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Arctoryctes and Some Other Chadronian Vertebrate Microfossils from Nebraska

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In a report by Hough and Alf (1956) on a collection of small fossils from anthills in Sioux County, Nebraska, a number of species known previously only from Orellan (mid-Oligocene) and higher strata were recorded as coming from a Chadronian (early Oligocene) horizon. One such identification cautiously published as "(?)*Proscalops*" would be (if verified) the earliest record of a true mole (Mammalia: Talpidae) in North America. At our request, the material upon which this tentative identification had been made (plus some other unidentified pieces) was kindly turned over to us by the original collector, Mr. Raymond Alf, for further study. He has since donated the specimens to Chicago Natural History Museum, and thus they bear CNHM catalogue numbers.

The original report did not carry an exact locality reference for the anthill fauna. According to Alf (personal communication, 1959) the locality was designated as no. 5302 of the Raymond Alf Museum of Natural History, Webb School, Claremont, California, and is located on the Frank Arner Ranch, north of Crawford (T. 33 N., R. 53 W., Sec. 26), Sioux County, Nebraska.

Among the unidentified materials turned over to us by Mr. Alf were several problematical foot bones, an (?)*Arctoryctes* radius (discussed below), and four distal ends of humeri, two of lizards (PR403 and PR404) and two of rodents. Both lizard humeri have the distinctive bulbous surfaces for articulation with radius and ulna and are about the size of the counterpart in *Phrynosoma*, although they

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differ in detail. We doubt that a family assignment is possible. One of the rodent fragments appears to belong to a myomorph (PM3892). It compares very well with the humerus of *Peromyscus* in size and detail, and probably belonged to one of the several species of *Eumys* known to be abundantly represented in the fauna. The other rodent fragment (PM3893) is somewhat broken on its medial and lateral surfaces. In detail, it compares best with the humerus of *Citellus*, although it is the size of that of *Eutamias*. Thus it probably belonged to one of the eomyids, *Adjidaumo* or *Paradjidaumo*, which Hough and Alf (1956) reported to be abundant in the fauna. Of these two genera, *Adjidaumo* has the smallest individuals, and so the most probable association is with this genus.

ARCTORYCTES¹

Humeri.—This small collection has proved to be intriguing because of the association of a number of problematical foot bones and two fragmentary, fossorially specialized mammalian humeri. The latter, both distal ends of left humeri (PM3878 and PM3879), were tentatively identified as *Proscalops* by Hough and Alf. However, we found these specimens to be Chadronian representatives of the enigmatic *Cryptoryctes*–*Arctoryctes* group of fossorial mammals. The resemblance is closer to *Arctoryctes* (as presently defined) than it is to *Cryptoryctes*, more particularly to the Orellan *A. galbreathi* Reed, 1956, but the present specimens represent a somewhat less specialized form. Because of the fragmentary nature of these remains no new species is being described, although we are convinced of its validity.

The two pieces of the Chadronian *Arctoryctes* indicate that it had a humerus of approximately the same length and configuration as that of the Orellan *A. galbreathi* but less specialized in the following details: (1) it was more slender; (2) there was less fusion between the teres tubercle and the medial epicondyle; (3) the medial epicondyle was less projecting; (4) the groove for the brachial artery and the median nerve was shorter; (5) the lateral epicondyle probably was less projecting. The differences are best shown by direct comparison of the drawings (fig. 24).

¹ Since humeri are the only specimens known, the ordinal affinity within the Mammalia of *Arctoryctes* and the related *Cryptoryctes* remains a puzzle, which can only be solved by the finding of better-associated skeletal material than that known to date. The one definite conclusion we emphasize is that these animals were not moles (Reed, 1954). We do not agree with Saban (1958, p. 528) that these two genera are to be positively assigned to the epiotheriid edentates. We feel that assignment within the Insectivora is equally possible, and that any assignment is at present premature.

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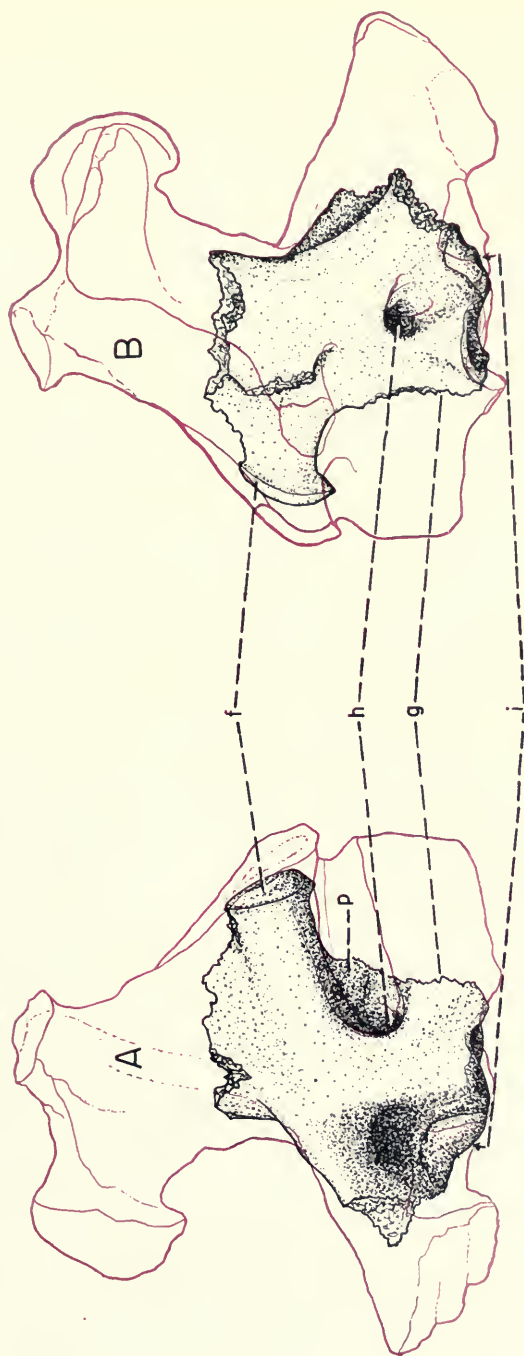


FIG. 24. Views of the left humerus of the Chadronian *Arcctoricyles* species shown oriented for comparison within outline drawings of *A. galbreathi* (right humerus reversed). The shaded drawings are composites, based on PM3878 and PM3879. A, posterior aspect. B, anterior aspect. Approximately $\times 7.2$. *f*, teres tubercle; *g*, medial epicondyle; *h*, supracondylar (entepicondylar) foramen; *i*, trochlea; *p*, groove for brachial artery and median nerve.

These Chadronian *Arctoryctes* humeri and those of the Orellan *A. galbreathi* are more similar to each other than either is to *A. terrenus* of the Miocene. Eventually, a new genus will probably have to be created for the Oligocene forms of *Arctoryctes*, as presently regarded.

Radius.—We tentatively associate the proximal end of a left radius (PM3880; fig. 25, B) with the humeri of *Arctoryctes* discussed above, on the basis of: (1) size; this radius and the humeri of the associated *Arctoryctes* sp. are both about half, or a little less, of the size of the radius and humerus of the equally fossorially specialized mole *Scapanus latimanus*; (2) having been collected, even if separately, from the same locality; and (3) remarkable fossorial adaptation, paralleled surprisingly by the true moles (fig. 25). The details of the capitular process and of the ulnar facet are somewhat different from those of the radius of moles of similar degree of specialization (*Talpa*, *Scapanus*, *Scalopus*), and the shaft is rounder and somewhat slimmer than in the talpids mentioned. Certainly, however, if this little piece of a radius had been found other than in its present association with humeri of *Arctoryctes* it would have been identified as that of a talpid, nor can we say *definitely* that it is not.

PROBLEMATICAL FOOT BONES

The foot bones consist of four carpals or tarsals (PM3881–PM3884), two of which are opposites (PM3883 and PM3884), seven metapodials, and one phalanx. At present the carpals or tarsals must remain unidentified. The seven metapodials would seem to belong to three different morphological groups. Five are of one general kind and each of the other two is individual in type; with one of these we associate a proximal phalanx.

All the metapodials (PM3885–PM3891) are relatively short stout bones with irregular proximal articular surfaces (fig. 26). In small mammals generally, the metatarsals more typically have flattened or somewhat more irregular proximal articular surfaces than do the metacarpals, whose articular surfaces are more typically rounded. Nevertheless, we believe all of these seven bones to be metacarpals derived from forefeet specialized for burrowing.

An examination of numerous species of Recent mammals with hands highly specialized for burrowing (or for opening termite nests) shows that the metacarpals in each case become shorter and wider and the primitive rounded proximal articular surfaces characteristic of man, mouse, dog, and cat become angular and irregular. On the

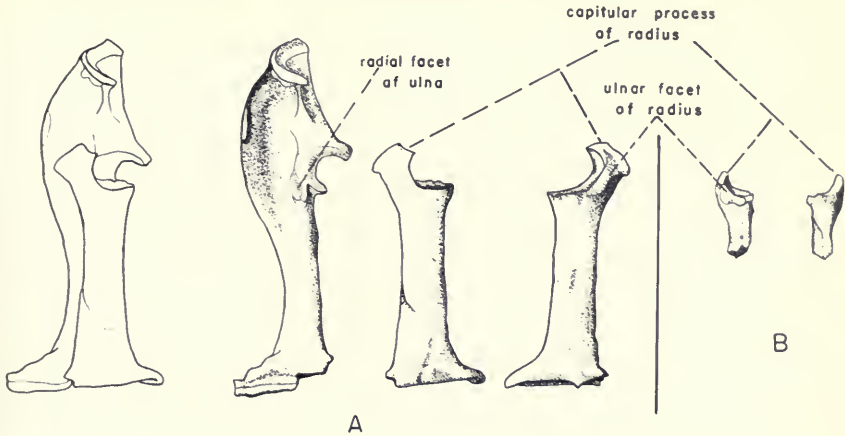


FIG. 25. A, *Scapanus latimanus*. Outline of articulated right radius and ulna in anconeal aspect; shaded drawings of the same aspect of each bone and the palmar aspect of the radius, showing the articular facets and the capitular process. B, (?*Arctoryctes* sp., PM3880. Proximal end of left radius in anconeal and palmar aspects, showing the ulnar facet and the capitular process. All approximately $\times 2.5$.

other hand, no metatarsals we can find in Recent small mammals are proportionately as short and thick as are these particular seven metapodials, nor do they usually have such irregular proximal articular surfaces; so we conclude that these seven bones are metacarpals from hands particularly specialized for digging.

One of the metacarpals (PM3885; figs. 26, C, and 27, A) has the general appearance of the third metacarpal in an anteater's hand. In the Recent anteaters (Myrmecophagidae: *Tamandua*, *Myrmecophaga* and *Cyclopes*) this third metacarpal is the most specialized of the five; the details vary in the different genera, but the bone is typically deepened and broadened in a manner parallel to that of PM3885. However, its closest likeness is to be seen in the fourth metacarpal of *Zaedyus*, one of the Recent armadillos (Dasypodidae), where it not only is similarly proportioned but also has a very similar distal articular surface (fig. 27, B). This most distinctive articular surface obviously would permit only restricted movement at the joint. Such a joint is found also between the first and second phalanges of the third digit in the manus of *Cyclopes* and the other myrmecophagids, but we know of no such metacarpal-phalangeal joint other than that in *Zaedyus* and the specimen here described.

Another of the metacarpals is the one with which we have associated a phalanx (PM3886; figs. 26, D, and 28). This metacarpal

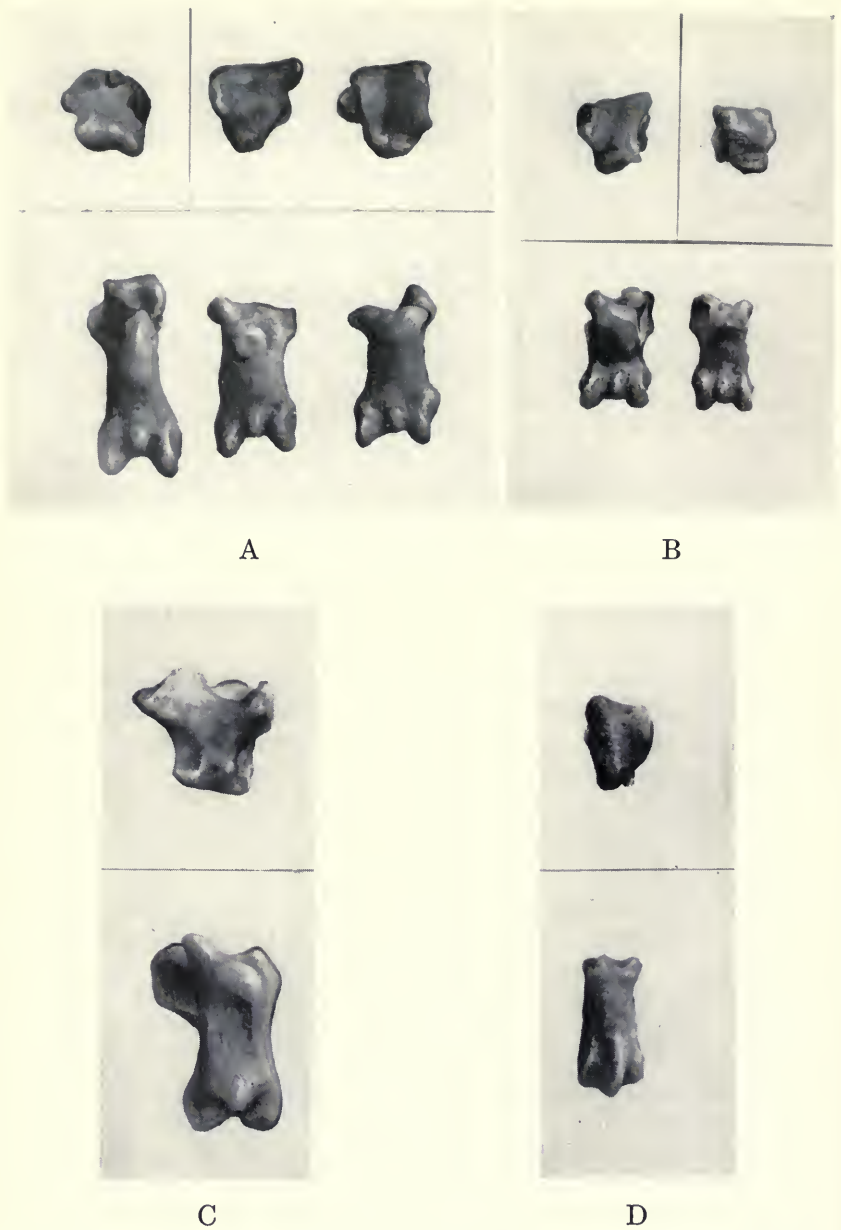


FIG. 26. Proximal and ventral aspects of the seven metacarpals. A, PM3887-PM3889, the type A metacarpals. B, PM3890 and PM3891, the type B metacarpals. C, PM3885, the metacarpal with the "immobile" distal articular surface. D, PM3886, the metacarpal with the high keel. All approximately $\times 5.3$.

is sharply characterized by a distal articular surface possessing a high median keel which is remarkable in that it continues proximally from the distal end of the bone nearly to the mid-ventral point of the shaft. Well-developed distal median keels occur on metacarpals in which lateral movement must be restricted (for example, in fleet artiodactyls and perissodactyls, and in some diggers, such as the myrmecophagids).¹ Usually the keel is intimately related to a well-developed roll-joint that allows generous movement through a considerable arc in the plane of the joint but virtually excludes motion at any angle to that plane.

In PM3886, the kind and degree of development of the median keel are, so far as we know, unparalleled in the Mammalia. The closest approximations to its condition that we have found are in the anteaters *Tamandua* and *Myrmecophaga* and in the modern pangolin *Manis*. Metacarpals 2, 3, and 4 of *Manis* have a pronounced ventral development of the distal median keel which appears to strengthen the joint by eliminating all side play during extreme flexion. The elongation of the keel on the metacarpal, PM3886, doubtless served as a similar but even more effective strengthening device. On the dorsal part of this same joint surface the entire roller, keel included, ceases to follow the sweep of the curve of the roll-joint; instead, it runs a short distance dorsally as a flattened surface which acts as a stop and thereby prevents hyperextension of the joint. In this character it is quite unlike *Myrmecophaga*, *Tamandua* and *Manis*, which have a full roll-joint.

The phalanx (also PM3886; fig. 28) which we associate with this metacarpal fits it well; indeed, the two make a surprisingly nice contact. However, inasmuch as the angulations of metapodial keel and phalangeal groove are not perfectly aligned, the two bones probably were not originally adjacent elements in the same digit. In any event, they certainly must represent metacarpal and first phalanx of very similar digits in the same species. This proximal phalanx differs from any homologous bone known to us, however, in that the distal articular surface has a median keel similar to the keel on the metacarpal. Thus, the proximal articular surface of the next distal (second) phalanx must in turn have had a median groove. Such an inter-phalangeal, mortise-and-tenon type of joint is otherwise unknown to us.

¹ Within the Myrmecophagidae, *Cyclopes* shows the keel development; indeed, the distal ends of metacarpals 2 and 4 are comprised of this expanded median keel and of little else. The specialized third metacarpal of *Cyclopes* has also retained the keel. However, in this latter instance, instead of an arched roll-joint surface, the keel forms a flat crest, and there results a joint drastically limited in its movements.

(It should be noted that we make the assumption that this phalanx is a proximal one, because of the fit with the metacarpal and because it would be even more unusual for a more distal one to be so keeled.)

If the two metacarpal bones and the phalanx discussed above (as well as the five metacarpals yet to be considered) are truly from edentates, they must have belonged to species of the Palaeanodonta (as presently defined by Colbert, 1942), since the Xenarthra were limited to South America until the Pliocene. However, we here compare these metacarpals with those of some living xenarthrous edentates, as well as with those of the Eocene metacheiromyids, to get ideas on the types of morphological specialization possible in semifossorial edentates.

The edentates of the North American Oligocene are known from four skulls, representing two or possibly three genera of the palaeanodont family Epoicotheriidae.¹ While these animals were probably burrowers, we do not know the ecological environment (flood plain, forest, etc.) in which they burrowed, and thus cannot argue from the probability of burrowing to the probability of preservation. The specimens known to date have all been found in flood plain deposits. If the flood plain was their natural habitat the chances of preservation would have been good, and this combination of circumstances would argue for an actual low population density. However, if these four skulls represent strays from a different habitat or carcasses washed to their burial place, the lack of specimens is no indication of the actual original numbers. Thus, we have no basis for determining the original habitat or population density, but the facts remain that specimens of these animals are rare in flood plain deposits, and that none are known to us from Nebraska. Therefore, we argue that any random and unattached small bones found in the Chadronian of Nebraska are not likely to be those of an edentate. Even so, *all* of these metacarpals here being considered have a most typical "edentate-like" appearance.

The other five metacarpals (PM3887-PM3891; figs. 26, A, B, 29, B) have in common a basic similarity in appearance and proportions, and in addition each possesses a peculiar and pronounced knob-like process projecting from the mid-ventral aspect of the distal articular surface. Among Recent forms a similar process was found in the small South American armadillo *Tolypeutes* (fig. 29, C), although a

¹ The four skulls of Oligocene epoicotheriids known to us are the type specimens of *Epoicotherium* (Simpson, 1927) and *Xenocranium* (Colbert, 1942), plus two skulls as yet undescribed: one from the Yoder formation (earliest Oligocene) of Wyoming in the Museum of Geology, South Dakota School of Mines and Technology, and the fourth (UM483, CNHM), from the Chadron formation (Early Oligocene) of South Dakota.

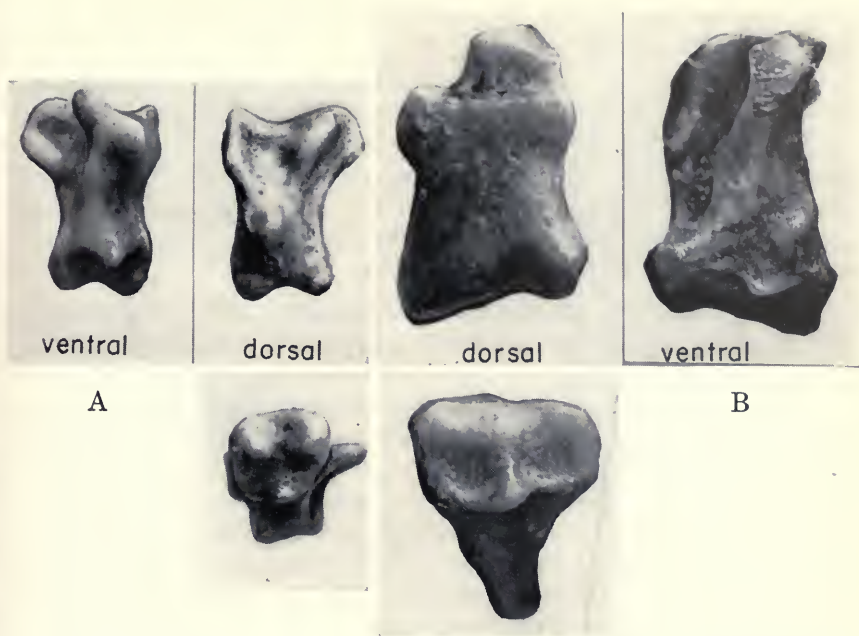


FIG. 27. Dorsal, ventral, and distal views of metacarpals with "immobile" distal articular joint. A, Fossil metacarpal, PM3885. B, Left fourth metacarpal of *Zaedyus pichiy*, CNHM 23809. All approximately $\times 5.3$.



FIG. 28. Dorsal and side views of keeled metacarpal and phalanx in articulation, PM3886, and a view of distal aspect of phalanx, showing keel. All approximately $\times 5.3$.

much smaller process is present in another small South American armadillo, *Zaedyus*. *Galliaetatus schlosseri*, a ?pholidotid from the Miocene of Europe (Ameghino, 1905; Matthew, 1918) also has a metacarpal with this same process and with the same squat proportions. This knob would seem to represent a remnant of the keel found distally on metacarpals of many mammals, but in these knobbed metacarpals (as in *Tolypeutes* and *Galliaetatus*) full flexion would have been seriously limited at that joint.

These five fossil metacarpals fall naturally into two size groups, which for convenience we shall call type A (the larger) and type B. These two types possibly belonged to two different but related kinds of animals; if so, the smaller was about one-half to two-thirds the size of the larger. Of the three type A metacarpals (PM3887-PM3889; fig. 26, A), two may reasonably be articulated at their adjacent proximal articular facets. The three differ in detail, but are of approximately the same size, indicating that the hand was probably not disproportionately specialized by a tremendous development of the middle finger, as in some anteaters. The two type B metacarpals are tentatively believed to be right and left representatives of the same skeletal element. The larger one (PM3890; figs. 26, B, 29, B), with the more pronounced features, we assume to be from an older individual; the other (PM3891; figs. 26, B, 29, B) we think was from a smaller, juvenile individual.

One further comment should be made as regards all of these metacarpals. More than one morphologically distinct type of metacarpal is known in the same hand in a number of Recent forms; for example, *Zaedyus* has a manus with a very reduced but otherwise generalized first digit, and the metacarpals of digits 2 and 3 have well-developed "normal" distal roll-articular surfaces. In contrast, as has been noted previously, on the metacarpal of digit 4, and on 5 to a lesser extent, very specialized distal articular surfaces exist—surfaces which morphologically are quite unlike those of the other metacarpals. Also the over-all proportions of metacarpals 4 and 5 are entirely different from the others, since they are extremely short and broad. Numerous other instances of this sort could be cited. Thus, some of these remarkably different types of metacarpals may actually go together, and it would not be absurd to think of the first two "individual" types as belonging to the same animal.

With regard to the metacarpals of types A and B the idea appealed to us—since humeri of a species of *Arctoryctes* were found in the same locality—that one of these sets of metacarpals might have

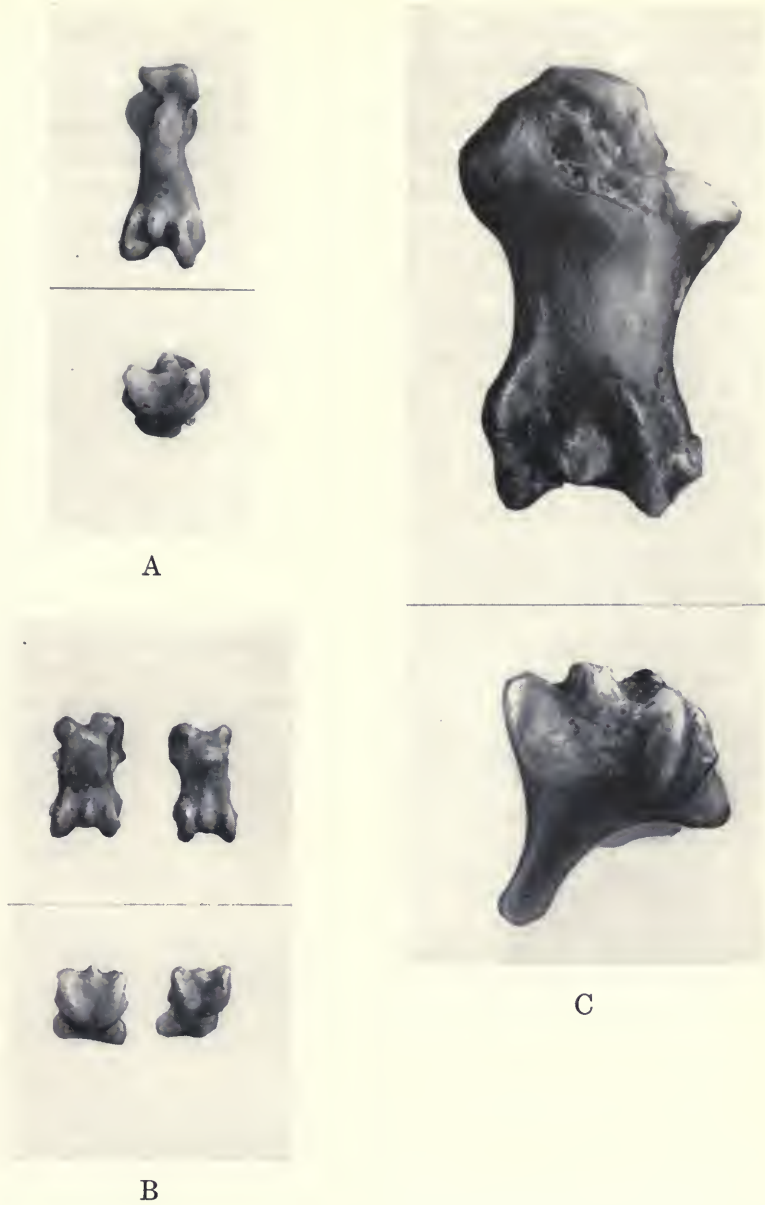


FIG. 29. Comparison of "knobbed" metacarpal of *Tolypeutes* sp. with the type A and type B fossil metacarpals, in ventral and distal aspects. All approximately $\times 5.3$. A, PM3887; B, PM3890 (left) and PM3891; C, *Tolypeutes* sp., CNHM 28342.

belonged to the same animal that had the humeri. Further, since the related but larger genus *Cryptoryctes* (Reed, 1954) is known to have lived in Chadronian time (to date known only from Montana, however), perhaps the larger metacarpals (type A) might have belonged to *Cryptoryctes* and the smaller ones to *Arctoryctes*. If we assume that the humerus of the Chadronian *Arctoryctes* was approximately the same length as was the humerus of the Orellan *A. galbreathi*, as it seems to be (fig. 24), then the average length of the metacarpals of type A is a trifle more than 30 per cent of the length of the humerus of *Cryptoryctes*, and the length of the metacarpals of type B is only a trifle less than 30 per cent of the humeral length of *A. galbreathi*. At first glance, the agreement at 30 per cent was enticing, but is this metacarpal/humeral relationship logical for small mammals as fossorially specialized as are *Arctoryctes* and *Cryptoryctes*?

Howell (1944, pp. 195-205) investigated the ratio between the functional lengths of humerus and metacarpus (using the longest metacarpal bone as a standard), in relation to locomotor behavior. He stated that in generalized mammals the metacarpus was usually between 25 and 33 per cent of the length of the humerus. He did not indicate, however, upon which "generalized mammals" he based this claim, nor are we certain that our concept of a "generalized mammal" would fit his or anyone else's ideas. The following metacarpal/humeral ratios are from mammals of several genera, whose behavior and whose limbs seemed to us to fit the "generalized" pattern.

Marsupialia

Didelphidae: *Didelphis*, 26.

Caenolestidae: *Caenolestes*, 27.5.

Insectivora

Erinaceidae: *Erinaceus*, 30; *Echinosorex*, 38.5.

Solenodontidae: *Solenodon*, 37.

Tenrecidae: *Hemicentetes*, 35.5.

Soricidae: *Crocidura*, 41; *Sorex*, 43.

Carnivora

Felidae: *Felis* (domestic cat), 33.5.

Mustelidae: *Gulo*, 32.5.

Rodentia:

Muridae: *Rattus*, 26; *Mus*, 32.5.

Cricetidae: *Peromyscus*, 28.5.

In taking measurements for the ratios presented we followed Howell's method and used the longest of the metacarpals, and measured the "functional length" of both bones. Usually a single ratio

represents measurements on only a single skeleton. We recognize that a much more thorough investigation could have been undertaken to determine differences and limits of variability within a genus as to species, sex, age, and individual factors. The survey presented here, however, is offered only as a preliminary one which serves the purpose of answering the original question we asked.

The range (26-43) of the above group is higher and broader than that (25-33) suggested by Howell; even if we remove the shrews as being too specialized because of small size, the range is still 26-38.5. Thus, within the group we have called "generalized" there are considerable differences in metacarpal/humeral ratios, arguing for more bio-mechanical variability within such a group than might at first be thought.

Howell did not present metacarpal/humeral ratios for animals that dig, and so we have presented them here for such of them as are available to us, using Ellerman (1956) as a guide to the more fossorial forms. It would not be expected that all digging animals would have the various segments of the forelimb in the same proportions, nor do they, inasmuch as digging is accomplished in at least three fundamentally different ways. These are: (1) the "rapid-scratch" or "terrier-type"; (2) the "lateral-push" or "talpid-type"; and (3) the "tooth-type," in which the incisor teeth are used to loosen the dirt; the forefeet in this latter type tend to be only secondarily specialized as burrowing organs. Following are the metacarpal/humeral ratios for a variety of mammals that dig:

Monotremata

Tachyglossidae: *Tachyglossus*, 18.

Marsupialia

Phascolomidae: *Phascolomis* (= *Vombatus*), 24.

Notoryctidae: *Notoryctes*, ca. 40. (We get ratios of 32.5 and 43, using pl. 6, figs. 7-8, Carlsson, 1904. The metacarpal in fig. 7 appears to be foreshortened, and we, therefore, place greater reliance on fig. 8.)

Necrolestidae: *Necrolestes*, 20 (measured on pl. 64, Scott, 1905).

Insectivora

Chrysochloridae: *Amblysomus*, 23.

Soricidae: *Blarina*, 38.

Tenrecidae: *Oryzorictes* (= *Nesoryctes*), 22.

Talpidae: *Scapanus*, 13.5; *Scalopus*, 14; *Neurotrichus*, 17.5; *Talpa*, 19; *Condylura*, 22; *Uropsilus*, 38. (*Uropsilus* probably does little burrowing; the measurements on *Scapanus* and *Neurotrichus* were taken from original drawings by Reed.)

Edentata

Myrmecophagidae: *Cyclopes*, 21; *Tamandua*, 26; *Myrmecophaga*, 33.

Dasypodidae: *Zaedyus*, 20; *Prionodontes*, 20; *Tolypeutes*, 27; *Dasybus*, 35.5.

Metacheiromyidae: *Metacheiromys*, 24.5 (measured on figs. 16-17, Simpson, 1931); *Palaeonodon*, 28.5 (measured on figs. 59 and 61, Matthew, 1918).

Pholidota

Manidae: *Manis*, 20.5.

Incertae sedis: *Galliaetatus* metacarpus/*Teutomanis* humerus, 26.5 (measured on figs. 1 and 49, Ameghino, 1905; we feel justified in calculating a metacarpal/humeral ratio from two of Ameghino's genera on the basis of Schlosser's statement [1907] that the bones in question all came from the same skeleton. If, instead of the metacarpal which Ameghino designated as the type of *G. schlosseri*, we use the metapodials claimed by Schlosser to be metacarpals [figured by Ameghino as metatarsals (fig. 11), then changed back again to metacarpals by Schlosser (1907); see Matthews, 1918, p. 645, for summary] we get a metacarpal/humeral ratio of 25).

Carnivora

Mustelidae: *Meles*, 25; *Taxidea*, 29.

Lagomorpha

Leporidae: *Oryctolagus*, 35.

Rodentia

Aplodontidae: *Aplodontia*, 28.

Sciuridae: *Citellus*, 29; *Marmota*, 30; *Tamias*, 32.5; *Eutamias*, 35; *Cynomys*, 36.

Geomyidae: *Geomys*, 32.

Castoridae: *Castor*, 26.5.

Cricetidae: *Notiomys*, 29.

Spalacidae: *Spalax*, 28.

Rhizomyidae: *Tachyoryctes*, 28.

Dasyproctidae: *Cuniculus*, 31.5.

Chinchillidae: *Lagostomus*, 26.

Octodontidae: *Spalacopus*, 28.

Bathyergidae: *Cryptomys*, 34.5.

Of the above, the Talpidae are "lateral-thrust" diggers and *Spalax*, *Tachyoryctes* (probably), and *Cryptomys* excavate with their incisors; all the others presumably are "rapid-scratch" diggers. One can see at a glance in looking at the specimens, that there are wide extremes in some families, caused primarily by variations in the length of the longest metacarpal. The spread in families noted for their diggers is broad and overlaps that of the generalized forms. Good burrowers or diggers thus need not have an exceptionally low metacarpal/humeral ratio. Animals burrow in different ways, and each uses its limbs for other purposes, too; thus, the functioning morphology is a result of selection from several sources.

Cryptoryctes and *Arctoryctes* were, however, highly specialized burrowers, with talpid-type digging mechanics (in so far as we know), closely analogous to the most specialized of the talpids, and so one would expect that the metacarpus might also have been relatively short. It would appear, then, that 30 per cent is perhaps too high

for a metacarpal/humeral ratio for *Cryptoryctes* and *Arctoryctes*, although we cannot state that it is impossibly high. We must, therefore, make it clear that the idea that the metacarpals of type A may go with *Cryptoryctes* and those of type B with the Chadronian *Arctoryctes* remains both intriguing and possible, but that the metacarpal/humeral ratio does argue against such a conclusion. (Actually, the shorter metacarpals of type B would seem to be of a better length to match the humerus of *Cryptoryctes*, since this particular index is 23.)

SUMMARY AND CONCLUSIONS

An intensive study has been made of 15 small bones, the "scrap" left from a much larger collection of Chadronian fossils from Nebraska (Hough and Alf, 1956). Recognized were two partial lizard humeri, two partial rodent humeri, and two partial humeri of the fossorial mammal *Arctoryctes*, hitherto known only from the middle Oligocene and the early Miocene. Another of the bones is suggested to be a radius of *Arctoryctes*. Of the remaining bones, one is a phalanx and seven are metacarpals, of three distinct morphologic types. Two of these types are represented by a single bone each, while the third group consists of five bones of two different sizes.

These foot-bones are most similar to those of the edentates that dig or open termite nests. Edentate fossils are rare in the North American Oligocene, however, and the possibility was investigated that certain of these bones may have belonged to the manus of *Arctoryctes* and certain others to the related Chadronian *Cryptoryctes*. No conclusion is possible on the basis of the present material, but we feel that this association is possible, in spite of the relatively high metacarpal/humeral ratio.

We believe that it is useful to attempt to reconstruct functional anatomical units from such miscellaneous associated but non-articulated materials as we had here. In fact, in those cases for which no articulated skeletal materials have been found, the methods of comparative anatomy are the only ones capable of offering clues as to what the animals, represented by the fragments, might have been like or how they might have lived. In this way, rare or allochthonous members of a fossil assemblage might be recognized, whereas otherwise they might be overlooked.

Obviously, in this instance, we need more facts, and these can be acquired only by more intensive collecting and more intensive morphologic and faunistic study of the remains collected, particularly of

post-cranial parts of skeletons. Both of us have seen vertebrate paleontologists discard in the field multiple small bones which were not immediately recognizable, and there has been a tendency to ignore non-articulated, post-cranial parts of small forms, even if collected. We suggest that such "trash" accumulated over the years from the same collecting sites may well be a fruitful source from which to articulate—by logical inferences as based on comparative anatomy and relative numbers—skeletons of small forms never found naturally articulated.

Figures 26–29 are all retouched photographs. We wish to thank Miss Maidi Wiebe, staff artist, Department of Geology, for the art work in the retouching.

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