

Late Paleozoic Ostracode Species From the Conterminous United States

GEOLOGICAL SURVEY PROFESSIONAL PAPER 711-B



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By I. G. SOHN

A REVISION OF THE PARAPARCHITACEA

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*Description of eight new species and reas-
signment of two species previously assigned
to Paraparchites*



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A REVISION OF THE PARAPARCHITACEA

LATE PALEOZOIC OSTRACODE SPECIES FROM THE CONTERMINOUS UNITED STATES

By I. G. SOHN

ABSTRACT

Growth stages of eight new species of ostracodes of Early Mississippian through Permian age from California, Indiana, Nevada, New Mexico, and Texas are described and illustrated; one species, *Shishaella* sp., from the Permian of Texas is illustrated but not formally named. *Paraparchites subcircularis* Geis, 1932, is considered a synonym of *P. carbonaria* (Hall, 1858), here referred to *Chamishaella*, and a lectotype for *C. carbonaria* is designated and illustrated. *Paraparchites marathonsensis* Hamilton, 1942, is reillustrated and referred to *Shishaella*. *Paraparchites humerosus* var. *kansasensis* Harris and Lalicker, 1932, is elevated to specific rank and is reillustrated. All three North American species of *Proparaparchites* Cooper, 1941, are reillustrated. The following are new: *Dorsoobliquella bachmani*, *Paraparchites gelasinos*, *P. miseri*, *Shishaella cooperorum*, *S. eureka*, *S. geisi*, *S. mackinneyi*, and *Shivaella macallisteri*.

INTRODUCTION

This part of the revision of *Paraparchites* and related genera deals with genera and species found in the conterminous United States. A few of the species from this area were described and illustrated in Sohn (1971) in order to document the genera described in that paper which deals primarily with Alaskan species. Some of the genera referred to the Paraparchitacea have not as yet been found in Alaska.

These genera, except *Pseudoparaparchites* Kellett, 1933, are here revised, and additional new species, as well as species transferred to the new genera established in Sohn (1971), are described and illustrated in this paper.

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COLLECTION LOCALITIES

Locality No.	Field No.	Stratigraphic position, description of locality, collector, and date
<i>USGS upper Paleozoic</i>		
1208.....		Spergen Limestone. Weingarten quadrangle, Ste. Genevieve County, Mo. North Gabouri Creek, about 2 miles west of the town of Ste. Genevieve, in creek, below oolite. Collected by G. H. Girty, Sept. 25, 1913. (See Cumings, 1922, p. 499-505.)
1211A.....		Spergen Limestone, upper 5 ft of oolite, below white limestone of quarry. Weingarten quadrangle, Ste. Genevieve County, Mo. Road to quarries, 2 miles south of Ste. Genevieve. Collected by G. H. Girty, Sept. 26, 1913.
6567.....		Limestone recurring in black shale in lower part of Diamond Peak Formation, approximately 200 ft above base. Eureka 15-minute quadrangle, White Pine County, Nev. Apparently just west of Bold Bluff and just east of fault—south of Diamond Peak. Collected by H. G. Ferguson and G. H. Girty, June 1928.
7522C (green).....		Salem Limestone. Washington County, Ind. Spergen Hill, railroad cut, Norris Station. Collected by F. C. Greene, Nov. 24, 1909. (See Cumings, 1922, p. 499-505.)
12848.....	1 of F-58-37	Hueco Limestone, gray calcareous shale, 6 in. to 1 ft thick at base of petroliferous limestone about 50 ft above base of Hueco Limestone. Escondido quadrangle, Otero County, N. Mex., east side of roadcut in E½ sec. 25, T. 19 S., R. 11 E. Collected by G. O. Bachman, 1958.
12849.....	2 of F-58-37	Hueco Limestone, thin-bedded petroliferous limestone about 6 ft thick, just above loc. 12848. Same locality and collector as above.

Locality No.	Field No.	Stratigraphic position, description of locality, collector, and date
<i>USGS upper Paleozoic</i>		
12855	3 of F-58-37	Hueco Limestone, limestone 6 in. to 1 ft thick directly above petroliferous limestone of loc. 12849. Same locality and collector as above.
12856	5/21/3/60	Getaway Limestone Member of Cherry Canyon Formation, slabs approximately in the middle of the Getaway Limestone Member. Culbertson County, Tex. Road to Guadalupe Summit beacon, from slope below road on flat area just before road climbs to beacon. Collected by I. G. Sohn, George Bachman, and Don Meyers, May 21, 1960.
12858		Tin Mountain Limestone, 10-ft interval, thin bedded, above massive crinoidal limestone. Ryan Quadrangle, Inyo County, Calif. Bat Mountain, Hill 2997. Collected by J. F. McAllister, 1965.
12863	10/29/11/66	Tin Mountain Limestone with cherty layers, 12.0-12.6 ft above base of unit t4. Same locality as 12858. Collected by I. G. Sohn and J. F. McAllister, Oct. 29, 1966.
12864	10/29/12/66	Tin Mountain Limestone, unit t4, 15.2-15.9 ft stratigraphically above base of unit. Same locality as 12858, about 40 ft south of 12863, along strike. Collected by I. G. Sohn and J. F. McAllister, Oct. 29, 1966.
12865	10/29/13/66	Tin Mountain Limestone, unit t4, 14.3-14.5 ft stratigraphically above base of unit. Same locality as above. Collected by I. G. Sohn and J. F. McAllister, Oct. 29, 1966.
12885	6/16/1/62	Upper Sandia Formation (Lower Pennsylvanian), approximately 50 ft above the base of 1,000-ft shale, probably more than 1,000 ft above base of the Pennsylvanian. Mora County, N. Mex. About ½ mile west of Holman Hill, in roadcut along old part (1962) of State Highway 3. Collected by G. O. Bachman, June 16, 1962.
12886	5/14/1/54	Salem Limestone, weathered and spalled. Washington County, Ind. Railroad cut south of Spergen Hill. Collected by I. G. Sohn and J. J. Galloway, May 14, 1954. (See Cumings, 1922, p. 499-505).
12879	10/31/5/66	Narrow Canyon Limestone, 4 in. limestone pod, 152 ft above base at type-locality. Mercury quadrangle, Clark County, Nev. In Narrow Canyon, approximate lat 36°42'10" N., long 115°53'27" W. Collected by I. G. Sohn, Mackenzie Gordon, Jr., and F. G. Poole, Oct. 31, 1966.
<i>USNM</i>		
702c		Base of Road Canyon Formation. Hess Canyon 7½-minute quadrangle, Brewster County, Tex. From knob on south side of road at elbow just west of south branch Hess Canyon, 4½ miles by road northeast of Hess gate, 1.35 miles S. 66.5° W. of Old Word Ranch, 4.03 miles N. 50° E. of Hess Ranchhouse. Collected by G. A. Cooper and various parties over some 30 years.
703a		Upper Cathedral Mountain Formation. Same area and collectors as above. About ¼ mile west of forks on road to Apple Ranch, near Old Word Ranch.
703c		Road Canyon Formation, sponge bed in basal part of dark platy limestone. Same area and collectors as above. Just above reefy beds on crest of slope on north side road, ¼ mile southwest of road fork near Old Word Ranch, 0.22 mile N. 1° E. of the ranch.
706		Willis Ranch Member of Word Formation. Same area and collectors as above. North slope of hill on south side of Hess Canyon, 4 miles N. 35° E. of Hess Ranch, 14 miles north-northeast of Marathon.
706e		Willis Ranch Member of Word Formation. Same area and collectors as above. East side of small arroyo, 4.1 miles (airline) N. 34° E. of Hess Ranchhouse.
726z		Road Canyon Formation. Same area and collectors as above. 1.03 miles N. 43° E. of Old Word Ranch, 0.53 mile S. 20° E. of hill 5461.
AMNH 501		Road Canyon Formation. Same area and collectors as above. 0.3 mile northwest of the Old Word Ranchhouse site. Same as Cooper 703 goniatite locality but from a different lens.
3069-2		Limestone in Helms Formation. El Paso quadrangle, El Paso County, west Texas; 1.1 miles west of Powwow Tanks, approximate lat 31°50'16" N., long 106°02'55" W. Collected by A. L. Bowsler, 1948.
3070-2		Limestone in Helms Formation. El Paso quadrangle, El Paso County, west Texas; 2½ miles west of Powwow Tanks, approximate lat 30°50'17" N., long 106°04'40" W. Stop 13, West Texas Geological Society Guidebook, Field Trip 5, 1949, and limestone bed 9, section "C", West Texas Geological Society Guidebook Field Trip, May-June 1946 (stop 1 on map accompanying that trip). Collected by A. L. Bowsler, 1948.

SYSTEMATIC DESCRIPTIONS

Class OSTRACODA, Latreille, 1802

In my previous discussion of the Ostracoda (Sohn, 1961b [1962], p. 111), I noted that Lalicker and Moore (in Moore and others, 1952, p. 470, 471) had raised the Ostracoda from subclass to class, and I then listed the group as a subclass because neontologists at that time considered the Crustacea, the next higher category, as a class. During the intervening years, the classification of the Arthropoda has been revised; the Crustacea have been elevated to superclass category and the Ostracoda to class category (Sharov, 1966, p. 1, 2; Manton in Moore, 1969, p. R13). Current research on the detailed anatomy of living ostracodes suggests that some of the groups hitherto classified as orders in the Ostracoda may differ sufficiently to be elevated to subclass

category. Pending completion of this research, the currently accepted ordinal classification in the Ostracoda is used in this study.

Order PODOCOPIDA Sars, 1866 Suborder unknown

Superfamily PARAPARCHITACEA Scott, 1959

See Sohn (1971, p. A5) for a discussion of this superfamily.

Family PARAPARCHITIDAE Scott, 1959

See Sohn (1971, p. A5) for a discussion of this family.

Genus PARAPARCHITES Ulrich and Bassler, 1906 emend Scott, 1959

See Sohn (1971, p. A5) for a discussion of this genus. Two new species from New Mexico—one from the Lower Pennsylvania the other from the Lower Permian—are described here.

Paraparchites gelasinos Sohn, n. sp.

Plate 1, figures 1-24

Name.—Gelasinos (Greek) for dimple.*Holotype.*—USNM 167982.*Paratypes.*—USNM 167976-167981.*Material.*—More than 65 steinkerns and partly abraded carapaces representing various stages of growth.*Type-locality.*—Northwestern Mora County, N. Mex., about half a mile west of Holman Hill, in road-cut along old part (1962) of State Highway 3 (USGS loc. 12885).*Type-level.*—Upper Sandia Formation (Lower Pennsylvanian), approximately 50 feet above the base of 1,000-foot shale unit, probably more than 1,000 feet above the base of the Pennsylvanian.*Diagnosis.*—Characterized by a dimplelike subcentral shallow horizontal groove.*Description.*—The carapace is elongate ovate in lateral outline; the greatest height being in front of midlength, resulting in an arched to gently curved dorsal margin. The ventral margin is gently convex; the curvature of the posterior margin is truncated towards the venter so that its greatest convexity is above midheight. The anterior margin starts at the point of greatest height, slopes gently downward anteriorly, then arches forward and downward to join the ventral margin; its greatest convexity is approximately at midheight. The dorsal outline is lanceolate, narrower towards the front, the greatest width being at or slightly behind midlength; the dorsum is relatively deeply incised. The overlapping valve overreaches the smaller valve along the free margins and abuts against a narrow selvage on the smaller valve. A shallow subcentral horizontal groove below midheight is developed on both valves.*Measurements (in mm).*—

	Greatest length	Greatest height	Greatest width
Paratype (pl. 1, figs. 1-5)	0.57	0.36	0.24
Paratype (pl. 1, figs. 6-10) .....	.82	.58	.36
Paratype (pl. 1, figs. 11-15)	1.05	.73	.48
Paratype (pl. 1, figs. 16-18)	1.45+	1.05+	.69+
Holotype (pl. 1, figs. 19-22)	1.75	1.16	.81
Paratype (pl. 1, figs. 23, 24)	1.94	1.2+	.80

Discussions.—The new species differs from *P. texana* Delo, 1930, by having a slightly more distinct dorsoposterior margin, by a more gently curved ventral margin, and by a more incised dorsum. Asso-ciated specimens of *Kirkbya* Jones, 1859, indicate that the species lived in a marine environment.*Stratigraphic range.*—Upper Sandia Formation (Lower Pennsylvanian).*Geographic distribution.*—Known only from the type-locality in Mora County, N. Mex.*Paraparchites kansasensis* Harris and Lalicker, 1932

Plate 1, figures 25-29

Paraparchites humerosus var. *kansasensis* Harris and Lalicker, 1932, Am. Midland Naturalist, v. 13, p. 396, pl. 36, figs. 1a, b. Wreford Limestone (Lower Permian), Cowley County, Kans.? *Paraparchites humerosus* var. *spinosus* Upson, 1933, Nebraska Geol. Survey Bull. 8, 2d ser., p. 12, pl. 1, figs. 2a, b. Funston Limestone (Lower Permian), Cowley County, Kans.? *Paraparchites humerosus* Ulrich and Bassler, 1906 [part], U.S. Natl. Mus. Proc., v. 30, p. 151, Wreford Limestone (Lower Permian), Butler County (probably Greenwood County), Kans.*Diagnosis.*—Dorsoanterior and ventroanterior margins of approximately equal curvature, greatest height just behind anterior cardinal angle.*Description.*—The valves are subovate in lateral outline, the anterior margin is almost a third higher than the posterior margin, the ventral margin begins its upward curve at or just behind midlength. The overlap is approximately of equal width around the free margins.*Measurements (in mm).*—

	Greatest length	Greatest height	Greatest width
Plate 1, figures 26-29...	1.58	1.16	0.68

Discussion.—The holotype of *P. kansasensis* is a young instar. This is based on the small size of the carapace which has a recorded length of only 0.75 mm. *P. humerosus* var. *spinosus* Upson, 1933, is more than twice this size, having a recorded length of 1.6 mm. Upson defined this species as having a row of minute beads bordering its end margins. Kellett (1935, p. 162) was of the opinion that Upson's type-specimen is roughened and weathered and that the "beads" are calcite granules resulting from this weathering. Upson's type (this report, pl. 1, figs. 26-29) has a single spinelet at approximately the middle of the anterior margin of the left valve. This spinelet is adventitious to the specimen and not a part of the shell. This carapace is somewhat crushed, causing the ends to appear more spindle shaped in dorsal outline than *P. kansasensis*. Slide USNM 35657 contains a single specimen from the Wreford Limestone, 6 miles west of Reece, Kans., included by Ulrich and Bassler in *P. humerosus*. This specimen (pl. 1, fig. 25) is not as elongated as the types of *P. humerosus* Ulrich and Bassler, 1906; it appears to be conspecific with *P. humerosus* var. *spinosus*, and

consequently it is here questionably referred to *P. kansasensis*. The ventral margin is less truncated towards the posterior than in *P. texanus* Delo, 1930 (Sohn, 1971, pl. 2, figs. 1, 8, 9, 13, 15).

Stratigraphic range.—Wreford Limestone, shale 1 foot above the base of Funston Limestone (Lower Permian).

Geographic distribution.—Cowley County, and ?Greenwood County, Kans.

Paraparchites miseri Sohn, n. sp.

Plate 2, figures 16–41

Name.—In memory of the late Dr. Hugh D. Miser (1884–1969), U.S. Geological Survey.

Holotype.—USNM 167994.

Paratypes.—USNM 167987–167993.

Material.—More than 100 carapaces representing various stages of growth.

Type-locality.—East side of an old roadcut in the E $\frac{1}{2}$ sec. 25, T. 19 S., R. 11 E., Otero County, N. Mex.

Type-level.—Hueco Limestone directly above thin-bedded petroliferous limestone 6 feet thick (USGS loc. 12855).

Diagnosis.—Differs from all other species in *Paraparchites* in convex ventral margin, incised venter in heteromorphs, narrower posterior margin, and in lanceolate dorsal outline.

Description.—The adult carapace is subovate in lateral outline; the ventral margin is convex, curves back and upwards at approximate midlength; the dorsal margin is gently arched; the anterior margin is broadly curved with the point of maximum convexity at or slightly below midheight, the posterior margin narrower than anterior margin with the point of greatest convexity well above midheight. The cardinal angles are obtuse, almost rounded. The hinge margin is incised, terminated by the narrowly overlapping left valve that extends around the free margin. The venter is broad and flat in heteromorphs, narrow in juveniles and tecnomorphs.

Measurements (in mm).—

	Greatest length	Greatest height	Greatest width
Paratype (pl. 2, figs. 16–19)	0.50	0.38	0.24
Paratype (pl. 2, figs. 20–23) .....	.58	.44	.31
Paratype (pl. 2, figs. 26–29)	1.16	.87	.60
Paratype (pl. 2, figs. 24, 30–33)	1.17	.86	.58
Paratype (pl. 2, figs. 34–37)	1.32	1.0	.73
Holotype (pl. 2, figs. 25, 38–41)	1.34	.97	.73

Discussion.—Upson (1933, p. 11, pl. 1, figs. 1a, b) mistook the ventral margin for the dorsal margin

in his description of *P. gibbosus*. His figure 1a should be rotated 180° as it is here on plate 2, figure 44, and is the lateral view of the right valve, and his figure 1b is a ventral view and not a dorsal view. The valves overhang the venter as shown here in the posterior view (pl. 2, fig. 42). *P. miseri* has a more pronounced indentation along the venter (pl. 2, figs. 37, 41) in presumed heteromorphs. This species resembles in ventral view *Aparchites dentis* McGill (1963, p. 4, pl. 1, fig. 9) from the Upper Devonian of Alberta, Canada. McGill's species differs, however, from species assigned to *Paraparchites* in having a straight dorsal margin and an incised hinge that extends to the cardinal angles. *P. miseri* is abundant at the type-level and also in two collections below the type-level in the petroliferous limestone (USGS loc. 12849) and the shale at the base of the petroliferous limestone (USGS loc. 12848), but is best preserved at the type-level, where it is associated with rare specimens of *Cavellina*. The collection from the underlying shale (USGS loc. 12848) also contains representatives of typically marine genera (*Acratia*, *Bairdia*, *Healdia*?, *Cavellina*?, and "*Knoxina*"). I interpret this species to have been deposited in a hypersaline lagoon.

Stratigraphic range.—Hueco Limestone (Lower Permian).

Geographic distribution.—New Mexico.

Genus **PROPARAPARCHITES** Cooper, 1941

Proparaparchites Cooper, 1941, Illinois Geol. Survey Rept. Inv. 77, p. 62.

Type-species (original designation).—*P. ovatus* Cooper, 1941, page 62, plate 14, figures 8, 9. Kinkaid Limestone, Illinois.

Diagnosis.—Differs from *Paraparchites* in similarly rounded ends in lateral outline and in greatest length, usually less than 1 mm.

Description.—The carapace is small, usually less than 1 mm in greatest length; it is elongate-ovate in lateral outline, with obtuse cardinal angles and equally rounded ends. The dorsal and ventral margins are subparallel. The shell apparently is relatively thin, and the hingement is undeterminable. Dimorphism is at present unknown.

Discussion.—Cooper (1941, p. 62) based *Proparaparchites* on two species from Illinois: *P. ovatus* Cooper, 1941, the type-species from the Kinkaid Limestone (pl. 2, figs. 1–5) and *P. fabulus* Cooper, 1941, from the Renault Formation. *P. parallelus* Cooper, 1946, from the Pennsylvanian of Illinois is the only other North American species assigned to this genus. Mrs. Lois S. Kent, curator, Illinois Geological Survey, kindly loaned me the types of all three species that are reillustrated in this study.

The type of *P. fabulus* Cooper is apparently a steinkern (pl. 2, figs. 6–10). The slide with the holotype of *P. parallelus* (pl. 2, figs. 11–15) contained also a single valve, illustrated as a paratype (pl. 2, figs. 11, 12). This valve is 0.55 mm in greatest length and 0.35 mm in greatest height.

Buschmina (1968, p. 33) described and illustrated *Proparaparchites tersiensis* and *P. sibiricus* from the upper Tournaisian of the Kuznetsk Basin. The former belongs to this genus, whereas *P. sibiricus* Buschmina, 1968, was transferred to *Shemonaella* because the illustrated specimen (Buschmina, 1968, pl. 4, fig. 7, left and dorsal) does not have an incised hingeline.

Scott (in Moore, 1961, p. Q194, text fig. 136, figs. 2a, b) illustrated a specimen as *Proparaparchites ovatus* Cooper, 1941, from the Upper Mississippian of Illinois that differs in lateral outline, dorsal outline, and lack of incised hinge from the holotype of that species.

Stratigraphic range.—Mississippian–Pennsylvanian.

Genus SHIVAELLA Sohn, 1971

See Sohn (1971, p. A8) for a discussion of this genus. A new Early Mississippian species from California and Nevada is described.

Shivaella macallisteri Sohn, n. sp.

Plate 3, figures 1–38

Name.—In honor of James F. McAllister, U.S. Geological Survey, who collected the samples that contain this species.

Holotype.—USNM 168024.

Paratypes.—USNM 168005–168023.

Material.—15 silicified carapaces, 45 left valves and fragments, and 50 right valves and fragments.

Type-locality.—Between 175 and 190 feet above base of hill 2997, Bat Mountain, Inyo County, Calif. (USGS loc. 12858, 12864, 12865).

Type-level.—Tin Mountain Limestone, 14.3–14.5 feet above its base, unit t4 of McAllister's measured section (unpub. 1971) (USGS loc. 12865).

Diagnosis.—Distinguished by greatest height in anterior quarter of greatest length, spines at posterior quarter, and pillbox overlap.

Description.—The lateral outline is elongated, the anterior margin being much higher than the posterior margin. The spines are broad at the base, tapering, and have a slight bend near the tips; they may be as much as half the length of the dorsal margin in size and are removed from the posterior margin more than twice their distance from the dorsal margin. The overlap along the free margins is not incised; the left valve bends along the free margins to form a flat relatively narrow venter that covers

in pillbox fashion the right valve, abutting against a distinct selvage on the free margin of the right valve.

Measurements (in mm).—

	Greatest length	Greatest height	Greatest width
Paratype (unfigured USNM 168023)	0.52	0.34	.....
Paratype (pl. 3, figs. 4, 5) .....	.62	.42	0.18
Paratype (pl. 3, figs. 6, 7) .....	.69	.45	.34
Paratype (pl. 3, figs. 8–10) .....	.76	.48	.18
Paratype (pl. 3, figs. 11, 12) .....	.86	.50	.34
Paratype (pl. 3, figs. 13–15) .....	.80	.54	.42
Paratype (pl. 3, figs. 16–18) .....	.78	.55	.40
Paratype (pl. 3, figs. 19, 20)	1.04	.67	.25
Paratype (pl. 3, figs. 21, 22) .....	.74	.48	.20
Paratype (pl. 3, figs. 23, 24)	1.03	.67	.23
Paratype (pl. 3, figs. 25, 26)	1.20	.77	.25
Paratype (pl. 3, figs. 27–29)	1.15	.70	.26
Paratype (pl. 3, figs. 30, 31)	1.30	.79	.39
Paratype (pl. 3, figs. 32, 33)	1.23	.83	.33
Holotype (pl. 3, figs. 34–37)	1.83	1.16	≈ .56
Paratype (pl. 3, fig. 38)	1.83+	1.23	.54

Discussion.—All the carapaces recovered are juveniles. The few larger valves are poorly preserved but seem to indicate a dimorphism in width along the venter. The juveniles have the shape in end view of an inverted triangle that is blunted at the point (pl. 3, fig. 3); in older specimens (pl. 3, figs. 11, 15, 21, 34) the greatest width moves downward towards the midheight in end view. The best preserved and greatest number of specimens are from a composite collection by J. F. McAllister (USGS loc. 12858). Subsequent detailed collections in that interval contained this species from 14.3 feet to 15.9 feet above the base of that interval.

This species differs from *S. armstrongiana* (Jones and Kirkby, 1886) in that the spine is closer to the dorsal margin but not as close as in *S. spinigera* (McCoy, 1844), originally referred to *Cythere*. The greatest height in lateral outline is closer to the anterior margin in the new species than in both the above species.

Stratigraphic range.—Tin Mountain Limestone and Narrow Canyon Limestone (lowermost Osagian or Kinderhookian) (USGS loc. 12879).

Geographic distribution.—California and Nevada.

Genus CHAMISHAELLA Sohn, 1971

See Sohn (1971, p. A11) for a discussion of this genus. A lectotype for *Chamishaella carbonaria* (Hall, 1858) is here designated.

***Chamishaella carbonaria* (Hall, 1858)**

Plate 5, figures 3–8, 12–21; plate 6, figures 1–24

Cythere carbonaria Hall, 1858, Albany Inst. Trans., v. 4, p. 33 (no illustrations). St. Louis Limestone, Spergen Hill, Ind.

Leperditia carbonaria (Hall). Whitfield, 1882, Am. Mus. Nat. History Bull. 1, p. 94, pl. 9, figs. 24–27. St. Louis Group (=Salem Limestone fide Cumings, 1922, p. 499–505), Spergen Hill and Bloomington, Ind.

Hall, 1883, Indiana Dept. Geology and Nat. History, Ann. Rept. 12, 1882, p. 375, pl. 32, figs. 24–27. (Copy of Whitfield's plate.) Same formation and localities as above, also Lanesville, Ind.

Lesley, 1889, Pennsylvania Geol. Survey, 2d, Rept. P4, p. 309, text fig. 11. (Copy of Whitfield's figs. 24–27.)

Cumings, 1906, Indiana Dept. Geology and Nat. Resources, Ann. Rept., 30, 1905, p. 1373 (list), pl. 26, figs. 24–27. (Copy of Whitfield's plate.) Salem Limestone, Harrodsburg, Bloomington, Ellettsville, Stineville, and Romona, Ind.

?Weller, 1916, Walker Museum Contr., v. 1, no. 10, p. 263, pl. 19, fig. 23. Ste. Genevieve Limestone, Waterloo, Monroe County, Ill.

Paraparchites carbonarius (Hall). Geis, 1932, Jour. Paleontology, v. 6, p. 156, pl. 23, figs. 2a, b. Salem Limestone, Indiana.

Paraparchites subcircularis Geis, 1932 [part], Jour. Paleontology, v. 6, p. 156, pl. 23, figs. 1a–c [not fig. 1d=*Shishaella geisi* n. sp.]. Salem Limestone, Indiana.

[not] *Paraparchites carbonarius* (Hall). Gorak, 1967, Akad. Nauk Ukrain. SSR, p. 46, pl. 25, figs. 4a–e=*Shivaella* sp.

Diagnosis.—Distinguished by large, robust, thick valves.

Description.—The carapaces are large, more than 3 mm in greatest length, the shells are thicker than any other in this genus, and the valves are wide relative to the length of the carapace. The lateral outline is subcircular; the anterior margin more broadly rounded than posterior margin. The hingeline is relatively short, with a distinct overreach of the overlapped valve in the adult and postadult stages. The greatest width of heteromorphs is near the posterior and ventral margins (compare pl. 6, figs. 16 and 22, with fig. 19).

Measurements (in mm).—

	Greatest length	Greatest height	Greatest width
Figured specimen (pl. 5, fig. 3)	1.45	1.18	0.84
Topotype (pl. 6, figs. 1–5)	1.57	1.26	.87
Figured specimen (pl. 6, figs. 6–10) ..	1.64	1.47	.96
Figured specimen (pl. 5, fig. 8)	1.92	1.57	1.18

	Greatest length	Greatest height	Greatest width
Figured specimen (pl. 5, figs. 5–7)	2.01	1.65	1.14
Figured specimen (pl. 5, fig. 4)	2.06	1.61	1.19
Figured specimen (pl. 6, figs. 11–14)....	2.20	1.61	1.25
Lectotype (pl. 5, figs. 18–21)....	2.40	1.80	1.57
Topotype? (pl. 5, figs. 14, 15)....	2.48	2.00	1.49
Figured specimen (pl. 6, figs. 15–17)....	2.50	2.02	1.52
Figured specimen (pl. 5, figs. 12, 13)....	2.53+	1.77+	1.35+
Topotype? (pl. 5, figs. 16, 17)....	2.56	2.09	1.49
Figured specimen (pl. 5, figs. 18–20)....	2.84	2.33	1.70
Figured specimen (pl. 6, figs. 21–24)....	3.25	2.45	1.61

Discussion.—Geis (1932, p. 155–157) accepted the assumption that the tubercle in "*Paraparchites*" was in the dorsoanterior area, had something to do with the eyes, and was present only in the younger stages. The classification proposed in this study and supported by illustrations of ontogenetic series is based on the thesis that the presence or absence of tubercles is of generic significance. Consequently, in this paper, Geis' *Paraparchites subcircularis* is regarded as a synonym of the older *Cythere carbonaria* Hall, 1858, and the one-spined specimen that Geis illustrated as a paratype of his *P. subcircularis* (1932, pl. 23, fig. 1d) is here referred to the new species *Shishaella geisi*.

Dr. J. L. Carter, Department of Geology, University of Illinois, loaned me two slides representing the types of the two species that Geis illustrated. One microslide has two cells labeled "*Paraparchites subcircularis* Holotype, M300 and Paratypes, M301, Salem, R.R. Cut at Spergen Hill, Norris, Indiana. Coll. H. L. Geis." The second is labeled "*Paraparchites carbonarius* (Hall), Plesiotypes M302" from the same collection as above. In addition to the two specimens that Geis illustrated for *P. subcircularis*, the type-series consists of two paratypes without tubercles. These have greatest lengths of 1.45 mm and 2.0 mm, respectively.

Dr. R. L. Batten, American Museum Natural History, New York, loaned me Hall's types. He sent me two cardboard rectangles approximately 7 by 4½ cm each, having two rows of specimens attached with water-soluble glue on each cardboard, and three plastic vials, each with a specimen. It is not possible to determine from which cardboard the specimens in the vials became detached. One cardboard

(7703/1) is from Spergen Hill, Ind., the second (7703/2), from Bloomington, Ind. "Cytherina carbonaria" is written in pencil on the backs of both cardboards. The fact that, in his original description, Hall (1858, p. 33) listed only Spergen Hill under "Locality" indicates that the collection labeled 7703/1 represents the type-series. This cardboard has, in addition to a green diamond, four white squares, on three of which are glued specimens.

Whitfield and Hovey (1901, p. 410, 411) described both of these cardboards. The one from Spergen Hill under catalog No. 5242/1 as follows: "An individual. Seventeen others from this locality are in the original type series." This slide presently contains, in addition to the three specimens on white squares, 18 specimens. The 18 specimens include a fragment of the ventral part of a valve with the impression of the carapace that had broken off in the glue and a piece of a valve. This fact suggests that Whitfield (1882) illustrated a carapace that was not part of the original 18 that constitute the type-series. Because a lectotype was never designated for this species, I am selecting one of the original 18 specimens as the lectotype and am illustrating it on plate 5, figures 18-21. It is significant that the type-series contains only two carapaces (greatest length approximately 1.3 and 1.7 mm) that have posterodorsal spines. These belong to *Shishaella geisi* n. sp. A carapace with the greatest length of approximately 1.5 mm does not have the spine.

Weller (1916) illustrated the lateral view of a left valve having the greatest length of approximately 3 mm. Because the right valve and dorsal view are not known, this specimen, from the Ste. Genevieve Limestone, cannot be assigned with any degree of certainty to this species.

Stratigraphic range.—Salem and Ste. Genevieve (?) Limestones (Meramecian).

Geographic distribution.—Indiana and Illinois (?)

Genus SHISHAELLA Sohn, 1971

See Sohn (1971, p. A14) for a description of this genus. Three new species from the Mississippian of Indiana, Nevada, and Texas and one new species from the Permian of Texas are described. One species from the Permian of Texas is illustrated but not formally described.

Shishaella geisi Sohn, n. sp.

Plate 5, figures 1, 2, 9-11; pl. 7, figures 1-21

Paraparchites subcircularis Geis, 1932 [part], Jour. Paleontology, v. 6, p. 155, pl. 23, fig. 1d [not figs. 1a-c = *Chamishaella carbonaria* (Hall, 1858)]. Salem Limestone, Spergen Hill, Norris Station, Ind., see however, Cumings (1922, p. 499).

Paraparchites carbonarius (Hall). Geis 1932 [part], Jour. Paleontology, v. 6, p. 156, pl. 23, fig. 2a [not fig. 2b =

Chamishaella carbonaria (Hall, 1858)]. Salem Limestone, Spergen Hill, Norris Station, Ind.

Name.—In honor of Dr. H. L. Geis.

Holotype.—USNM 168136.

Paratypes.—USNM 168137-168146.

Material.—More than 40 carapaces showing various stages of growth.

Type-locality.—Spergen Hill, railroad cut at Norris Station, Ind. (USGS loc. 7522C green; 12866 PC).

Type-level.—Salem Limestone (Meramecian).

Diagnosis.—Differs from all other species in this genus in subcircular lateral outline.

Measurements (in mm).—

	<i>Greatest length</i>	<i>Greatest height</i>	<i>Greatest width</i>
Paratype (pl. 7, figs. 1, 2) ..	0.74	0.56	0.39
Paratype (pl. 7, figs. 8, 9) ....	.98	.76	.52
Paratype (pl. 7, figs. 10, 11)	1.27	.99	.67
Paratype (pl. 7, figs. 3-7)	1.33	1.04	.73
Paratype (pl. 5, figs. 1, 2)	1.44	1.12	.80
Holotype (pl. 7, figs. 12-15)	1.95	1.52	1.24
Paratype (pl. 5, figs. 9-11) ..	2.01	1.60	1.22
Paratype (pl. 7, figs. 16, 17)	3.30	2.50	1.92
Paratype (pl. 7, figs. 18-21)	3.70	2.75	2.20

Descriptions.—The carapaces are large, more than 3 mm in greatest length, robust, with convex ventral margins and almost straight dorsal margins. The overlapping valve overreaches along the venter but has a relatively narrow overlap. The spined valve overreaches along the dorsal margin, develops a horizontal, poorly defined swelling near the dorsal margin. The end margins are rounded; the greatest convexity of anterior margin is slightly below midheight, of the posterior margin above midheight. The spine is more robust in younger individuals than in adult and gerontic stages; the number of specimens on hand is insufficient to determine whether this is an allometric rate. The cardinal angles are distinct in adult and preadult stages; in larger stages they become less distinct because of the increased width of the carapace. Females are wider near the posterior in dorsal outline and below midheight in end outline.

Discussion.—Individuals larger than the holotype are present in the type-series. I deliberately chose a carapace with the greatest length of 2 mm as the holotype, because I consider it to be an adult and

the larger specimens as representing gerontic stages. As indicated in my discussion of *Chamishaella carbonaria* (Hall), this new species was included in *C. carbonaria* on the assumption that the spine is lost during ontogeny. In addition to having a posterodorsal spine, *S. geisi* differs from *C. carbonaria* in having more distinct cardinal angles, in greater overreach and more distinct overlap of the larger valve, in that the greatest height is in front of the greatest length, and in having a slightly longer hingeline. The fact that all the collections I examined contained individuals without spines, here assigned to *Chamishaella*, that are smaller than individuals with spines, here assigned to *Shishaella*, indicates that two closely related but distinct genera were present in the same area at the same time.

Stratigraphic range.—Salem Limestone (Upper Mississippian, middle Meramecian).

Geographic distribution.—Indiana (USGS collns. 7522c green, 12886 PC), Missouri (USGS colln. 1208 blue).

Shishaella marathonsensis (Hamilton, 1942)

Plate 8, figures 10–15; plate 9, figures 11–16

Paraparchites marathonsensis Hamilton, 1942, Jour. Paleontology, v. 16, p. 712, pl. 110, figs. 12a, b. Middle Permian, Glass Mountains, Tex.

Shishaella marathonsensis (Hamilton). Sohn, 1971, U. S. Geol. Survey Prof. Paper 711–A, text fig. 1.

Diagnosis.—Dorsoposterior corners of spined valve distinct, spine small, located about a third the greatest length in front of posterior, with a rough shoulderlike bulge parallel to dorsal margin of spined valve. Overlapping valve with convex dorsal margin.

Description.—See Hamilton, 1942, page 712, for description. The original orientation is here reversed 180°.

Measurements (in mm).—

	Greatest length	Greatest height	Greatest width
Holotype (pl. 8, figs. 10, 11)	2.51	1.73	0.76
Left valve, figured by Hamilton (USNM 11231a	2.68	1.97	.82
Figured specimen (pl. 9, figs. 11–13)	2.44	1.70	.84
Figured specimen (pl. 9, figs. 14–16)	2.62	1.84	.95
Figured specimen (pl. 8, figs. 12–15)	2.45	1.64	.65
Unfigured female, USNM 168129	2.61	1.90	.89

Discussion.—Hamilton's type-series consists of a right valve, the holotype, and three paratypes, all left valves. The holotype is a male (pl. 8, figs. 10, 11). Although present in several collections, small individuals were not found; the smallest available speci-

mens are 1.7 mm in greatest length. Specimens of this species are associated in some of the collections with spined valves that do not have the characteristic dorsal bulge. Because individuals that are equal in greatest length to *S. marathonsensis* do not have the dorsal bulge, they are here named as a distinct species (*S. cooperorum*). Both species have similar overlapping valves.

Geologic range.—Permian, Glass Mountains, Tex. Road Canyon Formation (Leonard Series) (USNM collns. 702c, 703a, 703c, 726z, AMNH 501); Willis Ranch Member of Word Formation (Guadalupe Series) (USNM 706?, 706e).

Shishaella cooperorum Sohn, n. sp.

Plate 8, figures 1–4, 6–9; plate 9, figures 1–8

Name.—In honor of Dr. and Mrs. G. Arthur Cooper, U.S. National Museum.

Holotype.—USNM 168110.

Paratypes.—USNM 168111–168117.

Material.—In addition to the figured paratypes, four poorly preserved carapaces and two right valves from the type-collection, three carapaces and 14 right valves ranging in greatest length from approximately 1.5 to 2.4 mm, and five valves from three additional collections.

Type-locality.—Three-tenths of a mile northwest of the old Ward ranchhouse site, Hess Canyon quadrangle, Glass Mountains, Tex.

Type-level.—Road Canyon Formation, (Permian, Leonard Series) (AMNH 501).

Diagnosis.—Differs from *S. marathonsensis* (Hamilton, 1942) in absence of dorsal bulge on spined valve.

Description.—The carapaces are medium sized, 1.3–2.5 mm in greatest length; they are subovate in lateral outline, the ventral margin is slightly more convex than in *S. marathonsensis*, and the direction of the spine varies from perpendicular to the dorsal margin to a backward slant.

Measurements (in mm).—

	Greatest length	Greatest height	Greatest width
Paratype (pl. 9, figs. 1–4)	1.36	0.98	0.37
Paratype (pl. 9, figs. 5–8)	1.56	1.19	.83
Paratype (pl. 8, figs. 1–4)	2.15	1.32	.67
Holotype (pl. 8, figs. 6–9)	2.41	1.70	.76

Discussion.—The left valve is similar to that of *S. marathonsensis* in having a slightly curved dorsal margin, so that the right valve with its grooved hinge overreaches slightly along the dorsum. It is not possible to distinguish the left valves of *S. cooperorum* from those of *S. marathonsensis*. I rule out the possibility that because the specimens are

silicified the absence of the dorsal bulge in the right valve is due to lack of preservation, or that the bulge in *S. marathonsensis* is an artifact. Too many specimens fall in either one group or the other, and both have dimorphic individuals; the presumed females are more convex near the venter. The dorsal outline of *S. cooperorum* is more convex than that of *S. marathonsensis*, as shown on plate 8, figures 2, 6, which illustrate the presumed male and female of the new species, whereas plate 8, figure 12, shows a presumed male and plate 9, figure 13, shows a presumed female of *S. marathonsensis*.

Geologic range.—Road Canyon Formation (Permian, Leonard Series (USNM colln. 703a, 703c, AMNH 501); Willis Ranch Member of Word Formation (Guadalupe Series) (USNM 706e).

Shishaella sp.

Plate 8, figure 5; plate 9, figures 9, 10

Paraparchites marathonsensis Hamilton. Sohn, 1961a, U.S. Geol. Survey Prof. Paper 424-D, p. D244 (list).

Two silicified right valves, one of which is broken, and two fragments of left valves were present in USGS collection 12856 PC, the Getaway Limestone Member of the Cherry Canyon Formation. Prior to this study, I had referred these specimens to *Paraparchites marathonsensis* Hamilton, 1942 (Sohn, 1961a), but the spine on the right valve is more robust than in the other species known from the Permian. Because of insufficient material, the best specimen is illustrated, but the taxon is not formally named.

Measurements (in mm).—

	Greatest length	Greatest height	Greatest width
Figured specimen ...	1.75	1.23	0.80

Geologic range.—Getaway Limestone Member of the Cherry Canyon Formation (Permian, Guadalupe Series).

Geologic distribution.—Known only from Culbertson County, Tex.

Shishaella mackinneyi Sohn, n. sp.

Plate 10, figures 1-33

Name.—In honor of Robert H. McKinney, photographer, U.S. Geological Survey.

Holotype.—USNM 168147.

Paratypes.—USNM 168148-168160.

Material.—More than 100 silicified valves and a few carapaces representing various stages of growth.

Type-locality.—El Paso quadrangle, 2½ miles west of Powwow Tanks, El Paso County, west Texas.

Type-level.—Limestone, bed 9, section "C" West Texas Geological Society Guidebook, Field Trip, May-June 1946 (stop 1 on map accompanying that trip), USNM loc. 3070-2.

Diagnosis.—Distinguished by subovate lateral outline; convex venter; anterior bend below midheight; and ventrolateral bulge on unspined valve.

Description.—The carapace is subovate in lateral outline, the dorsal margin is straight, the anterior margin evenly curved, the ventral margin is strongly convex in presumed females, more gently convex in tecnomorphs; it grades into the curved posterior margin that is truncated by an almost straight line in the dorsoposterior quarter. The spine on the right valve is relatively close to the dorsal margin and two to three times that distance from the posterior. The right valve overreaches slightly above the hingeline. The left valve overlaps evenly along the free margin from the anterior cardinal angle to the posterior cardinal angle and abuts against a thin selvage along the free margins of the right valve. The calcified inner lamella is narrow and of equal width along the free margins except for a short distance near the cardinal angles. The adductor muscle-scar pattern is circular; individual scars and mandibular scars are not discernible. Dimorphic, the presumed females having more parallel sides in dorsal outline than the presumed males and also having greatest width closer to the ventral margin than in presumed males. The dorsoposterior spine is removed from the posterior edge slightly more than from the dorsal edge of the right valve.

Measurements (in mm).—

	Greatest length	Greatest height	Greatest width
Paratype (pl. 10, figs. 1, 2) ..	0.59	0.41	0.30
Paratype (pl. 10, figs. 6-8) .....	.67	.50	.36
Paratype (pl. 10, figs. 3-5) ..	.77	.56	.39
Paratype (pl. 10, figs. 13-15) ..	1.04	.74	.54
Paratype (pl. 10, figs. 9-12)	1.14	.73	.58
Paratype (pl. 10, figs. 19, 20) ..	1.32	.94	.34
Paratype (pl. 10, figs. 16, 17) ..	1.39	1.03	.42
Paratype (pl. 10, figs. 21, 22) ..	1.42	1.04	.43
Paratype (pl. 10, figs. 26-29) ..	1.52	1.07	.51
Holotype (pl. 10, figs. 23-25) ..	1.56	1.10	.42
Paratype (pl. 10, figs. 30-33) ..	1.74	1.23	.49

Discussions.—All the specimens are silicified and were obtained by etching with dilute acid. Fragments indicate that individuals larger than any of the valves recovered were present in the population. This species is represented by a growth series rang-

ing in greatest length from 0.57 to 1.77 mm, dimorphism being shown by specimens larger than 1.3 mm. This species differs from *S. kinkaidensis* as illustrated by Cooper (1941, pl. 13, figs. 20, 21) by the left valve not overlapping at the posterior cardinal angle. The contact along the hingeline joins in a straight line the contact along the end margins in *S. mackinneyi* and is sharply offset in the *S. kinkaidensis*. The largest specimen of *S. kinkaidensis* (Croneis and Thurman) is that illustrated by Cooper (1941, pl. 13, figs. 20, 21), which measures on the illustration slightly more than 1.0 mm in greatest length, and the holotype has a recorded length of 0.82 mm (Croneis and Thurman, 1939, p. 301); both specimens probably represent juvenile individuals, as they have convex sides in dorsal outline. The contact of the dorsoposterior margin is more abrupt in *S. mackinneyi* than in *S. williamsae* Sohn, 1971.

The left valves of specimens of *S. mackinneyi* as small as 0.73 mm in greatest length (pl. 10, fig. 5) have an elongated swelling near and subparallel to the ventral margin at approximate midlength. This bulge is similar to the structure seen on *S. cyclopea* (Girty, 1910), from which *S. mackinneyi* differs in lateral outline, in smaller size, and in absence of overreach and swelling near the dorsal margin of the right valve.

The holotype is a single right valve of a presumed female illustrated on plate 10, figures 23–25; the left valve of a presumed male paratype is shown on the same plate by figures 30–33.

Geologic range.—Helms Formation (Upper Mississippian). In addition to the type-locality, this species is common in limestone at approximately the same stratigraphic level in a saddle 1.1 miles west of Powwow Tanks (USNM loc. 3069–2).

Shishaella eureka Sohn, n. sp.

Plate 11, figures 1–13; plate 12, figures 1–9

Holotype.—USNM 168161.

Paratypes.—USNM 168162–168166.

Material.—35 carapaces and valves, some in matrix, representing various stages of growth.

Type-locality.—Eureka quadrangle, White Pine County, Nev., (USGS loc. PC–6567).

Type-level.—Diamond Peak Formation; associated megafossils indicate Member D (Gordon, in Brew, 1971, p. 35, 41), regarded as probably equivalent to P₁ of ammonoid zone of the British standard section.

Diagnosis.—Differs from all other species in *Shishaella* in having a flattened rim along the end margins.

Description.—The adults are large, more than 3 mm in greatest length, subovate with a very gently

curved ventral margin. Females are wider than males near the posterior in dorsal outline and near the venter in end outline. The dorsoposterior spine is closer to the dorsal margin than to the posterior margin. The anterior margin is smoothly convex, with the bend at approximately midheight. The posterior margin is not as long and starts higher from the ventral margin than the anterior margin; its bend is above the midheight. The end margins of the smaller valve have a flattened rimlike band. In younger stages, the ventral margin is slightly more convex, and the dorsoposterior spine appears to be farther removed from the posterior than in adults. The subcentral adductor muscle scar is subround and large and without discernible individual scars.

Measurements (in mm).—

	Greatest length	Greatest height	Greatest width
Paratype (pl. 11, figs. 1–5).....	1.29	0.85	0.63
Paratype (pl. 11, figs. 6–9).....	2.16	1.60	1.06
Paratype (pl. 11, figs. 10–13)...	3.5	2.05	1.60
Holotype (pl. 12, figs. 1–4) ..	3.3	2.32	1.76
Paratype (pl. 12, figs. 5–9) ..	3.4	2.22	1.57

Discussion.—The first specimen of this species that I saw was an adult tecomorph, and I predicted that heteromorphs would have wider posteriors. I found one; hence the specific name—*eureka*. The youngest individual of this species (pl. 11, figs. 1–5) resembles *S. kinkaidensis* (Croneis and Thurman, 1939) from the Chesterian of Illinois, from which it differs in that the smaller valve is not flattened where it overreaches along the dorsal margin and in the flattened rim along the end margins. As can be seen in figure 5, the ventral part of the larger valve is missing; therefore the lateral outlines in figures 1 and 3 are not correct along the venter.

Shishaella eureka was listed as "*Paraparchites*" n. sp. aff. "*P.*" *cyclopeus* Girty, 1910, by Gordon (in Brew, 1971, p. 41). My preliminary list to Mr. Gordon (1968) included the following associated ostracodes:

"*Paraparchites*" cf. "*P.*" *nicklesi* Ulrich, 1891 *Shishaella* Sohn, 1971.

Graphiodactyllis sp.

Sansabella? sp.

"*Bairdia*" sp.

Geologic range.—Known only from the type-level, upper Meramecian (upper Visean).

?Superfamily PARAPARCHITACEA Scott, 1959

Family unknown

Genus DORSOBLIQUELLA Knüpf, 1967

Type-species (original designation).—*Dorsoobliquella pulchra* Knüpf, 1967, page 76, plate 1, figures 2–4, plate 4, figures 3a, b, Zechstein, well in Rügen.

Diagnosis.—Differs from all other genera in this group in overreach of smaller valve above hingeline; in convex dorsal margin; in narrow ventral overlap; and in absence of spines.

Discussion.—Knüpf assigned this monotypic genus to the Aparchitidae Jones, 1901. Unfortunately, the nominate lower Paleozoic genus *Aparchitites* Jones, 1889, is based on the subsequently designated type-species *A. whiteavesi* Jones, 1889, from the Red River Formation (Middle Ordovician), Manitoba. Dr. M. J. Copeland, Geological Survey of Canada, sent me photographs of the holotype and only known specimen of this species, and Prof. F. M. Swartz, The Pennsylvania State University, sent me manuscript copy of his paper dealing with this species (Swartz, 1969). The photographs clearly indicate that the specimen is for the most part, especially along the venter, a steinkern. The “velar ridge” of Hessland (in Moore, 1961, p. Q171), or, as originally described (Jones, 1889, p. 385), “The ventral and end margins of the united valves are thick and beveled inwards and slightly fluted there (see woodcuts figs. 5 and 6)” consists of the impressions of the overlap and the infilling of the vestibules formed by a narrow calcified inner lamella. Similar structures can be seen on steinkerns and specimens that are partly exfoliated. (See Sohn, 1971, pl. 5, figs. 22, 32, 34). Prof. Swartz independently arrived at the same conclusions.

The status of the Aparchitidae is beyond the scope of this paper. Neither the type-species of *Dorsoobliquella* nor the new species described here indicate dimorphism, possibly because two few representatives are known. The circular adductor muscle-scar pattern, which in the type-species consists of a dozen individual spots, could not be discerned on the specimens studied, consequently the genus is questionably referred to the Paraparchitacea.

Geologic range.—Lower Pennsylvanian–Permian.

Dorsoobliquella bachmani Sohn, n. sp.

Plate 4, figures 1–36

Name.—In honor of G. O. Bachman, U.S. Geological Survey.

Holotype.—USNM 168044.

Paratypes.—USNM 168034–168043.

Material.—18 carapaces in various stages of growth.

Type-locality.—Northwestern Mora County, N. Mex., about half a mile west of Holman Hill, in roadcut along old part (1962) of State Highway 3. USGS collection 12885.

Type-level.—Upper Sandia Formation (Lower Pennsylvanian) approximately 50 feet above the base of a 1,000-foot shale unit, probably more than 1,000 feet above the base of the Pennsylvanian.

Diagnosis.—Distinguished by horizontal shallow swelling at the crest of the overreaching valve and similar swelling near ventral margin of overlapping valve.

Description.—Suboval in lateral outline; the anterior margin of the overreaching valve is evenly rounded and extends without any break along the anterior part of the overreaching dorsal margin. The dorsal margin is gently curved and makes an obtuse but definite angle with the forward-trending posterior margin. The posterior margin is curved with a perceptible break in the dorsal part at about a third of the greatest length. The anterior margin is curved and extends farthest to the front below mid-height. The ventral margin is curved or gently curved, never straight. A shallow horizontal groove on the overreaching valve opposite and slightly higher than the hingeline makes an indistinct lobe on the overreaching part, and a similar swelling is present along the central part near the venter of the overlapping valve. The overlap along the free margins is narrow. The overlapping valve bends sharply along the free margins and results in a thin ridge along the junction of the lateral surface with the venter. The edge of the overlapping valve abuts against a thin selvage of the smaller valve. Because single valves are not available, the hinge-ment is uncertain.

Measurements (in mm).—

	<i>Greatest length</i>	<i>Greatest height</i>	<i>Greatest width</i>
Paratype (pl. 4, figs. 1–5) ...	0.51	0.39	0.24
Paratype (pl. 4, figs. 6–10) ..	.78	.56	.34
Paratype (pl. 4, figs. 27–29) ....	.80	.58	.37
Paratype (pl. 4, figs. 11–15) ....	.92	.67	.46
Paratype (pl. 4, figs. 16–20)	1.01	.74	.48
Paratype (pl. 4, figs. 21–24)	1.20	.84	.53
Paratype (pl. 4, figs. 25, 26)	1.20	.95	.58+
Holotype (pl. 4, figs. 30–33)	1.45	1.00	.66
Paratype (pl. 4, figs. 34–36)	1.48	1.20	.72

Discussion.—This species differs from *D. pulchra* Knüpfer, 1967, in that the dorsal margin of the overreaching valve is less convex, in that the upper part of the posterior margin bends obtusely forward at approximately the upper third of the greatest height; the smaller valve has a horizontal shallow swelling at the crest of the overreach, and the overlapping valve has a similar swelling near the ventral margin. A polished section through a carapace of about 1 mm in greatest length revealed a very thin shell in contrast with other genera in the Paraparchitacea. It is plausible that the shell was partly dissolved. Poorly preserved, obviously corroded specimens have sharp ridges along the free margins of right valve (pl. 4, figs. 23, 34); this is the selvage against which the overlapping valve abuts.

Dr. Knüpfer examined two carapaces (USNM 168042) and some photographs of this species and wrote that it belongs to *Dorsoobliquella*.

Stratigraphic range.—Lower Pennsylvanian.

Geographic distribution.—New Mexico.

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PLATES 1-12

Contact photographs of the plates in this report are available, at cost, from U.S.
Geological Survey Library, Federal Center, Denver, Colorado 80225.

PLATE 1

[Magnification approximately $\times 30$; photographs by R. H. McKinney]

FIGURES 1-24. *Paraparchites gelasinos* Sohn, n. sp. (p. B3).

- 1-5. Left, dorsal, right, ventral, and posterior views of a carapace. Young instar, paratype USNM 167976. Upper Sandia Formation (Lower Pennsylvanian), Mora County, N. Mex.
- 6-10. Posterior, left, dorsal, right, and ventral views of a carapace. Older instar than above, paratype USNM 167977. Same collection and locality as figures 1-5.
- 11-15. Posterior, right, dorsal, left, and ventral views of carapace. Still older instar, paratype USNM 167978. Same collection and locality as figures 1-5.
- 16-18. Left, dorsal, and posterior views of an abraded carapace. Still older instar, paratype USNM 167979. Same collection and locality as figures 1-5.
- 19-22. Posterior, left, dorsal, and right views of a carapace. Holotype, USNM 167982. Same collection and locality as figures 1-5.
- 23, 24. Ventral and right views of a broken carapace. Note structure of internal mold along venter of fig. 23 that shows also the cross section of the ventral part of the right valve. Paratype, USNM 167980. Same collection and locality as figures 1-5.
- 25-29. *Paraparchites kansasensis* Harris and Lalicker, 1932 (p. B3).
25. Left valve of the specimen included by Ulrich and Bassler (1906) in *P. humerosus*. Figured specimen USNM 35657. Wreford Limestone (Lower Permian), probably Greenwood County, Kans.
- 26-29. Left, ventral, dorsal, and right views of the holotype of *P. humerosus* var. *spinosus* Upson, 1933. University Nebraska State Museum 8801. Funston Limestone (Lower Permian), Cowley County, Kans.

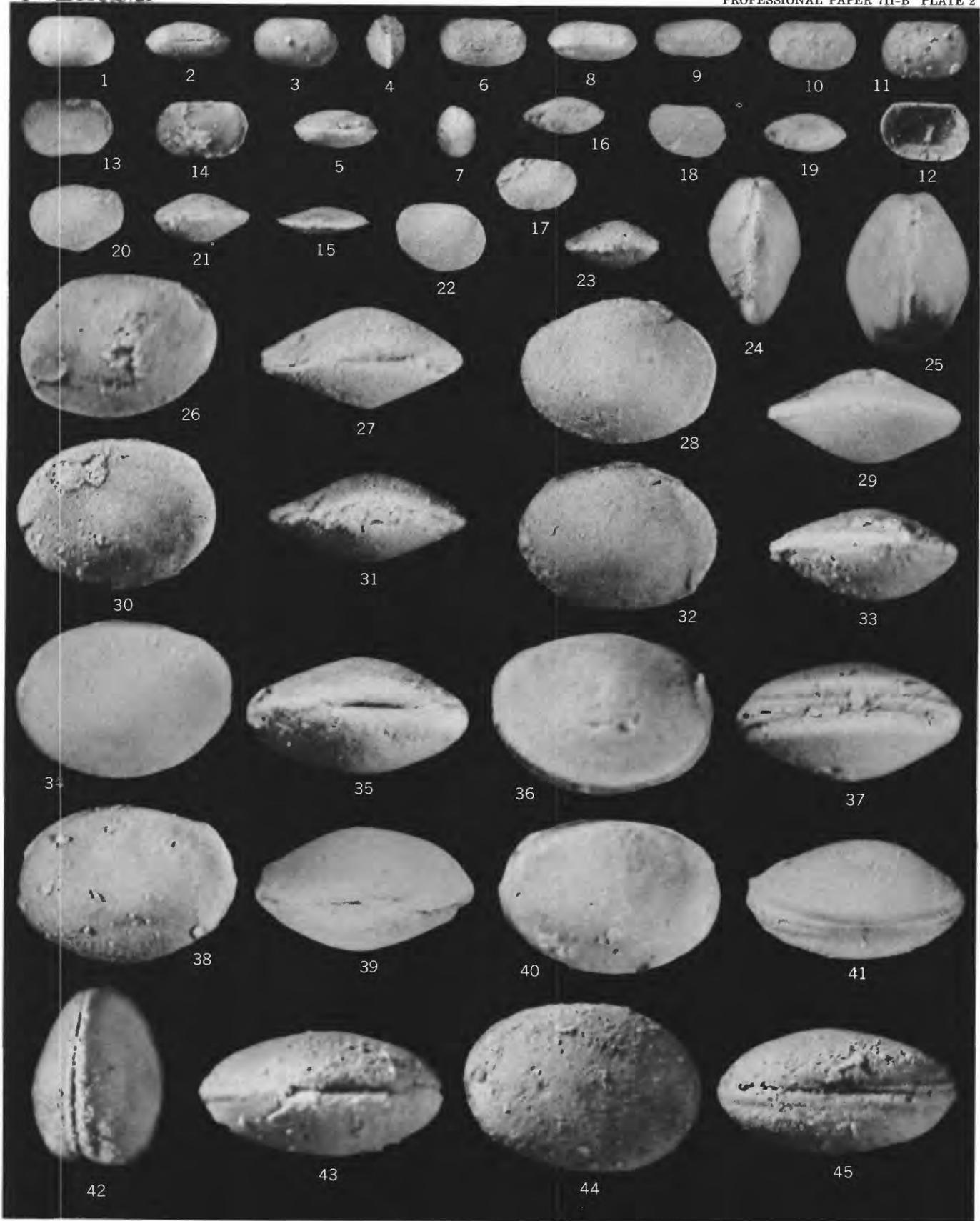


PARAPARCHITES

PLATE 2

[Magnification approximately $\times 30$; photographs by R. H. McKinney]

- FIGURES 1- 5. *Proparaparchites ovatus* Cooper, 1941 (p. B4).
Left, dorsal, right, posterior, and ventral views of carapace. Holotype, Illinois State Geol. Survey 45P291. Kinkaid Limestone (Upper Mississippian), Johnson County, Ill.
- 6-10. *Proparaparchites fabulus* Cooper, 1941 (p. B5).
Left, posterior, dorsal, ventral, and right views of carapace. Holotype, Illinois State Geol. Survey 45P289. Renault Formation (Upper Mississippian), Union County, Ill.
- 11-15. *Proparaparchites parallelus* Cooper, 1946 (p. B5).
11-12. Outside and inside of left valve. Paratype, Illinois State Geol. Survey 44P432. Shale below lower bench of Lonsdale Limestone of Marmoton Group (Middle Pennsylvanian). Marshall County, Ill.
13-15. Right, left, and dorsal views of carapace. Holotype, Illinois State Geol. Survey 44P431. Same collection and locality as figures 11 and 12.
- 16-41. *Paraparchites miseri* Sohn, n. sp. (p. B4).
16-19. Dorsal, left, right, and ventral views of carapace of a very young instar. Paratype USNM 167987. Hueco Limestone (Lower Permian), Otero County, N. Mex.
20-23. Left, dorsal, right, and ventral views of carapace of a slightly larger growth stage. Paratype USNM 167988. Same collection and locality as figures 16-19.
26-29. Left, dorsal, right and ventral views of a tecnomorph carapace. Paratype USNM 167989. Same collection and locality as above.
24, 30-33. Posterior, left, dorsal, right, and ventral views of a tecnomorph carapace. Paratype USNM 167990. Same collection and locality as figures 16-19.
34-37. Left, dorsal, right, and ventral views of a heteromorph carapace. Paratype USNM 167991. Same collection and locality as figures 16-19.
25, 38-41. Posterior, left, dorsal, right, and ventral views of a heteromorph carapace. Holotype USNM 167994. Same collection and locality as figures 16-19.
- 42-45. *Paraparchites gibbosus* Upson, 1933 (p. B4).
Posterior, dorsal, right, and ventral views of heteromorph. Holotype University Nebraska State Museum 8800. Middle Funston Limestone, Marshall County, Kans.



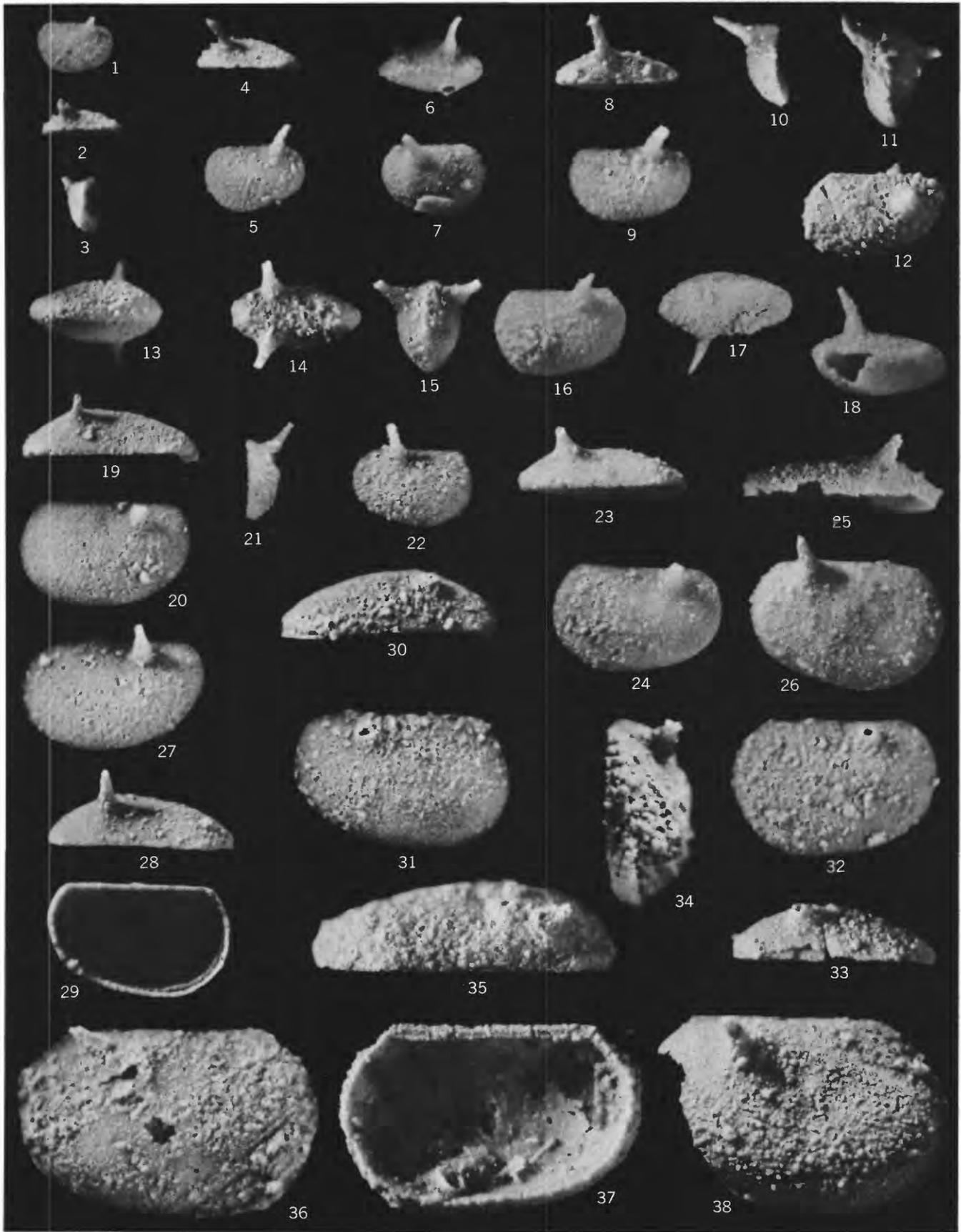
PROPARAPARCHITES AND PARAPARCHITES

PLATE 3

[Magnification approximately $\times 30$; photographs by R. H. McKinney]

FIGURES 1-38. *Shivaella macallisteri* Sohn, n. sp. (p. B5).

- 1-3. Left, dorsal, and posterior views of a left valve. Very young individual. Paratype, specimen lost. Tin Mountain Limestone, California. USGS loc. 12858.
- 4, 5. Dorsal and left views of a left valve. Slightly larger individual. Paratype USNM 168005. Same collection and locality as figures 1-3.
- 6, 7. Dorsal and right views of a carapace, note hole resulting by missing spine on left valve in fig. 6. Young growth stage. Paratype USNM 168006. Same collection and locality as figures 1-3.
- 8-10. Dorsal, lateral, and posterior views of left valve. Slightly larger individual. Paratype USNM 168007. Same collection and locality as figures 1-3.
- 11, 12. Dorsal and left views of carapace, part of right spine is missing. Slightly larger individual. Paratype USNM 168008. Same collection and locality as figures 1-3.
- 13-15. Ventral, dorsal, and posterior views of carapace. Paratype USNM 16809. Same collection and locality as figures 1-3.
- 16-18. Left, ventral, and dorsal views of carapace with dorsoposterior part of right valve missing. Paratype USNM 168010. Same collection and locality as figures 1-3.
- 19, 20. Dorsal and lateral views of left valve. Larger growth stage. Paratype USNM 168011. Narrow Canyon Limestone, Nevada. USGS loc. 12879.
- 21, 22. Posterior and lateral views of right valve, compare trend of spine with that in fig. 10. Relatively young individual. Paratype USNM 168012. Tin Mountain Limestone, California. USGS loc. 12863.
- 23, 24. Dorsal and lateral views of left valve. Paratype USNM 168013. Tin Mountain Limestone, California. USGS loc. 12858.
- 25, 26. Dorsal and lateral views of right valve. Paratype USNM 168014. Tin Mountain Limestone, California. USGS loc. 12864.
- 27-29. Lateral, dorsal, and inside views of left valve. Paratype USNM 168015. Narrow Canyon Limestone, Nevada. USGS loc. 12879.
- 30, 31. Dorsal and lateral views of right valve. Paratype, USNM 168016. Same collection and locality as figures 27-29.
- 32, 33. Lateral and dorsal views of a left valve. Paratype USNM 168017. Tin Mountain Limestone, California. USGS loc. 12858.
- 34-37. Posterior, dorsal, lateral, and inside views of a right valve. Holotype USNM 168024. Tin Mountain Limestone, California. USGS loc. 12865.
38. Lateral view of a broken right valve, one of the largest specimens recovered. Paratype USNM 168018. Tin Mountain Limestone, California. USGS loc. 12858.



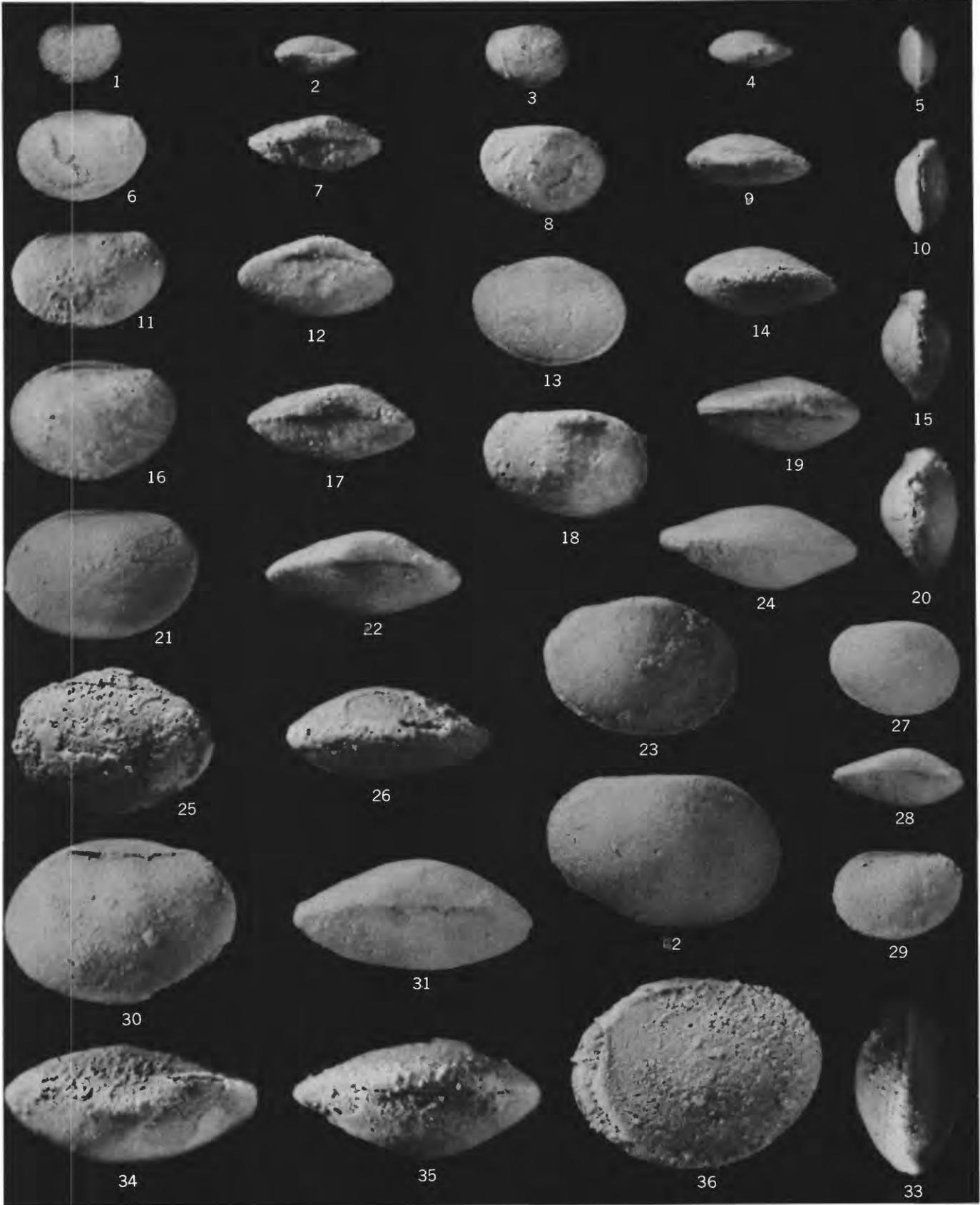
SHIVAELLA

PLATE 4

[Magnification approximately $\times 30$; photographs by R. H. McKinney]

FIGURES 1-36. *Dorsoobliquella bachmani* Sohn, n. sp. (p. B11).

- 1-5. Left, dorsal, right ventral, and posterior views of a carapace of a young instar. Paratype USNM 168034. Upper Sandia Formation, Mora County, N. Mex.
- 6-10. Left, dorsal, right, ventral, and posterior views of a carapace of a much larger instar. Paratype USNM 168035. Same collection and locality as figures 1-5.
- 11-15. Left, dorsal, right, ventral, and posterior views of a carapace of a still larger instar than illustrated above. Paratype USNM 168036. Same collection and locality as figures 1-5.
- 16-20. Left, dorsal, right, ventral, and posterior views of a carapace. Paratype USNM 168037. Same collection and locality as figures 1-5.
- 21-24. Left, dorsal, right, and ventral views of a carapace. Paratype USNM 168038. Same collection and locality as figures 1-5.
- 25, 26. Left and ventral views of an abraded carapace. Paratype USNM 168039. Same collection and locality as figures 1-5.
- 27-29. Right, dorsal, and left views of a carapace of a young instar. Paratype USNM 168040. Same collection and locality as figures 1-5.
- 30-33. Left, dorsal, right, and posterior views of a carapace. Holotype USNM 168044. Same collection and locality as figures 1-5.
- 34-36. Ventral, dorsal, and left views of adult corroded carapace. Paratype USNM 168041. Same collection and locality as figures 1-5.



DORSOBLIQUELLA

PLATE 5

[Magnification approximately $\times 20$; photographs by R. H. McKinney]

FIGURES 1, 2, 9-11. *Shishaella geisi* Sohn, n. sp. (p. B7).

1, 2. Right and left views of Geis' paratype of *Paraparchites subcircularis*. Illinois Univ. M-301. Illustrated by Geis, 1932, pl. 23, fig. 1d.

9-11. Right, dorsal, and posterior views of a carapace, Geis' plesiotype of *Paraparchites carbonarius* (Hall). Illinois Univ. M-302. Illustrated by Geis, 1932, pl. 23, fig. 2a.

3-8, 12-21. *Chamishaella carbonaria* (Hall, 1858). (p. B6).

3, 4. Right views of two carapaces, Geis' paratypes of *Paraparchites subcircularis*. Illinois Univ. M-301.

5-7. Right, dorsal, and left views of carapace; holotype of *Paraparchites subcircularis* Geis, 1932. Illinois Univ. M-300.

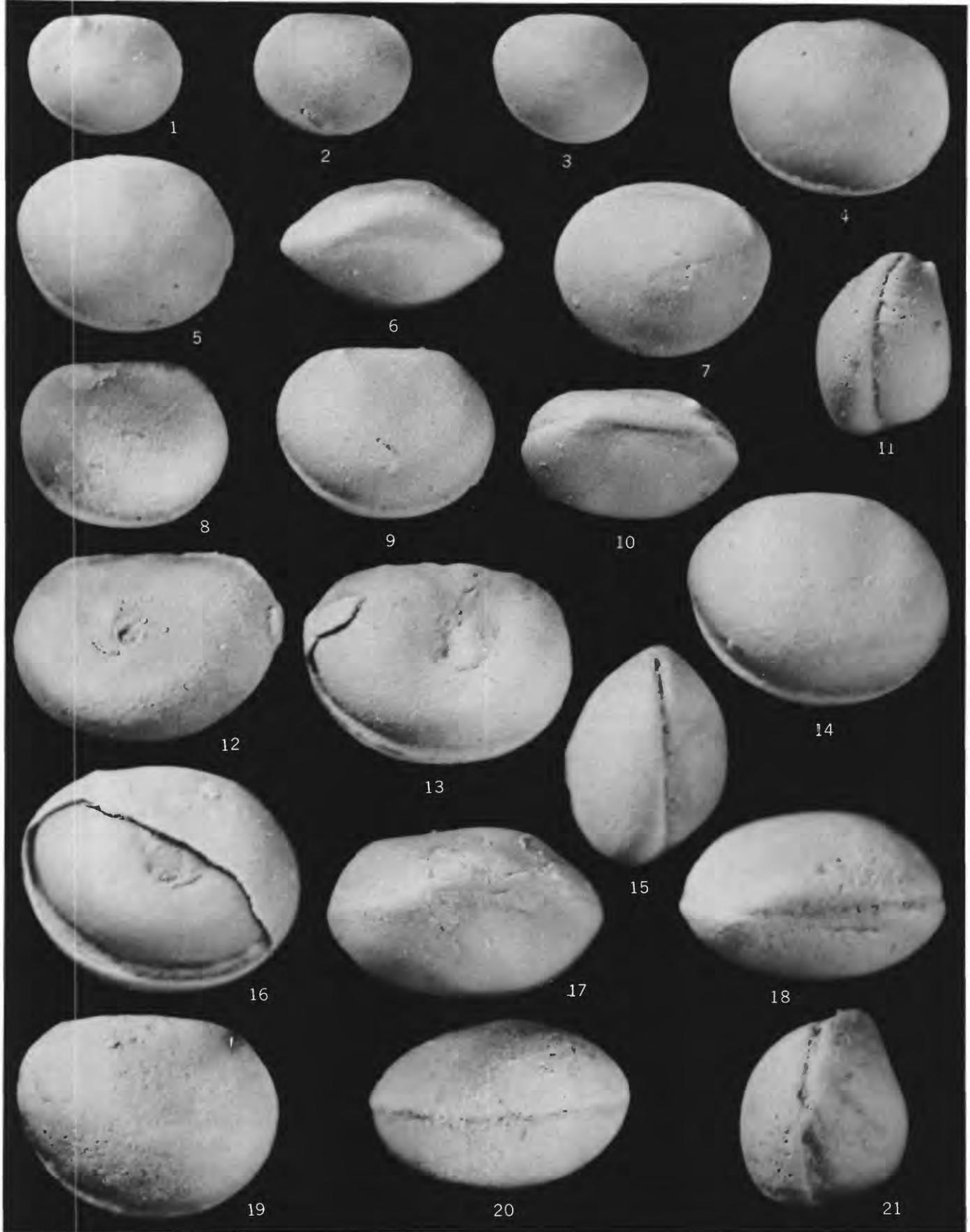
8. Right view of carapace, Geis' plesiotype of *Paraparchites carbonarius* (Hall). Illinois Univ. M-302. Illustrated by Geis, 1932, pl. 23, fig. b in dorsal outline. The source of light was intentionally reversed in order to compare with Geis' fig. 2 a photographed in the same manner.

12, 13. Left and right views of a steinkern showing the muscle-scar pattern. Specimen from Hall's original collection that was detached from either of two cardboards with many specimens (see text). Am. Mus. Nat. History (AMNH) 29100.

14, 15. Lateral and posterior views of carapace. Topotype? from white square cardboard with specimens from Spergen Hill, Ind. 7703/1, AMNH 29101.

16, 17. Right and dorsal views of partly exfoliated carapace, note muscle-scar pattern. Topotype?, from second white square of above cardboard. AMNH 29102.

18-21. Dorsal, right, ventral, and posterior views of a carapace. Lectotype, from green part of above cardboard. AMNH 29103.



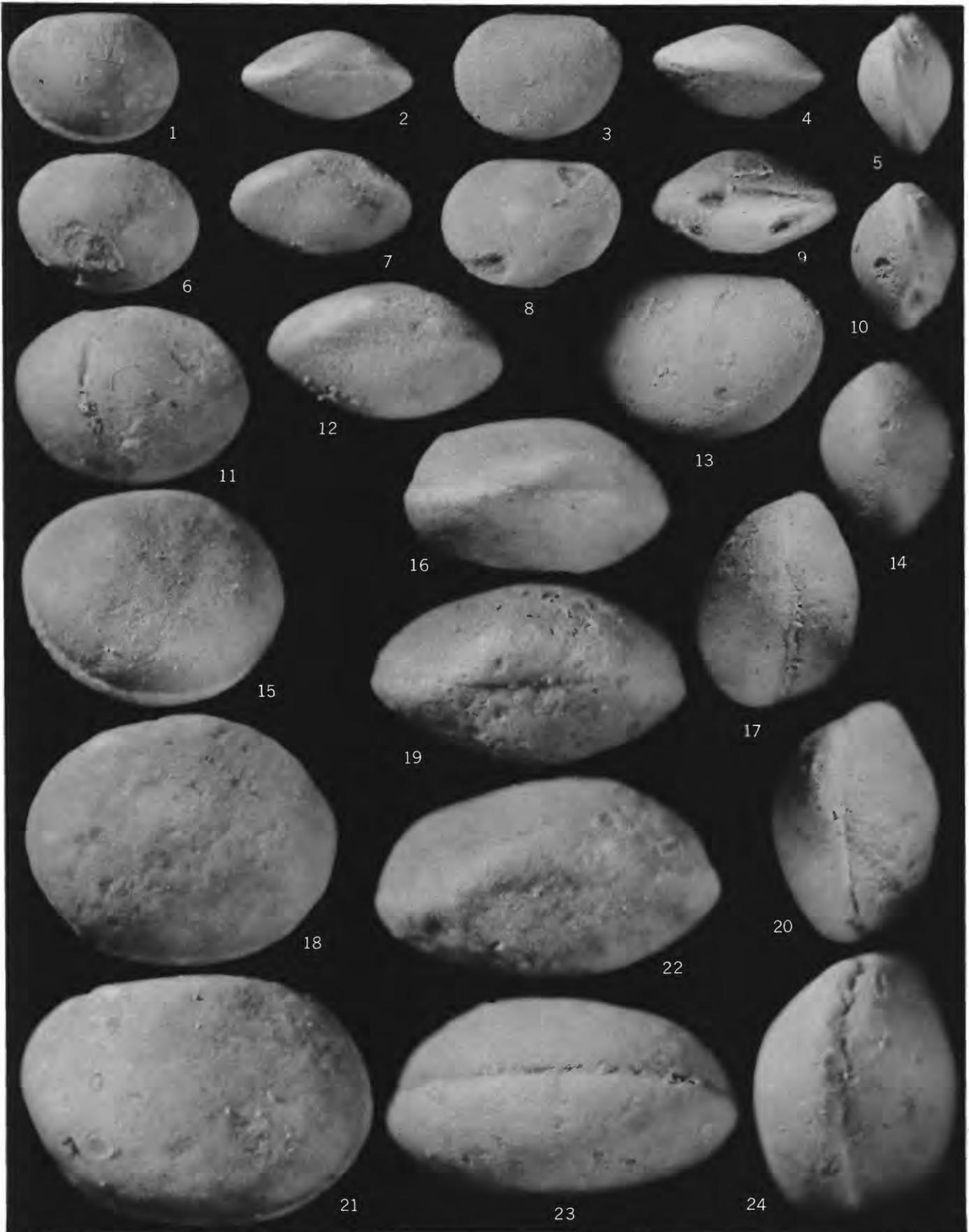
SHISHAELLA AND CHAMISHAELLA

PLATE 6

[Magnification approximately $\times 20$; photographs by R. H. McKinney]

FIGURES 1-24. *Chamishaella carbonaria* (Hall, 1858) (p. B6).

- 1-5. Right, dorsal, left, ventral, and posterior views of a carapace, young growth stage. Figured specimen USNM 168130. Topotype, Spergen Hill, Ind., USGS colln. 7522C green.
- 6-10. Right, dorsal, left, ventral, and posterior views of a carapace, young individual. Figured specimen USNM 168131. Spergen Limestone, Ste. Genevieve County, Mo., USGS colln. 1208 PC.
- 11-14. Right, dorsal, left, and posterior views of a subadult carapace. Figured specimen USNM 168132. Same collection and locality as figures 6-10.
- 15-17. Right, dorsal, and posterior views of a female carapace. Figured specimen USNM 168133. (?) Spergen Limestone, Ste. Genevieve County, Mo., USGS colln. 1211A PC.
- 18-20. Right, dorsal, and posterior views of a male carapace, gerontic individual. Figured specimen USNM 168134. Same collection and locality as figures 15-17.
- 21-24. Right, dorsal, ventral, and posterior views of female carapace, gerontic individual. Figured specimen USNM 168135. Spergen Limestone, Ste. Genevieve County, Mo., USGS colln. 1208 PC.



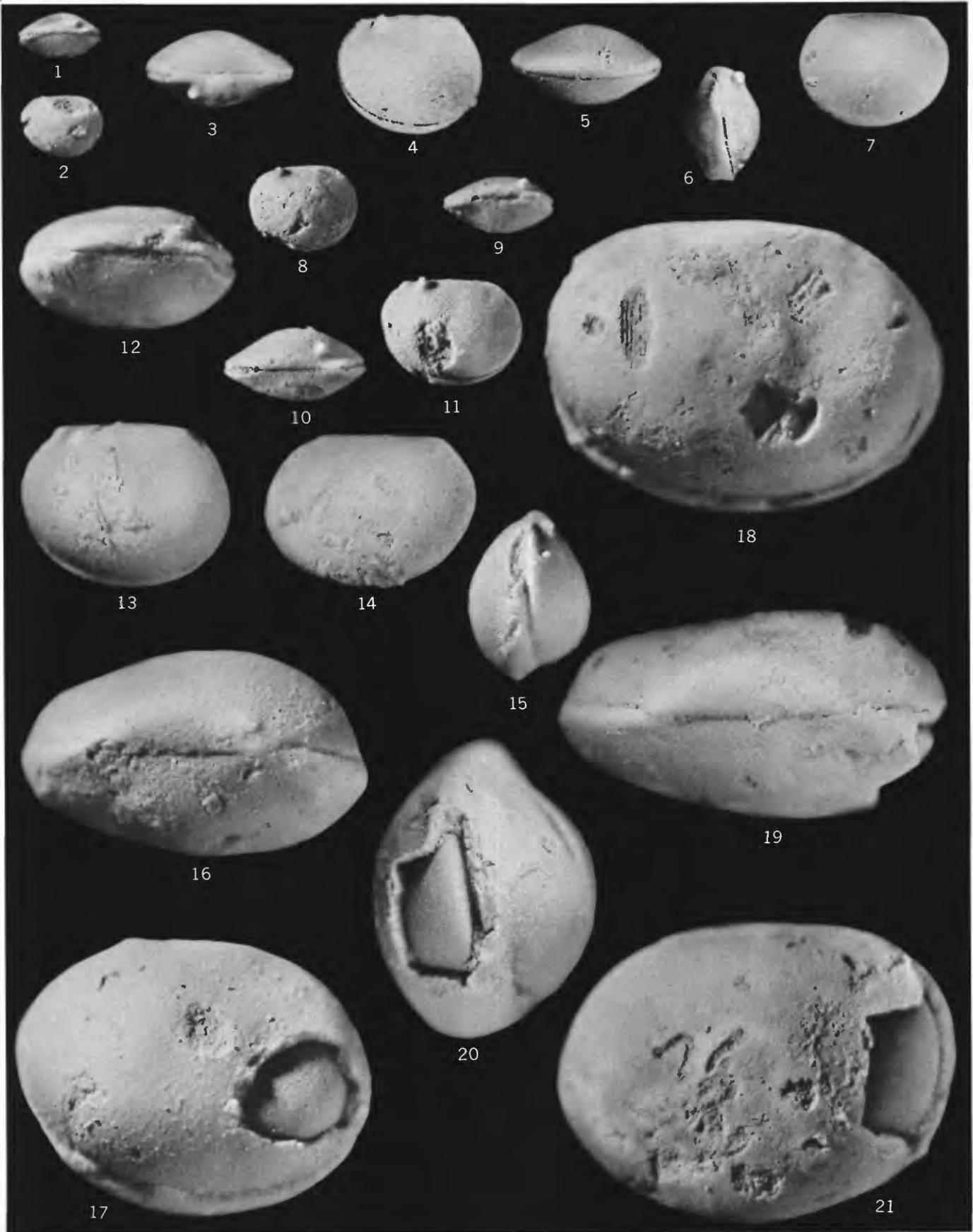
CHAMISHAELLA

PLATE 7

[Magnification approximately $\times 20$; photographs by R. H. McKinney]

FIGURES 1-21. *Shishaella geisi* Sohn, n. sp. (p. B7).

- 1, 2. Dorsal and right views of carapace, very young individual. Paratype USNM 168137. Salem Limestone, Spergen Hill, Ind., USGS colln. 12886 PC.
- 3-7. Dorsal, right, ventral, posterior and right views of a larger preadult carapace. Paratype USNM 168138. Same locality as figures 1 and 2, USGS colln. 7522C green.
- 8, 9. Right and dorsal views of a smaller carapace. Paratype USNM 168139. Same collection and locality as figures 1 and 2.
- 10, 11. Dorsal and right views of carapace, slightly larger growth stage than above. Paratype USNM 168140. Same collection and locality as figures 1 and 2.
- 12-15. Dorsal, right, left, and posterior views of adult female. Holotype USGS 168136. Same locality as figures 1 and 2, USGS colln. 7522C green.
- 16, 17. Dorsal and right views of gerontic female, note reduced size of spine. Paratype USNM 168141. Salem Limestone, Ste. Genevieve County, Mo., USGS colln. 1208 blue.
- 18-21. Right, dorsal, posterior, and left views of a very large individual. Paratype USNM 168142. Same collection and locality as figures 16 and 17.



SHISHAELLA

PLATE 8

[Magnification approximately $\times 30$; photographs by R. H. McKinney]

FIGURES 1-4, 6-9. *Shishaella cooperorum* Sohn, n. sp. (p. B8).

1-4. Outside, dorsal, inside, and posterior views of a right valve, probably adult male. Paratype USNM 168111. Road Canyon Formation (Permian), Glass Mountains, Tex. USNM colln. 703c.

6-9. Dorsal, right, inside, and posterior views of a right valve, adult female. Holotype USNM 168110. Same collection and locality as figures 1-4.

5. *Shishaella* sp. (p. B9).

Posterior view of a right valve, same specimen as on pl. 9, figs. 9, 10. Getaway Limestone Member of Cherry Canyon Formation (Permian). Culbertson County, Tex. USGS colln. 12856.

10-15. *Shishaella marathonensis* (Hamilton, 1942) (p. B8).

10, 11. Outside and posterior views of a right valve, probably adult male. Holotype USNM 110231. Road Canyon Formation (Permian), Glass Mountains, Tex. AMNH colln. 501.

12-15. Dorsal, outside, inside, and posterior views of a right valve. Figured specimen USNM 168120. Same formation and locality as figures 10 and 11.



SHISHAELLA

PLATE 9

[Magnification approximately $\times 30$; except where noted, photographs by R. H. McKinney]

FIGURES 1-8. *Shishaella cooperorum* Sohn, n. sp. (p. B8).

1-4. Dorsal, outside, inside, and posterior views of a right valve, young growth stage. Paratype USNM 168112. Road Canyon Formation, (Permian), Glass Mountains, Tex., USNM colln. 703c. Photographs by H. N. Shupe.

5-8. Posterior, dorsal, right, and left views of a carapace, larger growth stage. Paratype USNM 168113. Same collection, locality, and photographer as figures 1-4.

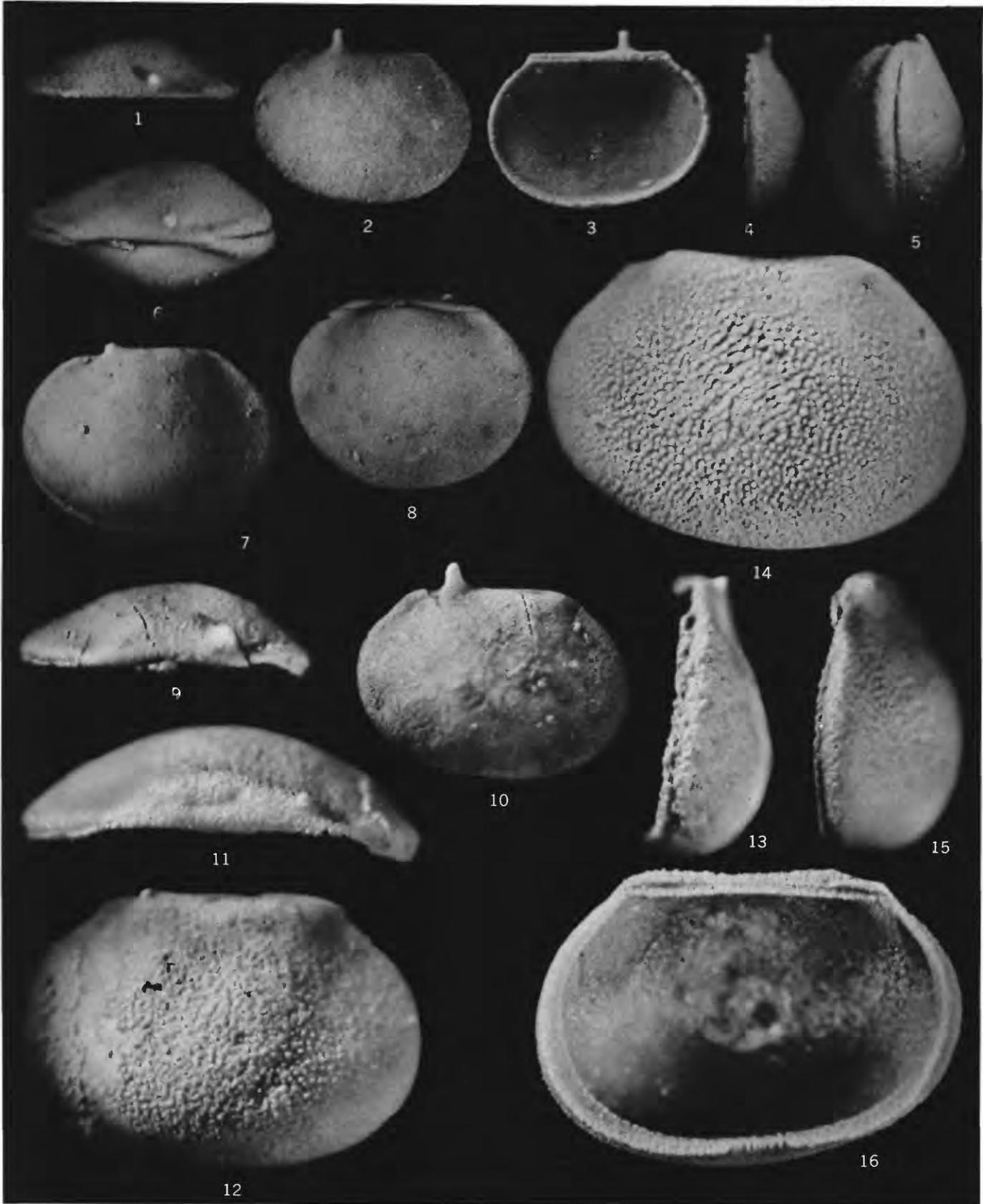
9, 10. *Shishaella* sp. (p. B9).

Dorsal and outside views of a right valve. Figured specimen USNM 168128. Getaway Limestone Member of Cherry Canyon Formation (Permian), Culbertson County, Tex., USGS loc. 12856.

11-16. *Shishaella marathonensis* (Hamilton, 1942) (p. B8).

11-13. Dorsal, outside, and posterior views of a right valve, adult female. Figured specimen USNM 168118. Road Canyon Formation (Permian), Glass Mountains, Tex. AMNH colln. 501.

14-16. Outside, posterior, and inside views of a right valve, adult female, note the muscle-scar pattern in fig. 16. Figured specimen USNM 168119. Same formation and locality as figures 11 and 13. USNM colln. 702c.



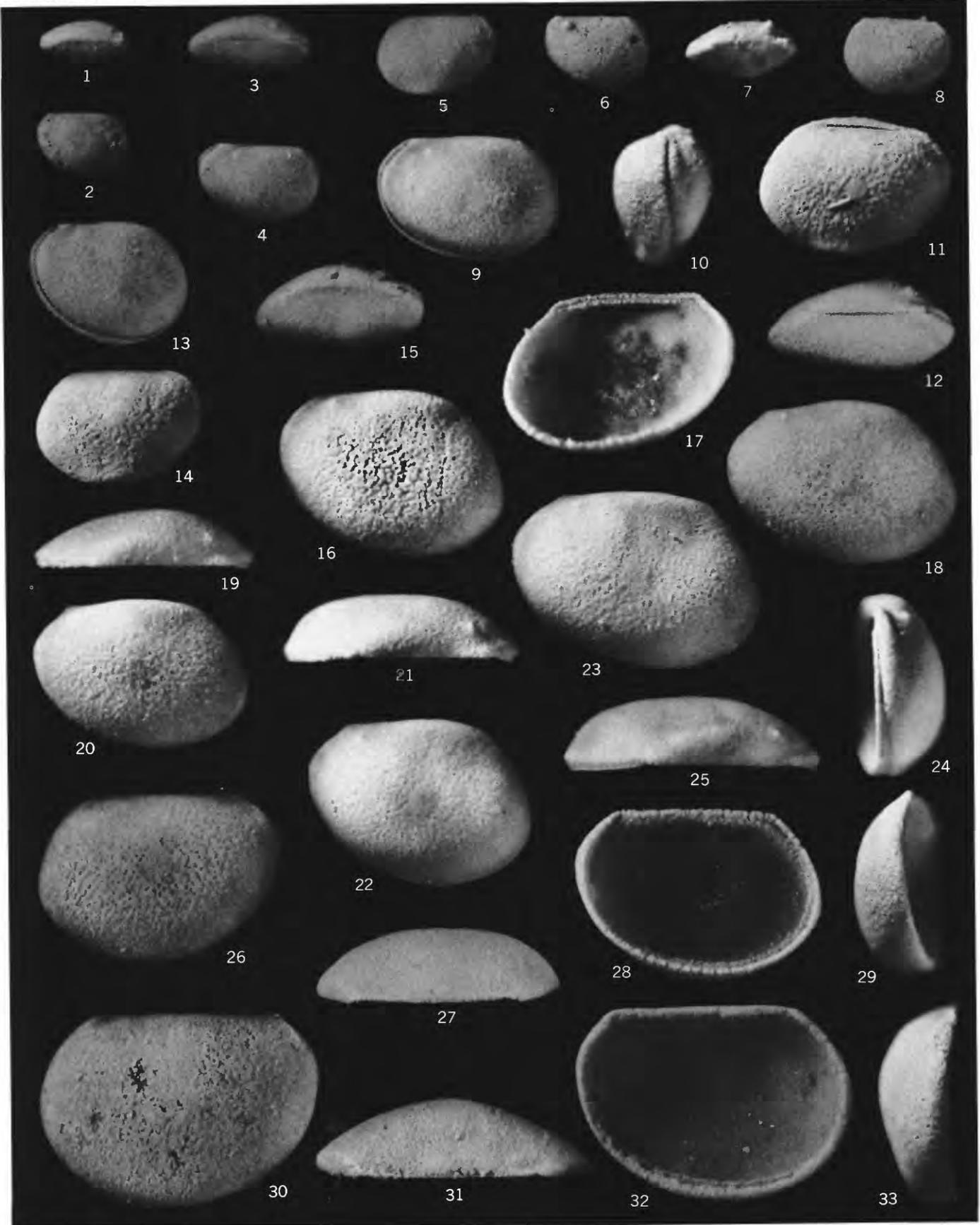
SHISHAELLA

PLATE 10

[Magnification approximately $\times 30$; except where noted, photographs by N. W. Shupe. All specimens from the Helms Formation (Upper Mississippian), Texas. USNM loc. 3070-2]

FIGURES 1-33. *Shishaella mackinneyi* Sohn, n. sp. (p. B9).

- 1, 2. Dorsal and right views of carapace, young instar. Paratype USNM 168148.
- 3-5. Dorsal, right, and left views of a carapace, slightly larger instar. Paratype USNM 168149.
- 6-8. Right, dorsal, and left views of a carapace, approximately the same growth stage as above. Note absence of slight bulge near ventral margin of fig. 8, shown in figs. 5, 11, and 14. Paratype, USNM 168150. Photograph of fig. 8 by R. H. McKinney.
- 9-12. Right, posterior, left, and dorsal views of carapace, larger individual. Paratype USNM 168151.
- 13-15. Right, left, and dorsal views of carapace, slightly younger instar than above. Paratype USNM 168152.
- 16, 17. Outside and inside views of right valve, probably adult female. Note hinge on fig. 17. Paratype USNM 168153. Photographs by R. H. McKinney.
18. Lateral view of right valve, note muscle-scar area. Paratype USNM 168154.
- 19, 20. Dorsal and lateral views of right valve, subadult stage. Paratype USNM 168155. Photographs by R. H. McKinney.
- 21, 22. Dorsal and lateral views of right valve, probably female. Paratype USNM 168156. Photographs by R. H. McKinney.
- 23-25. Lateral, posterior, and dorsal views of right valve, female. Holotype USNM 168147. Photographs by R. H. McKinney.
- 26-29. Outside, dorsal, inside, and posterior views of left valve, adult female. Paratype USNM 168157. Photograph of fig. 29 by R. H. McKinney.
- 30-33. Outside, dorsal, inside, and posterior views of a left valve, adult male. Paratype USNM 168158. Photograph of fig. 33 by R. H. McKinney.



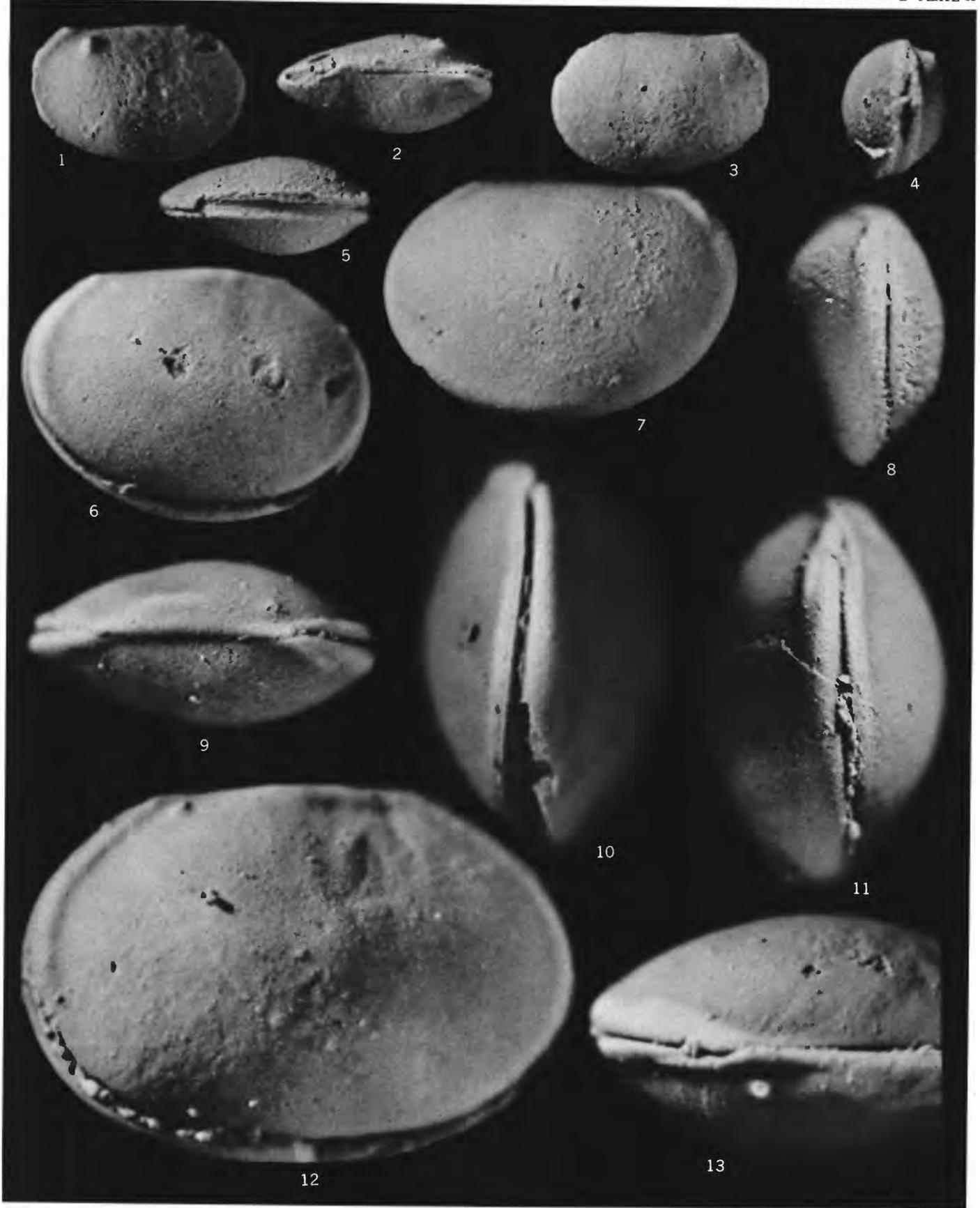
SHISHAELLA

PLATE 11

[Magnification approximately $\times 30$; photographs by R. H. McKinney]

FIGURES 1-13. *Shishaella eureka* Sohn, n. sp. (p. B10).

- 1-5. Right, dorsal, left, posterior and ventral views of a young instar. Paratype USNM 168163. Diamond Peak Quartzite (Upper Meramecian), Eureka quadrangle, White Pine County, Nev. USGS loc. PC-6567.
- 6-9. Right, left, posterior and dorsal views of a carapace of a larger instar than illustrated above. Paratype USNM 168164. Same collection and locality as figures 1-5.
- 10-13. Anterior, posterior, right and dorsal views of adult tecomorph. Paratype USNM 168165. Same collection and locality as figures 1-5. The anterior part of fig. 13 was cut off in order to fit the plate.



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PLATE 12

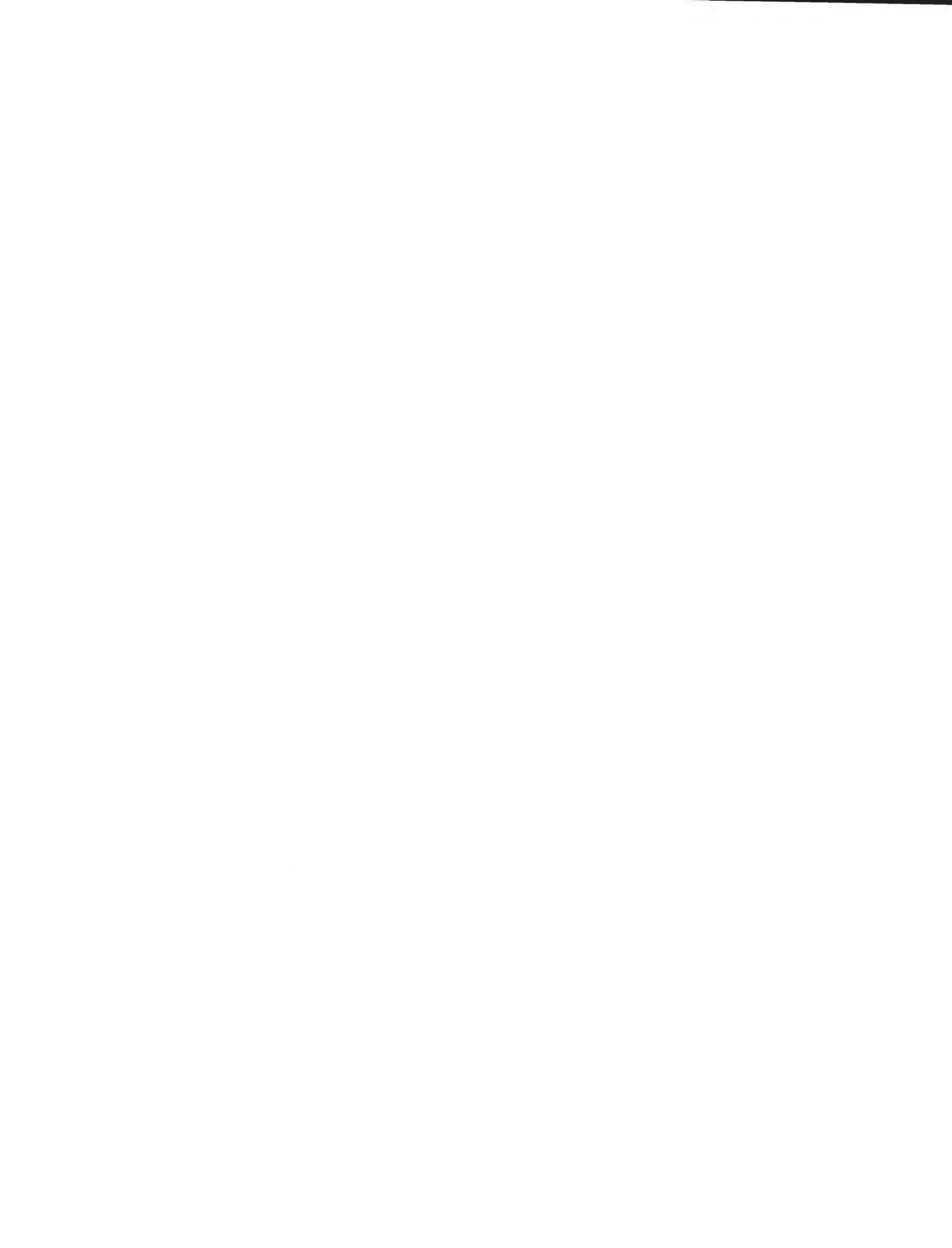
[Magnification approximately $\times 20$; photographs by R. H. McKinney]

FIGURES 1-9. *Shishaella eureka* Sohn, n. sp. (p. B10).

- 1-4. Posterior, ventral, dorsal, and right views of heteromorph carapace. Holotype USNM 168161. Diamond Peak Formation (upper Meramecian), Eureka quadrangle, White Pine County, Nev., USGS colln. PC-6567. The spine in fig. 4 was retouched.
- 5-9. Posterior, left, ventral, dorsal, and right views of tecnomorph carapace. Paratype USNM 168162. Same collection and locality as figures 1-4.



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ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

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