were derived roughly as an emergency measure not only for detecting significant cycles, but even more for checking the exuberant production of cycles claimed without adequate tests, or, worse, after misleading applications of distorted *periodogram* tests.

PALEONTOLOGY.—*A new mustelid carnivore from the Neocene beds of northwestern Nebraska.*[1] C. LEWIS GAZIN, U. S. National Museum.

In the spring of 1935 the U. S. National Museum purchased from Mr. Ted Galusha of Hay Springs, Nebraska, a fossil mustelid skull from the later Tertiary of Nebraska. The specimen was found in a draw to the south of Antelope Valley, near the center of the southern half of Sec. 30, T. 31 N., R. 47 W., Dawes County, Nebraska. The deposits at this locality are believed to be equivalent to the Snake Creek beds, but the horizon represented in this series is not definitely known. The age is apparently upper Miocene or possibly lower Pliocene.

The skull is unique in comparison with living forms and is distinct from known skulls of fossil mustelids, and although comparisons with fossil forms known only from lower jaws are difficult, and perhaps unsatisfactory, an analysis of the requirements for dental occlusion apparently eliminates it from previously described genera.

Craterogale,[2] n. gen.

Type.—*Craterogale simus.*

Generic characters.—Skull short and broad; strong postorbital processes and rugged, separate temporal ridges; prominent lambdoidal crests and mastoid processes; zygomae deep, powerful, and widely expanded; infraorbital foramen of moderate size and nearly circular; basicranial region short with large bullae firmly fused to surrounding elements; bullae project markedly downward, forward, and slightly inward, with antero-externally directed foramen through projected portion; audital tube short; foramen ovale, foramen lacerum medius, and eustachian foramen closely grouped; dental formula $\frac{?\text{-}1\text{-}3\text{-}1}{}$; teeth small and stout; P^3 relatively small; P^4 with small parastyle, deuterocone well forward, and without tetartocone; M^1 with elongate external portion, conspicuous parastyle, and moderately large heel which is expanded anteroposteriorly to about the same extent as the external portion; protocone of M^1 large and hypocone less prominent.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received February 17, 1936.

[2] Derived from the Greek *krateros*, strong, *gale*, weasel.

Craterogale simus,[3] n. sp.

Type.—Nearly complete skull, U.S.N.M. no. 13801, including P^3 to M^1 on both sides.

Horizon and locality.—Snake Creek (?) beds, Upper Miocene or Lower Pliocene, Dawes County, Nebraska.

Specific characters.—Only known species; size of skull approximately one-fifth larger than that of *Mephitis nigra*, but much more rugged; P^2 to M^1 about 24 mm. Other specific characteristics are not clearly discernible in the absence of additional species.

Description of skull.—The skull of *Craterogale simus* is intermediate in size between that of a fisher, *Martes pennanti*, and of a martin, *Martes americana*, but relatively much broader and more rugged than either. The skull is proportioned somewhat more as in *Mephitis*, though larger, and with a breadth suggestion of the felids.

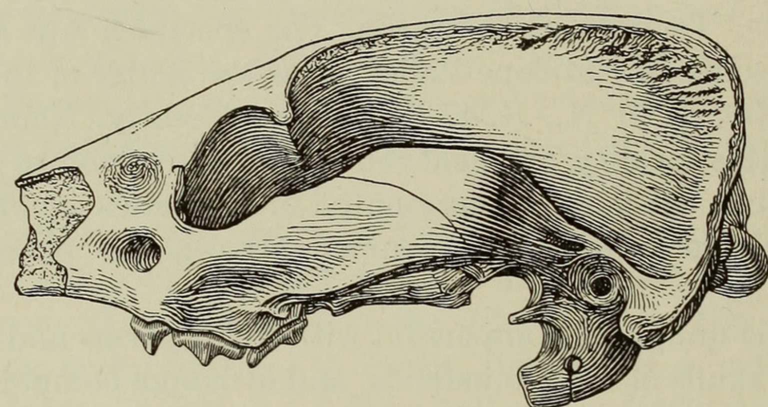

Fig. 1.—*Craterogale simus*, n. gen. and sp. Skull, type specimen, U.S.N.M. no. 13801, lateral view, natural size. Upper Miocene or lower Pliocene, Dawes County, Nebraska. Drawing by Sydney Prentice.

The rostrum is short and broad with prominent pre-orbital or lachrymal fossae. The orbital cavities, though open posteriorly, are well defined by prominent postorbital processes of the frontals and noticeable, but less developed, processes on the jugals. The anterior margin of the orbit is interrupted by a marked outward and upward projection of the lachrymal bone. Laterally the maxillae join deep and powerful zygomae. The relative development of the zygomatic arch is not approached in any of the living mustelids and its depth is actually equal to or greater than that in much larger individuals of the wolverine. On its anterior and ventral surface the zygoma shows a marked excavation, presumably for attachment of the anterior masseter lateralis. The infraorbital foramen is of moderate size, nearly circular, and terminates anteriorly above P^3. On the dorsal surface of the rostrum the premaxillae project backward between the nasals and maxillae to a point of contact with the frontals. In some mustelids, as in the Mephitinae the premaxillae apparently do not extend so far back, but in the Lutrinae, for example, both conditions are found.

The cranial portion of the skull is moderately elongate and not greatly inflated, much less so than in *Lutra* or *Taxidea*. The dorsal surface of the cranium is characterized by strong, outstanding temporal ridges, more

[3] Derived from the Greek *simos*, snub-nosed.

rugged than in *Helictis*, extending from the prominent postorbital processes and remaining separate to the occipital crest. The ridges most closely approach one another at a point slightly posterior to the postorbital constriction and are most outstanding near the occipital crest. A weak sagittal crest is present from about the postorbital constriction to the occiput.

The posterior or occipital portion of the skull exhibits heavy lambdoidal crests which extend from the temporal ridges at the top of the occiput in diverging, nearly straight lines to the prominent mastoid processes. These ridges project outward and backward to a marked degree. The paroccipital processes, just posterior and median to the mastoid processes, are not completely preserved but do not appear to have been developed so strongly as the mastoid processes. The surface of the occiput shows a moderately in flated median ridge from the foramen magnum below to the crest of the occiput. The foramen magnum and the occipital condyles are of moderate size and the surface of articulation extends entirely around the lower margin of the foramen.

The palate is broad and short, though relatively a little longer than in *Mephitis*, and shows a prominent groove on each side extending forward from the principal posterior palatine foramina. These foramina are located inward from about the middle of the carnassials, not so far forward as in the otters and skunks, nor so posteriorly placed as in the badgers. The portion of the palate extended posterior to the dentition is noticeably concave transversely and projects backward to a point about equivalent to that in *Lutra* or *Helictis*, more than in *Mephitis*, and distinctly less than in many forms such as *Tayra*, *Grisonella*, *Taxidea*, *Meles*, and the fisher, *Martes pennanti*. The width of the posterior narial opening is about as in *Mephitis* or *Conepatus*, but with no indication of the partition conspicuous in the mephitines. Between the molar tooth and the posterior narial opening, on each side of the extended portion of the palate, is a small though conspicuous process, apparently defining the antero-ventral limit of the origin or attachment of the pterygoid muscles. A similar process is present on the external surface of the pterygoid plate, on the antero-dorsal margin of the pterygoid fossa opposite the hammular process. These appear well defined in comparison with living mustelids.

Perhaps the most striking character of the skull is the extent to which the bullae project below the basis cranii. The bulla appears well inflated, relatively perhaps as much as in *Taxidea*, with a more transversely compressed portion extending downward, forward and slightly inward. Just below the inflated portion the tympanic exhibits a large foramen directed outward and forward from the medial surface. The osseous portions extending downward behind and in front of this aperture are tightly closed below but not coossified. Apparently this remarkable development on the tympanic is due to a muscular attachment along the ventral margin, possible extending back nearly or entirely to the base of the paroccipital process. In all probability this muscle was the digastricus. Such a marked development at its origin would be entirely in keeping with the unusual development indicated for the masseter and temporalis. The digastricus usually originates at the paroccipital process, but according to Windle and Parsons[4] in terrestrial carnivora it also arises "often from the contiguous paramastoid and bulla tympani." Reighard and Jennings[5] note that in the cat the digastricus originates

[4] Windle, B. C. A., and Parsons, F. G. Proc. Zool. Soc. London, pp. 376–377. 1897.

[5] Reighard J., and Jennings, H. S. *Anatomy of the Cat*, p. 107, New York, 1929.

"from the outer surface of the jugular (paroccipital) process of the occipital bone, and by tendon from the tip of the mastoid process and from the ridge between the mastoid and jugular processes." This latitude for attachment in carnivora leads one to suppose that in this instance the origin of the digastricus extended well forward on the bulla. Other muscles originating in this region, with forward insertions, such as the styloglossus and stylohyoid, are not eliminated but it seems unlikely that these would be developed to the extent indicated by the process on the bulla.

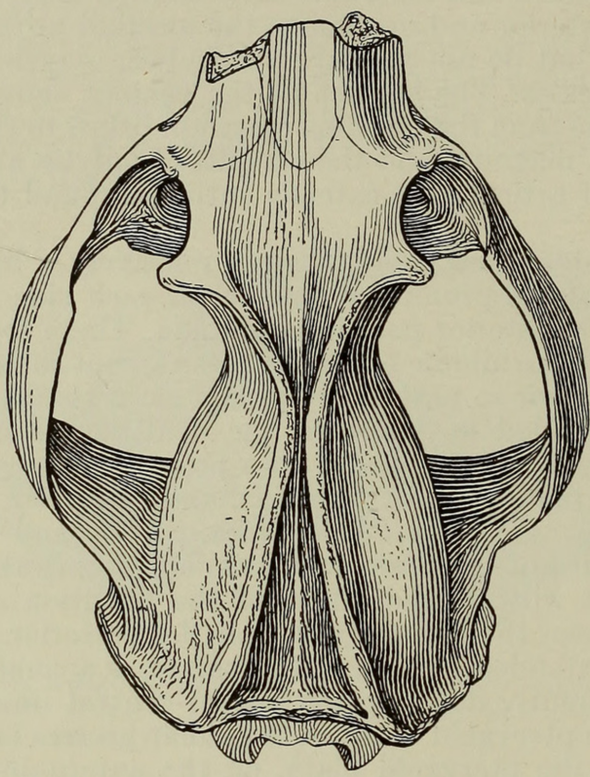

Fig. 2.—*Craterogale simus*, n. gen. and sp. Skull, type specimen, U.S.N.M. no. 13801, dorsal view, natural size. Upper Miocene or lower Pliocene, Dawes County, Nebraska. Drawing by Sydney Prentice.

The foramen enclosed by the ventral projection from the tympanic is relatively large. Its direction and position suggest that it may have carried the external carotid artery. After leaving the side of the trachea this artery turns outward, gives off various branches including the internal carotid and occipital arteries, passes deep to the digastricus and between the digastricus and styloglossus. Assuming that the muscle which has its origin on the bulla was the digastricus, the external carotid in maintaining its normal relations would have either passed through the foramen or anterior to the bulla and thence external to the styloglossus and the bones of the hyoid. If the styloglossus muscle in part originated at or near the mastoid process and the stylohyoid bone was attached in a normal position near the stylomastoid foramen then the external carotid in passing through the foramen in question would be in a position to meet these conditions with the least deviation from its normal course. The inferred course of the external carotid through the foramen which is approximately in its normal path seems likely inasmuch as the position of the artery would have been established in the tissue before ossification had surrounded the vessel. If it could be demonstrated that the carotid ascended external to the bulla then the foramen might have been occupied by the posteriorly directed internal carotid and occipital arteries.

The jugular veins are apparently eliminated as possibilities since the internal jugular passes posteriorly from the foramen lacerum posterius and the external jugular descends superficial to the position in question. Of the nerves which pass forward from the vicinity of the foramen lacerum posterius only the ninth and twelfth, the glossopharyngeal and hypoglossal, are not entirely eliminated, but these would apparently descend to the vicinity of the pharynx and then forward to the tongue, and not outward enough to have gone through the foramen in the projected portion of the bulla.

The bullae in *Craterogale simus* are of additional interest in being so completely fused with the adjacent bone elements, apparently a strengthening associated with the muscular attachment to the bullae. Medially the bullae join the basioccipital and basisphenoid forming a nearly smooth, transversely concave surface. Postero-externally and posteriorly the prominent mastoid process and incomplete paroccipital process are separated from the bulla by an acute notch, but at the roots of these processes the mastoid and exoccipital bones are firmly joined to the bulla. Anteriorly and antero-externally the bulla is strongly united to the alisphenoid and squamosal. The anterior margin of the bulla is not curved backward dorsally to meet the alisphenoid and squamosal, and does not exhibit a transverse fissure as observed in forms having inflated bullae, such as *Taxidea, Gulo,* and *Martes,* but is extended forward, lapping out on the postero-ventral surface of the postglenoid almost or quite to its anterior margin (a condition noted by Matthew[6] in *Leptarctus*).

The external audital tube is short due to the inflation of the bulla, and is solidly joined to the adjacent squamosal and periotic bones, quite filling the space between the zygomatic and mastoid processes. The meatus is moderately large, nearly circular and directed outward about perpendicular to the median vertical plane of the skull, not forward as in so many of the mustelids.

The glenoid surface is well developed, with a relatively broad postglenoid process as in *Mephitis* and with the anterior margin of the fossa extended forward uniformly about as in *Martes.* The outer portion of the anterior margin is prominent but does not recurve to form a locking joint as in *Lutra* and *Gulo.*

As general in mustelids the alisphenoid canal is absent, unless its openings are entirely concealed in the recesses of the foramen rotundum and foramen ovale, which seems unlikely. The opening of the optic foramen occupies a position farther forward from the foramen lacerum anterius than in *Mephitis* but relatively not so far forward as in *Martes.* The foramen lacerum anterius and foramen rotundum are separate but placed very close together. Posterior to these and at the antero-median margin of the bulla the foramen ovale, eustachian foramen, and foramen lacerum medius are very closely grouped together. The foramen ovale opens unusually close to the eustachian foramen, closer than in *Mephitis,* and is separated from this opening and the foramen lacerum medius by a thin plate of bone which extends forward as a ridge to form the posterior margin of the pterygoid plate. The small posterior opening of the carotid canal is forward of the foramen lacerum posterius about one third of the distance to the foramen lacerum medius. Be-

[6] MATTHEW, W. D. Bull. Amer. Mus. Nat. Hist., 50: 138–146. 1924.

cause of the obliterated contact between the bulla and the basioccipital and basisphenoid the elements forming the canal cannot be certainly determined but the position of the canal opening on the bulla suggests that it was probably entirely within the bulla. The small condylar or hypoglossal foramen is situated close to the postero-median margin of the large foramen lacerum posterius. In this respect its position is similar to that in *Martes* and some of the other genera of mustelids. In specimens of *Mephitis* examined the condylar foramen is much closer to the condyles. The stylomastoid foramen is partially obscured in the deep cleft between the bulla and the ridge connecting the paroccipital and mastoid processes. In the case of the postglenoid foramen a somewhat anomalous condition exists in which the postglenoid or temporal canal opens in two positions on both sides. In one position the opening is approximately as in *Lutra, Taxidea,* and *Gula,* antero-ventral to

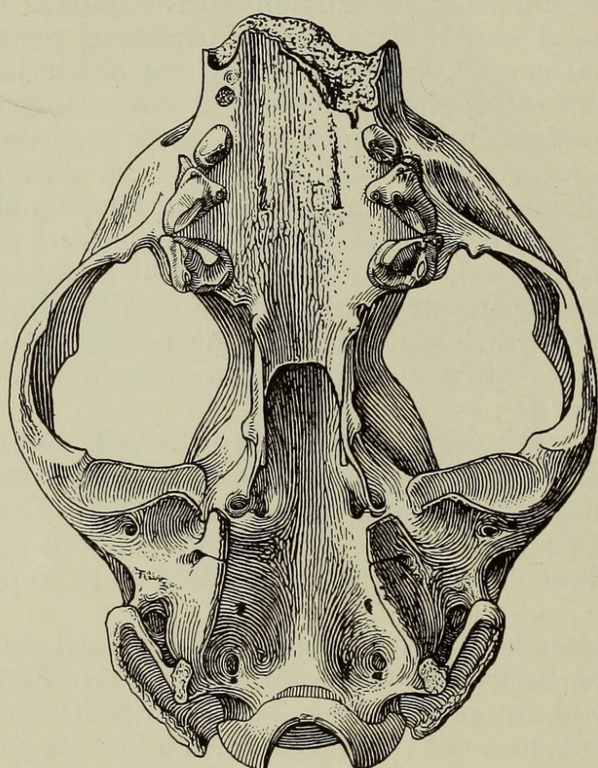

Fig. 3.—*Craterogale simus,* n. gen. and sp. Skull, type specimen, U.S.N.M. no. 13801, ventral view, natural size. Upper Miocene or lower Pliocene, Dawes County, Nebraska. Drawing by Sydney Prentice.

the audital tube, but is very close to the postglenoid process. In the second position, antero-dorsal to the audital tube and along the posterior wall of the zygomatic process of the squamosal, the opening is similar to that in *Mephitis.* The two openings though widely separate at the surface presumably join beneath the included segment of the audital tube which has fused to the squamosal. A similar condition was observed in a recent skull of *Taxidea taxus.*

Description of teeth.—The type of *Craterogale simus* exhibits the 3rd and 4th upper premolars and the 1st molar on both sides, and alveoli for the canine and 2nd premolar. In all probability the completed formula was as follows: $I\frac{3}{3}$, $C\frac{1}{1}$, $P\frac{3}{3}$, $M\frac{1}{2}$. The combination of cheek teeth is common among mustelids, occurring typically in such genera as *Mustela, Mephitis, Spilogale,* and *Taxidea.*

The teeth, though sturdy, are small considering the muscular development indicated for the lower jaw. P^2, as shown by the alveoli, was two rooted, with the anterior root small and placed inward from the canine alveolus. P^3 is simple, without accessory cusps or styles, and exhibits a slight cingulum around the medial and posterior margin of the tooth. This tooth is separated by a short diastema from the posterior alveolus of P^2.

The carnassial is moderately low crowned and in occlusal view is nearly triangular in outline. The shearing blade is relatively broad transversely, and blunt, although the bluntness may be largely due to wear. The deuterocone (or protocone) is a distinct conical cusp placed well forward at the antero-lingual angle of the tooth, much as in *Martes* and *Mustela*, farther forward than in *Mephitis*. The lingual margin of the tooth posterior to the deuterocone is almost a straight line, with no appreciable indentation to set off the deuterocone such as observed in *Martes*. This inner portion of the tooth is without talon or tetartocone, but exhibits a weak cingulum for a short distance posterior to the deuterocone. The anterior margin of the tooth, extending from the deuterocone to a weak parastyle at the antero-external angle of the tooth, is only slightly indented, much less so than in *Martes* or *Mustela*. On this portion of the tooth margin the cingulum is conspicuous, and continues around on the outer surface, becoming weaker posteriorly.

The molar tooth is relatively large, with the outer portion distinctly long anteroposteriorly and the summits of the paracone and metacone well spaced. The portion of the tooth extending outward from the ridge connecting the paracone and metacone projects prominently forward and outward from the paracone, forming a conspicuous style at the antero-buccal angle of the tooth. The lingual portion of the tooth is well developed, but the heel is not so markedly expanded as in *Lutra*, *Taxidea*, or *Conepatus*, though almost as much as in *Mephitis*. The fossil molar, however, does not show the median anteroposterior constriction seen in *Mephitis* and many other mustelids. The protocone is prominent and rather centrally placed as compared with *Mephitis* and *Lutra*. It may be noted that the antero-ventral surface of the ridge connecting the protocone to the paracone is considerably worn. The hypocone is moderately developed but is not expanded so prominently as in *Mephitis* and *Lutra*. A moderate cingulum extends forward from the hypocone, around the antero-lingual side of the protocone, but its development is not comparable to that in *Martes* and *Mustela*. The ridge extending buccally from the posterior extremity of the hypocone is also noticeably worn, presumably through occlusion with M_2.

Comparisons with fossil forms.—Of the comparisons which may be made with other fossil mustelids, that with *Leptarctus* is among the most pertinent. *Craterogale simus* shows a striking resemblance in skull structure to *Leptarctus primus*, as illustrated by Matthew,[7] but exhibits a distinctly different type of dentition. Points of similarity between the two are seen in the short and broad skull, deep and widely expanded zygomae, prominent postorbital processes, separate and rugged temporal ridges, heavy lambdoidal crests, short basicranial region with large bullae which are markedly fused with the postglenoid processes, very short audital tube, and in the absence of P^1 and M^2. No detailed comparisons with the bullae can be made since these elements are incomplete in the *Leptarctus* skull. *Craterogale simus* differs from *Leptarctus primus* in a narrower postorbital constriction, less widely sepa-

[7] Matthew, W. D. Bull. Amer. Mus. Nat. Hist., 50: 138–146, fig. 37, 1924.

rated temporal ridges (perhaps a matter of age), a less convex profile antero-posteriorly along the temporal ridges and dorsoventrally along the lambdoidal crests, P^4 without tetartocone (hypocone), and M^1 shorter and relatively wider transversely. The dental structure in *Craterogale* is more nearly that of a typical mustelid, whereas that in *Leptarctus* makes a closer approach to certain of the Melinae.

Among the other mustelids known from the Snake Creek beds, *Mionictis* makes the nearest approach to the type of lower dentition presumed for *Craterogale*, and comparisons between the two forms are not entirely satisfactory. The species of *Mionictis* are of relatively small size, though actually larger than *Craterogale simus*. The premolars are three in number and do not have accessory cuspules, but the premolar series is relatively longer and the premolars relatively larger and more elongate than would be expected in *C. simus*. The lower carnassial in species of *Mionictis* has a large talonid, as seems evident for *C. simus*, but the length of this tooth in the smallest of the two forms, *Mionictis elegans*, is 11 mm. The length of this tooth in *C. simus* apparently could not have been greater than about 9 1/2 mm and was probably about 8 1/2 mm.

Plionictis is one of the better known upper Miocene mustelids, having as its type *P. ogygia*[8] which is represented by both skull and mandible. The skull of *Craterogale simus* is quite unlike that of *Plionictis ogygia* in the development of the zygomae, and in having rugged temporal ridges. Moreover, the upper molar in the *Plionictis* skull is much shortened anteroposteriorly. This and other characters in both upper and lower dentitions of *Plionictis* are modifications in the direction of *Mustela*.

Craterogale is distinct from *Brachypsalis* in having a more reduced dentition. The maxillary portions referred by Matthew to species of *Brachypsalis* show alveoli for a second molar, and the upper carnassials and molars in these specimens belong to much larger species than *C. simus*. The upper carnassials in the species referred to *Brachypsalis* are illustrated[9] as having more medially extended deuterocones, and the first upper molars show a less prominent antero-buccal angle, a stronger hypocone, and a more outstanding cingulum antero-medial to the protocone.

The species of *Sthenictis* are characterized by a less reduced lower premolar series as are species of *Martes*, unlike the shortened type of jaw which is evident for *Craterogale*. The lower carnassial in *Sthenictis bellus* and *S. dolichops* from the Sheep Creek and lower Snake Creek horizons respectively, and in the similar *Cernictis hesperus*[10] from the Pliocene of California, has a relatively smaller talonid than is indicated for *Craterogale*.

Plesictis[11] from the Oligocene of Europe exhibits marked temporal ridges, and the upper carnassial, though relatively longer, resembles that in *Craterogale*. However, the skull of *Plesictis* is more elongate, has weaker zygomae, four instead of three premolars, and the bullae, though inflated, do not project ventrally as in *Craterogale*. M^1 in *Plesictis genettoides* is relatively short and transversely wider, with a somewhat less expanded heel than in *Craterogale*.

Remarks.—The relationships of *Craterogale simus* are obscure, due largely

[8] Matthew, W. D. Mem. Amer. Mus. Nat. Hist. **1** (7): 383–384, figs. 8–9, 1901.

[9] Matthew, W. D. Ibid., pp. 131–134, figs. 29–33, 1924.

[10] Hall, E. R. Jour. Mammalogy **16**: 137–138. 1935.

[11] See H. Helbing, Abh. schweiz. palaeont. gesells. **50**: 1–21, pls. 1–4, 1930; and J. Viret, Ann. Univ. Lyon, n. s. fasc. **47**: 166–183, pl. 15: pl. 16, figs. 1–2; pl. 30, figs. 1–4, 1929.

to the incomplete nature of so much of the fossil mustelid material which has been described from North America. It is possible that *Craterogale* is related to *Mionictis*, but this can not be demonstrated from the known material. On the other hand the structural similarity between this skull and that of *Leptarctus* as far as known seems more than mere coincidence, although the teeth are very distinct. However, the differences between the dentitions may not be much greater than between some mustelid genera which have been referred to the same subfamily, such as between *Meles, Helictus, Arctonyx,* and *Taxidea,* or as between *Lutra, Latax,* and *Enhydriodon.*

The skull characters exhibited by *Craterogale,* which possesses a truly mustelid dentition, furnish additional evidence for mustelid affinities of *Leptarctus.* Moreover, the cranial characters of *Leptarctus,* as described and figured by Matthew, seem to warrant recognition of a separate subfamily, the Leptarctinae, to which *Craterogale simus* may be referred tentatively.

Measurements (in millimeters) of Skull of Craterogale simus

Length from anterior margin of nasals to occipital condyles	79.2
Length of nasals	17.3
Distance from anterior margin of nasals to line between postorbital processes of frontals	27.3
Distance from postorbital processes to posterior margins of lambdoidal crests	49.6
Width between orbits	21.8
Width at postorbital constriction	15.5
Width across zygomatic arches	61.0
Greatest depth of zygomatic arch	13.8
Width across mastoid processes	41.2
Width across occipital condyles	19.4
Depth from temporal crests to ventral extremities of bullae	41.3
Distance from posterior margin of palate to foramen magnum	38.0
Width of palate between molars	14.3
Length of cheek tooth series, P^2–M^1	24[a]
P^3, anteroposterior diameter	5.0
P^3, transverse diameter	3.0
P^4, anteroposterior diameter parallel to outer wall	7.7
P^4, greatest length over deuterocone	8.7
P^4, transverse diameter perpendicular to outer wall	5.6
M^1, anteroposterior diameter perpendicular to anterior margin	5.8
M^1, greatest diameter	9.6
M^1, transverse diameter perpendicular to outer margin	7.2

[a] Approximate

BOTANY.—*Three new grasses from Mexico and Chile.*[1] Jason R. Swallen, Bureau of Plant Industry.

Among the grasses in a recent collection of plants made by Francis W. Pennell in Mexico, were two new species of *Muhlenbergia.* One of these was found in the Sierra Gazachic, 35 kms. southwest of Minaca, Chihuahua, and the other in the Sierra Madre Occidental, near El Salto, Durango. The third species here described was collected at Cajon de los Pelambres, Dept. Illapel, Chile, by G. Looser.

[1] Received February 14, 1936.