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A NEW PLEISTOCENE FAUNA AND NEW SPECIES
OF FOSSIL SNAILS FROM THE HIGH PLAINS

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NUMEROUS Pliocene and Pleistocene mollusks from southwestern Kansas and the adjacent part of Oklahoma have been collected by Dr. Claude W. Hibbard, of the University of Michigan Museum of Paleontology, in the course of studying the paleontology and stratigraphy of the area. From this material a new Pleistocene assemblage, the Berends fauna, is named in this paper. Descriptions of new species from other faunas are appended, together with lists of the associated mollusks. These associates are only listed for the present; it is hoped that a fuller discussion will be possible at a later date.

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BERENDS FAUNA

The name Berends fauna is proposed here for the vertebrates and mollusks known from deposits in secs. 5 and 6, T. 5 N., R. 28 E., Beaver Co., Oklahoma. A late Pleistocene age for the beds is indicated by the fact that they were laid down in a sink or series of sinks which were developed after the deposition of the underlying late Kansan Pearlette ash. The fauna is considered to be probably of Illinoian age on the basis of the vertebrates (Hibbard, 1953). The mollusks indicate a cool moist climate, which is more likely to be glacial than interglacial. The presence of extinct species not known from Wisconsin deposits also supports the assignment of an Illinoian age to the fauna.

The fauna is named for Berends Sand Draw, on the Coy Berends ranch, where the deposits containing the fauna occur.

PREVIOUS WORK.—Most of the mollusks discussed here and the previously reported vertebrates (Mengel, 1952; Rinker and Hibbard, 1952)

were collected by Claude W. Hibbard and a University of Michigan Museum of Paleontology field party on July 24, 1950. *Paradipoides stovalli* Rinker and Hibbard occurred at the base of the mollusk-bearing silt horizon in these deposits. A second field party under the direction of Hibbard visited this horizon again on July 6, 1952. A small amount of surface collecting yielded *Microtus*, unstudied bird remains, and a few mollusks represented by the previous collecting.

MOLLUSKS OF THE BERENDS FAUNA.—In the following discussion the species name is followed by the University of Michigan Museum of Zoology catalogue number and the number of specimens examined. Geological ranges are based on the collections of this institution, unless otherwise indicated. Outlines of Recent ranges, unless stated otherwise, are based on the collections of the Academy of Natural Sciences of Philadelphia, University of Michigan Museum of Zoology, and the United States National Museum.

Fresh-water Snails

Valvatidae

Valvata tricarinata (Say). 177523, 18. Geological range: Lower Pliocene Laverne fauna to Recent. Recent distribution: "Eastern United States west to Iowa; Great Slave Lake south to Virginia and the Ohio River" (Baker, 1928:14). Ecology: A species found only in permanent lakes and rivers.

Lymnaeidae

Lymnaea caperata Say. 177524, 25. Upper Pliocene unnamed fauna above Rexroad fauna to Recent. "Quebec and Massachusetts west to California; Yukon Territory and James Bay south to Maryland, Indiana, Colorado, and California" (Baker, 1928:263). "In the Mississippi Valley this species seems to almost invariably occupy intermittent streams or small pools, ponds and ditches which dry up in the summer" (Baker, 1928:263).

Lymnaea obrussa Say. 177525, 23. Nebraskan Sand Draw fauna to Recent. "From the Atlantic to the Pacific oceans, and from Mackenzie Territory, Canada, south to Arizona and northern Mexico" (Baker, 1928:296). "The normal habitat of this species is in small bodies of water, as creeks, ponds, sloughs, bays, and marshy spots along river banks. It is at home on sticks, stones, and any other debris that may be in the water or along its edge" (Baker, 1928:296).

Lymnaea turritella Leonard. 177526, 37. The University of Michigan Museum of Zoology has specimens representing this species from the

upper Pliocene Saw Rock Canyon and Rexroad faunas, Nebraskan Sand Draw fauna, Kansan Cudahy fauna, Sangamon Jinglebob fauna (reported by van der Schalie, 1953:84, as *Lymnaea* cf. *galbana* and *L. humilis modicella*), and Wisconsin deposits in Jones Sink, Meade Co., Kansas (not with certainty from the Jones fauna level). This range is given for a concept of the species which allows for only moderate variation; a greater allowance for variation would increase the range.

Lymnaea palustris (Müller). 177527, 40 juvenile; 177548, 2 adult. Upper Pliocene Rexroad fauna to Recent. "Eastern Quebec west to Nebraska, Manitoba south to southern Illinois and southern Kansas. The typical habitat of *reflexa* in northern Illinois and Wisconsin is in small pools or ponds which may become more or less dry in summer" (Baker, 1928: 224). *L. reflexa* is considered a synonym of *L. palustris* by Hubendick (1951).

Planorbidae

Gyraulus circumstriatus (Tryon). 177528, about 300. Kansan Cudahy fauna to Recent. North America approximately between 40° and 50° N. lat.; south in the Rocky Mountains to central New Mexico. Ecology uncertain.

Gyraulus parvus parvus (Say). 181106, 31. Kansan Cudahy fauna to Recent. "Eastern North America east of the Rocky Mountains from Florida northward to Alaska and northern British America" (Baker, 1928:377). "Usually in quiet bodies of water, often of small size . . . *parvus* is partial to a habitat which has rather thick vegetation" (Baker, 1928:376-77).

Armiger crista (Linné). 177529, 7. Probably Illinoian, Berends fauna to Recent. Holarctic; in North America north of about 41° N. lat.; south of this parallel in central Utah and San Mateo Co., California. Ecology uncertain.

Helisoma trivolvis (Say). 177530, fragments and 4 immature; 177549, 4 adult. Kansan Cudahy fauna to Recent. "Atlantic coast and Mississippi River drainages, northward to Arctic British America and Alaska and southward to Tennessee and Missouri" (Baker, 1928: 332). "Typical *trivolvis* is always an inhabitant of quiet, more or less stagnant water" (Baker 1928:332).

Planorbula vulcanata Leonard. 177531, about 150, only 10 adult. 177550, 1 adult. Kansan Cudahy fauna to Illinoian Berends fauna.

Promenetus pearlettei (Leonard). 177532, 44. Kansan Cudahy fauna to Berends fauna (probably Illinoian).

Physidae

Physa elliptica Lea. 177534, 38, only 9 adult. Nebraskan Sand Draw fauna to Recent. Recent distribution uncertain, but probably over a large area in the central and northeastern United States. "It is an inhabitant of brooks, living either on mud or stones, and it lives also in stagnant, ephemeral pools" (Leonard, 1950:22).

Physa skinneri, new species. Described below; 111 specimens. Nebraskan Sand Draw fauna to probably Illinoian Berends fauna.

Aplexa hypnorum (Linné). 177535, 27, of all ages. Nebraskan Sand Draw fauna to Recent. Holarctic; in North America "from east of the Cascade Mountains to the Atlantic and from Alaska and Hudson Bay south to the vicinity of the Ohio River" (Baker, 1928:474). ". . . a species of swales and intermittent streams or stagnant pools . . . especially abundant in woodland pools which become dry in summer . . ." (Baker, 1928:474).

Land Snails

Pupillidae

Gastrocopta armifera (Say). 177536, 1. Lower Pliocene Laverne fauna to Recent. "Eastern United States and Canada: Quebec to northern Florida, west to Red Deer, Alberta, Dakota, near Boulder, Colorado, Lincoln Co., New Mexico, and the mouth of the Pecos River, Texas" (Pilsbry, 1948:875). "*Gastrocopta armifera* is a gregarious species occurring commonly on wooded slopes, near or removed from a stream. It is to be found under dead wood, limestone rocks, or light cover of leaf mold or other debris" (Franzen and Leonard, 1947:329).

Gastrocopta procera (Gould). 177537, 3. One specimen approaches *G. cristata* Pilsbry and Vanatta in having the angular and parietal parts of the lamella only slightly divergent. Kansan Cudahy fauna to Recent; a closely related and possibly identical form occurs in the upper Pliocene Saw Rock Canyon and Rexroad faunas. "Eastern United States, Maryland to South Carolina, west to Shawnee Co., Kansas, and Payne Co., Oklahoma; south to Alabama and eastern Texas" (Pilsbry, 1948:907). "This pupillid lives on timbered slopes of streams" (Franzen and Leonard, 1947:342).

Gastrocopta tappaniana (C. B. Adams). 177538, 42. Upper Pliocene Saw Rock Canyon fauna to Recent. "Ontario and Maine to Virginia and Alabama, west to South Dakota and Kansas, southwest to Arizona, but not known from the southeastern Atlantic States, Virginia to

Florida" (Pilsbry, 1948:889). "Its most frequent habitat is on shaded slopes near streams" (Franzen and Leonard, 1947:337).

Pupoides albilabris (C. B. Adams). 177539, 1 fragment. Lower Pliocene Laverne fauna to Recent. "Eastern North America from Ontario and Maine to the Gulf of Mexico, west to the Dakotas, Colorado, and western Arizona (Yuma Co.); in northern Mexico on islands in the Gulf of California, at Monterrey and Tampico. Cuba; Haiti; Porto Rico; Bermuda" (Pilsbry, 1948:923). "This species, tolerant of high summer temperatures and drought, is found in woodlands, in deep grass, or even among the roots of short grass in unshaded areas" (Franzen and Leonard, 1947:371).

Vertigo ovata (Say). 177540, 51. Lower Pliocene Laverne fauna to Recent. "Prince Edward I. and Ungava Bay, Labrador, south to Florida Keys and Texas, west to Puget Sound and northern Oregon, southwest to Fruita, Utah, Tempe and Huachuca Mts., Arizona. Alaska on Kadiak and Tigalda Is. West Indies" (Pilsbry, 1948:953). ". . . lives only in moist environs afforded by shaded slopes near streams and shores of ponds" (Franzen and Leonard, 1947:355).

Succineidae

Succinea cf. *grosvenori* Lea. 177541, 4 immature. Succineidae can be reliably identified only by dissection of animals; hence work with fossils is open to serious question. Shells similar to *S. grosvenori* are known since the lower Pliocene Laverne fauna. Pilsbry (1948:821) stated: "*S. grosvenori*, as now understood, tolerates an astonishingly wide range in practically all external conditions. It occurs from the warm humid Gulf coast to semi-arid areas in the great plains and mountain states, and in British America it extends north within the border of Northwest Territory."

Oxyloma haydeni (Binney). 177542, 52, immature and fragments; 177551, 1 adult. Kansan Cudahy fauna to Recent. Distribution uncertain; the type locality is in Nebraska, between the Loup Fork and L'Eau qui Court rivers. Ecology unknown; presumably it is semiamphibious like others of the genus.

Endodontidae

Helicodiscus parallelus (Say). 177543, 1. Kansan Cudahy fauna to Recent. Eastern North America as far west as South Dakota and Oklahoma, south to Georgia and Alabama (Pilsbry, 1948:626). "It lives on decaying wood in shady or humid places, also on damp leaves" (Pilsbry, 1948:627).

Limacidae

Deroceras cf. *laeve* (Müller). 177544, 6. Fossil slug shells from the High Plains may be divided into three categories: (a) *D. aenigma* Leonard: larger shells, about 5 by 3 mm., thick and heavy; (b) smaller shells, about 3.5 by 2 mm., thick or thin, which probably represent immature *D. aenigma* Leonard in at least some cases; (c) smaller shells, sometimes of the size of form *b*, but sometimes also broader (4 by 2.5 mm.), and very rarely thickened, termed *D. cf. laeve* (Müller).

The stratigraphic occurrence of these categories as indicated by specimens in the University of Michigan Museum of Zoology is as follows: (a) Saw Rock Canyon, Rexroad, Sand Draw, and Jinglebob faunas; (b) Saw Rock Canyon, Rexroad, Sand Draw, and Cudahy faunas; (c) Berends and Jinglebob faunas.

Large specimens were used for specific allocation of entire lots, except where there was no intergradation, as in the Jinglebob fauna. Small unidentifiable specimens are referred to the species clearly established for the horizon, with the following distribution:

Deroceras aenigma Leonard. Upper Pliocene Saw Rock Canyon and Rexroad faunas, Pleistocene Sand Draw (Nebraskan) and Jinglebob (Sangamon) faunas, and (?) Cudahy (Kansan) fauna.

Deroceras cf. laeve (Müller). Probably Illinoian Berends fauna and Sangamon Jinglebob fauna. *D. laeve*, the only native *Deroceras* in eastern North America, is found "generally from the Arctic to middle Florida and Central America, the southern limit not determined" (Pilsbry, 1948:540).

Zonitidae

Hawaiiia minuscula (Binney). 177545, 38. Upper Pliocene Saw Rock Canyon fauna to Recent; lower Pliocene Laverne fauna (Leonard and Franzen, 1944:29). "North America from Alaska and Maine to Costa Rica; . . . West Indies" (Pilsbry, 1946:421). "Its most common habitat is in woodlands of oak, hickory, and sycamore" (Baker, 1939:72).

Polygyridae

Stenotrema leai (Binney). 177546, 1 adult, 8 young, and fragments; 177552, 2 adult. Kansan Cudahy fauna to Recent. Ontario and New York south to Maryland, west to South Dakota and eastern Kansas (Pilsbry, 1940:678). "The habitat . . . is in lowlands, usually on the floodplains of rivers and creeks or the margins of lakes, in woodlands of oak, hickory, elm and willow" (Baker, 1939:60).

INTERPRETATION OF MOLLUSKS.—*Age*. Of the 25 species of mollusks recorded from the Berends fauna, 22 are now living, and three are extinct and unknown from Wisconsin deposits. As discussed later, the

mollusks are indicative of a climate which was probably glacial. In the stratigraphically defined post-Kansan time in which the Berends fauna lived there are two such periods, Illinoian and Wisconsin. The three extinct forms, *Planorbula vulcanata*, *Physa skinneri*, and *Promenetus pearlettei*, are not known from Sangamon or Wisconsin deposits. These species thus indicate an Illinoian age for the fauna.

Local habitat. Fourteen aquatic and 11 terrestrial species compose the Berends mollusk fauna. The presence of fresh-water snails which inhabit shallow water, also the unworn condition of all land snails and the abundance of some indicate that the deposit is of near-shore origin. Deposition of the sediments in a sink or series of sinks, as well as the presence of the mollusks characteristic of standing waters, shows the presence of a lake.

Seven species of fresh-water snails are of no use in habitat interpretation, because of uncertainty of identification, lack of definitive information (*Lymnaea turritella*, *Gyraulus circumstriatus*, *Armiger crista*, *Planorbula vulcanata*, *Promenetus pearlettei*, *Physa skinneri*), or a wide range of habitat (*Physa elliptica*). Three species require a permanent water habitat (*Valvata tricarinata*, *Gyraulus parvus*, *Helisoma trivolvis*), three are characteristic of temporary ponds (*Lymnaea caperata*, *L. palustris*, and *Aplexa hypnorum*), and one is frequently in marginal areas of ponds (*L. obrussa*).

These data are interpreted to mean that the Berends fauna fresh-water mollusks lived in a habitat which had shallow permanent and temporary water near the shore of a lake, with little or no rough water. Connection of this lake to a permanent stream at some time is indicated by *Valvata*, which must have continuity in aquatic conditions.

Four species of land snails are also at present of no use in habitat reconstruction, because of uncertainty of identification, lack of information (*Succinea* cf. *grosvenori*, *Oxyloma haydeni*, *Deroceras* cf. *laeve*), or a wide range of habitat (*Pupoides albilabris*). The ecology of the other species indicates a probable association with moist leaf mold and rotting wood. Hence, there must have been a wooded zone, not necessarily extensive, beside the lake.

Climate. The following species of mollusks from the Berends fauna are considered useful for climatic interpretations: *Valvata tricarinata*, *Lymnaea caperata*, *L. palustris*, *Gyraulus circumstriatus*, *Armiger crista*, *Aplexa hypnorum*, *Gastrocopta procera*, *Stenotrema leai*. The remaining species are considered of no value on account of uncertainty of identification, lack of data, or wide range.

The interpretation of the distributional data made here is based on the assumption that species live wherever possible in the area accessible to them. Many of the species have a wide north-south distribution and thus live under varied climatic conditions. Of the remainder, two species occur in the central United States; all others show a distinctly northern distribution. The most reasonable explanation for this distribution seems to me to be climatic. The occurrence in Oklahoma of these forms which are now northern appears to indicate that the climate under which they lived there was not merely more humid than at present, but was also cooler, for almost all of these forms live well north of the latitude of Oklahoma even where the climate is definitely humid.

Gastrocopta procera ranges from Texas to Kansas in the High Plains area; *Lymnaea palustris* is widely distributed in the northern United States, but is found as far south as Kansas. The southern limits of distribution for the distinctly northern forms are as follows: *Valvata tricarinata* and *Aplexa hypnorum*, Ohio River; *Stenotrema leai*, eastern Kansas; *Lymnaea caperata*, about 39°; *Gyraulus circumstriatus*, about 40°; *Armiger crista*, about 41°.

These distributional data seem to indicate that the climate under which the Berends fauna mollusks lived was similar to that now found at least 5° farther north, with more moisture than is usually present in the High Plains. Such a cooler, moister climate appears more likely glacial than interglacial.

This interpretation of the climate is of special interest when compared with that postulated for the immediately preceding and subsequent faunas. No mollusks are known from the Yarmouthian Borchers fauna (Hibbard, 1949:76), but the vertebrates indicate a warm temperate assemblage (Hibbard, 1949a:1424).

The Jinglebob fauna, a pre-Wisconsin interglacial assemblage, must come from part of the Sangamon if only four major glaciations are assumed. The large molluscan fauna was discussed by van der Schalie (1953), who concluded (p. 85) that it represented "a warm and moist climate in a wooded region containing temporary woods pools."

VERTEBRATES OF THE BERENDS FAUNA.—The following list of the vertebrates is taken from Mengel (1952) and Rinker and Hibbard (1952), with the addition of the *Microtus* collected subsequently.

Osteichthyes

Perca cf. *flavescens* (Mitchill)

Reptilia

Turtle remains

Aves

Pelecanus erythrorhynchos Gmelin

Other remains

Mammalia

Microtus pennsylvanicus (Ord)

Castoroides sp.

Paradipoides stovalli Rinker and Hibbard

Equus sp.

Mammuthus cf. *columbi* Falconer

The distribution of *Perca* and *Microtus* is of interest in interpretation of paleoecology. The range of *Microtus pennsylvanicus* as given by Burt and Grossenheider (1952:123) shows it to be an essentially northern species, coming south in the High Plains to Nebraska. Distributional data given by Jordan and Evermann (1896:1024) indicate that the native range of *Perca flavescens* in the High Plains does not extend as far south as Kansas. Later southern records are probably due to artificial introductions. These vertebrate ranges substantiate further the postulation of a cooler, moister climate, as was previously indicated by the mollusks recovered there.

Physa skinneri,¹ new species

HOLOTYPE.—UMMZ 181292. Paratypes: UMMZ 177533; others to be deposited in Harvard University Museum of Comparative Zoology and the United States National Museum.

HORIZON AND TYPE LOCALITY.—Pleistocene, probably Illinoian age, Berends fauna. SE. cor. sec. 6, T. 5 N., R. 28 E., Beaver Co., Oklahoma. Type series collected by Claude W. Hibbard and party, 24-7-1950.

DIAGNOSIS.—A species distinguished by its small size (less than 5 mm.), narrow ovoid form, and obtusely rounded apex. It apparently has no close relatives.

DESCRIPTION OF TYPES.—Shell small, narrowly ovoid, polished; apex obtusely rounded. Whorls about three, gently and regularly convex, slowly enlarging, at first overlapping; body whorl over three-fourths of total shell length. Suture weakly impressed, slightly descending at first but later more strongly; above periphery of first whorl, at periph-

¹ Named for Morris F. Skinner, Frick Laboratory, American Museum of Natural History, who has contributed greatly to knowledge of the Pleistocene of the High Plains.

ery of later whorls. Aperture narrowly elongate; outer lip slightly convex, more strongly so toward base; base strongly rounded; inner lip nearly straight or with a pronounced angle at junction of columella and parietal lip; peristome usually heavily callused in larger specimens, in which case the suture descends slightly at the callus; parietal wall covered by a thin callus. Nucleus smooth; later sculpture of very fine, indistinct growth lines occasionally cut by very faint, short segments of spiral striae between which growth lines may be locally more prominent.

MEASUREMENTS.—The mean of 21 adults of three whorls is followed by the range in parentheses. These are judged to be adult because they usually have a heavy peristome callus and because specimens with more whorls are rare. Measurements are given in millimeters. Length, 3.7 (3.0–4.3); width, 2.0 (1.7–2.5); length of aperture, 2.2 (1.7–2.6); width of aperture, 1.1 (0.8–1.3).

VARIATION.—The proportions vary slightly, as indicated by the measurements, but the obtuse apex is constant. In the shorter shells the shallow suture gives an almost unbroken curve from apex to base. Sometimes an earlier peristomal callus is visible through the shell. The callus is accompanied by the usual brief descent of the suture, which thereafter ascends and resumes the former angle of descent.

COMPARISON.—From the commonly associated *Physa elliptica* Lea and *P. anatina* Lea, *P. skinneri* differs in its smaller size, narrower form, obtuse and rounded apex, regularly convex whorls, and proportionately smaller aperture.

OCCURRENCE AND MATERIAL.—Pleistocene, Sand Draw fauna, late Nebraskan age, Brown Co., Nebraska: NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 12, T. 31 N., R. 23 W. (100 specimens, UMMZ 177339); NW. $\frac{1}{4}$ sec. 33, T. 31 N., R. 22 W. (3, UMMZ 177322); center N. side sec. 34, T. 31 N., R. 22 W. (100, UMMZ 181232); SE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 27, T. 31 N., R. 22 W. (25, UMMZ 181137); NW. cor. SW. $\frac{1}{4}$ sec. 25, T. 31 N., R. 22 W. (100, UMMZ 181216); center S. side NW. $\frac{1}{4}$ sec. 25, T. 31 N., R. 22 W. (4, UMMZ 177433); SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 4, T. 30 N., R. 21 W. (20, UMMZ 177233).

Cudahy fauna, late Kansan age: NE. $\frac{1}{4}$ sec. 26, T. 32 S., R. 28 W., Meade Co., Kansas (50, UMMZ 177249 and 177273). Probably Cudahy fauna: W. $\frac{1}{2}$ sec. 35, T. 33 S., R. 32 W., Seward Co., Kansas (17, UMMZ 177297).

Berends fauna, probably Illinoian age, SE. cor. sec. 6, T. 5 N., R. 28 E., Beaver Co., Oklahoma (type series of 111 specimens).

Gastrocopta (*s. s.*) *lavernensis*,² new species

HOLOTYPE.—UMMZ 181274. Paratypes: UMMZ 181275.

HORIZON AND TYPE LOCALITY.—Lower Pliocene, Laverne formation. NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 5, T. 3 N., R. 28 E., Beaver Co., Oklahoma. Type series collected by Claude W. Hibbard and party, 24–7–1950.

DIAGNOSIS.—A species most closely related to the lower Pleistocene *Gastrocopta chauliodonta* Taylor and to the Pleistocene to Recent *G. procera* (Gould). It is characterized by the bifid anguloparietal lamella, descending columellar lamella, absence of a subcolumellar lamella, and long, narrow, curved, very deeply immersed lower palatal fold.

DESCRIPTION OF TYPES.—Shell small, cylindrical, rimate; apex obtuse. Whorls about five, convex, slowly and regularly enlarging; sutures strongly impressed; body whorl less than half of total shell length, about one-half whorl behind aperture becoming flattened and then slightly concave in the middle of the outer side, convex again at a low, rounded crest just behind the reflected peristome. Sculpture of nuclear whorl minutely granular; postnuclear sculpture of fine, irregular, oblique growth lines. Aperture slightly oblique, rounded, with dentition of five folds and lamellae, as follows: a prominent, bifid, sinuous anguloparietal lamella, angular part directed toward the outer lip, the parietal part toward the base of the columella; a tubercular upper palatal fold immersed behind the palatal callus; a very deeply immersed (dorsal in position), long, curved, deeply entering lower palatal fold, increasing in height abruptly and decreasing gradually, the inner half approximately parallel to the base and roof of the body whorl; a tubercular basal fold immersed equally with the upper palatal fold; columellar lamella elongate, usually entering horizontally, abruptly descending the columella to its base. Inner and outer lips moderately callused except in the conspicuous sinus.

MEASUREMENTS.—The mean of the 13 whole specimens in the type series is followed by the range in parentheses. Measurements are given in millimeters. Length, 2.58 (2.3–2.8); width, 1.24 (1.2–1.3); length of aperture, 0.91 (0.9–1.0); width of aperture, 0.84 (0.7–0.9); number of whorls, 5.1 ($4\frac{3}{4}$ – $5\frac{1}{2}$).

VARIATION.—The lower palatal fold varies in length and in amount of curvature. The inner part is approximately parallel to the suture, but the outer part diverges at from 0° to 40° from the inner part. In one specimen the basal fold is barely visible as an inconspicuous node.

² Named for the Laverne formation, in which it occurs.

The columellar lamella may enter horizontally, in which case the inner half turns downward abruptly, or it may descend gradually.

COMPARISON.—*Gastrocopta lavernensis* differs from *G. chauliodonta* Taylor in its less massive lamellae and peristome callus, bifid anguloparietal lamella, less deeply immersed basal fold and tubercular upper palatal fold. The two species share a descending columellar lamella; very deeply immersed, long, curved lower palatal fold; absence of a subcolumellar lamella; and a similar size and shape.

G. lavernensis differs from *G. procera* (Gould) in its proportionately wider shell, descending columellar lamella, absence of a subcolumellar lamella, and longer, curved, and more deeply immersed lower palatal fold.

OCCURRENCE AND MATERIAL.—*Gastrocopta lavernensis* is known only from the type series of eighteen specimens, five incomplete.

ASSOCIATED FORMS.—About 150 pounds of dirt from the type locality of *Gastrocopta lavernensis* were washed through screens. The mollusks contained in this material represent all of the species listed by Leonard and Franzen (1944) for the fauna as a whole with the exception of *Hawaiiia minuscula* (Binney). The following new records for the fauna were also found:

- Valvata tricarinata* (Say)
- Lymnaea* cf. *modicella* Say
- L. (Stagnicola)* sp.
- Gyraulus* sp.
- Vallonia* sp.
- Gastrocopta armifera* (Say)
- G. contracta* (Say)
- G. cristata* Pilsbry and Vanatta
- Pupoides* cf. *inornatus* Vanatta
- Succinea* cf. *grosvenori* Lea
- Hawaiiia minuscula neomexicana* (Cockerell and Pilsbry)
- Retinella* sp.
- Zonitoides arboreus* (Say)

Gastrocopta (*s. s.*) *chauliodonta*,³ new species

HOLOTYPE.—UMMZ 181120. Paratypes: UMMZ 181121.

HORIZON AND TYPE LOCALITY.—Pleistocene, late Nebraskan age, Sand Draw fauna. Center of S. side of NW. $\frac{1}{4}$ sec. 25, T. 31 N., R. 22 W.,

³ *Χαυλιόδων*, with a projecting tooth; in reference to the especially prominent anguloparietal lamella.

Brown Co., Nebraska. Exposure on east side of tributary of Sand Draw. Type series collected by Claude W. Hibbard and party, 22-8-1950.

DIAGNOSIS.—A species most closely related to the lower Pliocene *Gastrocopta lavernensis* Taylor and to the upper Pliocene *G. paracristata* Franzen and Leonard. It is characterized by the massive anguloparietal lamella which almost hides the deeply immersed palatal folds, the descending columellar lamella, and the absence of a subcolumellar lamella.

DESCRIPTION OF TYPES.—Shell small, cylindrical, rimate; apex obtuse. Whorls about five and one-half, convex, slowly and regularly enlarging; sutures strongly impressed; body whorl less than half of total shell length, about one-half whorl behind aperture becoming flattened and then slightly concave in the middle of the outer side, convex again at a prominent, rounded crest just behind the reflected peristome. Sculpture of nuclear whorl minutely granular; postnuclear sculpture of fine, irregular, oblique growth lines. Aperture slightly oblique, rounded, with dentition of five folds and lamellae, as follows: a prominent, massive, sinuous anguloparietal lamella, gradually increasing in height and terminating abruptly, the angular part continuous with the parietal lip; a deeply immersed, small, lamelliform upper palatal fold of about equal length and height; a still more deeply immersed (dorsal in position) long, angulate, deeply entering, lower palatal fold, of about the same height as the upper palatal fold, increasing in height abruptly and decreasing gradually, the outer third ascending slightly, the inner two-thirds approximately parallel to the base and roof of the body whorl; a tubercular basal fold immersed equally with, or slightly more than, the lower palatal fold; all palatal folds situated well behind the palatal callus; columellar lamella heavy, elongate, descending the columella to its base. Inner and outer lips heavily callused except in the conspicuous sinus.

MEASUREMENTS.—The mean of the eleven whole specimens in the type series is followed by the range in parentheses. Measurements are given in millimeters. Height, 2.51 (2.2-2.7); width, 1.22 (1.1-1.3); height of aperture, 0.86 (0.7-0.9); width of aperture, 0.87 (0.8-0.9); number of whorls, $5\frac{1}{2}$ (5-6).

VARIATION.—The anguloparietal lamella varies in shape considerably. Usually the angular part is represented by a slightly prominent ridge which gives the lamella a sinuous appearance; sometimes this ridge is curved toward the outer lip and the lamella is bifid, the sinus almost completely enclosed; occasionally the whole lamella is nearly straight. The anguloparietal varies in width also, from about

one-fourth to one-sixth of the internal width of the aperture. The columellar lamella may enter horizontally, in which case the inner half turns downward abruptly, or it may descend gradually.

COMPARISON.—*Gastrocopta chauliodonta* differs from *G. lavernensis* Taylor in its more massive lamellae and peristome callus, simple anguloparietal lamella, more deeply immersed basal fold, and lamelliform upper palatal fold.

G. chauliodonta differs from *G. paracristata* Franzen and Leonard (1947:346) in its more massive anguloparietal lamella and peristome callus; deeply immersed palatal folds, not in contact with the callus as in *G. paracristata*; lamelliform upper palatal fold; longer, narrower, more deeply immersed, angulate lower palatal fold; and descending columellar lamella. In these other species, all the denticles are relatively conspicuous; in *G. chauliodonta*, however, the massive anguloparietal lamella and the deep immersion of the palatal folds give the species the first appearance of having but one lamella.

OCCURRENCE AND MATERIAL.—Sand Draw fauna, late Nebraskan age, Pleistocene; Brown Co., Nebraska. Center S. side NW. $\frac{1}{4}$ sec. 25, T. 31 N., R. 22 W. (type series of eleven whole specimens and the last two whorls of a twelfth); NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 12, T. 31 N., R. 23 W. (1 specimen, UMMZ 181204); NW. cor. SW. $\frac{1}{4}$ sec. 25, T. 31 N., R. 22 W. (1, UMMZ 181218); SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 4, T. 30 N., R. 21 W. (2 $\frac{1}{2}$, UMMZ 177236).

SUBGENERIC POSITION.—According to the diagnosis of *Gastrocopta* (*s.s.*) given by Pilsbry (1948:903), the group has a short, horizontal, columellar lamella. Both *G. lavernensis* and *G. chauliodonta* differ in possessing a columellar lamella which enters horizontally or nearly so and then descends to the base of the columella. This difference is not considered sufficient to warrant the establishment of a new subgenus, however. This is the only respect in which these two species differ from *Gastrocopta* (*s.s.*), and the divergences between the various subgenera are considerably greater than this relatively minor one.

ASSOCIATED FORMS.—The University of Michigan Museum of Zoology has material from several localities in Brown Co., Nebraska, representing the Sand Draw fauna. Only the species in addition to those listed by McGrew (1944) and Baker (1938) are given here:

Valvata tricarinata (Say)

Carychium perexiguum F. C. Baker

Lymnaea megasoma Say

L. obrussa Say

Helisoma anceps (Menke)

Planorbula sp.
Ancylus coloradensis Henderson
Ferrissia rivularis (Say)
F. cf. *pumila* (Sterki)
Physa elliptica Lea
P. skinneri Taylor
Aplexa hypnorum (Linné)
Vallonia pulchella (Müller)
Gastrocopta chauliodonta Taylor
Pupoides albilabris (C. B. Adams)
Vertigo milium (Gould)
Strobilops sparsicostata F. C. Baker
Succinea sp.
Deroceras aenigma Leonard
Hawaiiia minuscula (Binney)

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