *mediana propria* relative to that of the medianoradialis is subject to considerable variation. It may enormously exceed the medianoradialis at one extreme (*Procyon*), and at the other it may be reduced to a thread-like vessel, with the medianoradialis continuing the *mediana communis* practically undiminished (e.g. *Felidae*).

In some carnivores there is a good-sized lateral (ulnar) branch of the *mediana propria*. The distribution of this vessel is somewhat erratic. It is uniformly present in the bears, for example, while among the pandas it is present in *Ailuropoda* but absent in *Ailurus*. This branch, which resembles a collateral branch of the distal part of the *mediana propria*, has a very characteristic pattern when it is present. It is joined by the terminus of the *ulnaris volaris* to form a common trunk that accompanies the *R. volaris manus* of the ulnar nerve on the volar side of the fifth metacarpal. This trunk divides at the level of the pisiform, one branch forming the ulnar end of the deep volar arch while the other continues distad as *A. metacarpea volaris* 5; the latter completes the superficial volar arch by means of a slender (occasionally strong) transverse anastomotic loop.

A. medianoradialis:

Radialis Ellenberger and Baum, 1891; Bradley, 1935.

Medianoradialis Schwalbe, 1895; Müller, 1904; Göppert, 1905; Zuckerkandl, 1907.

Radialis (part) Reighard and Jennings, 1901, 1935.

The medianoradial artery passes from its origin diagonally toward the base of the first metacarpal; it does not accompany a nerve. At the base of the thumb it winds around the radial border of the carpus, passing beneath the tendon of *M. abductor pollicis longus* onto the dorsum of the hand, where it terminates in one of several different ways but is always associated with the deep dorsal arch.

On the vola the medianoradialis gives rise to a constant *R. carpeus volaris* at the carpus. This twig passes ulnaward into the

volar rete, usually forming an anastomotic loop with one of the terminal twigs of the interossea volaris. In some animals the medianoradialis gives off a volar branch just before it passes under the tendon of the abductor pollicis longus. This branch, judging from conditions in various carnivores, appears to have arisen as a branch of the carpeus volaris and to have migrated distad to varying degrees. It usually enters the radial end of one of the volar arches; exceptionally (e.g. *Taxidea*) it may exceed the continued dorsal trunk of the medianoradialis in caliber. Its distribution within the Carnivora is quite erratic, although it seems to be confined to the arctoids and mustelids.

On the dorsum manus the medianoradialis first gives off a constant slender anastomotic loop to the radialis superficialis; this twig usually arises immediately after the parent vessel emerges from beneath the tendon. It is followed by the *R. perforans pollicis*,¹ which arises from the opposite (outer) wall of the medianoradialis and perforates between the base of the first metacarpal and the radial sesamoid to the vola. On the volar side its termination is quite variable; usually it empties into the radial end of the deep volar arch, giving off a twig to the outer border of the pollex. It may, however, terminate in the superficial volar arch, in both arches, or in neither. Beyond the origin of the perforans pollicis the medianoradialis gives rise to a constant *R. carpeus dorsalis*, which passes into the dorsal carpal rete, usually forming an anastomotic loop with one of the terminal twigs of the dorsal interossea volaris.

The medianoradialis terminates (1) by passing practically undiminished to the second intermetacarpal space (Canidae, Mustelidae, Felidae); (2) by dividing into subequal branches that pass to the first and second intermetacarpal spaces, respectively (most Procyonidae, pandas, Ursidae); or (3) by passing directly into the dorsal carpal rete (*Procyon*, *Taxidea*). Exceptionally it may end (4) by continuing directly into the deep dorsal arch (*Hyaena*). *Herpestes* is unique among carnivores so far studied in that the medianoradialis (5) passes directly to the first intermetacarpal space.

A. ulnaris:

R. volaris interossea Ellenberger and Baum, 1891.

Ulnaris Schwalbe, 1895; Reighard and Jennings, 1901, 1935; Müller, 1904; Göppert, 1905; Zuckerkandl, 1907.

Unnamed muscle branch Bradley, 1935.

¹ This branch, which was present in all carnivores studied, does not appear to have been described hitherto. The name given is used here for the first time.

The ulnar artery is closely related to the interosseae, and these vessels often arise by a common trunk. The two branches of the ulnaris and the two interosseous vessels bear an extremely varied relation to one another at their origins, but when the ulnar comes off independently its origin is invariably proximad of the origin of the interosseae.

The ulnaris is concerned chiefly with the blood supply of the flexor muscles on the ulnar side of the forearm, and secondarily with the formation of the ulnar ends of all four of the arches of the hand. At a variable distance beyond its origin it divides into a volar branch, which enters the volar arches, and a dorsal branch, which winds around onto the dorsum to enter the dorsal arches. In some carnivores (e.g. Mustelidae) this division is near the carpus; in most it is near the middle of the forearm; while in a few (e.g. Ursidae) it takes place just beyond the origin of the ulnaris, in which case there is only a very short common ulnar trunk. Exceptionally the volar and dorsal branches may arise independently of one another. The two branches of the ulnar artery accompany the corresponding branches of the ulnar nerve. In those animals where the artery bifurcates at the carpus the two divisions of the nerve also remain associated down to this point, the corresponding nerve and vessel branches then paralleling each other to their destinations.

The ulnaris volaris exceeds the dorsalis in caliber in some carnivores (e.g. Mustelidae, Hyaenidae, Felidae), while in other groups it is usually the smaller of the two vessels. The volaris usually unites either with the volar branch of the interossea volaris or with the lateral branch of the mediana propria to form a common trunk. In most cases this trunk bifurcates to form the ulnar ends of both volar arches, although the connection with one or the other of the arches may be lacking. A constant twig, the *R. perforans minimi*,¹ arises from the ulnar end of the deep volar arch just below the pisiform, and perforates between M. abductor digiti quinti and M. opponens digiti quinti at the base of the fifth metacarpal. On the dorsum manus it enters the ulnar end of the deep dorsal arch.

The ulnaris dorsalis always winds around the ulnar border of the forearm, at the base of the carpus, onto the dorsum. There it almost invariably forms the ulnar ends of both dorsal arches; when the deep dorsal arch is absent a twig goes to the fourth deep dorsal metacarpal, which represents the ulnar end of the arch.

¹ This branch, which closely resembles the perforans pollicis, was present in all carnivores studied. It does not appear to have been described hitherto, and the name given here is used for the first time.

Typically it receives an anastomotic loop from the interossea volaris on the vola; occasionally this loop may come from the lateral branch of the mediana propria; and in one instance only (*Taxidea*) there was no anastomotic loop from any source. In sporadic cases the ulnaris dorsalis may give off a volar twig which, when present, is associated with the ulnaris volaris.

A. volaris antibrachii:

Volaris antibrachii Ellenberger and Baum, 1891.

This vessel was described by Ellenberger and Baum for the domestic dog, and up to the present does not seem to have been noted in any other carnivore. It arises from the volar wall of the mediana communis, and when well developed (as in the dog) is a good-sized artery, equaling the ulnaris in caliber. It always accompanies the large muscle branch of the median nerve that supplies the digital flexors, thus passing toward the ulnar border of the forearm and then distad, deep to the superficial flexors of the forearm. Near its base it gives off one or more recurrent twigs that pass back to anastomose with the recurrens ulnaris. The vessel terminates in the distal part of the forearm by anastomosing with the ulnaris volaris. Thus it is apparent that the volaris antibrachii practically duplicates the volar ulnar circulation.

This vessel was present in every carnivore dissected, although in none of the others did it reach the same size and importance as in the Canidae.

A. interossea communis:

There is almost invariably a short common interosseous trunk. As was noted above, the ulnar artery is closely related to this trunk, often arising from it instead of directly from the mediana communis. The interossea communis gives off the relatively small interossea dorsalis a short distance beyond its origin, the main trunk continuing as the interossea volaris. A third, much smaller, branch usually arises from the common interosseous, occasionally from the interossea volaris. It ramifies to the proximal parts of the forearm extensors, one of its terminal twigs often entering the base of the mediano-radialis. Often it receives a slender anastomotic loop from the radialis superficialis. This branch has been disregarded in the present study.

A. interossea dorsalis:

R. dorsalis antibrachii a. interossea Ellenberger and Baum, 1891.

Interossea externa Schwalbe, 1895.

Interossea posterior Reighard and Jennings, 1901, 1935.

Interossea dorsalis Müller, 1904; Göppert, 1905; Zuckerkandl, 1907; Bradley, 1935.

The dorsal interosseous is invariably smaller than the volar interosseous. It immediately perforates through to the dorsum at the proximal end of the interosseous membrane, gives off a recurrent branch to the outer side of the elbow, and then passes distad under cover of the superficial extensors of the forearm. It does not accompany a nerve. The major bulk of the vessel is dissipated in ramifications to the forearm extensors, although there is always a slender twig that descends to anastomose with the dorsal (perforating) branch of the *interossea volaris*.

The recurrent branch arises independently of the *interossea dorsalis* in some animals, while in others these two vessels have a common trunk of varying length.

A. interossea volaris:

R. interosseus a. interossea Ellenberger and Baum, 1891.

Interossea interna Schwalbe, 1895.

Interossea anterior Reighard and Jennings, 1901, 1935.

Interossea volaris Müller, 1904; Göppert, 1905; Zuckerkandl, 1907; Bradley, 1935.

The volar interosseous runs distad on the volar surface of the interosseous membrane, accompanying the volar interosseous nerve. It reaches its maximum caliber in the Canidae and in *Procyon*; in these animals it is only slightly smaller than the *mediana communis*. Just above the radio-carpal joint (occasionally higher) the *interossea volaris* divides into a strong volar branch and a weaker dorsal branch that perforates through to the dorsum at the distal end of the interosseous membrane.

The volar branch first gives off a constant twig that forms a transverse anastomotic loop with the *R. carpeus volaris a. mediano-radialis*, then one or more twigs to the volar carpal rete. Typically the volar branch terminates by combining with the *ulnaris volaris*, the resulting common trunk forming the ulnar end of the deep volar arch. There is much erratic variation in this region, however, and it may enter both volar arches, may split to give a branch to the *ulnaris dorsalis*, may terminate in the volar carpal rete without reaching the arches, etc.

The dorsal (perforating) branch, upon reaching the dorsum, receives the comparatively slender descending terminal twig from

the interossea dorsalis. The vessel then terminates in the dorsal carpal rete, often giving off an anastomotic loop to the dorsal branch of the radialis superficialis.

Rete carpi dorsale:

The dorsal carpal rete is formed, as in man, by interanastomosis of the R. carpeus dorsalis a. medianoradialis, a twig from the ulnaris dorsalis (R. carpeus dorsalis a. ulnaris of human anatomy), and terminal twigs of the dorsal interossea volaris into which the slender descending branch of the interossea dorsalis has emptied. The ulnar contribution is always relatively very slender, and may be replaced by the perforating twig from the mediana propria + ulnaris volaris that passes between the pisiform and the base of the fifth metacarpal.

The rete exhibits two basically different forms in the Carnivora. In primitive carnivores it forms an arch, homologous with the "dorsal arch" of human anatomy, from which the deep dorsal metacarpals arise. In these cases there is no true deep dorsal arch (cf. p. 149). In other carnivores the rete is merely a network of relatively slender vessels, and has no direct connection with the deep dorsal metacarpals. In these cases a deep dorsal arch is present, and the deep dorsal metacarpals arise from it.

Rete carpi volare:

The volar carpal rete is much less important than the dorsal rete. It never substitutes for the deep volar arch, and consequently never gives rise to the deep volar metacarpals. It is formed by interanastomosis of the R. carpeus volaris a. medianoradialis and twigs from the interossea volaris. The carpeus volaris and a strong twig from the interossea volaris form an arch that marks the proximal boundary of the rete.

Arcus dorsales et volares:

Typically there are four arches in the metacarpal region in the Carnivora: two on the dorsum and two on the vola. These arches are always formed by anastomosis between the termini of a vessel situated on the radial side (in the case of the mediana propria nearly at the midline) of the forearm and a vessel situated on the ulnar side. One of the components of an arch may dominate the other so completely that the larger vessel alone breaks up in leash formation to form the metacarpeae. But the second component is always present, however insignificant it may be, and for the sake of uniformity all formations are referred to as "arches."

Each of the arches (except the deep dorsal arch), and the meta-carpal vessels radiating from it, is associated with a particular nerve system.

Arcus dorsalis superficialis is without a homologue in man, but in the Carnivora it is the most consistent of the four arches. It is subcutaneous, and is associated with the nerves of the *dorsum manus*. The stronger radial end of the arch is formed by the *radialis superficialis*, to which a feeble twig from the *dorsal medianoradialis* is added as the vessel passes the radio-carpal articulation. The ulnar end is formed by the *ulnaris dorsalis*. Metacarpeae dorsales superficiales 1-5 are radiated from the arch to their respective inter-metacarpal spaces.

In primitive carnivores there is often a tendency for the arch to be compound, with the *radialis superficialis* giving rise to metacarpeae 1-3, the *ulnaris dorsalis* to metacarpea 5, and twigs from both vessels combining to form metacarpea 4.

Arcus dorsalis profundus is situated deep to the fascia and extensor tendons, and is not associated with nerves. In primitive carnivores the deep dorsal metacarpals arise directly from the dorsal carpal rete, without a transverse vessel interconnecting them above the perforating vessels, and consequently these forms lack the deep dorsal arch.¹ In most Arctoidea, on the other hand, the *medianoradialis* and *ulnaris dorsalis* unite in a true arch on the back of the hand. In these cases the deep dorsal metacarpals arise from the arch, rather than from the rete. The radial half of the arch is usually considerably stronger than the ulnar half.

Arcus volaris superficialis is associated with the distal end of the median nerve, and to a lesser degree with the superficial ulnar nerve. Its radial end is formed by the *mediana propria*, to which the *perforans pollicis* is added; in exceptional cases other twigs may contribute. The ulnar end of the arch is formed typically by the combined trunk of the *ulnaris volaris* and *interossea volaris*. Exceptionally either one of these vessels alone may form the end of the arch, and when a lateral branch of the *mediana propria* is present it replaces the *interossea volaris* in the formation of the arch.

The mode of origin of the deep volar metacarpals produces several different forms of the arch (fig. 11). The most primitive appears to be the *triradiate* or *trigeminal* form, with metacarpeae 2-4 arising like the tines of a pitchfork. Other animals exhibit the

¹ Nevertheless, for the sake of uniformity and clarity, this region is referred to in the descriptions as the "deep dorsal arch," whether the arch is present or not.

arch form, with the metacarpeae radiating at more or less regular intervals. The Mustelidae are characterized by the *quadrigenous* form, with metacarpeae 1-4 arising from a common center. *Potos*, finally, is unique in having an *arc* type, with metacarpeae 1-3

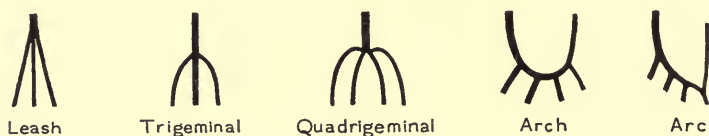


FIG. 11. Types of arches found in the Carnivora.

arising from the *mediana propria*, the latter vessel and the interosseous ulnar trunk combining to form metacarpea 4.

ARTERIES IN A PRIMITIVE MAMMAL (*Echinosorex*)

(Figs. 12, 13)

An examination of the literature failed to reveal an adequate description of the arteries of the foreleg in any insectivore. Since a knowledge of the vessels in some unspecialized member of this group is desirable as a clue to what is actually "primitive" in the Carnivora, a specimen of *Echinosorex albus* (= *Gymnura rafflesi* of authors) collected near Sandakan, British North Borneo, was dissected.

A. brachialis gives off a long interosseous ulnar trunk in the cubital fossa, and the *radialis superficialis* arises from this trunk. There is a small entepicondylar foramen, which transmits the median nerve; the brachial artery fails to pass through the foramen. Since the interosseous ulnar trunk arises in the cubital fossa, and the main vessel is regarded as the *mediana communis* beyond the origin of this trunk, it follows that the *brachialis* proper does not reach the forearm in this animal.

A. radialis superficialis is very slender. In the cubital fossa it gives off twigs to the flexors of the upper arm and an anastomotic twig that runs down to the base of the *medianoradialis*. A fine twig arising independently from the *mediana communis* supplies the pronator teres, and hence may represent the volar branch of the *radialis superficialis* of carnivores; or the volar branch may be represented by the anastomotic twig to the *medianoradialis*.

The trunk of the superficial radial divides into subequal dorsal and volar collateral branches in the proximal part of the forearm.

The very short dorsal branch winds directly onto the dorsum, where it terminates in the much larger descending branch of the external circumflex humeral. The resulting common trunk forms the radial end of the superficial dorsal arch. The volar collateral branch winds onto the dorsum at the carpus, and terminates in *A. metacarpea dorsalis superficialis* 1.

A. mediana communis is very short, passing onto the forearm between the biceps and the pronator teres, and dividing at the proximal fifth of the forearm into the large *mediana propria* and the much smaller *medianoradialis*. Throughout its course it lies superficial to all the musculature. Farther proximad it also gives rise to a slender vessel that runs the length of the forearm to empty into the interosseo-ulnar trunk at the carpus. This vessel is superficial throughout its course, and in the middle half of the forearm is separated from the *mediana propria* by the median nerve, which there lies between them. This branch does not appear to be homologous with the *volaris antibrachii* of carnivores.

A. mediana propria forms the radial end of the superficial volar arch. It is the chief source of this arch, the ulnar contribution being relatively slender. *A. metacarpea volaris superficialis* 1 is given off very high, at the carpo-metacarpal articulation, and is connected with the *medianoradialis* by a short anastomotic loop.

A. medianoradialis gives off a very short and slender *carpeus volaris* at the carpus, followed by the above-described anastomotic loop to the first superficial volar metacarpal just before it passes under the tendon of the abductor pollicis longus. On the dorsum it breaks up into three subequal terminal twigs. One of these enters the dorsal carpal rete, anastomosing with a terminal twig of the dorsal interossea volaris. The other two pass to the first and second intermetacarpal spaces as *perforantes* 1 and 2, that to the second being slightly the larger. The first and second deep dorsal metacarpals arise from these perforating branches. The dorsal end of the *perforans pollicis* arises from *perforans* 1.

There is no deep dorsal arch, *metacarpeae dorsales profundae* 3 and 4 being the direct continuations of the corresponding perforating branches. Each receives a twig from the dorsal carpal rete. *Metacarpea dorsalis profunda* 5 is the direct dorsal continuation of the *perforans minimi*, and it also receives a twig from the dorsal carpal rete.

A. ulnaris arises by a long trunk common to it and the common interosseous. It divides into subequal dorsal and volar branches

just above the middle of the forearm. The ulnaris volaris is joined to the ulnaris dorsalis by a transverse anastomotic loop near the carpus. It also receives a terminal twig of the interossea volaris and the terminus of the long lateral branch of the mediana communis,

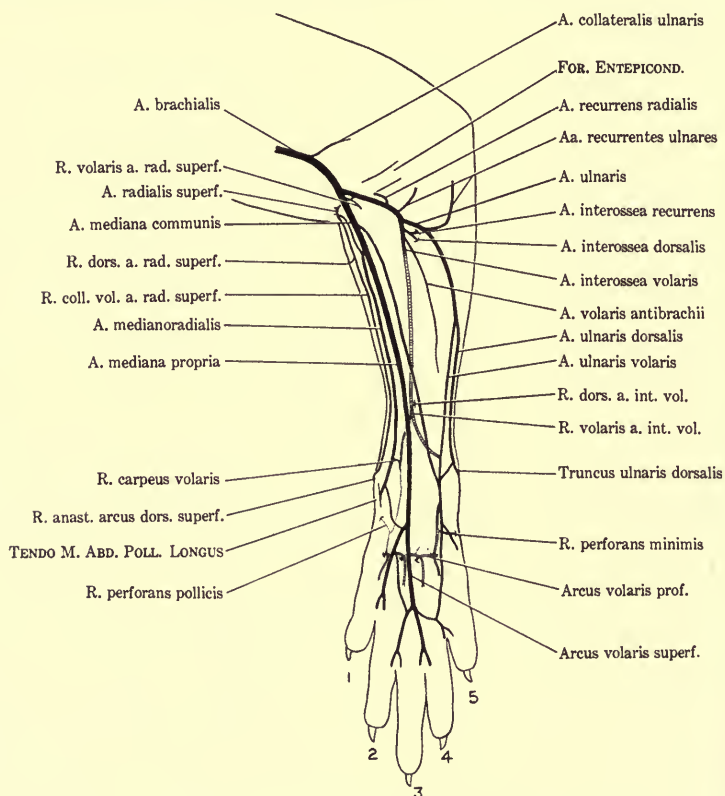


FIG. 12. Vessel pattern in *Echinosorex albus*; volar view.

the resulting trunk forming the ulnar ends of both volar arches. The ulnaris dorsalis winds onto the dorsum near the carpus. It terminates on the dorsum manus by forming the ulnar ends of both dorsal arches.

Aa. interossee arise by a very short common trunk. The interossea volaris considerably exceeds the dorsalis in caliber. Near its base the volaris gives off a branch that ramifies to the flexors on the ulnar side of the forearm; this branch may represent the volaris antibrachii of carnivores. The interossea volaris divides into volar

and dorsal branches at the distal quarter of the forearm. The volar branch gives twigs to the volar carpal rete, the largest of its terminal branches emptying into the ulnaris volaris. The dorsal branch perforates through to the dorsum, where it first receives a descending

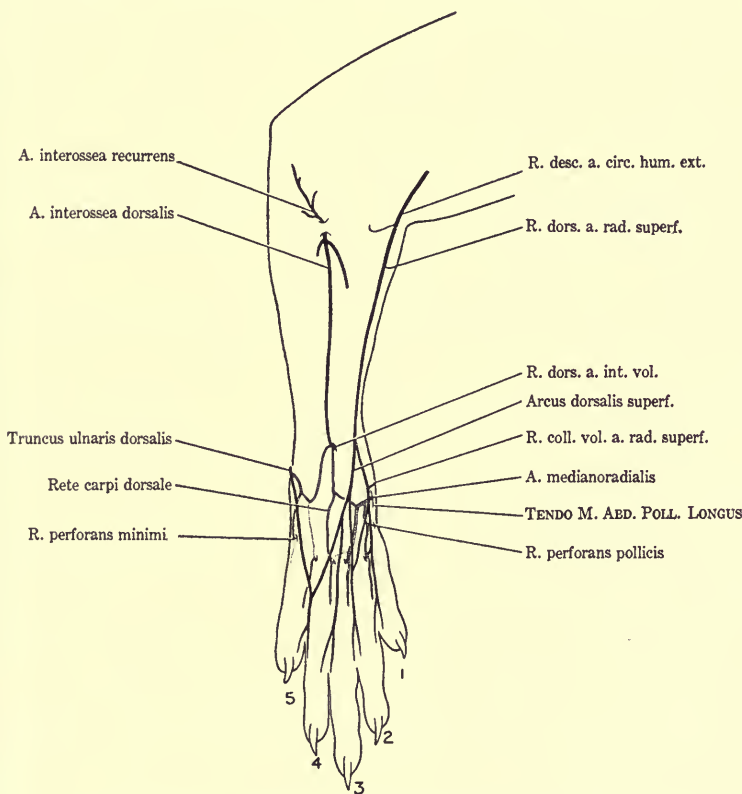


FIG. 13. Vessel pattern in *Echinorex albus*; dorsal view.

twig from the interossea dorsalis, then ramifies to the dorsal carpal rete. The interossea dorsalis gives off the recurrens before perforating, and the two vessels perforate to the dorsum side by side. On the dorsum the main dorsal trunk ramifies to the extensors of the forearm, terminating by anastomosing with the dorsal interossea volaris.

Numerous features of the arterial arrangement in *Echinorex* are extremely helpful in diagnosing primitive conditions in the Carnivora. It may be unsafe to draw extensive conclusions from

a single dissection, but the vessel pattern in *Echinosorex* conforms so closely to the expected primitive pattern that the evidence it supplies is actually confirmatory rather than critical. Passage of the brachial artery through the entepicondylar foramen is certainly primitive, and its failure to do so in *Echinosorex* would consequently be a specialization or an individual anomaly. This, however, was the only important non-primitive character encountered.

The following points in *Echinosorex* are of particular interest in connection with the vessel patterns of carnivores:

(1) The large size of the descending circumflexa humeri anterior, which indicates that this vessel originally supplied the superficial dorsal arch and that the arch has been secondarily transferred to the radialis superficialis.

(2) The fact that the volar collateral branch of the radialis superficialis remains on the volar side of the forearm down to the carpus.

(3) The very short mediana communis, i.e. its high division into the mediana propria and medianoradialis.

(4) The large caliber of the mediana propria, and the correspondingly slender medianoradialis.

(5) The fact that the terminal (perforating) branch of the medianoradialis to the second dorsal intermetacarpal space exceeds the branch that goes to the first.

(6) The relatively long common ulnar, i.e. its low division into the ulnaris dorsalis and ulnaris volaris.

(7) The equal caliber of the two branches of the ulnaris.

(8) The fact that the interossea dorsalis and the recurrens perforate separately.

(9) The absence of a true deep dorsal arch, with the deep dorsal metacarpals arising directly from the dorsal carpal rete.

DESCRIPTION OF ARTERIES IN CARNIVORA

CANIDAE

DOMESTIC DOG (*Canis familiaris*)

(Figs. 14, 15)

A. brachialis gives off the superficial radial and radial recurrent above the elbow, followed by two ulnar recurrens immediately below the elbow. A common trunk for the common interosseous and ulnaris comes off a few millimeters below the elbow. Beyond this the main trunk continues as the mediana communis.

A. radialis superficialis is very slender. It gives off a twig to the biceps before passing onto the forearm. The vessel fails to divide into dorsal and volar branches, the entire system representing the dorsal branch of other carnivores. The trunk divides in the proximal part of the forearm into three collateral branches, one of which remains on the vola while the other two wind onto the dorsum. The delicate volar collateral branch¹ supplies only cutaneous structures on the volar side of the forearm; it may be followed down to the carpus. The dorsal collateral branches are connected by a delicate transverse anastomotic loop in the distal part of the forearm. The more slender of these collateral branches terminates in the dorsal branch of the medianoradialis, thus contributing to the radial end of the superficial dorsal arch. The main collateral branch gives off a recurrent twig to the flexors of the upper arm, then receives the delicate descending circumflex humeral. The resulting common trunk receives one of the terminal twigs of the dorsal interossea volaris and a twig from the medianoradialis near the distal end of the forearm, then continues onto the metacarpus where it enters the center of the superficial dorsal arch. The radial end of this arch is formed by the medianoradialis-radialis superficialis trunk referred to above, the ulnar end by the ulnaris dorsalis.

A. mediana communis divides just below the proximal third of the forearm into the large mediana propria and the slender medianoradialis.

Near its origin the mediana communis gives off a large vessel (the volaris antibrachii of Ellenberger and Baum), which accompanies the branch of the median nerve that supplies the flexor digitorum sublimis and palmaris longus. This vessel, which is represented only by a minor muscle branch in most carnivores, parallels the ulnaris strikingly in its ramifications and terminates by emptying into the ulnaris volaris in the distal part of the forearm.

A. mediana propria forms the strong superficial volar arch. A branch of the interossea volaris, which also carries blood from both ulnars, enters the ulnar side of this arch. A minute twig from the volar branch of the medianoradialis passes to the radial side of the arch.

A. medianoradialis divides into volar and dorsal branches at the carpus. The volar branch sends twigs to the volar carpal rete,

¹ This vessel accompanies N. cutaneus antibrachii lateralis, exactly like the volar collateral branch in other carnivores. The true volar branch of other carnivores is a muscle branch, and is not related to any nerve.

then forms the radial end of the deep volar arch. This arch, in addition to supplying the metacarpeae volares profundae 1-4,

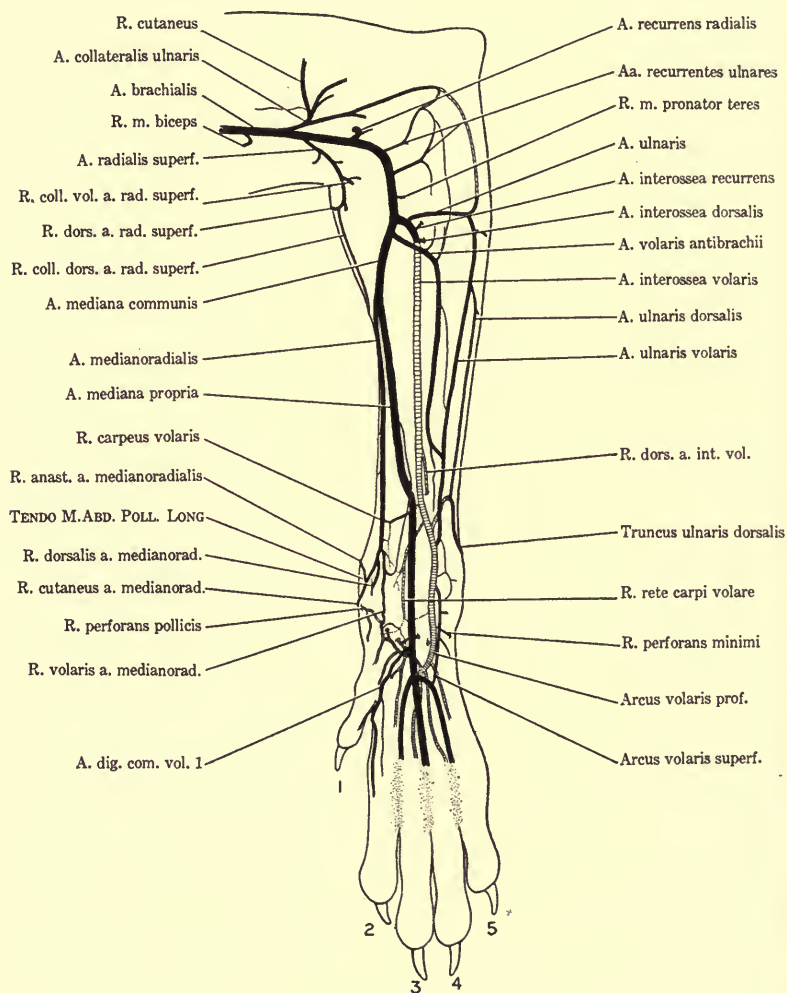


FIG. 14. Vessel pattern in *Canis familiaris*; volar view.

sends four perforating branches through the first to fourth inter-metacarpal spaces.

The dorsal branch divides immediately, one resulting twig passing external to the tendon of the abductor pollicis longus onto the back of the hand, while the other runs deep to this tendon.

The first of these twigs receives the terminus of the radialis superficialis, then passes distad to enter the radial end of the superficial

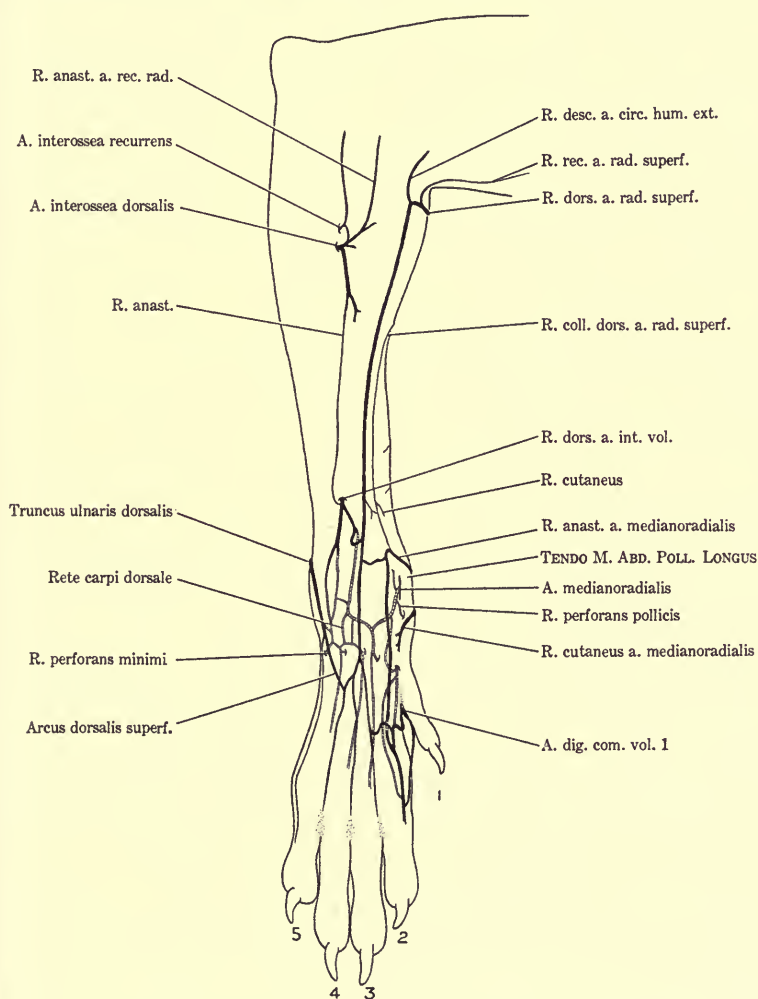


FIG. 15. Vessel pattern in *Canis familiaris*; dorsal view.

dorsal arch. The second twig terminates in the arch-like dorsal carpal rete, where it is joined by the ulnar half of the rete to form a perforating branch for the second intermetacarpal space.

There is no deep dorsal arch; all the deep dorsal metacarpals (except the feeble second one) are the direct continuations of the

corresponding volar perforating branches. Each metacarpal receives a slender twig from the dorsal carpal rete.

A. ulnaris is much smaller than the *interossea volaris*, and arises by a short trunk common to it and the *interosseae*. It divides into volar and dorsal branches at the proximal third of the forearm; the *volaris* exceeds the *dorsalis* in caliber. The *ulnaris volaris* is joined by the *volaris antibrachii* at the distal quarter of the forearm, and the resulting common trunk empties into the *volar interossea volaris*, thus contributing to both volar arches. The *ulnaris dorsalis* receives a strong anastomotic loop from the *interossea volaris*, and the resulting common trunk forms the ulnar ends of both dorsal arches.

Aa. interosseae arise by a short trunk common to them and the *ulnaris*. This trunk is very large, equaling the *mediana communis* in caliber. The *interossea dorsalis* immediately perforates to the dorsal side of the forearm, where it sends a recurrent twig back to the elbow, and a descending twig distad to anastomose with the dorsal *interossea volaris*. The *interossea volaris* almost equals the *mediana propria* in caliber. It gives off a relatively slender dorsal branch at the distal third of the forearm. The powerful volar branch gives off twigs to the volar carpal rete, then an anastomotic twig to the *ulnaris dorsalis*, finally receiving the combined trunk of the *ulnaris volaris* and *volaris antibrachialis* at the proximal border of the carpus. The resulting common trunk forms the ulnar ends of both volar arches. The dorsal *interossea volaris* receives the descending anastomotic twig from the *interossea dorsalis*, then breaks up into three twigs on the *dorsum*. One of these is an anastomotic loop to the descending external circumflex humeral, while the other two enter the dorsal carpal rete.

TIMBER WOLF (*Canis nubilis*)

Dissection of the arteries in the foreleg of a wolf revealed only two very trivial deviations from conditions in the domestic dog. *A. collateralis ulnaris* arose from the base of the *radialis superficialis* instead of independently from the *brachial*, and *A. interossea communis* was relatively slightly smaller than in the dog. Either of these is well within the limits of slight individual variations.

RACCOON DOG (*Nyctereutes procyonoides*)

The arteries of this animal differed little from the typical canid pattern seen in the domestic dog. Only the following differences were found:

The dorsal collateral ramus of the *radialis superficialis*, which in the dog divided into a pair of vessels at its origin (while still on the vola), remained single in *Nyctereutes* as far as the middle of the dorsum of the forearm. This unimportant variation did not affect the pattern of the superficial dorsal arch, which was practically identical with that of *Canis*. The volar ramus of the *radialis superficialis* was absent, as in other *Canidae*.

A. volaris antibrachii arose immediately proximad of the interosseous-ulnar trunk, instead of distad of that trunk. Otherwise this vessel did not differ from that of *Canis*.

A. ulnaris divided into dorsal and volar branches at the distal third of the forearm, instead of at the proximal third.

A. interossea dorsalis and *A. interossea recurrens* arose by a common trunk. The *recurrens* came off after the trunk had emerged on the dorsal side of the forearm.

RED FOX (*Vulpes fulva*)

A. brachialis gives off the superficial radial and radial recurrent above the elbow, followed by the ulnar recurrent below the elbow. The dorsal ulnar arises immediately below the elbow, followed by the common interosseous and volar ulnar which arise from a common center. Beyond this the main trunk continues as the *mediana communis*.

A. radialis superficialis is very slender. It gives off a twig to the biceps before passing onto the forearm. As in the dog, the true volar branch is absent, the trunk dividing into three collateral branches that represent the true dorsal branch. A delicate volar collateral branch supplies only cutaneous structures on the volar side of the forearm. The dorsal branch gives off a recurrent twig to the flexors of the upper arm, then receives the terminus of the descending circumflex humeral. The vessel then divides into a pair of collateral branches, which are connected by a transverse anastomotic loop in the distal part of the forearm. The larger collateral branch receives one of the terminal twigs of the *interossea dorsalis*, then continues onto the metacarpus, where it enters the center of the superficial dorsal arch. The smaller collateral branch gives off a twig above the carpus that winds around to the dorsum, where it anastomoses with the *medianoradialis*. Distad of this it receives one of the terminal twigs of the dorsal *interossea volaris*, then forms the radial end of the superficial dorsal arch. The ulnar end of this arch is formed by the *ulnaris dorsalis*.

A. mediana communis divides just below the proximal third of the forearm into the very large *mediana propria* and the extremely delicate *medianoradialis*.

A. volaris antibrachii arises from the *mediana communis* at its base. The course and relations of this vessel are identical with those of the dog. It terminates by emptying into the *ulnaris volaris* in the distal part of the forearm.

A. mediana propria forms the strong superficial volar arch. A branch of the *interossea volaris*, which carries blood from both ulnars, enters the ulnar side of this arch. A twig from the volar branch of the *medianoradialis* enters the radial side of the arch.

A. medianoradialis divides into volar and dorsal branches at the carpus, the dorsal branch being reduced to a thread-like vessel. The volar branch sends twigs to the volar carpal rete, then divides to send a twig to the radial ends of both volar arches. The deep volar arch, in addition to supplying the *metacarpeae volares profundae* 1-4, sends four perforating branches through the first to fourth intermetacarpal spaces. The second of these runs up into the dorsal carpal rete, while the others join *metacarpeae dorsales profundae* 1, 3, and 4.

The dorsal branch passes under the tendon of the *abductor pollicis longus* onto the back of the hand, where it forms the radial end of the arch-like dorsal carpal rete. There is no deep dorsal arch, all the deep dorsal metacarpals (except the second) being the direct continuations of the corresponding perforating branches. A slender twig descends from the dorsal carpal rete to each of the metacarpals. The deep dorsal arch sends a stout perforating branch through the second intermetacarpal space, which gives off a delicate *metacarpea dorsalis profunda* 2 before perforating. Delicate twigs also go from this arch to the first, third, and fourth perforating branches, which pass from the vola to the dorsum to form the larger *metacarpeae dorsales profundae* 1, 3, and 4.

A. ulnaris is much smaller than the *interossea communis*, and arises independently, proximad of the *interosseae*. It divides into volar and dorsal branches at about the distal third of the forearm; the *volaris* slightly exceeds the *dorsalis* in caliber. The *ulnaris volaris* is joined by the *volaris antibrachii* in the distal part of the forearm, and the resulting common trunk empties into the volar *interossea volaris*, thus contributing to both volar arches. The *ulnaris dorsalis* receives a thread-like anastomotic loop from the *interossea volaris*, and the resulting common trunk forms the ulnar ends of both dorsal arches.

Aa. interosseae arise by a relatively long common trunk, which comes off from a common center with the volaris antibrachii. The common interosseous slightly exceeds the mediana communis in caliber. The interossea dorsalis immediately perforates to the dorsal side of the forearm, where it sends a recurrent twig back to the elbow, and a descending twig distad to anastomose with the radialis superficialis. The interossea volaris equals the mediana propria in caliber. It gives off a relatively slender dorsal branch at the distal third of the forearm. The powerful volar branch gives off twigs to the volar carpal rete, then a fine anastomotic twig to the dorsal ulnar, finally receiving the trunk of the combined volar ulnar and ulnaris antibrachii at the carpus. The resulting common trunk forms the ulnar ends of both volar arches. The dorsal interossea volaris breaks up into three twigs on the dorsum, all of which go to the dorsal carpal rete.

PROCYONIDAE

CACOMISTL (*Bassariscus astutus*)

(Figs. 16, 17)

A. brachialis gives off the superficial radial above the entepicondylar foramen, then detours around the foramen onto the forearm. The ulnar and common interosseous arise by a short common trunk in the proximal quarter of the forearm, beyond which the trunk continues as the mediana communis.

A. radialis superficialis divides shortly beyond its origin into a volar and a dorsal branch. The smaller volar branch supplies the flexors of the forearm, and a twig from it anastomoses with the medianoradialis near the middle of the forearm. The dorsal branch sends a recurrent twig back to the superficial pectoral musculature; this twig receives an extremely delicate descending branch from the external circumflex humeral. The main trunk of the dorsal branch passes down the dorsum of the forearm to the manus, where it forms the superficial dorsal arch with the dorsal branch of the ulnaris dorsalis. A fine anastomotic twig at the carpus connects the dorsal branch of the radialis superficialis with the medianoradialis.

A. mediana communis divides near the middle of the forearm into the mediana propria and the smaller medianoradialis.

A. mediana propria forms the strong superficial volar arch with a common trunk formed by the ulnaris dorsalis, the ulnaris volaris, and the interossea volaris. From this arch arise metacarpeae volares superficiales 1-4 and the perforans pollicis.

A. medianoradialis gives off the carpeus volaris at the carpus, then passes under the tendon of the abductor pollicis longus onto the dorsum manus where, after receiving a delicate anastomotic loop from the radialis superficialis, it gives off the perforans pollicis and the carpeus dorsalis. The medianoradialis terminates by dividing

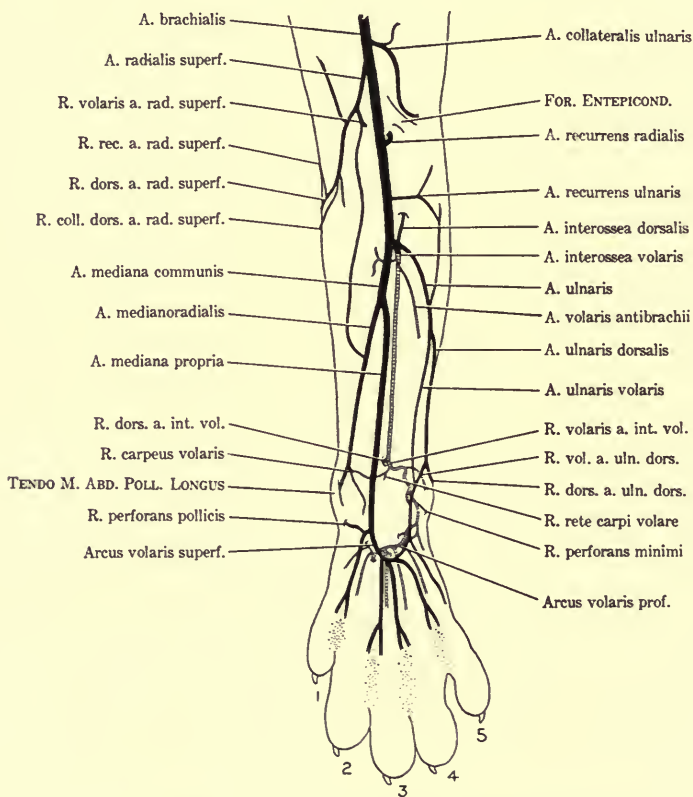


FIG. 16. Vessel pattern in *Bassariscus astutus*; volar view.

into perforantes 1 and 2, of which 2 is the larger. Each of the latter gives off its corresponding deep dorsal metacarpal, and together they represent the radial half of the deep dorsal arch.

The deep dorsal arch is interrupted across the third metacarpal bone, but is otherwise complete and gives rise to all the deep dorsal metacarpals. The radial half of the arch considerably exceeds the ulnar half in caliber. The second perforating branch is the largest.

A. ulnaris, which slightly exceeds the interossea volaris in caliber, divides near the middle of the forearm into a volar and a dorsal

branch. The smaller volaris empties into the volar branch of the ulnaris dorsalis at the pisiform. The dorsalis divides into volar and dorsal branches at the carpus. The volar branch is joined by the ulnaris volaris, then by a branch of the interossea volaris, the resulting common trunk forming the ulnar end of the superficial volar

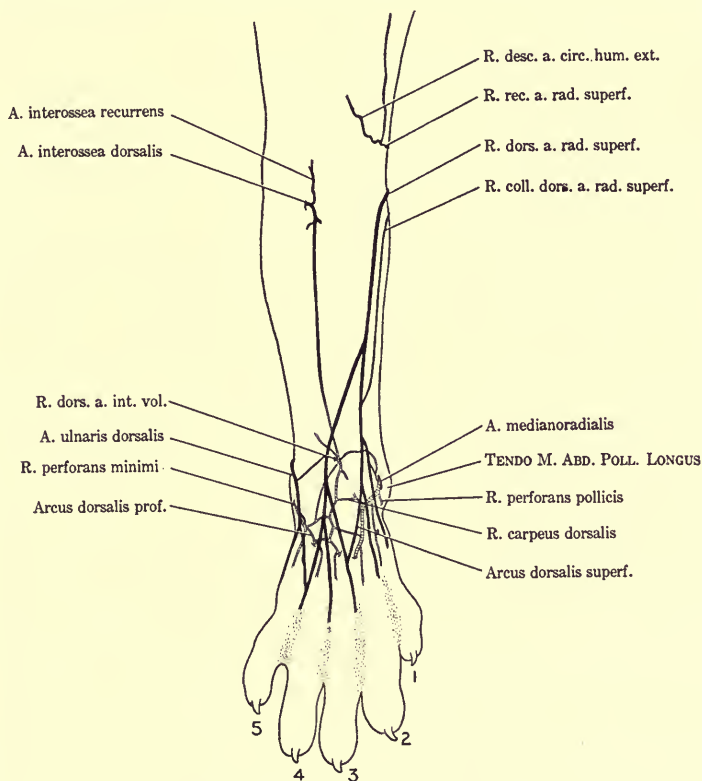


FIG. 17. Vessel pattern in *Bassariscus astutus*; dorsal view.

arch. The dorsal branch receives an anastomotic twig from the radialis superficialis, then splits to form the ulnar ends of both dorsal arches.

Aa. interossee.—The volar interosseous considerably exceeds the dorsal in caliber. It divides into a volar and a dorsal branch near the proximal border of the carpus. The volar branch gives off an anastomotic twig to the carpus volaris and twigs to the volar carpal rete, then divides. One resulting branch joins the common trunk formed by the volar branches of the ulnaris, the other

forming the ulnar end of the deep volar arch. The dorsal branch of the volar interosseous sends a slender recurrent twig back to anastomose with the dorsal interosseous, then itself ramifies to the dorsal carpal rete. The interossea dorsalis supplies the extensor muscles of the forearm, the greatly reduced trunk continuing to the carpus, to anastomose with the dorsal recurrent twig of the interossea volaris.

COATI (*Nasua narica*)

A. brachialis gives off the superficial brachial above the entepicondylar foramen, then detours around the foramen onto the forearm. The radial recurrent comes off immediately below the foramen, followed a few millimeters farther distad by the smaller ulnar recurrent. The ulnar arises at the proximal fifth of the forearm, followed immediately by the common interosseous. Beyond this the main trunk continues as the *mediana communis*.

A. brachialis superficialis divides shortly beyond its origin into a volar and a dorsal branch. The smaller volar branch supplies the flexors of the forearm. The dorsal branch sends a delicate recurrent twig back to the flexors of the upper arm; this twig receives an extremely delicate descending branch from the external circumflex humeral. The main trunk of the dorsal branch passes down the dorsum of the forearm to the manus, where it forms the superficial dorsal arch with the dorsal ulnar. A fine anastomotic twig at the carpus connects the *brachialis superficialis* with the *medianoradialis*.

A. mediana communis divides just below the middle of the forearm into the *mediana propria* and the larger *medianoradialis*.

A. mediana propria divides almost immediately into a pair of collateral branches. The more medial of these forms the radial end of the superficial volar arch, while the other enters the center of this arch. The ulnar end of the arch is formed by the *interossea volaris*.

A. medianoradialis gives off the *carpeus volaris* at the carpus, then passes under the tendon of the *abductor pollicis longus* onto the dorsum manus, where, after receiving a delicate anastomotic loop from the *radialis superficialis* it gives off the *perforans pollicis* and *carpeus dorsalis*. The *medianoradialis* terminates by dividing into *perforantes* 1 and 2, of which 2 is the larger. Each of the latter gives off its corresponding deep dorsal metacarpal, and together they represent the radial half of the deep dorsal arch.

The deep dorsal arch is interrupted across the third metacarpal bone, but is otherwise complete and gives rise to all the deep dorsal

metacarpals. The radial half of the arch slightly exceeds the ulnar half in caliber. The second perforating branch is the largest.

A. ulnaris is slightly smaller than the *interossea volaris*. It divides immediately into a slender volar and a strong dorsal branch. The volar branch terminates by entering the *interossea volaris* at the carpus; thus this branch contributes to the formation of the ulnar ends of both volar arches and of the *metacarpea volaris* 5. The dorsal branch gives off a recurrent branch near its origin, and receives an anastomotic branch from the *interossea volaris* at the carpus. It then winds around the ulnar border of the carpus onto the dorsum, where it forms the ulnar ends of both dorsal arches.

Aa. interosseae.—The *interossea volaris* greatly exceeds the *dorsalis* in caliber. It divides into a volar and a dorsal branch at the distal third of the forearm. The volar branch gives off an anastomotic twig to the dorsal ulnar, then receives the terminus of the volar ulnar; both volar arches arise from the common trunk so formed. The dorsal branch perforates to the dorsum near the proximal border of the carpus; on the dorsum it enters the dorsal carpal rete, in addition to sending a slender recurrent anastomotic twig back to the *interossea dorsalis*. The *interossea dorsalis* supplies the extensors of the forearm.

RACCOON (*Procyon lotor*)

(Figs. 18, 19)

A. brachialis gives off the superficial radial above the entepicondylar foramen, then detours around the foramen onto the forearm. The ulnar and common interosseous arise from a common center at the proximal fifth of the forearm, beyond which the considerably reduced trunk continues as the *mediana communis*.

A. radialis superficialis divides shortly beyond its origin into a volar and a dorsal branch. The smaller volar branch supplies the flexors of the forearm, and a twig from it anastomoses with the *medianoradialis* in the proximal part of the forearm. The dorsal branch sends several recurrent twigs back to the superficial pectoral musculature and the flexors of the upper arm, then divides into a pair of collateral branches that reunite farther distad to form the radial end of the superficial dorsal arch. The dorsal collateral receives the descending external circumflex humeral in the proximal part of the forearm, and is connected with terminal twigs of both *interosseae* and the *ulnaris dorsalis* by a loose subcutaneous network of threadlike twigs.

A. mediana communis divides at the proximal third of the forearm into the large mediana propria and the remarkably slender medianoradialis.

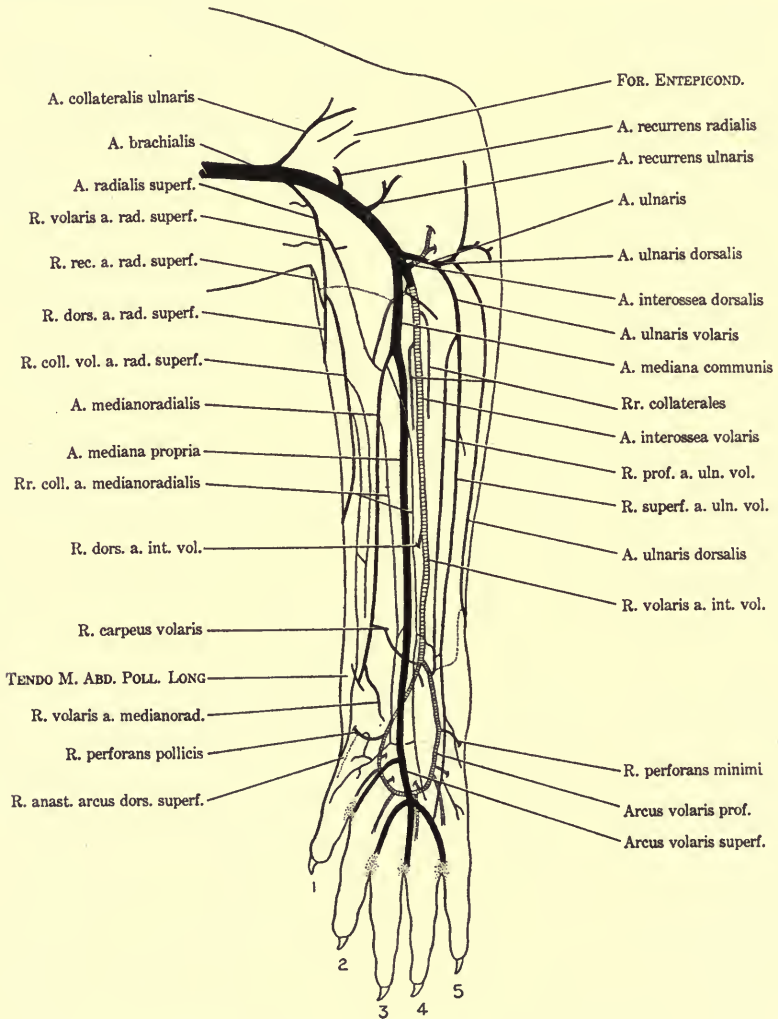


FIG. 18. Vessel pattern in *Procyon lotor*; volar view.

A. mediana propria forms the strong superficial volar arch practically unassisted. A threadlike twig from the ulnaris volaris enters the ulnar end of the arch.

A. medianoradialis, despite its small size, gives off near its origin a pair of minute vessels that accompany the mediana propria,

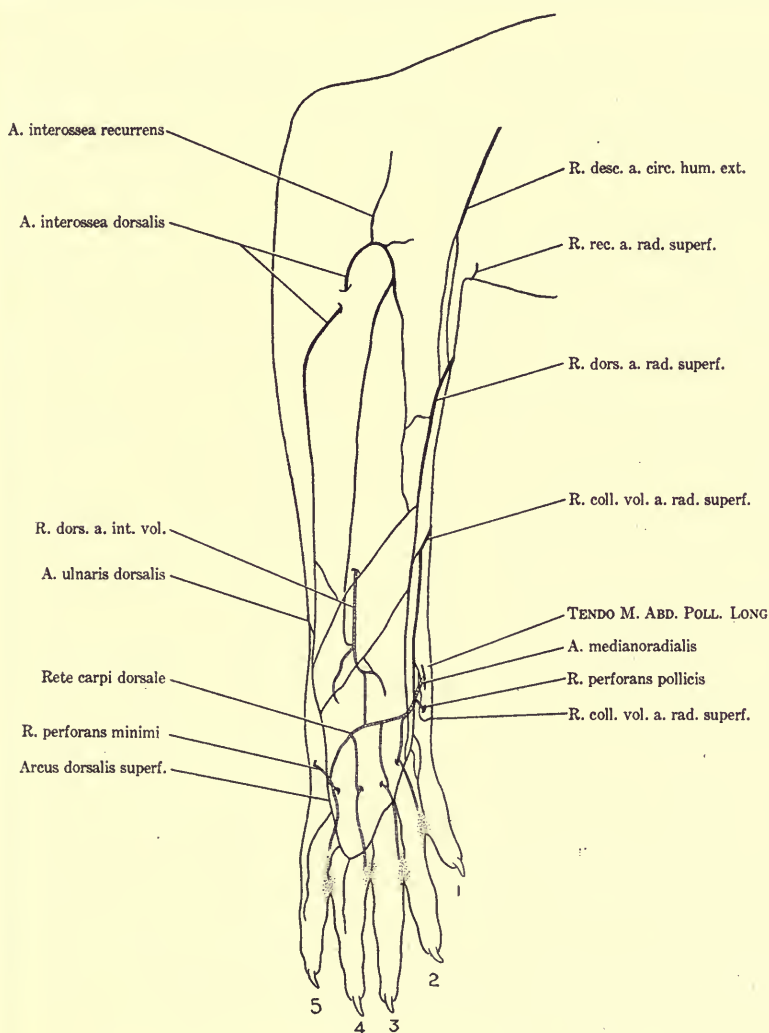


FIG. 19. Vessel pattern in *Procyon lotor*; dorsal view.

lying one on either side, down to the palm.¹ After giving off the carpeus volaris, the medianoradialis passes under the tendon of the

¹ These two accompanying vessels were present in both specimens dissected. They appear to be characteristic of *Procyon*, since Müller (1904) also found them in his specimen, although he says that they arose from the interossea volaris.

abductor pollicis longus onto the dorsum manus, where, after receiving an anastomotic loop from the radialis superficialis it gives off the perforans pollicis, then terminates in the dorsal carpal rete instead of continuing as the second perforans.

There is no deep dorsal arch; all the deep dorsal metacarpals are the direct continuations of the corresponding volar perforating branches, and each receives a slender twig from the dorsal carpal rete. The second perforating branch does not exceed the others in caliber.

A. ulnaris is much smaller than the interossea volaris. It divides almost at once into a volar and a dorsal branch. The volaris is slightly the larger. It divides into collateral branches at the proximal third of the forearm; the deeper of these, after receiving the volar ulnaris dorsalis, terminates in the interossea volaris at the carpus; the more superficial branch, after receiving a delicate anastomotic loop from one of the fine accompanying vessels of the mediana propria, enters the ulnar side of the superficial volar arch. The ulnaris dorsalis divides into volar and dorsal branches at the carpus. The volar branch terminates in the ulnaris volaris; the dorsal branch receives a descending twig of the interossea dorsalis, the resulting common trunk forming the ulnar end of the superficial dorsal arch.

Aa. interossee arise by a very short common trunk. The volaris greatly exceeds the dorsalis in caliber, and is flanked by a pair of threadlike vessels. It divides into volar and dorsal branches at the distal quarter of the forearm. The volar branch gives off an anastomotic twig to the carpeus volaris, then divides. The larger of the resulting branches receives the deep branch of the ulnaris volaris, the resulting common trunk forming the ulnar end of the deep volar arch; the other branch passes to the radial end of the deep volar arch. The interossea dorsalis supplies the extensors, its terminal twigs entering extensively into the dorsal subcutaneous network of the forearm. One of two descending twigs anastomoses with the ulnaris dorsalis at the carpus, the other with the dorsal recurrent twig of the interossea volaris.

KINKAJOU (*Potos flavus*)

(Figs. 20, 21)

A. brachialis gives off the superficial brachial in the distal quarter of the upper arm, then accompanies the median nerve through the entepicondylar foramen. The radial recurrent is given off immediately below the foramen, the ulnar recurrent farther distad.

The volar ulnar comes off at the proximal sixth of the forearm, followed 5 mm. farther distad by the dorsal ulnar, beside which the common interosseous arises. Beyond this the main trunk continues as the *mediana communis*.

A. brachialis superficialis divides shortly beyond its origin into a slender volar branch and a much larger dorsal branch. The volar branch supplies the flexors of the forearm. The dorsal branch gives off recurrent twigs to the pectorals and the flexor muscles of the upper arm. The *brachialis superficialis* then divides into a pair of collateral branches that are united by several transverse anastomotic loops as they pass down the forearm, and which at the carpus form the superficial dorsal arch with the dorsal ulnar. The dorsal collateral gives off a branch at the middle of the forearm that receives a very delicate descending branch from the external circumflex humeral, then passes to the ulnar side of the superficial dorsal arch, where it joins the *ulnaris dorsalis*. A fine anastomotic twig at the carpus also connects the dorsal collateral branch with the *medianoradialis*.

A. mediana communis divides near the middle of the forearm into the *mediana propria* and the smaller *medianoradialis*.

A. mediana propria gives off a stout lateral branch at the distal third of the forearm that passes toward the base of digit 5. This branch first receives the terminus of the *ulnaris volaris*, then two anastomotic twigs from the *ulnaris dorsalis*; finally it passes onto the palm, where it gives off the *metacarpea volaris* 5, then forms the ulnar end of the superficial volar arch.

The main trunk of the *mediana propria* forms the radial end of the superficial volar arch.

A. medianoradialis gives off the *carpeus volaris* at the carpus, then passes under the tendon of the *abductor pollicis longus* onto the back of the hand. On the dorsum it receives a delicate anastomotic loop from the *radialis superficialis*, gives off the *perforans pollicis* and the *carpeus dorsalis*, and then continues as the radial end of the deep dorsal arch.

The deep dorsal arch is complete and uninterrupted. It gives rise to *metacarpeae dorsales profundae* 1-5, of which 1 and 2 considerably exceed the others in caliber. The radial half of the arch exceeds the ulnar half in caliber; the second *perforans* is the largest.

A. ulnaris slightly exceeds the common interosseous in caliber. It divides almost immediately into dorsal and volar branches; the dorsal is slightly the larger (on the right arm the two branches of the *ulnaris* arise independently from the *mediana communis*).

The ulnaris volaris, besides giving off a large muscular twig, terminates by uniting with the lateral branch of the mediana propria; it thus contributes to the superficial volar arch, and indirectly via anastomotic twigs to the deep volar arch.

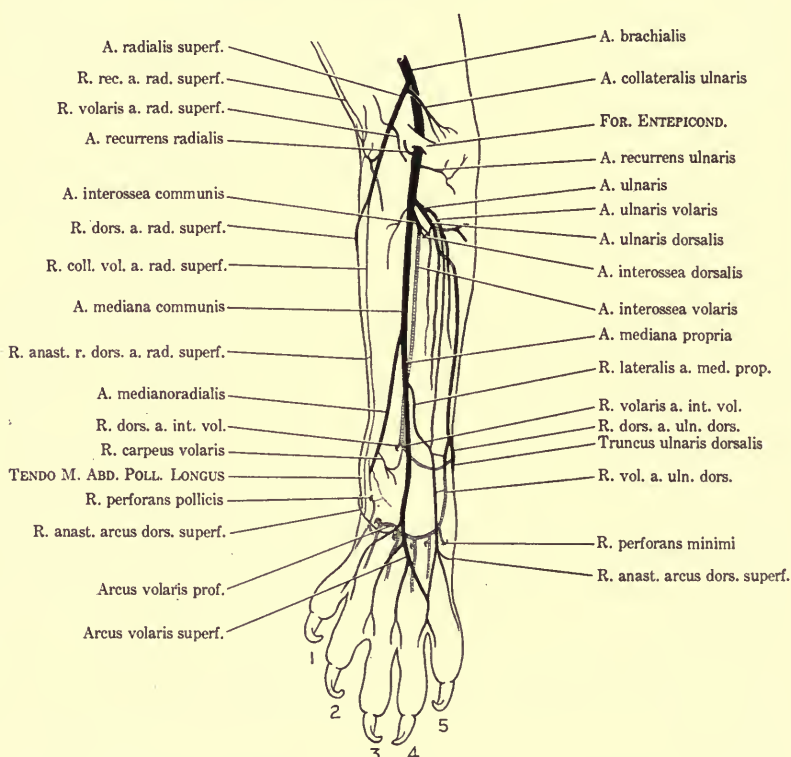


FIG. 20. Vessel pattern in *Potos flavus*; volar view.

The ulnaris dorsalis gives off a large muscular twig and a recurrent twig near its base. Near the carpus it divides into volar and dorsal branches. The volar branch forms the ulnar end of the deep volar arch. The dorsal branch gives off a strong transverse anastomotic branch to the volar interosseous, then passes onto the back of the hand, where it receives an anastomotic twig from the perforating branch of the volar interosseous, then continues distad to form the ulnar ends of both dorsal arches in addition to entering the dorsal carpal rete.

Aa. interossee arise by a short common trunk. The volar interosseous considerably exceeds the dorsal in caliber. It divides

into a volar and a dorsal branch at the proximal border of the carpus. The volar branch gives off a slender anastomotic twig to the R. carpeus volaris, then passes across the base of the carpus to terminate by anastomosing with the dorsal branch of the ulnaris

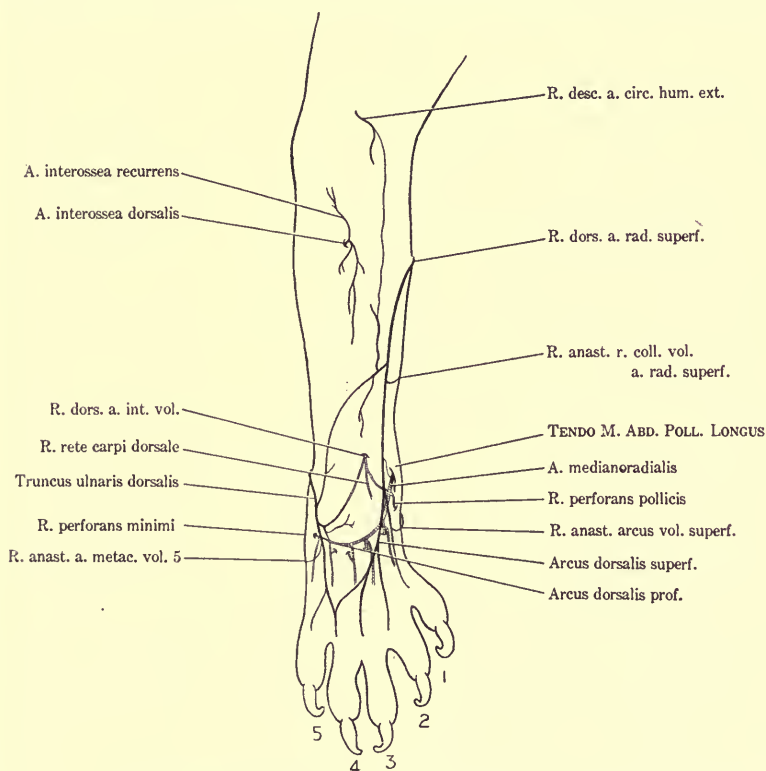


FIG. 21. Vessel pattern in *Potos flavus*; dorsal view.

dorsalis. The dorsal branch perforates through to the dorsum, where it sends one branch to the dorsal carpal rete, a second branch anastomosing with the dorsal branch of the ulnaris dorsalis.

The dorsal interosseous supplies the extensor muscles of the forearm.

AILURIDAE

LESSER PANDA (*Ailurus fulgens*)

(Figs. 22, 23)

A. brachialis gives off the superficial radial above the entepicondylar foramen, then detours around the foramen onto the fore-

arm. In the proximal quarter of the forearm the brachial trunk appears to bifurcate into the common median and a common trunk for the ulnaris and interossea.

A. radialis superficialis gives off twigs to the biceps before passing onto the forearm. The vessel fails to divide into dorsal and volar

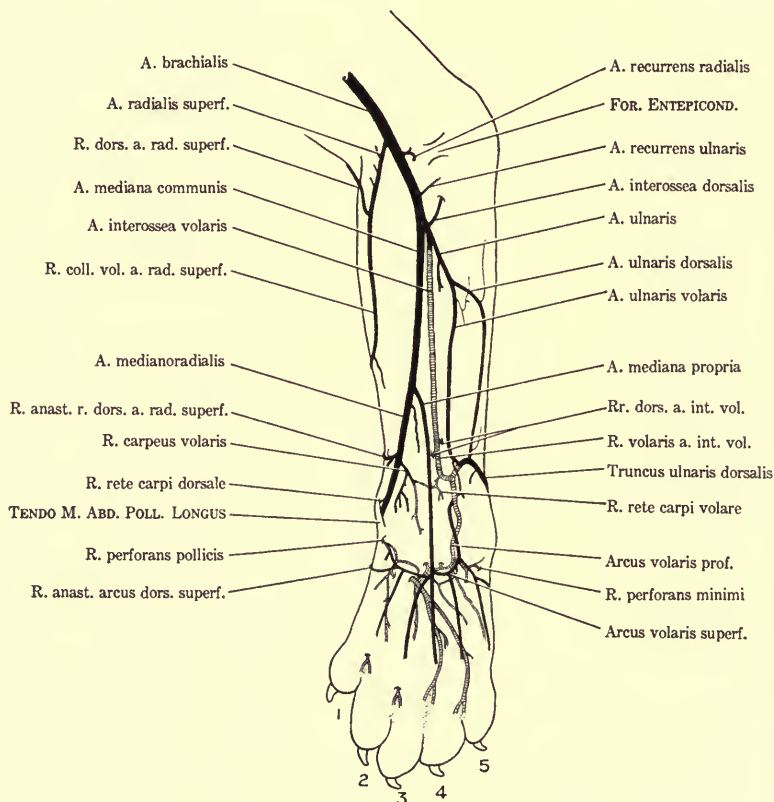


FIG. 22. Vessel pattern in *Ailurus fulgens*; volar view.

branches,¹ the entire system representing the dorsal branch of other carnivores (see also *Canis*). The trunk divides into dorsal (the dorsal divides again into a pair of vessels) and volar collateral branches in the proximal part of the forearm; these are reunited at the carpus. The dorsal collateral branch receives the descending circumflex humeral at the elbow. The reunited collateral vessels form the radial end of the superficial dorsal arch. One anastomotic

¹ This point was carefully checked in four arms.

loop near the base of the carpus connects with the medianoradialis, while a second, farther distad, enters the radial end of the superficial volar arch.

A. mediana communis divides at the distal third of the forearm into the slender *mediana propria* and the larger medianoradialis.

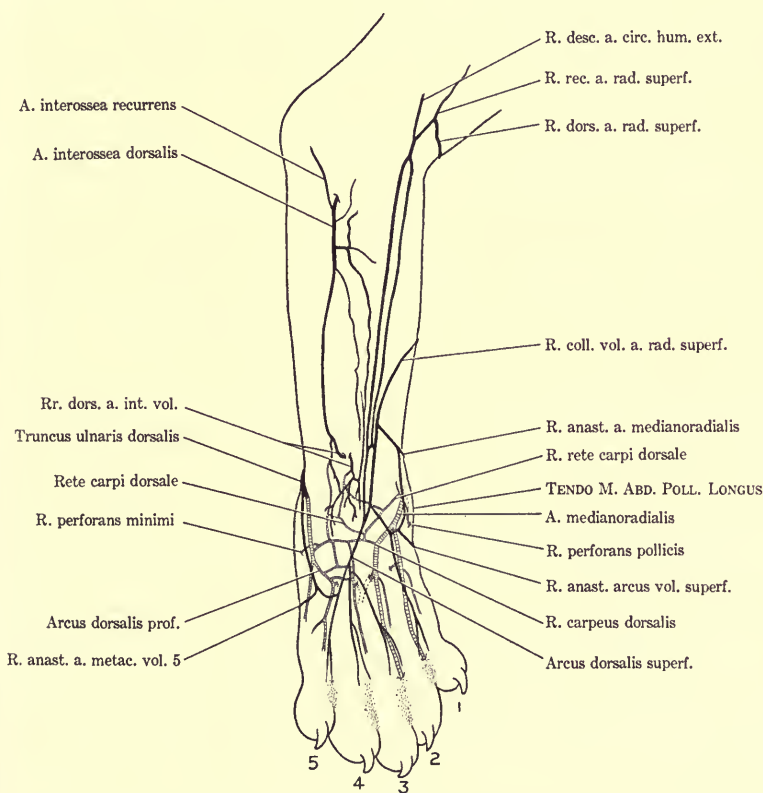


FIG. 23. Vessel pattern in *Ailurus fulgens*; dorsal view.

In one out of four arms the division took place slightly above the middle of the forearm.

A. mediana propria enters the middle of the superficial volar arch. The radial end of this arch is formed by the perforans pollicis and an anastomotic loop from the radialis superficialis, the ulnar end by the combined trunk of the interossea volaris and ulnaris volaris. The *mediana propria* is accompanied by a slender collateral branch.

A. medianoradialis passes under the tendon of the abductor pollicis longus onto the dorsum manus; the perforans pollicis is given off beneath the tendon, and is followed by two dorsal carpal twigs. The main trunk of the medianoradialis terminates by dividing into perforantes 1 and 2, of which 2 is the larger. Each of the latter gives off its corresponding deep dorsal metacarpal, and together they represent the radial half of the deep dorsal arch. The first metacarpea exceeds its perforating branch in caliber; the reverse is true of the second.

The deep dorsal arch is interrupted across the third metacarpal bone, but is otherwise complete and gives rise to all the deep dorsal metacarpals. The radial half of the arch considerably exceeds the ulnar half in caliber. The second perforating branch is the largest.

A. ulnaris is smaller than the interossea volaris. It divides at the proximal third of the forearm into a strong volar and a weaker dorsal branch (the volaris was the stronger in all four arms studied). The volaris terminates in the strong dorsal ulnar trunk arising from the interossea volaris; a branch from it also joins the main volar branch of the interossea volaris, thus contributing to both volar arches. The ulnaris dorsalis empties into the dorsal ulnar trunk.

Aa. interossee arise by a trunk common to them and the ulnaris. The interossea volaris considerably exceeds the dorsalis in caliber. It gives off a pair (in all four arms) of dorsal branches near the proximal border of the carpus, then continues as the volar branch. The latter, after giving off twigs to the volar carpal rete, divides to form a strong dorsal ulnar trunk into which both ulnars empty, and a main volar branch, which is joined by a branch from the ulnaris volaris, then continues to form the ulnar ends of both volar arches. Of the two dorsal branches of the interossea volaris, one is a recurrent branch that passes proximad to anastomose with the interossea dorsalis; the other ramifies to the dorsal carpal rete. The interossea dorsalis supplies the forearm extensors, terminating by anastomosing with the recurrent branch of the interossea volaris.

GIANT PANDA (*Ailuropoda melanoleuca*)¹

(Figs. 24, 25)

A. brachialis gives off the superficial brachial above the entepicondylar foramen, then detours around the foramen onto the fore-

¹ A more comprehensive description will appear in a forthcoming monograph on *Ailuropoda*, from which this description has been abstracted.

arm. The ulnar artery comes off at the proximal fifth of the forearm, followed immediately by the interosseae. Beyond this the main trunk continues as the *mediana communis*.

A. brachialis superficialis divides at its origin into a volar and a dorsal branch. The smaller volar branch supplies the flexors of the forearm. The dorsal branch gives off recurrent twigs to the flexors of the upper arm, then divides into a pair of collateral branches, which reunite at the carpus. One collateral branch perforates the brachioradialis to reach the dorsum of the forearm, where it passes to the carpus. The second collateral branch winds along the distal border of the brachioradialis onto the dorsum, where after receiving the first collateral branch it divides into its terminal twigs. One of these anastomoses with the dorsal branch of the interossea volaris; the other opens into an anastomotic branch of the medianoradialis, the resulting common trunk forming the radial end of the delicate superficial dorsal arch.

A. mediana communis divides a short distance above the carpus into the subequal *mediana propria* and medianoradialis.

A. mediana propria gives off a stout lateral branch at the carpus that passes to the outer side of digit 5. This branch first receives the terminus of the fine ulnaris volaris, then divides into superficial and deep twigs. The superficial twig gives off an anastomotic loop to the *mediana propria*, then passes to the outer border of digit 5 as the metacarpea volaris 5; the deep twig forms the ulnar end of the deep volar arch.

The main trunk of the *mediana propria* arches across the palm to form the stout superficial volar arch, from which arise the *digitales volares communes* 1-4. At its base this arch is connected by an anastomotic loop with the metacarpea volaris 5, and thus indirectly receives blood from the ulnaris volaris.

A. medianoradialis gives off the carpeus volaris at the carpus, followed immediately (while still on the vola) by an anastomotic loop to the radialis superficialis; the latter winds around the border of the hand to reach the dorsum. The medianoradialis then passes under the tendon of the abductor pollicis longus, where it gives off the perforans pollicis and the carpeus dorsalis and then continues as the radial end of the deep dorsal arch. A second perforans pollicis, arising from the vessel to the outer border of the pollex, perforates between the pollex and the radial sesamoid, near the distal end of the latter. This division was lower than in any other carnivore dissected.

The deep dorsal arch is complete and uninterrupted. It gives rise to metacarpeae dorsales profundae 1-4, which are subequal in caliber. The second perforans is the largest.

A. ulnaris is approximately the same diameter as the interossea volaris. Numerous muscular twigs greatly reduce its caliber as it

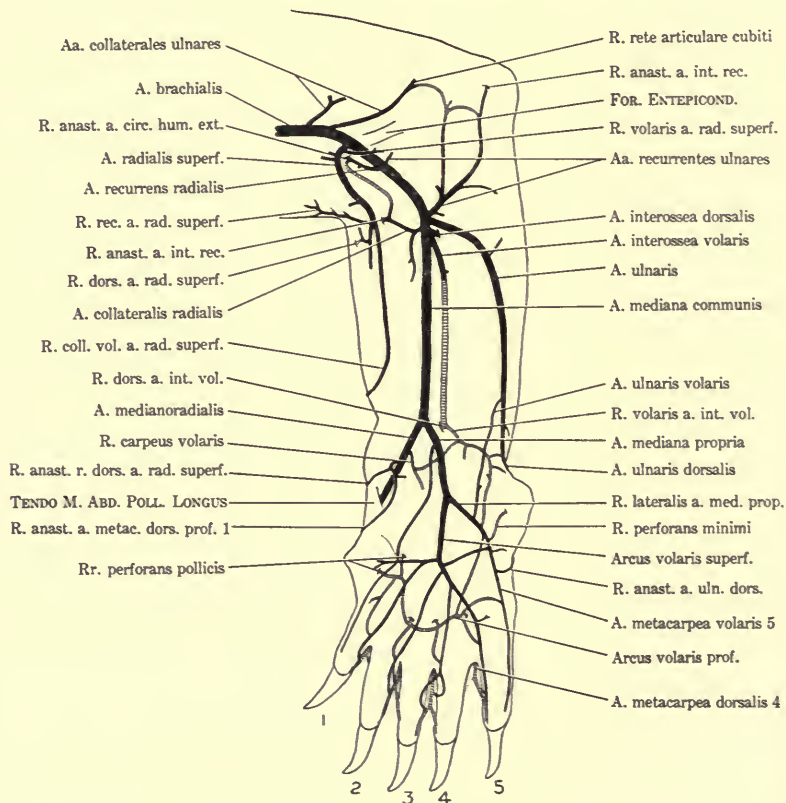


FIG. 24. Vessel pattern in *Ailuropoda melanoleuca*; volar view.

passes down the forearm. At the distal quarter of the forearm the greatly reduced trunk divides into a very delicate ulnaris volaris and a larger ulnaris dorsalis. The volaris unites with the lateral branch of the mediana propria; the resulting common trunk forms the metacarpea volaris 5 and the ulnar end of the deep volar arch, an anastomotic loop also connecting it with the superficial volar arch. On the dorsum manus the dorsalis gives off twigs to the dorsal carpal rete, then divides into a superficial branch, which

forms the ulnar end of the superficial dorsal arch, and a deep branch, which forms the ulnar end of the deep dorsal arch.

Aa. interosseae arise together, but without the intervention of a common trunk. They are subequal in size. The volaris divides into a volar and a dorsal branch at the proximal border of the carpus.

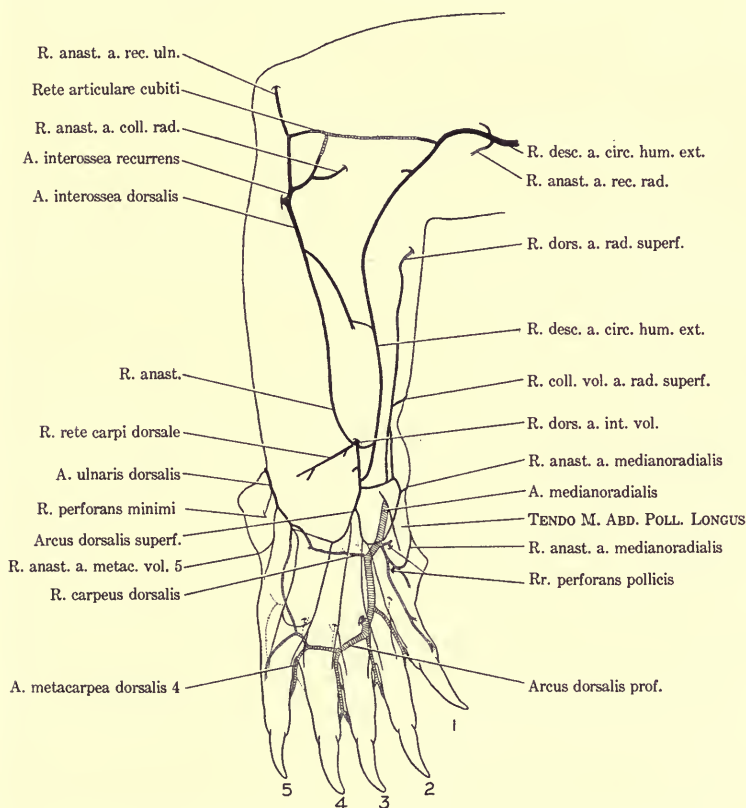


FIG. 25. Vessel pattern in *Ailuropoda melanoleuca*; dorsal view.

The volar branch gives off an anastomotic twig to the carpeus volaris, then passes toward the ulnar side of the carpus, sending a twig to the volar carpal rete and terminating by anastomosing with a branch of the mediana propria by one twig and with the ulnaris dorsalis by a second. The dorsal branch perforates through to the dorsum. Here it first gives off a stout twig to the dorsal carpal rete that receives the terminus of the interossea dorsalis at its base, then receives the terminus of the descending external circumflex

humeral and the dorsal collateral branch of the brachialis superficialis. The dorsal branch terminates by entering the middle of the superficial dorsal arch.

The interossea dorsalis perforates to the dorsum near the elbow. Here it gives off a stout recurrent branch before passing distad. One of two terminal twigs anastomoses with the dorsal branch of the interossea volaris; the other empties into the descending circumflex humeral.

URSIDAE

AMERICAN BLACK BEAR (*Euarctos americanus*)

(Figs. 26, 27)

A. brachialis gives off the superficial radial above the elbow. The large ulnar recurrent arises just below the elbow, followed a few millimeters farther distad by the ulnar and common interosseous, which arise from a common center. Beyond this the vessel continues as the *mediana communis*.

A. radialis superficialis divides almost at once into volar and dorsal branches. The smaller volar branch supplies the flexors of the forearm. The dorsal branch gives off a threadlike volar collateral twig that accompanies *N. cutaneus antibrachii lateralis*, terminating just below the distal third of the forearm by emptying into the medianoradialis. Upon reaching the dorsum the dorsal branch gives off a recurrent twig to the flexors of the upper arm, immediately beyond which it receives the extremely delicate descending circumflex humeral. It also receives a stout anastomotic branch from the dorsal interosseous at the middle of the forearm, then continues onto the back of the hand. Here it forms the extremely delicate superficial dorsal arch with the *ulnaris dorsalis*. A fine anastomotic twig at the carpus connects the superficial radial with the medianoradialis.

A. mediana communis divides at the distal third of the forearm into the *mediana propria* and the medianoradialis. The *mediana propria* slightly exceeds the medianoradialis in caliber.

A. mediana propria gives off a stout lateral branch just above the carpus that passes to the outer side of digit 5. This branch first receives the terminus of the *ulnaris volaris*. It then gives off a dorsal twig that winds around the distal end of the ulna, receiving the terminus of the *ulnaris dorsalis*, to form the ulnar ends of both dorsal arches. Immediately beyond the origin of this dorsal twig the main lateral vessel divides, one resulting twig forming the ulnar end of the deep volar arch, while the other passes to the outer border

of digit 5 as *A. metacarpea volaris* 5. The latter is connected with the *mediana propria* by an anastomotic loop that extends across the palm; this loop represents the ulnar end of the superficial volar arch.

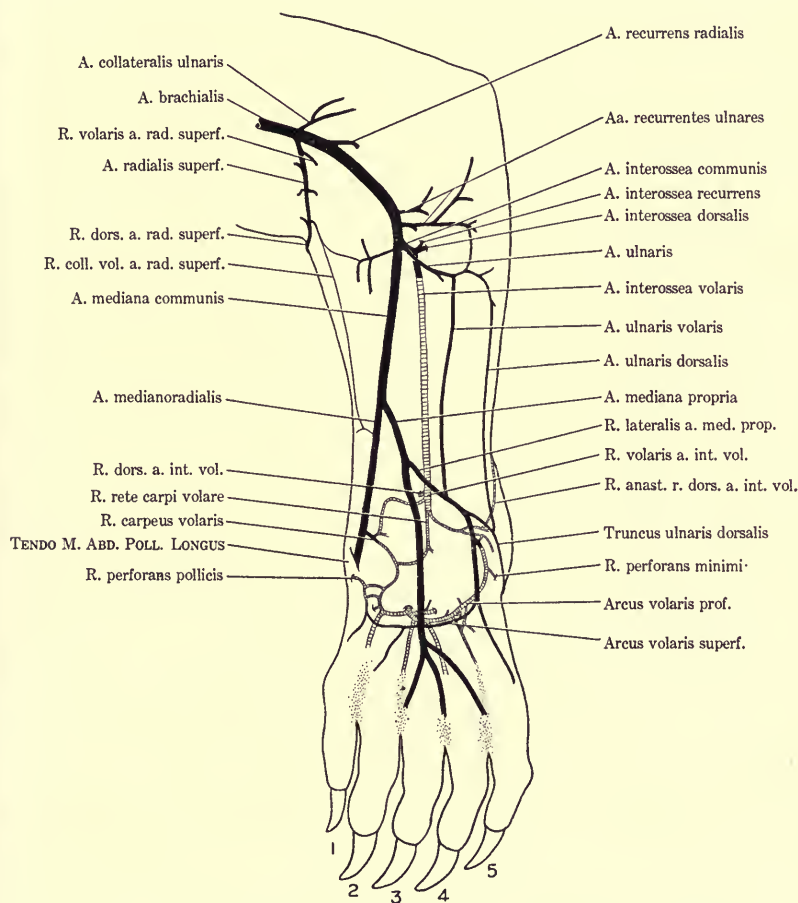


FIG. 26. Vessel pattern in *Euarcotus americanus*; volar view.

The main trunk of the *mediana propria* gives off a slender transverse anastomotic loop to the perforating branch of the *medianoradialis*; the slender *metacarpea volaris superficialis* 1 arises from this loop. The trunk then breaks up into *metacarpeae volares superficiales* 2-4.

A. medianoradialis gives off the *carpeus volaris* at the carpus, then passes under the tendon of the *abductor pollicis longus* onto

the dorsum manus, where, after receiving an anastomotic loop from the radialis superficialis, it gives off the perforans pollicis and several threadlike dorsal carpal twigs. The medianoradialis terminates by dividing into perforantes 1 and 2, of which 2 is the larger. The first

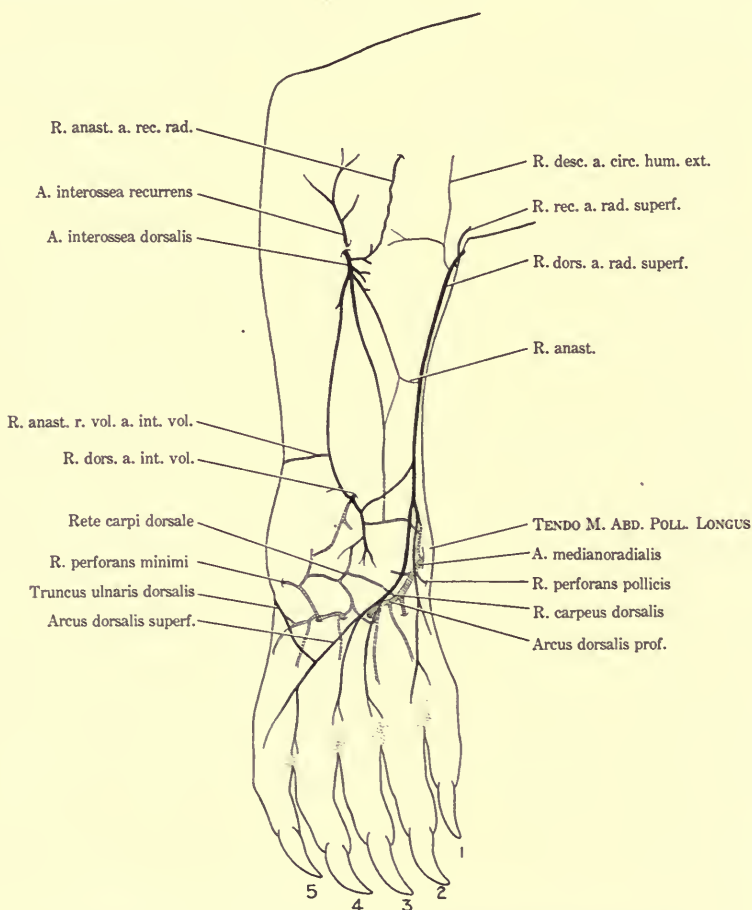


FIG. 27. Vessel pattern in *Euarctos americanus*; dorsal view.

deep dorsal metacarpal arises from the trunk independently of its perforating branch in one of three feet studied.

The deep dorsal arch is interrupted across the third metacarpal, but is bridged even here by a slender loop, connected with the dorsal carpal rete, that runs from perforans 3 to metacarpea dorsalis pro-

funda 2. The radial half of the arch is the larger, and the second perforans is the largest.

A. ulnaris is the smallest of the main arteries of the forearm. It divides just above the middle of the forearm into a volar and a dorsal branch, of which the volar is the larger. Both of these pass distad on the volar side of the forearm. The ulnaris volaris unites with the lateral branch of the mediana propria; the resulting common trunk forms the metacarpea volaris 5 and the ulnar end of the deep volar arch, an anastomotic loop also connecting it with the superficial volar arch. The ulnaris dorsalis unites with the dorsal twig of the mediana propria, and the resulting common trunk contributes to both dorsal arches.

Aa. interossee arise by a short common trunk. The interossea volaris considerably exceeds the dorsalis in caliber. It divides into volar and dorsal branches at the proximal border of the carpus. The volar branch gives off a slender anastomotic twig to the carpeus volaris, then continues into the volar carpal rete; the dorsal branch perforates through, to ramify to the dorsal carpal rete. The interossea dorsalis supplies the extensor muscles, terminal twigs anastomosing with the radialis superficialis at the middle of the forearm, and with the dorsal interossea volaris.

A second individual, a litter mate of the preceding one, differed from it in two points only. *A. radialis superficialis* was stronger, corresponding more closely with the caliber of this vessel in the specimens of *Ursus middendorffi* dissected. *A. ulnaris* divided into volar and dorsal branches just beyond its origin instead of near the middle of the forearm.

KODIAK BEAR (*Ursus middendorffi*, new-born)

A. brachialis gives off the superficial radial by a very short common trunk with the ulnaris collateralis (both arms) that arises above the elbow. The large radial recurrent arises immediately below the elbow, followed by the ulnar recurrent, the ulnar, and the common interosseous, all of which arise from a common center. Beyond this the vessel continues as the mediana communis.

A. radialis superficialis divides shortly beyond its origin into a volar and a dorsal branch. The smaller volar branch supplies the flexors of the forearm. The dorsal branch gives off a threadlike volar collateral twig that accompanies *N. cutaneus antibrachii lateralis*, reuniting with the main dorsal branch at the carpus. Upon

reaching the dorsum the dorsal branch gives off a recurrent twig to the flexors of the upper arm that receives the delicate descending circumflex humeral. A threadlike twig from the descending circumflex humeral continues down to the middle of the forearm, where it receives a slender anastomotic loop from the interossea dorsalis before entering the radialis superficialis. The main trunk continues onto the back of the hand, where it forms the extremely delicate superficial dorsal arch with the dorsal ulnar. A fine anastomotic twig at the carpus connects the superficial radial with the medianoradialis.

A. mediana communis divides at the distal third of the forearm into the mediana propria and the slightly larger medianoradialis.

A. mediana propria gives off a stout lateral branch at the proximal border of the carpus that passes to the outer border of digit 5. This branch first receives the terminus of the ulnaris volaris, then divides into superficial and deep twigs. The superficial twig gives off an anastomotic loop to the mediana propria, then passes to the outer border of digit 5 as the metacarpea volaris 5; the deep twig receives a fine anastomotic loop from the interossea volaris, then forms the ulnar end of the deep volar arch.

The main trunk of the mediana propria receives an anastomotic loop from the volar branch of the medianoradialis, then arches across the palm to form the stout superficial volar arch, from which arise the digitales volares communes 2-4; a fine twig is also sent to the first intermetacarpal space, which accompanies the larger true digitalis volaris communis 1 coming from the volar branch of the medianoradialis.

A. medianoradialis gives off the carpeus volaris at the carpus. At the same level it gives off a slender volar branch that forms the radial ends of both volar arches. The main trunk of the medianoradialis passes under the tendon of the abductor pollicis longus onto the back of the hand, where, after receiving an anastomotic loop from the radialis superficialis, it gives off the perforans pollicis and several dorsal carpal twigs. The trunk of the medianoradialis then continues as the radial end of the deep dorsal arch.

The deep dorsal arch is complete and uninterrupted. It gives rise to metacarpeae dorsales profundae 1-5, and each of the first four of these receives a perforating branch at or near its base. The second perforating branch is the largest, but only slightly exceeds the first; both of these greatly exceed the third and fourth in caliber.

A. ulnaris is much smaller than the interossea volaris. It divides a short distance beyond its origin into volar and dorsal branches.

The volar branch, which considerably exceeds the dorsal in caliber, terminates in the lateral branch of the mediana propria. The slender dorsalis passes distad along the ulnar border of the forearm, receiving a transverse anastomotic loop from the interossea volaris at the middle of the forearm, and terminal twigs of the interossea volaris farther distad, and at the carpus winding onto the dorsum to form the ulnar end of the superficial dorsal arch.

Aa. interossee arise by a powerful short common trunk that equals the mediana communis in caliber. The volaris greatly exceeds the dorsalis in caliber. It gives off an anastomotic loop to the ulnaris dorsalis at the middle of the forearm, then divides into volar and dorsal branches near the proximal border of the carpus. The volar branch splits immediately, one twig forming an anastomotic loop with the carpeus volaris from which arise twigs to the volar carpal rete, while the second twig breaks up into twigs that go to the ulnaris dorsalis and the common trunk formed by the ulnaris volaris and the lateral branch of the mediana propria. The dorsal branch perforates through, receiving the fair-sized descending terminal twig of the interossea dorsalis, then giving off a threadlike anastomotic loop to the radialis superficialis, and terminating in the dorsal carpal rete.

The interossea dorsalis perforates to the dorsum in the proximal part of the forearm. Here it gives off a stout recurrent branch to the elbow, then runs distad to terminate by anastomosing with the recurrent branch of the dorsal interossea volaris. A slender anastomotic loop unites it with the radialis superficialis near the middle of the forearm.

A second specimen of *Ursus middendorffi* (a litter mate of the preceding one) differed from the first only in three very minor particulars. The dorsal and volar branches of the radialis superficialis arose independently (on both arms) instead of by the usual common trunk. In the medianoradialis the carpeus volaris and volar medianoradialis arose by a short common trunk, instead of side by side; and the metacarpea dorsalis profunda 1 came off the deep dorsal arch independently of its corresponding perforating branch.

MUSTELIDAE

FERRET (*Mustela putorius*)

(Figs. 28, 29)

A. brachialis gives off the superficial radial above the entepicondylar foramen by a trunk common to it and the ulnar collateral,

then accompanies the median nerve through the foramen. The radial recurrent arises immediately below the foramen, followed by the ulnar recurrent. A common trunk for the ulnar and dorsal interosseous comes off at about the proximal quarter of the forearm,

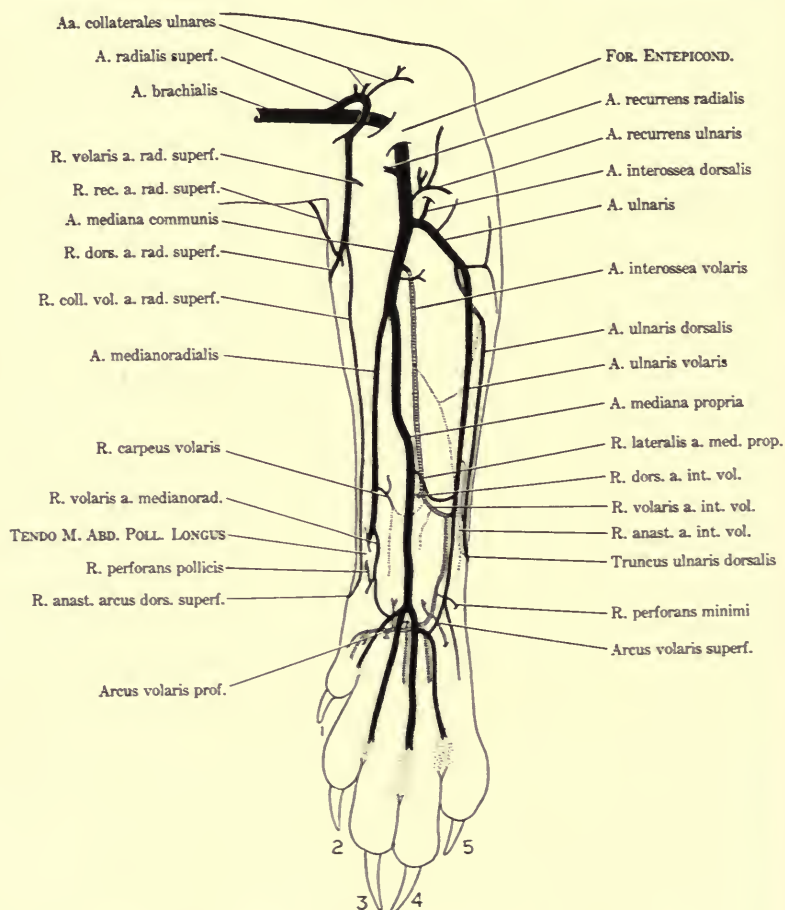


FIG. 28. Vessel pattern in *Mustela putorius*; volar view.

followed a few millimeters farther distad by the interossea volaris. On the left leg the ulnar and interosseae arise by a common trunk. Beyond this the main trunk continues as the mediana communis.

A. radialis superficialis divides shortly beyond its origin into a volar and a dorsal branch. The much smaller volar branch supplies the flexors of the forearm. The dorsal branch divides into dorsal and volar

collateral branches, which reunite at the carpus, then pass to the superficial dorsal arch. The larger dorsal collateral branch gives off two recurrent twigs to the pectoral muscles and the flexors of the upper arm, one of which receives the terminus of the descending

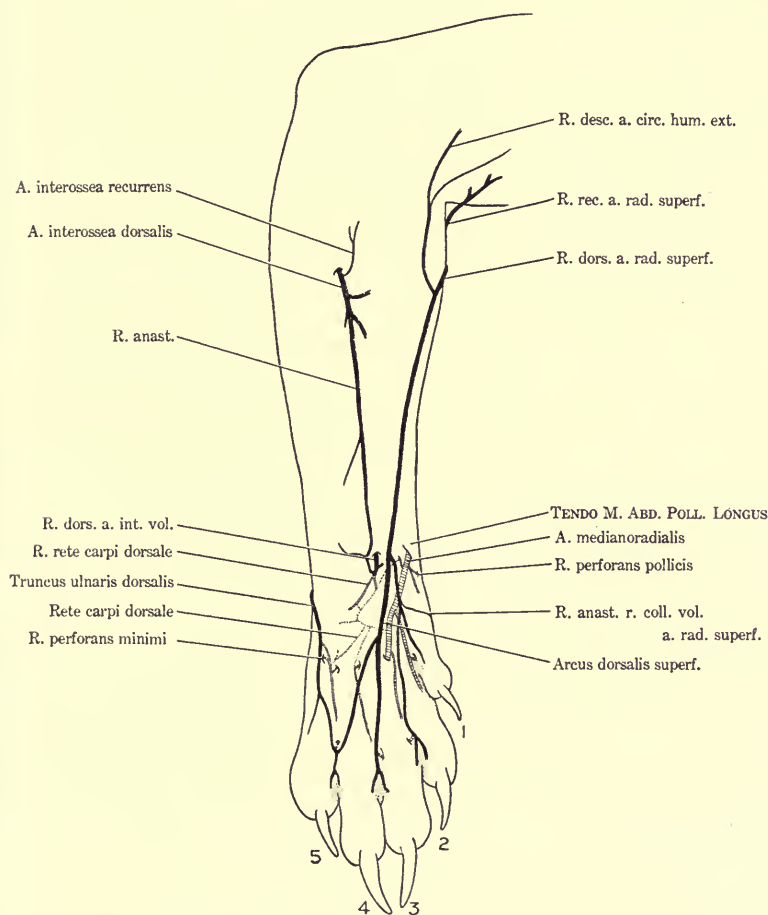


FIG. 29. Vessel pattern in *Mustela putorius*; dorsal view.

external circumflex humeral. The resulting common trunk forms the radial end of the superficial dorsal arch. A fine anastomotic twig at the carpus connects the main dorsal branch with the medianoradialis.

A. mediana communis divides just above the middle of the forearm into the mediana propria and the somewhat smaller medianoradialis.

A. mediana propria terminates in the middle of the superficial volar arch, and is the chief source of this arch. The radial end of this arch is formed by the volar medianoradialis, the ulnar end by the common trunk of the ulnaris volaris and interossea volaris.

A. medianoradialis gives off the carpeus volaris, then divides at the base of the carpus into a dorsal branch and a slender volar branch. The volar branch forms the radial end of the superficial volar arch. The dorsal branch passes under the tendon of the abductor pollicis longus onto the back of the hand, where, after receiving an anastomotic twig from the radialis superficialis, it gives off the perforans pollicis and carpeus dorsalis, then terminates as the powerful perforans 2.

There is no deep dorsal arch; all the deep dorsal metacarpals (except the feeble second one which arises directly from perforans 2) are the direct continuations of the corresponding volar perforating branches, each receiving a slender twig from the dorsal carpal rete. The second perforating branch is much the largest.

A. ulnaris slightly exceeds the volar interosseous in caliber. It divides into volar and dorsal branches slightly above the proximal third of the forearm. The larger ulnaris volaris gives off an anastomotic loop to the ulnaris dorsalis, then receives an anastomotic twig from the mediana propria; the resulting common trunk forms the ulnar end of the superficial volar arch and participates in the formation of the deep volar arch. The ulnaris dorsalis, in addition to the anastomotic loop from the ulnaris volaris, is connected with the interossea volaris by several threadlike anastomotic loops. It winds onto the dorsum, where it forms the ulnar ends of both dorsal arches.

Aa. interossee arise independently on the right leg, and by a common trunk on the left. The interossea dorsalis is slightly smaller than the volaris. It perforates to the dorsum, where it ramifies to the extensors, a twig descending to anastomose with the interossea volaris at the carpus. The interossea volaris gives off a delicate anastomotic loop to the ulnaris dorsalis, then divides into volar and dorsal branches at the proximal border of the carpus. The volar branch receives a short stout anastomotic branch from the ulnaris volaris, then passes to the metacarpus where it forms the ulnar end of the deep volar arch; the radial end of the arch is formed by the main (second) perforating branch of the medianoradialis. This arch, in addition to giving off the metacarpeae volares profundae 1-4, gives rise to three perforating branches that pass through

the first, third, and fourth intermetacarpal spaces to enter the deep dorsal arch. The dorsal branch perforates through to the dorsum, where it terminates in the dorsal carpal rete in addition to receiving the descending twig of the interossea dorsalis.

WEASEL (*Mustela noveboracensis*)

A. brachialis gives off the superficial radial and ulnar collateral above the entepicondylar foramen, then accompanies the median nerve through the foramen. The radial recurrent arises immediately below the foramen, followed by the ulnar recurrent. The ulnaris volaris arises at the proximal fifth of the forearm, followed by a common trunk for the ulnaris dorsalis and interossea dorsalis. The interossea volaris arises independently a short distance farther distad. Beyond this the main trunk continues as the *mediana communis*.

A. radialis superficialis divides shortly beyond its origin into a volar and a dorsal branch. The smaller volar branch supplies the flexors of the forearm. The dorsal branch divides into a pair of collateral branches, the smaller of which remains on the volar surface of the forearm; these two branches reunite at the carpus, then pass to the superficial dorsal arch. The larger dorsal collateral branch gives off two recurrent twigs to the pectoral muscles and the flexors of the upper arm, one of which receives the terminus of the descending external circumflex humeral. The resulting common trunk forms the radial end of the superficial dorsal arch. A fine anastomotic twig at the carpus connects the main dorsal branch with the *medianoradialis*.

A. mediana communis divides some distance below the middle of the forearm into the *mediana propria* and the slightly smaller *medianoradialis*.

A. mediana propria terminates in the middle of the superficial volar arch, and is the chief source of this arch. The radial end of the arch is formed by the volar *medianoradialis*, the ulnar end by a common trunk formed by the combined ulnars and the interossea volaris.

A. medianoradialis gives off the *carpeus volaris*, then passes under the tendon of the *abductor pollicis longus* onto the back of the hand. Here it immediately gives off the *perforans pollicis*, then receives an anastomotic loop from the *radialis superficialis*, finally giving off the *carpeus dorsalis* before terminating as the powerful *perforans* 2. There is no deep dorsal arch; all the deep dorsal

metacarpals (except the feeble second one which arises directly from perforans 2) are the direct continuations of the corresponding volar perforating branches, each receiving a slender twig from the dorsal carpal rete. The second perforating branch is much the largest.

Aa. ulnares.—The dorsal and volar ulnars arise independently. The ulnaris volaris receives a strong anastomotic branch from the ulnaris dorsalis, the anastomotic branch exceeding the trunk of the ulnaris volaris itself in caliber, and then a slender anastomotic loop composed of combined twigs from the mediana propria and interossea volaris. The resulting common trunk forms the ulnar end of the superficial volar arch and participates in the formation of the deep volar arch. The ulnaris dorsalis divides at the distal third of the forearm into a strong anastomotic branch that goes to the ulnaris volaris and a branch that winds onto the dorsum of the hand. The latter, which receives an anastomotic twig from the interossea volaris, forms the ulnar ends of both dorsal arches.

Aa. interossee arise independently. The interossea dorsalis is slightly smaller in caliber than the volaris. It perforates to the dorsum, where it ramifies to the extensors; one twig descends to anastomose with the interossea volaris at the carpus, and a delicate anastomotic loop passes from this twig across to the ulnaris dorsalis. The interossea volaris divides into volar and dorsal branches at the proximal border of the carpus. The volar branch gives off a stout anastomotic branch to the ulnaris volaris, then passes to the metacarpus where it forms the ulnar end of the deep volar arch; the radial end of the arch is formed by the main (second) perforating branch of the medianoradialis. This arch, in addition to giving off the metacarpeae volares profundae 1-4, gives rise to three perforating branches that pass through the first, third, and fourth intermetacarpal spaces to enter the deep dorsal arch. The dorsal branch perforates through to the dorsum, where it terminates in the dorsal carpal rete in addition to receiving the descending twig of the interossea dorsalis.

TAYRA (*Tayra barbara*)

(Figs. 30, 31)

A. brachialis gives off the superficial brachial above the entepicondylar foramen, then accompanies the median nerve through the foramen. The brachial vein does not pass through the foramen. The ulnar and radial recurrents arise opposite each other immediately below the foramen, and a second ulnar recurrent is given off farther

distad. The ulnar artery comes off at the proximal quarter of the forearm, followed by the common interosseous. Beyond this the main trunk continues as the *mediana communis*.

A. brachialis superficialis divides shortly beyond its origin into a volar and a dorsal branch. The smaller volar branch supplies the flexors of the forearm, one twig descending toward the carpus to anastomose with a twig from the *mediana propria*. The dorsal branch breaks up into collateral branches upon reaching the forearm. One of these perforates through to the dorsum at the middle of the forearm, then joins the second collateral branch. A second collateral branch also perforates through to the dorsum, and after receiving the first collateral branch and a twig from the third, terminates in the dorsal branch of the *interossea volaris*. The third and largest collateral branch gives off recurrent twigs to the flexors of the upper arm; the largest of these receives an anastomotic twig from the delicate descending external circumflex humeral. In the proximal part of the forearm the collateral branch gives off a fine collateral twig that joins the descending circumflex humeral, the resulting delicate trunk opening into the superficial dorsal arch; the main superficial brachial trunk forms the radial end of the superficial dorsal arch.

A. mediana communis divides at the middle of the forearm into the *mediana propria* and the somewhat smaller medianoradialis.

A. mediana propria gives off a stout branch at the distal quarter of the forearm that passes to the outer side of digit 5. This branch first receives the terminus of the *ulnaris volaris*, then gives off an anastomotic branch that runs to the ulnar border of the ulno-carpal articulation where it anastomoses with the terminus of the volar branch of the *ulnaris dorsalis* and sends a fine twig onto the carpus that anastomoses with the dorsal branch of the *ulnaris dorsalis* and the volar branch of the *interossea volaris*. Immediately beyond the origin of the foregoing anastomotic branch the main vessel divides, one resulting twig forming the ulnar end of the deep volar arch, while the other passes to the base of the fifth metacarpal where it divides into the *metacarpea volaris* 5 and a twig that forms the ulnar end of the superficial volar arch.

The main trunk of the *mediana propria* terminates in the middle of the superficial volar arch, and is the chief source of this arch. The radial end of the arch is formed by the fine first perforating branch of the medianoradialis, the ulnar end by the lateral branch of the *mediana propria*.

A. medianoradialis gives off the carpeus volaris, then passes under the tendon of the abductor pollicis longus onto the dorsum manus. On the dorsum, after receiving an anastomotic loop from the radialis superficialis, it gives off the perforating pollicis and several dorsal carpal twigs. The medianoradialis terminates by dividing into perforantes 1 and 2, of which 2 is much the larger.

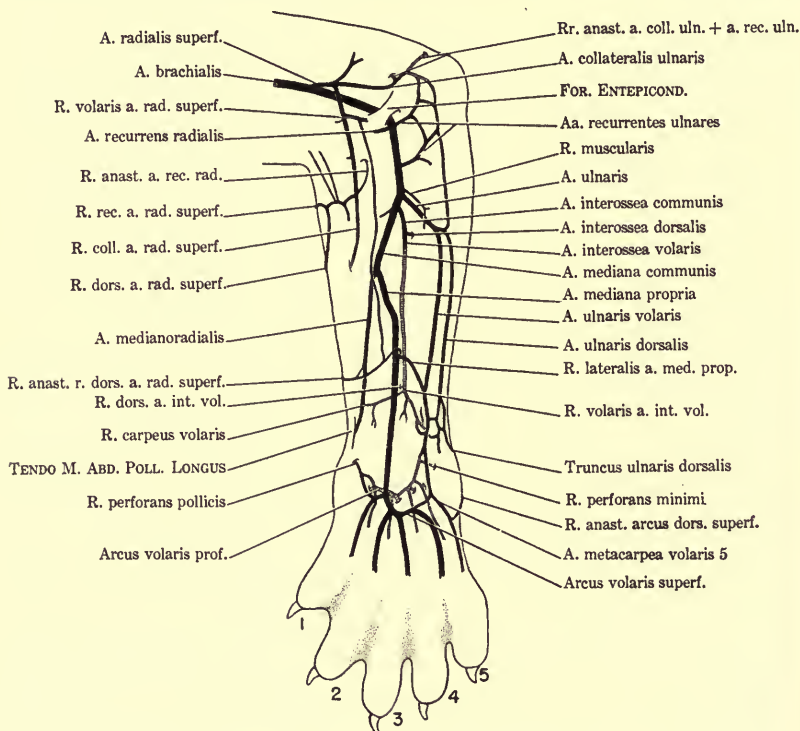


FIG. 30. Vessel pattern in *Tayra barbara*; volar view.

Each of the latter gives off its corresponding deep dorsal metacarpal and together they represent the radial half of the deep dorsal arch.

The deep dorsal arch is interrupted across the third metacarpal bone, but is otherwise complete and gives rise to all the deep dorsal metacarpals. The radial half of the arch considerably exceeds the ulnar half in caliber. The second perforating branch is the largest.

A. ulnaris exceeds the common interosseous in caliber. It divides into volar and dorsal branches at the proximal third of the forearm, of which the volaris is slightly the larger. The ulnaris

volaris terminates in the lateral branch of the mediana propria. The ulnaris dorsalis divides into dorsal and volar branches near the carpus. The volar branch enters the lateral branch of the mediana propria and the dorsal carpal rete, while the dorsal branch forms the ulnar ends of both dorsal arches, in addition sending a twig into the dorsal carpal rete.

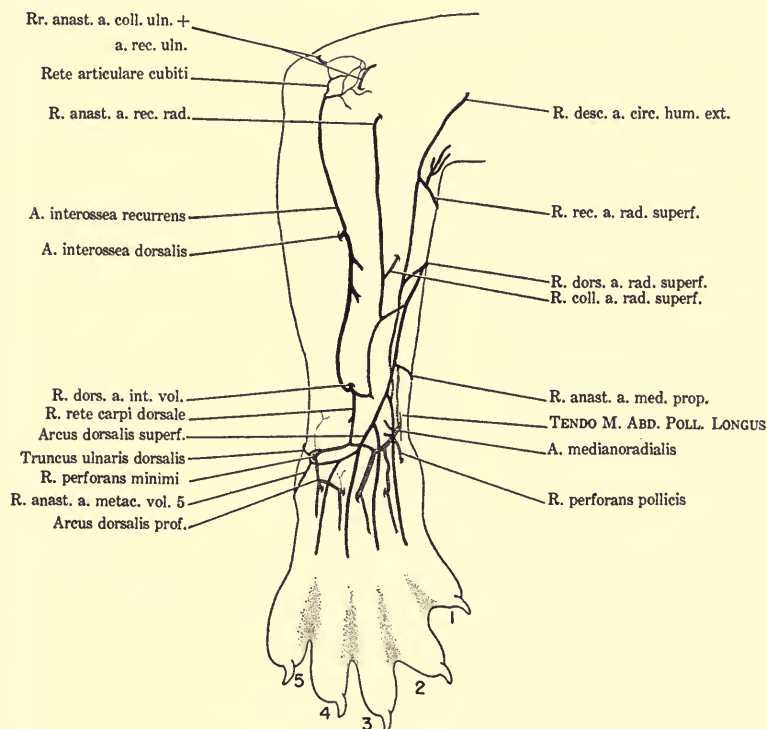


FIG. 31. Vessel pattern in *Tayra barbara*; dorsal view.

Aa. interossee arise by a common trunk. The volaris considerably exceeds the dorsalis in caliber. The interossea dorsalis immediately perforates to the dorsal side of the forearm, where it ramifies to the extensor muscles, terminating near the carpus by anastomosing with the dorsal branch of the interossea volaris. The interossea volaris divides into volar and dorsal branches near the carpus. The volar branch immediately gives off an anastomotic twig to the R. carpeus volaris, then twigs to the volar carpal rete, a strong anastomotic twig to the lateral branch of the mediana propria, and another to the ulnaris dorsalis. The dorsal branch

sends one anastomotic twig back to the interossea dorsalis, another back to the brachialis superficialis, and a smaller twig into the dorsal carpal rete.

AMERICAN BADGER (*Taxidea taxus*)

(Figs. 32, 33)

A. brachialis gives off the superficial radial just above the entepicondylar foramen, then accompanies the median nerve through the

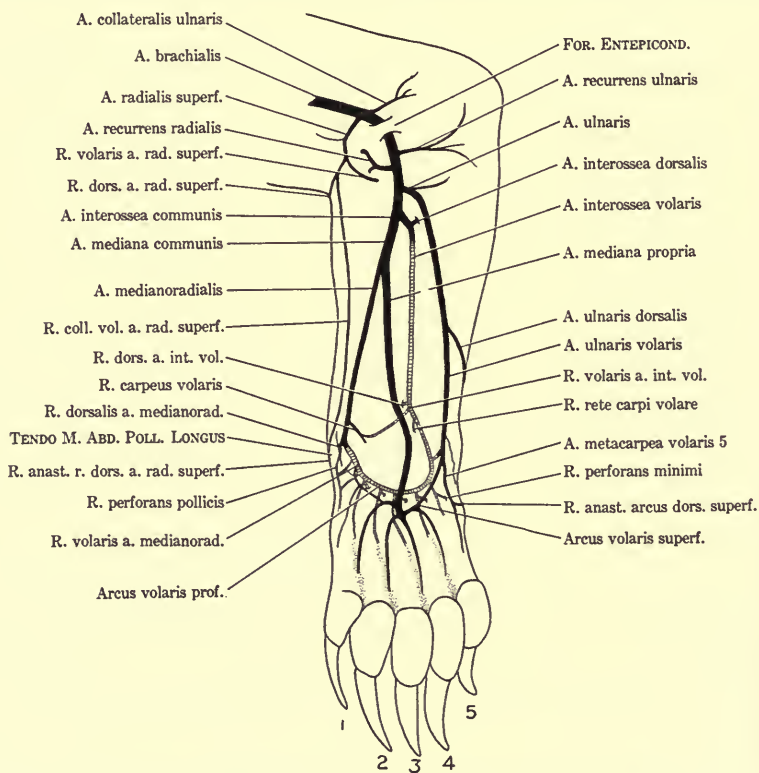


FIG. 32. Vessel pattern in *Taxidea taxus*; volar view.

foramen. The ulnar recurrent arises immediately below the foramen, the radial recurrent slightly distad. The ulnar artery comes off at the proximal quarter of the forearm, followed 3 mm. farther distad by the common interosseous. Beyond this the main trunk continues as the mediana communis.

A. radialis superficialis divides shortly beyond its origin into a volar and a dorsal branch. The much larger volar branch supplies

the flexors of the forearm. The dorsal branch divides into a pair of collateral branches, which pass to the superficial dorsal arch. The larger collateral branch interanastomoses with the descending branch of the external circumflex humeral at the carpus, to form the superficial dorsal arch with it. A fine anastomotic twig at the carpus connects the main dorsal branch with the medianoradialis, and the smaller collateral dorsal branch terminates in this.

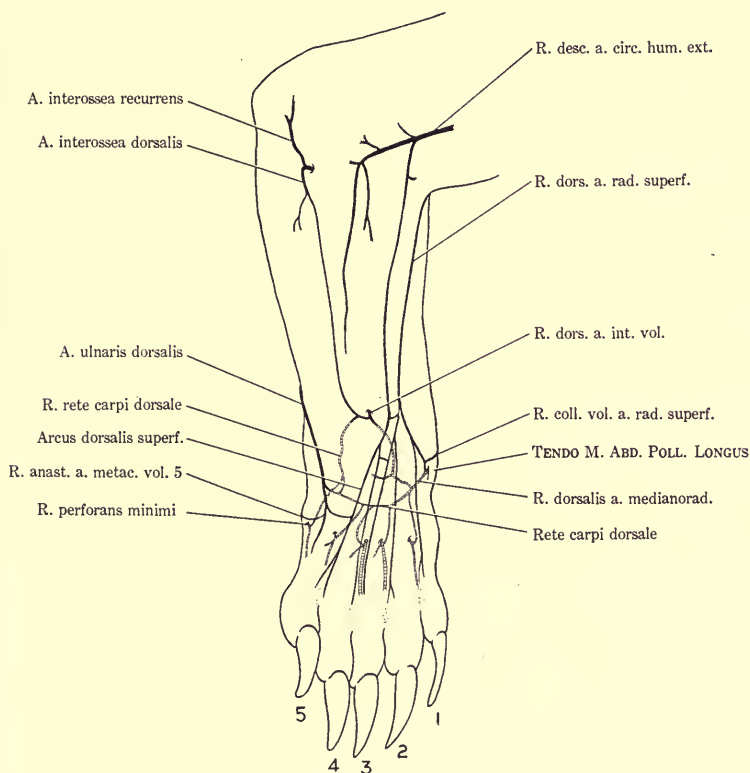


FIG. 33. Vessel pattern in *Taxidea taxus*; dorsal view.

A. mediana communis divides a short distance above the middle of the forearm into the mediana propria and the somewhat smaller medianoradialis.

A. mediana propria terminates in the middle of the superficial volar arch, and is the chief source of this arch. The radial end of the arch is formed by the volar branch of the medianoradialis, the ulnar end by the ulnaris volaris.

A. medianoradialis gives off the carpeus volaris, then divides at the base of the carpus into a slender dorsal and a much larger volar branch. The volar branch forms the radial ends of both volar arches. The perforans pollicis arises from the dorsal branch before the latter passes under the tendon of the abductor pollicis longus (hence on the *volar* side); it passes through the notch between the outer borders of the scapholunar and the trapezium, joining twigs from both volar arches to form the artery for the outer border of the pollex.

On the dorsum manus the dorsal branch receives an anastomotic loop from the radialis superficialis, then terminates in the dorsal carpal rete without forming a powerful perforans 2.

There is no deep dorsal arch; all the deep dorsal metacarpals are the direct continuations of the corresponding volar perforating branches, each receiving a slender twig from the dorsal carpal rete. The second and third deep dorsal metacarpals exceed the others in caliber.

A. ulnaris slightly exceeds the volar interosseous in caliber. It divides into volar and dorsal branches near the middle of the forearm. The larger ulnaris volaris gives off a short anastomotic twig to the volar interosseous at the carpus, then gives off *A. metacarpea volaris* 5, and forms the ulnar end of the superficial volar arch. An anastomotic twig from *A. metacarpea volaris* 5 passes around the outer border of the hand to the ulnaris dorsalis. The ulnaris dorsalis forms the ulnar ends of both dorsal arches.

Aa. interosseae arise by a short common trunk. The volar interosseous considerably exceeds the dorsal in caliber. The interossea dorsalis immediately perforates to the dorsal side of the forearm, where it ramifies to the extensor muscles. Near the carpus it anastomoses with the dorsal branch of the interossea volaris. The interossea volaris divides into volar and dorsal branches near the carpus. The volar branch immediately gives off an anastomotic twig to the *R. carpeus volaris*, then a twig to the rete carpi volare; after receiving a short stout anastomotic branch from the ulnaris volaris the trunk terminates as the ulnar end of the deep volar arch. The dorsal branch ramifies to the dorsal carpal rete, in addition to sending an anastomotic twig back to the interossea dorsalis.

SKUNK (*Mephitis mesomelas*)

A. brachialis gives off the superficial radial just above the elbow (the entepicondylar foramen is wanting). The radial recurrent arises at the elbow, followed by a short common trunk for the

ulnar recurrent and a second radial recurrent branch. The ulnar and common interosseous arise from a common center at the proximal quarter of the forearm, beyond which the greatly reduced main trunk continues as the *mediana communis*.

A. radialis superficialis divides shortly beyond its origin into a volar and a dorsal branch. The smaller volar branch supplies the flexors of the forearm, one delicate twig running down to the carpus where it anastomoses with the *medianoradialis*. The dorsal branch divides into a pair of collateral branches, which pass to the superficial dorsal arch. The larger collateral branch gives off a recurrent twig to the flexors of the upper arm, and receives a descending branch of the external circumflex humeral at the middle of the forearm, the resulting common trunk forming the radial end of the superficial dorsal arch. A fine anastomotic twig at the carpus connects the main dorsal branch with the *medianoradialis*.

A. mediana communis divides slightly above the middle of the forearm into the *mediana propria* and the somewhat smaller *medianoradialis*.

A. mediana propria terminates in the middle of the superficial volar arch, and is the chief source of this arch. The radial end of the arch is formed by the volar branch of the *medianoradialis*, the ulnar end by the common trunk of the *ulnaris volaris* and the *interossea volaris*.

A. medianoradialis gives off the *carpeus volaris*, then divides at the base of the carpus into a dorsal and a slender volar branch. The volar branch forms the radial end of the superficial volar arch. The dorsal branch, after receiving an anastomotic loop from the *radialis superficialis*, gives off the *perforans pollicis* and a slender *perforans* 1, then terminates by dividing into the *carpeus dorsalis* and *perforans* 2, which are subequal in caliber. *Perforantes* 1 and 2 give off their corresponding deep dorsal metacarpals, and together they represent the radial half of the deep dorsal arch.

There is no deep dorsal arch; all the deep dorsal metacarpals (except the second one, which arises directly from *perforans* 2) are formed by union of the volar perforating branches with vessels from the dorsal carpal rete. The second perforating branch is the largest.

A. ulnaris is somewhat smaller than the common interosseous. It divides into volar and dorsal branches at the distal third of the forearm; the volaris is slightly the larger. The volar branch terminates at the carpus by anastomosing with the volar interosseous, thus contributing to the superficial volar arch. The dorsal branch

joins a branch of the volar interosseous, the resulting common trunk forming the ulnar end of the superficial dorsal arch.

Aa. interosseae arise by a short common trunk. The volar interosseous considerably exceeds the dorsal in caliber. The interossea dorsalis immediately perforates to the dorsal side of the forearm, where it ramifies to the extensor muscles, a twig descending to anastomose with the dorsal interossea volaris. The interossea volaris divides into volar and dorsal branches a short distance below the middle of the forearm. The volar branch immediately gives off a branch that passes to the carpus, where it forms a common trunk with the dorsal ulnar; then a second branch that joins the volar ulnar, the resulting common trunk supplying the ulnar ends of both volar arches. The much reduced main trunk gives off an anastomotic twig to the carpeus volaris, and terminates by entering the volar carpal rete. The dorsal branch terminates in the deep dorsal arch, also supplying twigs to the dorsal carpal rete.

VIVERRIDAE

BINTURONG (*Arctictis binturong*)

A. brachialis gives off the superficial radial above the entepicondylar foramen, then accompanies the brachial vein and the median nerve through the foramen. The radial recurrent is given off immediately below the foramen, the ulnar recurrent farther distad. The ulnar and common interosseous arise by a short common trunk in the proximal quarter of the forearm, beyond which the trunk continues as the *mediana communis*.

A. radialis superficialis divides shortly beyond its origin into a volar and a dorsal branch. The volar branch supplies the flexors of the forearm. The dorsal branch sends a recurrent twig back to the superficial pectoral muscle, the main trunk passing down the dorsum of the forearm toward the manus. At the middle of the forearm it receives a strong descending branch from the external circumflex humeral, and a terminal twig of the interossea dorsalis; the resulting common trunk forms a pair of collateral branches, which form the radial end of the superficial dorsal arch. A fine anastomotic twig at the carpus connects the dorsal branch of the *radialis superficialis* with the *medianoradialis*.

A. mediana communis divides just above the middle of the forearm into the small *mediana propria* and the much larger *medianoradialis*. These two vessels are united farther distad by a short anastomotic loop.

A. mediana propria forms the superficial volar arch with a common trunk formed by the ulnaris volaris and interossea volaris. From this arch arise metacarpea volares superficiales 1-5.

A. medianoradialis gives off the carpeus volaris, then receives an anastomotic twig from the radialis superficialis before passing under the tendon of the abductor pollicis longus onto the dorsum manus. On the dorsum it receives a second anastomotic twig from the radialis superficialis and gives off the perforans pollicis and a threadlike carpeus dorsalis, then terminates by dividing into perforantes 1 and 2, which are subequal in caliber. Each of the latter gives off its corresponding deep dorsal metacarpal.

There is no deep dorsal arch, metacarpeae dorsales profundae 3 and 4 being the direct continuations of the corresponding volar perforating branches. Each receives a slender twig from the dorsal carpal rete. The first and second perforating branches are the largest, and are subequal in size.

A. ulnaris considerably exceeds the common interosseous in caliber. It divides almost immediately into a dorsal and a volar branch; the volar is slightly the larger. The ulnaris volaris gives off an anastomotic loop (the dorsal ulnaris volaris) to the ulnaris dorsalis near the distal end of the forearm, then receives an anastomotic twig from the interossea volaris, and the resulting trunk forms the ulnar ends of both volar arches; twigs perforate the third and fourth intermetacarpal spaces to enter the ulnar half of the incomplete deep dorsal arch. The ulnaris dorsalis receives the dorsal ulnaris volaris, then an anastomotic twig from the interossea volaris. It then winds onto the dorsum, where it forms the ulnar ends of both dorsal arches.

Aa. interossee arise by a very short common trunk. The volar interosseous slightly exceeds the dorsal in caliber. It divides into a volar and a dorsal branch at the proximal border of the carpus. The volar branch arches ulnaward at the proximal border of the carpus, and the following twigs radiate from this arch: an anastomotic twig that sends one twig to the carpeus volaris, a second going to the first perforating branch of the medianoradialis; a twig to the volar carpal rete; and an anastomotic twig to the ulnaris volaris. The much reduced trunk itself terminates in the ulnaris dorsalis. The dorsal branch terminates in the dorsal carpal rete.

The interossea dorsalis supplies the extensor muscles of the forearm. At the middle of the forearm it sends a transverse anastomotic branch across to the descending branch of the external circumflex humeral, thus contributing indirectly to the superficial dorsal arch.

PALM CIVET (*Paradoxurus hermaphroditus*)

(Figs. 34, 35)

A. brachialis gives off the superficial radial above the entepicondylar foramen, then accompanies the median nerve through the foramen. The radial and ulnar recurrens arise from the interossea

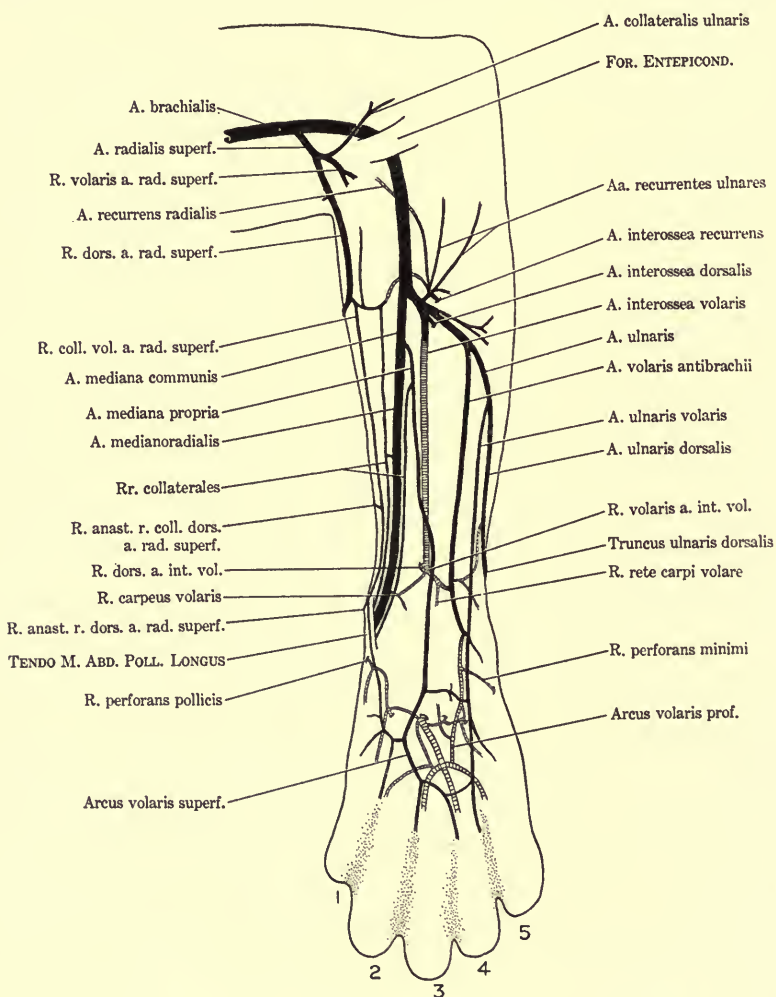


FIG. 34. Vessel pattern in *Paradoxurus hermaphroditus*; volar view.

recurrens. The ulnar and common interosseous arise by a short common trunk at the proximal third of the forearm, beyond which the main trunk continues as the mediana communis.

A. radialis superficialis is very large. Immediately beyond its origin it divides into volar and dorsal branches. The volar branch supplies the flexors of the forearm, also giving off the ulnar collateral near its base. The dorsal branch gives off an anastomotic loop to the interossea recurrens in the proximal part of the forearm, and from

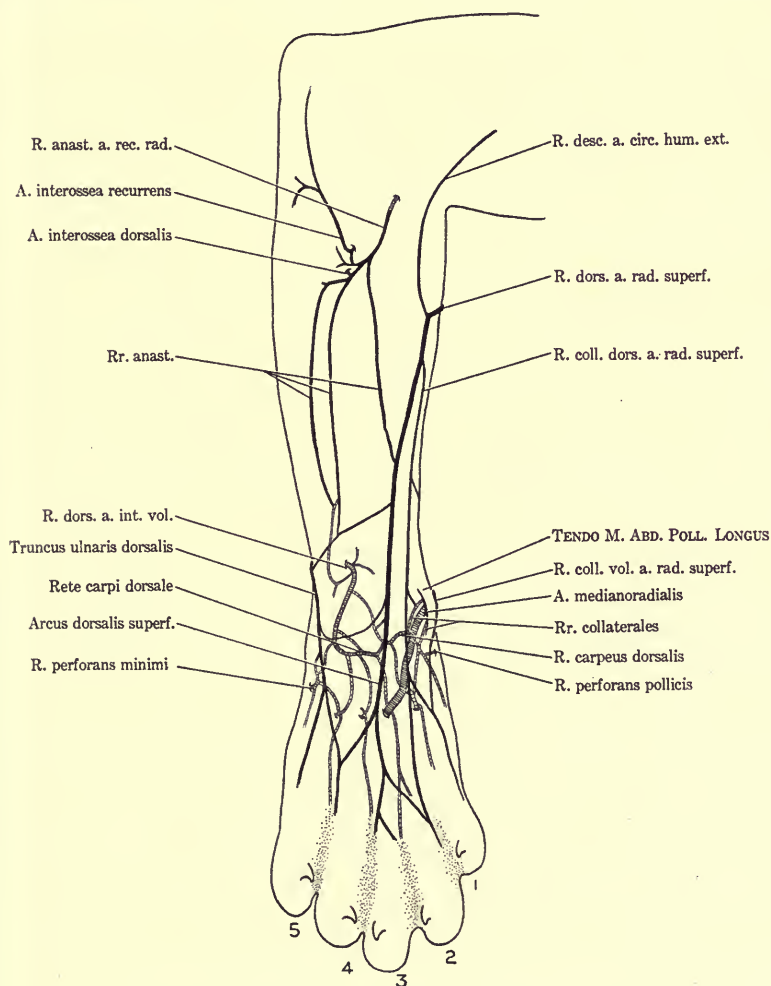


FIG. 35. Vessel pattern in *Paradoxurus hermaphroditus*; dorsal view.

this loop arise a recurrent twig to the biceps, a volar collateral branch that rejoins the main dorsal branch below the carpus, and a second volar branch that flanks the medianoradialis. The main dorsal

branch, which forms a pair of collateral branches on the dorsum, receives the slender descending circumflex humeral in addition to a terminal twig of the interossea dorsalis. It forms the radial end of the superficial dorsal arch and is also connected with the ulnaris dorsalis by two slender transverse arches just proximal of the arch.

A. mediana communis divides immediately below the proximal third of the forearm into the small mediana propria and the much larger medianoradialis.

A. mediana propria gives off a branch near its origin that flanks the medianoradialis. The main trunk forms the superficial volar arch, with a common trunk formed by the ulnaris volaris and volaris antibrachii + interossea volaris. From this arch arise metacarpeae volares superficiales 1-5.

A. medianoradialis is flanked on either side by a small accompanying vessel; one of these arises from the radialis superficialis, the other from the mediana propria. They accompany the main vessel beneath the tendon of the abductor pollicis longus onto the dorsum manus. The main trunk gives off the carpeus volaris before passing onto the dorsum. On the dorsum it terminates by dividing into perforantes 1 and 2, of which 2 is much the larger although 1 exceeds the other perforantes in caliber. The carpeus dorsalis and perforans pollicis arise from the accompanying vessels.

There is no deep dorsal arch, metacarpeae dorsales profundae 3 and 4 being the direct continuations of the corresponding volar perforating branches. Each of the four metacarpeae receives a twig from the dorsal carpal rete.

A. ulnaris arises by a trunk common to it and the volaris antibrachii; the trunk divides to form these two subequal vessels below the proximal third of the forearm, a short distance beyond its origin. All the recurrent vessels of the forearm—the radial, ulnar, and interosseous—arise by a single trunk from the interosseo-ulnar trunk. The ulnaris divides at the middle of the forearm into a dorsal and a volar branch, of which the dorsal is considerably the larger. The ulnaris volaris is joined by the terminus of the volaris antibrachii at the carpus, and the anastomotic loop so formed gives rise to the ulnar ends of both volar arches. The ulnaris dorsalis receives an anastomotic loop from the volaris antibrachii, then winds onto the dorsum where it forms the ulnar ends of both dorsal arches.

The volaris antibrachii appears to have taken over a part of the duties of the ulnaris volaris. Near the distal end of the forearm

it gives off the usual anastomotic loop to the ulnaris dorsalis, then receives the good-sized terminus of the volar interossea volaris.

Aa. interossee arise by a very short common trunk, the interossea recurrens arising from a separate trunk along with the other recurrent vessels, as described above. The interossea volaris considerably exceeds the dorsalis in caliber. It divides into a volar and a dorsal branch near the proximal border of the carpus. The short volar branch gives off twigs to the volar carpal rete, then empties into the volaris antibrachii. The dorsal branch perforates through to the dorsum, receives a terminal twig from the interossea dorsalis, and ramifies to the dorsal carpal rete.

The interossea dorsalis perforates to the dorsum beside the perforating recurrent branch. On the dorsum it receives an anastomotic twig from the radial recurrent, then ramifies to the forearm extensors.

WEST AFRICAN TREE CIVET (*Nandinia binotata*)

A. brachialis gives off the superficial radial above the entepicondylar foramen, then accompanies the median nerve through the foramen. The radial recurrent arises below the foramen, followed almost at once by an ulnar recurrent. The ulnar and common interosseous arise from a common center above the proximal third of the forearm, and beyond this the main trunk continues as the mediana communis.

A. radialis superficialis divides shortly beyond its origin into volar and dorsal branches. The volar branch supplies the flexors of the forearm. The dorsal branch gives off a delicate volar collateral branch in the proximal part of the forearm; distally this terminates in the anastomotic loop that connects the main dorsal branch with the medianoradialis. The main dorsal branch gives off a threadlike recurrent twig to the flexors of the upper arm, and receives the stout descending circumflex humeral near the middle of the forearm. Near the carpus it receives a terminal twig of the dorsal interossea volaris and gives off an anastomotic loop to the medianoradialis. The vessel terminates by forming the radial end of the superficial dorsal arch, and is also connected with the ulnaris dorsalis by a slender transverse arch just proximad of the arch.

A. mediana communis divides at the distal third of the forearm into the mediana propria and the larger medianoradialis. Near its origin the mediana communis gives off a fair-sized volaris antibrachii, which terminates in the flexors of the forearm.

A. mediana propria forms the radial end of the superficial volar arch. From this arch arise metacarpeae volares superficiales 1-5.

A. medianoradialis gives off the carpeus volaris and an anastomotic loop to the brachialis superficialis before passing onto the dorsum. On the dorsum it gives off the carpeus dorsalis and perforans pollicis, then terminates by perforating the second intermetacarpal space. This perforating branch enormously exceeds the other perforantes in caliber.

There is no deep dorsal arch, metacarpeae dorsales profundae 3 and 4 being the direct continuations of the corresponding volar perforating branches, each receiving a twig from the dorsal carpal rete.

A. ulnaris divides near the middle of the forearm into a dorsal and a volar branch, which are about equal in caliber. The volaris is joined by a terminal twig of the interossea volaris at the carpus, and the resulting common trunk forms the ulnar ends of both volar arches. The ulnaris dorsalis also receives a terminal twig of the interossea volaris, then winds onto the dorsum where it forms the ulnar ends of both dorsal arches.

Aa. interossea arise by a common trunk, the interossea recurrens coming from the base of this trunk. The interossea volaris divides into volar and dorsal branches just above the carpus, the volar branch ramifying to the volar carpal rete and both branches of the ulnar, while the dorsal branch terminates as usual in the dorsal carpal rete. The interossea dorsalis perforates to the dorsum at a considerable distance from the perforating recurrent branch. It ramifies as usual on the dorsum.

GENET (*Genetta* sp.)

A. brachialis gives off the superficial radial above the entepicondylar foramen, then accompanies the median nerve through the foramen. The radial recurrent is given off below the foramen, followed after a short interval by the ulnar recurrent. The dorsal interosseous arises at the proximal quarter of the forearm while the volar interosseous and ulnar arise by a short common trunk at the proximal third of the forearm. Beyond this the main trunk continues as the *mediana communis*.

A. radialis superficialis is large. Immediately beyond its origin it gives off the ulnar collateral, then divides into volar and dorsal branches. The smaller volar branch supplies the flexors of the forearm. The dorsal branch gives off a volar collateral branch in the proximal part of the forearm; distally this is reunited to the main dorsal branch by a series of transverse anastomotic loops. The most proximal of these loops receives one of the terminal twigs of

the interossea dorsalis. The main dorsal branch gives off a recurrent twig to the flexors of the forearm. Near the carpus it receives a terminal twig of the dorsal interossea volaris. The vessel terminates by forming the radial end of the superficial dorsal arch.

A. mediana communis divides at the distal third of the forearm into the subequal mediana propria and medianoradialis.

A. mediana propria forms the radial end of the superficial volar arch, and is the chief source of this arch. From the arch arise metacarpeae volares superficiales 1-5.

A. medianoradialis gives off the carpeus volaris and an anastomotic loop to the brachialis superficialis before passing onto the dorsum. On the dorsum it gives off the perforans pollicis and a delicate carpeus dorsalis, then terminates by dividing into perforantes 1 and 2, of which 2 is much the larger although 1 exceeds the other perforantes in caliber.

The arrangement of the deep dorsal arch is like that of *Herpestes*, with threadlike anastomotic loops simulating a true arch.

A. ulnaris slightly exceeds the interossea volaris in caliber. It divides into a dorsal and a volar branch at the middle of the forearm, the dorsal branch considerably exceeding the volar in caliber. The ulnaris volaris is joined by a terminal twig of the interossea volaris below the carpus, and the resulting common trunk forms the ulnar end of the superficial volar arch. The ulnaris dorsalis is joined by a second terminal twig of the interossea volaris, then winds onto the dorsum where it forms the ulnar ends of both dorsal arches.

Aa. interossee arise independently. The interossea volaris divides into a volar and a dorsal branch, at the distal quarter of the forearm. The volar branch, in addition to giving twigs to the volar carpal rete, supplies a terminal branch to each of the ulnars, while a third forms the ulnar end of the deep volar arch. The dorsal branch has the usual relations with the dorsal interossea volaris and radialis superficialis.

The interossea dorsalis is represented by two branches, the recurrens arising independently and perforating to the dorsum beside the main trunk. These have been the usual relations.

HERPESTIDAE

MONGOOSE (*Herpestes ichneumon*)

(Figs. 36, 37)

A. brachialis gives off the superficial radial above the entepicondylar foramen, then accompanies the median nerve through the

foramen. The radial recurrent is given off below the foramen, followed immediately by the ulnar recurrent. The ulnar and common interosseous arise by a short common trunk just above the proximal third of the forearm, beyond which the trunk continues as the mediana communis.

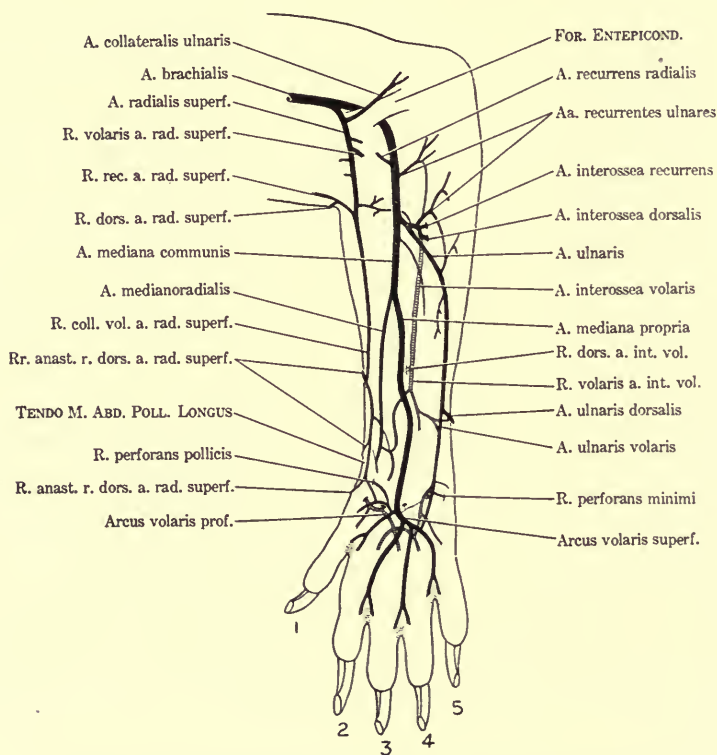


FIG. 36. Vessel pattern of *Herpestes ichneumon*; volar view.

A. radialis superficialis is very large. Immediately beyond its origin it gives off the ulnar collateral, then divides into volar and dorsal branches. The volar branch supplies the flexors of the forearm. The dorsal branch gives off a powerful volar collateral branch in the proximal part of the forearm; distally this is reunited to the main dorsal branch by a series of transverse anastomotic loops. The main dorsal branch gives off a recurrent twig to the flexors of the upper arm and receives the stout descending circumflex humeral at the proximal end of the forearm. Farther distad it gives off a slender transverse anastomotic loop to the interossea dorsalis, and

pollicis, then terminates by perforating the first intermetacarpal space; this is the only instance encountered in which the medianoradialis passed to the first intermetacarpal space rather than to the second.¹

All the deep dorsal metacarpals (except the first, which arises directly from the medianoradialis) are continuations of the corresponding perforating branches, each also receiving a twig from the dorsal carpal rete. Threadlike anastomotic loops extend across from one to the other at the level of the perforating branches, and these collectively give the appearance of a deep dorsal arch. That it is not homologous with the arch of other carnivores is indicated by the direct relation of the metacarpals to the dorsal carpal rete.

A. ulnaris and the interossea are subequal in caliber. The ulnar divides into a dorsal and a volar branch a short distance above the carpus, the dorsal branch being considerably the larger. The ulnaris volaris is joined by a terminal twig of the interossea volaris above the carpus, and the resulting common trunk gives rise to the ulnar ends of both volar arches. The ulnaris dorsalis is joined by a second terminal twig of the interossea volaris, then winds onto the dorsum where it forms the ulnar ends of both dorsal arches.

Aa. interossee arise by a very short common trunk. The interossea volaris exceeds the dorsalis only slightly in caliber. It divides into a volar and a dorsal branch at the distal quarter of the forearm. The volar branch gives twigs to the volar carpal rete, then terminates by emptying into the ulnars. The dorsal branch perforates through to the dorsum, where it breaks up into twigs that ramify to the dorsal carpal rete. One of these twigs receives a terminal twig from the interossea dorsalis.

The interossea dorsalis is represented by two branches, the *recurrens* arising independently and perforating to the dorsum beside the main trunk. On the dorsum the interossea dorsalis receives an anastomotic twig from the radial recurrent, then ramifies to the extensor muscles of the forearm.

HYAENIDAE

STRIPED HYENA (*Hyena striata*)

(Figs. 38, 39)

A. brachialis gives off the superficial radial above the elbow, then accompanies the median nerve through the entepicondylar

¹ This apparently is the normal condition in *Herpestes*, since Zuckerkandl found a similar arrangement in a specimen of *H. fasciatus* and one of *H. javanicus*, and Schwalbe also described it for *H. griseus*.

foramen.¹ The large radial recurrent arises immediately below the foramen, followed by the smaller ulnar recurrent. The ulnaris dorsalis comes off a few millimeters below the elbow, followed immediately by the common interosseous. The ulnaris volaris arises from the volaris antibrachii.

A. radialis superficialis is very large; a short distance beyond its origin it gives off a slender volar branch, the main trunk continuing as the dorsal branch. At the crease of the elbow the latter gives most of its bulk to a powerful recurrent branch that passes proximad to anastomose with the large descending external circumflex humeral. The remaining trunk at once forms three collateral vessels, two dorsal and one volar. The volar branch, which accompanies *N. cutaneus antibrachii lateralis*, had been cut off before it reached the middle of the foreleg, so that its distal ramification is unknown. The smaller of the two dorsal collaterals runs through beneath the brachioradialis to reach the dorsum. The two dorsal vessels reunite on the dorsum; after receiving an anastomotic twig from the interossea dorsalis and giving off an anastomotic loop to the medianoradialis, the combined trunk forms the radial end of the superficial dorsal arch.

A. mediana communis divides at the proximal third of the forearm into the mediana propria and the smaller medianoradialis. Near its origin the mediana communis gives off a powerful volaris antibrachii, which in every respect is similar to the corresponding vessel in *Canis*, except that here it spends itself in the digital flexors.

A. mediana propria does not form the strong superficial volar arch until near the distal end of the metacarpals. A threadlike twig from the interossea volaris, which also carries blood from the ulnaris volaris, enters the ulnar end of this arch. Two fine anastomotic vessels passing around the radial border of the hand connect the mediana propria with the superficial dorsal arch.

A. medianoradialis gives off the carpus volaris and an anastomotic loop to the radialis superficialis before passing beneath the tendon of the abductor pollicis longus onto the dorsum. On the dorsum it gives off several carpal twigs and the perforans pollicis, then continues into the radial end of the dorsal carpal rete.

There is no deep dorsal arch, although the arch formed by the distal end of the dorsal carpal rete is situated so close to the perforat-

¹ This foramen is often absent in hyenas, but apparently when it is present it transmits the artery. A hyena dissected by Zuckerkandl agreed with the present specimen in this respect.

ing branches that it simulates a true dorsal arch. Metacarpeae dorsales profundae 2-4 are the direct continuations of the corre-

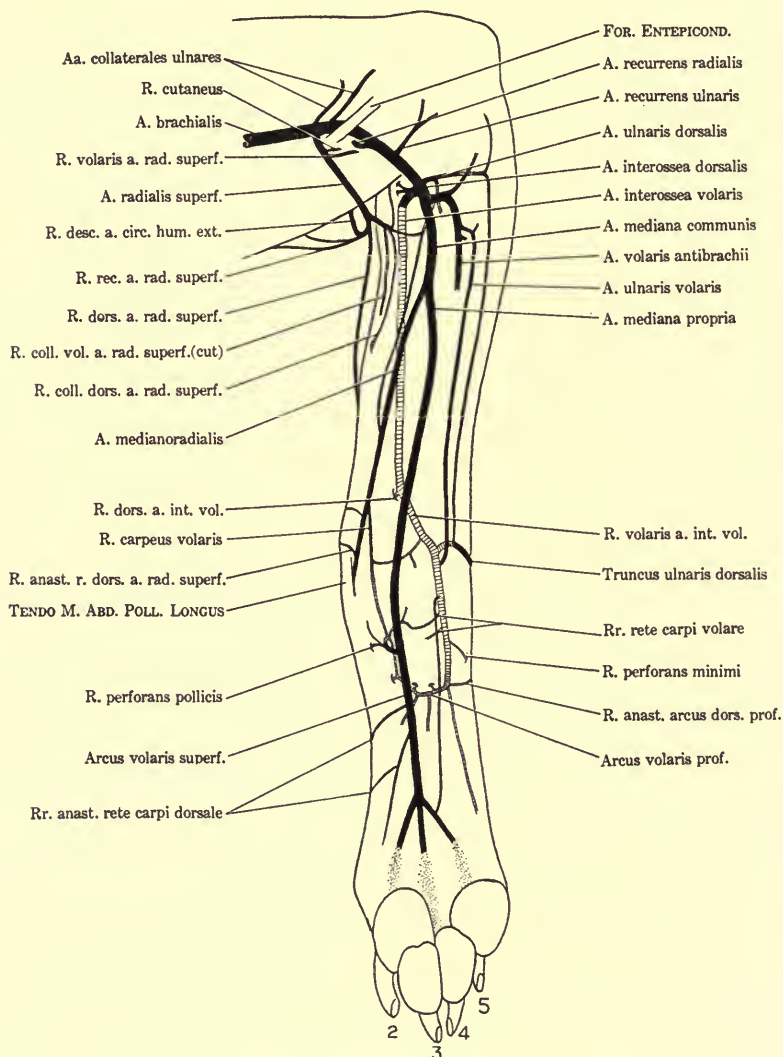


FIG. 38. Vessel pattern of *Hyaena striata*; volar view.

sponding perforating branches, each also receiving a large twig from the dorsal carpal rete. The fourth and fifth metacarpals are much larger than the others, while the first (the pollex is absent in

Hyaena) is represented by a threadlike vestigial twig that is without a perforating branch.

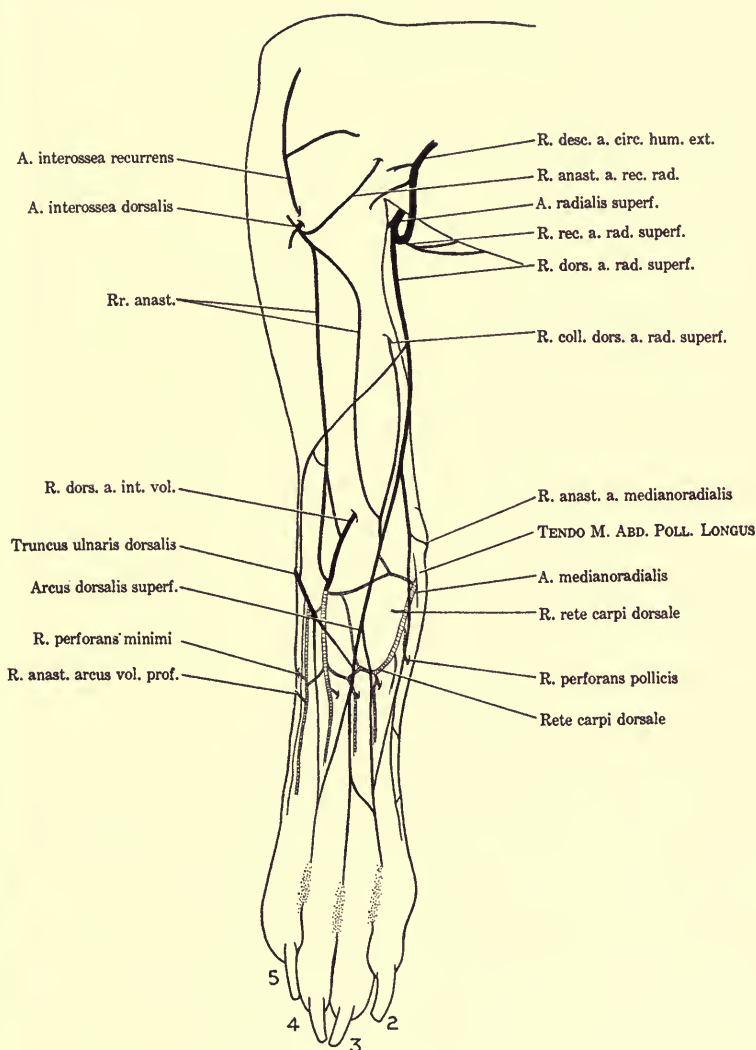


FIG. 39. Vessel pattern of *Hyaena striata*; dorsal view.

Aa. ulnares arise independently, the dorsalis coming directly from the brachialis while the volaris arises from the volaris anti-brachii; the two vessels are nearly equal in size, with the volaris

very slightly the larger, and the two together are much smaller than the *interossea volaris*. The *ulnaris volaris* terminates in the volar *interossea volaris* near the pisiform. The *ulnaris dorsalis* receives a strong anastomotic loop from the *interossea volaris*, and the resulting common trunk forms the ulnar ends of both dorsal arches.

Aa. interossee arise by a very short common trunk. The *interossea dorsalis* immediately divides into two branches, which perforate to the dorsal side of the forearm side by side. One of these is a recurrent twig to the elbow; the other sends two descending twigs distad, one of which anastomoses with the dorsal *interossea volaris*, while the other joins the *radialis superficialis*. The *interossea volaris* almost equals the *mediana propria* in caliber. It gives off a good-sized dorsal branch near the proximal border of the carpus. The powerful volar branch gives off twigs to the volar carpal rete, then a stout anastomotic branch to the *ulnaris dorsalis*, finally receiving the relatively slender *ulnaris volaris* at the proximal border of the carpus. The resulting common trunk forms the ulnar ends of both volar arches. The dorsal *interossea volaris* receives the descending anastomotic twig from the *interossea dorsalis*, then continues into the dorsal carpal rete. Most of its bulk may be followed directly through the rete into the fourth deep dorsal metacarpal.

FELIDAE

DOMESTIC CAT (*Felis domestica*)

(Figs. 40, 41)

A. brachialis gives off the superficial radial above the elbow, then accompanies the median nerve through the entepicondylar foramen. The large radial recurrent arises immediately below the foramen, followed by the smaller ulnar recurrent. The dorsal *interosseous* is given off at the proximal quarter of the forearm, while the volar *interosseous* and ulnar arteries arise by a short common trunk (in two individuals; the *interossea volaris* comes off farther distad in a third) at the proximal third of the forearm. Beyond this the vessel continues distad as the *mediana communis*.

A. radialis superficialis divides into volar and dorsal branches a short distance beyond its origin. The smaller volar branch supplies the flexors of the forearm. The dorsal branch gives off several recurrent twigs to the flexors of the upper arm, then divides into dorsal and volar collateral branches. At the crease of the elbow the larger dorsal collateral branch gives off a large recurrent twig,

which receives the delicate descending circumflex humeral; near the carpus it is connected with the medianoradialis by a fine anastomotic loop. The volar collateral branch terminates in this anastomotic loop.

A. mediana communis gives off an extremely delicate *mediana propria* at the distal quarter of the forearm, beyond which the trunk continues, undiminished in caliber, as the medianoradialis.

A. mediana propria forms the radial end of the delicate superficial volar arch. The ulnar end of this arch is formed by a thread-like branch of the *ulnaris volaris*.

A. medianoradialis gives off the *carpeus volaris* and a fine anastomotic loop to the *radialis superficialis*, then passes under the tendon of the *abductor pollicis longus* onto the back of the hand. On the dorsum it gives off the *carpeus dorsalis*, then the *perforans pollicis*, which enters the radial end of the superficial volar arch. The main trunk of the medianoradialis continues as the *perforans 2*, which enormously exceeds the other perforantes in caliber; on the vola this branch forms the radial end of the powerful deep volar arch.

There is no deep dorsal arch. *Perforantes 3* and *4* arise from the irregular dorsal carpal rete, chiefly from a vessel that can be followed directly back to the dorsal *interossea volaris*. *Perforans 1* comes from medianoradialis.

A. ulnaris and the *interossea volaris* are subequal in caliber. The *ulnaris* divides into volar and dorsal branches near the middle of the forearm; the volaris greatly exceeds the dorsalis in caliber. The *ulnaris volaris* divides into volar and dorsal branches near the base of the carpus; the volar branch forms the ulnar ends of both volar arches, while the dorsal branch combines with the minute dorsal ulnar and a twig from the *interossea volaris* to form the dorsal ulnar trunk. The dorsal ulnar trunk sends twigs into the dorsal carpal rete; it forms the ulnar end of the superficial dorsal arch.

Aa. interossee arise independently. The volaris slightly exceeds the dorsalis in caliber. It divides into volar and dorsal branches near the base of the carpus. The volar branch divides, an anastomotic twig going to the *carpeus volaris* while a second terminal twig divides again, one twig joining the *ulnaris volaris* and the other the dorsal ulnar trunk. The dorsal branch terminates in the dorsal carpal rete. The *interossea dorsalis* gives off the *recurrens* at its origin, then supplies the extensor muscles of the forearm, sending two slender terminal twigs down to the dorsal carpal rete.

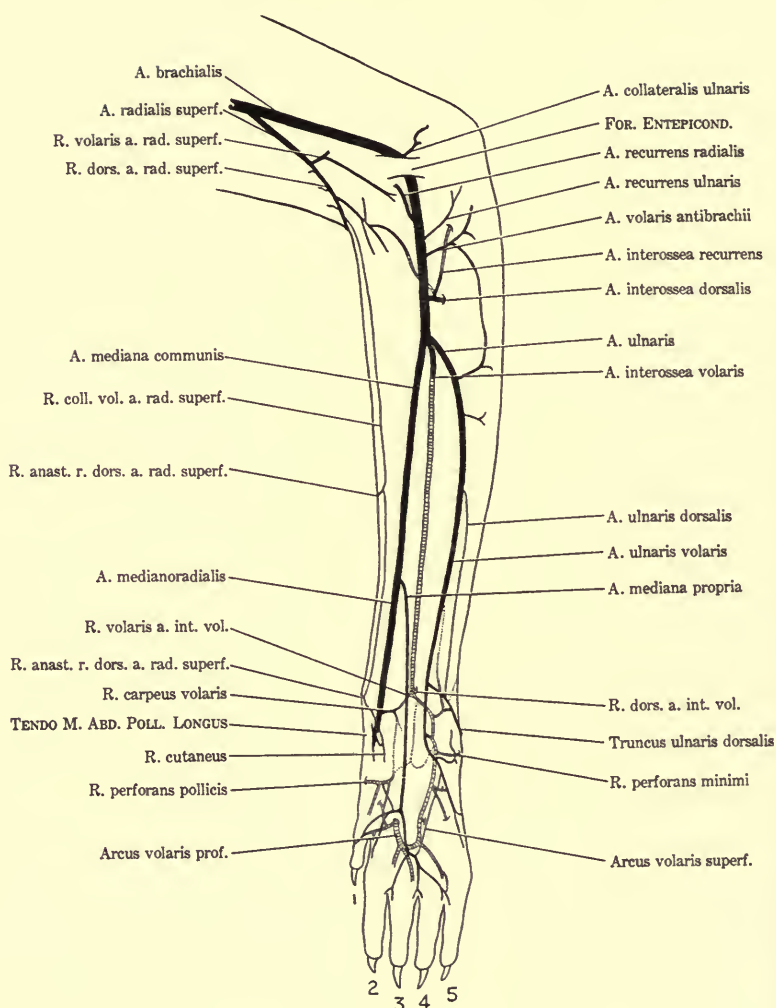


FIG. 40. Vessel pattern of *Felis domestica*; volar view.

JUNGLE CAT (*Felis chaus*)

An Indian jungle cat differed from the domestic cat only in two points related to the interosseous vessels. The first of these is insignificant—the fact that the interossea dorsalis and recurrens have a rather long common trunk. Possibly more significant is the fact that the interossea volaris was somewhat smaller than the ulnaris. This, however, was because of reduction of the interossea, and not because of increase in the caliber of the ulnaris, as in *Panthera*.

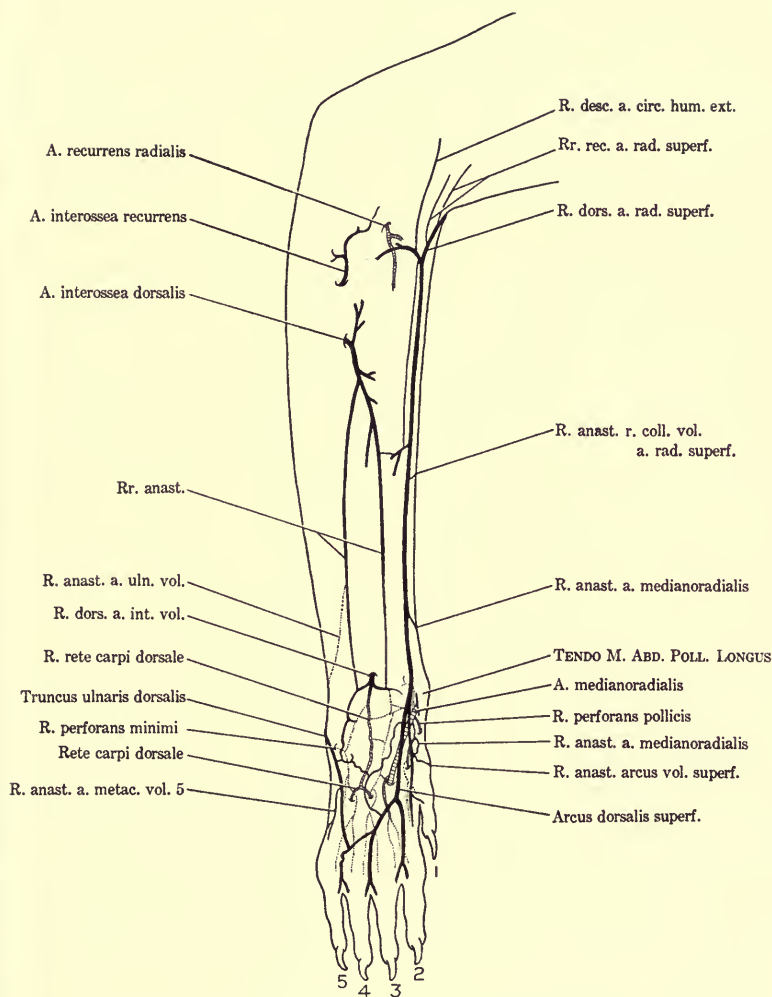


FIG. 41. Vessel pattern of *Felis domestica*; dorsal view.

LYNX (*Lynx lynx*)

A Siberian lynx differed from the domestic cat only in a few minor details. The interossea recurrens and interossea dorsalis arose separately, instead of by a common trunk, at the proximal quarter of the forearm. The interosseo-ulnar trunk also came off at the proximal quarter, instead of the proximal third, of the forearm. The volaris antibrachii was relatively somewhat larger than in the cat, equaling the ulnaris in caliber, but otherwise nearly identical.

LION (*Panthera leo*)

(Figs. 42, 43)

A. brachialis accompanies the median nerve through the entepicondylar foramen, first giving off a stout common trunk for the

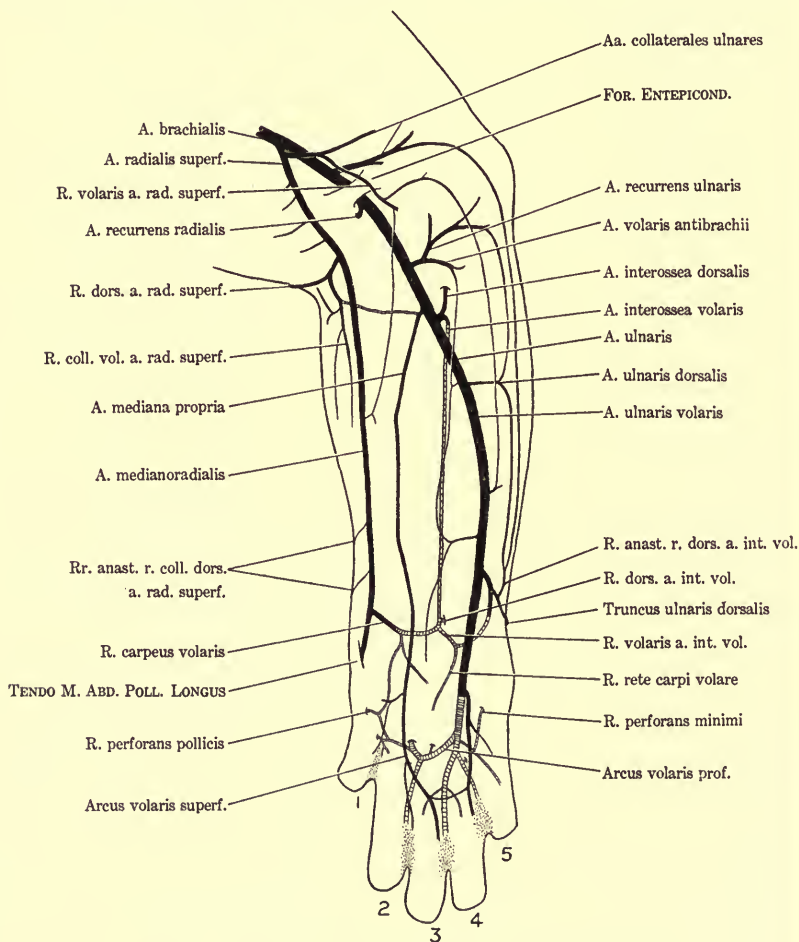


FIG. 42. Vessel pattern of *Panthera leo*; volar view.

superficial radial and medianoradialis. The radial recurrent arises from the brachial artery immediately below the foramen, followed farther distad by the ulnar recurrent. The common interosseous and a minute mediana propria come off at the proximal quarter of the forearm, and beyond this the main trunk continues as the huge ulnar artery.

A. radialis superficialis arises in the usual way, although actually representing the combined proximal ends of this vessel and the medianoradialis.¹ This trunk supplies numerous twigs to the flexors of the upper arm as it crosses them, and divides in the fossa cubiti

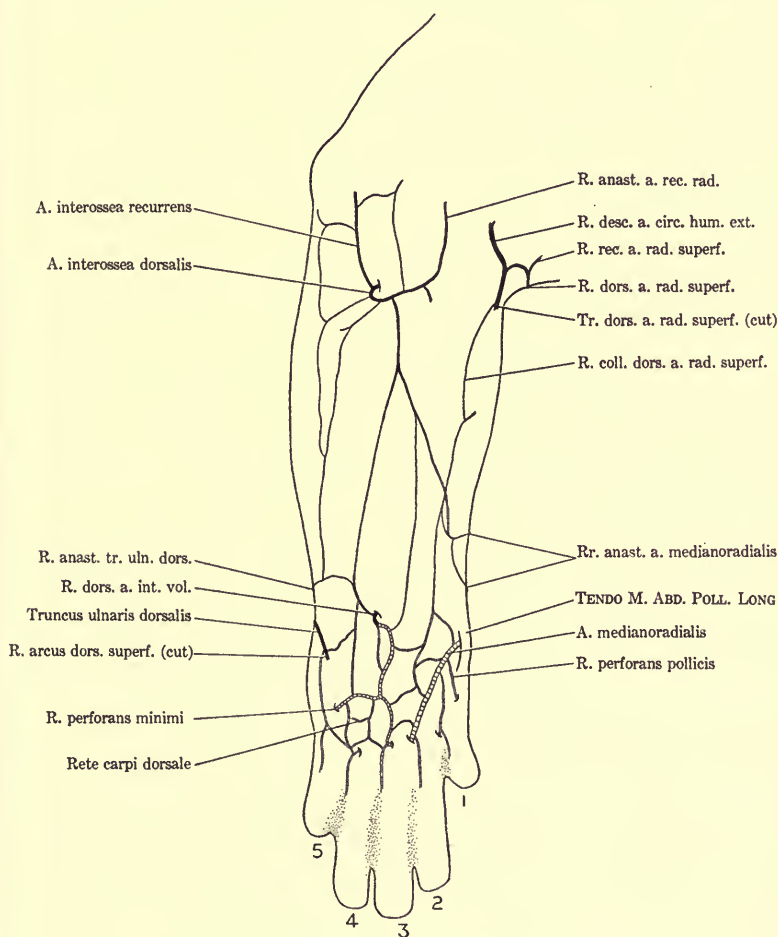


FIG. 43. Vessel pattern of *Panthera leo*; dorsal view.

into the radialis superficialis proper and the medianoradialis. The radialis superficialis then gives off a transverse anastomotic loop to the base of the mediana propria, before winding onto the dorsum

¹ This origin of the medianoradialis, the only one encountered in 35 dissections, is doubtless an individual anomaly. A similar high origin of the radial artery is well known in man.

of the forearm. On the dorsum it combines with the larger descending circumflex humeral and passes distad, presumably to form the radial end of the superficial dorsal arch (this arch had been destroyed in removing the skin).

A. mediana communis is not represented because of the abnormal origin of the medianoradialis.

A. mediana propria forms the radial end of the superficial volar arch. The formation of this arch is peculiar; the mediana propria terminates in the third intermetacarpal space as *A. metacarpea volaris superficialis* 3, the ulnar in the fourth space as *A. metacarpea volaris superficialis* 4. These two vessels are then united across digit 4 by a delicate transverse loop.

A. medianoradialis gives off the carpeus volaris before winding onto the dorsum manus. On the back of the hand it gives off several dorsal carpal twigs and the perforans pollicis, the main trunk continuing as the perforans 2, which greatly exceeds the other perforantes in caliber.

There is no deep dorsal arch. Perforantes 3 and 4 arise from the complex dorsal carpal rete, while perforans 1 comes from the medianoradialis.

A. ulnaris is the main continuation of the brachial artery, and far exceeds any of the main volar branches in caliber. Just above the middle of the forearm it gives off an extremely slender dorsal branch, the main trunk continuing almost undiminished as the very powerful volar branch. The ulnaris volaris gives off a good-sized dorsal branch near the carpus, which after supplying a branch to the volar carpal rete is joined by the ulnaris dorsalis and winds onto the dorsum. The main volar trunk continues onto the palm, where it forms the ulnar ends of both volar arches. The minute ulnaris dorsalis joins the larger dorsal branch of the ulnaris volaris, and the resulting dorsal ulnar trunk forms the ulnar ends of both dorsal arches.

Aa. interosseae arise by a very short common trunk, and the two branches are subequal in caliber. The volaris, which is comparatively slender, divides into volar and dorsal branches near the base of the carpus. The volar branch divides, one anastomotic twig going to the carpeus volaris while a second anastomoses with a volar branch of the dorsal ulnar trunk. The dorsal branch terminates in the dorsal carpal rete. The interossea dorsalis gives off the interossea recurrens on the dorsal side of the forearm, the main trunk ramifying to the extensor muscles of the forearm; several slender terminal twigs extend down to the dorsal carpal rete.

CHEETAH (*Acinonyx jubata*)

A. brachialis gives off the superficial radial above the elbow, then accompanies the median nerve through the entepicondylar foramen. The radial and ulnar recurrent vessels arise from opposite sides of the brachial immediately below the foramen. The three interosseous vessels arise very high (at the proximal eighth of the forearm) and independently of each other, immediately beyond which the brachial divides into an enormous ulnar artery and a very slender *mediana communis*.

A. radialis superficialis divides into volar and dorsal branches at the crease of the elbow. The volar branch supplies the flexors of the forearm. The dorsal branch gives off several recurrent twigs to the flexors of the upper arm, then divides into dorsal and volar collateral branches before passing onto the forearm. The larger dorsal collateral branch winds onto the dorsum of the forearm, where it receives the descending circumflex humeral before passing distad; the distal part of this vessel, including the superficial dorsal arch, had been destroyed in removing the skin. The slender volar collateral branch terminates in muscles before reaching the wrist.

A. mediana communis, which is very slender, divides at the distal quarter of the forearm into the extremely delicate *mediana propria* and the larger *medianoradialis*.

A good-sized vessel, corresponding closely to the *volaris anti-brachii* of the Canidae and *Hyaena*, arises from the brachial just above the *mediana communis*. As in the dogs and hyena, this vessel accompanies the branch of the median nerve that supplies the flexor digitorum sublimis and palmaris longus, giving off a recurrent twig that passes back to the olecranal rete. The vessel differs in *Acinonyx* only in that it terminates in the *mediana communis* instead of in the *ulnaris volaris*.

A. mediana propria forms the radial end of the delicate superficial volar arch. The ulnar end of this arch is formed by an equally slender branch of the *ulnaris volaris*.

A. medianoradialis gives off the *carpeus volaris* before passing onto the dorsum manus. On the dorsum it gives off the perforans pollicis, then terminates in the dorsal carpal rete by several twigs, the resulting arrangement being similar to that in *Taxidea* (fig. 33).

There is no deep dorsal arch, all the deep dorsal metacarpals being continued from the corresponding perforating branches. They are augmented by numerous twigs from the dorsal carpal rete. The second perforating branch does not exceed the others in caliber.

A. ulnaris is the main continuation of the brachial artery, and greatly exceeds any of the other main branches in caliber. It divides into volar and dorsal branches at the distal quarter of the forearm. The ulnaris volaris, which enormously exceeds the dorsalis in caliber, forms the ulnar ends of both volar arches. The ulnaris dorsalis is connected with the dorsal interosseous vessels by several slender transverse anastomotic loops, and near the carpus it is connected with the ulnaris volaris by a similar loop. On the dorsum it supplies twigs to the dorsal carpal rete, then forms the ulnar ends of both dorsal arches.

Aa. interossee arise from the brachial as three independent vessels, just proximad of its bifurcation into the *mediana communis* and *ulnaris*. The *interossea volaris* arises from the radial side of the brachial. It divides into volar and dorsal branches near the carpus. The volar branch terminates in the volar carpal rete, while the dorsal branch perforates through to terminate in the dorsal carpal rete. The *interossea dorsalis* and *interossea recurrens* arise close together but independently, from the ulnar side of the brachial. On the dorsum of the forearm the *recurrens* sends a delicate descending twig down to the dorsal carpal rete, in addition to the usual descending twig from the *interossea dorsalis*.

DISCUSSION

On the basis of their vessel patterns the carnivores studied fall into four rather well-marked groups. These are (1) the Canidae, which differ radically from the remaining Arctoidea; (2) the remaining Arctoidea; (3) the Musteloidea; and (4) the Aeluroidea. Each of these groups is discussed below, where data that could not be presented in the accompanying table are also considered.

Phylogenetic trends.—The basic vessel pattern of the Carnivora (fig. 44) is primitive, with the main trunk of the upper arm (the *brachialis*) continued through the entepicondylar foramen directly onto the forearm as the *mediana communis*, and the latter bifurcating in the upper third of the forearm to form a larger vessel that supplies the palm (the *mediana propria*) and a slightly smaller one that supplies the back of the hand (the *medianoradialis*). The ulnar and interosseous arteries are concerned chiefly with the blood supply of the forearm musculature.

This fundamental pattern is characteristic, with relatively minor modifications, of the Carnivora, but has evolved in two quite different directions within the group. The first of these is typical of the

Arctoidea, exclusive of the Canidae, which have largely retained the primitive pattern. The brachialis fails to pass through the entepicondylar foramen; its bifurcation migrates distad (reaching an extreme in the bears and pandas, where it divides almost at the carpus), and the medianoradialis increases in caliber at the expense of the mediana propria. The second, and quite different, trend is found in the cats. Here there is an astonishing increase in the caliber of one of a pair of vessels, with corresponding reduction of the other. Thus, in the domestic cat the ulnar circulation is essentially normal, while in the median circulation the medianoradialis is so large that

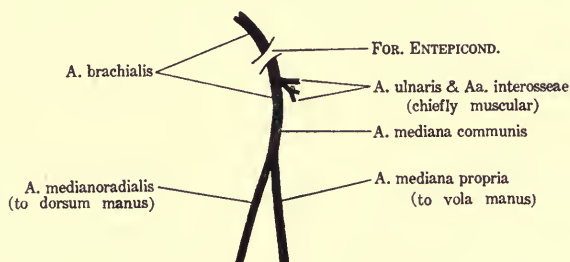


FIG. 44. Diagram of the chief vessels of the forearm in the Carnivora.

the bifurcation of the mediana communis must be looked for carefully, the mediana propria being so threadlike that it was ignored by Reighard and Jennings. In the lion and cheetah, on the other hand, the brachialis continues almost without reduction as the ulnaris, with the whole median circulation reduced to a very secondary system.

Functional adaptations.—No obvious adaptive significance can be attached to either of the "trends" described above, at least not at present. In fact, only one instance was noted that could with reasonable certainty be regarded as a definite functional adaptation—the hypertrophy of the volaris antibrachii in connection with cursorial locomotion. The dogs, the hyenas, and the cheetah are by far the most cursorial of the carnivores, and in all of these the volaris antibrachii has undergone a notable increase in size. This vessel forms a part of the blood supply to the forearm (strictly, digital) flexors, and these muscles are obviously important in opposing the thrust of the limb during locomotion.

Suppression of the entepicondylar foramen is probably also associated with cursorial adaptation in some way, as witness its absence in the otherwise very primitive foreleg of the dogs and its

SUMMARY OF CHARACTERS OF ARTERIES IN FOREARM
Characters in italic type are primitive, those in roman specializations

	Brach. through enceph. foramen	Rad. superf. (dors. and vol.)	Terminal div. med. com.	Rel. caliber med. prop. and medianorad.	Med. propr. lateralis	Rel. caliber uln. and interossea	Terminal div. uln. com.
Echinorex	No (p. 150)	Both	<i>Prox. fifth</i>	<i>Med. propr. much larger</i>	Absent	<i>Interossea larger</i>	<i>Middle</i>
Canidae	Foramen abs.	Vol. abs.	<i>Prox. third</i>	<i>Med. propr. much larger</i>	Absent	<i>Interossea larger</i>	<i>Near middle</i>
Bassariscus Nasua	No	Both	Middle	Med. propr. usually larger?	Absent	<i>Interossea larger or subequal</i>	<i>Middle or proximal</i>
Procyon	No	Both	<i>Prox. third</i>	Med. propr. very much larger	Absent	<i>Interossea larger</i>	<i>Proximal</i>
Potos	Yes	Both	Middle	<i>Med. propr. larger</i>	Present	Ulnaris larger	<i>Proximal</i>
Aluridae	No	Both	Distal third or lower	Medianorad. larger	Present or absent	<i>Interossea larger or subequal</i>	Middle or distal
Ursidae	Foramen abs.	Both	Distal third	Medianorad. usually larger	Present	<i>Interossea larger</i>	<i>Proximal</i>
Mustelidae	Yes	Both	Near middle	<i>Med. propr. larger</i>	Present or absent	Ulnaris usually larger	Variable
Viverridae	Yes	Both	Middle or distal third	Medianorad. larger	Absent	Ulnaris larger or subequal	<i>Middle or proximal</i>
Herpestidae	Yes	Both	Middle	<i>Med. propr. larger</i>	Absent	<i>Subequal</i>	Distal
Hyaenidae	Yes	Both	<i>Prox. third</i>	<i>Med. propr. larger</i>	Absent	<i>Interossea larger</i>	<i>Proximal</i>
Felis Lynx	Yes	Both	Distal quarter	Medianorad. much larger	Absent	Subequal	<i>Middle</i>
Panthera	Yes	Both	?	Medianorad. larger	Absent	Ulnaris much larger	<i>Middle</i>
Acinonyx	Yes	Both	Distal quarter	Medianorad. larger	Absent	Ulnaris much larger	Below middle

SUMMARY OF CHARACTERS OF ARTERIES IN FOREARM—Continued
Characters in italic type are primitive, those in roman specializations

	Rel. caliber uln. vol. and uln. dors.	Interos. dors. and recurrens arise indepen.	Volaris antibrachii enlarged	Arcus dorsalis prof.	Metac. dorsalis prof.	Form of arcus vol. superf.	Index No.*
Echinosorex	<i>Subequal</i>	No	No	<i>No arch</i>	<i>2 largest</i>	<i>Trigeminal</i>	0.85
Canidae	<i>Volaris larger</i>	Yes	Yes	<i>No arch</i>	<i>2 largest</i>	<i>Trigeminal</i>	0.77
Bassariscus Nasua	Dorsalis larger	No	No	Arch present	1 and 2 larger, subequal	Arch	0.31
Procyon	<i>Volaris larger</i>	No	No	<i>No arch</i>	All small, subequal	<i>Trigeminal</i>	0.69
Potos	Dorsalis larger	No	No	Arch present	1 and 2 larger, subequal	Arc	0.38
Ailuridae	Variable	No	No	Arch present	1 and 2 larger, subequal	Arch	0.23
Ursidae	<i>Volaris larger</i>	No	No	Arch present	1 and 2 larger, subequal	<i>Trigeminal</i>	0.46
Mustelidae	<i>Volaris larger</i>	No	No	<i>Usually no arch</i>	<i>2 usually largest</i>	Usually quadrigeminal	0.54
Viverridae	Dorsalis usually larger	Yes	Usually	<i>No arch</i>	Variable	Arch	0.46
Herpestidae	Dorsalis larger	Yes	No	<i>No arch</i>	1 largest	Arch	0.62
Hyaenidae	<i>Subequal</i>	No	Yes	<i>No arch</i>	<i>2 largest</i>	<i>Trigeminal</i>	0.85
Felis Lynx	<i>Volaris larger</i>	No	No	<i>No arch</i>	<i>2 largest</i>	Arch	0.62
Panthera	<i>Volaris much larger</i>	No	No	<i>No arch</i>	<i>2 largest</i>	Arch	0.54
Acinonyx	<i>Volaris much larger</i>	Yes	Yes	<i>No arch</i>	All subequal	Arch	0.38

* The percentage of those characters listed that are primitive in each instance, hence providing a measure of the relative degree of specialization.

unstable character in the hyenas. On the other hand, its absence in the bears and skunks can hardly be so construed.

The Canidae.—The forearm arteries of the dogs are noteworthy for two reasons—their extreme uniformity within the family, and the primitive nature of the vessel pattern. As shown in the table, the Canidae show fewer specializations (i.e. non-primitive characters) than any other family except the Hyaenidae. This is particularly striking in view of the cursorial adaptations that have modified their limb structure in other respects, and sets them off sharply from the remaining Arctoidea.

The Canidae differ consistently from all other carnivores studied in one feature, the persistent absence of the volar branch of the radialis superficialis. No particular importance can be attached to this fact at present.

The remaining Arctoidea.—The procyonids, pandas, and bears form a rather closely knit group, agreeing more closely among themselves than any of them does with any other group. The bears and pandas agree with each other particularly closely. The group as a whole shows a higher degree of specialization in the arteries of the forearm than does any other group of carnivores. With the two exceptions discussed separately below, this group is characterized by the following non-primitive characters:

(1) The brachialis does not pass through the entepicondylar foramen, although with the exception of the bears that foramen is present and transmits the median nerve. This is a very striking and highly characteristic feature of this group.

(2) The deep dorsal arch is a true arch.

(3) The bifurcation of the mediana communis exhibits a tendency to shift distad, reaching an extreme position near the carpus in the bears and pandas.

(4) There is often a lateral branch of the mediana propria. This feature is encountered elsewhere only in the Mustelidae.

(5) The hypertrophy and subequal caliber of metacarpeae dorsales profundae 1 and 2 are characteristic.

(6) The interossea dorsalis and interossea recurrens always arise independently.

Procyon is unique among the members of this group in the large number of primitive characters retained in its vessel pattern; this is even true in contrast with such a supposedly primitive form as *Bassariscus*. *Procyon* does have the brachialis by-passing the entepi-

condylar foramen and a true deep dorsal arch, which are perhaps the most diagnostic features of the non-canid Arctoidea. On the other hand, it lacks features almost equally diagnostic, and has several unique features of its own, such as the great reduction of the mediano-radialis and the presence of a persistent pattern of threadlike accompanying vessels. In view of these radical differences between *Procyon* and the other members of this group, the close agreement between *Nasua* and *Bassariscus* is striking. The possible significance of the vessel pattern in *Procyon* can be determined only after additional data from other parts of the anatomy are available for similar comparison.

Potos, the second non-conforming member of this group, is even more striking. The most consistent feature of the arctoid group, and one that appears to be unique among living mammals except as an occasional anomaly, is the failure of the brachial artery to pass through the entepicondylar foramen. No procyonid or ailurid examined to date has failed to exhibit this feature (the foramen is absent in the Canidae and Ursidae), while the vessel *has passed through the foramen* in every specimen of *Potos*.¹ This character points toward the Mustelidae, since the relation between the brachial artery and the foramen is the only feature in the forearm circulation that positively differentiates the non-canid Arctoidea from the Mustelidae. A second non-arctoid character, the fact that the ulnaris exceeds the interossea in caliber, is also shared by *Potos* with the Mustelidae. *Potos* differs from the remaining Procyonidae in having a *mediana propria lateralis*, sharing this character with the Ailuridae, Ursidae, and Mustelidae.

The Musteloidea.—As far as can be judged from the limited material available (only four of about 30 known genera were studied), the Mustelidae are moderately specialized in their forearm arteries, and differ from the Arctoidea in several characters. They are, however, much closer to the Arctoidea than to any other group. The brachial artery always passes through the entepicondylar foramen. The most distinctive feature of the group is the characteristic quadrigeminal form of the superficial volar arch.

Tayra differs in a number of respects from the other mustelids studied, which suggests that subgroupings within the Mustelidae, somewhat different from those now current, would be revealed by further study. It is also noteworthy that the vessel pattern in *Tayra* approaches that of the Arctoidea.

The Viverridae.—The civets exhibit a rather surprising amount of specialization, the vessel pattern in this group being the least

¹ A *Potos* dissected by Zuckerkandl agreed with ours.

primitive among the Aeluroidea. The four genera studied (out of approximately 22 known) vary considerably among themselves, and are probably far from representing a cross section of the family.

Most characteristic of the Viverridae is the form of the deep volar arch (cf. fig. 34). The large medianoradialis, perforating from the dorsum through the second intermetacarpal space, runs distad on the palm for some distance before breaking up in triradiate fashion into metacarpeae 2-4. The arch is completed by a slender ulnar branch entering the base of metacarpea 4.

The Herpestidae.—*Herpestes*, the sole representative studied of the 17-odd genera making up this family, is unique among known carnivores in that the medianoradialis *perforates the first intermetacarpal space* instead of the second. It differs from the Viverridae in that the mediana propria exceeds the medianoradialis in caliber, but otherwise conforms fairly closely to the viverrid pattern.

The Hyaenidae.—If the single hyena dissected is representative, this family has retained more primitive characters than any other family of carnivores—this in spite of the modification of its limbs for cursorial locomotion. Of its two non-primitive characters listed in the table, one (enlargement of the volaris antibrachii) has been construed as a cursorial adaptation (p. 219), and the second cannot be regarded as a very fundamental character.

The Felidae.—The cats, except for the highly specialized cheetah, have retained a fair proportion of primitive characters. Their tendency to increase the caliber of one of a pair of vessels at the expense of the other was noted on page 219.

The Felidae were divided by Pocock (1916) into three subfamilies: the Pantherinae, containing the lion and other large cats, in which the larynx is loosely attached to the skull by the largely ligamentary suspensorium of the hyoid; the Felinae, containing the smaller cats and the puma, in which the suspensorium of the hyoid is normally ossified; and the Acinonychinae, including only the cheetah, which lacks the integumentary sheaths of the claws and has the hyoid as in the Felinae. Little additional evidence has since been adduced to support these characters. The four cats (exclusive of the cheetah) dissected in connection with this study fall into two very extreme types, and it is interesting that these types agree completely with Pocock's Pantherinae and Felinae. In the lion (fig. 42) the ulnar is an enormous vessel, while in the remaining cats the ulnar and interosseous are subequal in caliber and exceeded by the mediana communis; a puma dissected by Zuckerkandl agreed with the latter.

Conditions in the cheetah are similar to the lion, and hence do not bear out the evidence of the hyoid apparatus.

With respect to the major thesis of this study, there can be no doubt that vessel patterns, if studied in a large and sufficiently representative series of forms, may supply important data as to inter-family and inter-generic relationships. It is true that the inter-relationships of the Carnivora as indicated by the artery pattern of the foreleg are somewhat at variance with current views derived chiefly from the dentition of recent carnivores and from the usual interpretation of fossil carnivore material. Our conclusions, however, are supported by a considerable mass of data, as yet unpublished, from other morphological features in the Carnivora. It is perhaps heretical to hint that the soft anatomy may sometimes be a more reliable guide to relationships than that venerable stand-by of taxonomists, the dentition. It may be pointed out, however, that few anatomical structures come into more intimate contact with the environment than does the dentition, and that it would be difficult to find among the Carnivora more striking examples of isolated specialization (and hence more suspect as a basis for postulating relationships) than are provided by the teeth of the kinkajou and the pandas.

It may also be emphasized that it is extremely hazardous to attempt to homologize the limb vessels of a single species with those of man without knowledge of the fundamental pattern in the group as a whole. In my own case the present study made it necessary to revise the description of these vessels in *Ailuropoda*, and Reighard and Jennings' extraordinary misinterpretations and oversights provide an even more eloquent example and one that is the more unfortunate because their "Anatomy of the Cat" is the standard basis for any morphological work on the Carnivora.

SUMMARY

(1) Dissection of the forearm arteries of 35 carnivores reveals that:

- (a) Individual anomalies of the type common in human anatomy are singularly rare.
- (b) The vessel patterns in this region afford important evidence as to inter-family and inter-generic relationships.
- (c) To some extent vessel patterns may be correlated with functional specializations of the foreleg.

(2) The Canidae exhibit little variation in the pattern. It is an extremely primitive one, fundamentally different from the pattern in other Arctoidea.

(3) The Procyonidae, Ailuridae, and Ursidae, with two individual exceptions, form a compact, closely knit group, with a comparatively specialized vessel pattern.

(a) *Procyon* has a very aberrant, but basically quite primitive, pattern. It is, however, different from that of the Canidae.

(b) *Potos* differs basically from all other Arctoidea, exhibiting several mustelid characters.

(4) The Mustelidae differ from the Arctoidea in several basic features, but limited material makes evaluation of inter-generic differences impossible.

(5) The Viverridae exhibit the least primitive pattern among the Aeluroidea. Limited material prevents evaluation of characters and the variations they show.

(6) The Herpestidae have a somewhat more primitive pattern than the Viverridae, but differ from the Viverridae and all other carnivores in the condition of the deep dorsal metacarpals.

(7) The Hyaenidae have the most primitive vessel pattern among the Carnivora. This, however, is associated with several cursorial adaptations.

(8) The Felidae fall into two types, and these agree with the subfamilies Pantherinae and Felinae of Pocock. *Acinonyx* has a highly specialized pattern, which, however, agrees fundamentally with that of the Pantherinae.

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A PLEISTOCENE OTTER FROM IOWA

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The fragmentary skull of an otter, consisting of most of the anterior part of the upper segment and one of the parietals back to near the occipital crest, with one second incisor and all of the molariform teeth in place, was found in the southeast part of a marsh of about 1,200 acres, known as Big Wall Lake, southeast of Clarion, Wright County, Iowa. The specimen was forwarded for determination by Thomas G. Scott, Leader of the Iowa Cooperative Wildlife Unit conducting investigations under the joint auspices of the Fish and Wildlife Service, Department of the Interior, and the State of Iowa, at Iowa State College, Ames, Iowa. The skull is quite unlike that of *Lutra canadensis interior*, a recent inhabitant of the region, now apparently extirpated. The bone is very dark, as though impregnated by long contact with decayed marsh vegetation, but the teeth are only slightly discolored. The specimen is unweathered or eroded, however, and probably came from a recently uncovered section of a Pleistocene deposit. It seems to represent an unrecognized species and is described as follows:

***Lutra iowa* sp. nov.**

Type from Big Wall Lake, seven miles south and four miles east of Clarion, Wright County, Iowa. No. 266580 (fragmentary skull only) United States National Museum, Biological Survey Collection. Collected January 18, 1940, by Paul Lester Errington and Thomas George Scott. X-catalog No. 30230.

Distribution.—Known only from the type specimen, from northern Iowa; assumed to be of Pleistocene age.

Characters.—A species of medium size, with remarkably heavy dentition; upper carnassials very broad, with large internal lobes and prominent antero-external cusps, the anterior borders distinctly excavated, or notched, immediately behind the third upper premolars; upper molars with inner sides decidedly longer than outer sides, owing to posterior extent of large inner lobes, the anterior borders nearly straight and transverse to axis of skull; crown of third upper premolar relatively short (antero-posterior diameter) and broad (transverse diameter). Similar to *Lutra annectens* of

western Mexico in form of cranium and dental sculpture, but teeth larger; upper carnassial with a well-developed antero-external cusp and distinct emargination of anterior border of crown much as in *annectens*, but anterior border sloping less obliquely inward and back-



FIG. 45. *Lutra iowa* sp. nov. Wall Lake, Wright County, Iowa. No. 266580 United States National Museum, Biological Survey Collection. Type specimen. Upper, lower, and lateral views (left side) of cranium. Natural size.

ward; inner lobe of upper carnassial much larger, more extended antero-posteriorly, the inner border with a distinct notch in front of a small, subsidiary cusp (absent in *annectens*); upper molar with anterior border of crown more transverse, or at a right angle with axis of skull, and inner lobe much larger; upper molar with inner side of basal border (or cingulum) of crown decidedly longer than

outer side (about equal in *annectens*); posterior base of upper molar crown more deeply emarginate. Compared with that of *Lutra canadensis* of Canada and the United States, the skull is broader across zygomata at postorbital processes and exhibits a departure in dental detail; upper carnassial considerably larger, with a more prominent antero-external cusp and much more extensive inner lobe; upper molar crown more quadrate in outline, the anterior basal border nearly straight and transverse to axis; molar crown with inner basal border or cingulum longer than outer border (about equal in *canadensis*), owing to greater development of an antero-internal shelf; posterior base of upper molar crown deeply emarginate, much as in *canadensis*; crown of third upper premolar broader.

Measurements.—Type (cranial and dental dimensions): zygomatic breadth near postorbital processes 66.4; width of rostrum at swelling over outer sides of canines 31.3; interorbital width 27.3; postorbital constriction 20; distance between tips of postorbital processes 39; maxillary toothrow (alveolus at anterior base of canine to back of molar crown) 39; upper molariform toothrow (crown length) 35.1; upper carnassial, crown length (outer side) 13.2, crown width (transverse diameter) 11; upper molar, crown length (inner side) 10.4, crown length (outer side) 9.5, crown width (transverse diameter near anterior border) 12.8; third upper premolar, crown length 6.9, crown width 5.8.

Remarks.—*Lutra iowa* does not appear to require close comparison with any of the fossil otters described from North America. I have not seen the material on which Cope (Proc. Acad. Nat. Sci. Phila., p. 391, 1896) based *Lutra rhoadsii* from Port Kennedy, Pennsylvania; but Hall, who has examined it in connection with his recent review of the group, states (Carnegie Inst. Wash., Pub. 473, p. 75, 1936) that no characters are presented that distinguish it from *Lutra canadensis lataxina*, the race which occurs in the same region today. *Lutra parviuspis* Gidley and Gazin (Journ. Mamm., 14, p. 351, 1933), from the Cumberland Cave Pleistocene of Maryland, is a small species of the *Lutra canadensis* group. The characters presented by *Lutra iowa* indicate closer alliance to *Lutra annectens* than to *Lutra canadensis*, and suggest the former extension of the range of the *annectens* group much farther north than at present.

REVISION OF THE RODENT GENUS MICRODIPODOPS

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University of California Museum of Vertebrate Zoology

HISTORY

The history of *Microdipodops* begins with the autumn of 1890 when Vernon Bailey took six specimens in Nevada. C. Hart Merriam studied this material and in July of the following year named *Microdipodops megacephalus* as a new genus and new species. In 1901 he named *Microdipodops megacephalus oregonus* from southern Oregon, *Microdipodops pallidus* from Nevada, and *Microdipodops californicus* (= *M. megacephalus californicus*) from Plumas County, California. Grinnell in 1914 named *Microdipodops polionotus* (= *M. megacephalus polionotus*) from Mono County, California. In 1926 Goldman named *Microdipodops megacephalus lucidus* from Esmeralda County, Nevada, and in 1927, *Microdipodops megacephalus dickeyi* from Mono County, California. Both these names now are placed in the synonymy of *M. pallidus pallidus*. In 1929 Hall and Linsdale published notes on the life history of the kangaroo mouse. In 1932 Hatt published a paper on the vertebral columns of ricochet rodents, in which *Microdipodops* was given detailed consideration. Wood in 1935 gave a comprehensive account of the skeleton and dentition and compared the animal with other heteromyids. Hall and Durrant in 1937 named *Microdipodops pallidus albiventer* (= *M. megacephalus albiventer*) from southeastern Nevada, and in 1941 *Microdipodops megacephalus paululus* and *Microdipodops megacephalus leucotis* from western Utah. In the same year Hall named *Microdipodops megacephalus sabulonis* and *Microdipodops pallidus ruficollaris*. Six new subspecies are named in the present paper.

In all, 16 named kinds, belonging to two full species, are recognized, as follows:

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MATERIAL AND ACKNOWLEDGMENTS

This revision of *Microdipodops* is the result of the study of 2,025 specimens, almost all of which are study skins accompanied by skulls, and the usual data as to locality, date, external measurements, weights, and numbers of embryos. Nearly all of the specimens are adult individuals. The criterion of maturity accepted was some wear on the fourth permanent upper premolars. Some complete skeletons and entire animals preserved in alcohol are included in the material studied. Of this total, 1,751 specimens are from Nevada. These are available because of the interest of Miss Annie M. Alexander in the mammals of that state, and many of the specimens were collected and prepared by her and Miss Louise Kellogg. Eighty-five of the specimens are from collections other than that of the Museum of Vertebrate Zoology, and for the opportunity to examine these I make grateful acknowledgment to Stephen D. Durrant, Ralph Ellis, Edward A. Goldman, Hartley H. T. Jackson, Stanley G. Jewett, Adriaan van Rossem, Jack C. von Bloeker, Jr., and George Willett.

I am grateful also to Miss Jean Boulware, who prepared the distribution maps, to Miss Viola H. Memmler, who made the drawings of the skulls, and to Mr. Donald F. Hoffmeister, who made preliminary segregations of the specimens and rendered much assistance in other ways.

Kangaroo mice have been regarded as rare by most naturalists, and as late as 1927 there were probably no more than 150 specimens in all collections combined. Ten years before and after 1900, when the earlier collections of mammals were made from within the geographic range of *Microdipodops*, the collectors relied on horses for transportation. Stops for overnight trapping were made where water and, if possible, green forage for the horses were to be had. *Microdipodops* prefers a habitat more arid than is ordinarily found

at a place of this kind, and, therefore, but few were taken. The collections here reported upon were made mostly between 1927 and 1937, when automobiles were used for transportation, making it easy to stop overnight in dry places far removed from water. This change in means of transportation, I think, was responsible more than anything else for the taking of large numbers of kangaroo mice in later years. Of course, once it was learned where profitably to look for *Microdipodops*, special effort was made to get them. Even so, it probably is fair to say that the automobile is responsible for the present abundance of study specimens of *Microdipodops*.

OCCURRENCE

If any list of genera be drawn up as typical of the Great Basin, the genus *Microdipodops* must be included. It ranges from the eastern base of the Sierra Nevada to, or nearly to, the western base of the Wasatch Range and the connected mountains that extend south thereof, and from the low country of eastern Oregon into southern Nevada a short distance north of 37° N. Lat. Altitudinally, the mice have been taken from as low as 3,900 feet at Smoke Creek, Nevada, up to 7,600 feet in Monitor Valley of the same state. All the known occurrences are in the Upper Sonoran Life-zone. Within this zone, edaphic features control the distribution of each species and even some subspecies.

The subspecies *M. m. megacephalus* and *M. m. sabulonis* occur on gravelly soil, more often where gravel is mixed with either fine or coarse sand. At some places, for example at Cobre, the animals seem to avoid fine sand. Where mice of these two races have been found on sandy soil, it is, as often as not, packed and firm. The species *M. pallidus*, including all its subspecies, is restricted to fine, loose, wind-blown sand. At eleven of the twelve places where the two species were taken together, careful note was made of the character of the soil on which each species was caught, and in every instance *M. pallidus* was restricted to the fine sand and *M. megacephalus* to coarser soils. This was true in Great Smoky Valley, where the ranges of the two met northeast of San Antonio. Along the eastern bank of the wash in the center of the valley, *M. pallidus* ranged continuously from San Antonio, on fine sand of uniform character, northward for $4\frac{3}{4}$ miles. Here a smaller side wash, ten feet wide and four feet deep, with fine sand in the bottom and with gently sloping, sandy sides, comprised the boundary between the ranges of the two species. The sand itself is indistinguishable north and south of this wash but dark-colored gravel up to the

size of the ball of a man's thumb is mixed with the sand, beginning at the center of the wash and extending for an undetermined distance northward, and gives the soil a much darker color. On this darker soil, only *M. megacephalus* was taken. An individual of *M. pallidus* was caught in the bottom of the wash on the fine sand only four feet from its edge, and an individual of *M. megacephalus* was caught only 35 feet farther north on the darker-colored, coarser soil. A change in flora was as abrupt as those in the soil and in the mice. South of the wash the shrubs were a third taller than to the north. *Atriplex canescens* was dominant on the south side and absent on the north. *Parosela* sp. (blue flowers) was common on the south side and represented by a mere trace on the north side. *Chrysothamnus viscidiflorus* var. *pumilis* occurred on the north side only. *Tetradymia* sp. was equally common on the two sides. From observations at other places where the ranges of the two species meet it is concluded that the difference in flora, like the difference in the mice, depended on the change in type of soil; the change in type of flora was not the limiting factor for the mice, or vice versa.

SPECIATION

At the place near San Antonio, described in the preceding paragraph, as at ten other places where the two species of mice were taken together, there was no evidence of crossbreeding. At the twelfth place, Penoyer Valley, north of Groom Baldy (see fig. 52, p. 268), the population of mice appears to be an exception. There the difference in color between the two species is less than at any of the eleven other places, by reason of addition of much buff color in each of the two kinds. Also the difference in length of hind foot is less than at most other places where the two kinds meet or occur together. These resemblances, at first glance, suggest that crossbreeding to some degree has occurred. Shape of the incisive foramina, breadth of the interorbital region, width of skull across the auditory bullae, and closer attention to color nevertheless permit ready identification as to species of all but three of the 57 specimens.

Specimen No. 52672 has the color and incisive foramina as in *megacephalus*, and the interorbital breadth and greatest breadth of the skull as in *pallidus*. No. 52728 is intermediate in color and interorbital breadth, like *pallidus* in the shape of incisive foramina, and like *megacephalus* in the greatest breadth across the auditory bullae. No. 52718 has the color and the interorbital breadth as in *pallidus*, the breadth across the auditory bullae and the breadth across the maxillary processes of the zygomata as in *megacephalus*,

and the incisive foramina of an intermediate shape. These three specimens appear to be the result of crossbreeding between the two species. Because only three of a total of 57 specimens are of this nature, they are regarded as hybrids rather than intergrades. Unfortunately, the field notes for this catch record only that the mice were taken on sandy areas alternating with areas of hard-packed soil; the precise kind of soil on which the three seeming hybrids were taken is not stated.

By referring to the three individuals described in the preceding paragraph as hybrids, it is not intended to imply that they are infertile. Although no conclusive information is available on that point, it is supposed that hybrids here are fertile, because individuals of the two kinds at this locality closely resemble one another in color and in the relation of nasals to premaxillae, and are indistinguishable in length of hind foot. These are some of the features by which the two kinds can be distinguished at all other places where they have been found in the same locality.

Two of the possible explanations for the situation existing in Penoyer Valley are (1) that two full species, long separated without any crossbreeding between them, happen now to crossbreed at this one place among the several at which their ranges meet, or (2) that this is "a species in the making"—an instance where the two kinds have ceased to crossbreed except at this one place where separation never has been wholly accomplished.

No evidence has been found which supports the first explanation and not the second. Some evidence which lends credence to the second explanation and not the first is this: The northern, western, and eastern limits of the geographic range of *pallidus* coincide with those of several other mammalian species, for example, *Dipodomys merriami*, *D. deserti*, and *Perognathus formosus*. The southern limit of the range of each of the other species does not coincide with the southern limit for *pallidus* but is much farther south, well down in the Lower Sonoran Life-zone. The other species differ from their nearest relatives to the northward more than *pallidus* does from *megacephalus*, its nearest relative to the northward. The differentiation from one another of *megacephalus* and *pallidus* probably, therefore, has occurred relatively recently, and the suggestion is that they are species in the making.

If this hypothesis should prove to be correct, the question will remain as to how this division of one species into two took place. Possibly it began by an ecological separation of the animals living

on the fine sand from those on firmer soils. Like many plants and some kinds of animals which live in the bottom of the valley on the fine sands, the *Microdipodops* there may have begun their reproductive cycle earlier than mice of their kind on firmer soils, which in general are at a higher elevation, with the result that a measure of isolation occurred because of physiological differences. The possibility that some physiological separation now exists was first considered on May 31, 1932, when adults and a few young of both species were taken 14½ to 15 miles south of Groom Baldy. The young of *pallidus* were older than those of *megacephalus*.

To speculate further, and with even less factual basis: If from Penoyer Valley the incipient species *pallidus*, adapted to existence in the fine sand, spread to the westward (appropriate soils occur in that direction), a plausible explanation of the limits of range of *pallidus* is provided. With a progressive diminution in the area of Lake Lahontan to the westward of the main range of *megacephalus*, it, like *pallidus*, may have extended its range into the areas newly available because of the drying up of Lake Lahontan, but this was in a part of the Lahontan Basin north of that first invaded by *pallidus*. Before this occurred, *megacephalus*, to judge from its present distribution, may have extended its geographic range around the northern end of Lake Lahontan and then on southward along the western shore. When populations of the two species met west of Penoyer Valley, for example in Cactus Flat and at the southern end of Great Smoky Valley, it is conceivable that differentiation had progressed to the point where no crossbreeding at all occurred.

At still more western localities, for example in the area about Mono Lake, California, and in the eastern part of its range, for example Skull Valley, Utah—places reached and now inhabited by *megacephalus* but probably never reached by *pallidus*—*megacephalus* has several characters of *pallidus*, namely, long hind foot, large auditory bullae, and white under parts. In these places *megacephalus* lives in the fine sand. This parallelism between sand-inhabiting populations of *megacephalus* lends greater probability to the view that *pallidus* has developed some of its characters as a result of adaptation to living in the one kind of soil, fine sand. Also, the fact that *megacephalus* inhabits fine sand only on the margins of its range, places far removed from known occurrences of *pallidus*, lends greater probability to the above-postulated origin of *pallidus* in Penoyer Valley or in some nearby part of south-central Nevada (see figs. 48 and 52, pp. 247 and 268).

The larger tympanic bullae of *pallidus* indicate that it is the more specialized of the two species and I think of it as the offspring rather than the parent or even sibling of *megacephalus*. Because *M. pallidus* lives on the fine sands in the bottoms of valleys where plants and animals associated with *Microdipodops* prosper most—population-densities for most species are greater there than on any one type of the firmer soils—it appears to be the more advanced of the two species. *M. megacephalus* has a wider tolerance as regards kind of soil. This fact and its more generalized structure (smaller auditory bullae) indicate for it greater potentialities in speciation; if additional species of *Microdipodops* are formed they probably will stem from *megacephalus* rather than from *pallidus*.

In review, a hypothesis sufficing for the meager factual information now available is that: The two species are at the stage rarely observed which can be designated as that between the last stage of a subspecies and the first stage of a species. The progress registered toward the formation of two full species has been accomplished by ecological separation, physiological separation, and extension of the geographic range, in the order mentioned.

HABITS

Kangaroo mice are nocturnal. In the daytime they live below ground in burrows which are closed to the outside by earth that the mice probably push into the opening; in any event, the wind soon after sunrise ordinarily drifts sand over the mouths of the burrows. A caged mouse invariably kept the entrance to its small nest box closed with sand during the day. This mouse, *M. p. pallidus*, was kept for six months in captivity without any water to drink. The burrows of *M. p. pallidus* studied ranged in length from eight inches to nearly three feet, and in depth from four inches to two feet. None had a nest and probably all were only resting places for the mice during the day.

Tracks of kangaroo mice are essentially miniatures of those of kangaroo rats. The relatively large impressions of the hind feet usually are not parallel but have the toes pointing outward. This position permits the hind feet, equipped as they are with stiff, projecting hairs on the sides of the soles, to function effectively in the sand when the animal leaps, which it does by using the two hind feet at the same time rather than alternately. Impressions of the forefeet usually are present, but if not, consecutive pairs of tracks left by the hind feet are farther apart than otherwise. This indicates that rapid progress is accomplished mainly or wholly by use of the

hind feet. The mark ordinarily left by the dragging tail is absent under these circumstances; the tail is apparently carried higher off the ground when the animal makes haste. One young kangaroo mouse at Halleck repeatedly jumped out of a can the sides of which were 17 inches high. This it did without touching the sides of the can, which was only ten inches in diameter.

Ordinarily the wanderings of one of these mice over the sand can not be traced far because there are tracks of so many animals that an individual trail is blotted out by those from another direction. Once, however, five miles west of Halleck, I followed the tracks of one individual between two points that were 70 yards apart.

I do not know whether the mice come out in the snow. Each of the two species has been trapped on bare ground on nights so cold that their bodies were solidly frozen in the morning. On nights when rain fell they seemed not to come out of their burrows; traps then caught but few kangaroo mice and sometimes none in places where they were known to be numerous.

Although commonly thought of as rare, these mice, like other desert rodents, become truly abundant at times in their preferred habitat. Indication of this abundance is provided by catches as follows: On July 10, 1933, nine miles west and three miles south of Tybo, 121 kangaroo mice, species *M. megacephalus*, and 35 other rodents were taken in one night in 313 traps. On May 17, 1931, 92 of the species *M. pallidus* were taken in 198 traps in one night in Kawich Valley.

The food probably consists mostly of seeds, but insects comprise a considerable share. In the cheek pouches of *M. megacephalus* we found one freshly killed larva of an insect 13 mm. long and 5 mm. in diameter; a second mouse had a larva of an insect in each pouch; a third had several plant seeds and one insect larva in each pouch; and a fourth had in the two pouches a few fragments of a leopard lizard and 57 plant seeds. In the cheek pouches of *M. pallidus* caught in Fish Lake Valley we found seeds of *Gilia* sp. and *Oryzopsis hymenoides* and a larva, three-fourths of an inch long, of an insect. In the next valley to the east, eight miles southeast of Blair, W. B. Davis (MS.) recorded that the contents of the cheek pouches of several of these mice comprised two scarabæid beetles, one small centipede, the pupa of a moth, and several kinds of seeds.

In each species the number of embryos per litter averaged 3.9, the usual number being four. For *megacephalus* (54 pregnant) the number ranged from two to seven, and in *pallidus* (56 pregnant), from two to six. No mice were trapped from mid-October to March 27,

but pregnancies were recorded from March 28 to September 22. The data suggest but do not prove that there is more than one litter per year.

Averages of measurements of 70 adults of each sex of *M. megacephalus* and 40 adults of each sex of *M. pallidus* reveal no secondary sexual difference in size save possibly in weight. The males averaged 0.9 and 0.8 per cent heavier, respectively.

Molt was in progress in 74 adults of *megacephalus*. Of these, 14 were taken in May, one in June, and the remaining 59 in July. Of *M. pallidus*, 25 adults were in process of molt. Two of these were taken in June and the remainder in July. There seems to be but one molt per year.

Genus *Microdipodops* Merriam.

Microdipodops Merriam, N. Amer. Fauna, 5, p. 115, 1891.

Type species.—*Microdipodops megacephalus* Merriam.

Diagnosis.—Size small, adults from 130 to 180 mm. in total length with tail averaging slightly longer than head and body; tail short-haired, lacking terminal tuft and of greater diameter in middle than at base or tip; sole of hind foot densely covered with long hair; no dermal gland on back between shoulders; auditory bullae more highly inflated than in any other heteromyid, reaching below level of grinding surface of cheek-teeth and in many individuals extending anteriorly beyond glenoid fossae; bullae meeting in a symphysis across ventral face of basisphenoid; antero-lateral face of zygomatic process of maxilla not much expanded, resulting in hamular process of lacrimal projecting free of maxilla; dental formula: $\frac{1}{1}, \frac{0}{0}, \frac{1}{1}, \frac{3}{3}$; upper incisors grooved; cheek-teeth hypsodont but each with more than one root, except $M_{\frac{3}{3}}$; molars with H-pattern; P^4 as in *Perognathus*; $P_{\frac{4}{4}}$ with five or six cusps; cusps soon worn away with result that occlusal face of each cheek-tooth is an area of dentine completely surrounded by enamel; no pit behind $M_{\frac{3}{3}}$; manus long and slender; tibia and fibula fused throughout almost three-fifths of their length; cervical vertebrae mostly fused; caudal vertebrae lacking median ventral foramen; locomotion ricochetal.

Remarks.—Among living genera of heteromyids, *Microdipodops* is in many features intermediate between *Dipodomys* and *Perognathus* but shows greater resemblance to the latter. The best account of the osteology and dentition in comparison with that of other genera, living and extinct, is by Wood (1935). Hatt (1932) made a comparison of the vertebral column with that of other ricochetal rodents.

Merriam's (1891, p. 115) mention of rootless molars was properly queried by Wood (1935), whose limited material prevented him from satisfying himself on this point. Teeth extracted from specimens in the Museum of Vertebrate Zoology show that M^1 is rooted in both old and young specimens of *M. pallidus*, and that the roots are present in both adult and young topotypes of *M. megacephalus* although small in the young. Indeed, in one of two young topotypes of *megacephalus* no indication of roots was found. Thus Merriam's statement probably was correct for the specimen examined by him, but actually the anterior molar above is normally rooted, as is also the first molar below, the upper and lower premolar, and sometimes the second upper and lower molar. The third (last) molar is single-rooted above and below.

The short-haired tail of *Microdipodops* is notable for being larger in the middle and most of the proximal third than at either the base or the tip. Probably this fleshiness near the middle permits it to function as a balancing organ in somewhat the same way as does the tail in *Dipodomys* and *Perognathus* but what *Dipodomys* accomplishes by a combined lengthening of the tail and growth of long hairs on its tip, or what *Perognathus* accomplishes by a mere lengthening of the tail, *Microdipodops* does by an increase in diameter of the middle part of the tail. The adaptation resembles that in the fat-tailed mice of the desert of northern Africa, but the degree of "fattening" is much less.

The increased diameter of the tail about a third of its length back from the base in *Microdipodops* is only a little less than in *Salpingotus crassicauda* (Vinogradov, 1924, p. 150, fig. 1) from the deserts of central Asia. Probably ecologically, and certainly in structural features of an adaptive sort, these two genera are extreme developments in the same direction within their respective families, Heteromyidae and Dipodidae. Each has tremendously enlarged auditory bullae, thick and stiff hair on the sole of the hind foot, a tail that is long, short-haired, and thicker in its middle and most of its proximal third than at the base. In each of the mentioned features, *Salpingotus* is more specialized than *Microdipodops*, probably because the deserts of central Asia are older than those of America and evolution along the adaptive lines mentioned has been operative for a longer time.

***Microdipodops megacephalus*. DARK KANGAROO MOUSE.**

Diagnosis.—Upper parts brownish, blackish, or grayish depending upon the subspecies, with basal two-thirds of hair plumbeous,

followed by brownish or buffy portion, and, on most longer hairs, tip of darker brown or black; under parts lighter, usually plumbeous in basal half and distally white, but in some subspecies white to

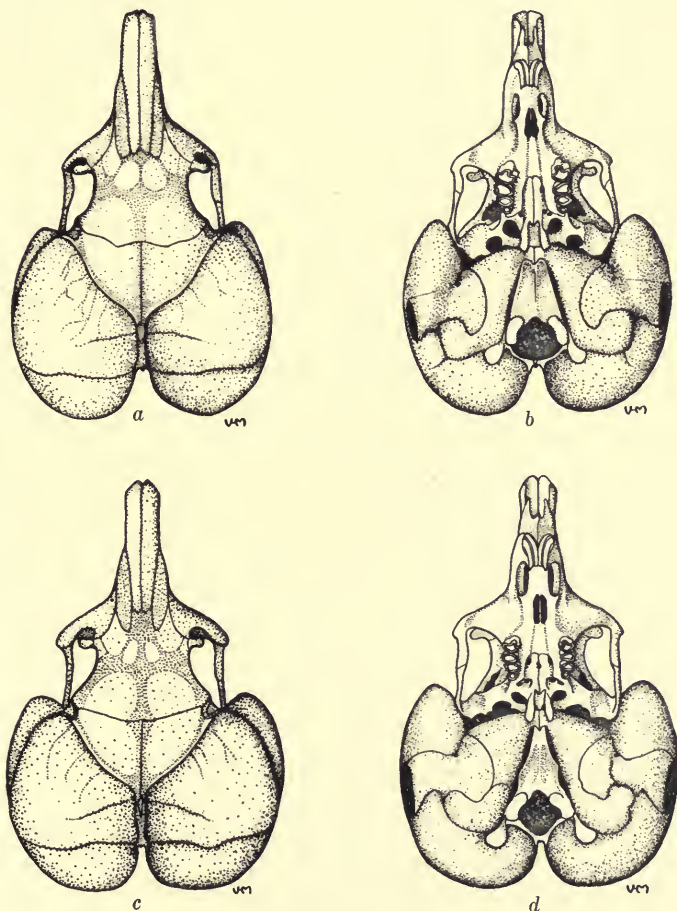


FIG. 46. *a, b*, Skull of *Microdipodops megacephalus megacephalus*, No. 70942, female, Winzell, Eureka County, Nevada. *a*, Dorsal view. *b*, Ventral view. *c, d*, Skull of *Microdipodops pallidus pallidus*, No. 59344, female, eight miles southeast of Blair, 4,500 feet, Esmeralda County, Nevada. *c*, Dorsal view. *d*, Ventral view. Note in *a* and *b*, in comparison with *c* and *d*, shortness of nasals relative to premaxillae, smaller auditory bullae, narrowness across maxillary arms of zygomata, and expansion posteriorly of incisive foramina. All $\times 1\frac{1}{2}$.

base, and in others plumbeous basally, then white and tipped with buffy; color of under parts extending over fore and hind legs, flanks and sides of head, but not encroaching as far upward as base of ear

or lower lid of eye; length of hair about 12 mm. on back and 8 mm. on under parts; facial vibrissae (about 35 mm. long) reaching to behind ear; supraorbital light spot present in many populations and all but a few populations have a light postauricular patch shaded with buffy; antipalmar and antiplantar faces of feet short-haired and grayish or brownish; tail likewise short-haired and, although not sharply bicolor, of same color above and below as corresponding parts of body except that distal half to sixth ordinarily is darker than back, sometimes black; skull relatively narrow (see below).

Remarks.—The races *M. m. megacephalus* and *M. m. sabulonis* in comparison with *M. pallidus* (all races included) differ in brownish or blackish rather than whitish or light buffy upper parts; buffy rather than white postauricular light patches; hair of under parts plumbeous basally rather than everywhere white entirely to base; tail above tipped with black rather than without darker color terminally; hind foot shorter (23 to 25 rather than 25 to 27 mm.); skull with less inflated auditory bullae and hence less in maximum width; upper incisors more recurved; anterior palatine foramina wider posteriorly and tapering to sharper point anteriorly rather than narrow and parallel-sided with less obviously tapered anterior ends; nasals extending posteriorly quite or almost as far as do premaxillae rather than extending posteriorly to a point considerably short of that reached by premaxillae. At the eleven places where the race *M. m. sabulonis* and some race of *M. pallidus* meet or occur together, the two kinds are easily distinguished either by the skins or by the skulls. Exception is to be made only for Penoyer Valley, as described in detail under the account of the genus, where three seeming hybrids were found among a total of 57 animals, including 34 of *M. pallidus ruficollaris* and 20 of *M. megacephalus sabulonis*.

In the other, more western and more eastern, subspecies of *M. megacephalus*, not one of the characters above mentioned as diagnostic of *M. m. megacephalus* and *M. m. sabulonis* everywhere holds. In the western races it is true that the upper parts always are darker colored than in *pallidus*, but the narrower skull as measured across the mastoids, especially in relation to the basal length, although nearly always diagnostic of populations is less often of individuals. The terminal darkening of the tail and basally plumbeous pelage of the under parts serve to distinguish most specimens of *M. megacephalus* from *M. pallidus*, but at a few localities most specimens resemble *M. pallidus* in these two features. The shape of the incisive foramina closely approaches that in *M. pallidus*, and the curvature of the upper incisors is in even more specimens the

same as in *M. pallidus*, as is also the relation to one another of the posterior ends of the nasals and premaxillae. The hind foot in these western forms of *M. megacephalus* often is as long as in *M. pallidus*. Furthermore, these western forms of *megacephalus* are partial to fine wind-drifted sand, as is *M. pallidus*. At only one place in this western region, in Granite Spring Valley, 21 miles west

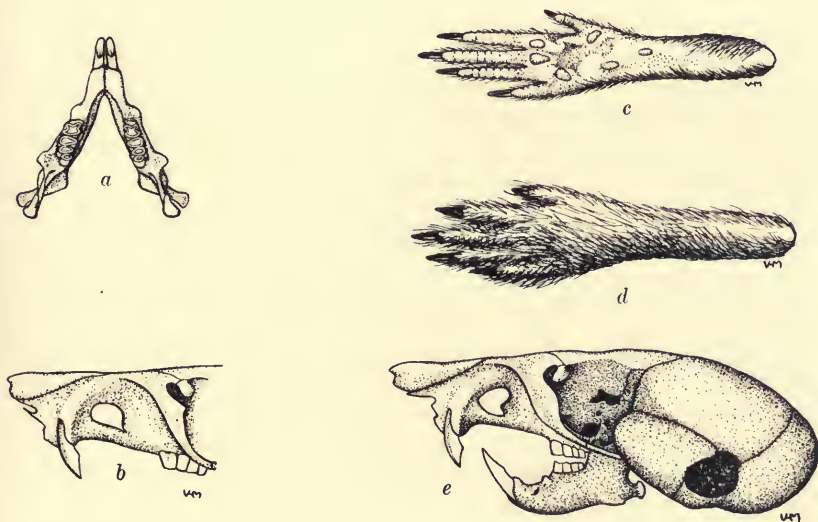


FIG. 47. *a, b, Microdipodops megacephalus megacephalus*, No. 70942, female, Winzell, Eureka County, Nevada. *a*, Occlusal view of teeth and lower jaw. *b*, View of left side of preorbital part of skull. *c*, *Perognathus parvus columbianus*, No. 86892, male, Ritzville, Adams County, Washington; plantar view of right hind foot. *d*, *Microdipodops pallidus pallidus*, No. 38757, male, seven miles north of Arlemont, 5,500 feet, Esmeralda County, Nevada; plantar view of right hind foot. *e*, *Microdipodops pallidus pallidus*, No. 59344, female, eight miles southeast of Blair, 4,500 feet, Esmeralda County, Nevada; view of left side of cranium and lower jaw. Note in *e*, in comparison with *b*, greater antero-posterior extent of lateral face of maxillary arm of zygoma, and less recurved upper incisors. *d* illustrates the hairiness of the sole of the hind foot of *Microdipodops* in comparison with the naked sole of the foot of *Perognathus*. All $\times 1\frac{1}{2}$.

and two miles north of Lovelock, have we found the two species together. If there was a difference in type of soil occupied by the two we did not note it at this place. The two specimens of *M. megacephalus* are easily differentiated from the 11 *M. pallidus* by darker color and by lesser width across the auditory bullae. Otherwise, the 46 places of capture of these western races of *M. megacephalus* and the 19 places of capture of *M. pallidus*, west of Nye County, yielded mice of only a single kind at any one locality. Between the sandy soils supporting the two kinds of mice, some barrier of soil

inhospitable to mice of this genus intervenes. For example, the sand about Wadsworth and southeastward for a mile and a half harbors *M. megacephalus*. Twenty-five miles southward, near Fallon, the fine sand harbors *M. pallidus*. In the low pass, to the east of Fernley, connecting the two sandy areas, *Microdipodops* do not occur, according to our testing (365 traps) and observation of the area. Along the eastern base of the Sierra Nevada, *M. megacephalus* keeps to the sandy areas, and *M. pallidus* occupies similar soils in the generally slightly lower and hotter terrain in the bottom of the trough lying along the eastern base of the Sierra Nevada. In this general area, then, not an edaphic difference but some other difference or factor, at this writing unknown, accounts for the different ranges of the two kinds.

In view of the foregoing it may reasonably be asked whether these western dark-colored *Microdipodops* (races *oregonus*, *californicus*, *ambiguus*, *nexus*, *medius*, *nasutus*, and *polionotus*) are conspecific with *M. megacephalus*. The test of actual intergradation, involving continuous geographic distribution, probably cannot be applied to these mice because they seem to have an interrupted distribution conforming to the distribution of a few types of soils. Therefore, actual crossbreeding does not occur between some populations. The critical area as regards the relation (intergradation or lack of it) between *M. m. megacephalus* and the more western races referred to the species *megacephalus* is the territory of northern Eureka County and a part of northern Lander County, or the country (see fig. 48, p. 247) between the eastern border, as now known, of the race *M. m. nexus* and the westernmost known occurrence of *M. m. megacephalus*. The westernmost *nexus* were taken in sand, and the easternmost *M. m. megacephalus* on firmer, less sandy soil. Between the two places there are areas judged by W. C. Russell and W. B. Richardson, who tested the area for *Microdipodops*, to be unsuitable for either of the subspecies concerned. Apparently the two kinds do not actually meet. Nevertheless, the difference between the two is relatively slight, as is set forth in the accounts of the subspecies. Also, *M. m. nexus* is, in color, in length of the hind foot, and in some cranial proportions, intermediate between *M. m. megacephalus* known from about 75 miles to the eastward and *M. m. ambiguus* known from five miles or less to the westward. This is the basis for regarding the western dark-colored races (*oregonus*, *californicus*, *nasutus*, *polionotus*, *medius*, *ambiguus*, and *nexus*) as conspecific with *M. megacephalus* rather than as a third species distinct from *M. megacephalus* and, of course, from *M. pallidus*.

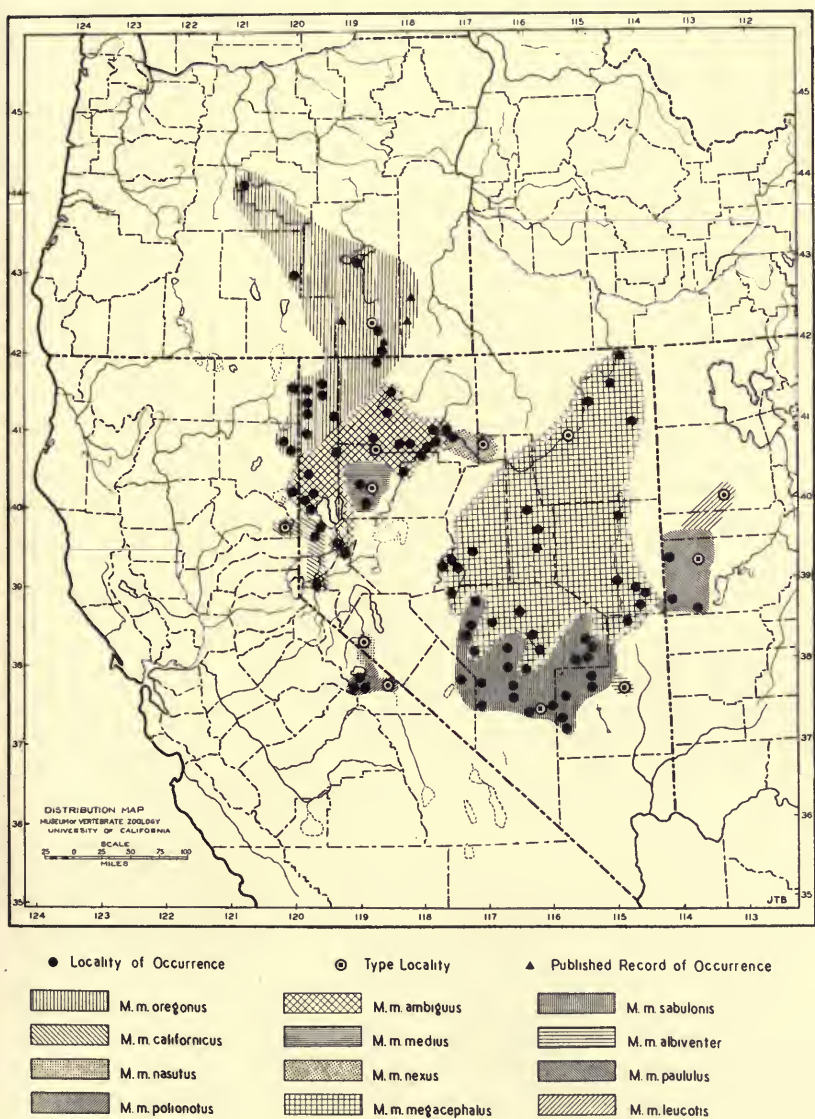


FIG. 48. Map showing geographic range of the subspecies of *Microdipodops megacephalus*.

Microdipodops megacephalus oregonus Merriam.

Microdipodops megacephalus oregonus Merriam, Proc. Biol. Soc. Wash., 14, p. 127, 1901; Bailey, N. Amer. Fauna, 55, p. 241, 1936.

Type.—Male, not fully adult (crown of P⁴ barely worn), skin with skull; No. 80128 United States National Museum, Biological Survey Collection; Wild Horse Creek, four miles northwest of Alvord Lake, Harney County, Oregon; August 18, 1896; collected by Clark P. Streater; original No. 5430.

Range.—Southeastern Oregon, northeastern California, and northwestern Nevada (see fig. 48, p. 247).

Diagnosis.—Body short; tail relatively long; upper parts, including upper side of tail, blackish with a reddish hue; tail black above distally; postauricular and supraorbital light spots small or wanting and ordinarily overlaid with buffy; hair of under parts usually with faint plumbeous shade basally and tipped with buffy; skull with basal length more or less than greatest breadth; incisive foramina averaging widest posteriorly, but sometimes widest near middle; nasals extending posteriorly as far as premaxillae.

Comparisons.—From *M. m. californicus* this race differs in: upper parts darker, more reddish and less grayish; hair of under parts more often plumbeous basally and buffy distally rather than white entirely to base; skull narrower across maxillary arms of zygomatics. From *M. m. ambiguus*, *oregonus* differs in: body shorter; upper parts lighter, less reddish and more grayish; feet lighter-colored; skull averaging narrower across auditory bullae and maxillary arms of zygomatic arches.

Remarks.—Intergradation with *ambiguus* is indicated by specimens of that race from Smoke Creek, nine miles east of the California boundary, and by specimens assigned to *oregonus* from Denio.

Some geographic variation is shown by specimens from Oregon, which suggests that more than one race should be recognized there. From "Lake Alvord" there are nine specimens obtained in 1930 by Miss Annie M. Alexander and Miss Louise Kellogg, which include two animals colored about like the abundant material from two miles south of Borax Spring and from seven miles south of Andrews. The seven other specimens are so much lighter above as instantly to catch the eye. The seven have white rather than buffy postauricular patches and the fur of the under parts is distally white rather than buffy. In three, the hair of the under parts is white all the way to the base, as it is in the one specimen taken in 1920 by S. G. Jewett at Powell Butte. On the upper parts this

specimen from Powell Butte is intermediate in color between the light and dark specimens from Lake Alvord. Specimens from the northeast edge of Alkali Lake in Lake County differ in color from the dark specimens from Lake Alvord, so far as I can see, only in that the hair on the under parts is distally white rather than buffy. The skull of the lightest-colored animal from Lake Alvord (M.V.Z. No. 45329) has the premaxillae extending exceptionally far behind the nasals. Otherwise it, and the skulls of the other light-colored specimens, including the one from Powell Butte, so far as I can see, present no features distinguishing them from the skulls of the dark-colored specimens from Oregon. Possibly more than one geographic race is present in Oregon but with the information which is outlined above I can find basis for recognizing only one.

The darkest specimens of all are those from northeastern Washoe County, Nevada. These animals from near Painted Point, Vya, and Hausen are more blackish and have a darker red color than others. Also, in some populations from this area, the postauricular and supraorbital spots are absent. This tendency to darker color is associated with longer body, which occurs also in animals of the race *californicus*. In referring these Nevadan populations to *oregonus* the fact should not be lost sight of that relatively dark color and large body are associated with this area of dark-colored lavas and that *Microdipodops* has responded in the same direction, namely, darker color, as has *Dipodomys microps*. Of the latter species, the subspecies *aquilonius* has become differentiated in this region and several other mammals vary in the same way. Californian specimens from Observation Peak and from one mile west of Red Rock Post Office are slightly lighter-colored than the Nevadan specimens mentioned but have much reddish color in the upper parts.

Specimens examined.—Total number 205, as follows:

OREGON.—Crook County: Becker Ranch, Powell Butte, 1 (Coll. Stanley G. Jewett). Lake County: 2½ miles northeast of Alkali Lake Ranch, 2; northeast edge of Alkali Lake, 4,200 feet, 20. Harney County: one mile south of Narrows, 4,200 feet, 3; five miles southwest of Narrows, 4,000 feet, 24; seven miles south of Andrews, 4,300 feet, 4; Lake Alvord, Alvord Desert, 11; two miles south of Borax Spring, south end of Lake Alvord, 4,300 feet, 20; 1½ miles east of Denio, 4,200 feet, 6.

CALIFORNIA.—Modoc County: Sand Creek, 1 (U. S. Nat. Mus., Biol. Surv. Coll.); three miles east of Eagleville, 1 (L. A. Mus.). Lassen County: two miles west of Red Rock Post Office, 5,200 feet,

2; one mile west of Red Rock Post Office, 5,300 feet, 11; seven miles north of Observation Peak, 5,300 feet, 1; six miles north of Observation Peak, 13.

NEVADA.—Washoe County: three miles north of Vya, 5,900 feet, 4; $4\frac{1}{2}$ miles northeast of Painted Point, 5,800 feet, 10; $8\frac{1}{2}$ miles east of Vya, 5,900 feet, 7; three miles east of Painted Point, 5,850 feet, 3; $10\frac{1}{2}$ miles south of Vya, 5,800 feet, 2; 11 miles south of Vya, 5,800 feet, 1; 12 miles south of Vya, 5,800 feet, 4; 13 miles south of Vya, 5,800 feet, 1; 15 miles south of Vya, 5,800 feet, 1; Little High Rock Canyon, 5,000 feet, 1; mouth of Little High Rock Canyon, 5,000 feet, 11; one mile east of mouth of Little High Rock Canyon, 5,000 feet, 1; one mile west of Hausen, 4,650 feet, 4; Hausen, 4,800 feet, 3; ten miles southeast of Hausen, 4,675 feet, 13. Humboldt County: one mile south of Denio (Oregon), 4,200 feet, 19.

Microdipodops megacephalus californicus Merriam.

Microdipodops californicus Merriam, Proc. Biol. Soc. Wash., 14, p. 128, 1901.

Type.—Male, not fully adult (crown of P⁴ barely worn), skin with skull; No. 101227 United States National Museum, Biological Survey Collection; Sierra Valley, near Vinton, Plumas County, California; August 7, 1900; collected by Walter K. Fisher; original No. 1596.

Range.—Intermontane valleys of eastern Plumas County, California, and southern Washoe and Ormsby counties, Nevada (see fig. 48, p. 247).

Diagnosis.—Tail and hind foot of medium length or long; upper parts grayish brown with reddish hue; tail distally blackish or dark brownish; postauricular and supraorbital light patches usually present but sometimes absent; feet grayish; hair of under parts white all the way to base; skull with width across auditory bullae not much if any greater than basal length; broad across zygomatic arms of maxillae and interorbitally; incisive foramina generally widest near middle; relation between posterior ends of nasals and premaxillae variable but nasals usually extending nearly as far posteriorly as premaxillae.

Comparisons.—Comparisons with *oregonus*, *ambiguus*, and *nasutus* are made in the accounts of those forms.

Remarks.—The one specimen from near Carson City is notable for the large, nearly white postauricular patches and for the narrowness of the skull as measured across the auditory bullae (17.1 mm.) and maxillary processes of the zygomata (11.2). The basal length is 18.4.

Specimens examined.—Total number 23, as follows:

CALIFORNIA.—Plumas County: Sierra Valley, Vinton, 13 (12 in U. S. Nat. Mus., Biol. Surv. Coll.).

NEVADA.—Washoe County: $2\frac{3}{4}$ miles southwest of Pyramid, 4,300 feet, 6; Junction House, 4,500 feet, 3. Ormsby County: $3\frac{1}{2}$ miles east of Carson City, 4,700 feet, 1.

***Microdipodops megacephalus nasutus* subsp. nov.**

Type.—Female, adult, skin with skull; No. 40439 Museum of Vertebrate Zoology; Fletcher, 6,098 feet, Mineral County, Nevada; July 22, 1928; collected by Louise Kellogg; original No. 374.

Range.—Known only from the type locality (see fig. 48, p. 247).

Diagnosis.—Tail of short to medium length; hind foot long; upper parts grayish marked with blackish; supraorbital patches faint or absent; postauricular patches light gray rather than white or buffy; feet light gray; under parts white but light plumbeous basally; skull with greatest breadth slightly exceeding basal length; broad across zygomatic arms of maxillae and interorbitally; incisive foramina broad, either parallel-sided or widest posteriorly; relation of posterior end of nasals and premaxillae variable but premaxillae extending well behind nasals in three of four adults.

Comparisons.—From *californicus*, this race differs in: tail and body slightly shorter; upper parts grayer (distinctly less reddish); skull broader across auditory bullae. From *polionotus*, *nasutus* differs in: body longer; tail relatively shorter; hind foot longer; skull relatively broader across auditory bullae; nasals longer.

Specimens examined.—Total number 6, as follows:

NEVADA.—Mineral County: Fletcher, 6,098 feet, 6.

***Microdipodops megacephalus polionotus* Grinnell.**

Microdipodops polionotus Grinnell, Univ. Calif. Pub. Zool., 12, p. 302, 1914.

Type.—Male, adult, skin with skull; No. 17031 Museum of Vertebrate Zoology; McKeever's Ranch, two miles south of Benton Station, 5,200 feet, Mono County, California; July 10, 1912; collected by C. D. Holliger; original No. 184.

Range.—Mono Lake Basin and extreme head of Owens Valley, in Mono County, California (see fig. 48, p. 247).

Diagnosis.—Tail long relatively; body and hind foot short; upper parts grayish, with mixed brownish and blackish; tail above colored like upper parts and scarcely darker distally than proximally;

supraorbital patches faint or wanting; postauricular patches white; feet light gray; under parts with hair white all the way to base; skull with greatest breadth only slightly exceeding basal length; broad across zygomatic arms of maxillae and interorbitally; incisive foramina widest posteriorly; premaxillae extending well behind nasals.

Comparisons.—Comparison with *nasutus* is made in the account of that race. Most, but not all, specimens are lighter-colored on the upper parts than *nasutus*.

Remarks.—The upper parts range from a color almost as dark as in *nasutus* to one much paler because of a reduction of the blackish pigment and addition of light cinnamon color. The palest animals, nevertheless, are much darker than those of the species *pallidus*. Both the dark and light specimens of *polionotus* differ from other races of the species *megacephalus* along the California-Nevada boundary in having the black on the top of the terminal fourth of the tail much reduced in amount, although in no specimens seen is the black entirely lacking.

Despite what has been said above about the pale color of *polionotus*, and Grinnell's (1914, p. 302) statement, made when first describing the form, that it "differs from all those previously described in extreme pallor of coloration," this race is darker-colored on the upper parts than is *M. m. leucotis*, is no paler and probably always darker than *M. m. albiventer* and *M. m. paululus*, and is darker-colored than races of the species *M. pallidus*.

Specimens examined.—Total number 65, as follows:

CALIFORNIA.—Mono County: east side of Mono Lake, 1 (U. S. Nat. Mus., Biol. Surv. Coll.); Salmon Ranch, 6,600 feet, Mono Lake, 4; Farrington Ranch, Mono Lake, 4 (U. S. Nat. Mus., Biol. Surv. Coll.); Pellisier Ranch, 5,600 feet, five miles north of Benton, 6; Benton, 5,639 feet, 8; Dutch Pete's Ranch, 6,500 to 6,600 feet, four miles west of Benton, 6; Taylor Ranch, 5,300 feet, two miles south of Benton Station, 25; McKeever's Ranch, 5,200 feet, two miles south of Benton Station, 10; Taylor Valley, 7,000 feet, 25 miles west of Benton Station, 1 (L. A. Mus.).

***Microdipodops megacephalus ambiguus* subsp. nov.**

Type.—Male, adult, skin with skull; No. 73840 Museum of Vertebrate Zoology; 1¼ miles north of Sulphur, 4,050 feet, Humboldt County, Nevada; July 25, 1936; collected by E. Raymond Hall; original No. 5285.

Range.—Smoke Creek and Black Rock deserts and lower part of Humboldt River Valley in Nevada and in extreme eastern California; from Quinn River Crossing southwest to Warm Spring, south to Humboldt, and east to Golconda (see fig. 48, p. 247).

Diagnosis.—Tail and hind foot long; upper parts grayish with olive hue; tail black above distally; feet whitish; postauricular and supraorbital patches of moderate size; hair of under parts white, plumbeous at base in topotypes but white all the way to base in many populations; skull with tympanic bullae much inflated, resulting in greatest breadth of skull amounting to more than basal length; narrow across zygomatic arms of maxillae; interorbital breadth medium; incisive foramina generally widest posteriorly but sometimes widest at middle; nasals projecting nearly as far posteriorly as premaxillae in northern populations but falling much short of premaxillae in southern populations, although variable there.

Comparisons.—From *californicus*, this race differs in: body shorter; tail longer; upper parts lighter (more grayish olive and less reddish); skull broader across auditory bullae but narrower across maxillary arms of zygomata and interorbitally. Comparisons with *oregonus* and *medius* are made in the accounts of those forms. From *nexus*, *ambiguus* differs in: tail shorter; upper parts and upper side of tail lighter (more yellowish and less blackish and less reddish); hair of under parts often white entirely to base rather than plumbeous basally. From the race *megacephalus*, *ambiguus* differs in: tail and hind foot longer; upper parts, including upper side of tail, markedly lighter; postauricular patches white or nearly so rather than buffy; black on upper side of tail more extensive and more intense; skull broader across tympanic bullae, and interorbitally.

Remarks.—The geographic range of *ambiguus* is relatively large and in it there are exposures of many different geological formations. Lying on these are varied products of relatively recent volcanic activity and in addition there are the even more recent deposits left by the Pleistocene Lake Lahontan. These diverse formations have contributed to the building up of many different kinds of sandy soils suitable for occupancy by *Microdipodops*. The populations of mice themselves show a wide variation. This is true to some extent of the skulls, is even more evident in the external proportions, and is most pronounced in the coloration. The palest of the animals are those from one mile west of Humboldt. In order of increasing darkness the others are those from the vicinities of Jungo, Sulphur, Flanigan, Winnemucca, and Wadsworth. The difference in color

is not, however, entirely a matter of lightness and darkness. Those from Smoke Creek are intermediate in color, as they are also geographically, between *oregonus* and *ambiguus*, and resemble *californicus* in color, although the resemblance is judged not to be the result of continuity in geographic range with *californicus*, nor the result of close genetic relationship with it. In color, those from Jackson Creek Ranch approach the population from Denio assigned to *oregonus*; those from Wadsworth approach *californicus*; those from Winnemucca tend toward *nexus*. Thus, intergradation is evidenced with each of the subspecies of *megacephalus* whose range meets or closely approaches that of *ambiguus*.

In external measurements, evidence of intergradation with nearby races is provided by the greater length of tail in animals from nine to ten miles north of Golconda, as well as by the shorter body. These strongly resemble *nexus*. The reduced length of tail in animals from Quinn River Crossing is a feature better developed farther north in the populations of *oregonus*.

Cranially, animals from Quinn River Crossing and from Flanigan tend to be broad interorbitally much as in *oregonus* and *californicus*. This suggests intergradation in this feature. The incisive foramina are widest posteriorly in animals from the vicinities of Quinn River Crossing and Golconda, as they generally are in animals from Sulphur. At Flanigan the incisive foramina are widest near the middle in most specimens.

Of populations assigned to *ambiguus*, that from the vicinity of Flanigan, including the animals from the vicinity of Warm Spring just across the boundary in California, is the most aberrant. At the same time the variation between individuals here is greater than at any other locality. In the population as a whole, the body is long, the tail short, the hind foot long, the weight great, the color light, the skull narrow across the auditory bullae and wide across the maxillary arms of the zygomata and in the interorbital region. The cranial proportions mentioned suggest intergradation of *ambiguus* with *californicus*, as does the longer body, but the other features enumerated in some measure set the population from Flanigan apart from any of the surrounding races. The incisive foramina tend to be widest at the middle rather than posteriorly as in most of the dark races. The situation is complicated because the variation in color between individuals is greater here than at any other locality. In one animal the color is as dark as in *oregonus*, and in some others as light as in *pallidus*. The vast majority of the specimens agree in color with topotypes of *ambiguus*. The skulls are more uniform

than the skins. The skulls of the dark and light animals agree with those of the specimens colored as in typical *ambiguus*.

With the information now available, it appears that the populations of *Microdipodops* from the vicinity of Flanigan and Warm Spring (1) agree in essential characters with *ambiguus*, (2) in several features are intermediate toward the race *californicus* to the south-westward, (3) in a few characters differ from any of the surrounding subspecies, and (4) embrace a few individuals which in color and color pattern have preserved the characters of nearby races.

This interpretation is the best that I can offer for the facts in hand, but additional field work with particular attention to type of soil on which animals of different colors occur would be worth while, to see if a better explanation can be found.

Peromyscus maniculatus and some other mammals in this low area about Flanigan show a high percentage of light-colored individuals such as predominate in populations farther to the southeast. *Microdipodops*, then, is not unique in showing much color variation here.

Specimens examined.—Total number 259, as follows:

CALIFORNIA.—Lassen County: Warm Spring, 4,000 feet, nine miles east of Amadee, 3; one mile southwest of Warm Spring, 4,000 feet, 4.

NEVADA.—Washoe County: 2½ miles east and 13 miles north of Gerlach, 4,050 feet, 1; 2½ miles east and 11 miles north of Gerlach, 4,050 feet, 4; three miles east and ten miles north of Gerlach, 4,000 feet, 1; Smoke Creek, nine miles east of California boundary, 3,900 feet, 9; north side of Sand Pass, 3,900 feet, 5; four miles northwest of Flanigan, 4,200 feet, 7; 3½ miles northwest of Flanigan, 4,200 feet, 17; one-half mile northwest of Flanigan, 4,200 feet, 3; 2½ miles east of Flanigan, 4,200 feet, 8; 3½ miles east of Flanigan, 4,200 feet, 4; 1½ miles north of Wadsworth, 4,100 feet, 2. Lyon County: one-half mile southeast of Wadsworth, 4,200 feet, 4; one mile southeast of Wadsworth, 4,200 feet, 12. Humboldt County: one-half mile west of Quinn River Crossing, 4,100 feet, 2; two miles southwest of Quinn River Crossing, 4,000 feet, 7; 2½ miles southwest of Quinn River Crossing, 4,100 feet, 1; 4½ miles south of Quinn River Crossing (4,000 feet, 5; 4,100 feet, 3), 8; Jackson Creek Ranch, 17½ miles south and five miles west of Quinn River Crossing, 4,000 feet, 7; seven miles north of Winnemucca, 4,400 feet, 20; nine miles northwest of Golconda, 21; ten miles north-northwest of Golconda, 12; six miles north of Golconda, 19; Flowing

Spring, 2 (U. S. Nat. Mus., Biol. Surv. Coll.); $9\frac{1}{2}$ miles north of Sulphur, 4,050 feet, 6; eight miles east and one mile north of Jungo, 4,200 feet, 22; 11 miles east and one mile north of Jungo, 4,200 feet, 1; three miles southwest of Winnemucca, 4,500 feet, 2; five miles southwest of Winnemucca, 4; ten miles southwest of Winnemucca, 4,500 feet, 7; $1\frac{1}{4}$ miles north of Sulphur, 4,050 feet, 14; one mile west of Sulphur, 4,040 feet, 3; three-quarters of a mile south of Sulphur, 4,050 feet, 3. Pershing County: 15 miles southwest of Winnemucca, 1; one mile west of Humboldt, 4,180 feet, 13.

***Microdipodops megacephalus medius* subsp. nov.**

Type.—Female, adult, skin with skull; No. 73890 Museum of Vertebrate Zoology; three miles south of Vernon, 4,250 feet, Pershing County, Nevada; July 28, 1936; collected by E. Raymond Hall; original No. 5324.

Range.—Southwestern Pershing County, Nevada (see fig. 48, p. 247).

Diagnosis.—Tail of short to medium length; hind foot short; upper parts, including upper side of tail, blackish with a reddish hue; tail blackish above distally; feet light dusky; postauricular light patches well developed and whitish; supraorbital light patches present but less conspicuous than postauricular patches; under parts white although hair often plumbeous at base; skull with auditory bullae moderately inflated; interorbital breadth "average" for the species; incisive foramina widest posteriorly; premaxillae extending relatively far, for this species, behind the nasals, but variable.

Comparisons.—From *ambiguus*, this race differs in: upper parts darker, more blackish and more reddish (less gray); skull narrower as result of lesser inflation of auditory bullae. From *oregonus*, *medius* differs in: upper parts lighter, less blackish and slightly less reddish; feet lighter; postauricular patches more prominent; under parts white rather than frequently tipped with buffy; hind foot shorter; skull broader as result of greater inflation of auditory bullae; premaxillae extending farther behind nasals.

Remarks.—Near Vernon, *medius*, as might be expected from the color of the upper parts, occurs on dark-colored soils. It occurs also on light-colored soils, as is shown by the two specimens from west of Lovelock which were taken on a light-colored area which yielded also 11 specimens of the different species, *M. pallidus*. At this place the skins of the two can readily be separated by color. The skulls can be told apart by the lesser breadth (18.3 and

19.2 mm.) across the auditory bullae. In the 11 specimens of *pallidus* the average and extremes for the corresponding measurements are 19.7 (19.3–20.1).

Specimens examined.—Total number 21, as follows:

NEVADA.—Pershing County: three miles southwest of Vernon, 4,300 feet, 1; three miles south of Vernon, 4,250 feet, 18; 21 miles west and two miles north of Lovelock, 4,000 feet, 2.

***Microdipodops megacephalus nexus* subsp. nov.**

Type.—Male, adult, skin with skull; No. 70917 Museum of Vertebrate Zoology; three miles south of Izenhood, Lander County, Nevada; May 22, 1936; collected by Ward C. Russell; original No. 4466.

Range.—From $5\frac{1}{2}$ miles northeast of Golconda, Humboldt County, east to Izenhood, Lander County, Nevada (see fig. 48, p. 247).

Diagnosis.—Tail and hind foot long; upper parts grayish-brown; tail distally black; supraorbital spots indistinct; postauricular patches buffy; under parts white but plumbeous basally; skull with auditory bullae much inflated, resulting in greatest breadth amounting to more than basal length; narrow across zygomatic arms of maxillae; interorbital breadth medium; incisive foramina generally parallel-sided but rounded posteriorly and sharply pointed anteriorly; premaxillae extending a relatively short distance behind nasals.

Comparisons.—Comparisons with *ambiguus* and *megacephalus* are made in the accounts of those forms.

Remarks.—The range of this race is separated from that of *ambiguus* by a low range of mountains extending in a northeast direction from Golconda. In isolated populations from $5\frac{1}{2}$ miles northeast of Golconda to Izenhood, the characters are maintained in uniform fashion. In color these animals are almost exactly intermediate between *ambiguus* and *megacephalus* and thus bridge the gap between the western gray mice and the black mice from farther east. Geographically, there is a gap of about 75 miles between *nexus* and *megacephalus* to the eastward. In 1936 vain search was made for *Microdipodops* in this area about Battle Mountain, Cortez and Beowawe, by Ward C. Russell and William B. Richardson, who concluded that the mice did not occur in this area.

Specimens examined.—Total number 36, as follows:

NEVADA.—Humboldt County: five miles northeast of Golconda, 16. Lander County: Izenhood, 6; three miles south of Izenhood, 14.

Microdipodops megacephalus megacephalus Merriam.

Microdipodops megacephalus Merriam, N. Amer. Fauna, 5, p. 116, 1891.

Type.—Male, adult, skin with skull; No. 24417/31823 United States National Museum, Biological Survey Collection; Halleck, Elko County, Nevada; October 23, 1890; collected by Vernon Bailey; original No. 2005.

Range.—Northeastern Nevada; from northern Elko County south to northern Nye and Lincoln counties; from western Lander County east almost to Utah boundary (see fig. 48, p. 247).

Diagnosis.—Body large, tail and hind foot short; upper parts dark brown mixed with black; distal fourth to half of tail black; supraorbital spots faintly developed or absent; postauricular patches buffy; feet dusky; under parts with hair whitish to base only on throat, otherwise deep plumbeous basally with terminal wash of buffy; skull with auditory bullae moderately inflated, resulting in greatest width slightly exceeding basal length; maxillary and interorbital breadth moderate to slight; incisive foramina widest posteriorly and sharply pointed anteriorly; nasals projecting posteriorly nearly as far as premaxillae.

Comparisons.—From *nexus*, this race differs in: tail and hind foot shorter; upper parts, including upper side of tail, more blackish and less reddish; hair of under parts distally buffy rather than white; skull narrower across tympanic bullae. From *sabulonis*, *megacephalus* differs in slightly longer hind foot, in color in almost the same way as from *nexus*, and in tendency to slightly narrower incisive foramina. Comparisons with *leucotis*, *paululus*, and *albi-venter* are made in the accounts of those forms.

Remarks.—So far as known, there are no fully adult topotypes of this race in any collection. Adult specimens to the number of ten from Elko County, northeast of Halleck, differ from other populations here assigned to the race in longer body and shorter tail. These are the only specimens of the genus in which the tail is shorter than the combined length of the head and body. In some of the specimens from Elko County the incisive foramina are widest near the middle. Except in these particulars the animals agree with others from farther south. For this reason and because adult topotypes of *megacephalus* are unknown, it seems best to refer these short-tailed specimens to *megacephalus*.

Geographic variation is shown by other populations. The darkest specimens are from central Nevada, those from Reese River Valley and from Eureka County being darker even than specimens from

Elko County. Specimens from Eureka County are notable for long tail, which possibly reflects intergradation with *nexus*. Specimens from Dutch Flat Schoolhouse in Reese River Valley have short tails like the population of *sabulonis*, which occurs near Millett in the next valley (Great Smoky Valley) to the east. Specimens from Steptoe Valley, $5\frac{1}{2}$ miles south of Ely, are notable for generally large size but narrow interorbital region. Specimens from Greens Ranch, fifty-odd miles to the north in the same valley, are not exceptionally large but of a size about average for the subspecies.

Intergradation with *sabulonis* is complete. Specimens referred to *megacephalus* which have lighter (less blackish and more reddish) upper parts and the hair of the under parts white or only lightly tipped with buffy are those from Hot Creek Valley south to Old Mill at the north end of Reveille Valley, and those from Ralston Valley, $15\frac{1}{2}$ miles northeast of Tonopah. Specimens from Spring Valley, near Osceola and Shoshone, are lighter (grayer) above, lack the buffy terminal tipping of the hair of the under parts, which in many specimens is white entirely to the base, and thus are intermediate toward *paululus*, known from Utah.

Specimens examined.—Total number 296, as follows:

NEVADA.—Lander County: Reese River Valley, seven miles north of Austin, 4; six miles east-northeast of Smiths Creek Ranch, 5,550 feet, 11; $2\frac{1}{2}$ miles northeast of Smiths Creek Ranch, 5,800 feet, 5; Smiths Creek Valley, two miles west of Railroad Pass, 5,550 feet, 4. Eureka County: Winzell, 18; four miles southeast of Romano, Diamond Valley, 18; eight miles west of Eureka, 15. Nye County: Dutch Flat Schoolhouse, Reese River, 6,715 feet, 10; 30 miles north of Belmont, Monitor Valley, 1 (U. S. Nat. Mus., Biol. Surv. Coll.); $6\frac{1}{2}$ miles north of Fish Lake, Fish Spring Valley, 6,700 feet, 14; nine miles east of Toquima Peak, Monitor Valley, 7,600 feet, 2; $10\frac{1}{2}$ miles east of Toquima Peak, Monitor Valley, 6,900 feet, 24; five miles north of Belmont, Monitor Valley, 1 (U. S. Nat. Mus., Biol. Surv. Coll.); $3\frac{1}{2}$ miles east of Hot Creek, Hot Creek Valley, 5,650 feet, 17; $15\frac{1}{2}$ miles northeast of Tonopah, Ralston Valley, 5,800 feet, 13; $2\frac{1}{2}$ miles east and north of Twin Spring, south end of Hot Creek Valley, 5,400 feet, 3; Old Mill, north end of Reveille Valley, 6,200 feet, 36. Elko County: nine miles northeast of San Jacinto, 5,300 feet, 1; 15 miles south of Contact, 5,800 feet, 6; Marys River, 22 miles north of Deeth, 5,800 feet, 9; Cobre, 6,100 feet, 5; two miles southwest of Cobre, 2; three to five miles west of Halleck, 5,200 to 5,300 feet, 6 (1 in Coll. Ralph Ellis). White

Pine County: five miles southeast of Greens Ranch, Steptoe Valley, 5,900 feet, 11; $5\frac{1}{2}$ miles southeast of Ely, Steptoe Creek, 6,400 to 6,500 feet, 7; seven miles southwest of Osceola, Spring Valley, 6,275 feet, 24; $5\frac{1}{2}$ miles northwest of Shoshone Post Office, 6,100 feet, 3; four miles south of Shoshone, Spring Valley, 5,900 feet, 16. Lincoln County: three miles south of Geyser, Duck Valley, 6,050 feet, 10.

Microdipodops megacephalus sabulonis Hall.

Microdipodops megacephalus sabulonis Hall, Proc. Biol. Soc. Wash., 54, p. 59, 1941.

Type.—Male, adult, skin with skull; No. 49381 Museum of Vertebrate Zoology; five miles southeast of Kawich Post Office, 5,400 feet, Kawich Valley, Nye County, Nevada; September 27, 1931; collected by Robert T. Orr; original No. 384.

Range.—South-central Nevada from Esmeralda County eastward across Nye County to western Lincoln County (see fig. 48, p. 247).

Diagnosis.—Tail and hind foot short; upper parts brownish with much reddish; distal fourth to sixth of tail dark brown or black; supraorbital and postauricular patches light buffy; feet light gray; under parts white (basally plumbeous); skull with auditory bullae much inflated for this species, which results in greatest width exceeding basal length; maxillary and interorbital breadth moderate to slight; incisive foramina widest posteriorly; nasals extending posteriorly almost as far as premaxillae.

Comparisons.—From *albiventer*, this race differs in: body and tail longer; tail relatively longer; skull, including nasals, longer; upper parts, including upper side of tail, darker (more reddish); hair of under parts sometimes plumbeous basally rather than always white. From *paululus*, *sabulonis* differs in: longer body and much longer tail, in color in the same way as described for *albiventer*, and in shorter, narrower skull.

Remarks.—Specimens assigned to *sabulonis* from Coal Valley closely approach *albiventer* in pallor of coloration and indicate intergradation between the two. Specimens from Garden Valley also are lighter-colored than most populations of *sabulonis* and differ also in larger size of all parts measured, although relative proportions of the parts are about as in other populations. The animals from Great Smoky Valley (near Millett and San Antonio) have as much red in the upper parts as any other population, and more than most. Topotypes have longer tails than most specimens. At some localities, occasional specimens have a light wash of buffy on the tips of the hairs of the under parts.

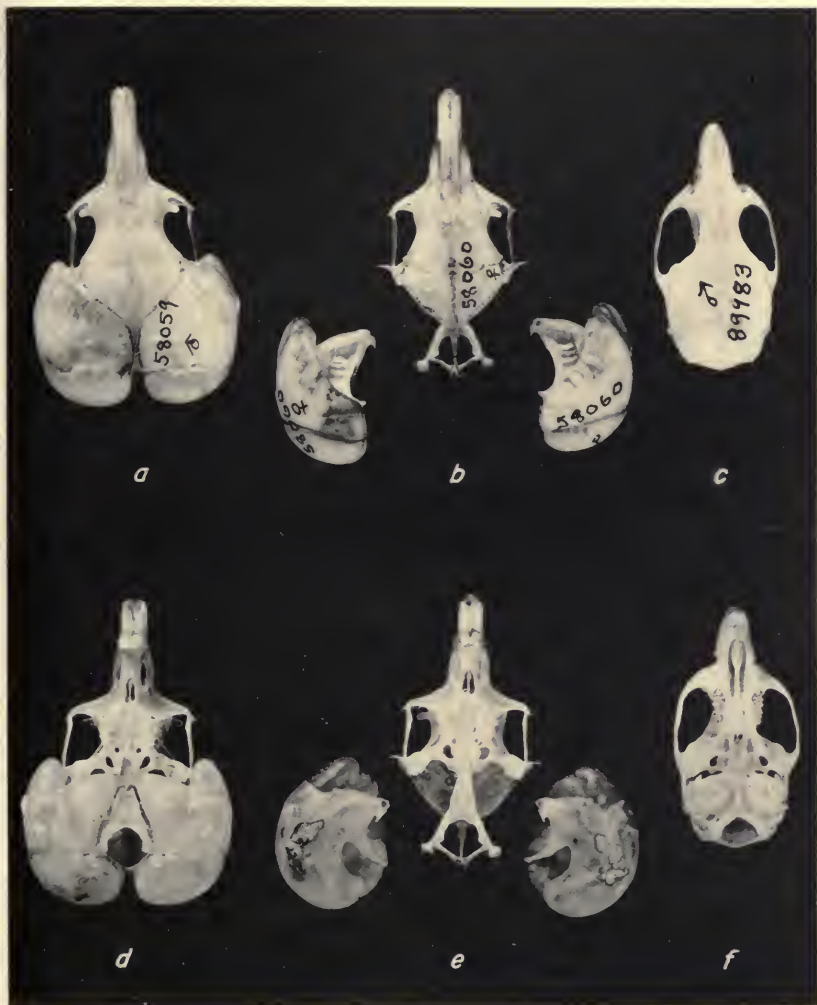


FIG. 49. *a, b, d, e, Microdipodops megacephalus sabulonis*, from nine miles west and three miles south of Tybo, 6,200 feet, Nye County, Nevada. $\times 1\frac{1}{2}$. *c, f, Mus musculus* subsp.?, from $2\frac{1}{2}$ miles west of Hazen, Lyon County, Nevada. $\times 1\frac{1}{2}$. The dorsal and ventral views of the cranium of a kangaroo mouse (*a, d*) show the greatly enlarged auditory bullae in place. Compare with corresponding structures in the house mouse (*c, f*), a rodent of more generalized structure. In the kangaroo mouse (*b, e*) the bullae are detached, revealing the great reduction in size of the interparietal and occipital bones, which in the house mouse enclose the brain posteriorly. Photograph by W. C. Matthews.

This subspecies of *megacephalus* occurs in the same general area as *ruficollaris*, a race of the different species *pallidus*. The firmer soils were favored by *sabulonis* at each of the eleven places where the two species were taken in the same trap line. *M. pallidus* occupied the fine sands. It follows from the distribution of these two types of soils that *sabulonis* occurs on the sides of the valleys and has a more nearly continuous distribution than does *pallidus*, which occurs ordinarily in the lowest parts of the valleys. The



FIG. 50. Skeleton of *Microdipodops megacephalus sabulonis*, male, from nine miles west and three miles south of Tybo, 6,200 feet, Nye County, Nevada. $\times 4/5$. Note the great length of the head relative to that of the body. Photograph by W. C. Matthews.

two kinds are easily distinguished by the color, and to me the difference is more easily perceivable in the live or freshly killed animals than in prepared study skins. The occurrence of three seeming hybrids among the 57 animals (34 *pallidus*, 20 *megacephalus*, and three "crosses") saved from Penoyer (Sand Spring) Valley makes further study at this place desirable, to learn for certain if two free-living species of wild mammals do here hybridize. If they do so, opportunity to study an unusual stage in the formation, or extinction by dilution, of a species would be afforded. The characters of the seeming hybrids are discussed in detail in the preceding section (p. 236) entitled "Speciation."

Specimens examined.—Total number 413, as follows:

NEVADA.—Esmeralda County: 13½ miles northwest of Goldfield, 4,850 feet, 22. Nye County: four miles southeast of Millett, 5,500 feet, 17; five miles southeast of Millett, 4; four miles south of Millett, 5,500 feet, 5; 11½ to 13 miles northeast of San Antonio, 5,700 to 6,700 feet, 26; 4¾ to six miles northeast of San Antonio, 5,650

to 5,700 feet, 29; 17 miles west of Sunnyside, White River Valley, 12; nine miles west and three miles south of Tybo, 6,200 feet, 43; 15 to 16½ miles west-southwest of Sunnyside, White River Valley, 5,500 feet, 11; 14 to 15 miles northeast of Sharp, Garden Valley, 23; 8½ miles northeast of Garden Valley, 28; 34 miles east and one mile north of Tonopah, 5,650 feet, 6; north shore of Mud Lake, south end of Ralston Valley, 5,300 feet, 2; 1½ to 3⅔ miles south of Silverbow, Kawich Mountains, 6,200 to 6,400 feet, 19; five to 6½ miles southwest of Silverbow, Cactus Flat, 5,700 to 6,000 feet, 18; 11½ miles southwest of Silverbow, Cactus Flat, 5,400 feet, 9; 14 miles southeast of Goldfield, Stonewall Flat, 4,700 feet, 2; 7½ miles east of Cliff Spring, 5,900 feet, 37; 4½ miles northwest of Indian Spring, Kawich Valley, 5,700 feet, 6; five to 5⅞ miles southeast of Kawich Post Office, Kawich Valley, 5,400 feet, 12. Lincoln County: 14 miles north of Seeman Pass, east side of Coal Valley, 4,850 feet, 26; ten miles north of Seeman Pass, 4,650 feet, Coal Valley, 14; 17 miles north of Groom Baldy, Penoyer Valley, 14; 14 to 15 miles north-northwest of Groom Baldy, Penoyer Valley, 8; nine miles west of Groom Baldy, 5,500 feet, 13; 11½ miles east of Jonnies Water, 1; 14½ to 15 miles south of Groom Baldy, 6.

Microdipodops megacephalus albiventer Hall and Durrant.

Microdipodops pallidus albiventer Hall and Durrant, Journ. Mamm., 18, p. 357, 1937.

Type.—Male, adult, skin with skull; No. 52803 Museum of Vertebrate Zoology; Desert Valley, 5,300 feet, 21 miles west of Panaca, Lincoln County, Nevada; May 30, 1932; collected by Ward C. Russell; original No. 2188.

Range.—Desert Valley, central Lincoln County, Nevada (see fig. 48, p. 247).

Diagnosis.—Tail, body, and hind foot short; upper parts grayish faintly lined with brownish; top of tail at tip with blackish markings faint or absent; postauricular patches white; supraorbital patches white, sometimes with trace of buffy; hair of under parts white to base; skull with auditory bullae much inflated and greatest width of skull greatly exceeding basal length; maxillary breadth slight; interorbital breadth moderate for the species; incisive foramina widest posteriorly; nasals short and not extending nearly as far posteriorly as premaxillae.

Comparisons.—From *megacephalus*, this race differs in: average size of external measurements less; upper parts lighter; postauricular patches and under parts white rather than buffy; distal part of upper

side of tail almost white rather than distinctly blackish; skull with nasals shorter. From *paululus*, *albiventer* differs in: tail longer; upper parts lighter; tip of tail more blackish; skull larger in all parts measured except length of nasals, which is less. Comparison with *sabulonis* is made in the account of that form.

Remarks.—When *albiventer* was named, the describers knew that there were two full species of *Microdipodops* in western Lincoln County, Nevada, and because of its pale color *albiventer* was assigned to the paler of these two species. Subsequent study, which revealed cranial differences between the two species, indicates that *albiventer* is, instead, a race of the darker species, *M. megacephalus*. In the original description, animals from Pine Valley, Utah, were assigned to the race *albiventer*, but these were later separated from *albiventer* and made the basis of the name *Microdipodops megacephalus paululus* (Hall and Durrant, p. 5, 1941). Thus, *albiventer* as here understood is restricted to Desert Valley in central Lincoln County. Animals from Coal Valley, about 25 miles to the west and north, although assigned to the race *sabulonis*, are much paler than typical specimens and approach *albiventer* in color.

Specimens examined.—Total number 23, as follows:

NEVADA.—Lincoln County: Desert Valley, 21 miles west of Panaca, 5,300 feet, 23.

***Microdipodops megacephalus paululus* Hall and Durrant.**

Microdipodops megacephalus paululus Hall and Durrant, The Murrelet, 22, p. 5, 1941.

Microdipodops pallidus albiventer Hall and Durrant, Journ. Mamm., 18, p. 357, 1937 (in part).

Type.—Male, subadult, skin with skull; No. 74660 Museum of Vertebrate Zoology; Pine Valley, one-half mile east of headquarters building of the Desert Range Experiment Station of the United States Forest Service, sec. 33, T. 25 S., R. 17 W., Salt Lake B. M., Millard County, Utah; July 17, 1936; collected by Stephen D. Durrant; original No. 955.

Range.—Western Utah in Pine, White, and Snake valleys (see fig. 48, p. 247).

Diagnosis.—Hind foot and tail short; upper parts brownish gray lightly mixed with blackish; under parts with hair everywhere white to base; supraorbital patches buffy white; postauricular patches white; tail bicolored, corresponding to body with terminal fourth or less blackish above; feet and ears whitish; skull small;

auditory bullae moderately inflated; maxillary breadth across zygomata slight; interorbital constriction moderate; incisive foramina widest posteriorly.

Comparisons.—From *megacephalus*, as known by specimens from Elko and White Pine counties, Nevada, including topotypes, *paululus* differs in: body shorter; tail much shorter; color above slightly lighter; hair of under parts everywhere white to base rather than plumbeous basally and buffy distally; postauricular light patches white rather than buffy; skull averaging shorter but otherwise closely resembling that of *M. m. megacephalus*. From *albiventer*, *paululus* differs in: tail shorter; upper parts darker; tip of tail with more blackish; skull averaging smaller in all measurements taken except length of nasals, which is more. Comparison with *leucotis* is made in the account of that form.

Remarks.—The type specimen has the permanent upper fourth premolars in place but almost unworn. Therefore it may be correctly referred to as a subadult.

Snake Valley and White Valley are only provisionally included in the range of this subspecies. The one animal (No. 3073 Univ. Utah) seen from White Valley has paler upper parts than *paululus*, a longer tail, and is smaller as regards those parts of the broken skull that can be measured. In these features the specimen approaches *leucotis* as it does also geographically. From Snake Valley, two young specimens from five miles south of Garrison differ from topotypes of *paululus* only in longer tail but one from about 35 miles farther north in the same valley (four miles south of Gandy) has the coloration of the upper parts more as in *leucotis* although not so light. All these animals from Snake Valley are so young that they do not satisfactorily display in either the skull or the pelage characters diagnostic of subspecies.

Of the 24 topotypes of *paululus*, all but two have the black tip on the upper surface of the tail. Intergradation with the race *megacephalus* is suggested by specimens from Spring Valley, Nevada, four miles south of Shoshone. They have the upper parts lighter than in other populations of *megacephalus* and thus approach *paululus*, although otherwise they are referable to *megacephalus*.

Specimens examined.—Total number 29, as follows:

UTAH.—Millard County: four miles south of Gandy, 5,000 feet, 2 (Mus. Vert. Zool.); White Valley, 60 miles west of Delta, 1 (Univ. Utah Mus. Zool.); five miles south of Garrison, 5,400 feet, 2 (Mus.

Vert. Zool.); type locality, 24 (23, Univ. Utah Mus. Zool.; 1, Mus. Vert. Zool.).

Microdipodops megacephalus leucotis Hall and Durrant.

Microdipodops megacephalus leucotis Hall and Durrant, The Murrelet, 22, p. 6, 1941.

Type.—Female, adult, skin with skull; No. 3525 University of Utah Museum of Zoology; 18 miles southwest of Orr's Ranch, 4,400 feet, Tooele County, Utah; June 6, 1940; collected by Stephen D. Durrant; original No. 1904.

Range.—Known only from the type locality (see fig. 48, p. 247).

Diagnosis.—Size small; hind foot short; tail relatively long; upper parts near (e) Light Pinkish Cinnamon (capitalized color terms after Ridgway, Color Standards and Color Nomenclature, Washington, D.C., 1912); under parts with hair everywhere white to base and encroaching on area ordinarily occupied by upper parts almost to lower margin of eye; postauricular and supraorbital white patches prominent; tail without black tip; feet and ears white; skull small except that auditory bullae are much inflated, resulting in greatest width exceeding basal length; skull relatively broad posteriorly; incisive foramina widest posteriorly; nasals projecting posteriorly nearly as far as premaxillae.

Comparisons.—From *paululus*, this race differs in: tail longer; upper parts strikingly lighter; area of white on head much more extensive than light areas on head of *paululus*; tail without blackish or darker color on tip; skull smaller in all parts measured except width across auditory bullae, which is more. The much greater inflation of the auditory bullae and lesser interorbital breadth are the two most prominent cranial differences. From *megacephalus*, *leucotis* differs in: body shorter; color everywhere paler; all light areas more extensive and white rather than buffy or plumbeous; upper parts of *leucotis* at first glance appearing white in contrast to the dark brown or blackish of *megacephalus*; skull differing in same way as from *paululus*.

Remarks.—This animal is one of the palest known for the genus; it is paler than topotypes of *M. p. pallidus*, and rivals topotypes of *M. p. purus*. It agrees with the species *pallidus* in the great inflation of the auditory bullae. Other cranial features, the short hind foot, and the geographic place of occurrence indicate that its affinities are with the species *M. megacephalus*.

Specimens examined.—One, the type.

Microdipodops pallidus. PALLID KANGAROO MOUSE.

Diagnosis.—Upper parts near (*e*) Light Pinkish Cinnamon, lightly marked with buffy or blackish; basal two-thirds or more of hair plumbeous and distal third buffy, in some races with a short terminal tip of blackish; hair of under parts everywhere white to base, as is that on legs, feet, and under side of tail; upper side of tail about same color as upper parts of body but lacking black tip; length of



FIG. 51. Typical habitat of the pallid kangaroo mouse (*Microdipodops pallidus*). Fine, wind-blown sand with xerophytic shrubs, seven miles north of Arlemont, Esmeralda County, Nevada. Photograph taken June 4, 1927, by Miss Annie M. Alexander.

hair and facial vibrissae as described in species *megacephalus*; postauricular patch prominent and pure white in all races; supraorbital spot white or faintly tinged with buffy, in some forms wanting; hind foot large, averaging more than 25 mm. in length; auditory bullae showing maximum degree of inflation for genus; upper incisors relatively straight; incisive foramina parallel-sided; premaxillae extending well behind nasals. Several of these features are of a comparative nature and are mentioned in greater detail in the preceding account of the full species *M. megacephalus*.

Remarks.—Fine sand supporting some plant growth meets the requirements of this species; as previously pointed out (Hall and Linsdale, p. 299, 1929), fine sand without plants does not harbor the

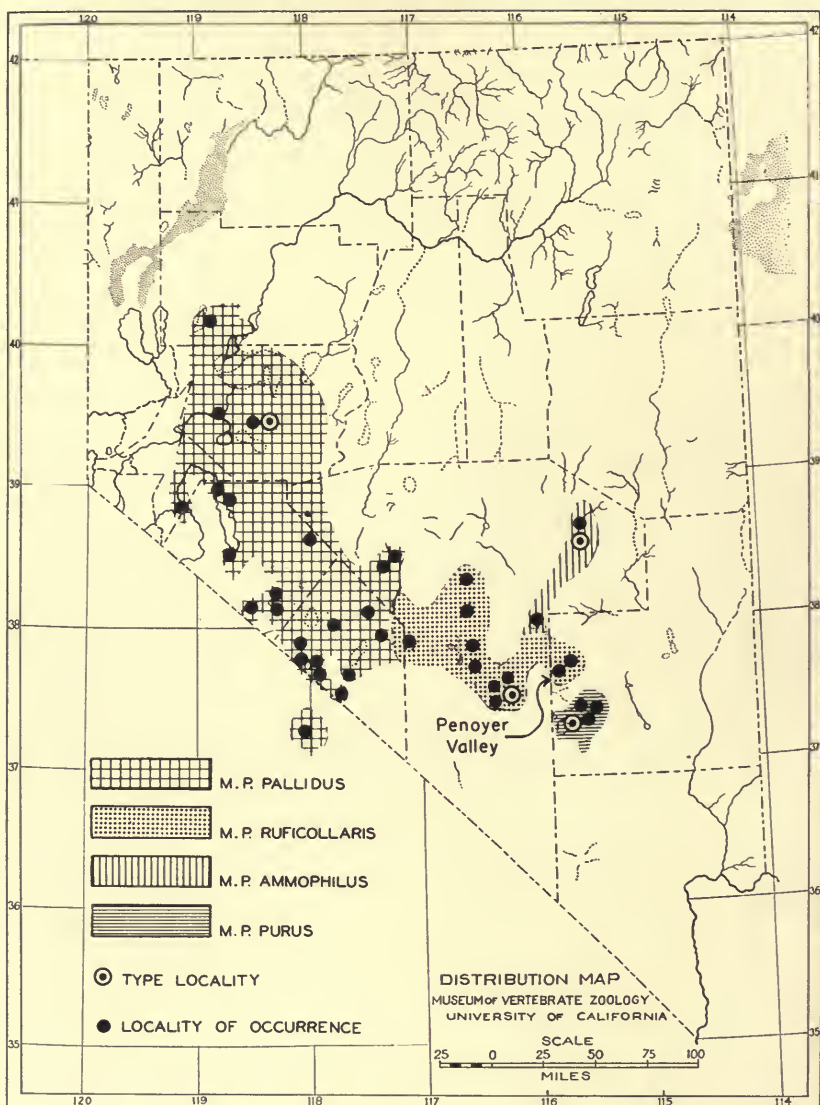


FIG. 52. Map showing geographic range of the subspecies of *Microdipodops pallidus*.

mice. Because the finest sand ordinarily occurs in the bottoms of valleys, as on the windward side of a playa, the mice are most abundant in the low parts of valleys. The distribution of the species is less continuous than that of *M. megacephalus*, which lives in coarser soils.

Elevations of occurrence range from about 3,900 feet at Soda Lake up to 5,700 feet in Huntoon Valley. At every place where specimens were taken, the vegetation is of a kind which favors a zonal position lower than places supporting *Artemisia tridentata*. *Atriplex* and *Sarcobatus* are shrubs characteristic of the areas in which the mice occur. Nowhere have they been found at a place low enough zonally to support the creosote bush, *Larrea*. By our definition of zones, then, this mouse has not been found in the Lower Sonoran Life-zone, although edaphic conditions appear suitable for it there. The nearest approach to occurrence in this zone was in Desert Valley, the next valley west of Pahrnagat Valley. At this place Joshua trees, cholla, and *Artemisia tridentata* grew together. In the lower part of the Upper Sonoran Life-zone, *M. pallidus* occupies the same territory as do *Dipodomys deserti*, *D. merriami*, and some other mammalian species which, unlike *M. pallidus*, are predominantly Lower Sonoran in distribution.

***Microdipodops pallidus pallidus* Merriam.**

Microdipodops pallidus Merriam, Proc. Biol. Soc. Wash., 14, p. 127, 1901.

Microdipodops megacephalus lucidus Goldman, Proc. Biol. Soc. Wash., 39, p. 127, 1926—type from eight miles southeast of Blair, 4,500 feet, Esmeralda County, Nevada.

Microdipodops megacephalus dickeyi Goldman, Proc. Biol. Soc. Wash., 40, p. 115, 1927—type from three miles southeast of Oasis, 5,150 feet, Mono County, California.

Type.—Female, adult, skin with skull; No. 93520 United States National Museum, Biological Survey Collection; Mountain Well [according to Vernon Bailey, MS.], Churchill County, Nevada; May 11, 1898; collected by Harry C. Oberholser; original No. 101.

Range.—Low western part of Nevada from southern Pershing County southward through Fish Lake Valley to Oasis, Mono County, California, and in Deep Spring Valley, Inyo County, California (see fig. 52, p. 268).

Diagnosis.—Size large; tail relatively long; color pale; nasals long.

Comparisons.—From *M. p. ruficollaris* this race differs in less reddish color of the upper parts, absence of the cinnamon-colored collar, longer tail, and longer nasals.

Remarks.—The occurrence of this mouse well up near the summit of a pass in the Stillwater Range, at the type locality, is unusual. At this place wind-borne sand of fine texture has accumulated in dunes and provides the requisite habitat ordinarily found low down in valleys.

Intergradation with *ruficollaris* is suggested by the redder than average color of specimens from Millers Wells.



FIG. 53. Live adult pallid kangaroo mouse (*Microdipodops pallidus pallidus*) from seven miles north of Arlemont, Esmeralda County, Nevada. Photograph taken June 14, 1927, by J. Dixon. Slightly less than half natural size.

Note the large eye, small pinna of ear, large head, long hind foot, and long, non-penicillate tail, which is of greatest diameter in the middle portion.

There is some geographic variation within the subspecies. Specimens from 21 miles west and two miles north of Lovelock, the northernmost record-station of occurrence for the species, represent one of the two palest-colored populations, the other being the far southern population from eight miles southeast of Blair. Topotypes are more reddish by a slight degree than are any other specimens. Animals from Mountain Well and from the vicinity of Schurz have actually and relatively shorter tails than others. In most of the measurements taken, animals from Fingerrock Wash average larger than those from any other place. Sixteen specimens from Deep Spring Valley have on each shoulder a slight suggestion of the collar that is well developed

in *ruficollaris* but otherwise agree well with specimens of *pallidus* from Fish Lake Valley.

Specimens from eight miles southeast of Blair average 0.2 mm. less in basal length and 0.1 mm. less in interorbital breadth than any other population. These animals, like those from the same latitude farther west, have upper molariform toothrows that average between 0.1 and 0.2 mm. longer than in the northernmost populations. The name *Microdipodops megacephalus lucidus* Goldman was based on animals from eight miles southeast of Blair. Another name, *Microdipodops megacephalus dickeyi* Goldman, was based on specimens from three miles southeast of Oasis, California. Topotypes and abundant material from other places in the same valley present no differences from other populations. Both of these names are placed as synonyms of *pallidus*.

Specimens examined.—Total number 415, as follows:

CALIFORNIA.—Mono County: three miles southeast of Oasis, 14 (L. A. Mus.); $4\frac{1}{2}$ to $5\frac{1}{2}$ miles southeast of Oasis, 5,300 feet, 9. Inyo County: Deep Spring Valley, 4,900 to 5,000 feet, 16 (L. A. Mus.).

NEVADA.—Lyon County: $11\frac{3}{4}$ miles south and $2\frac{3}{4}$ miles east of Yerington, 4,650 feet, 23. Pershing County: 21 miles west and two miles north of Lovelock, 4,000 feet, 11. Churchill County: one mile north of Soda Lake, 4,000 feet, 1; west end of Soda Lake, 3,900 feet, 2; one mile west of Mountain Well, 5,350 feet, 16; Mountain Well, 5,600 feet, 20. Mineral County: three miles south of Schurz, 4,100 feet, 26; eight miles southeast of Schurz, 4,100 feet, 2; Fingerrock Wash, Stewart Valley, 5,400 feet, 34; Cat Creek, four miles west of Hawthorne, 4,500 feet, 1; Marietta, 4,900 feet, 3; Huntoon Valley, 5,700 feet, 8; south side of Teels Marsh, 4,900 feet, 7. Esmeralda County: $1\frac{1}{2}$ miles west of Millers Wells, 4,800 feet, 16; $3\frac{1}{2}$ to four miles southeast of Coaldale, 4,850 feet, 12; $13\frac{1}{2}$ miles northwest of Goldfield, 4,850 feet, 2; seven miles north of Arlemont, 5,500 feet, 78; $1\frac{1}{2}$ to $2\frac{1}{2}$ miles north of Dyer, 4,800 to 4,850 feet, 17; Fish Lake Valley, 4,945 feet, 1; two miles southeast of Dyer, 4,900 to 4,950 feet, 10; eight miles southeast of Blair, 4,500 feet, 46; mouth of Palmetto Wash (5,350 feet, 3; 5,500 feet, 1), 4 (Coll. D. R. Dickey). Nye County: northeast of San Antonio ($5\frac{1}{2}$ miles, 5,700 feet, 1; $4\frac{3}{4}$ miles, 5,650 feet, 3; $4\frac{2}{3}$ miles, 5,650 feet, 3; $4\frac{1}{2}$ miles, 5,640 to 5,650 feet, 7; $4\frac{1}{4}$ miles, 5,650 feet, 2; four miles, 5,650 feet, 3), 19; San Antonio, 5,407 feet, 17.

Microdipodops pallidus ruficollaris Hall.

Microdipodos [misspelling for *Microdipodops*] *pallidus ruficollaris* Hall, Proc. Biol. Soc. Wash., 54, p. 60, 1941.

Type.—Female, adult, skin with skull; No. 49254 Museum of Vertebrate Zoology; five miles southeast of Kawich Post Office, 5,400 feet, Kawich Valley, Nye County, Nevada; September 25, 1931; collected by Robert T. Orr; original No. 367.

Range.—Fine sands of valleys from western Nye County eastward to western Lincoln County, Nevada (see fig. 52, p. 268).

Diagnosis.—Upper parts near (e) Light Pinkish Cinnamon mixed with blackish, with a broad collar of more nearly cinnamon color; otherwise as described for the species.

Comparisons.—From *purus*, this race differs in more reddish upper parts, presence of the cinnamon-colored collar, lesser maxillary breadth, and slightly less inflated auditory bullae. Comparisons with *pallidus* and *ammophilus* are made in the accounts of those races.

Remarks.—There is surprisingly little variation between populations of this race considering the fact that it occurs mainly or entirely on fine sand, which results in a noncontinuous distribution. The population which shows the greatest departure from the mean is that in Penoyer Valley. These animals are more reddish than typical specimens, by weight are the heaviest of any, have relatively short tails and greatly inflated auditory bullae. This inflation of the bullae is reflected in the great average breadth of the skull, which actually (20.1 mm.) and also relative to the basal length (18.5) is more than in any other population studied of Nevadan *Microdipodops*. Additional comment on this population from Penoyer Valley is made in the accounts of *M. p. purus* and *M. m. sabulonis*, and in the account (p. 236) headed "Speciation."

Specimens examined.—Total number 165, as follows:

NEVADA.—Nye County: nine miles west and three miles south of Tybo, 6,200 feet, 2; 34 miles east and one mile north of Tonopah, 5,650 feet, 39; north shore of Mud Lake, south end of Ralston Valley, 5,300 feet, 10; $1\frac{1}{2}$ to $3\frac{3}{8}$ miles south of Silverbow, Kawich Mountains, 6,200 to 6,400 feet, 3; $11\frac{1}{2}$ miles southwest of Silverbow, Cactus Flat, 5,400 feet, 5; six miles west of Kawich Post Office, Gold Flat, 5,150 feet, 5; five to $5\frac{1}{2}$ miles west of Kawich Post Office, Gold Flat, 5,100 to 5,200 feet, 8; five to $5\frac{7}{10}$ miles southeast of Kawich Post Office, Kawich Valley, 5,400 feet, 46; six miles southwest of Kawich Post Office, Gold Flat, 5,100 feet, 12. Lincoln County:

17 miles north of Groom Baldy, Penoyer Valley, 25; 14 to 15 miles north-northwest of Groom Baldy, Penoyer Valley, 10.

Microdipodops pallidus ammophilus subsp. nov.

Type.—Female, adult, skin with skull; No. 58208 Museum of Vertebrate Zoology; Railroad Valley, Able Spring, $12\frac{1}{2}$ miles south of Locks Ranch, 5,000 feet, Nye County, Nevada; July 29, 1933; collected by E. Raymond Hall; original No. 3934.

Range.—Railroad Valley, Nye County, Nevada (see fig. 52, p. 268).

Diagnosis.—Upper parts near (*e*) Light Pinkish Cinnamon, heavily mixed with blackish; a broad collar of cinnamon color lightly mixed with blackish; otherwise as described for the species.

Comparisons and remarks.—In some ways this is the most handsome of all the kangaroo mice. Its ground color is that of the light-colored species *pallidus*, but this color is overlaid with a frosting of black. The collar is barely evident, much less so than in *ruficollaris* from which *ammophilus* is further distinguished by the frosting of black. Specimens from $9\frac{1}{2}$ miles east of New Reveille, which is at the southern end of Railroad Valley, show only slight approach to *ruficollaris* and indicate for *ammophilus* a range, in Railroad Valley, of 50 miles in extent in a southwest to northeast direction.

Specimens examined.—Total number 30, as follows:

NEVADA.—Nye County: Railroad Valley, 5,000 feet ($2\frac{1}{2}$ to $3\frac{1}{4}$ miles south of Locks Ranch, 10; nine miles south of Locks Ranch, 10; $12\frac{1}{2}$ miles south of Locks Ranch, Able Spring, 2), 22; $9\frac{1}{2}$ miles east of New Reveille, Railroad Valley, 5,100 feet, 8.

Microdipodops pallidus purus subsp. nov.

Type.—Male, adult, skin with skull; No. 52753 Museum of Vertebrate Zoology; $14\frac{1}{2}$ miles south of Groom Baldy, Lincoln County, Nevada; June 1, 1932; collected by H. Robert Poultney; original No. 3618 of E. Raymond Hall.

Range.—Emigrant and Desert valleys in eastern Lincoln County, Nevada (see fig. 52, p. 268).

Diagnosis.—Upper parts near (*e*) Light Pinkish Cinnamon; distinctly whitish; otherwise as described for the species.

Comparisons and remarks.—This race, at the type locality, is the palest, most nearly white, of any. It is rivaled in this respect only by the population from eight miles southeast of Blair, here referred to the race *pallidus*. Cranially the topotypes are notable for the

greater average width across the maxillary processes of the zygomata and the reduced interorbital breadth. In the population from the next valley to the east, the interorbital breadth is larger, as in most other populations of the full species *pallidus*, but the narrowness across the zygomatic arches anteriorly is as in the topotypes.

Reference to the distribution map (fig. 52, p. 268) reveals that from the main geographic range of *ruficollaris* there are three projections to the eastward. These are (1) *ammophilus* to the northeast, (2) the populations in Penoyer Valley to the east, and (3) *purus* to the southeast. Each of these differs appreciably from *ruficollaris*; *ammophilus* is "blackier," animals from Penoyer Valley are "redder," and *purus* is "whiter." From one another, they differ far more than any of them differs from *ruficollaris*. Perhaps this is, in a measure, the result of isolation from one another by hills and mountains, whereas closer connection is maintained with *ruficollaris*. A low pass through which mice of this species may occur connects the range of *ammophilus* with that of *ruficollaris*, and another similar pass connects Penoyer Valley with the range of *ruficollaris*, but there is no such low pass between Penoyer Valley and the range of *ammophilus* (see fig. 52, p. 268). The range of *purus* may not be continuous with that of *ruficollaris*, but the two are less isolated than *purus* is from the population in Penoyer Valley.

The habitat of *purus* is the fine, exceptionally white sand which in large part probably results from the disintegration of Sieberts Tuff, a white deposit abundantly exposed in the area where *purus* occurs.

Specimens examined.—Total number 38, as follows:

NEVADA.—Lincoln County: Desert Valley, eight miles southwest of Hancock Summit, 5,300 feet, 3; eight miles north of Summit Spring, 3; 5½ miles north of Summit Spring, 4,700 feet, 3; 14½ to 15 miles south of Groom Baldy, 29.

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MEASUREMENTS OF ADULTS OF MICRODIPODOPS
(In millimeters)

	Total length	Length of tail	Length of hind foot	Weight in grams	Basal length*	Nasal length	Greatest breadth	Maxillary breadth	Least inter-orbital breadth
<i>M. m. oregonus</i> , 13 (7 ♂, 6 ♀); two miles south of Borax Spring									
Average.....	154	87	25.2	13.1	18.3	10.0	18.5	11.7	6.9
Minimum.....	146	76	23	11.9	17.7	9.5	17.7	11.0	6.6
Maximum.....	163	94	27	15.0	19.0	10.9	19.5	12.3	7.1
<i>M. m. californicus</i> , 5 (4 ♂, 1 ♀); 2¾ miles south of Pyramid									
Average.....	161	87	25.2	....	18.7	10.1	18.3	12.0	6.8
Minimum.....	158	81	24	....	18.6	9.9	17.9	11.9	6.7
Maximum.....	163	91	26	....	18.9	10.6	18.6	12.2	7.1
<i>M. m. nasutus</i> , 4 (2 ♂, 2 ♀); Fletcher									
Average.....	155	83	25.3	....	18.5	10.1	18.9	12.0	6.8
Minimum.....	150	78	24	....	18.0	10.0	18.2	11.2	6.5
Maximum.....	159	88	26	....	19.2	10.4	19.4	12.4	7.2
<i>M. m. polionotus</i> , 20 (10 ♂, 10 ♀); Taylor and McKeever ranches									
Average.....	152	85	24.4	....	18.1	9.8	18.2	12.1	6.8
Minimum.....	143	77	23	....	17.4	9.2	17.8	11.7	6.7
Maximum.....	155	93	26	....	18.8	10.3	18.7	12.6	7.2
<i>M. m. ambiguus</i> , 17 (10 ♂, 7 ♀); within 1¼ miles of Sulphur									
Average.....	165	91	25.0	12.4	18.4	10.1	19.3	11.6	6.7
Minimum.....	162	85	24	10.2	17.7	9.5	18.6	11.1	6.4
Maximum.....	176	98	26	14.0	19.0	10.4	19.8	12.5	7.0
<i>M. m. medius</i> , 18 (9 ♂, 9 ♀); three miles south of Vernon									
Average.....	166	90	24.8	....	18.6	10.1	19.1	11.7	6.5
Minimum.....	155	83	23	....	18.0	9.4	18.8	11.2	6.2
Maximum.....	177	95	26	....	19.1	10.6	19.6	12.2	6.9
<i>M. m. nexus</i> , 20 (10 ♂, 10 ♀); Izenhood and three miles south									
Average.....	166	94	25.0	....	18.5	9.9	19.3	11.5	6.6
Minimum.....	160	86	24	....	17.8	9.4	18.8	11.0	6.3
Maximum.....	176	103	27	....	19.0	10.2	20.0	12.2	6.8
<i>M. m. megacephalus</i> , 10 (4 ♂, 6 ♀); Elko County									
Average.....	155	76	24.0	13.4	18.4	10.0	18.6	11.8	6.5
Minimum.....	145	67	23	12.3	17.9	9.9	18.2	11.5	6.3
Maximum.....	163	80	25	14.5	18.7	10.1	19.1	12.4	6.7

* Measured from anterior face of incisor tooth.

MEASUREMENTS OF ADULTS OF MICRODIPODOPS—continued

	Total length	Length of tail	Length of hind foot	Weight in grams	Basal length*	Nasal length	Greatest breadth	Maxillary breadth	Least inter-orbital breadth
<i>M. m. sabulonis</i> , 9 (4 ♂, 5 ♀); five miles southeast of Kawich									
Average.....	154	84	24.1	11.6	18.2	9.9	19.0	11.7	6.5
Minimum.....	150	81	22.3	10.5	17.3	9.5	18.1	11.2	6.1
Maximum.....	159	88	25.0	13.5	19.1	10.3	20.0	12.4	6.8
<i>M. m. albiventer</i> , 14 (9 ♂, 5 ♀); 21 miles west of Panaca									
Average.....	150	80	24.1	13.1	18.2	9.6	19.1	11.9	6.5
Minimum.....	138	72	23.0	11.6	17.7	9.1	18.7	11.4	6.2
Maximum.....	158	89	25.3	15.3	18.6	10.2	19.6	12.3	6.9
<i>M. m. paululus</i> , 10 (6 ♂, 4 ♀); Pine Valley									
Average.....	137	69	24.5	....	17.9	9.7	18.7	11.5	6.5
Minimum.....	130	64	24	....	17.6	9.3	18.5	11.3	6.3
Maximum.....	148	74	25	....	18.5	10.2	19.3	11.8	6.6
<i>M. m. leucotis</i> , 1 (♀); type specimen									
	142	75	24	....	17.5	9.3	19.2	11.3	6.1
<i>M. p. pallidus</i> , 20 (10 ♂, 10 ♀); Mountain Well									
Average.....	162	86	25.5	14.7	18.6	10.0	19.7	12.3	6.8
Minimum.....	150	74	25	12.2	17.9	9.6	18.4	11.7	6.5
Maximum.....	169	94	27	16.8	19.1	10.6	20.8	12.7	7.1
<i>M. p. ruficollaris</i> , 10 (3 ♂, 7 ♀); five miles southeast of Kawich Post Office									
Average.....	160	88	25.1	12.3	18.3	9.9	19.6	12.2	6.9
Minimum.....	154	83	25	10.8	18.0	9.5	19.2	11.8	6.7
Maximum.....	164	91	26	13.3	18.7	10.3	20.1	12.7	7.3
<i>M. p. ammophilus</i> , 12 (8 ♂, 4 ♀); 3¼ to 12½ miles south of Locks Ranch									
Average.....	161	89	25.5	....	18.3	9.7	19.5	12.2	6.9
Minimum.....	154	81	25.0	....	17.9	9.3	18.8	11.6	6.7
Maximum.....	173	99	26.5	....	18.9	9.9	20.4	12.6	7.1
<i>M. p. purus</i> , 20 (10 ♂, 10 ♀); 14½ to 15 miles south of Groom Baldy									
Average.....	160	87	25.6	13.6	18.7	9.8	19.6	12.4	6.7
Minimum.....	152	83	25	10.3	18.1	9.4	19.1	11.9	6.4
Maximum.....	168	94	26	15.6	19.2	10.3	20.2	12.9	6.9

* Measured from anterior face of incisor tooth.

THE FEMORAL TROCHANTERS

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Recently I have had occasion to consider in much detail the question of the precise identity of the femoral trochanters in tetrapods. In spite of the fact that some twenty years ago the subject was given attention by Gregory (1918) and by Romer (1922, 1924) a number of important points still are unsettled. In order to refresh my memory and seek for details that formerly I had not considered, I repeated dissection of the hip region of a number of vertebrates, including *Iguana* and *Gallus*, with a reconsideration of the architecture of this area, paying attention particularly to exact attachments of muscles and their effects on the adjacent bone.

The pitfalls in this problem always have concerned the proper identification of homologous muscles, and some of the previous investigators, not primarily myologists themselves and relying on the literature or the illustrations of others, became much confused in their homologies. It seems better to approach the question of the trochanters from a myological rather than from an essentially osteological angle.

Muscle attachments to bone may be marked by a process, a mere roughened scar, a pit or depression, or there may be no mark that is clearly discernible. It may be said that these differences are due to the dissimilarity of the kinds and directions of the muscle pulls involved, and I think it may be accepted that this assertion is true in part. But no one knows what other factors are involved. Trochanters exist where the muscular pull is essentially at a right angle to the bone, but it cannot be said that a pull of this angle always results in such a process. In mammals the trochanters constitute what Parsons (1904) has called traction epiphyses, but the femoral trochanter is not epiphyseal in most reptiles.

Appleton (1925) cut the deep gluteal muscles of young rabbits and found that this did not affect the growth of the greater trochanter, although the results would have been more conclusive if his experiments had been more extensive. This fact does not prove that the muscles regularly attached to a trochanter are unimportant. Trochanters and similar bony processes are the result over a very long period of time of applied stresses, most of which have been

muscular. Part is due to inheritance and part is effective during the development of the individual. That is all that can be safely affirmed at present.

In order properly to present my views it is necessary to offer at this point some discussion of muscle relationship.

The muscles of the limbs appear to have been derived from the muscles of the trunk, but they are, for the most part, so distinct that it is now convenient to recognize separate groupings of the muscular system, comprising axial and appendicular musculature. But in this there is still much arbitrary decision. Thus the levator scapulae, from trunk to scapula, is called a muscle of the limb, while the external oblique and iliococcygeus, from trunk to pelvis, are always termed muscles of the trunk. The criterion is whether the muscle in question does or does not move the girdle or other part of the limb, providing it does not basically belong to some other major subdivision (the trapezius, for instance, a branchial apparatus muscle that now is utilized by the limb).

The limb muscles are most logically divisible into a main dorsal group, often termed extensors, innervated by more dorsal nerves of the plexus, and a main ventral or primarily flexor group, supplied by ventral branches of the plexus. In addition, other axial muscles may later intrude (as caudofemoralis) and align themselves with either dorsal or ventral units.

In the case of the pelvic limb, the girdle became attached to the axial skeleton in such a manner as to bisect the limb plexus and make of it two plexuses, now termed respectively the lumbar and the sacral plexus. The former of these is cranial to the sacroiliac articulation and accordingly is prozonal or prepelvic, and the latter metazonal or postpelvic in situation. Each has dorsal and ventral branches to main muscle groups that it is most convenient to designate by the name of their main nerve branches. Thus the muscles innervated by the dorsal prozonal nerves are termed the Femoral group of muscles, the ventral prozonals the Obturator group, the dorsal metazonal ones Peroneal, and the ventral metazonals Tibial. This scheme has been set forth in more detail in many of my papers.

These four muscle groups are the fundamental muscle "elements" of the pelvic limb. Each element usually splits into two or more units and the latter are not always equivalent in different animals. To illustrate, the crural flexors number six—*a, b, c, d, e, f*—in some reptiles. In some mammals there are but three. These may be, for instance, *a, c, e*; or *ac, b* and part of *d*, part of *d* and *f*, with *e*

unrepresented; or any other combination. Exact homology of such slips is absolutely impossible. When it is realized that these different combinations have diverse effects upon the parts of the bones to which they are attached, according to differences in posture and other factors, it is apparent that perhaps there can be no real homology of either muscle units or processes in different classes of tetrapods. Not only is this the case but conditions may so vary between major groups within the same class that it is unsafe to attempt exact parallels even after careful dissections.

The above concepts have not been entertained in connection with any work on the homology of the femoral trochanters, so far as I am aware. Other workers have appeared to regard the trochanters as definite entities which, like bones, could be present or absent or appear *de novo*. Instead, the concept here followed is that if a muscle causes a process in one animal, the "element" of that process is also present in another animal provided that muscle inserts upon the same bone, even though there may be no bony evidence of the fact. The element can be absent only when the muscle disappears or its attachment shifts to another bone. Similarly, no process can be a neomorph unless it is due to a muscle that has newly migrated from one bone to another.

Gregory's (1918) contention was that the internal trochanter of reptiles is homologous to the lesser trochanter of mammals, and the external trochanter of reptiles to the greater trochanter of mammals. He also maintained that the third trochanter of some mammals is a neomorph, while the fourth trochanter of crocodilians, dinosaurs, and some birds is a divergent derivative of the reptilian internal trochanteric crest. Romer (1922, 1924) believed that the lesser trochanter of mammals is entirely different from the internal trochanter of reptiles, and that the latter, as well as a fourth trochanter, is unrepresented in living mammals. He contended that the mammalian greater trochanter occurs only in the remains of mammal-like reptiles and in mammals.

In the following pages particular attention is paid to the condition in man, the best-known mammal, the reptile *Iguana*, and the bird *Gallus*. Reference is made to many other forms but no serious attempt is made to analyze the condition of the trochanters in any fossil reptile. The muscular details in neither *Iguana* nor any other living reptile should be considered as in any wise ancestral to those in mammals. On the contrary, living members of the former class, with very different postures, have probably departed farther from

basic reptiles in the plan of their hip musculature than have mammals. The plan in birds, of course, is different from either but probably is suggestive of that in archosaurs, and, likely because of similarity in posture, by parallelism, possibly of conditions in ornithischian dinosaurs.

The names of the trochanters employed for mammals are too firmly established for a change to be feasible, yet it would be better if they were more diagnostic, and, in the present paper only, I wish to employ alternate terms, based on the muscles concerned, for easier discussion.

The lesser trochanter of mammals is situated upon the medio-caudal aspect of the proximal femur. Associated with it is the iliopsoas; the fibers of the psoas major part of this complex insert upon the trochanter, and those of the iliacus part mostly directly distal to the process. In this class, therefore, the lesser trochanter properly may be termed a femoral process (process of the femoral nerve group of muscles), or more restrictedly a psoas process.

The mammalian greater trochanter is situated lateral to the head of the femur and may be high or low. Upon it are inserted all of the deep gluteal muscles (innervated by the superior gluteal branch of the peroneal nerve) that are attached to the femur (gluteus medius and piriformis above, gluteus minimus laterally). But associated with the margin of the trochanter are quadratus femoris (tibial group) inserted upon the trochanteric crest, between greater and lesser trochanters, obturator internus and gemelli (tibial group) at the medial base of the trochanter just above the trochanteric fossa, and obturator externus (obturator group) into the fossa. Accordingly, the greater trochanter is a peroneal, or more properly a deep gluteal, process, with ventral, chiefly tibial, elements associated.

But these muscles vary in different mammals and there is corresponding variation in the composition of the trochanter. Appleton (1928) has claimed that in the marsupial *Dasyurus* the caudofemoralis is inserted upon the greater trochanter; but I am not entirely convinced of the homology of this muscle slip. In some mammals the attachment of the quadratus femoris has wandered away from the trochanteric crest. The gluteus maximus (inferior gluteal branch of peroneal nerve) also is often associated in some degree with the greater trochanter, either along both the process and its distal base as in some rodents, restricted upon its distal base as in some carnivores, or at times really beyond the trochanter proper as is

usual in man. Associated, and indeed fairly continuous, with the gluteus maximus in many mammals is a longer unit of the superficial gluteal muscle (sometimes termed femoro-coccygeus, or erroneously considered as being the anterior part of the biceps femoris). At times its connection with the femur is hardly more than fascial, its real insertion being on the lower leg. In some mammals, however, it is attached firmly to the femur along the gluteal line, distal to the

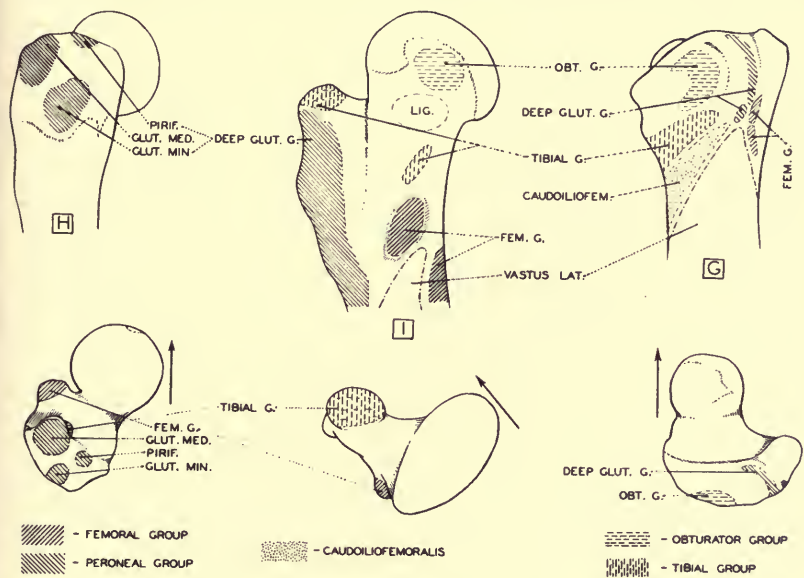


FIG. 54. The proximal right femur of man (H), *Iguana* (I), and *Gallus* (G), external views above and end views below. The arrows are disposed in the transverse plane. The labeling is a combination of individual muscle units and basic groups. Tibial group of *Iguana* is compound, also with some obturator innervation.

greater trochanter, and this may be defined as a sharp ridge continued from the greater trochanter or as a separate process, the so-called third trochanter, at a greater or lesser distance but always proximal to the center of the shaft. A well-defined third trochanter is characteristic of menotyphlous insectivores, some edentates, the armadillo, many rodents in varying degree, hyraxes, and perissodactyls. The superficial gluteal seems solely responsible for its definition and it may be called the superficial gluteal process. Where undefined the potentiality may be present, either united with or separate from the greater trochanter.

It is not generally recognized that there is a small but well-marked process approximately midway of the linea aspera in

kangaroos and bandicoots, and the situation is marked by a scar in some other marsupials (as some of the Didelphidae). Its position suggests a fourth trochanter, but it is distinct from that, for the caudofemoralis is inserted more proximally in kangaroos and this muscle is absent in *Didelphis*. It is caused by a part of the adductor muscle, and a desirable name would be the adductor process, in spite of its distinctness from the adductor tubercle.

In *Iguana*, the single large trochanter is located mediocaudally, in almost exactly the same position as, but more proximally than, the lesser trochanter of mammals. It has a proximal projection or tip, and, extending distal from this, a pronounced crest. Upon the tip of this process is inserted the main mass of the puboischiofemoral flexor musculature (obturator and tibial nerves, chiefly the latter), although small slips of this insert in two other situations, both laterally (superiorly). In mammals, the slips of this muscle group likewise are inserted in three situations. The sum of the three is equivalent in each class but it is likely that the individual units are not. If a decision must be made, however, then choice falls upon the reptilian slips inserting upon the tip of the trochanter as the equivalent of gemelli and obturator internus, the one inserted laterally most proximally (the ischiotrochantericus, with tibial innervation), as the quadratus femoris, and the other, inserted laterally and slightly more distally, as the representative of obturator externus, or in other words the shortest of the adductor muscles. I repeat, however, that the attempt at such exact homologies is rash.

Along the anterior face of the crest extending from the trochanter of *Iguana* inserts the extensor iliofemoralis (peroneal nerve), or the equivalent of the mammalian deep gluteal group of muscles. It pulls anteromedially, so as to rotate the femur inward, while the flexor puboischiofemoralis, with insertion upon the tip of the trochanter, depresses and retracts the thigh.

In *Iguana*, the extensor iliotibialis (homologue of the superficial gluteals) is inserted distal to the femur, so that the potential of the third trochanter is lacking.

It is difficult in the literature to ascertain just what the various authors had in mind when they referred to the external trochanter of reptiles, particularly as this is always poorly defined and otherwise variable. In *Iguana*, for instance, there is a pronounced roughness laterally (dorsally) just below the articular surface marking the insertion of the flexor ischiotrochantericus most proximally, a strong ligament of the joint next, and slightly more distally a

slip of the coxofemoral flexor group that in position is rather comparable to the quadratus femoris but in innervation (chiefly obturator, possibly with some tibial fibers) is closest to the mammalian obturator externus (the one of this group that is inserted separate from both quadratus femoris, gemelli, and obturator internus). This can be homologous to no part of the mammalian trochanters, but probably at least in part to the scar in many mammals marking the insertion of m. quadratus femoris.

The real "external" trochanter in lacertilians should undoubtedly be considered as occurring upon the caudolateral border of the shaft a short distance below the head, where is inserted a part of the following muscle. In *Iguana* the coxofemoral extensor puboischiofemoralis, or group equivalent to the mammalian iliopsoas, is extensive and complex and the origins are very different in the classes of tetrapods, reflecting dissimilar postures. In *Iguana* the most anterior slip does not reach the femur and may well represent m. psoas minor. The most extensive part is inserted upon the anterior border of the femur and slightly medially, where there is no process. It is separated laterally by the lateral vastus¹ from insertion upon the laterocaudal border of the femur of another slip of this division, and this is marked by a slight but definite process. Now if the two parts of this muscle division inserting separately represent the mammalian iliacus and psoas major, then the one attached more anteriorly should be the latter and the more posterior the iliacus. In this case the slip that in the reptile causes no process would be the one that in mammals is chiefly responsible for the definition of the lesser trochanter, a circumstance by no means unexpectable as a result of very dissimilar postures. But there is no way of making sure that the posterior slip in *Iguana* is represented in mammals—the anterior units of the former might possibly represent both iliacus and psoas major. So in reptiles the external trochanter is also a femoral process (like the lesser trochanter of mammals), but caused chiefly by the muscle that appears to represent the iliacus.

In *Gallus* there is a single large and powerful trochanter situated laterally. In old individuals one can sometimes distinguish a more anterior or extensor area, and a more posterior or flexor area, the

¹ More extensive work on *Iguana* than that previously reported by me (Howell, 1938b) has indicated that the lateral vastus can be the homologue of the division of the same name in mammals. The extensor iliofibularis is perfectly double in some individuals. The "extensor pubotibialis medius" in a later specimen proved to have only ventral innervation, so instead of being the possible homologue of an accessory sartorius of mammals it seems to be an adductor element, possibly representing the adductor longus of mammals.

two separated by a slight groove, subtended by the origin of the vastus lateralis. Accordingly if this muscle extended upward it would separate the two areas. The insertions of these extensor muscles are narrowly tendinous and do not cover the whole area. Above is the deep gluteal (peroneal nerve) element, with a more inferior slip comparable in some respects to a piriformis, and below the femoral nerve element, or psoas and iliacus. Upon the posterior portion of the trochanter is inserted the obturator (obturator nerve) above, next the short tibial nerve muscle (flexor ischiofemoralis), and finally the caudo- and iliofemoralis slips.

In the fowl, there is no other trochanter and no hip muscles are inserted upon the medial aspect of the proximal femur, except that the attachment of the adductor mass, on the "linea aspera," occurs some distance below the head. Accordingly in *Gallus* the single trochanter to some extent represents the combined elements of the greater and lesser trochanter of mammals and the fourth trochanter of Sauropsida as well.

The fourth trochanter is a process of variable definition located mediocaudally on the femur and usually well down the shaft, assertedly (by many authors) in crocodilians, dinosaurs, and birds. Most agree that it marks the insertion of the caudofemoralis. In the case of birds, the statement is usually made that the process occurs in the extinct moas *Dinornis* and *Apatornis*. Dollo (1888) mentioned its presence in the black swan. It is detectable, with considerable variation, in a number of genera of moas that I have examined through the kindness of those in charge of the collections of the United States National Museum. It can also be discerned in most old swans, and usually to a lesser degree in a number of geese and ducks. I have sought for it without success in a large number of other avian groups, both Recent and fossil. In the domestic duck, at least, the caudofemoralis is associated with this process, but I am unable to say that the former is solely responsible.

In crocodilians and apparently in sauropods the process usually termed fourth trochanter (Gregory, 1918; Romer, 1923a, b) is really nothing but the internal trochanter situated more distally than in some other reptiles and with the caudofemoralis in closer relation to it than in lacertilians. In the alligator no muscle is inserted upon the medial femur proximal to this process. In *Iguana* the caudofemoralis is inserted upon the medial base of the trochanteric crest and causes no process. The condition in dinosaurs can, of course, never be analyzed with assurance, but some of the Ornith-

ischia have a strong process medially and well down the shaft which occasionally (*Camptosaurus*) may be long and falciform. This is in the position that one would expect to find the insertion of a caudofemoralis powerfully developed for retracting the limb and thus elevating the body to a bipedal position.

In mammals the insertion of the caudofemoral element is extremely variable. The muscle is absent in not a few mammals.

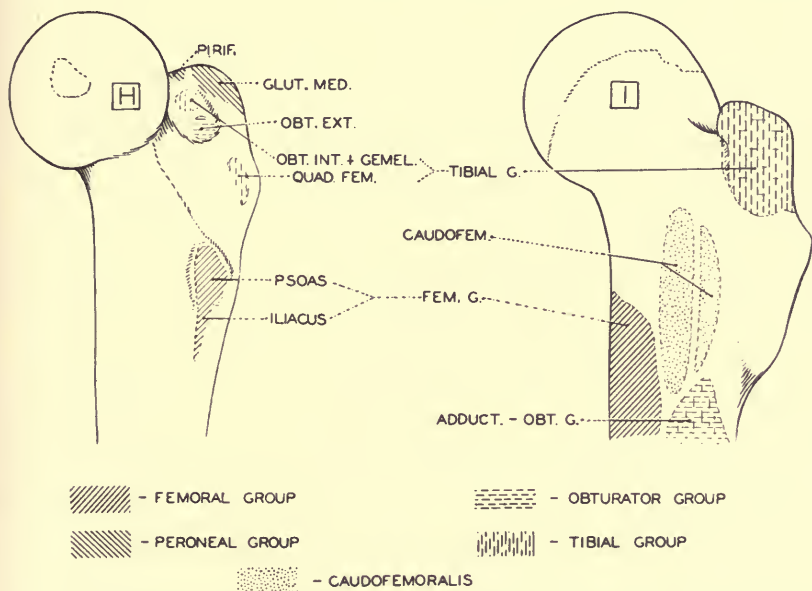


FIG. 55. The proximal right femur of man (H) from the medial aspect, and of *Iguana* (I) from the cranioventral aspect.

When present in placental mammals it is inserted well down the femur, then being known as the presemimembranosus, or in man the part of the adductor magnus innervated by n. tibialis. Where it leaves evidence of its insertion this is known as the adductor tubercle, just above the medial condyle. In marsupials and monotremes, however, the muscle usually is inserted higher. In these groups it causes no process, so far as I am aware, but a caudofemoral process (which would be a better name than adductor tubercle) may well be discovered in some of them.

Unquestionably the hind limb of both a lizard and a bird is very highly specialized, the former especially in regard to a particular posture very different from that of mammals, and the latter in all

respects. I have no hesitancy in saying that the muscle insertions of the lizard hip do not reflect the conditions that obtained in the stem reptiles. Accordingly, the "elements" stimulating the formation of the trochanters are different, and the trochanters themselves must be different. A posteriorly located chief trochanter probably was basic for reptiles. From this position it must have migrated caudomedially to attain its position in modern lizards and laterocranially in the case of mammals and in birds with their largely similar limb posture. The position of the "lesser" trochanter in the *Iguana* appears to be exaggerated. The basic situation of this probably was anteriorly or essentially so. From here it has migrated laterocaudally in *Iguana*, slightly laterally in the fowl, and medio-caudally in mammals. In some mammals, as man, the two trochanters are in such close relation that they are separated merely by a ridge. A relatively small movement by the lesser would merge the two and there would then be a condition similar to that in birds, but in reverse—the lesser upon the caudal rather than the cranial part of the greater trochanter. The stimulus of increased outer rotation of the limb might eventually effect this.

In summary, the mammalian lesser trochanter is a femoral group or iliopsoas process. The greater trochanter is a deep gluteal or partly peroneal group process with associated short flexor, chiefly tibial, elements around its margin and either a superficial gluteal element included or separate, in the latter case sometimes causing a third trochanter. The adductor tubercle is the fourth trochanter of mammals. An adductor process also occurs in some marsupials.

The internal trochanter of *Iguana* is essentially a short flexor, largely tibial, and a deep gluteal or peroneal process. The faint process more laterally (dorsally), or external trochanter, is a femoral or probably iliacus process. The fourth trochanter of some fossil reptiles is probably a caudofemoral process.

In modern birds, the large lateral trochanter represents a fusion of the elements of the mammalian greater and lesser trochanters, but without the element (superficial gluteal) of the mammalian third trochanter and with, in the fowl, the element of the fourth trochanter. Where the last is defined it is a caudofemoral process.

A condensed list of these processes, but too short for the inclusion of all qualifications, may be desirable.

Lesser trochanter of mammals (=femoral or psoas process). Psoas major (chiefly) and iliacus.

Greater trochanter of mammals (=deep gluteal process). Deep gluteal (chiefly), with tibial (and sometimes other) elements associated.

Third trochanter of mammals (=superficial gluteal process). Superficial gluteal element.

Adductor process of marsupials. Middle adductor fibers.

Internal trochanter of reptiles. Tibial (chiefly) and obturator, with deep gluteal element associated.

External trochanter of reptiles. A femoral process, caused by a femoral (probably=iliacus) unit.

Lateral trochanter of birds. Chiefly deep gluteal and obturator, but also tibial and femoral elements.

Caudofemoral process (=fourth trochanter or adductor tubercle). Caudofemoral or presemimembranosus muscle.

To facilitate comparisons there is presented on page 290 a table of homologies of the coxofemoral muscles in the three animals under consideration.

HOMOLOGIES OF COXOFEMORAL MUSCLES

	<i>Iguana</i>	<i>Gallus</i>	<i>Homo</i>
Dorsal (FP).....	I. Ext. puboischiofemoralis (F): a (=psoas minor?) b, c (=psoas major?) d (=iliacus?)	I. Psoas (F) Iliacus (F)	I. Psoas minor? Psoas major (F) Iliacus (F)
	II. Ext. iliofemoralis (P) (=deep gluteals)	II. Gluteus prof. (P) Piriformis (P)	II. Gluteus med. (P) Gluteus min. (P) Piriformis (P) Tensor f. latae (P)
Ventral (OT).....	III. Adductor (OT)	III. Adductor superf. (O) Adductor prof. (O) Obturator (O)	III. Pectineus (O) Adductors (O) Obturator extern. (O)
	IV. Flex. puboischiofemoralis (OT) or deep adductor: a, b, c, d (=obtur. intern. and gemelli?) (OT) e (=obtur. extern.?) (O) f ischiothrochantericus (=quadratus femoris?) (T)	IV. Flex. ischiofemoralis (T)	IV. Gemelli (T) Obturator intern. (T) Quadratus femoris (T)
	V. Caudofemoralis	V. Caudofemoralis Iliofemoralis	V. T part adductor magnus (=presemimembranosus)

Attention is called (by an interrogation mark) to the fact that exact comparison of individual muscle slips (indicated for *Iguana* by letters in italic) can be only of a general nature. Innervations are indicated by capital letters in parentheses. Muscles are arranged in five main groups: prozonal and metazonal dorsal, supplied by femoral (F) and peroneal (P) nerve branches; prozonal and metazonal ventral, in the main by obturator (O) and tibial (T) nerves; and caudofemoral group. In *Iguana*, the ventral prozonal and metazonal innervations have not completely separated; where this admixture occurs the main nerve involved is indicated by underscoring. The innervation of the human pectineus is given according to the source (ventral) of its fibers rather than the pathway followed (n. femoralis).

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ON THE IDENTITY OF THE PORPOISE SAGMATIAS AMBLODON

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Species and even genera of porpoises have been based repeatedly on the more or less complete skull and mandibles of one individual. In many instances the external form, the color pattern, and the skeleton of the supposed new form of porpoise were unknown to the original describer. Furthermore, the literature relating to the porpoises, and particularly the accounts published by naturalists accompanying the early nineteenth century cruises of exploration, contain specific names based on external features alone and in many instances the descriptions and illustrations are based on porpoises seen at a distance from the ship. Duplication of names for some of these porpoises would therefore seem inevitable, but the correlation of names based on external form with those based on osteological characters has proved troublesome chiefly because of the difficulty of observing and capturing porpoises in remote oceans and seas.

Among the specimens collected by the United States Exploring Expedition, 1838-42, under the command of Charles Wilkes, U.S.N., were two porpoises. The description for one of these, *Phocaena australis*, is based solely on external form and color. Our knowledge of the other, *Sagmatias ambodon*, has been restricted hitherto to the skull and jaws described by Cope in 1866. During the hundred years since the termination of this exploratory cruise no additional specimens allocated to either of the above specific names have been recorded in the literature. Examination of the cetacean collections in the principal museums of Europe by the writer in 1930, 1937, and 1938 failed to reveal the existence of unrecorded specimens. It was, therefore, an agreeable surprise to have the skull, mandibles, measurements, and photographs of a porpoise from Chile submitted for identification by Colin Campbell Sanborn. In the fall of 1922, Dr. Wilfred H. Osgood, Mr. Boardman Conover, and Mr. Sanborn arrived in Chile and commenced extensive field work, in the course of which the above-mentioned porpoise was found on January 12, 1923, on the beach near the mouth of the Rio Inio, Chiloé Island, Chile. It is a matter of some satisfaction that the Chiloé Island por-

poise has cleared up the relationship between *Phocaena australis* and *Sagmatias ambodon*.

The clarification of the status of the two porpoises collected by the United States Exploring Expedition is complicated somewhat by the absence of precise information as regards the collectors of the specimens on which these names are based. Four of Peale's diaries have been acquired by the Library of Congress, but unfortunately the one containing his observations during the period between August 19, 1838, and April, 1839, is missing. It is a matter of record that the collections made by this expedition were shipped to Washington, D.C. In accordance with orders, the boxes containing the collections were transferred to the National Institution of Washington where the covers were removed and the contents scattered before arrangements had been completed to have competent naturalists prepare reports on the results of the cruise. Hence it is quite possible that whatever data originally accompanied some of the specimens got misplaced or lost. Furthermore, the collections stored on the U.S.S. *Peacock* were destroyed when that ship was lost July 18, 1841, at the mouth of the Columbia River, Oregon. Peale (1848, p. 305) in his list of specimens collected by the expedition makes no mention either of a skull for *Phocaena australis* or of the skull which Cope subsequently made the basis for *Sagmatias ambodon*.

On February 12, 1839, while off the coast of Patagonia one day's sail north of the Straits of Le Maire between Staten Island and Cape San Diego, Tierra del Fuego, a porpoise was harpooned by someone on one of the ships of the United States Exploring Expedition. This porpoise was considered by Peale (1848, p. 33) to represent an undescribed species to which he gave the name *Phocaena australis*. Peale lists an illustration for this porpoise (pl. 6, fig. 2) which was not published at the time. Since this volume was subsequently withdrawn from circulation, Peale's brief description will be repeated here.

"Snout, back, and all the fins, dark slate-colour; sides paler, or gray; a white lateral line commences opposite the posterior edge of the dorsal fin and reaches the tail; beneath white, which joins the gray of the sides by an undulated line.

"Total length, 7 feet [2,133 mm.]; greater diameter, opposite the dorsal fin, 18 inches [457 mm.]; pectoral fin, 16 inches [406 mm.]; dorsal fin, 17 inches [432 mm.]; across the tail 20 inches [508 mm.].

"Dental formula: $\frac{31-31}{29-29} = 120$."

Cassin (1858, p. 27), however, when he republished Peale's description identified this porpoise with Gray's *Delphinus obscurus*;

the illustration listed by Peale appears in the atlas for volume 8 (pl. 5, fig. 1).

When the expedition ships sailed from the mouth of the Rio Negro for Cape Horn on February 2, 1839, Titian R. Peale was on board the U.S.S. *Peacock*, commanded by William L. Hudson, U.S.N. Charles Pickering, naturalist, and Joseph Drayton, artist, were assigned to the U.S.S. *Vincennes*, commanded by Charles Wilkes, U.S.N. It is probable that the illustration of the external form of this porpoise was made shortly after the animal had been hauled on board, but Peale does not indicate whether the drawing was made by himself or by Drayton.

No explanation is given by Peale for the measurements of the dorsal fin and the pectoral flipper, and consequently some allowance must be made when these measurements are compared with those of the porpoise from Chiloé Island. It is also very probable that teeth hidden in the gums are not included in the dental formula. The illustration for *australis*, however, agrees in all essential details with the photographs of the Chiloé Island porpoise. Since the skull of the Chiloé Island porpoise is indistinguishable from that of *Sagmatias ambodon*, there exists the possibility that the skull of the latter may have actually belonged to the porpoise which was taken off the coast of Patagonia and described by Peale.

The skull and mandibles of a porpoise "caught at sea" by someone on board the U.S.S. *Vincennes* were made the basis of a new genus and species, *Sagmatias ambodon*, in 1866 by E. D. Cope. Dr. Charles Pickering, naturalist assigned to that ship, informed Cope that he had no record or recollection of the capture of this porpoise and that it was therefore probably procured while he was absent from the ship during the voyage from Cape Horn to Lima, Peru, or afterwards during his stay in Australia and New Zealand (Cope, 1866, p. 295). On the left mandible of the type of *Sagmatias ambodon* the original inscription in ink is in part illegible. It has been possible, however, to restore temporarily the inscription, which reads as follows: "No. 2; lower jaw of a porpoise, caught at sea, U.S. Ship Vincennes." The entry under No. 3887 in the catalogue of the Division of Mammals, United States National Museum, reads as follows: "Original No. 2; porpoise; caught at sea; Vincennes; Ex. Ex." The handwriting on the mandible has not been identified with that of anyone employed by the National Museum. Whether or not this inscription was placed on the mandible during the cruise or after it arrived at the National Institution of Washington can

not be determined from available information. On the skulls of other specimens received from this expedition, the data are recorded in ink.

Lagenorhynchus australis Peale. PEALE'S PORPOISE.

Phocaena australis Peale, U. S. Explor. Exped. 1838-42, 8, Mammalogy and Ornithology, p. 33, 1848.

Delphinus obscurus Cassin, U. S. Explor. Exped. 1838-42, 8, Mammalogy and Ornithology, p. 27; atlas, pl. 5, fig. 1, 1858 (not of Gray, 1828).

Sagmatias ambledon Cope, Proc. Acad. Nat. Sci. Phila., 18, No. 4, p. 294, 1866.

Sagmatias ambledon True, Bull. U. S. Nat. Mus., 36, pp. 106, 175, pl. 30, fig. 1, 1889.

Type.—Nothing is known about this specimen. Off coast of Patagonia, one day's sail north of the Straits of Le Maire between Staten Island and Cape San Diego, Tierra del Fuego. Collected February 12, 1839, by someone on one of the ships of the United States Exploring Expedition, 1838-42.

Referred specimens.—(1) Skull of old adult, the type of *Sagmatias ambledon*, No. 3887 United States National Museum. Locality unknown, "caught at sea." Collected by someone on U.S.S. *Vincennes*, United States Exploring Expedition, 1838-42. (2) Skull of adult male, No. 22248 Field Museum of Natural History. Rio Inio, Chiloé Island, Chile. Collected January 12, 1923, by Colin C. Sanborn and Wilfred H. Osgood. Original No. 60 (C.C.S.).

Diagnostic characters.—Size medium in adults, total length greater than 2,100 mm.; height of dorsal fin greater than 200; greatest spread of caudal flukes greater than 500; anterior lateral area light gray; entire head black, including snout, upper and lower lips, chin and throat; eye located within black of head; narrow dark streak extending from side of black throat (and not from eye or angle of mouth as in *obscurus*) to base of pectoral flipper; white under parts separated from anterior lateral light gray area by an undulating narrow dark streak; skull with premaxillaries distinctly swollen and elevated above orbital plates of maxillaries between choanae and premaxillary foramina; premaxillaries not depressed in front of premaxillary foramina to form a distinct triangular prenasal depression, which is replaced by a rugose area; exposed portions of frontals on vertex separating nasals from the prominent knob-like anterior quadrangular process of supraoccipital; tooth formula 32 to 33 on each side of rostrum and 29 to 33 in each mandible.

Color.—Since no color notes were recorded at the time the Chiloe Island porpoise was collected, comments are necessarily restricted to the details shown on the five available photographs. The dark areas on the upper parts were presumably black or dark slate color, the light lateral areas light gray or white, and the under parts between the throat and the caudal peduncle pure white. The dark color extends over the whole head from the tip of the snout and the upper lips to at least 35 mm. behind the eye. The lower lips, chin, and throat to behind the level of the eyes are likewise dark. A narrow curved dark stripe extends forward from base of the dark pectoral flipper to the side of the dark throat. The dark-colored area on the upper parts is constricted between the level of the eye and the pectoral flippers, but increases in width up to the level of the center of the dorsal fin, and then continues as an attenuated dorsal band toward the caudal flukes. Falcate dorsal fin, pectoral flippers, and both surfaces of caudal flukes are black. Under parts from vent to throat pure white, separated by a thin dusky streak from the anterior lateral light gray area. The light gray anterior lateral area commences on this thin dusky streak at about the level of the hinder margin of the dorsal fin and increases in width anteriorly, extending forward above base of pectoral flipper to behind the eye and possibly below the latter as a narrow streak to the angle of the mouth. A posterior white lateral band, attenuated at both ends and separated from the anterior light gray lateral area by an oblique prong-like backward extension of the dark color of the upper parts, extends from the peduncle forward to about the level of the center of the dorsal fin. The white under parts are distinctly separated from the anterior lateral lighter area by an undulating dusky streak, but the dark areas on the upper parts seem to shade to some extent into the light-colored lateral areas.

The possibility is not excluded that *Delphinus albigena* (Quoy and Gaimard, 1824-26, p. 87, pl. 11, fig. 2), which was based on a porpoise observed in January, 1820, near 49° S. Lat. somewhere between New Holland [=Australia] and Cape Horn, may have been the first name given to the species here designated as *Lagenorhynchus australis*. The illustration and description are, however, not based on a harpooned porpoise. Accurate description of porpoises is uncertain under the most favorable conditions of observation and consequently the status of the name *albigena* is questionable. The entire body of *albigena*, with the exception of the anterior lateral elliptical white area which extends forward from about the level of the middle of the dorsal fin to beyond the eye, is represented as being

black. So far as known, no species of *Lagenorhynchus* has entirely black under parts.

Externally, *australis* seems to be distinguishable readily from the North Pacific *obliquidens*. The under parts of *obliquidens* are pure white from behind the vent forward to the dark chin, the white extending upward on the throat to the lower lips. A sharply defined dark streak, extending from the angle of the mouth to the pectoral flipper and from the hinder basal angle of the latter to behind the vent, separates the white under parts from the anterior lateral light gray area. Further, the anterior lateral light gray area of *obliquidens* is more elliptical in outline, terminating posteriorly at about the level of the center of the dorsal fin, shading along its dorsal border into the dark color of the upper parts and the top of the head, and extending forward across the side of the head through the eye and above the black upper lip to the base of the black snout. This anterior lateral light-colored area does not extend upward on the neck as high as on *australis* and is separated from the posterior lateral light-colored area by a broader downward continuation of the dark upper parts.

The synonymy of *Lagenorhynchus obscurus*, which seems to be closely related to *australis*, is involved in complications which center around inferences that may be drawn from the external form and the color patterns depicted in the published illustrations of the type specimens of *obscurus*, *fitzroyi*, *breviceps*, and *posidonia*, and the lack of precise information as regards the structural peculiarities of the skulls and mandibles removed from these same specimens.

The status of *Lagenorhynchus obscurus* from the seas south of the Cape of Good Hope is still unsatisfactory although more than a hundred years have elapsed since the original specimens were brought back to England by Captain Heaviside. The original description of *Delphinus (Grampus) obscurus* (Gray, 1828, p. 2, pl. 2, figs. 2-5) is based on stuffed skins of a young and of an adult, and crania. These specimens should thus be considered cotypes. Attention is directed particularly to Gray's illustrations which show no distinct beak on either the young or the adult.

The lower lips and chin of the stuffed skin of the young porpoise, according to the illustration published by Gray (1828, pl. 2, fig. 2), are black and the under parts from chin to vent are white. A broad light band, continuous ventrally with the white under parts, commences at about the level of the vent and extends obliquely forward almost to the head above the fairly wide dark band extending from the base of the pectoral flipper to the eye. The posterior lateral light

band is somewhat narrower and about half the length of the anterior one. It commences near level of hinder end of caudal peduncle and extends obliquely forward to level of hinder edge of dorsal fin. Under surface of caudal peduncle dark, continuous anteriorly with broad oblique dark band which separates posterior lateral light band from anterior one. Pectoral flippers, dorsal fin, caudal flukes, and upper parts, with exception of lateral light bands, from tip of snout to caudal flukes are dark, presumably black.

Furthermore, Gray (1828, p. 2) states that "even in the older specimens the white lateral streaks are to be seen in certain positions, —a fact which is not shown in the drawing" (i.e., the stuffed skin of the adult, 1828, pl. 2, fig. 3). Unfortunately, Gray did not state that these white lateral streaks corresponded in position to those on the stuffed skin of the young porpoise. Lateral light streaks in somewhat different positions are present in some species of *Stenella*, but all show a distinct demarcation between the moderately long snout and the forehead. Flower (1885, p. 28) made the stuffed skin of the adult the lectotype and allocated *obscurus* to *Prodelphinus* [= *Stenella*], presumably because of characters revealed by the skull which had been removed from this stuffed skin in 1884. The skull of the lectotype, however, has not been described, and the crania mentioned by Gray are not recorded in subsequent British Museum (Natural History) catalogues.

If one accepts Flower's allocation of the lectotype of *obscurus* to *Stenella* as accurate, two alternative assumptions should be considered. The first is that the skull removed from the lectotype stuffed skin was substituted for the original one by the taxidermist who prepared the skin, and the second that Gray's comments on the presence of lateral white streaks on the adult stuffed skin are not to be interpreted as indicating a color pattern of the same general type as that exhibited by the stuffed skin of the young porpoise. In this connection, it should be noted that Gray later (1866, p. 265) stated that "the *Delphinus obscurus* var. (Quoy and Gaimard, 1830, vol. 1, p. 151, pl. 28) is described from a specimen prepared by M. Jules Verreaux belonging to the Museum of Cape Town. He prepared the specimen I described [1828, p. 2, pl. 2, fig. 3]; indeed it is probably the same example." The external coloration of the stuffed skin described and figured by Quoy and Gaimard differs from that of Gray's young individual in several respects. The most obvious dissimilarity is the deep anterior bifurcation of the posterior lateral grayish white band. Secondly, the anterior lateral grayish white band, which commences at about the level of the

vent, extends forward above the pectoral flipper, across the side of the head through the eye and around the forehead to the base of the snout. The tip of the snout, according to the description, is more or less grayish white, but is not so depicted in the illustration.

Although doubt may always be raised, it seems advisable to base the determination of *obscurus* on Gray's original description in which the diagnostic color pattern of this porpoise is described as follows: "collo ventreque albidis, fascia nigra ab angulo oris usque ad pinnas pectorales; striga obliqua laterali alba postica; caeterum totus niger." It should also be noted that Gray's original description of *obscurus* is limited to the external form, coloration, external measurements, and dentition, no cranial characters being listed.

Further confirmation of the external color pattern of this porpoise is given in the following description of another individual (1,651 mm. in length), which was captured in Hout Bay near Cape Town (Sclater, 1901, p. 204): "General color of upper parts black, shading on head and at base of pectoral flippers to slaty gray; upper lips black shading to slaty gray above; lower lips black shading to white below; throat and under parts backward to vent white; under surface of caudal peduncle slate-colored; from near level of vent there extends obliquely forward into the black of the sides two slate-colored bands; caudal flukes and pectoral flippers dark slate."

This embarrassing confusion in the nomenclature of southern porpoises has arisen evidently from the confounding of the short-beaked *Lagenorhynchus obscurus* with another longer-beaked porpoise of approximately the same size.

During the cruise of the "Terra Nova," Wilson prepared illustrations for porpoises (Lillie, 1915, pl. 8, figs. 2-5) seen near Cape Town, south of Australia, between Australia and Tasmania, and off New Zealand. These illustrations depict a porpoise that has the dark upper parts separated from the lighter-colored sides and the white under parts by a lateral black streak of variable conformation which encircles the forehead at the base of the white-tipped snout and extends backward through or above the eye almost to the caudal flukes and in some individuals is interrupted at the level of the vent by an oblique light streak that extends forward toward the level of the anterior edge of the dorsal fin. They were considered by Lillie (1915, pp. 122-123) to represent *Lagenorhynchus obscurus*, although the porpoise clearly belongs to the long-beaked group. The conclusion seems inescapable that a porpoise with a moderately long and narrow snout has been erroneously identified as *Lagenorhynchus obscurus*.

For this porpoise Gray's name *Clymenia* [= *Stenella*] *similis* may be available and to this species should be referred a number of skulls listed under *Prodelphinus obscurus* by Flower (1885, p. 28).

Gray (1850, p. 108; 1866, pp. 265, 400) seems to have been the first to suggest that *Delphinus fitzroyi* of Waterhouse (1838) is specifically identical with *Lagenorhynchus obscurus*. This porpoise has been captured at St. Joseph's Bay, Golfo de San Matias, and Mar del Plata, Argentina.

With the exception of the chin and normally the under surface of the caudal peduncle as far forward as the vent, the under parts of Fitz-Roy's porpoise are white. The caudal flukes, dorsal fin, pectoral flippers, upper parts, and sides (with exception of the light oblique lateral bands), top of head, snout, and lower lips are usually black. The lateral light bands vary from white to deep gray. The broad band extending from the pectoral flipper to the angle of the mouth varies from black to gray. According to Gallardo (1912, p. 395, figs. 1, 2) the eye of the female from Mar del Plata is in the dark area of the head. On the specimen from Golfo de San Matias described by Lahille (1901), the eye is located in the gray band that extends from the base of the snout and the angle of the mouth across the side of the head and then curves downward to the base of the pectoral flipper.

Lahille (1901, pp. 4-5) noted that even the oblique lateral light bands vary in width, length, and number on porpoises seen in Golfo de San Matias. One of these variants was harpooned at Joseph's Bay during the voyage of the *Beagle*. The colored drawing of this female made by Captain Fitz-Roy was reproduced by Waterhouse (1839, pl. 10). This porpoise has a deep gray lateral band about midway between the base of the caudal flukes and the dorsal fin, and a second longer oblique deep gray band below the former which extends forward beyond the level of the dorsal fin. The third or anterior lateral band is white and is continuous ventrally with the white under parts behind the pectoral flipper. It extends forward above the pectoral flipper through the eye to the angle of the mouth, blending with gray above the eye. A broad gray band extends from the pectoral flipper to the angle of the mouth. The porpoise captured at Golfo de San Matias (Lahille, 1901, pl.) has much wider white lateral bands than either the type (Waterhouse, 1839, pl. 10) or the specimen taken at Mar del Plata (Gallardo, 1912, figs. 1, 2).

A short-beaked porpoise captured during the cruise of the *Astrolabe* and the *Zélée* in the Rio de La Plata is figured under the

name of "Dauphin à museau court" by Hombron and Jacquinot (1842-53, pl. 22, fig. 1). This illustration became the basis of Wagner's *Delphinus breviceps* (1847, Theil 7, p. 427, pl. 368, fig. 1), but it should be noted that the figure published by Wagner is a crude copy of the original one. Jacquinot and Pucheran (1853, pp. 39, 40) have accepted Wagner's name *Delphinus breviceps* for this porpoise. They state, however, that they have only fragments of the skull and that the tooth formula is $\frac{31}{29}$. True (1889, pp. 89-90) has commented on the two figured skulls that have been identified as *breviceps*. Hombron and Jacquinot's illustration represents a short-beaked porpoise that has the external form and coloration of a *Lagenorhynchus* and should be regarded as one of the color variants of the porpoise hitherto known as *Lagenorhynchus fitzroyi*. The original of Hombron and Jacquinot's illustration of *breviceps* was painted by Werner from a field sketch made by Lebreton. The lateral oblique light bands are indistinctly indicated in this illustration, but are discernible in essentially the same positions as on the porpoise figured by Gallardo (1912, fig. 1).

Philippi's *Phocaena posidonia* (1893, p. 9), which was based on a short-beaked porpoise harpooned off the coast of Chile in 48° 10' S. Lat., 77° 0' W. Long., is closely related to and doubtfully distinct from *obscurus*. The illustration of *posidonia* (Philippi, 1893, pl. 2, fig. 1), if correctly drawn, represents a porpoise that has a slate gray dorsal area extending from the base of the short snout to the caudal flukes. The snout, upper and lower lips, pectoral flippers, dorsal fin, and caudal flukes are black. The anterior lateral light gray area originates behind the level of the dorsal fin and extends forward above the pectoral flipper through the eye and above the black upper lip to the base of the snout. The posterior lateral light gray band originates near the caudal flukes and is bifurcated anteriorly, the lower fork extending forward beyond the level of the anterior edge of the dorsal fin. Two slate-gray prongs from the dark upper parts are directed backward and downward, the anterior or lower prong reaching almost to the level of the vent and separating the anterior lateral light gray area from the lower fork of the posterior light gray band, the upper prong, shorter than the lower one, separating the two forks of the posterior lateral light gray band. This porpoise is represented as having entirely white under parts from chin to caudal flukes. Philippi concluded that *posidonia* was distinct from *Lagenorhynchus fitzroyi* because of the absence of the dark streak extending from the angle of the mouth to the base of the pectoral flipper and because of supposed differences in the shape of the head.

Lesson and Garnot's *Delphinus superciliosus* (1827, p. 181, pl. 9, fig. 2) was based on a short-beaked porpoise measuring 50 French inches (1,353 mm.) in length. This porpoise was harpooned at the side of the *Castle-Forbes* in 44° S. Lat., off Cape Diémen [=South Cape], Tasmania. The external color pattern is described by Lesson and Garnot as follows: "All of back, head and conical rostrum black; dorsal fin, pectoral flippers and caudal flukes brown [brunes]; sides and under parts satiny white; a white band passes above eye to forehead; a lateral white streak in dark upper parts in front of caudal flukes." The illustration shows that the rostrum and the upper lip were likewise black. Curiously enough, *superciliosus* resembles *posidonia* in having the under parts entirely white from the tip of the lower jaw to the caudal flukes. The under surface of the caudal peduncle of porpoises previously identified as *obscurus*, *fitzroyi*, and *breviceps* is, however, slate gray or black. Furthermore, both *superciliosus* and *posidonia* are depicted as lacking entirely the dusky streak that extends forward from the base of the pectoral flipper in the general direction of the angle of the mouth or the eye in the above-mentioned porpoises, and as having an entirely white lower lip and chin. The Chilean *posidonia* has light gray lateral bands in contrast to the satiny white sides and white posterior streak of the Tasmanian *superciliosus*. The short-beaked *Delphinus superciliosus* has the external form and coloration of a *Lagenorhynchus* and should be regarded as a species distinct from *obscurus*.

Within the limitations of the data furnished by published descriptions and illustrations, it seems reasonable to conclude that the range of variation in the external color pattern of *Lagenorhynchus obscurus* is greater than that exhibited by any other species in this genus. Sufficient material is not available at present to determine whether or not some of the names now placed in the synonymy of *obscurus* may eventually be employed to designate geographic races. The external color patterns of all of the above-mentioned porpoises, previously allocated to *obscurus*, *fitzroyi*, *breviceps*, *posidonia*, and *superciliosus*, resemble that of *australis* in some details. The two known specimens of *australis* are, however, somewhat larger than any of the above and have a black chin and throat. Furthermore, the eye is located within the black which covers the entire head, including the snout and upper lip. The narrow dark streak extends from the side of the black throat and not from the eye or the angle of the mouth to the base of the pectoral flipper, and the white under parts are separated from the anterior lateral light area by an undulating dusky streak.

Peale's porpoise is not likely to be confused with *Lagenorhynchus cruciger* (D'Orbigny and Gervais, 1847), which has a black and white color pattern and has been reported off the coast of Patagonia, south of Cape Horn, and off the coast of southern Chile. On the latter (Nichols, 1908, fig. 3), the black areas cover chin and fore part of throat, lower and upper jaws to angle of mouth, snout, top of head, dorsal fin, median portion of upper parts from head to caudal flukes, caudal flukes, lower half of caudal peduncle, and the lateral stripe extending from caudal peduncle to eye, which is expanded dorso-ventrally below dorsal fin and is connected with pectoral flipper by band of corresponding width. The lateral white band extends from in front of level of base of caudal peduncle to about level of center of dorsal fin where it is pinched off by median expansion of black lateral band, and from in front of level of base of anterior edge of dorsal fin forward over eye to base of snout. The under parts with the exception of chin, throat, and caudal peduncle are white. Liouville (1913, pp. 90-93) contends that marked polymorphism exists in the color pattern of this porpoise.

External form.—The head of the porpoise from Chiloé Island has a very short beak, which is distinctly outlined. The flattened forehead slopes obliquely downward from in front of the "blow-holes" to the shallow groove which marks off the short beak. The falcate dorsal fin is relatively shorter than in *obliquidens* and is less strongly recurved; it has an elongated base and its backwardly curved tip is bluntly rounded. The pectoral flippers are of moderate length, falcate in shape, pointed at the distal end, and relatively broad near the base, the hinder edge being concave and the anterior edge convex.

External measurements (taken by collectors in millimeters).—Field Museum No. 22248: total length 2,159; length from tip of snout to anterior edge of eye 260; length from tip of snout to anterior edge of dorsal fin 990; vertical height of dorsal fin 210; length of pectoral flipper, proximal end to tip, 350; greatest spread of caudal flukes 530.

Skull.—Cope (1866, p. 294) stressed the importance of the thin and shelving edges of the supraorbital plates of the maxillaries on the type skull of *Sagmatias amblyodon*. This modification, however, is not constant, since the Chiloé Island skull has the orbital plates of each maxillary noticeably thickened above the lacrimal. The rostrum is attenuated and rather broad at the base, but lacks the pronounced basal swelling or enlargement that is characteristic of

Lagenorhynchus cruciger. The rostrum of the type and of the referred skull are equal, respectively, to 49.2 and 48.1 per cent of the condylo-basal length. No lateral longitudinal groove is present on the palatal surface of the maxillary. On the anterior half of the rostrum, the maxillaries are not decurved to the alveolar margin, but slope obliquely. The maxillaries are closely in contact on most of the palate, revealing only a short section of the distal portion of the vomer and the terminal 10 mm. or so of the premaxillaries. On the type skull of *Sagmatias ambodon*, the supraorbital plates of the maxillaries are in contact with the crest of the supraoccipital, but terminate 6 to 10 mm. from the latter on the referred skull from Chiloé Island.

Between the choanae and the premaxillary foramina, the premaxillaries are conspicuously swollen and elevated above the orbital plates of the maxillaries. In this detail, the skull of this species differs from those of *obliquidens*, *cruciger*, and *obscurus*. The groove extending forward and backward from each premaxillary foramen is delimited externally for only a short distance by an elevated ridge on the outer edge of the premaxillary. Furthermore, the premaxillaries are not depressed in front of the premaxillary foramina to form a distinct triangular depression as in *L. obliquidens*. The rugose area, which replaces the triangular prenasal depression, occupies two-fifths of the length of the rostrum from the notch. The dorsal profile of the rostrum is nearly straight, the premaxillaries being distinctly flattened. The hinder end of the right premaxillary is separated by an interval of 10 mm. from the right nasal on the type skull of *Sagmatias ambodon*, but is in contact with this bone on the referred skull. The left premaxillary terminates about 16 mm. in front of the left nasal on both of these skulls.

The nasal bones are irregular in shape, flattened against the frontals on the vertex and slightly over-ridden ventrally by the mesethmoid. The exposed portions of the frontals on the vertex, measuring 8 to 19 mm. antero-posteriorly, separate the nasals from an anterior quadrangular apical process of the supraoccipital and rise slightly above the level of both of these elements. The supraoccipital crest is quite prominent and is curved forward on the type skull, but is less strongly developed on the referred skull. Strong lambdoid crests bound the occipital swelling of the braincase.

The pterygoids are in contact on the median line on the type skull of *Sagmatias ambodon*, but are separated by a gap of 2.5 to 5.5 mm. on the referred skull from Chiloé Island, although the inner edges of the hamular portions of these bones on both skulls are

widely divergent. The common suture of the palatines is equivalent to about half the length of the longitudinal ridge on the ventral surface of each pterygoid.

Mandible.—The coronoid process of the mandible is everted, the symphysis is short, and the ramus is thickened internally on the distal half. The outer alveolar edge is lower than the inner edge, the teeth being progressively deflected outward anteriorly up to about the middle of the symphysis.

Teeth.—The teeth of the Chiloé Island porpoise progressively increase in length from the posterior to near the anterior end of the toothrow. The enamel crowns of these teeth are imperceptibly compressed in an antero-posterior direction, the height of the unworn crown ranging from 3 to 7 mm. All of the crowns are covered with smooth enamel. The maximum transverse diameter of the crowns of the largest teeth in the upper jaws ranges from 2.9 to 3 mm. and the antero-posterior diameter from 2.8 to 3 mm. In the mandible, the diameter of the crowns of the teeth ranges from 2.7 to 3.2 mm.

The tooth formulae of the southern porpoises discussed on the preceding pages are given in the table on page 308.

Detailed measurements of the skull of the Field Museum specimen and of the type of *Sagmatias amblodon* follow.

MEASUREMENTS OF SKULL

	U.S.N.M. No. 3887*	F.M.N.H. No. 22248†
Maximum condylo-basal length.....	371.0	370.0
Maximum length of rostrum.....	182.8	178.0
Width of rostrum at base (maxillary notches).....	95.4	105.0
Width of rostrum, 60 mm. anterior to maxillary notches.....	71.0	77.5
Breadth across preorbital angles of supra-orbital processes.....	163.7	184.2
Breadth across postorbital angles of supraorbital processes.....	189.0	204.8
Zygomatic width.....	193.7	207.2
Width of braincase across parietals....	170.5	171.8
Maximum distance between outside margins of premaxillaries.....	74.0	76.2
Rostrum equals per cent of condylo-basal length.....	49.2%	48.1%

	R	L	R	L
Total number of teeth in upper tooth-row.....	32	33	33	33
Length of upper toothrow.....	153.4	153.0	157.0	158.8
Hinder end of upper toothrow to anterior end of premaxillary.....	154.8	155.5	159.8	160.5
Total number of teeth in lower toothrow	30	29	31	33
Length of lower toothrow.....	135.3	135.0	154.8	156.6
Hinder end of lower toothrow to anterior end of mandible.....	143.7	142.0	157.5	160.5
Maximum length of mandible.....	300.0	302.0	306.0	308.0
Maximum height of mandible through coronoid process.....	68.3	67.4	74.0	73.0
Length of symphysis.....	35.0	34.8	42.5	41.5

*Type, *Sagmatias ambodon*. U. S. Explor. Exped., 1838-42. Locality unknown.

†Rio Inio, Chiloé Island, Chile, January 12, 1923.

TOOTH FORMULAE OF SOUTHERN PORPOISES

<i>Sagmatias amblyodon</i>	$\frac{32-33}{30-29}$ (type)
<i>Lagenorhynchus australis</i>	$\left\{ \begin{array}{l} \frac{31}{29} \text{ (type, Peale, 1848, p. 33)} \\ \frac{33-33}{31-33} \text{ (Field Museum No. 22248)} \end{array} \right.$
<i>Delphinus breviceps</i>	$\frac{31}{29}$ (type, Jacquinot and Pucheran, 1853, p. 40)
<i>Lagenorhynchus fitzroyi</i>	$\left\{ \begin{array}{l} \frac{28}{27} \text{ (type, Waterhouse, 1838, p. 23)} \\ \frac{28}{27} \text{ (Lahille, 1901, p. 4)} \\ \frac{32}{29} \text{ (Gallardo, 1912, p. 395)} \end{array} \right.$
<i>Lagenorhynchus obscurus</i>	$\left\{ \begin{array}{l} \frac{24-26}{24-26} \text{ (cotype, Gray, 1828, p. 2)} \\ \frac{27}{26} \text{ (Quoy and Gaimard, 1830-33, p. 152)} \\ \frac{28}{28} \text{ (Sclater, 1901, p. 204)} \end{array} \right.$
<i>Phocaena posidonia</i>	$\frac{28-30}{28-30}$ (type, Philippi, 1893, p. 10)
<i>Delphinus superciliosus</i>	$\frac{30}{29}$ (type, Lesson and Garnot, 1827, p. 181)

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EXPLANATION OF PLATES

PLATE 6

FIG. 1. *Delphinus obscurus*. Cotype, young individual; total length not stated. Cape of Good Hope, South Africa. After Gray, 1828, pl. 2, fig. 2.

FIG. 2. *Lagenorhynchus fitzroyi*. Female; total length 1,650 mm. Golfo de San Matias, Argentina. After Lahille, 1901, pl., reversed.

FIG. 3. *Delphinus fitzroyi*. Type, female; total length 1,625 mm. St. Joseph's Bay, Argentina. After Waterhouse, 1839, pl. 10.

FIG. 4. *Lagenorhynchus fitzroyi*. Female; total length 1,830 mm. Mar del Plata, Argentina. After Gallardo, 1912, fig. 1.



1



2



3



4

PLATE 7

FIG. 1. *Delphinus breviceps*. Type; sex and total length not stated. Rio de La Plata, Argentina. After Hombron and Jacquinot, 1842-53, pl. 22, fig. 1, reversed.

FIG. 2. *Delphinus obscurus* var. Sex not stated; total length 1,651 mm. Cape of Good Hope, South Africa. After Quoy and Gaimard, 1830-33, pl. 28, fig. 2.

FIG. 3. *Phocaena posidonia*. Type, female; total length 1,850 mm. Lat. 48° 10' S., Long. 77° 0' W., off coast of Chile. After Philippi, 1893, pl. 2, fig. 1, reversed.

FIG. 4. *Delphinus superciliosus*. Type, sex not stated; total length 1,353 mm. Lat. 44° S., off Cape Diémen [=South Cape], Tasmania. After Lesson and Garnot, 1827, pl. 9, fig. 2.

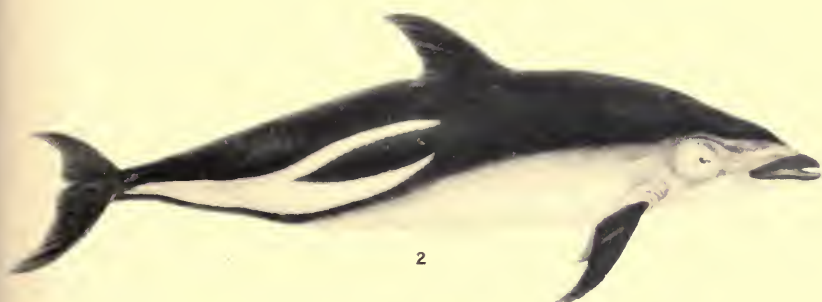


PLATE 8

FIG. 1. *Phocaena australis*. Type, sex not stated; total length 2,133 mm. Off coast of Patagonia, one day's sail north of Straits of Le Maire. After Cassin, 1858, pl. 5, fig. 1.

FIG. 2. *Lagenorhynchus australis*. Male; total length 2,159 mm. Rio Inio, Chiloé Island, Chile. No. 22248 Field Museum of Natural History.

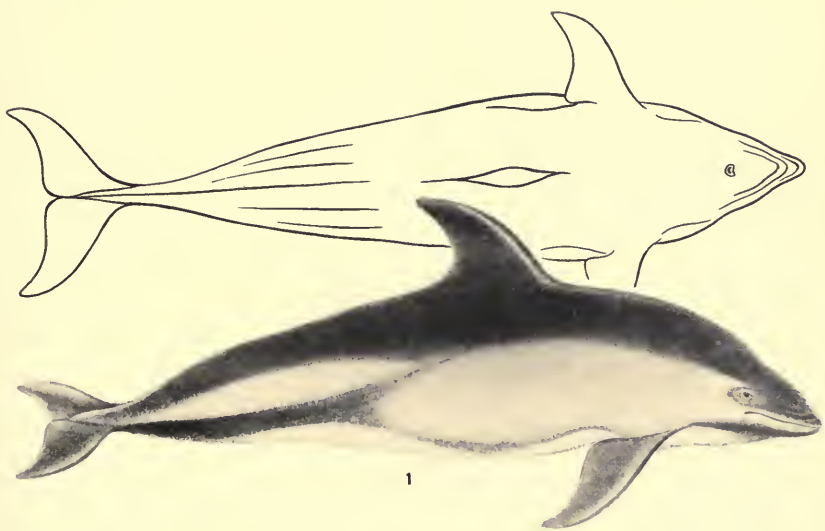


PLATE 9

Lagenorhynchus australis. Lateral, posterior, and ventral views of carcass. Rio Inio, Chiloé Island, Chile. No. 22248 Field Museum of Natural History. Photographs by Wilfred H. Osgood and Colin C. Sanborn.



PLATE 10

Lagenorhynchus australis. Dorsal view of skull. Rio Inio, Chiloé Island, Chile. No. 22248 Field Museum of Natural History.



PLATE 11

Lagenorhynchus australis. Ventral view of skull. Rio Inio, Chiloé Island, Chile. No. 22248 Field Museum of Natural History.



PLATE 12

Lagenorhynchus australis. Lateral views of skull and left mandible. Rio Inio, Chiloé Island, Chile. No. 22248
Field Museum of Natural History.



INCISOR TIPS OF YOUNG RODENTS

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The modification of the incisors of the Simplicidentata into chisel-shaped cutting organs is one of the most characteristic features of this group. It now appears that in three genera at least, and very likely in more, the tips of these teeth have been further modified to perform an entirely different function during the early postnatal life of the animal. As the teeth are permanently growing, these tips wear off when they are no longer of use, and the tooth assumes the normal adult appearance. In some other groups of mammals, as in certain bats, the two sets of incisors bear no resemblance to each other as they are specialized for entirely different functions, the milk set by its hook-like tips being especially adapted to enable the young animal to cling more securely to the fur of the mother. The rodents under discussion lack deciduous milk incisors and in their absence the permanent set has assumed such a double function, the young stage being adapted to clinging to the nipples of the mother. As the teeth are rootless the transition to the typical adult stage is gradual.

This specialization of the incisors was first noticed during the examination of some *Aethomys kaiseri hindei* collected by Mr. Arthur Loveridge in East Africa in 1939. The series includes adults and a litter of three young, two in formalin, one skin and skull. In the young specimens each of the incisors of both the upper and the lower jaw has a deeply notched, broadly flaring tip so that in front view it appears roughly Y-shaped (fig. 56). In the teeth of the upper jaw this shape is further emphasized by a shallow V-shaped depression proximal to the notch. Seen in profile the incisors of both jaws have a strong backward curve giving the teeth a hooked appearance that, in the upper incisor particularly, is in striking contrast to the adult form of the tooth. As the shape of the adult incisor is directly related to the way in which the teeth wear against each other, it is interesting to see that in the young animals the point of wear is entirely at the tip of the tooth. Adults of this species have the anterior enamel surface of the incisors deep orange, in the young specimens at hand it is white; in one of them, when the bony socket was cut away and the tooth exposed all the way to

the base, no trace of any color was found in either the upper or the lower jaw. The animals are evidently very young. The one skinned out, a male, measured (field measurements): total length 70, tail 50, hind foot 15, ear 8, and none of the molar teeth is in place. Of the first molar, a single longitudinal row of cusps is beginning to appear between the narrowly separated alveolar margins. Of the second molar, only one such cusp appears. The mother shows no trace of bifurcation of the incisors and measured: total length 155, tail 141, hind foot 28, ear 20.

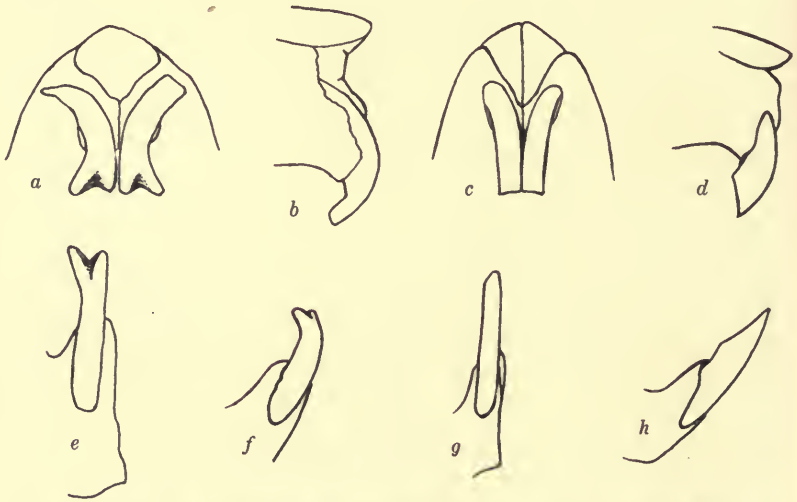


FIG. 56. Young *Aethomys kaiseri hindei*, M.C.Z. 39056: upper incisors, a, front view, b, side view; lower incisors, e, front view, f, side view; all $\times 12$. Nursing mother of the above, M.C.Z. 39136: upper incisors, c, front view, d, side view; lower incisors, g, front view, h, side view; all $\times 3$.

Mr. Loveridge states in his field notes that the female, when her nest was exposed in the process of clearing debris, "ran from the tractor dragging along three large young attached to her nipples . . . I am told that this is a common occurrence." This suggests that the curious development of the incisors actually has survival value in that it helps the young cling securely to the mother and thus enables her, if necessary, to transport the whole litter at once. No trace of a second pair of incisors was found. Milk incisors have not been reported in the Muridae except as minute, calcified rudiments near the base of the permanent tooth in the upper jaw (M. J. Woodward, On the Milk Dentition of the Rodents, *Anat. Anz.*, 9, p. 622, 1894). Altogether, even in the absence of material showing other stages

of development in *Aethomys*, it seems clear that we are dealing with the early stages of the permanent tooth.

A modification, similar in function although slightly different in form, occurs in some, possibly all, species of *Neotoma*. Material kindly lent by Dr. E. Raymond Hall is interesting in that a number of different growth stages are represented in a race of one species, *N. fuscipes annectens*, and slightly different stages in two other forms,

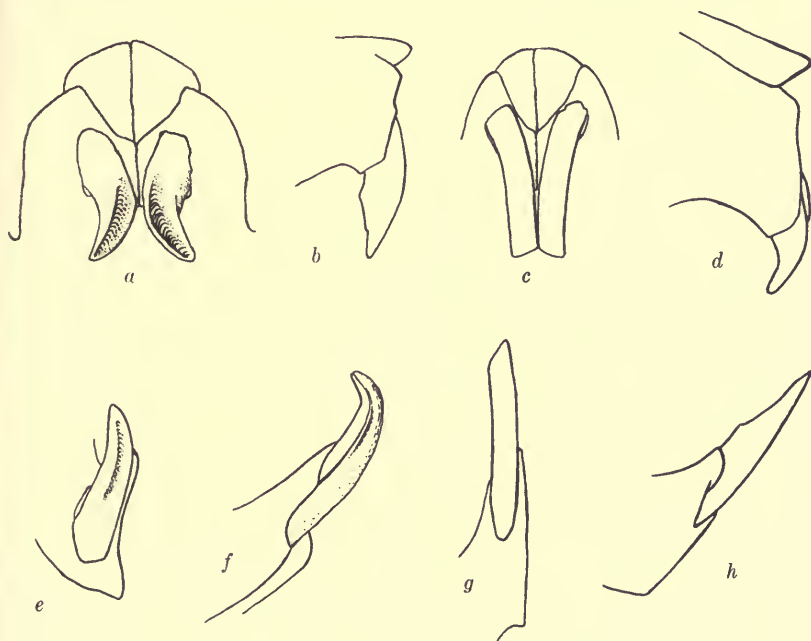


FIG. 57. Young *Neotoma fuscipes annectens*, M.V.Z. 84312: upper incisors, a, front view, b, side view; lower incisors, e, front view, f, side view; all $\times 12$. Adult male of same, M.C.Z. B9264: upper incisors, c, front view, d, side view; lower incisors, g, front view, h, side view; all $\times 3$.

N. fuscipes macrotis and *N. lepida lepida*. In all three, the incisors instead of being bifurcated are grooved and curve sharply outward at the tips, leaving a wide V-shaped space between the pair of teeth in each jaw (fig. 57). In the upper incisor, the groove is wide and shallow and does not extend all the way to the end of the tooth; instead, as shown in the unworn teeth of the youngest specimens of *annectens*, the scimitar-shaped tips as well as the sides have a sharp, raised margin. This is most acute along the inner border of the tooth. The back of the tooth is triangular rather than rounded in cross section, with the sides sloping to an ill-defined ridge which follows

the curve of the tooth medially. As in *Aethomys*, the anterior enamel surface is white, not orange as in the adult. The tooth wears first at the extreme tip where a transverse edge is soon formed at right angles to the axis of the tooth, and hence sloping slightly outward; at the end of the groove a notch appears, slight in *annectens*, more pronounced in *lepida*. Then, as the outward curving tip wears off, the groove disappears, the enamel becomes pale orange proximally, and, as the dentine on the posterior surface of the tooth begins to wear more rapidly than the anterior enamel layer, we have the beginning formation of the chisel-shaped edge characteristic of the adult tooth. The specimens examined show different transitional stages in the three forms. The ages are not quite comparable and the material is certainly not extensive enough to permit the making of any conclusive comparisons; nevertheless it is interesting to note that in *lepida* and *macrotis* the somewhat deeper groove is more persistent than in *annectens*, and the partially worn tooth of *macrotis*, instead of being notched, has the outer half of the tip projected well below the inner. Probably in all of them the juvenile tips of the incisors disappear early. In a skull of *annectens* which has the third molars beginning to show between the bony alveolar margins, the incisors, although small, are fully adult in character with the anterior surface orange and slightly convex, the tooth is deeper antero-posteriorly than it is wide, and the posterior surface is notched by the lower incisors.

The lower incisors in the specimens of *Neotoma* examined are also grooved in their earlier stages and curved backward and outward from the mid-line to a pointed tip. This is flattened antero-posteriorly and the inner edge is almost knife-like. The sharp outer edge continues in a ridge down the outer side of the tooth. Here, as in the upper incisors, the point of wear is first at the tip of the tooth, which, when worn, appears slightly notched. As the tooth gets older, wear becomes more apparent on the posterior surface and the characteristic beveled edge begins to appear, gradually lengthening in proportion to the exposed area of the tooth. The adult character is assumed earlier in the lower than in the upper incisors.

The following observations indicate that here, as in *Aethomys*, the modification is functional. Frank F. Gander (Journ. Mamm., 10, No. 1, p. 57, 1929), referring to *N. fuscipes macrotis*, states: "The young, when small, cling tightly to the nipples of the mother and bump along behind her even when she is fleeing for her life."

Fae Donat Wood (Journ. Mamm., 14, No. 1, p. 21, 1933), in reference to a female *N. fuscipes annectens*, states: "She scampers and climbs about with the young protruding between her hind legs, and though I have seen a mother squeeze through small cracks and run over piles of sticks so as to jolt the young violently, they have never become dislodged. That there are times when the young either let go voluntarily or are disengaged by the mother is shown by the fact that she frequently comes out at dusk without them. I attempted to remove two young ones from their mother at the age of 23 days but they held on so tightly that, for fear of tearing the flesh of the mother, I let them remain."

The third example, a very young specimen of *Hylomyscus aeta weileri*, also has the incisors modified, presumably for the same purpose, although I have found no description of any correlated habits in this genus. The degree of specialization is less than in either *Aethomys* or *Neotoma*, the incisors being neither grooved nor bifurcated. The upper pair differs from that of an adult in that the teeth flare slightly at the tips, leaving a V-shaped space between them; and the lower incisors, although they do not flare, are hooked backward, somewhat as in *Aethomys*. In both, the point of wear is, in the first instance, at the tip.

SUMMARY

Three different genera of rodents have been found to have the tips of the incisors in very young animals highly specialized, presumably for the purpose of giving the young a more secure hold on the mother's nipple. The parallel development of such a modification in two genera as unrelated as *Neotoma* and *Aethomys* is interesting. Further study may show that other genera having this same habit are similarly modified. However, the author found no such specialization in the equally young skulls of twenty-five other genera examined, possibly because the early life habits of the animal do not call for any such adaptation.

THE RACES OF THE OCELOT AND THE MARGAY

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This paper is an effort to disentangle some of the knots of difficulties in the determination and distribution of the described local races of two American tiger cats, the last attempt of the kind having been made in 1919 by J. A. Allen, who was the first to assign all the known forms of each to a single species. The paper is based primarily on the skins and skulls in the British Museum, and incidentally, from examination of the types, I have been able to settle, at all events to my own satisfaction, the position of the three forms of ocelot called *griseus* and *pictus* by Gray and *melanura* by Ball which my predecessors of this century set aside as indeterminable. It is regrettable that apparently the least known of all the races of ocelot is the typical form *Leopardus pardalis pardalis* Linnaeus. From lack of material I have been unable to add anything of importance to our knowledge of this race, and in the account of it I have been compelled to rely on the meager, sometimes conflicting information supplied by American authors.

SPECIFIC AND GENERIC CHARACTERS

In a paper on the classification of existing Felidae (Ann. Mag. Nat. Hist., (8), 20, p. 344, 1917) I assigned the ocelots (*pardalis*) and the so-called margays (*wiedii*) to the genus *Leopardus* Gray 1842, of which *Oncoides* Severtzow 1858 and *Pardalis* Gray 1867 are synonyms. *Leopardus wiedii*, it was pointed out, might be described "as a small, long-tailed, smooth-skulled representative of the Ocelot." Living examples of the two species, with which I was well acquainted at the London Zoological Gardens, were so strikingly alike that *wiedii* could only be distinguished by its smaller size and longer tail. As further evidence of the similarity in external characters, it may be added that Lönnberg, until he examined the skull, mistook for an ocelot the skin of a *wiedii* which he subsequently made the type of a race *ludovici*; and that Thomas marked as a topotype of *L. pardalis aequatorialis* Mearns (an undoubted ocelot) a specimen from Paramba, Ecuador, equally unmistakably a margay, which I assign to *Leopardus wiedii pirrensis* Goldman. In extreme cases there is a well-marked difference between the two

species in the muscular molding of the skull by the masticatory muscles, which profoundly affects its shape; but both show considerable variations in this respect and there is a decided approach to intergradation between the two extremes.

In most adult male skulls of *pardalis* the zygomata are salient, the temporal muscles constrict the cranium, particularly its post-orbital area, and are supplemented by a prominent occipital and a complete sagittal crest; and these features as a rule, perhaps always, increase as age advances. Variations in these respects may be illustrated by two skulls. In an old male of *L. p. mearnsi*, from Costa Rica, the total length of the skull exceeds the condylo-basal length by about 14 mm. owing to the prominence of the occipital crest, the sagittal crest is about 13 mm. high at the fronto-parietal suture, and the postorbital area is so constricted that it is 2 or 3 mm. narrower than the interorbital area and only one-fourth the zygomatic width, which is about five-sevenths of the condylo-basal length. Sharply contrasted with this is the fully adult, but younger, male skull of the type of *L. p. pusaeus* from west Ecuador in which the sagittal crest is represented on the fore part of the cranium by the two temporal ridges which are about 5 mm. apart at the suture; the postorbital area is actually about 7 mm. wider than in the skull from Costa Rica, although the total length of the skull is some 20 mm. less, and it is 7 mm. wider than the interorbital area and about two-fifths of the zygomatic width, which is only about two-thirds of the condylo-basal length.

In female skulls of *pardalis* the postorbital is always wider than the interorbital area and about the same width as the muzzle; the sagittal crest, if complete, is always low. In an old female of *L. p. mearnsi* from Panama the temporal ridges are 12 mm. apart at the suture. This is a very different-looking skull from that of the old male of the same race from Costa Rica.

In *L. wiedii*, as a rule, the crown is noticeably more rounded, the postorbital area is considerably wider than the interorbital and maxillary areas, the sagittal crest is, at most, present, but low on the occiput, and the temporal ridges are over 20 mm. apart at the suture. But there is a good deal of individual variation in these particulars. Two skulls, racially unidentifiable because they have no skins and no localities beyond "Tropical America," are of special interest in having the temporal ridges 17 and 8 mm. apart at the suture and the postorbital area about as wide as the maxillary. These skulls are practically only distinguishable from some adult skulls of *L. pardalis* by their smaller size and smaller teeth.

In view of these facts I see no reason to abandon the opinion that *pardalis* and *wiedii* belong to the same genus and that the characters of *wiedii* do not deserve the generic importance attached to them by J. A. Allen, who in 1916 (Bull. Amer. Mus. Nat. Hist., 35, p. 580) selected *wiedii* as the type of *Margay* Gray and three years later (idem, 41, p. 354) attempted to distinguish that genus from *Leopardus* by cranial characters. His material, however, was clearly inadequate for the purpose, since his diagnoses apply to skulls of the two species in which the differences reach the maximum. But even so the differences are not much greater than those known to exist between large, strongly molded and small, weakly molded skulls of different races of leopards (*Panthera pardus*).

In external characters the species *pardalis* and *wiedii* resemble each other not only in the structure of the feet, as I pointed out in 1917 (Ann. Mag. Nat. Hist., (8), 19, p. 131), but in the color pattern, which on the flanks at least consists of rosettes usually confluent to a greater or less extent in chains or long bands; and typically in the reversal of the hair-growth on the nape, although in both species the degree of reversal is individually variable and the feature may be altogether absent.

THE RACES OF THE OCELOT (*Leopardus pardalis*)

The following alleged race of ocelot may be briefly considered before the others are dealt with: *Felis sanctae-martae* J. A. Allen (Bull. Amer. Mus. Nat. Hist., 20, p. 332, 1904; idem, 41, p. 347, 1919, as *Leopardus pardalis sanctae-martae*). The locality of the type, an adult male, was Bonda, Santa Marta, Colombia; and on the evidence of an additional immature specimen the distribution was said to be the coastal region of northern Colombia and the adjoining district of northern Venezuela.

From the described color and pattern and the reversed nape-hair the type belongs either to *pardalis* or *wiedii*, but the flesh-dimensions (head and body 20.8, tail 14.2, foot 5.6 inches) are those of a smallish, long-footed *wiedii*. The length of the head and body, however, is irreconcilable with that of the total length of the skull, 117 mm. The skull is 10 mm. longer than the longest skull of *wiedii* recorded, namely, the adult male called *nicaraguae* by J. A. Allen, whereas the head and body are 10 inches shorter. This suggests that the skull did not belong to the skin. Allen also cited a difference of only 9 mm., impossible in an adult male skull of an ocelot, between the total and basal lengths, the latter being 108 mm. In one of the smallest adult male skulls of an ocelot

known to me, namely, the type of *L. p. pusaeus* Thomas, the two lengths are 131 and 110 mm., respectively. This suggests that the cited total length of the skull of *sanctae-mariae* may be a misprint for 127. There the question must rest until the type be re-examined.

Leopardus pardalis brasiliensis Oken.

Lynx brasiliensis Oken, Lehrb. Naturg. Zool., 3, p. 1050, 1816—based on Azara's *mbaracaya* and *chibigouazou*; cf. Osgood, Journ. Mamm., 1, p. 89, 1920.

Felis chibigouazou Gray¹ in Griffith's Anim. Kingd., 5, p. 167, 1827—based on *Felis ocelot* No. 1, Hamilton Smith in Griffith's Anim. Kingd., 2, p. 475, pl., 1827; Fischer, Syn. Mamm., Addenda, p. 568, 1830 (*chibigouazou*); Mearns, Proc. U. S. Nat. Mus., 25, pp. 237, 239, 246, 249, 1902 (in part, not specimen from Surinam).

Oncoides pardalis chibigouazou J. A. Allen, Bull. Amer. Mus. Nat. Hist., 35, p. 580, 1916.

Leopardus pardalis chibigouazou J. A. Allen, Bull. Amer. Mus. Nat. Hist., 41, p. 348, figs. 14–18, 1919.

Felis hamiltoni Fischer, Syn. Mamm., Addenda, p. 568, 1830—based on *Felis ocelot* No. 2, Hamilton Smith (see next reference).

Felis smithii Swainson, Anim. in Menag., p. 120, 1838—based on *Felis ocelot* No. 2, Hamilton Smith in Griffith's Anim. Kingd., 2, p. 476, pl., 1827 and *Felis ocelot* β J. E. Gray in Griffith's Anim. Kingd., 5, p. 168, 1827.

Felis maracaya Wagner, Schreb. Säug., Suppl., 2, p. 492, 1841—based on Azara's *mbaracaya*.

Leopardus pictus Gray, Ann. Mag. Nat. Hist., 10, p. 260, 1842; Proc. Zool. Soc. Lond., 1867, p. 403 (*Felis*); Cat. Carn., etc., Brit. Mus., 1869, p. 19 (*Felis*).

Type locality.—St. Ignace, Paraguay (here selected from Azara). *L. chibigouazou*² and *maracaya* are regarded as having this same type locality; *hamiltoni* and *smithii* are from "South America."

Distribution.—According to the characters of the race here adopted, Paraguay and Brazil from Rio Grande do Sul to the Amazons.

A comparatively pale, rather dull-tinted race, the ground color above and inside the flank-bands varying from dullish ochreous

¹ Gray, not Hamilton Smith as usually cited, was the author of Volume 5 of Griffith's "Animal Kingdom," apart from the Ruminantia which Smith wrote (see Gray's List of Memoirs, etc., p. 7, 1875, by Saunders).

² The specimen figured by Hamilton Smith, *Felis ocelot* No. 1, was believed to have come from "South America." He suggested that it represented the *chibigouazou* of Azara from Paraguay and Gray's acceptance of that name in a specific sense justifies, in my opinion, the adoption of Paraguay as the type locality. The names *hamiltoni* and *smithii* given to *Ocelot* No. 2 of Smith, differing from *chibigouazou* in having the back and thighs more extensively red, are doubtful for the synonymy, but since they cannot be definitely assigned elsewhere, they may be thus disposed of.

tawny to brighter ochreous, with the interspaces on the flanks and on the thighs sometimes grayish white; the pattern also variable, ranging on the flanks from isolated rounded or elongate rosettes, set lineally, to complete broad and long, narrowly black-rimmed bands. The skull, which is large and strongly molded muscularly, has broad, wedge-shaped nasals, at most slightly constricted.

Allen published photographs of flat skins, all from Descalvados in Matto Grosso, showing the variation in the pattern above described. The skins I have seen from scattered localities in Brazil fit in with these.

Individual variation is shown by the following skins in the British Museum which I refer to this race. A young adult male (Lord Derby. No. 1852.8.27.15) from Rio Janeiro has the ground color of the head, nape, and back to the root of the tail dullish ochreous tawny, of the flanks and thighs gray with faint dusky speckling; forelegs washed with buff in front; hind legs nearly the same, slightly paler; pattern on the back consisting of solid, mostly elongated spots or short bands, on the sides mostly of irregular, sinuous, partly looped, black stripes, with patches of ochreous tawny in the hollows above or below. The pattern of this skin is abnormal in the disruption of the black rims of the lateral bands and the absence of definite rosettes. Another skin, without skull, from Rio Janeiro (Zool. Soc.) is like the last in ground color but has the pattern of the back and flanks consisting of rosettes, with black rims and ochreous tawny centers, running in lines or here and there forming definite chains or bands. A female from Manaus on the Amazon (A. Raymond. No. 1915.2.15.1) closely resembles the last in color and pattern, but the ground color is a trifle brighter. A male from Santa Maria on the Amazon (H. W. Bates. No. 1856.1.12.2) is like the female from Manaus in color and pattern. A male from the Rio Purus, a tributary of the Amazon (R. Ward. No. 1933.6.12.1), has the color of the upper side and within the bands rather paler and brighter ochreous than in the preceding and the bands are more complete and longer. The type of *pictus*, an adult male (Warwick. No. 1839.12.20.1), is like the skin from Rio Purus in its brighter ochreous tint, but the lateral bands are more broken up into rosettes.

I am acquainted with the measurements of only two examples of this race. In English inches they are as follows:

	Head and body	Tail	Hind foot
Chapada, Brazil (skin; Mearns)..... adult ♂	32.4	13.4	6.4
Manaos, Brazil (flesh)..... adult ♀	27.2	11.4	5.8

The skin from Chapada, although not a big ocelot, was probably stretched rather than otherwise, at least in the head and body.

The largest male skull, unrepresented by a skin, came from Rio Grande do Sul (Von Ihering. No. 1884.2.8.2) and may therefore be regarded as certainly assignable to *brasiliensis*. It is an old skull with salient occipital crest, making its total length one of the largest recorded amongst ocelots, a high sagittal crest, 4.5 mm. at the suture and 10 mm. on the occiput; the teeth are a good deal worn and, partly in consequence, rather small, but the mesopterygoid fossa is wide. The second largest, from Rio Purus (R. Ward. No. 1933.6.12.1), is younger and although its condylo-basal length is the same, the total length is shorter owing to the less salient occipital crest; the sagittal crest also is lower, 3 and 9 mm. at the places stated, the zygomata are narrower, as also is the mastoid width, 58 as against 63 mm., and the postorbital area is less constricted, probably all age-differences. More noticeable differences are the considerably narrower mesopterygoid fossa and larger upper teeth. The shortness of P^4 in the Rio Grande skull is due in a measure to the wear of its posterior point; but the smaller size of the alveolus of the canine cannot presumably be assigned to age any more than can the considerably greater width of the mesopterygoid fossa. In view of the wide geographical separation of the two specimens these differences might be assumed, without further evidence, to be of subspecific value, but Bates' skull from Santa Maria on the Amazon, of which the Rio Purus is a tributary, so closely resembles the skull from Rio Grande do Sul in all particulars, except that it is a trifle shorter in its condylo-basal length, that it supplies cogent evidence of the extension of *brasiliensis* as far north as that river. On the other hand, Lord Derby's young adult male skull from Rio Janeiro has the mesopterygoid fossa and P^4 practically the same as in the skull from Rio Purus from which it only differs in proportions due to its immaturity. The closeness of the likeness of the skull of the type *pictus* in all its available dimensions and in other respects to the foregoing, calls for no comment. The only available female skull, from Manaus on the Amazon, is a good deal smaller than the male skulls; but its dorsal profile is less evenly arched owing to the inflation with air-cells of the frontal bones just behind the level of the postorbital processes, which makes the profile from that point to the end of the muzzle straighter and more evenly sloped. The greater width of the postorbital area than in the male skulls is a well-known female character. The sagittal crest is only complete from the salient occipital crest, in front of which it is 8 mm.

CRANIAL AND DENTAL MEASUREMENTS OF *Leopardus pardalis brasiliensis**

Locality	Sex	Total length	Condyllo-basal length	Basal length	Zygomatic width	Postorbital width	Interorbital width	Maxillary width	Bulla, length and width	Mesopterygoid fossa, width	P ⁴	C ¹	M ₁
Rio Grande do Sul	adult ♂	153	139	131	104	26	28	39	26 x 18	16.0	14.5	10.0	12.0
Rio Purus, Amazon	adult ♂	147	139	128	101	28	29	41	24 x 15	10.5	17.0	13.0	12.0
Santa Maria, Amazon . . .	adult ♂	142	137	...	103	26	26	36	26 x 17	15.5	15.0	9.5	11.5
Rio Janeiro	young adult ♂	...	(131)	...	92	24	25	36	.....	11.0	16.5	10.0	12.5
Type of <i>pictus</i>	adult ♂	...	(138)	...	102	27	27	38	.....	14.0	17.0	10.5	13.0
Manaos	adult ♀	128	118	109	86	31	23	31	22 x 15	12.5	15.0	6.5	11.5

* The dimensions recorded in this table and elsewhere in this paper are taken as follows: total length from the occipital crest to the tip of the premaxillae; condyllo-basal length from the posterior edge of the occipital condyles to the same point; basal length from the anterior edge of the foramen magnum to the same point; the zygomatic width is the greatest width across the zygomatic arches; the postorbital and interorbital widths are the least widths of those areas; the maxillary width is the width of the muzzle above the alveolus of the canines; the dimensions of the bulla relate to the swollen portion; the width of the mesopterygoid fossa is its inside width at the pterygoid suture; the measurements of P⁴ and M₁ are the total lengths of the crown, of C¹ the length of the tooth just below the alveolus. Figures in parentheses are dimensions estimated on defective skulls.

high, to the middle of the parietals where it expands into a lyrate area, 11 mm. wide at the suture. The teeth agree with those of the males, although the canine, as is usual in the female, is thinner.

As stated above under the diagnosis of the race, the nasals in these skulls have for the most part straight, posteriorly convergent sides, showing no marked constriction. In the type of *pictus* and the male from Rio Janeiro they are 8 mm. wide at the frontal points; in the Rio Purus, Rio Grande do Sul, and Santa Maria skulls they are respectively 10, 11, and 12, the average in the five being about 10 mm. In the female from Manaos they are 7 mm.

***Leopardus pardalis steinbachi* subsp. nov.**

Type from Buenavista, Santa Cruz, Bolivia. No. 1928.2.9.15, British Museum. Adult male, skin and skull. Collected by José Steinbach.

Distribution.—Central Bolivia, as far as known.

Distinguished on the average from *brasiliensis* by its brighter color and less massive, finer pattern and from *melanurus* and the Andean race *aequatorialis* by its pattern, which is narrower on the back and sides of the body, being noticeably less extensive than the paler interspaces, and by the small size of the black bands and the tendency to the suppression of the bright color on the upper side of the tail, which is more extensively white at the sides. The skull is distinguished by the narrowness of the posterior half of the nasals, which are on the average only half the width of those of *brasiliensis* and *melanurus*.

The type has the ground color of the upper side and of the central area of the rosettes and bands darkish, rich coppery ochreous, passing into grayish buff on the lateral interspaces; the upper side of the tail is like the back, the black stripes being dominant only at the distal end; the foreleg is buff in front, the hind paler and grayer; the pattern on the nape and back consists of thin stripes and spots on the sides of narrow-rimmed, often imperfect rosettes lineally arranged, sometimes forming complete bands. An adult female skin of a topotype (No. 1934.9.2.34) has the color and pattern very similar to those of the type, but the tint is a little brighter and the upper side of the tail is less well colored, the ground tint being narrower and fainter and the sides whiter. Another topotype, the flat skin of an adult male, with no skull (No. 1940.863), has the same narrow pattern as the last and the tail is similarly colored but duller in tint than the previous two, closely matching the skin of

brasiliensis from the Rio Purus. In a young female topotype (No. 1934.9.2.35), which has no skull, the bright color gradually fades away on the back and the lateral interspaces are grayish white, the upper side of the tail being narrowly buffy gray. An apparently adult male, from the Sara Province, central Bolivia (Steinbach, No. 1907.8.2.14), is duller-tinted than the three adults from Buena-vista, Santa Cruz, not quite so bright as the skin of *brasiliensis* from Rio Purus, and the lateral rosettes are rounder. It links this race with *brasiliensis*, although its tail is as defectively tinted above as in the typical forms of *steinbachi*.

Only two of the above-described specimens have trustworthy flesh measurements, both being conventionally made-up skins.¹

Their dimensions in English inches are as follows:

	Head and body	Tail	Hind foot
Santa Cruz..... adult ♂ (type)	31.2	14.2	5.2
Santa Cruz..... young ♀	22.4	10.8	4.0

The skull of the type is adult, but not old, as shown by the still open frontal suture. It has a condylo-basal length of 136 mm., about the same as in adult males of *brasiliensis*, and the dorsal profile is evenly convex, without frontal inflation, but the sagittal crest is exceptionally high, 7.5 mm. at the suture and 10 mm. on the occiput, higher at the suture than in older skulls of *brasiliensis*; the bullae are also considerably larger, 28 by 17 mm., and the nasals are narrower posteriorly, 4.5 mm. wide at the frontal points. The postorbital and interorbital widths are alike 30 mm., less than the maxillary width, which is 39 mm. The comparatively narrow interorbital and zygomatic widths, 97 mm., show that muscular molding had not reached its maximum. P^4 , C^1 , and M_1 are respectively 16, 10, and 11 mm.

The skull of the adult female, with a condylo-basal length of 127 mm., is considerably smaller, only the postorbital width of

¹ The skins of the adult female and of the male without skull are "flat" and were apparently measured after being stripped. For instance, the head and body measurement of the adult male is given as nearly one-half inch longer than that of the type, although the total length of the skull is 15 mm. shorter, and the head and body of the flat male skin are entered as 1,000 mm. (=40 inches), larger than in any ocelot hitherto recorded. It is also as well to record that Steinbach was hopelessly wrong about the sexes of his specimens. The type and the flat skin of the male were alike marked female, although the scrotum and penis on the skins clearly show that they are male, and the skull of the type is manifestly male. Conversely, the skin and skull of the adult female are marked male, although the skin has a couple of large teats, a vulva but no scrotum, and the skull has all the characters of a female. These mistakes show how zoologists may be misled by accepting, without verification, the data supplied by collectors.

29 mm. being approximately the same. It has a complete but low sagittal crest; the nasals are 5 mm. at the frontal points, the bulla is 25 by 17 mm., and P^4 , C^1 , and M_4 are respectively 15, 8, and 10 mm. A rather younger female (No. 1926.12.4.28) has no sagittal crest except on the occiput, the temporal ridges being 14 mm. apart at the suture; its condylo-basal length is 120 mm. and its other dimensions are a little smaller except the nasals, which are 5.5 mm. at the frontal points; the three teeth are 15, 7, and 11 mm. In the youngest female (No. 1926.12.4.27), with a condylo-basal length of 118 mm., the temporal area is about the same width as in the last, the nasals are 5 mm., the bulla 24 by 15 mm., and the teeth 14, 7, and 10 mm., respectively.

Leopardus pardalis melanurus Ball.

Felis melanura Ball, Proc. Zool. Soc. Lond., p. 128, 1844.

Felis (Pardalis) melanura Gray, Proc. Zool. Soc. Lond., p. 271, 1867.

Felis maripensis J. A. Allen, Bull. Amer. Mus. Nat. Hist., 20, p. 331, 1904.

Leopardus pardalis maripensis J. A. Allen, Bull. Amer. Mus. Nat. Hist., 41, p. 347, 1919.

Oncoides pardalis tumatumari J. A. Allen, Bull. Amer. Mus. Nat. Hist., 34, p. 632, 1915.

Leopardus pardalis tumatumari J. A. Allen, Bull. Amer. Mus. Nat. Hist., 41, p. 347, 1919.

Type locality.—Unrecorded, but perhaps more likely than not British Guiana. Type locality of *maripensis*, Maripa, Caura District of Venezuela; of *tumatumari*, Tumatumari, British Guiana.

Distribution.—Venezuela and British Guiana; also Dutch Guiana (Surinam) and possibly Trinidad.

Intergrading in color and pattern with *brasiliensis* but distinguished noticeably on the average by the darker, richer ochreous ground color of the head, nape, back, and within the black-rimmed bands or rosettes which are set off on the flanks by paler interspaces; the pattern forming more definite bands, the black more extensive and encroaching to a greater degree over the paler interspaces and markedly dominant in some cases. The skull also has the dorsal profile more dome-shaped, owing to inflation of the frontals with air-cells, and in adult males it is not so strongly molded, the sagittal crest being low on the crown, the zygomatic width a little narrower, the average being 98 mm. in six as against 102.5 in four skulls of *brasiliensis*, and the postorbital area less constricted, the average width in the same specimens being 33 as against 27 mm.; the nasals also are on the average narrower, being from 7 to 9 mm. wide at

the frontal points, instead of from 8 to 12 mm. in *brasiliensis*, and the bullae are a trifle longer, ranging from 25 to 27 mm. long and from 17 to 19 mm. wide as against an average of just over 24 mm. long and 16 mm. wide in *brasiliensis*. The condylo-basal length of the skulls is the same in the two races.

The type of *melanurus*, an adult, apparently female specimen, is exceptional in two respects. The hairs of the nape are not reversed in growth direction¹ and it is a color-mutant recalling in many respects some skins of leopards I have described, the black pigmentation, or pattern, being excessively developed at the expense of the pale interspaces. The ground color of the interspaces is rich ochreous on the upper side from the head backwards, where traceable, and in the central areas of the lateral bands, but on the sides between these bands it forms narrow whitish lines. On the nape the normal pale central area with its median black stripe is almost obliterated by the great expansion of the inner of the two lateral stripes, which in the middle of its length fuses with the equally expanded outer stripe, the two again joining to form a big black patch behind the shoulders; on the back there is a median broad spinal stripe separated on each side by a narrow ochreous stripe from a very wide black dorsal stripe, the three meeting behind to form a black shield on the rump; the tail is black except for a little white at the base below; the spots on the limbs are large.²

The type of *maripensis*, an adult male from the Caura District of central Venezuela south of the Orinoco, was described as having the black of the upper side greatly predominating over the inter-spaces, which were tawny, "like a jaguar,"³ above and a little paler on the flanks; the pattern consisted of heavy blotches and stripes, mostly solid, only a few forming rosettes; the outer lateral stripes on the neck were from 10 to 15 mm. thick and extended to the shoulders; the upper side of the tail was mostly black, the interspaces being reduced to half-rings on the sides and below. From this description

¹ This character seems to be subject to the same degree of variation in *pardalis* as in the related species *wiedii*. The hairs, for example, are not reversed in a specimen identified as *L. pardalis albescens*, from Coahuila, Mexico. In the female of *brasiliensis*, from Manaos, described above, they are also directed backwards, apart from a few local irregularities; in the type of *pictus* they are reversed only on the fore part of the nape from two whorls situated a short distance behind the ears and in the skin from the Rio Purus the two whorls are set about halfway along the nape; as a general rule the reversal starts at the shoulders.

² There is a colored figure of the specimen in Elliot's "Monograph of the Felidae."

³ The tint of a jaguar is not at all my conception of tawny. I should apply that term to the tint of an average lion; "jaguar-like" exactly expresses the color of the type of *melanurus*.

it seems that the specimen merely differs from the type of *melanurus* in being less extensively black and in the lateral interspaces being yellower, not so white.

The description of the color and pattern of the type of *tumatumari*, from British Guiana, with the black pattern "greatly predominating" and the ground color tawny on the back is the same as that of *maripensis*, although Allen made no comparison between these two forms. About the only color differences seem to be the whiteness of the interspaces on the flanks of *tumatumari* and the less extensive suppression of the pale interspaces on the tail. In the whiteness of the interspaces on the flanks, this type resembles that of *melanurus*.

A series of skins in the British Museum from British Guiana sent by F. V. McConnell, mostly from the Rio Supinaam, shows that the characters in which the types of *tumatumari* and *maripensis* differ from each other are individually variable in the same locality. Some of the skins distinctly approach *brasiliensis* in color. None of them appears to have the black pattern so markedly dominant as in the type of *tumatumari*.

Five skins from the Rio Supinaam (Nos. 1910.9.29.12, 13, 14; 1911.12.15.9; 1913.12.12.1) have the ground color of the head, nape, back, and within the bands varying from dark ochreous tawny or pale brown to a little brighter or to a duller more olivaceous tawny, the pattern forming long bands, sometimes with contained spots, and the interspaces varying from white to buffy white; the front of the legs is tinted with buff, sometimes only faintly and is paler than the back in all the skins; the upper side of the tail has the pale interspaces visible to the end, but the black is always dominant, though to a varying extent. A female skin from Tiger Creek, Essequibo River (No. 1914.6.25.3) has the ground color above as dark as in the darkest of the Rio Supinaam series, the pattern is similar, the lateral interspaces are white, the legs are buff-tinted and the black on the tail is noticeably dominant. A female skin from Takutu River, Rio Branco, on the Brazilian border of Guiana, has the ground color more sandy ochreous than the preceding and the legs are better-colored, the same tint as the back. In general this skin hardly differs from some of the skins assigned to *brasiliensis*. It may here be noted that Allen identified as *tumatumari* a skin recorded by Osgood from Santarem which, from its locality, should belong to the same race as my skins from Manaos and Santa Maria on the Amazon, assigned to *brasiliensis*; but since the skin looks like *melanurus*, the possibility of its having come from Guiana must be remembered.

Two skins from Dutch Guiana (Ivan Sanderson) differ individually. One (collector's No. 529M) has the same rich dark color above and within the bands as the best-colored skins from British Guiana, with the pattern forming long bands set off by whitish interspaces, slightly tinted close to the rich-tinted spinal area. The other skin has the ground color paler, with a narrower pigmented spinal area and the lateral pattern not forming definite long bands but consisting mainly of elongated lineally arranged rosettes.

A skin from Trinidad (F. Urich. No. 1932.11.11.15) is provisionally assigned to this race. It is not so bright or dark as the typically colored British Guiana skins, being grayer or more olivaceous, less ochreous tawny, with the limbs gray; but the lateral pattern is in bands and the black on the tail is dominant. It hardly differs from the dullest Rio Supinaam skins.

A moderately good series of skulls from British Guiana shows that although individually variable in all respects they differ on the average from those assigned to *brasiliensis* in some particulars. The dorsal profile is more dome-shaped, less evenly convex, more steeply sloped from the highest point to the occiput backwards and to the nasals forward, owing to inflation of the frontal bones with air-cells; and in adult males by the much lower sagittal crest. The frontal inflation varies in position. In an adult male from the Supinaam River (McConnell. No. 1913.12.12.1) it is well marked and situated just behind the position of the postorbital processes, the forehead and the muzzle being steeply sloped forwards and the cranium backwards from that position. In an adult male from the Moon Mountains, south British Guiana (McConnell. No. 1911.6.7.37), the inflation is similar. In an adult female from the Takutu River on the Brazilian frontier (McConnell. No. 1908.12.15.7) the inflation is equally prominent, but situated well in front of the postorbital processes, the muzzle being steeply sloped from that point. In other skulls the inflation is less marked. In two adult male skulls from the Supinaam River (Nos. 1913.12.12.1 and 1910.9.29.12) the sagittal crest is low, 3 mm. at the fronto-parietal suture and about 7 mm. on the occiput; and, in accordance with the low crest, the postorbital area is from 3 to 9 mm. wider than the interorbital area and the same as the maxillary width or a little less. Two adult female skulls differ a good deal in muscular development. The one from the Takutu River, above referred to, has a complete but small sagittal crest and the postorbital and interorbital areas 29 and 25 mm., respectively. Another younger skull from the Supinaam River (No. 1910.9.29.14) has scarcely any frontal inflation,

the temporal ridges are 7 mm. apart at the suture, and the two areas in question 34 and 26 mm., respectively.

The teeth vary individually, P^4 in the male from 16 to 18 mm. long, in the female from 14 to 16 mm., the upper canine in the male from over 8 to 9 mm., in the female from 7 to 8 and M_1 in the male from 12 to 13 mm., in the female from 11 to 12 mm.

The skull of the type of *melanurus*, apparently female, agrees very closely in size, shape, and proportions with McConnell's series. Its condylo-basal and basal lengths are 132 and 120 mm., respectively, those of the female from the Takutu River being 129 and 120 mm. The nasals are 9 mm. wide at the frontal points, the bulla is 24 by 18 mm., P^4 is 14.5 and the canine 7 mm. The skull of the adult male type of *tumatumari* is apparently older than the British Guiana skulls described above. Its condylo-basal length in the original description is 139 mm.,¹ the same as in the male skull from the Supinaam River (No. 1910.9.29.12), but its total length is 151 mm. as against 145, indicating a bigger occipital crest, its postorbital area is narrower, 32 mm. as against 36, and its interorbital area wider, 32 mm. as against 27 mm., the dimensions in question increasing with age after the total length is attained; P^4 is 16.5 by 8.5, not so large as the largest in the Supinaam skulls. Allen's measurements of the skull of the adult male type of *maripensis* from Venezuela with the total, basal, and basilar lengths 144, 130, and 121 mm. agree closely with those of my skull from the Supinaam River, British Guiana (No. 1910.9.29.12), in which the same dimensions are 145, 129, and 125 mm. He laid special stress on the large size of P^4 , which was 17.5 mm. long and 9.5 mm. wide in front. The same tooth in my skull from the Supinaam (No. 1913.12.12.1) is 18 mm. long and 9 mm. wide.

These skulls have been considered in some detail because the evidence they supply confirms that of the skins—that the names *melanura*, *maripensis*, and *tumatumari* were given to the same race of ocelot.

The adult unsexed but apparently male skull of Sanderson's skin (collector's No. 529M) from Dutch Guiana is a little smaller than the two adult male skulls from the Supinaam (Nos. 1910.9.29.12 and 1913.12.12.1), its condylo-basal and basilar lengths being 133 and 121 mm. as against 139, 137, and 125 mm.; but it has the same low sagittal crest and its dorsal profile is about the average in shape

¹ In 1919 this was said by Allen to be the "basilar" length, involving a condylo-basal length of about 150 mm., much bigger than in any known ocelot skull.

of the British Guiana skulls, the frontals being a little inflated both at the base of the nasals and behind the level of the post-orbital processes. But under the name *chibigouazou*, Mearns (Proc. U. S. Nat. Mus., 25, p. 249, 1902) gave the skull measurements of an alleged female from Dutch Guiana, which I strongly suspect was a male. At all events its basilar length of 125 mm. and zygomatic width of 100 mm. are the same as in the adult male from the Supinaam (No. 1910.9.29.12). In my two adult female skulls from British Guiana those dimensions are 117, 114 and 87, 91 mm., respectively. The skull of the skin from Trinidad (No. 1932.11.11.15), provisionally assigned to this race, is apparently female and a young adult. It is a smallish skull with the condylo-basal only 119 mm., but the postorbital area is narrow, 29 mm., and the temporal ridges form a narrow lanceolate area, 6 mm. at the parietals and 3 at the suture. The condylo-basal is the same length as in a much younger female skull of *melanurus* from Tiger Creek (1914.6.28.3), but in this the postorbital area is 36 mm. and the temporal ridges are 19 mm. apart at the suture.

None of the skins in the British Museum was measured in the flesh, but Allen recorded those of his types of *maripensis* and *tumatumari*, which, converted into English inches, are as follows:

		Head and body	Tail	Hind foot
Venezuela (<i>maripensis</i>).....	adult ♂	37.4	14	...
British Guiana (<i>tumatumari</i>).....	adult ♂	36.2	13	5.2

The dimensions of the type of *maripensis* were taken from a soft skin which was almost certainly stretched in the head and body. The type of *tumatumari* was measured in the flesh. The lengths of both suggest a larger ocelot than *brasiliensis* or *steinbachi*, a suggestion not borne out by the skulls.

***Leopardus pardalis aequatorialis* Mearns.**

Felis aequatorialis Mearns, Proc. U. S. Nat. Mus., 25, p. 246, 1902.

Oncoides pardalis aequatorialis J. A. Allen, Bull. Amer. Mus. Nat. Hist., 35, pp. 123 and 223, 1916.

Leopardus pardalis aequatorialis J. A. Allen, Bull. Amer. Mus. Nat. Hist., 41, p. 347, 1919.

Type locality.—Paramba, northern Ecuador.

Distribution.—Peru; Ecuador; Colombia.

Closely resembling both *brasiliensis* and *melanurus*. Color and pattern individually variable in the same locality, but the ground color above and in the pattern more ochreous on the average than

in *brasiliensis*, that tint varying from brighter and yellower to darker and browner or more rusty ochreous; pattern on the flanks varying from complete long bands to separate lineally arranged rosettes, the banded pattern being prevalent; typically the black on the tail is noticeably dominant over the pale interspaces, which in the posterior half or two-thirds of the organ are reduced to narrow, widely separated stripes. In the darkest specimen the ground color is not distinguishable from that of the darkest skins of *melanurus* from British Guiana, but on the whole it is a little paler and brighter ochreous, although none of the skins shows the marked dominance of the pattern over the interspaces recorded in the types of *melanurus*, *maripensis*, and *tumatumari*. In the skull the nasals are on the average noticeably narrower posteriorly than in *brasiliensis* and the frontals are not inflated as they are typically in *melanurus*.

Mearns described the type of this race, an adult female, the only specimen he had, as very large¹ with the ground color of the upper side nearly uniformly tawny rufous, the pattern of the back consisting of solid black spots, without pale centers, of the flanks of "jaguar-like" rosettes, apparently not confluent in bands, the tail above as reddish tawny, irregularly spotted with black on its basal three-fifths, and with five black rings in the terminal two-fifths.

The British Museum has only one adult skin from Ecuador, a male from Gualaquiza, altitude 2,500 feet (Hammond. No. 1914.4.25.42). The ground color of the back and of the centers of the lateral bands is dark ochreous brown, the spaces between these bands being buffy gray; there is a continuous black spinal stripe and on each side of it a series of elongated mostly solid blotches and lines, very much as in the type, but on the flanks the rosettes are not isolated, but form broad bands with smaller spots in the ochreous central areas; the tail is dominantly black above, but the pale interspaces are traceable nearly to the end; the legs are washed with buff. A kitten with the same history (No. 1914.4.25.47) has the ground color pale above, white laterally, the black on the tail being greatly dominant. Allen recorded a specimen from Daule in Guayas, altitude 2,000 feet.

A few Peruvian skins show a good deal of variation both in the ground color and the pattern. An adult male from Marcapata (Kalinowski. No. 1904.12.4.5) closely matches the skin from Gualaquiza, its ground color being rich dark ochreous tawny above, with

¹ His standard for size is not apparent. The type was not a big ocelot by the measurements recorded.

whitish streaks on the flanks; the pattern on the back consists of three continuous black stripes and of coalescent rosettes on the sides, but these do not form such broad bands as in the Gualaquiza specimen. A female with the same history (No. 1904.12.4.6) has the ground color a good deal paler, more sandy ochreous than in the male and the spots or rosettes forming the pattern do not form such complete bands. A youngish male from Yurac Yacu, San Martin (Hendee. No. 1927.1.1.66), closely resembles the female from Marcapata in color. An adult female from Pozuzo (Hoffman. No. 1903.12.5.1) is also paler than the male from Marcapata but is rather darker and duller than the other two. Still paler than any of the foregoing is a female skin from Santa Ana, Cuzco (Kalinowski. No. 1897.10.3.9), which is pale sandy buff above with the lateral interspaces nearly white; the pattern is not so coarse and the black bands on the tail are not so wide as in the other Peruvian skins.

Allen in 1916 described a male from Caquetá District, Colombia, as closely resembling *L. p. mearnsi*, which ranges from Panama to Nicaragua, in color, but having the tawny of the upper parts deeper and more rufous and extending much lower on the sides. Specimens from western Colombia, he added, agree closely with those from Ecuador. This description applies very well to the darker-tinted skins in the British Museum from Ecuador and Peru, but does not agree by any means with the Colombian skins in the British Museum. A skin, apparently male, from Bogotá (Niceforo Maria. No. 1924.6.3.1), is peculiar in having the nape hairs disturbed by two whorls, one a little behind the occiput, the other farther back to the left of the middle line; the ground color is brighter ochreous than in the male skins from Gualaquiza and Marcapata; the spots in the row on each side of the middle line mostly have pale centers, the rosettes on the sides are thin-rimmed, some isolated, others confluent in bands, and on the tail the black pattern is not noticeably dominant. Two skins from Bogotá (Welby. Nos. 1940.864 and 865), June, are not so bright as the last, both closely matching the dull skin from Pozuzo. An adult female skin from Medellín (Salmon. No. 1878.8.31.4) similarly closely matches the female skin from Marcapata, Peru, in the ground color, but the interspaces on the flanks are buff and this tint invades the sides of the abdomen and the throat below; the legs are well tinted, matching the back; the black on the tail is not dominant; there are no complete stripes on the dorsal area, even the normal spinal stripe being broken up into solid spots. The peculiarities of this skin make its reference to *aequatorialis* a little doubtful; but the disruption of the dorsal pattern is

foreshadowed in the female Peruvian skins from Marcapata and Santa Ana.

The following are the flesh measurements in English inches of some of the above-described specimens:

		Head and body	Tail	Hind foot
Gualaquiza, Ecuador.....	adult ♂	39.4	14.4	6.4
Caquetá, Colombia (Allen).....	adult ♂	34.0	14.0	6.4
San Martin, Peru.....	young ♂	29.2	14.6	6.2
Guayas, Ecuador (Allen).....	adult ♀	30.8	16.8	6.8
Paramba, Ecuador (type).....	adult ♀	29.0	14.6	6.0
Santa Ana, Cuzco, Peru.....	young ♀	23.6	11.6	...

The male from Gualaquiza appears to be the record ocelot for size and the skull, as stated below, is in keeping with the flesh measurements. The female from Guayas, Ecuador, has an exceptionally long tail for the species, well over half the length of the head and body. There is probably some error in the figure. But it is interesting to note that in the young male from San Martin and the young female from Santa Ana, Peru, the tail is as nearly as may be half the length of the head and body as it is in the type of the race from Paramba.

There are only a few adult skulls of this race in the British Museum and they do not differ in any important respects from those of *brasiliensis*, although the nasals are on the average narrower in their posterior portion. The skull from Gualaquiza (No. 1914.4.25.42), an oldish male, with the total and condylo-basal lengths 157 and 142 mm., respectively, is a little longer than any recorded skull of the previous three races. It is strongly molded, the zygomatic width being 101 mm. and the constricted postorbital and the interorbital widths 27 mm.; the sagittal crest is high, 4.5 mm. at the suture, 9 on the occiput; the nasals are 8 mm. wide at the frontal points; the bullae are low and narrow, 25 by 15 mm., and exhibit a feature not observed in any other skull, namely, a low, sharp crest extending forwards along the posterior half of the outer surface from the paroccipital process; the teeth are normal in size, P^4 17 mm., C^1 9.5 mm., and M_T 12 mm. long. The adult male skull from Marcapata, Peru (No. 1904.12.4.5), is a little shorter than the last, its total and condylo-basal lengths being 151 and 133 mm., respectively; but its zygomatic width, 107 mm., is a little greater and its sagittal crest, 7 and 10 mm. at the places indicated, is higher; the nasals, 6 mm. wide at the frontal points, are narrower; the bullae are not so flat and have no crest; the postorbital and interorbital areas are the same width and the three teeth are the same length as in the Ecuador skull. The skull of an adult male from Caquetá

District of Colombia, measured by Allen in 1916, had practically the same condylo-basal length, 132 mm., as the male from Marcapata, Peru, but its much shorter total length, 142 mm., narrower zygomata, 94 mm., and postorbital width, 32 mm., considerably exceeding the interorbital, 26.5 mm., show that its muscular molding was on a very inferior scale. Probably it was a much younger skull and not fully developed. Its upper carnassial P^4 , 15 mm., is also noticeably shorter, 1 mm. shorter than the alveolus of that tooth in the Marcapata and Gualaquiza skulls.¹ I have seen no female skull from Ecuador, but that of the type from Paramba, measured by Mearns, had a basilar length of 113 mm., indicating a condylo-basal length of about 126 mm.; the cranial, zygomatic, postorbital, and interorbital widths were 57, 95, 39, and 27 mm., respectively, and P^4 was 17.5 mm., longer if anything than in my male skulls from Ecuador and Peru and decidedly longer than in Allen's male from Colombia. Possibly the skull was that of an undeveloped male with the postorbital area unconstricted. The largest female skull in the British Museum, from Pozuzo (No. 1903.12.5.1), with a total length of 140 mm. and an estimated basilar length of 118 mm., is longer than the skull of the type; the zygomatic width is the same, but the postorbital area is more constricted, 30 mm., and only a few mm. wider than the interorbital, 26 mm.; the sagittal crest is complete, 1 mm. at the suture, 8 mm. on the occiput; the nasals are 6 mm. wide at the frontal points; the bullae are large, 27 by 18 mm., and P^4 is 15.5 mm. The skull of the female from Marcapata, Peru (No. 1904.12.4.6), is much smaller than the one from Pozuzo and than the type, its total and condylo-basal lengths being 124 and 116 mm. and its basilar length 103, and is quite a dwarf compared with the male from Marcapata. It is just adult and not so muscularly molded as the female from Pozuzo, the sagittal crest being complete only posteriorly and represented in front by a ridge 5 mm. wide at the suture; the nasals are broader, 7 mm. wide at the points; the bulla is 22 by 15 mm., and P^4 is 14 mm. The adult female skull from Medellin, Colombia (No. 1878.8.31.4), has its back cut away, but its estimated condylo-basal length is about the same as in the female from Marcapata, which it further resembles in the presence of a temporal area 6 mm. wide and in the length of P^4 ; but it differs in the narrower facial portion of the skull, the interorbital and maxillary widths being 19 and 29 mm. instead of 23 and 32; and the nasals are compressed behind, only 4 mm. wide at

¹ In the immature male skull (No. 1927.1.1.66) from San Martin, Peru, the alveolus is 15 mm., which indicates about 16 mm. for the crown.

the points. An adult female skull from Daule in Guayas, Ecuador, measured by Allen, was nearly intermediate in size between the females from Marcapata and Pozuzo, and a little shorter than the type of *aequatorialis*, its total and condylo-basal lengths being 131 and 121.5 mm., respectively; its P^4 , 16 mm., was about the same length as in the female from Marcapata.

Possibly the specimens recorded above may prove to be referable to more than one race; but the material is quite inadequate to justify the introduction of new names.

Leopardus pardalis pusaeus Thomas.

Felis pardalis pusaeus Thomas, Ann. Mag. Nat. Hist., (8), 13, p. 347, 1914.

Leopardus pardalis pusaeus J. A. Allen, Bull. Amer. Mus. Nat. Hist., 41, p. 348, 1919.

Type locality.—Changon, fifteen miles west of Guayaquil, coastal region of Ecuador. Altitude 60 meters. Collected by P. O. Simons (No. 1899.8.1.29).

Distribution.—Western Ecuador, at comparatively low levels.

Distinguished from the above-described races by its small size, rather pale dullish color and weakly developed skull, that of the adult male resembling in dimensions and muscular molding the female skull of the other South American races.

The type, an adult male, November, has noticeably paler ground color than typical *aequatorialis*, duller ochreous, more sandy tawny, gradually fading laterally and especially paler on the sides behind the shoulders; the pattern is not so massive, more spotty, with the lateral rosettes less confluent in bands, at least on the average; the pale interspaces on the tail are better developed; the legs are grayer. A young adult male with the same history (No. 1899.8.1.28) is very similar to the type in color and pattern, but has the flanks whiter and the pale interspaces on the tail broader. A younger female from western Ecuador (Zool. Soc. No. 1915.11.3.1) is colored like the last, but the rosettes are more confluent in bands than in the other two.

The flesh measurements in English inches are as follows:

	Head and body	Tail	Hind foot
Changon (type)..... adult ♂	29.0	12.0	6.0
Changon..... young adult ♂	28.6	13.2	6.4
Western Ecuador..... young ♀	23.0	14.0	6.4

The adult male (type) is exactly the same in the length of the head and body as the adult female of *L. p. aequatorialis* from Paramba.

The skull of the type, which is just adult, has the condylo-basal and basilar lengths 121 and 108 mm.; the postorbital and maxillary widths are 32 mm., wider than the interorbital, which is 25 mm. The temporal ridges do not meet on the crown, where they form a lanceolate area 7.5 mm. wide at the suture, but they coalesce on the posterior part of the parietals, forming a short sagittal crest 5 mm. high on the occiput; the zygomatic width of 82 mm. is narrow; the nasals are not compressed, being 8 mm. wide at the frontal points; the bulla is 24 by 17 mm.; P^4 is 16 mm., the upper canine 8 mm., and M_T 12 mm. The young adult male has the condylo-basal and basilar lengths 119 and 108 mm. and, in accordance with its age, the temporal ridges are 14 mm. apart at the suture, the sagittal crest is restricted to the occiput, where it is 2.5 mm. high, and the postorbital, interorbital, and maxillary widths are 33, 23, and 30 mm., respectively. The measurements of the nasals, bulla, and teeth are the same, or very nearly so, as in the type. The young female skull does not call for detailed description; the undeveloped bulla is 19 by 19 mm. and P^4 , C^1 , and M_T are 14, 7, and 10 mm.

Leopardus pardalis mearnsi Allen.

Felis costaricensis Mearns, Proc. U. S. Nat. Mus., 25, p. 245, 1902 (name preocc. by Merriam for a race of puma).

Felis mearnsi J. A. Allen, Bull. Amer. Mus. Nat. Hist., 20, p. 71, 1904 (substituted for *costaricensis*).

Felis pardalis mearnsi J. A. Allen, Bull. Amer. Mus. Nat. Hist., 28, p. 108, 1910.

Leopardus pardalis mearnsi J. A. Allen, Bull. Amer. Mus. Nat. Hist., 41, p. 346, figs. of skull, 1919.

Type locality.—Talamanca, Costa Rica.

Distribution.—"From the eastern slopes of Nicaragua to Panama," according to Allen.

Ground color individually variable from "tawny" to "buffy gray," on the average at least noticeably paler, not so rich in hue as *aequatorialis*, *melamurus*, and *brasiliensis* and with the pattern consisting more of isolated rosettes, less "catenate" or coalescent in lateral bands.

Mearns described this ocelot on page 237 of his paper as having the ground color above tawny in front and becoming grayish or paler posteriorly. This description was probably taken from a series of skins; but the longer description on page 245 seems to have been derived from the type alone. Here he says: "size very large;

upper parts with ground color russet becoming tawny olive within the spots and cream-buff between the chains of spots on the sides; pattern consisting of a heavy black spinal stripe, of elliptical solid spots on each side of it, and of lateral dorsal spots including tawny-olive areas, these spots about twice as long as wide; the tail, more black than white, with eleven black stripes." Most of his specimens, including the type, were from Talamanca in Costa Rica, one from the Pacific coast of that state; but two came from Panama. In 1910 Allen described a male from Rio Choco, eastern Nicaragua, as having the ground color of the dorsal surface tawny and a female from Pena Blanca as exhibiting the "gray phase," the ground color of the dorsal surface being dull buffy gray. In spite of this record of the pale specimen, he diagnosed the race in 1919 as "a large dark form."

None of the skins in the British Museum can be described as "dark." An old male represented by skin and skull, from Costa Rica, with the rest of its history obliterated, has the upper surface and the rosettes pale buffy ochreous, gradually fading laterally and passing into white on the lower flanks; the pattern consists mainly of "jaguarine" rosettes with thick black rims and contained spots, mostly isolated but coalescent in bands on the sides behind the fore limbs. A skin (O. Salvin. No. 1865.5.18.16) without locality but assignable to this race, closely resembles the last except that the rosettes are a little more elongated. Two skins from Boquete, Chiriqui, Panama, 4,000-4,500 feet (H. J. Watson) are paler and altogether less brightly colored than the foregoing. A male (No. 1905.5.4.3) has the head, nape, and shoulders sandy, the spinal area quite light buffy gray passing high up on the flanks and thighs into white, which throws into bold relief the pattern consisting of solid spots or very thick-rimmed rosettes with sandy centers, but not "catenate" or coalescent in bands; the tail has the black dominant in its distal half, where it forms broad, narrowly separated stripes; the hind leg is grayish white, the foreleg faintly buffy at the base. A female (No. 1903.3.3.17) differs from the male in being grayer, less buffy above and in the pattern, with the white setting in lower down on the flanks, and the rosettes of the pattern thinner-rimmed and more coalescent in bands on the flanks; the black on the tail, as in the skin from Costa Rica, is hardly dominant over the pale interspaces. This Chiriqui female appears to resemble Allen's female from Pena Blanca in Nicaragua in exhibiting the "gray phase," attesting the occurrence of this phase in both the eastern and the western parts of the known geographical range of

the race. The general tint of the Chiriqui female very closely matches that of the female specimen of *griseus* from Mazatlan referred to under that heading.

The following, given in English inches, are the only flesh measurements of *mearnsi* known to me:

	Head and body	Tail	Hind foot
Chiriqui, Panama..... young adult ♂	30.0	11.6	5.6
Chiriqui, Panama..... old ♀	30.8	12.0	6.0
Talamanca (type)..... adult ♀	30.8	11.2	6.5
Pena Blanca, Nicaragua..... adult ♀	32.4	14.4	6.4

Mearns gave some measurements of five presumably adult male skulls, three from the type locality, Talamanca, with the basilar length ranging from 134 mm. in the type to 127 mm., one from the Pacific coast of Costa Rica and one from the Isthmus of Darien with that dimension 124 mm., the average being about 127 mm., a length slightly surpassed by only three adult male ocelot skulls I have seen, namely, those of *brasiliensis* from Rio Grande do Sul, and *aequatorialis* from Marcapata, Peru, and Gualaquiza, Ecuador. But the skull of the type of *mearnsi* is the biggest ocelot skull recorded, the other two males from Talamanca having the basilar length 128 and 127 mm. It is singular that in all Mearns's male skulls of this race the postorbital exceeds the interorbital width by from 2 to 4 mm., their widths in the type being 33 and 29 mm., suggesting that, despite its size, it was not an old animal. The upper carnassial (P^4) in these skulls is from 16 to 17 mm., and the lower (M_1) from 12 to 13 mm. In 1910 Allen recorded the skull of a very old male from Rio Choco, Nicaragua, with a condylo-basal length of 137 and a basilar length of 126 mm., the latter measurement being about the average of Mearns's series; but in accordance with its age the postorbital area is narrower than the interorbital, their widths being 28.5 and 30 mm.; the length of P^4 is 15.5 mm. In 1919 he published admirable figures, natural size, of an adult male skull from Matagalpa in Nicaragua. This is smaller, the condylo-basal and basilar lengths being 132 and 120 mm. Since the postorbital and interorbital widths are 29 and 26 mm., it is clearly a younger skull; its P^4 is 17 mm. and C^1 10 mm.

The skull of the skin in the British Museum from Costa Rica is very old and with the condylo-basal and basilar lengths and zygomatic width of 136, 124, and 103 mm. agrees very closely with Allen's old male skull from Rio Choco; the postorbital and interorbital areas are narrower, 25 and 27 mm., and P^4 is 16 mm. Its prominent occipital crest makes the total length 149 mm., 13 mm. in excess

of the condylo-basal length, as against only 5 mm. in Allen's skull from Matagalpa. It differs noticeably from the latter in some other respects. The sagittal crest is higher, 4 mm. at the suture and 13 on the occiput, as against 2 and 7 mm.; the widths across the zygomata and postorbital processes are 103 and 63 as against 95 and 56 mm., all age characters; but the nasals are the same width in both at the frontal points, 7 mm., and the bullae are nearly the same, 27 by 18 as against 25 by 17 and 15. A further difference is in the shape of the upper profile of the muzzle, which in my skull is flat from the postorbital processes to the distal end of the nasals, whereas in the Matagalpa skull it is markedly convex owing to the expansion with air cells of the area near the hinder end of the nasals. The young undeveloped male skull in the British Museum from Chiriqui, Panama, has the upper facial profile nearly as in the skull from Matagalpa, but a little more curved; the temporal ridges are 10 mm. apart at the suture and 16 on the parietals behind. It would certainly have grown to be a larger skull seeing that its condylo-basal and basal lengths of 130 and 119 mm. are only 2 and 13 mm., respectively, shorter than in Allen's skull, whereas the total length of 141 mm. is 4 mm. longer; the zygomatic, postorbital, interorbital widths and across the postorbital processes are respectively 90, 33, 25, and 51 mm. as against 95, 29, 26, and 56 mm. in the Matagalpa skull—all age differences; P^4 and M_T are 17 and 13 mm. These three male skulls—the old from Costa Rica, the adult from Nicaragua, and the young from Chiriqui—are good illustrations of the changes ocelot skulls pass through with increase in age.

The old female skull from Chiriqui has the upper facial profile more strongly convex and the muzzle more steeply sloped than in the Matagalpa skull, owing to greater inflation with air-cells; the sagittal crest is restricted to the occiput, where it is 4.5 mm. high, the temporal ridges being very strong and 12.5 mm. apart at the suture. Mearns's two adult female skulls from Talamanca have basilar lengths of 117 and 112 mm. In the Chiriqui skull that dimension is 118 and the condylo-basal and total lengths are 129 and 136. In all the other dimensions recorded by Mearns it is a few mm. bigger. In Mearns's skulls P^4 is 15 and 15.5 mm. and in the Chiriqui skull 16; and M_T is 11, 12.2, and 11 mm. in the same three skulls, respectively.

***Leopardus pardalis pardalis* Linnaeus.**

Felis pardalis Linnaeus, Syst. Nat., ed. 10, 1, p. 42, 1758.

Felis ocelot Link, Beytr. Zool., 2, p. 90, 1795.¹

Felis ocelot No. 3, Hamilton Smith in Griffith's Anim. Kingd., Mamm., 2, p. 476, pl., 1827.

Felis ocelot γ (*ocelot* γ of Hamilton Smith) J. E. Gray in Griffith's Anim. Kingd., 5, p. 168, 1827.

Felis griffithii Fischer, Syn. Mamm., Addenda, p. 369, 1829.

Felis canescens Swainson, Anim. in Menag., p. 118, 1838.

Felis pardalis Mearns, Proc. U. S. Nat. Mus., 25, p. 244, 1902.

Felis pardalis pardalis J. A. Allen, Bull. Amer. Mus. Nat. Hist., 22, p. 221, 1906.

Felis buffoni and *mexicana* Brass, Aus der Reiche der Pelze, p. 412, 1911.

Leopardus pardalis pardalis J. A. Allen, Bull. Amer. Mus. Nat. Hist., 41, p. 345, 1919.

(?)*Felis pardalis nelsoni* Goldman, Journ. Mamm., 6, p. 122, 1925.

Type locality.—Mexico (Vera Cruz according to Allen). Type locality of *ocelot* Link, also based on Hernandez's "Catopardus," the same; of *ocelot* γ , *griffithii*, *canescens*, *buffoni* and *mexicana*, Mexico.

Distribution.—Vera Cruz, also apparently Guatemala, and along the southwestern coast of Mexico from Oaxaca to Colima.

Distinguished from *mearnsi* at least by its smaller skull, the average basal length of which in the male is about 122 mm., in the female 109 mm., as compared with about 128 and 118 mm. in *mearnsi*. In flesh measurements the male seems to be about the size of the female of *mearnsi*.

The published information about this race is meager and unsatisfactory. There are no specimens in the British Museum, apart perhaps from a skin, without skull, doubtfully assigned to it, from Duenas, Guatemala (O. Salvin. No. 1865.5.18.17). This skin is not a "gray" ocelot like the Mexican skins in the British Museum, the ground color above and in the centers of the rosettes and bands being darker and duskier, owing to dark speckling of the hair-tips, and showing a dull buffy-ochreous tint, the interspaces lower down on the flanks being whitish; the rosettes on the sides form for the most part long continuous bands, very few being isolated, with many contained small spots; the tail is blotched and striped to the end. The pattern generally is closer set, not so open, and more definitely

¹ I have followed Osgood (Journ. Mamm., 1, pp. 89-90, 1920) in citing *ocelot* Link, *ocelot* γ Gray, *griffithii* Fischer, and *canescens* Swainson as synonyms of *pardalis*, and Miller (North Amer. Recent Mamm., p. 156, 1924) in adding the two names proposed by Brass. Miller did not accept Osgood's allocation of *griffithii* to this race; but from the evidence supplied by Hamilton Smith's figure and description of the type I think Osgood's opinion was justified.

catenate than in my examples of *mearnsi* from Costa Rica and Panama and differs similarly from my examples of *griseus*, described below, from Sinaloa in western Mexico. The catenate pattern suggests its likeness to that of a skin from Oaxaca, assigned by Allen in 1906, without description, to *catenata* Hamilton Smith.

Mearns described *pardalis* as larger than his Texan ocelot *limitis* (= *albescens*) and with its color on the whole more intense, the general ground tint being pale grayish buff, dark "clay" between the rings. In 1919 Allen referred to *pardalis* as paler and smaller than *mearnsi*, which he described as a large dark form, although none of the British Museum specimens is a dark ocelot and Allen himself had recorded one from Nicaragua as "gray." In the same paper he briefly dismissed *pardalis* as the large, strongly colored ocelot of southeastern Mexico.

Goldman's alleged new race, *Felis pardalis nelsoni*, ranges from Oaxaca to Colima in western Mexico, the type locality being Manzanillo in Colima. It was diagnosed as similar to *pardalis*, the color averaging much the same, but distinguished by being smaller, the skull considerably smaller throughout and the teeth decidedly smaller. The color of the type of *nelsoni*, and inferentially of his specimen or specimens of *pardalis*, was said to vary from cinnamon buff to light pinkish buff, the former tint being richer on the head and neck, lighter on the back and within the rosettes.

The source of Goldman's information about *pardalis* is unstated, but the flesh measurements he gave of the type of *nelsoni*, an adult male, namely, head and body 31.2 inches (778 mm.) is a little greater, not less than that dimension in a presumably adult male of *pardalis* from Achotal, Vera Cruz, recorded by Allen as 30.4 inches (760 mm.). There is clearly nothing to choose between the two on that score.

The skull of the type of *nelsoni*, the only one measured, was said to have a total length of 144 mm. and a condylo-basal length of 141.5 mm. One of these measurements is clearly wrong. No adult male ocelot skull has such a small difference between those lengths, which is seldom less than 10 mm. and usually more. Since, moreover, the largest ocelot skulls I have measured are barely 140 mm. in condylo-basal length, I conclude that Goldman's figure of 141.5 mm. was a mistake, possibly for 131.5. The view that the total length of 144 mm. was probably correct is borne out by Allen's record of 145 mm. as the total length of the male skull he identified as "*catenata*," as mentioned above, from Oaxaca, where *nelsoni*, according to Goldman, is found. This skull from Oaxaca had a

basal length of 124 mm. involving a condylo-basal length of about 132 mm., the same as nearly as may be as the suggested length in the type of *nelsoni*; and incidentally the zygomatic widths of the two skulls, namely, 96 mm. in *nelsoni* and 98 in the other, are practically the same.

The largest recorded skull assigned to *pardalis* known to me is that of a male from Mirador, which, according to Mearns, had a basilar length of 122 mm., involving basal and condylo-basal lengths of about 125 and 133 mm., thus agreeing very closely with the skull from Oaxaca and the type of *nelsoni*; its zygomatic width was 91 mm., less than in the type of *nelsoni*, and its interorbital width of 25 mm. is the same. Hence, on the evidence known to me, Goldman's claim that the skull of *nelsoni* is considerably smaller in all its dimensions than that of *pardalis* is contradicted by the recorded facts.

As regards the teeth the alveolar length of P^4 in the type of *nelsoni* was given as just over 12 mm. The total length, i.e. of the crown, in Mearns's skull of *pardalis* from Mirador was just over 16.5 mm. The difference between the alveolar and crown lengths in this tooth in ocelots is not infrequently 3 mm. when the posterior cusp is prominent—a very variable feature. This would make the tooth in *nelsoni* 1.5 mm. shorter in the crown than in the *pardalis* from Mirador, a difference which may be purely individual as attested by two male skulls of *melanurus* from Rio Supinaam, the crown of P^4 being 16.5 mm. in one, 18.5 in the other. Goldman also said that the alveolar width of the upper incisors in the type of *nelsoni* was 13.5 mm., the same dimension in the Mirador skull being 17 mm., according to Mearns. This character is also individually variable. In the two skulls of *melanurus*, mentioned above, the incisive width is 14 mm. in one and just under 18 mm. in the other. This disposes of the last of the differences claimed by Goldman as distinguishing *nelsoni* from *pardalis*. The former may prove to be different, but the data supplied fail to show it.

Additional skulls identified as *pardalis* that have been measured are as follows: A male recorded by Allen from Achotal, Vera Cruz, was considerably smaller than Mearns's male from Mirador, its basal length being only 118 mm.; but its zygomatic width of 91.5 suggests that it was adult. In both its dimensions given this skull is smaller than the type of *nelsoni*, instead of larger, still further disproving Goldman's statement regarding *nelsoni*. The total length of the male skull from Achotal was said to be only 130 mm., an impossible figure for an adult male skull, if the basal length was correct. Probably 130 mm. was a mistake for 138 or 140.

Of female skulls, one from Tehuantepec measured by Mearns had a basilar length of 102 mm., implying basal and condylo-basal lengths of about 105 and 112 mm.; the zygomatic, postorbital, and interorbital widths were 87, 30, and 22 mm., respectively, the postorbital, as usual, being wider than in the male from Mirador; and P^4 and M_7 were respectively just over 15 and just under 12 mm. A female from Achotal, measured by Allen, was larger than the one from Tehuantepec. With a total length of 133 mm. it had a basal length of 113 as against the estimated 105 for Mearns's skull; its condylo-basal length was probably about 120 mm. and its zygomatic width was 86.

Leopardus pardalis griseus Gray.

*Leopardus griseus*¹ Gray, Ann. Mag. Nat. Hist., 10, p. 260, 1842; Proc. Zool. Soc. Lond., 1867, pp. 270, 403 (*Felis*); Cat. Carn., etc., p. 19, 1869 (*Felis*).

Felis pardalis albescens J. A. Allen, Bull. Amer. Mus. Nat. Hist., 22, p. 219, 1906 (in part, specimens from Sinaloa, perhaps not *albescens* Pucheran).

Leopardus pardalis griffithii J. A. Allen, Bull. Amer. Mus. Nat. Hist., 41, p. 345, 1919.

Felis pardalis sonoriensis Goldman, Journ. Mamm., 6, p. 123, 1925.

Type locality.—Central America. Type locality of *sonoriensis*, Camoa, Rio Mayo, Sonora.

Distribution.—Western coast of Mexico from Sinaloa northwards, formerly at all events, to Arizona.

Distinguished from *pardalis* and the alleged race *nelsoni* by its more uniformly gray tint on the average and by its smaller skull, the average basal length of which in the largest known males is about 111 mm. and in females about 100 mm., as compared with about 122 and 109 in *pardalis*.

The British Museum has three specimens I assign to this race, two from the state of Sinaloa and the type. The two from known localities so closely resemble the type in skins and skulls that there is no escape from calling them *griseus*; and since their localities are very nearly the same as those of the series that Allen in 1906 described from Sinaloa as *albescens*, it is practically certain that the latter are also *griseus*.

The type of *griseus*, an adult female (No. 1839.7.25.5) has gray ground color with a sandy wash on the head, nape, and back and in the centers of the rosettes and bands; the stripes on the

¹ The name *griseus* was set aside by Mearns and Allen as connoting an unidentifiable ocelot. Gray recorded it in 1842 from Central America. I can find no justification for his statement in 1867 that the type came from Guatemala.

nape are not solid but divided by a central paler streak and the spots on each side of the spinal stripe are mostly elongated, with pale centers, but do not fuse to form a stripe; on the sides the rosettes are large, thin-rimmed, and to a great extent irregularly arranged and separated, but lower down especially in front they fuse into wide thin-rimmed bands, with a few small spots in the central areas; the pale hue of the skin is mostly noticeably dominant over the pattern except on the distal third of the tail where the black stripes are broader. This skin, although in good condition, is a century old and was formerly exhibited as a mounted specimen. Hence it is certainly faded; when fresh it was probably very like the following in color. An adult female from Presidio, near Mazatlan in Sinaloa (Ferrer. No. 1882.10.26.9) has the ground color a little darker and richer than in the type of *griseus*, the sandy hue of the upper side and inside the rosettes and bands having a decidedly more buffy tone and that of the interspaces on the flanks a sandy wash, not so gray; the legs also, especially the fore pair, which are creamy buff, are a little brighter; the general style of the pattern is the same except that the small spots enclosed in the rosettes and bands are less numerous. The tail has more white at its distal end. This skin was collected in May. A very nearly adult male from Mazatlan (Simons. No. 1898.3.2.15), collected in December, appears strikingly different, being the grayest of all the Central American skins in the British Museum. The lateral interspaces are clear, whitish gray, and the head, nape, shoulders, back, and the centers of the pattern have only a faint, dull sandy wash; the pattern is similar to that of the female, but the black stands out more boldly against the paler ground color and the end of the tail is a good deal blacker, more as in the type of *griseus*. The difference of seven months between these two skins suggests that the difference in color may be seasonal.

Allen's description of a large series from Esquinapa, close to Mazatlan, completely bears out the individual variation in skins attested by my two from Mazatlan. He said that the ground color varies from pale fulvous gray to quite strong fulvous, not, however, approaching the rich bright fulvous tint of Vera Cruz specimens [*pardalis*]; the pattern, he adds, may be small and sparse, consisting mainly of half rings and spots, without any marked tendency to form lines, or be coarser and more prominent over the mid-dorsal area, where they may be arranged in interrupted black lines. The pattern of the two Mazatlan specimens and of the type of *griseus*, in the British Museum, is more uniform and evidently of the bolder style mentioned by Allen.

Of my three specimens no flesh measurements were taken; but Allen recorded those of thirteen males and two females from Sinaloa. The dimensions of the largest and smallest males, showing great variation in size if both were full grown and correctly sexed, and of the two females were approximately as follows in English inches:

	Head and body	Tail	Hind foot
♂.....	31.0	15.0	6.0
♂.....	24.4	13.0	5.5
♀.....	27.5	12.4	5.25
♀.....	27.0	13.0	5.25

The average length of the head and body in the thirteen male specimens was approximately 27.5 inches. Possibly some of them were not quite fully grown; but the average of the largest five was just over 29 inches and of the smallest eight, some at least of which were probably full sized, was 26 inches. On the available evidence there is clearly no marked difference in size between the two sexes. The largest males are about the same size as the type of *nelsoni* and as the male of *pardalis* from Achotal, Vera Cruz; but the males may prove to be smaller on the average than those of that race.

In the smaller of the two males of which the full measurements are quoted above, the tail is over half the length of the head and body. In three additional males the same holds good, the specimen with relatively longest tail measuring: head and body 26.4 inches, tail 14.8. From this extreme there is every gradation to a specimen which has relatively the shortest tail, the head and body being 29.8 and the tail 12.8.

The closeness of the likeness in shape and dimensions between the adult female skulls of the type *griseus* and of the example from Mazatlan is quite unusual even in skulls of the same sex, race, and locality. The skull of *griseus* is a little younger and has lost its basioccipital and the condyles. Its total length is 126 mm., as against 128 in the other; the sagittal crest, complete but low in both skulls, is lower at the occiput, 4 mm. as against 7.5, and the width across the postorbital processes is 53 instead of 59 mm., the last two being age-variations. The chief difference is that the nasals of *griseus* are narrow and pointed behind the frontal processes, expanded and rounded in the Mazatlan skull, although their width between those points is almost the same, 7 and 8 mm. In the following dimensions the two skulls are as nearly as may be identical: the zygomatic, cranial, postorbital, interorbital, and maxillary widths, which are 88, 50, 32, 26, and 32 mm., respectively; the

bullae, which are alike 23 by 16; and P^4 , C^1 , and M_T , which are 14, 7, and 10 mm. The few measurements given by Allen for four presumably adult female skulls show them to be smaller than the foregoing, their basal lengths being 102, 98, 97, 97 mm., giving an average of 98.5 mm. as against 114 mm. in my female skull from Mazatlan and 109 (estimated) in the type of *griseus*. The young adult male skull from Mazatlan is a trifle shorter than the adult female skull from the same place, its total and condylo-basal lengths being 127 and 117 mm. as against 128 and 121 mm. in the female, the occipital crest being relatively better developed; it is also mostly narrower, its zygomatic, postorbital, and interorbital widths being 84, 27, and 21 mm., but the maxillary width, 32 mm., is the same in the two; the bullae are smaller, 21 by 14 mm., but the teeth are larger, P^4 , C^1 , and M_T being respectively 15, 18, and 11 mm. Allen gave a few dimensions of fourteen presumably adult males from Esquinapa, in which the basal length varies from 118 to 97 mm.—a remarkable difference—the average in the fourteen being 106 mm. Probably some of them were not full-sized; but the average of that dimension in the largest seven is 111 mm., the same approximately as in my two skulls, male and female, from Mazatlan.

Goldman diagnosed *sonoriensis* as most closely allied to *nelsoni*, but averaging smaller, with the color somewhat paler, the pattern on the back more widely spaced and the neck stripes mostly narrower, the skull being shorter and more rounded, with the nasals narrower, but the teeth the same. There is nothing in the description of the color and pattern to distinguish this alleged race from *griseus*. The flesh measurements of the head and body of the two adult males were about 27.6 and 26.4 inches, the latter being those of the type. The larger of the two is the same size as the average of Allen's fourteen males from Sinaloa and the type is only a little smaller. There is clearly nothing in the external characters to justify the admission of *sonoriensis* as distinct. The skull of the type, the only one measured, had a condylo-basal length of 115.5 mm., the basal length being inferentially about 108 mm., the same as in three of Allen's Sinaloa series, smaller than in four of them but decidedly larger than in the remaining seven and exceeding the average of the fourteen. The total length, 125.8 mm., is about the same as in two of the Sinaloa males, greater than in five, less than in seven, and the zygomatic width is almost the same as in three, greater than in seven, less than in five. But these two dimensions, which often increase with age after the skull has reached its full

length, have little systematic value. The alveoli of the upper incisors and of P⁴ in the type of *sonoriensis*, 13.5 and 12 mm., respectively, are almost exactly the same as in the type of *griseus* and in the female from Mazatlan; but smaller than in the male from Mazatlan in which they are 14 and 14, respectively. That such a difference may be purely individual was shown in the description of *pardalis*.¹

Leopardus pardalis albescens Pucheran.

Felis albescens Pucheran in Geoffroy St. Hilaire, Voy. Venus, Zool., Mamm., p. 149, Atlas, pl. 8, 1855.

Felis pardalis Baird, Mamm. U. S. and Mexican Boundary, p. 8, pl. 13 (skull), 1859.

Felis limitis Mearns, Proc. Biol. Soc. Wash., 14, p. 145, 1901; Proc. U. S. Nat. Mus., 25, pp. 237 and 241-244, 1902.

Felis pardalis limitis Bailey, N. Amer. Fauna, 25, p. 66, 1905.

Felis pardalis albescens J. A. Allen, Bull. Amer. Mus. Nat. Hist., 22, p. 219, 1906 (at least in part, perhaps not the examples from Sinaloa).

Leopardus pardalis griffithii J. A. Allen, Bull. Amer. Mus. Nat. Hist., p. 345, 1919 (not *griffithii* Fischer, now referred to typical *pardalis*).

Type locality.—Arkansas. Type locality of *limitis*, Brownsville on the Rio Grande, South Texas.

Distribution.—From Arkansas (at least formerly) as far south as the Rio Grande, Texas, and the adjoining districts of eastern Mexico to Tamaulipas.

Of this race there is not sufficient material in the British Museum enabling me to contribute anything to establish its status, by showing how it may be distinguished from *griseus*. When Allen in 1906 identified his series of specimens from Sinaloa as *albescens* he gave as his reason his inability to distinguish them from specimens from Texas, Arizona, and Chihuahua. So far as I am aware his verdict has not been shown to be wrong. In Pucheran's figure of the type the head, nape, shoulders, back, tail, and central areas of the pattern are darkish sandy, the pattern on the sides consisting mostly of long, wide, narrow-rimmed bands, with contained small spots, and thrown into relief by the clear gray tint of the interspaces.

The name *limitis* was proposed by Mearns as a substitute for *albescens*, which he considered inadmissible. His specimens came

¹ Although Sinaloa separates the two geographical areas where *nelsoni* and *sonoriensis* are respectively found, Goldman did not refer in his descriptions of these two alleged races to Allen's account of his large series of specimens from Sinaloa, despite the stress Allen laid on the great individual variations in color, pattern, flesh measurements, and cranial dimensions shown by the ocelots of that district.

from various parts of Texas, the type being from Brownsville, and he wrote of it as the Rio Grande ocelot. His descriptions of the color and pattern are puzzling. In the first account the tint of the unenclosed areas above was said to be whitish drab gray, of the enclosed areas pale broccoli brown; but the pattern on the sides consisted of series of elongate, partially or completely enclosed spots or irregular bands of drab gray separated by grayish white areas. In his later diagnosis *limitis* was said to differ from *pardalis* by its grayer hue, its less intense pattern, and the absence of strong contrast between the ground color inside and outside the dark rings. In Pucheran's figure the contrast is noticeable. A specimen in the British Museum, represented by the skin and skull, which I assign to this provisionally admitted race, is labelled Coahuila (Mexican Museum. No. 1894.12.18.3).¹ The head, nape, shoulders, a narrow spinal area, and the centers of the rosettes and bands are dull tawny, this tint being sharply contrasted with the whitish gray interspaces extending up to the spinal area which is less extensively darkened than in Pucheran's type, although in other respects the two are much alike. The pattern of rosettes and bands is on a smaller scale than in my three specimens of *griseus* and is thrown into bolder relief by the pale interspaces; but the tawny tint of the pattern is nearly intermediate between those of the male and the female from Mazatlan, being less gray than in the male and less buffy or yellowish than in the female; but the three, as well as the type of *griseus*, very likely fall within the range of color and pattern variation described by Allen in his series from Sinaloa.

The flesh measurements in English inches given by Mearns of two of his specimens of *limitis*, his largest male and female, were as follows:

	Head and body	Tail	Hind foot
Brownsville (type)..... adult ♂	30	13.2	6.4
Tamaulipas..... adult ♀	26	12.0	5.8

These dimensions closely agree with those of Allen's skins of *griseus* from Sinaloa.

Baird published what appears to be on the whole an accurately drawn figure of an adult skull of a specimen from Matamoros, close

¹ The skin is labelled merely "Coahuila" on the original label received from the Mexican Museum; but the skull was marked "Orizaba, Coahuila" apparently by some official in the British Museum; and, for some reason that I cannot divine, Thomas registered the skin and skull as coming from Orizaba, Vera Cruz, which would bring the specimen within the geographical area of typical *pardalis*. But, since the skin and skull agree much better with the description of *albescens* (*limitis*) than with that of *pardalis*, I accept Coahuila, where *albescens* is likely enough to occur, as the locality.

to Brownsville, the type locality of *limitis*. Although unsexed, it looks like a male and has a complete sagittal crest. It is smaller than the type of *limitis*, its total and basilar lengths being 129 and 111 mm. as against 140 and 114 mm.; but the basilar length is the same as in the second largest male skull measured by Mearns—from Tamaulipas—and in all the other dimensions given by Mearns there is close agreement between the two. They are as follows, those of Baird's specimen being set in brackets: zygomatic width 90 (88); postorbital width 30 (31); interorbital width 24 (24); cranium 52 (51); bulla 23.5 by 15 (23 by 18); alveoli of cheek-teeth 36.5 (37);¹ P^4 15 (15); M_T 11 (11.5). The bullae are noticeably wider in Baird's specimen, but in a male from Fort Rodney, Texas, measured by Mearns, they are larger than in the Tamaulipas skull, namely, 26 by 18 mm. In this skull, the smallest definitely stated by Mearns to be male, the basilar length is only 107 mm., the average of that dimension in his three male skulls and in Baird's being 111 mm. The average basal length of these same skulls would have been 113 or 114 mm., two or three mm. longer than the average of Allen's longest seven male skulls of *griseus* from Sinaloa. But Baird's skull has its main length-measurements very nearly the same as in my female skull of *griseus* from Mazatlan, its total, condylo-basal, basal, and basilar lengths being 129, 122, 113, and 111 mm., as against 128, 121, 112, and 109 mm., and Mearns's largest female skull from Tamaulipas had its total and basilar lengths 126 and 108, very nearly the same as in the Mazatlan female. Another skull, supposed to be female, from Tehuantepec had a basilar length of 103 mm.; and in my young adult, supposedly female skull from Coahuila that dimension is estimated as 100, the total length being 119 mm. It has strong temporal ridges, 25 mm. apart at the suture. The facts stated supply no trustworthy data for setting aside J. A. Allen's opinion that the Texan and western Mexican ocelots are racially identical.

THE RACES OF THE MARGAY (*Leopardus wiedii*)

Tail over half, generally about two-thirds the length of the head and body and three or four times as long as the hind foot. Pattern consisting of longitudinal stripes on the head, nape, and back, on the sides of the body of rosettes with black or brown rims and centers darker than the ground color, which generally coalesce to

¹ The size of the teeth in Baird's skull are taken from his figure of the lower view of the skull. In the side view of the skull P^4 is 16.5 mm. long. Since it is set obliquely in the jaw it should have been represented as a little shorter, not longer than in the inferior view.

a greater or less extent to form longer or shorter bands. The hair on the nape is usually reversed from a whorl situated behind the shoulders, sometimes only partly reversed from two whorls, sometimes not reversed, the variations having apparently no systematic significance, since the reversal may be complete or entirely absent in specimens from the same locality. The principal characters of the skull are mentioned in the first part of this paper.

Leopardus wiedii wiedii Schinz.

Felis wiedii Schinz, Das Thierreich, 1, p. 235, 1821.

Felis macroura Wied, Beitr. Nat. Brasil., 2, p. 371, 1826; Schinz, Syn. Mamm., 1, p. 437, 1844; and of many subsequent authors mostly in its emended form *macrura*.

Felis wiedii Thomas, Ann. Mag. Nat. Hist., (7), 12, p. 234, 1903.

Margay tigrina wiedii J. A. Allen, Bull. Amer. Mus. Nat. Hist., 35, p. 223, 1916 (in part, specimen from Matto Grosso); idem, p. 350.

Felis wiedii Pocock, Ann. Mag. Nat. Hist., (8), 19, p. 131, fig. 10A, B, 1917; idem, 20, p. 46, 1917.

Leopardus wiedii Pocock, Ann. Mag. Nat. Hist., (8), 20, p. 345, 1917.

(?) *Margay wiedii wiedii* J. A. Allen, Bull. Amer. Mus. Nat. Hist., 41, p. 356, figs. of skull from Matto Grosso, 1919.

Type locality.—Espírito Santo, Brazil, as pointed out by Allen. Type locality of *macroura*, based on the same material, the same.

Distribution.—Southeastern Brazil, roughly, as at present known, between 20 and 30° S. Lat.; Paraguay; northeastern Argentina.

Coat soft and full, with an average length on the back and nape in eight skins of 22 and 14 mm., respectively. Color exceedingly variable individually, ranging from very pale sandy buff on the back and creamy or soiled white on the flanks to intensely rich ochreous on the back and bright buff on the flanks; front of legs like the flanks; upper side of tail mostly like the back; the whole of the under side, the inner sides of the legs and the lower side of the tail white. Pattern also individually variable, consisting on the sides of larger or smaller irregularly shaped rosettes with thick or thin, black or brown rims and correspondingly larger or smaller paler buffy or ochreous centers; on the tail the black stripes are about the same width as the pale interspaces.

In 1821 Schinz described the color as whitish fawn or reddish gray and later, when he adopted the name *macroura*, as grayish fawn or tawny, the first description indicating variation from a pale to a darker richer hue.

This variation is borne out by the skins in the British Museum from which the above-given description was taken. A male topotype from Engenheiro Reeve, Espirito Santo, altitude 400 to 600 meters (Robert. 1903.9.4.38), March, seems to resemble very closely in color Schinz's pale phase. It is a pallid, dull-tinted skin, the dorsal surface having a sandy buff wash, passing into creamy or soiled white on the sides; the pattern on the flanks consists of mostly isolated rosettes with thick black rims and small obscure buffy gray centers. The hairs on the back and nape are 20 and 16 mm., respectively. A female skin from Alumbary, São Paulo, altitude 500 to 600 meters (Robert. No. 1903.7.1.199), January, is an almost exact match of the last, but is exceptional in having the hairs only on the fore part of the nape reversed from a pair of whorls, one of which is situated farther forward than the other; the hairs on the back and nape are 20 and 14 mm., respectively.

A male skin from Rio Janeiro (No. 1876.12.8.1) is better-colored than the last two, the back and flanks being decidedly richer, yellower buff; the pattern, too, is very different, consisting on the flanks of isolated, elongated rosettes, with very narrow, dark brown rims and large, richer-tinted centers. A male from Roca Nova, Paraná, altitude 930 to 1,150 meters (Robert. No. 1901.7.3.9), October, is a darker, richer-colored skin than the one from Rio Janeiro, the dorsal ground color being ochreous and the flanks buff, the pattern of the flanks consisting of rosettes with thick black rims and almost rusty-ochreous centers. The hairs on the back and nape are 25 and 15 mm., respectively. A male from Joinville, Santa Catherina (Spetter. No. 1922.5.29.3) has the ochreous hue of the back a little brighter and richer than in the skin from Roca Nova and the flanks richer buff; but a female with the same history (No. 1922.5.29.4) is still brighter, an intense vivid ochreous on the back and brighter buff on the flanks, but the lateral pattern is rather different, consisting of spots less obviously rosette-like, the paler central hairs being more diffused and spreading on to the darker rims. This skin is abnormal in having all the hairs of the nape directed backwards. A young male from El Dorado, Misiones, in northeastern Argentina (Shipton. No. 1926.9.13.1), November, is also a very bright skin, closely matching the male from Joinville; the hairs on the back and on the nape are 27 and 18 mm., respectively. A female skin from Paraguay (Brandt. No. 1846.2.13.6) is a little darker and not so bright as the skin from Roca Nova, Paraná, and the rosettes have rather thinner rims; the hairs on the back and nape are 18 and 12 mm., respectively.

The flesh measurements in English inches of a few of the above-described skins are as follows:

		Head and body	Tail	Hind foot
Roca Nova, Paraná.....	adult ♂	23	13.8	4.4
Espirito Santo.....	young adult ♂	20	14.4	4.0
Alumbary, São Paulo.....	adult ♀	20	13.0	4.2

What may possibly prove to be a Brazilian race distinct from typical *wiedii* is represented by the type of *Leopardus tigrinoides* Gray (Cat. Carn., etc., Brit. Mus., p. 22, 1869) which was named without description, in 1843 (List Mamm. Brit. Mus., p. 42). It was purchased at Liverpool and is labelled Brazil (No. 1842.4.10.2). It is dull-tinted, buffy olivaceous gray, considerably darker than the pale phase exhibited in the skins from Espirito Santo and São Paulo, not nearly so yellow as the skin from Rio Janeiro, nor so bright as the one from Paraná, but only a little duller than the skin from Paraguay; the pattern on the flanks consists of large irregular rosettes, with thick dark brown rims and yellowish brown centers. The color almost exactly matches that of a skin from Chapada, Matto Grosso. There is unfortunately no skull available. This skin is referred to below, under the Bolivian race.

From the evidence of available skulls there seems to be no appreciable difference between those of the male and female. They are smaller on the average than those of the other South American races. The skull of the male from Roca Nova, Paraná, which is just adult, has the condylo-basal 87 mm.; in two adult males from Joinville, Santa Catharina, it is 87 and 84 mm., respectively; in an adult female from São Paulo it is 84 mm., and in three unsexed skulls, without skins, from Rio Grande do Sul (Ihering) it is 87, 88, and 89 mm., respectively. Its average length in eight adult skulls is 87 mm. The total length ranges from 89 to 94 mm., its average in eight skulls being 92 mm. The length of P⁴ ranges from 10 to 12 mm., its average in thirteen skulls being 10.5 mm.

***Leopardus wiedii boliviae* subsp. nov.**

Type from Buenavista, Santa Cruz, Bolivia. Altitude 300 meters. No. 1926.1.5.4 British Museum (Natural History). Adult male. Collected by José Steinbach.

Distribution.—Bolivia and perhaps Matto Grosso, Brazil.

Distinguished from typical *wiedii* by its larger size as indicated by the skull and head and body measurements and, on the rather unsatisfactory evidence of two specimens, by a shorter coat and a

difference in color and pattern, the pattern being finer and more lineate and neither of the skins matching any of the skins of *wiedii* in tint; similarly differing from *vogens* in these last two particulars, but less markedly in the size of the skulls, although noticeably bigger, on the scanty evidence, in bodily size; matching the Andean race *pirrensis* in dimensions, but not in color or pattern, there being on the average at least less dark pigment in the pelage, the tail, for example, having the pale and dark bands about equal in width. From the type locality the British Museum has two skins with the same history. The type, an adult male, has the coat short and sleek, 15 and 9 mm. on the back and nape; the color above is bright ochreous buff, brighter and lighter than the brightest and lightest of the typical race, there being only very faint fuscous speckling in the contour hairs; the pattern on the back and even on the shoulders consists of narrow, mostly streaky spots, on the left side of small, irregular, separated rosettes, with brownish ochreous centers, and on the right side of narrow sinuous black stripes with some grayish ochreous patches above and below them, unlike the normal bands resulting from the fusion of rosettes. The paratype, an adult female (No. 1926.1.12.5), collected at 450 meters altitude in August, from the same locality as the type, has the coat equally short but the color is very different, much darker and duller, buffy, almost olivaceous, gray above, creamy low down on the flanks; the dorsal pattern consists of narrow stripes, not so broken up as in the male, and on the flanks it is more normal, consisting of narrow, sometimes double, black-rimmed bands completely or incompletely surrounding gray brown areas.

The flesh measurements in English inches are as follows, those of the female being set in parentheses: head and body 31.2 (26); tail 20 (14.5); hind foot 4 (3.5); ear 1.8 (1.6). The male is actually a little longer than any skin of the species known to me, of which the flesh measurements have been recorded. Even the much smaller female is larger than the majority of other flesh-measured skins.¹

The skull of the male is noticeably larger than that of the female, having a total and condylo-basal length of 102 and 98 mm., respectively, those dimensions in the female being 98 and 93 mm. They are a little larger sex for sex than the skulls of *vogens* and considerably larger than those of typical *wiedii*, being about the same size as in the race *pirrensis*. The bulla in the male skull is much more inflated than in the female, the length and width in the male being

¹I have other evidence that Steinbach's measurements were exaggerated, possibly taken over the curves.

23 and 13 mm., in the female 19 and 11.5 mm. In both male and female P^4 is 11 mm.

I should have assigned to this race an unmeasured native skin, without skull, from Chapada, Matto Grosso (Robert, not registered by Thomas), on account of its being a very close match in its dull olivaceous buffy gray color with the female from Santa Cruz, Bolivia, although its pattern is on a somewhat larger scale, were it not that J. A. Allen (Bull. Amer. Mus. Nat. Hist., **35**, p. 580, 1916) recorded as *Margay tigrina wiedii* an old male from Urucum, Matto Grosso, which with the head and body 22.5 inches long and the condylo-basal length 88 mm., is much smaller than the male type of *boliviae*, smaller even in all its dimensions, except the braincase, which is about the same as the female of that race. As suggested above, these Matto Grosso specimens may represent a distinct race *tigrinoides*, intermediate perhaps between typical *wiedii* and *wiedii boliviae*.

Leopardus wiedii pardictis subsp. nov.

Type from San Laurencio, Pernambuco. Altitude 28 to 60 meters. No. 1903.10.1.20 British Museum (Natural History). Immature male. Collected by A. Robert.

Distribution.—Known only from the type specimen.

Distinguished from the other races of *wiedii* by its very pale color, paler than the palest examples of typical *wiedii* and of *vogens*, and by the pattern, consisting on the flanks of numerous, small rosettes of which at most a few are confluent to form short bands.

The hair on the nape is not reversed but is nearly erect, about 14 mm. long, and just in front of the shoulders forms a pair of radiating whorls; coat on the back, August, about 18 mm. The color of the midline of the back is pale, dull, grayish sandy, passing into grayish white on the flanks, pale buff on the shoulders, nape, and head, and clean white below; the forelegs are gray with a faint tinge of sandy, the hind legs nearly white; the tail is like the back in its basal half but the interspaces become white towards the end where they form very narrow bands between broad black stripes, the stripes and interspaces about equal in width on the fore part. The pattern of the body above consists mainly of black spots on the back, and a few short stripes on the shoulders, the stripes on the nape and head being normal but irregular on the nape owing to the untidiness of the hairs; the numerous rosettes on the flanks have black interrupted rims with dull, sandy buff centers and they

stand out boldly against the grayish white ground color. The flesh measurements in English inches are: head and body 17.8; tail 9.6; hind foot 4.2; ear 2.

The only external characters showing that this specimen belongs to the *wiedii* and not to the *tigrina* or *pardinoides* group of smaller American cats is the presence of the two whorls of hair on the nape, the pattern being more as in *pardinoides*. But the size of the skull, which has the milk teeth in place and none of the permanent set even erupting, proves conclusively its kinship with *wiedii*. The condylo-basal length is 84 mm., slightly larger than in the majority of adult skulls of the *tigrina-pardinoides* group and the width of the cranium is 45 mm., a little wider than in any of the latter. It is also larger in both these dimensions than the immature skull of the example of *wiedii salvinia* from Duenas, Guatemala, referred to below, in which they are respectively 79 and 42 mm., although this is an older skull with all the permanent teeth in place. The facts suggest that this skull of *pardictis* would have been large, when adult, at least as large as in *vigens*. P⁴, cut out of the maxilla, is 11 mm. long, about the average size for *wiedii*.

The pale color of this cat, recalling that of the small Somaliland leopard (*Panthera pardus nanopardus*), suggests a dry rocky habitat, resembling perhaps that of the related species described by Thomas as *Felis emiliae* from Ceara, just north of Pernambuco.

Leopardus wiedii vigens Thomas.

Felis wiedii vigens Thomas, Ann. Mag. Nat. Hist., (7), 14, p. 192, 1904.

Type locality.—Igarapè Assu, Para, Brazil. Adult male (Robert. No. 1904.7.4.43).

Distribution.—Valley of the lower Amazon from Para westward at least to the Yamunda River; British and French Guiana.

Resembling typical *wiedii* in its color phases, but distinguished on the evidence of a few specimens by its shorter coat, which in five skins averages 13 mm. and 8 mm. on the back and nape, respectively, and by its slightly larger skull, the condylo-basal length in four adult skulls, two males and two females, averaging 91 mm., 4 mm. longer than the average of the skulls of typical *wiedii*. Also, male skulls are bigger than female, the average of the two males being 94, of the two females 88 mm.

Several skins from the region of the lower Amazon and its tributaries agree in coloration with those from southeastern Brazil.

An adult male, the type of *vigens* Thomas (Robert. No. 1904.7.4. 43), is an almost exact match with the skin of *wiedii* from Paraná, collected six months earlier in the year. A female from the Zoological Gardens, Para (No. 1913.12.18.2), probably locally captured, agrees with the type of *vigens*. A male from Obidos (Hoffman. No. 1908.5.9.16) is vivid ochreous, as bright above as the female of typical *wiedii* from Joinville, Santa Catharina, but the flanks are a little paler buff and the pattern, partly on account of the short coat, is sharply defined, but the rosettes are also bold and well spaced and mainly black, with the pale centers very little in evidence. A male from Faro, Rio Yamunda, a little to the west of Obidos (Goeldi Mus., Para. No. 1913.12.18.1) very closely matches the pale topotype of *wiedii* from Espirito Santo, but the buff on the back is a trifle richer. A female from Bonasica on the Essequibo River, a tributary of the Amazon, in British Guiana (McConnell. No. 1903.5.23.4) is the same vivid ochreous as the skin from Obidos, but has the pattern different, consisting to a great extent on the flanks of elongated stripes with narrow black rims and dusky ochreous centers.

The flesh measurements in English inches of four of the above described specimens are as follows:

		Head and body	Tail	Hind foot
Obidos.....	adult ♂	23.2	17.4	...
Para.....	adult ♂ (type)	22.4	16.2	5.0
Rio Yamunda.....	young ♂	20+	16.2	4.5
(?)Para (Goeldi Mus.).....	adult ♀	20.0	15.6	...

For the validity of this race, to which he only admitted the type, Thomas relied on the unusual inflation of the bullae, 22 mm. long and 15 wide, the prominence of the occipital crest and the width across the mastoids, 45 mm., which exceeds the width of the rather narrow cranium, 42 mm. That the bulla has not the value he attached to it is shown by its great variation in size in the two skulls from Santa Cruz, Bolivia, described above (see p. 356), and in the two from Peon. The other peculiarities, with which is associated a low sagittal crest, about 10 mm. long, behind the point of junction of the posteriorly abruptly convergent temporal ridges, which are 25 mm. apart at the suture, are due to abnormal muscular molding and are, I consider, purely individual. That the skull is not old, as Thomas claimed, is shown by the open sutures of the upper cranial bones. The skull of the female, probably from Para and about the same age as the type, with a condylo-basal length of 87 mm., is normal in form, the bullae are 19 by 13 mm., the

mastoid width is 41 mm. and less than the cranial width, which is 45 mm. In the type, P^4 is 11 mm., in the female 10. The male skull from Obidos, almost certainly racially the same as the one from Para, is also normal in form, the bullae are 21 by 13 mm., the mastoid is 43, the cranial width 46. The occiput is incomplete, but since the length from the premaxillae to the hinder end of the bullae is 86 mm., the same as in the type of *vigens*, it may be inferred that the condylo-basal length would have been the same, namely, 94 mm. P^4 is 11.5 mm. The female skull from Bonasica, Essequibo River, is a little older than the one believed to be from Para, but agrees very closely with it in dimensions; it has P^4 11.5 mm. as in the male from Obidos. Evidence for the occurrence of this race in French Guiana is supplied by Allen's record in 1919 of a skull from Cayenne closely agreeing in measurements with the type of *vigens*, even in the large size of the bullae. The average length of P^4 in the four skulls I assign to this race is a fraction over 11 mm.

Leopardus wiedii pirrensis Goldman.

Felis pirrensis Goldman, Smiths. Misc. Coll., 63, No. 5, p. 4, 1914; idem, 69, p. 169, fig., 1920.

Margay tigrina wiedii J. A. Allen, Bull. Amer. Mus. Nat. Hist., 35, p. 223, 1916.

Margay glaucula nicaraguae J. A. Allen, Bull. Amer. Mus. Nat. Hist., 41, p. 357, 1919.

Felis (Margay) glaucula ludovici Lönnberg, Journ. Mamm., 6, p. 272, 1925.

Type locality.—Cana, eastern Panama, altitude 2,000 feet. Type locality of *nicaraguae*, Volcan de Chinandega, Nicaragua; of *ludovici*, Pichincha, Ecuador, 4,000 feet.

Distribution.—Nicaragua; Panama; Colombia; Ecuador; Peru.

Resembling *wiedii* and *vigens* in the individual variability of its color, but distinguished by the presence of more dark pigment in the pelage, the lightest-tinted specimens being not quite so pale and the darkest darker than in those two races; the coat varies individually in luxuriance, as in *wiedii*; but the most noticeable difference lies in the size of the skull which is on the average considerably larger than in *wiedii* and a little larger than in *vigens*.

The type of *pirrensis*, an adult female, was described as having the pelage rather long and soft, with the hairs on the nape not reversed; the color above was ochraceous tawny and laterally cinnamon buff to pinkish buff; the upper side was heavily spotted and lined with black, with rosettes on the flanks, and the tail had broad black rings and narrow interspaces. The flesh measurements

in English inches were: head and body 21; tail 17.5; hind foot 5.2. The total and condylo-basal lengths of the skull were 99.5 and 95.5 mm., respectively.

An adult female in the British Museum from Calcobevora, eastern Veragua, Panama (O. Salvin. No. 1867.8.31.2) differs from the type in having the nape hairs reversed and the coat short, 12 mm. on the back and 8 on the nape, but seems to agree in other respects. The dorsal coloring is deep ochreous tawny, passing into dull buff on the flanks and white below, with hair gray at the base; the rosettes on the sides are mostly coalesced into irregular bands with moderately wide, black rims and grayish brown ochreous centers, darker nearer the spine than below, and the black bands on the tail are dominant, wider than the pale interspaces, as in the type. The skull has the back missing, but its palatal length and its width dimensions and the length of P^4 agree closely with the corresponding dimensions of the type.

The type of *nicaraguae*, an adult male, was distinguished by Allen from *glauca*, the only other Central American cat of this kind admitted in 1919, by its tawny (fulvous) color and its larger size, the head and body measuring 30, the tail 20.5 inches, and the skull having the total and condylo-basal lengths 107 and 101 mm., respectively, a trifle longer than the largest skull in the British Museum assigned to *pirrensis*, namely, that of an adult female from Paramba, Ecuador. But Allen also referred to *nicaraguae*, and no doubt correctly, a much smaller, slightly paler adult female from Matagalpa, Nicaragua, in which the head and body were 23, the tail 15.5 inches, and the condylo-basal length of the skull 89 mm. Allen gave no information about the pattern of the tail of either of these specimens. They may prove to differ from the types of *pirrensis* and *ludovici* and from the other skins here identified as *pirrensis* in the narrow black stripes on that organ.

The British Museum has no specimens from Nicaragua, but I provisionally assign to the same form an adult male labelled Central America (No. 1842.11.39.2) which in its color and the size of the skull closely resembles the type of *nicaraguae*. The color is ochreous tawny on the back, pale buff on the flanks, the pattern on the sides consisting of large, mostly isolated rosettes, with dark brown rims¹ and rather paler brown centers. The skull has lost its occipital region, including the greater part of the bullae, but comparison

¹ These rims were probably originally black. The specimen was exhibited in the gallery and the pattern on the side that was exposed to the light is paler than on the other.

between it and the skull from Paramba shows that its condylo-basal length was about 97 mm., only 4 mm. shorter than that of the type of *nicaraguae*, although it is slightly larger in its cranial, postorbital, and interorbital widths and between tips of the postorbital processes.

The skin differs from typical *pirrensis* and the others I assign to that race in having the pale areas of the tail approximately as wide as the stripes. It possibly represents a form intermediate between *pirrensis* and *salvinia*.

The type of *ludovici*¹ was described as having the coat sleek and short, 14 mm. on the back and 7 on the nape, the color dull, grayish buff, the pattern sharply defined and consisting on the flanks of "ocelot" bands, the tail being black all along the upper side, with the pale interspaces reduced to lateral spots narrower than the black stripe. The tail pattern is an exaggeration of the condition described in *pirrensis*. The skull, with a total length of at least 104 mm., is large, a little larger than the female type of *pirrensis* and a little shorter than that of *nicaraguae*.

The evidence for the extension of *pirrensis* southwards from Panama to Peru is attested by the almost precise resemblance in color between the skin from Veragua and skins from Sarayacu, Ecuador, and Pozuzo and Chanchamayo, Peru; and also by the close agreement between the two known female skulls of *pirrensis* from Panama and some of the skulls from the more southern countries; the condylo-basal length, for instance, of an adult female skull from Sarayacu, Ecuador, is 95 mm. and of a male skull from Pozuzo, Peru, 96 mm., both to all intents and purposes the same as in the type of *pirrensis*; and since the mandible of the skull from Veragua is only 2 mm. shorter than those of the same two skulls, it may be inferred that its condylo-basal length would have been correspondingly shorter by about that amount only.

The British Museum has the following skins from Ecuador: A male topotype of *ludovici* from near Mindo on the west of Pichincha, altitude 5,000 feet (Söderström. No. 1934.9.10.70), October, has the color dull and pale, very like the skins of typical *wiedii* from Espirito Santo and the skin from Faro in the Amazon Valley, but has the buff on the back a little brighter and a more perceptible tinge of buff on the flanks; the pattern is bold and well spaced, consisting of solid black blotches and lines with scarcely a trace of

¹ Lönnberg had but one specimen, and from his account it is quite clear that he had no material of the species to show the extreme variability of the color and pattern within subspecific limits, as in typical *wiedii*, for example. He admitted, however, his doubts about the distinctness of *ludovici* from *nicaraguae*.

paler centers; on the tail the pale areas form complete rings. The general color seems to be like that of the type of *ludovici*, but the lateral rosettes appear to be more solidly black and the pale interspaces on the tail are not reduced to lateral patches. These are no doubt merely individual differences.

Two skins from Andoas (Buckley) are widely different in color. One (No. 1880.5.6.31) has the coat 22 and 15 mm. on the back and nape and the pale color closely matching that of the topotype from Pichincha, but the pattern is very different, consisting of shorter or longer bands, with black rims and large ochreous brown centers. The other (No. 1880.5.6.32), an immature specimen, has the coat nearly the same length but the color is bright ochreous, about as vivid as in the brighter of the two skins of typical *wiedii* from Santa Catharina; the pattern also is quite different from that of the first from Andoas and more like that of the skin from Pichincha, in consisting of nearly solid black rosettes with small faint brown centers.

A female skin from Sarayacu, 1° 40' S. Lat., 77° 20' W. Long. (Buckley. No. 1880.5.6.29), with the coat very short, 10 and 7 mm. on the back and nape, is much darker than any of the above described, and than any of the Amazonian or southeastern Brazilian skins, the tint being brownish ochreous on the back; the pattern consists of large black-rimmed rosettes, with ochreous brown centers, larger and not so confluent in lines as in the first described specimen from Andoas. A second skin (No. 1880.5.6.30), a male with the same history, is still darker, browner ochreous and the pattern is similar but the rosettes are more coalescent in lines. A male skin from Gualaquiza, altitude 2,500 meters, 3° 21' S. Lat., 78° 27' W. Long. (Hammond. No. 1914.4.25.46), December, has the coat 23 and 16 mm. on the back and nape, is rich ochreous above, almost as vivid as the bright skin from Santa Catharina and the one from Andoas; the rosettes have rather narrow black rims and large brownish ochreous centers.

A female skin from Paramba, northern Ecuador (Miketta. No. 1901.1.6.2), February, has the coat very short, 14 and 6 mm. on the back and nape, and the color dark ochreous, nearly as dark as the Sarayacu skins, and the rosettes on the sides are mostly coalescent, forming black-edged stripes with ochreous brown centers.

Two skins from Peru are inseparable from the Ecuador series. An adult male from Pozuzo, altitude 800 meters (L. Egg. No. 1908.6.17.9), February, has the coat short and sleek on the back and

nape and the color dark brownish ochreous, closely resembling the two skins from Sarayacu, Ecuador; the lateral pattern consists mostly of confluent rosettes, forming longer or shorter bands with black rims and brownish ochreous centers. An adult female from Chanchamayo, altitude 1,200 meters (C. O. Schunke. No. 1905. 11.2.5), August, also has the coat short and sleek, 17 and 10 mm. on the back and nape, but the color is a little lighter and brighter than in the skin from Pozuzo and the pattern consists of large, isolated, irregular rosettes with blackish brown rims and ochreous brown centers.

Three skins from Colombia are as variable as those from Ecuador, and two at least are obviously inseparable from them. A young female from Mariquita, altitude 2,000 feet (H. H. Crease. No. 1912.4.2.2), is exceptional in having the nape hairs not reversed, but on the center of the occiput there is a whorl where the hairs turn forward for a short way on the crown. The coat is longish, 20 and 14 mm. on the back and nape; the color is pale, very closely matching the skin of the topotype of *ludovici* from Pichincha, but a little brighter buff on the back; the pattern is bold, the rosettes having black rims and ochreous brown centers, but they vary on the two sides in the degree of confluence into bands. An undated, unsexed skin, from Condoto, Choco (Spurrell. No. 1914.5.28.9), has the coat very short, 12 and 7 mm. on the back and nape; the color is rich darkish ochreous, almost exactly matching the skin from Paramba, Ecuador; the pattern also is very like, but the centers of the rosettes or bands are on the whole darker brown and therefore not so conspicuous. The color is a little brighter than in the Sarayacu, Ecuador, skins and a shade darker ochreous than the skin from Obidos. The third Colombian skin from Itoco, near Bogotá (G. D. Child. No. 1895.8.1.9), has the coat 15 and 7 mm. on the back and nape and the color paler, yellower ochreous than the one from Condoto, Choco, but the pattern is unusually well developed, the inner nape-stripes being about 25 mm. wide and indistinctly doubled by some median, brown hairs; the rosettes on the sides are exceptionally large, to a varying extent coalescent into bands, and have black rims and extensive ochreous brown central areas. No other skin in the British Museum has the pattern so massive, but no doubt the feature is merely an individual variation of no systematic importance.

The only available flesh measurements in English inches known to me are as follows:

		Head and body	Tail	Hind foot
Nicaragua (type of <i>nicaraguae</i>).....	adult ♂	30.0	20.4	4.6
Florencia, Colombia (Allen).....	adult ♂	24.4	16.8	4.8
Gualaquiza, Ecuador.....	young ♂	21.6	14.4	4.6
Pozuzo, Peru.....	adult ♂	22.0	15.4	...
Paramba, Ecuador.....	adult ♀	24.4	16.2	5.2
Panama (type of <i>pirrensis</i>).....	adult ♀	21.0	17.6	5.2
Andalucia, Colombia (Allen).....	adult(?) ♂	20.0	12.0	4.0

The great superiority in size of the type of *nicaraguae*, as recorded by Allen, lays the accuracy of its dimensions under suspicion. The length of the head and body and tail are not in keeping with that of the hind foot; and since the condylo-base of the skull is only 1 mm. longer than that of the female Paramba specimen, it is not likely that the head and body were nearly six inches longer. The length of the tail in Allen's skin from Andalucia is also perhaps wrong.

The largest skull in the British Museum assigned to this race is that of the adult female from Paramba, northern Ecuador, in which the condylo-base is 100 mm., 4.5 mm. longer than in the female type of *pirrensis*, 1 mm. shorter than in the type of *nicaraguae*, and its total length, 105 mm., is the same as in the male type of *ludovici*. But an adult female from Sarayacu, Ecuador, has the total and condylo-basal lengths 99 and 95 mm., respectively, the same as in the type of *pirrensis*. The only other adult female skull, one from Chanchamayo, Peru, is exceptionally small, having the total and condylo-basal lengths 89 and 83 mm. Provisionally, however, I regard this as belonging to *pirrensis* because the skin in color and pattern, except for having the feet grayer and less tawny, is indistinguishable from that of an adult male from Pozuzo, Peru, in which the skull has the total and condylo-basal lengths 100 and 96 mm., respectively, almost exactly the same as in the female type of *pirrensis*, in the female from Sarayacu, and in an adult male from Florencia, Colombia, recorded by Allen, but a few mm. shorter than a young adult male from Condoto, Choco, Colombia, in which the total and condylo-basal lengths are 103 and 100 mm., respectively. In a younger male from Andoas, Ecuador, the lengths are 96 and 94 mm.

When the cats of this species, ranging from Nicaragua to Peru, are better known it may prove that I have included under *pirrensis* more than one subspecies. But the material of adult skulls is at present quite inadequate to settle the point. At all events it seems clear that there is no evidence that the types of *nicaraguae*, *pirrensis*, and *ludovici* represent distinct subspecies.

Leopardus wiedii salvinia subsp. nov.

Type from Vera Paz, Guatemala. No. 1875.2.27.1 British Museum (Natural History). Adult male, skin and skull. Collected by O. Salvin.

Distribution.—Guatemala and perhaps British Honduras.

Intermediate between *nicaraguae* and the western Mexican race *glaucula*, resembling the former very closely in color, but with a much smaller skull, about the same size as in *glaucula*.

The type has the coat 16 mm. long on the back, 9 mm. on the nape. The color of the back is pale ochreous tawny, matching almost exactly that of the specimen from Central America assigned to *nicaraguae*; the flanks are buff and the pattern on the sides consists mostly of isolated, irregular rosettes with narrowish dark brown rims and dull ochreous centers, very much as in that specimen, but the rosettes are smaller and the centers paler and the black markings on the tail are not dominant over the pale interspaces. The skin of a young specimen from Duenas, Guatemala (O. Salvin. No. 1865.8.18.1), has the coat 25 and 14 mm. on the back and nape and the color paler, the back being paler ochreous with this tint restricted to a comparatively narrow spinal area, but becoming brighter and more extensive on the nape; the upper and lower flanks are whitish, throwing into bold relief the pattern of the rosettes, which have black rims, ochreous centers and are more or less confluent in bands. Considering the difference between this specimen and the type in the length of the coat, it is possible that the difference in tint is seasonal, but neither skin is dated and no flesh measurements were taken.

The skull of the type, judging from its upper sutures, is fully adult. It has lost its lower occipital area, but its total length is 95 mm. and I infer from comparison with other skulls that its condylo-basal length was 88 or 89 mm., both this dimension and the total length being 12 mm. less than in the type of *nicaraguae*. Its width dimensions are also mostly less; but the cranium is unusually broad, nearly equaling half the length, namely, 46 mm.¹ as against 43 in the type of *nicaraguae*. The teeth too are evidently smaller, P⁴ being 11 mm. as against 12.5 in the type of *nicaraguae* and 12 in the example identified above as that race. The skull of the skin from Duenas is too young to be worth measuring, but P⁴ is 11 mm. as in the type of *salvinia*, and in both M¹ is 7.5 mm.

¹ This measurement is 1.5 mm. less than in Allen's female of *nicaraguae* from Matagalpa, which also has the condylo-basal length 89 mm. But no error has been made over the sex of the type of *salvinia*.

Two skulls, without skins, from Belize, British Honduras, both received from the Zoological Society's Museum and marked "menagerie," probably belong to this race. One of them, entered as male (D. Dyson. No. 1858.5.4.71), has the condylo-basal length 91 mm., a little larger than in the type of *salvinia*, but the rest of the measurements are in close agreement except that the cranium is narrower, 43 mm., but the temporal area is much wider, 30 mm. as against 21. The teeth are the same size. The second skull, no doubt male (No. 1858.5.4.70), is longer and mostly narrower than the other, its condylo-base being 96 mm. and the cranium 41, with the temporal area 21. Most noticeable is the difference in the width of the posterior half of the nasals, which between the frontal points is 5 mm. in this skull, as in the type of *salvinia*, but only 2.5 mm. in Dyson's Belize skull.

Leopardus wiedii glaucula Thomas.

Felis glaucula Thomas, Ann. Mag. Nat. Hist., (7), 12, p. 235, 1903.¹

Felis glaucula glaucula Nelson and Goldman, Journ. Mamm., 12, p. 303, 1931.

Felis glaucula oaxacensis Nelson and Goldman, Journ. Mamm., 12, p. 303, 1931.

Type locality.—Beltran, Jalisco. Type locality of *oaxacensis*, Cerro San Felipe, altitude 10,000 feet, Oaxaca.

Distribution.—Southwestern Mexico from Sinaloa to Oaxaca.

The type of *glaucula*, an adult male (W. Lloyd. No. 1890.1.4.1), April, is dusky gray above on the back and paler gray on the upper flanks, passing into cream below towards the belly and there is just a faint buffy cast on the head and nape; the pattern consists of large rosettes mainly coalesced into irregular bands with narrow black rims and dusky gray centers. An adult male from Tatemaes, Sinaloa (Simons. No. 1898.3.2.16), May, is a little paler clearer gray above than the type and has white flanks; the pattern differs in the rosettes being less confluent, with thicker black rims and consequently much smaller darkish gray centers. Since this skin differs much less from the type of *glaucula* than individual skins of the South American races differ from each other, I follow Thomas in adopting that name for it. The same applies to a third skin, probably female, labelled "Mexico" (Bullock's Museum. No. 1842.4.10.2), which is not so gray as the type, having a faint buff cast over the dorsal surface and in the centers of the rosettes, which have thick, blackish brown rims, coalescent into bands or isolated.

¹ It is not quite clear why Thomas gave specific rank to this cat, nor why Allen, Lönnberg, and Nelson and Goldman followed him in that respect. It differs from South American forms only in trivial characters.

The type and only known example of *oaxacensis*, an adult male, was described as representing a small subspecies related to typical *glaucula* and similar in color, but larger, with quite different pattern, said to be "beautifully marbled" and with distinctive skull characters. The specimens in the British Museum fail to substantiate the validity of *oaxacensis*. "Marbled" is an apt epithet for the pattern of the type of *glaucula* and the "distinctive" cranial characters, namely, the nasals being narrower behind, the mesopterygoid fossa broader and the bullae smaller are individual variations without systematic significance. As regards size, the type of *glaucula* was not measured in the flesh; but the male from Sinaloa, as the following dimensions show, was so much larger than the male type of *oaxacensis* that it is permissible to suspect a mistake in the case of the former, the head and body being entered as 659 mm. (=26.5 inches). Assuming that 659 was an error for 559, the dimensions in English inches are as follows:

		Head and body	Tail	Hind foot
Sinaloa.....	adult ♂	22.4	13.33	4.4
Oaxaca.....	adult ♂	21.6	14.75	5.2

The suggested measurement of the head and body of the specimen from Sinaloa is much more in keeping with the length of the tail and hind foot than 26.5 inches.

The superiority in size indicated by the latter dimension, moreover, is not borne out by the skulls, which have practically the same condylo-basal length, namely, 90 mm. in the male from Sinaloa and 89.7 in the male from Oaxaca, the same dimension in the female type of *glaucula* being 88, just over 1.5 mm. shorter than in *oaxacensis*, a difference clearly of no systematic significance, especially in view of the sexes of the skulls. In the other cranial dimensions of the type of *oaxacensis* given by Nelson and Goldman I can find nothing supporting their claim that they are of systematic moment.

***Leopardus wiedii yucatanica* Nelson and Goldman.**

Felis glaucula yucatanica Nelson and Goldman, Journ. Mamm., 12, p. 304, 1931.

Type locality.—Merida, northern Yucatan.

Distribution.—Yucatan and Chiapas, Mexico.

Very closely allied to *glaucula* but apparently distinguishable by a difference in tint and a shorter skull.

The type of this race, a skin with no skull, was described as distinguished by its very pale buffy grayish ground color, decidedly

paler than in *oaxacensis*, with less dusky admixture especially along the median dorsal line. A skin from Chiapas was declared to be similar. The skin of an adult female in the British Museum from northern Yucatan (G. F. Gaumer. No. 1894.2.5.12) has the ground color tolerably similar to the type of *glaucula*, but the back is duller, without the "pepper and salt" speckle of that skin and the flanks are whiter; the pattern also is tolerably similar but the edges of the rosettes or bands are brown instead of black. It might be described as a faded edition of typical *glaucula*.

The skull of Nelson and Goldman's specimen, a young adult female from Chiapas, has a condylo-basal length of 84 mm., a zygomatic width of 55 mm., and a cranial width of 44. The female skull in the British Museum is much older and consequently has much wider zygomata, with a span of 62 mm. In other respects its dimensions agree very closely with those of the Chiapas skull, the cranium being 45 mm. wide and the estimated condylo-basal length 83 mm.¹ It is a short, wide skull compared with that of the adult female type of *glaucula*. Although 5 mm. shorter, the actual length from the premaxilla to the hinder end of the bulla being 76 and 81 mm. in the two, the zygomatic width is the same, and the cranial width 45 as against 42 mm. The teeth are smaller than in the female from Chiapas, P⁴ being 10.5 and the alveolar length of the upper cheek-teeth 25 mm., as against 11.8 and 26.7 mm. in the Chiapas skull, the difference being probably due in part to wear with age.

¹ The occiput is missing, but since the skull is complete to the hinder end of the bulla, the estimated length cannot be very far wrong.

DESCRIPTIONS AND RECORDS OF NEOTROPICAL BATS

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The bats recorded below are from various collections that have come to Field Museum during the past five years. Two of these collections were made by Mr. Ivan T. Sanderson. The first was turned over to us for study by the British Museum (Natural History) and contained material from Dutch Guiana, Haiti, Jamaica, and Trinidad, many of the Trinidad specimens having been collected by the Medical Department of Trinidad. The second was made in Haiti, Jamaica, British Honduras, and Yucatan, and is now on deposit in Field Museum. Specimens from these collections are followed by the initials I.T.S.

The Colombian records represent material sent for identification by Brother Niceforo Maria of the Instituto de La Salle at Bogotá, Colombia, and specimens in his collection are marked N.M. Two records from British Honduras are based on material in the Carnegie Museum, Pittsburgh, Pennsylvania. My thanks are due to these institutions and individuals. The following species are mentioned:

<i>Amorphochilus schnablii</i> Peters	<i>Lonchophylla mordax</i> Thomas
<i>Brachyphylla pumila</i> Miller	<i>Lonchophylla robusta</i> Miller
<i>Centronycteris maximiliani centralis</i>	<i>Micronycteris schmidtorum</i> Sanborn
Thomas	<i>Mimon bennettii</i> Gray
<i>Chiroderma salvini</i> Dobson	<i>Molossops temminckii griseiventer</i> subsp.
<i>Cormura brevirostris</i> Wagner	nov.
<i>Cynomops planirostris paranus</i> Thomas	<i>Myotis nigricans nicholsoni</i> subsp. nov.
<i>Didelidurus virgo</i> Thomas	<i>Natalus major</i> Miller
<i>Eptesicus hispaniolae</i> Miller	<i>Natalus stramineus</i> Gray
<i>Eptesicus melanopterus</i> Jentink	<i>Phyllops haitiensis</i> J. A. Allen
<i>Furipterus horrens</i> Cuvier	<i>Sphaeronycteris toxophyllum</i> Peters
<i>Glossophaga longirostris longirostris</i>	<i>Tadarida similis</i> sp. nov.
Miller	<i>Thyroptera tricolor albigula</i> G. M. Allen
<i>Histiotus macrotus</i> Poeppig	<i>Tonatia amblyotis</i> Wagner
<i>Leptonycteris nivalis</i> Saussure	<i>Tonatia venezuelae</i> Robinson and Lyon
<i>Lionycteris spurrelli</i> Thomas	<i>Trachops coffini</i> Goldman
<i>Lonchoglossa caudifera aequatoris</i> Lönn-	<i>Vampyrodes caraccioli</i> Thomas
berg	<i>Vampyrops fumosus</i> Miller
<i>Lonchoglossa caudifera caudifera</i>	<i>Vampyrus spectrum</i> Linnaeus
Geoffroy	

***Cormura brevirostris* Wagner.**

Emballonura brevirostris Wagner, Wiegmann's Arch. Naturg., 9, pt. 1, p. 367,
1843—Marabitanas, Amazonas, Brazil.

Dutch Guiana: Camp One on Coppename River above Kaaimanston, 2 males, 2 females, July 2, 8, 1938 (I.T.S.).

This is the first time this genus has been recorded from Dutch Guiana. The type of *Myropteryx* (*pullus* Miller) came from Dutch Guiana but these specimens do not agree with the characters given for that genus. In fact, they seem to provide further evidence that *Myropteryx* is probably synonymous with *Cormura*.

Measurements.—Forearm, males 46.3–46.5, females 48–48.

Collector's notes.—"Sleeping in hollow fallen tree," and "sleeping in light under eave (projecting end) of fallen tree."

***Centronycteris maximiliani centralis* Thomas.**

Centronycteris centralis Thomas, Ann. Mag. Nat. Hist., (8), 10, p. 638, 1912—Bogava, Chiriquí, Panama.

British Honduras: Double Falls, 1 female, December, 1939 (I.T.S.). "Bole of tree in daylight."

This extends the range of this rare bat northward from Guatemala to British Honduras. The forearm measures 45.2 mm.

***Diclidurus virgo* Thomas.**

Diclidurus virgo Thomas, Ann. Mag. Nat. Hist., (7), 11, p. 377, 1903—Escazu, Costa Rica.

Honduras: Three miles north of Gracias on Rio Grande, 1 male (alc.), December 22, 1937, P. O. McGrew (F.M.).

This is the first record for Honduras of this rare bat, known previously from Guatemala, Costa Rica, and Panama. The forearm measures 64 mm.

***Micronycteris schmidtorum* Sanborn.**

Micronycteris schmidtorum Sanborn, Field Mus. Nat. Hist., Zool. Ser., 20, p. 81, 1935—Bobos, Izabal, Guatemala.

Honduras: Copan, 1 male (alc.), March, 1938, Margaret Ennis (F.M.).

Slightly smaller than the type and topotype from Guatemala, heretofore the only known specimens.

***Tonatia amblyotis* Wagner.**

Phyllostoma amblyotis (Natt., MS.) Wagner, Arch. Naturg., p. 365, 1843—Matto Grosso, Brazil.

British Honduras: Freetown, Sittee River, 1 male, May 15, 1935, Blake and Agostini, Carnegie Mus. No. 10578.

No topotypes of this species are available. Four specimens from Santa Cruz and Sara, Bolivia (recorded as *Chrotopterus auritus* by Sanborn, Ann. Carnegie Mus., **21**, p. 175, 1932) have forearms measuring 54.5–55.7; the total length of the skulls is 26.5–27.5.

One female from Tingo Maria, Huánuco, Peru, measures: forearm 54.3, total length of skull 27.8. In a series from Ecuador the maximum and minimum measurements are: forearm 51.9–54; total length of skulls is 26.8–27.2.

The species occurs in Panama, but no Panamanian specimens have been examined. The specimen from British Honduras measures: forearm 50.2, total length of skull 25.7. This is small for the species but only slightly smaller than the minimum for the series examined. Many South American species tend to become smaller in the Central American part of their range.

Tonatia venezuelae Robinson and Lyon.

Lophostoma venezuelae Robinson and Lyon, Proc. U. S. Nat. Mus., **24**, p. 154—Macuto, Venezuela.

Trinidad: Aripo, 1 juv., August 24, 1937 (I.T.S.).

This is the first record of this species since the description of the type. It is unfortunate that the specimen is juvenile. The outer upper incisors and the middle lower premolars are still below the gums but can be seen to be present. The forearm measures 34.2, while in the adults of the type series it is 38–40.

Collector's notes.—"Home among cacao."

Mimon bennettii Gray.

Phyllostoma bennettii Gray, Mag. Zool. Bot., **2**, p. 488, 1838—South America.

Mexico: Buenavista, Yucatan, 1 male, March, 1898, G. F. Gaumer (F.M.); Tekom, Yucatan, 1 male (alc.), 1 female (alc.), April 15, 28, 1940 (I.T.S.).

There are few recent records of this rare bat, known from Ypanema, São Paulo, Brazil, and from El Hacha, Venezuela. A related species, *M. cozumelae*, occurs on Cozumel Island off the coast of Yucatan. The specimen from Buenavista is figured in Elliot's "Mammals of Middle America and the West Indies," pt. 2, p. 657, 1904, as "*Chrotopterus auritus*."

The external measurements for the two specimens in alcohol are: forearm 55.5–56.8; third finger metacarpal 48.1–50, first phalanx 19.6–19.9, second phalanx 26.3–27.9, third phalanx 12.6–13.2; fourth finger metacarpal 45.9–48.3, first phalanx 15.8–16.8, second phalanx

16.8–18.8; fifth finger metacarpal 50.6–52.2, first phalanx 15.6–15.9, second phalanx 15.2–16.7. Ear from meatus 34.6–35.7. Height of noseleaf 18.4. Tail 21.5–22.8; tibia 23–24.9; foot 14.5–14.6.

Trachops coffini Goldman.

Trachops coffini Goldman, Proc. Biol. Soc. Wash., 38, p. 23, 1925—Guayo, Peten, Guatemala.

British Honduras: Belize, 2 females (1 alc., 1 skull only), October 7, 1939 (I.T.S.).

This is the first record of this bat from British Honduras, and the first time it has been recorded since the original description. The measurements of these specimens are so near those of the type that they do not need to be given.

Vampyrus spectrum Linnaeus.

Vespertilio spectrum Linnaeus, Syst. Nat., ed. 12, p. 46, 1766.

Trinidad: Port of Spain, 1 female, March 10, 1937, 1 skull only, April 7, 1937 (I.T.S.).

Among the many references to this bat, there are no adequate measurements of the wings or the skull.

Measurements.—Forearm 113.3; third finger metacarpal 80.5, first phalanx 45.9, second phalanx 51.5, third phalanx 33.6, tip 9.7; second finger metacarpal 88.2, first phalanx 37, second phalanx 38.6; fifth finger metacarpal 97.3, first phalanx 35.6, second phalanx 35.6. Ear 44. Foot 30.7; tibia 60.5. Skull: greatest length 52.8; condylo-basal length 43.9, interorbital width 7.5, zygomatic width 24, mastoid width 21.5, width of braincase 15.5, upper tooththrow 20.8, width across canines 9.5, across last molars 14.7.

Collector's notes.—"Palm tree;" "among high trees."

Glossophaga longirostris longirostris Miller.

Glossophaga longirostris Miller, Proc. Acad. Nat. Sci. Phila., p. 330, 1898—near Santa Marta, Colombia.

Patos Island: In channel west of Trinidad, 1 male (alc.), 1 female (alc.), 1916, Trinidad Medical Department (F.M.).

This is a further extension of range of this species. The specimens agree with others from western Venezuela.

Lonchophylla mordax Thomas.

Lonchophylla mordax Thomas, Ann. Mag. Nat. Hist., (7), 12, p. 459, 1903—Lamarao, northwest of Bahia, Brazil.

Brazil: Barra, Bahia, 18 males (alc.), February 24, 1914, Robert H. Becker (F.M.).

This species was described by Thomas from eight specimens and has not been recorded since. The specimens here noted might be considered as topotypes; they agree closely with the original description. The forearms measure 33.8–36.7.

***Lonchophylla robusta* Miller.**

Lonchophylla robusta Miller, Proc. U. S. Nat. Mus., 42, p. 23, 1912—Chilibrillo Caves, Panama; Goldman, Smiths. Misc. Coll., 69, No. 5, p. 192, 1920—Panama; G. M. Allen, Journ. Mamm., 16, p. 227, 1935—Panama; Enders, Bull. Mus. Comp. Zool., 78, p. 418, 1935—Panama.

Colombia: San Gil, 1, no sex, June, 1934, Niceforo Maria (N.M.); Sasaima, 1 female (alc.), July 9, 1940, Niceforo Maria (F.M.).

All previously known specimens of this bat have been recorded from Panama, one taken at Cana and others from the Chilibrillo Caves. The specimen from San Gil is smaller, the skull especially, than two from Panama, but the other Colombian specimen does not differ from typical *robusta*.

***Lonchoglossa caudifera caudifera* Geoffroy.**

Glossophaga caudifer Geoffroy, Mem. du Mus., 4, p. 418, 1818—Rio de Janeiro, Brazil.

Venezuela: Cucuta, Santander del Norte, 2 males (alc.), April, 1940—Niceforo Maria (F.M.).

Brazil: Lagoa Santa, Minas Geraes, 4 females (alc.), 1 male (alc.), January 4, 5, 1914—R. H. Becker (F.M.).

Since the review of this genus (Sanborn, Field Mus. Nat. Hist., Zool. Ser., 20, p. 27, 1933), based on eleven specimens from eastern and central Brazil, two specimens have been recorded (Sanborn, Occ. Pap. Mus. Zool. Univ. Mich., 323, p. 3, 1938) from Venezuela. The above series almost doubles the number of specimens formerly available for study. The forearms of those from Venezuela and Brazil measure from 35.5–38.1, a slight increase in size from measurements given before.

***Lonchoglossa caudifera aequatoris* Lönnberg.**

Lonchoglossa wiedi aequatoris Lönnberg, Arkiv Zool., 14, No. 4, p. 65, 1921.

Peru: Vitoc Valley, Prov. Tarma, Dept. Junín, 1 male (alc.), July, 1940—Felix Wytkowski (F.M.).

The forearm of this specimen is 34.2, which is short for typical *caudifera* but about the minimum for *aequatoris*, which heretofore has been recorded only from Ecuador.

***Lionycteris spurrelli* Thomas.**

Lionycteris spurrelli Thomas, Ann. Mag. Nat. Hist., (8), 12, p. 271, 1913—
Condoto, Choco, Colombia.

British Guiana: Itabu Creek Head, Corentyne River, Boundary Camp, 1 male (alc.), 1 female (alc.), September–October, 1938—E. R. Blake (F.M.).

These specimens are the first to be recorded since the original description of the genus and the species based on an immature specimen. They were taken a great distance east of the type locality but agree with the original description; the skull agrees with a photograph of that of the type.

Measurements (type in parentheses).—Forearm 34.9–36 (33). Skull: greatest length 19.6 (18.7), condylo-basal length 18 (17.5), palatal length 9.2 (8.4), interorbital width 4.1 (3.7), mastoid width 8.2, width of braincase 8.1 (8), upper toothrow 6.2 (6.1), width across canines 3.4, across molars 5 (4.8). External measurements: third finger, metacarpal 35.8–36.2, first phalanx 9.8–9.9, second phalanx 17.4–17.7, third phalanx 7.7–7.8; fourth finger, metacarpal 32.2–32.6, first phalanx 7.6–7.2, second phalanx 12.4–11.6; fifth finger, metacarpal 29.8–29.8, first phalanx 7.5–6.7, second phalanx 9.8–9.6. Ear 12; tail 9.8; tibia 14.1–14.3; calcar 3.6–3.9; height of lancet 6.1–5.6.

***Leptonycteris nivalis* Saussure.**

Ischnoglossa nivalis Saussure, Rev. Mag. Zool., p. 492, pl. 20, figs. 2–2c (animal, noseleaf, skull and teeth), 1860—near snow-line on Mount Orizaba, Vera Cruz, Mexico.

Texas: Mount Emory, Chisos Mountains, Brewster County, 14 males (8 alc.), 44 females (33 alc., 2 skeletons), July 26, 1937, D. D. Davis (F.M.).

Mexico: Cerro Potosi, near La Jolla, Galeana, Nuevo Leon, 17 males (alc.), 64 females (alc.), August 17, 1938, E. J. Koestner (F.M.).

These are the first records for Texas and for this part of Mexico. The bat is known from Arizona south through western and central Mexico to Guatemala. An examination of all available material shows that the above series have much longer wings than those from farther west. Intermediate specimens were found in Jalisco and Michoacan. The type has been lost but, if the figure is accurate, it also had long wings.

Brachyphylla pumila Miller.

Brachyphylla pumila Miller, Proc. Biol. Soc. Wash., 31, p. 39, 1918; Miller, Smiths. Misc. Coll., 81, No. 9, p. 9, 1929; Goodwin, Journ. Mamm., 14, p. 154, 1933.

Haiti: Diquini, December 12, 14, 1937—3 females (one skin with skull), (I.T.S.).

Besides the three subfossil skulls recorded by Miller from Haiti, there have been five male alcoholic specimens described by Goodwin from the Dominican Republic.

In the present specimens the brown tips to the hairs are either very short or absent so that there is a white patch on the nape and one on each side, leaving a brown Y on the back and shoulders. The under parts are gray.

Measurements.—Forearm 55.1–59; third finger, metacarpal 50.3–51.1, first phalanx 15.2–16.4, second phalanx 21.1–22.6, third phalanx 15.6–16.9; fourth finger, metacarpal 47.3–48.2, first phalanx 13.5–15.1, second phalanx 18.1–19; fifth finger, metacarpal 50–51.7, first phalanx 12.1–13.9, second phalanx 13.6–14.6. Ear 19–20; tibia 23.5–24; foot 17.4–17.6. Skull: greatest length 29.3, condylo-basal length 25.3, rostral width 9, interorbital width 6.5, zygomatic width 15.5, mastoid width 13.6, braincase 12.2, upper toothrow 9.9, width across canines 6.4, maxillary width 10.3.

Collector's note.—"Sleeping in limestone cave."

Vampyrops fumosus Miller.

Vampyrops fumosus Miller, Proc. Acad. Nat. Sci. Phila., p. 405, 1902—Purus River, Brazil; Sanborn, Field Mus. Nat. Hist., Zool. Ser., 20, p. 101, 1936—Ecuador.

Peru: Vitoc Valley, Prov. Tarma, Dept. Junín, 1 male, 2 females, October 11, 1940, F. Wytkowski (F.M.).

This is the first record of the species in Peru. The collector records them as being taken "in the ruins of an abandoned huge farm in the forest, Hacienda Santa Ana."

Vampyrodes caraccioli Thomas.

Vampyrodes caracciolae Thomas, Ann. Mag. Nat. Hist., (6), 4, p. 167, 1889—Trinidad.

Vampyrodes caraccioli Thomas, Ann. Mag. Nat. Hist., (6), 11, p. 186, 1893 (change of ending of specific name); Journ. Trinidad Field Nat. Club, 1, p. 6 (reprint), 1893 (mention of second specimen).

Vampyrodes (Vampyrodes) caraccioli Thomas, Ann. Mag. Nat. Hist., (7), 5, p. 269, 1900.

Vampyrodes caracciolae Miller, Bull. U. S. Nat. Mus., 57, p. 156, 1907.

Vampyrodes caraccioli Thomas, Ann. Mag. Nat. Hist., (9), 6, p. 274, 1920—Para, Brazil.

Trinidad: Mount Aripo, 2 males, March 18, 1937 (I.T.S.).

These appear to be the fourth and fifth specimens to be recorded. Unfortunately, one was so badly shot that the front of the face is blown off and the wings are shattered.

Measurements.—Forearm 49.8; third finger, metacarpal 48.8, first phalanx 17.8, second phalanx 27.3, tip 15.5; fourth finger, metacarpal 46.6, first phalanx 14.1, second phalanx 17.2; fifth finger, metacarpal 47.6, first phalanx 11.2, second phalanx 11.8. Tibia 18.9; ear 19. Skull: greatest length 26.8, condylo-basal length 22.6, palatal length from in front of incisors 13.6, rostral width 10.3, interorbital width 6.3, zygomatic width 16.4, mastoid width 13, width of braincase 11.6, upper toothrow 9.4, width across canines 6.6, across molars 11.5, lower toothrow 10.6.

Collector's note.—"Sleeping under palm frond."

Chiroderma salvini Dobson.

Chiroderma salvini Dobson, Cat. Chiropt., p. 532, pl. xxiv, figs. 3-3b (skull and teeth), 1878—Costa Rica; Alston, Biol. Cent. Amer. Mamm., p. 49, pl. iv (animal), 1879—Costa Rica; Dobson, Proc. Zool. Soc. Lond., p. 465, 1880—Colombia; Thomas, Ann. Mus. Civ. Stor. Nat. Genova, p. 883, 1891—key; Miller, Proc. U. S. Nat. Mus., 42, p. 26, 1912—Costa Rica (skull meas.); Goldman, Smiths. Misc. Coll., 69, No. 5, p. 203, 1920—Panama.

Honduras: Tapasuna, 10 males (alc.), 12 females (alc.), December 31, 1937–January 1, 1938, P. O. McGrew (F.M.).

In the years since the description of this bat only three specimens have been recorded. Dobson reported one from Colombia in the collection of the Göttingen Museum in 1880; Miller gave skull measurements for a specimen from Costa Rica in 1912; and Goldman listed one record for Panama in 1920. H. Allen's reference appears to have been based on a specimen from Mexico that is probably *isthmicum*.

There is great variation in size in this series from Honduras, some being almost as small as *isthmicum*, which differs by its smaller teeth, proportionately broader skull, and absence of white markings. In a Field Museum specimen of *isthmicum* from Mexico the upper middle incisors are small and light, and their tips diverge, a condition similar to that described for *jesupi* from Colombia, except that the teeth are parallel. The photograph of the type skull of *isthmicum*, however, shows that the tips of the middle incisors converge as in *salvini*.

Chiroderma salvini appears to have the widest range, having been taken from Honduras to Colombia; *C. isthmicum* is known from southern Mexico, Costa Rica, and Panama; and *C. jesupi* from Colombia.

Measurements.—Forearm 46–52.3. Three skulls: greatest length 25.2–27.6, condylo-basal length 24.1–24.9, palatal length 12.8–14.6, interorbital width 5.6–6.3, zygomatic width 15.9–16.8, mastoid width 12.3–13.1, width of braincase 10.4–12.4, upper tooththrow 9.3–9.8, width across canines 6–6.2, across molars 11.5–11.8, lower tooththrow 10.2–10.7.

Phyllops haitiensis J. A. Allen.

Ardops haitiensis J. A. Allen, Bull. Amer. Mus. Nat. Hist., 24, p. 581, 1908; G. M. Allen, Bull. Mus. Comp. Zool., 54, p. 237, 1911.

Phyllops haitiensis Anthony, Bull. Amer. Mus. Nat. Hist., 37, p. 337, pl. 34, fig. 2 (type skull), 1917; Miller, Proc. Biol. Soc. Wash., 31, p. 39, 1918; Miller, Smiths. Misc. Coll., 81, No. 9, p. 9, 1929; idem, 82, No. 15, p. 6, 1930.

Haiti: Petionville, 2 females, May 25, 1937; Port au Prince, 1 female, December 10, 1937 (I.T.S.).

This species was described from one skin with skull taken at Cana Honda, Dominican Republic. Miller has recorded skulls found in owl pellets, from Port de Paix and Diquini; from cave deposits at St. Michel and the Atalaye plantation, Haiti; and from owl pellets from Monte Culo de Maco, near Constanza, Dominican Republic. There are no records of the bat's being found alive since the description of the species.

The specimens are a little larger than the type but otherwise agree with the short description.

Measurements.—Two adult females and one skull. Forearm 40.6–41.6, pollex 13.6–13.7; third finger, metacarpal 39.3–39.6, first phalanx 15.2–15.6, second phalanx 19.5–19.8, third phalanx with cartilage 13.7–13.8; fourth finger, metacarpal 39.3–39.6, first phalanx 12.4–12.8, second phalanx 12.8–13.7; fifth finger, metacarpal 40.1–40, first phalanx 9.9–10.2, second phalanx 11.8–12.3. Tibia 16.3–17, tibia with foot 26.6–27; ear from meatus 16–17.5; length of tragus 5.3–5.6; width of noseleaf 5.8–6.1; height from base of horseshoe 9.5–9.8. Skull: greatest length 20.5, condylo-basal length 17.6, palatal length 4.8, interorbital width 5.3, intertemporal width 13.7, mastoid width 11.8, braincase 9.8, upper tooththrow 5.8, width across canines 5.9, maxillary width (M^1 – M^1) 8.4, lower tooththrow 6.2.

Collector's notes.—"Sleeping in mango trees;" "house in town."

Sphaeronycteris toxophyllum Peters.

Sphaeronycteris toxophyllum Peters, Sitzungsber. Akad. Wiss. Berlin, p. 989, 1882—South America.

Colombia: Cucuta, 1 male, February, 1940, Niceforo Maria (N.M.).

Briceño Gabaldon y Hijos collected many of these bats near Merida, Venezuela, between 1904 and 1909, and Rehn (Proc. Acad. Nat. Sci. Phila., p. 259, 1900) recorded a specimen from Pebas, Peru. This is the first record for Colombia but it might be termed a "political" record as Cucuta is very near the border of Venezuela. It is interesting to have another specimen come to light after so many years.

Natalus major Miller.

Natalus major Miller, Proc. Acad. Nat. Sci. Phila., p. 398, 1902—Savaneta, Dominican Republic.

Natalus stramineus major G. M. Allen, Bull. Mus. Comp. Zool., 54, p. 240, 1911.

Haiti: Port au Prince, 1 male, August 1, 1937 (I.T.S.).

This appears to be the first published record of the capture of this bat since the description of the type and paratype. The specimen is slightly larger than the measurements given for the type.

Measurements.—Head and body 44.7; tail 61.8; tibia 25.1. Forearm 43.8; third finger, metacarpal 42.3, first phalanx 18.3, second phalanx 23.9; fourth finger, metacarpal 40.6, first phalanx 10.9, second phalanx 11.8; fifth finger, metacarpal 40.8, first phalanx 10.6, second phalanx 12.6. Ear 17.

Collector's note.—"Flying around house."

Natalus stramineus Gray.

Natalus stramineus Gray, Mag. Zool. Bot., 2, p. 496, 1838; Dobson, Cat. Chiropt., p. 342, pl. 17, fig. 8 (head), 1878—Brazil spec. only; Winge, Mus. Lundii, p. 13, pl. 2, fig. 2 (skull)—1892; Jentink, Notes Leyden Mus., 15, p. 279, 1893—British Guiana; Young, Timehri, (2), 10, p. 44, 1896—British Guiana; Beebe, Zoologica, 2, p. 219, 1919—British Guiana; Shamel, Proc. Biol. Soc. Wash., 41, p. 67, 1928—Brazil (Natal); Hayman, Proc. Agr. Soc. Trinidad and Tobago, 32, p. 313, 1932—Trinidad; Vesey-Fitzgerald, Trop. Agr., 13, p. 161, 1936—Trinidad.

Trinidad: 2 females, Trinidad Medical Department (I.T.S.).

This species was described from a specimen without locality and published references to specimens are still rare. Dobson, Winge, and Shamel have each recorded specimens from Brazil; Jentink's, Young's, and Beebe's references are all to the same specimen from

British Guiana; and Hayman and Vesey-Fitzgerald do not mention any specimens from Trinidad but the text gives the idea that the lists were based in part on the collections of Dr. Urich. Mr. Morrison-Scott and Mr. R. W. Hayman have been kind enough to send the measurements on the type in the British Museum. The specimens from Trinidad agree so closely that they may be confidently referred to *stramineus*. The difference in some of the external measurements is due to the methods used.

The next nearest form is *Natalus dominicensis* Shamel from Dominica, described as larger than *N. stramineus*. A comparison of the measurements shows it to have a longer condylo-basal length, a narrower zygomatic width, and a slightly longer forearm and ear.

Measurements (type in parentheses).—Forearm 39–40.1 (38); third finger, metacarpal 33.7–38.9, first phalanx 15.5–16.1 (15), second phalanx 21–22.6 (16 without cartilage); fourth finger, metacarpal 36.4–38 (33), first phalanx 9.5–9.8 (10), second phalanx 10–10.7 (11); fifth finger, metacarpal 35.7–37.8 (32), first phalanx 9.3–9.7 (10), second phalanx 10.6–11.3 (9). Tibia 20.1–20.8 (19.5); ear 14.5–15.5 (14). Skull: greatest length 16.8 (16.6), condylo-basal length 14.7 (15), interorbital width 3.5 (3.3), zygomatic width 8.5 (8.6), mastoid width 7.4 (7.6), width of braincase 7.9 (8.29), upper toothrow 7.2 (7.15), width across canines 3.9 (4), across molars 5.6 (5.8), lower toothrow 7.6 (7.6), mandibular length 12.5 (12.35).

***Furipterus horrens* Cuvier.**

Furia horrens F. Cuvier, Mem. du Mus., 16, p. 150, 1828—Mana River, French Guiana.

Dutch Guiana: Camp One, Coppename River, above Kaaimanston, 1 male, July 8, 1938 (I.T.S.).

This bat is known from Brazil, British and French Guiana, Trinidad, and Colombia.

Measurements.—Forearm 35.7; third finger, metacarpal 33.4, first phalanx 5, second phalanx 19.9; fourth finger, metacarpal 29.4, first phalanx 6, second phalanx 8.3; fifth finger, metacarpal 29, first phalanx 10.3, second phalanx 4.6. Ear 10; tail 35.8; tibia 15.

Collector's notes.—"Flying in tent at 10:30 A.M. Color—smooth bluish gray fur just tipped paler gray, slightly ochreous. Membranes dark gray. Chin and just above nose reddish brown."

***Amorphochilus schnablii* Peters.**

Amorphochilus schnablii Peters, Monatsber. Akad. Wiss. Berlin, p. 185, pl., figs. 1–10, 1877—Tumbez, Peru.

Peru: Hacienda de la Fuente, Vitor Valley, Arequipa, 12 females (alc.), October 10, 1939; Hacienda Chucarapi, Tambo Valley, Arequipa, 1 female, October 17, 1939, 1 male (alc.), 5 females (alc.), May 17, 1940; Hacienda Santa Maria, Tambo Valley, Arequipa, 23 males (21 alc.), 24 females (20 alc.), May 18, 1940.

Heretofore this bat was known from northern and central Peru, the type being from Tumbes, and it has been recorded from Puna Island, Ecuador, by J. A. Allen. The United States National Museum has three specimens from Piura, Peru, and one from Lima. The Museum of Comparative Zoology also has one from Lima and there is a specimen from there in the museum in Lima.

These specimens from two valleys in the southernmost part of Peru lead one to the conclusion that probably all the cultivated valleys of the arid coast are inhabited by it and possibly it may range farther south into northern Chile.

A few of the specimens were taken in dark wine-storehouses and an irrigation tunnel, but most of them came from an unused sugar-mill.

Measurements.—Forearms 34.2–37.

***Thyroptera tricolor albigula* G. M. Allen.**

Thyroptera tricolor albigula G. M. Allen, Proc. New England Zool. Club, 9, p. 1, 1923—Gutierrez, in mountains about 25 miles inland from Chiriquito, western Panama.

British Honduras: South Stann Creek, 15 miles west of All Pines, 1 male, March 6, 1935 (C.M.).

The forearm of the type, a female, measures 36.6. The specimen from Honduras is smaller, with a forearm of 35. Field Museum has a male and female from Esparta, Costa Rica, with forearms of 34.6 and 32, respectively.

***Myotis nigricans nicholsoni* subsp. nov.**

Type from Hacienda Chucarapi, Tambo Valley, Department of Arequipa, Peru. No. 50783 Field Museum of Natural History. Adult male. Collected October 17, 1939, by C. C. Sanborn. Original No. 2237.

Characters.—A very small, pale race of the arid region of southern Peru. Above, distal third of hairs slightly lighter than the Buffy Brown of Ridgway (1912); below, distal third grayish white, all hairs dark, almost black, for the basal two-thirds. In other characters like *nigricans*. Skull smaller than in *nigricans*, from measurements

about the size of *extremus*; narrower across rostrum and canines proportionately shorter.

Measurements.—Forearm of type 31.6 (others in alcohol 31.1–32.6). Skull of type, greatest length 13.1, condylo-basal length 11.9, rostral width over molars 4.4, interorbital width 3, zygomatic width (about) 6.8, mastoid width 6.5, width of braincase 6.3, upper toothrow 4.6, across canines 2.9, across last molars 4.8, lower toothrow 4.8.

External measurements of female paratype.—Forearm 32.5; third finger, metacarpal 29.4, first phalanx 9.7, second phalanx 8.6, tip 5.9; fourth finger, metacarpal 29, first phalanx 8.1, second phalanx 6.6; fifth finger, metacarpal 27.8, first phalanx 7.1, second phalanx 6.9. Tail 34.8; tibia 14.7; ear 12.

Specimens examined.—Type and one paratype. Two males and one female from Patasagua, a suburb of Arequipa, Dept. of Arequipa, Peru.

Remarks.—This is a pale race living in the semi-arid region of southern Peru from the coast to at least 7,500 feet altitude. It might have been given a geographic name, but almost the same result is obtained by naming it for Dr. Carlos Nicholson of the University of Arequipa, whose name is synonymous with the study of the natural history and geography of the region. Without the help of Dr. Nicholson these bats would not have been secured.

***Eptesicus hispaniolae* Miller.**

Eptesicus hispaniolae Miller, Proc. Biol. Soc. Wash., 31, p. 39, 1918—Constanza, Dominican Republic.

Haiti: Port au Prince, 1 female, August 1, 1937 (I.T.S.).

Jamaica: Chincona, altitude 6,000 feet, 1 male (alc.), 1 female (alc.), August 19, 1939; Sherwood Forest, 1 (alc.), August 29, 1939 (I.T.S.).

This bat has been reported from five localities in Haiti and the Dominican Republic on skulls from owl pellets and fossil remains, but no live specimens have been taken besides the type. This is the first record of it from Jamaica. The forearm of the specimen from Haiti measures 49.7 and in those from Jamaica it is 45.9, 47.8, and 47.9.

***Eptesicus melanopterus* Jentink.**

Vesperus melanopterus Jentink, Notes Leyden Mus., 24, p. 176, 1904—Paramaribo, Dutch Guiana.

E.[ptesicus] melanopterus Thomas, Ann. Mag. Nat. Hist., (9), 5, p. 361, 1920.

Dutch Guiana: Zanderij, adult male and female, 2 juv. males (1 mummy), (I.T.S.).

These appear to be the first specimens recorded since the description of the type, and agree with the description and external measurements. Measurements of the skull have never been published.

Measurements.—Forearm 40.2–41.6; third finger, metacarpal 36.6–37.9, first phalanx 13.5–14, second phalanx 9.6–12.7, tip 7.6–7.2; fourth finger, metacarpal 35.6–37.2, first phalanx 11.5–12.1, second phalanx 9.3–8.9; fifth finger, metacarpal 34.2–34.7, first phalanx 8.8–8.8, second phalanx 6.6–7.6. Ear 14; tail 42.6–38.2; tibia 16.7–16.8. Skull of female: greatest length 16.4, condylo-basal length 14.4, rostral width 6.6, interorbital width 4.1, zygomatic width 11.1, mastoid width 8.5, braincase 7, upper toothrow 5.9, across canines 4.9, maxillary width 7.1.

Histiotus macrotus Poeppig.

Nycticeius macrotus Poeppig, Reise in Chile, Peru and Amazonströme, 1, p. 451, footnote, 1835—Antuco, Province of Bio-Bio, Chile.

Histiotus macrotus Peters, Monatsber. Akad. Wiss. Berlin, p. 788, pl. opp. p. 792, figs. 2–2e (head, skull, teeth), (1875) 1876—Chile.

Chile: Probably near Santiago, 1 male (alc.), C. S. Reed (F.M.).

Peru: Yunguyo, south end of Lake Titicaca, 1 male, 1 female, March 15, 1940, C. C. Sanborn (F.M.); Hacienda Chucarapi, Tambo Valley, Dept. Arequipa, 5 females (3 alc.), October 15–19, 1939, C. C. Sanborn (F.M.).

These specimens have been referred to *macrotus* although the majority were taken a long way from the type locality. There have been but two specimens of *macrotus* recorded, so little is known about its characters. This series agrees in general with the main character, which is very long ears connected by a low band of skin. This separates these specimens from both *montanus* and *velatus*, and a much shorter palate also distinguishes them from *velatus*.

In 1916 (Ann. Mag. Nat. Hist., (8), 17, p. 225) Thomas described *Histiotus laephotis* from Caiza, southern Bolivia. Its characters are those of *macrotus* which Thomas did not have but he was influenced by the great distance from the type locality of *macrotus* and the difference in the fauna of the two regions. From what is known now of the distribution of the species it is clear that if *laephotis* can be recognized it will be as a subspecies of *macrotus*.

The specimen from Chile is darker than those from Peru but until topotypical *macrotus* from southern Chile is available it seems

best to let all specimens rest under the specific name. The Andes of central and southern Chile are becoming more accessible every year as roads are built in them towards summer resorts, ski shelters, and fishing grounds, so it is probable that typical *macrotus* may be taken at a not too distant time.

The Peruvian specimens from the Tambo Valley were taken on one of the lower floors of an observatory and in a room of the main house of the Hacienda in October. None were seen in May. The two from Lake Titicaca were purchased from an Indian who said he had caught them in his house.

Measurements.—Forearm 47–51.5. Skull: greatest length 17.9–18.9, condylo-basal length 17.6, palatal length 7.8–8.1, interorbital width 43–45, zygomatic width 10.6–10.8, mastoid width 9.2–9.4, width of braincase 8.1–8.4, upper tooththrow 5.8–6.4, width across canines 4.3–4.9, across molars 6.3–6.9. Ears from meatus 31–37; height of tragus 14–16.

***Molossops temminckii griseiventer* subsp. nov.**

Type from Espinal, west of Magdalena River on plains of Tolima, Colombia. No. 51727 Field Museum of Natural History. Adult female in alcohol, skull removed. Collected September 21, 1940, by Brother Niceforo Maria.

Characters.—In general like *temminckii* but white patch on throat larger and rest of under parts gray. Skull longer and slightly broader.

The color above is the same dark brown as in *temminckii* from Brazil and Paraguay, but the white patch on the throat is larger and the hairs are pure white to the roots. The rest of the under parts are gray instead of brown; the hairs have white bases, followed by a gray band, and the tips are again white.

The skull is longer and slightly broader, in comparison appearing larger than the measurements indicate.

Measurements.—Forearm, type and topotype, 31.9, 30.9, 30.7. Skull: greatest length 15.3, 15; condylo-basal length 13.8, 13.5; palatal length 7, 6.7; greatest rostral width 6.6, 6; interorbital width 4.3, 4.9; zygomatic width 9.6, 8.8; mastoid width 8.9, 8.3; width of braincase 7.4, 7.1; upper tooththrow 5.7, 5.5; width across canines 3.9, 3.6; width across molars 6.8, 6.3.

Specimens examined.—Type and male topotype in alcohol in Field Museum collection, and one male, skin and skull, from Honda, collected February, 1932, in collection of Brother Niceforo Maria.

Remarks.—*Molossops temminckii temminckii* is known from northern and central Brazil, Paraguay, and Jujuy and Misiones, Argentina. *M. t. sylvia* Thomas was described from Goya, Corrientes, Argentina, as a paler subspecies. Cabrera described *M. aequatorianus* from Ecuador but it has a much longer forearm (36) and a slightly shorter skull (14.5) than *M. t. griseiventer*.

Cynomops planirostris paranus Thomas.

Molossus planirostris paranus Thomas, Ann. Mag. Nat. Hist., (7), 8, p. 190, 1901—Para, Brazil.

Colombia: Cucuta, 2 males, February, 1939, 1 female, May, 1936, Niceforo Maria.

These bats are referred to this subspecies until topotypical material is available for comparison. Externally they agree with the original description. The skulls are slightly longer, however, and the distance "across the angular anteorbital ridges" is more than half the basal length as in *planirostris* and not less as in *paranus*. This is a difficult measurement to take accurately and the ridges probably increase with age so that this may prove to be a rather unstable character.

Tadarida similis sp. nov.

Type from Bogotá, Colombia. No. 48560 Field Museum of Natural History. Adult male. Collected August, 1938, by Brother Niceforo Maria. Original No. 4.

Characters.—A member of the *macrotis* group, intermediate in size between *macrotis* and *laticaudata*. Externally similar to *aurispinosa* but slightly smaller and grayish brown instead of red. The hairs are brown and the extreme bases are almost white.

The skull is much as in *laticaudata* and *femorosacca*, but is larger, especially broader, and has heavier teeth.

Measurements.—Forearm 49.5; tibia 15. Skull: greatest length 20.7, condylo-basal length 18.8, palatal length 8.5, interorbital width 3.9, zygomatic width 11.6, mastoid width 10.4, width of braincase 9.3, upper toothrow 7.8, width across canines 4.7, across molars 8.5, lower toothrow 8.5.

Specimens examined.—One, the type.

Remarks.—This is the west coast representative of *Tadarida aurispinosa*, known from one specimen without a skull. Shamel (Proc. U. S. Nat. Mus., 78, p. 12, 1931) listed *aurispinosa* but said he considered it synonymous with *laticaudata* whose range is Brazil

and Paraguay. The discovery of *similis* adds further evidence that there are species intermediate in size between *macrotis* and *laticaudata*. It is unusual that a bat with colonial habits as in most of the free-tailed species should be so rare, but it is only very recently that any colonies of *T. europs* have been discovered.

The *macrotis* group is divided into seven species separated from each other mainly by size, and six of these may be divided into three pairs. *Tadarida europs* of Brazil and Venezuela is about the size of *T. yucatanica* of Yucatan and Guatemala; *T. laticaudata* of southern Brazil and Paraguay is very similar to *T. femorosacca* of Arizona, California, and Mexico; next in size are *T. aurispinosa* and *T. similis* from opposite sides of northern South America, and largest of all is *T. macrotis*, ranging from California and Iowa to south-central Brazil.

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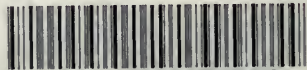
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