REVISTA ESPAÑOLA DE MICROPALEONTOLOGÍA
Vol. XXX, núm. 1, 1998, pp. 139-158

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OSTRACODA FROM THE SWIFT FORMATION (UPPER JURASSIC) OF MONTANA AND WYOMING

ABSTRACT

This paper describes and illustrates 20 species of Ostracoda from the Swift Formation (Oxfordian and early Kimmeridgian) of Montana and Wyoming. One species (*Cytherelloidea recurvoidea*, n. sp.) is new, 11 species were previously described (one is given a new name) and eight species are given affinitive status or are left in open nomenclature.

Among the Swift ostracode species 12 appear to be restricted to that formation or its correlatives in the area (Redwater Shale, upper Sundance Formation, South Dakota, Wyoming and Montana; and the upper Vanguard Formation in Saskatchewan) and are Oxfordian and early Kimmeridgian. The remaining eight Swift species occur also in pre-Oxfordian deposits in this region (Lower Sundance and Lower Vanguard Formation - Callovian). One species also has been recorded in Bathonian strata (upper member of Shaunavon Formation) in Saskatchewan by other workers.

Key words: Jurassic, Ostracoda, Montana, Wyoming, Swift Formation.

RESUMEN

Se describe y figura una fauna de 20 especies de Ostrácodos del Jurásico medio y superior de la Formación Swift (Oxfordiense y Kimmeridgiense) de Montana y Wyoming. Una especie (*Cytherelloidea recurvoidea*) es nueva, once fueron descritas anteriormente (una recibe nombre nuevo) y ocho se consideran afines o se dejan en nomenclatura abierta.

Doce especies de la Formación Swift se limitan a tal Formación o a sus correlativos (área de Redwater Shale, parte superior de la Formación Sundance, Sur Dakota, Wyoming, Montana, Formación superior Vanguard en Saskatchewan) y pertenecen al Oxfordiense y Kimmeridgiense inferior. Las otras ocho especies de la formación Swift se encuentran también en depósitos pre-Oxfordienses de esta región (Sundance inferior y Vanguard inferior, Calloviense). Una especie ha sido también mencionada por otros autores en el Bathoniense (Miembro superior de la Formación Shaunavon) en Saskatchewan.

Palabras clave: Ostrácodos, Jurásico, Formación Swift, Montana, Wyoming.

INTRODUCTION

The Swift Formation of Montana and northern Wyoming as discussed by Imlay (1980) consists of from 18 to 64 m of mainly shaly, glauconitic sandstone, commonly conglomeratic in the basal part. The Swift molluscan fauna is dated as late Oxfordian. The formation conformably underlies the non-marine Morrison Formation (Kimmeridgian and lower Tithonian) and unconformably overlies the Rierdon Formation (later Bathonian) and, in some places, the Sawtooth Formation (early Bathonian) or the Piper Formation (early Bathonian to late Bajocian).

Previous studies on the Upper Jurassic Ostracoda of the Western Interior region of the United States, including Montana, Wyoming and South Dakota include papers by Swain and Peterson (1951, 1952); Peterson (1954a, b); Wall (1960), and Brooke and Braun (1972).

In the present paper ostracodes from four localities in Montana and one in northern Wyoming are described and illustrated. The localities were briefly discussed by Swain and Peterson (1952), including a record of the ostracodes identified at the five localities. That list of species is modified and brought up to date in the present paper.

List of Localities

1. Southwest corner of Red Dome, east of Bridger, in Pryor Mountains, Sec. 19, T. 7 S., R. 24E., Carbon County, Montana (Locality 1 in Fig. 1, after Swain and Peterson, 1952).

Sample	*Position above base of section in m*
J-10a	at base
J-10b	Upper part of 2.1 m basal sandstone
J-10c	4.6
J-11a	5.3-7
J-11b	7.9
J-11c	8.8-10
J-11d	12.2
J-12a	12.2-13.9
J-12b	13.9-15.5

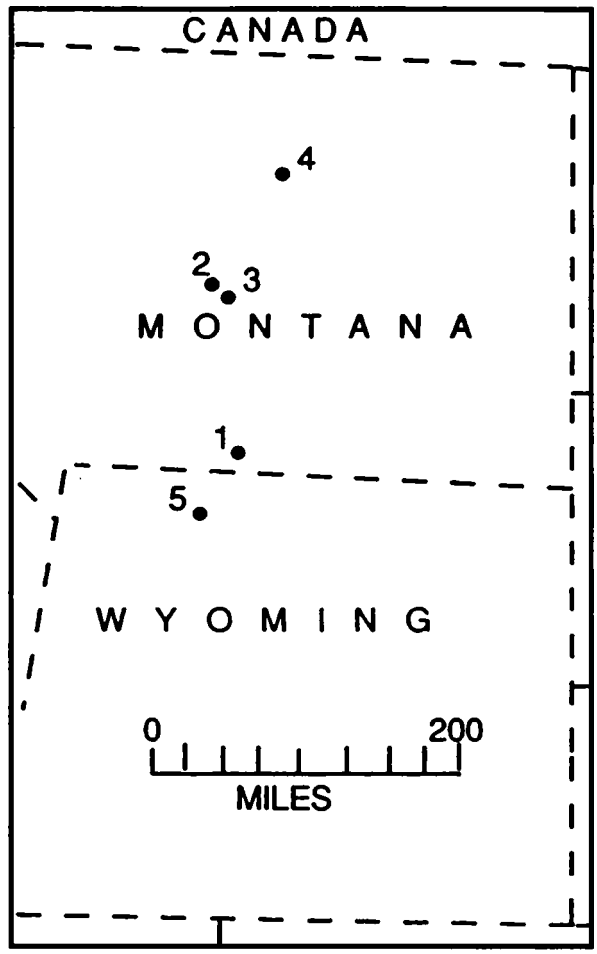

Figure 1

2. Along east side of road, 0.5 to 1 mile N. of gypsum factory in Sec. 2, T. 14N., R. 19E., near Heath, Fergus County, Montana (Locality 2 on Fig. 1, after Swain and Peterson, 1952).

Sample	*Position above base of section in m*
J-14a	1.8-3.6

3. One mile southwest of Piper on the northwest corner of the escarpment due east of Bacon Ranch, Sec. 17, R. 14N., R. 20E., Fergus County, Montana (Locality 3 on Fig. 1, after Swain and Peterson, 1952).

Sample	*Position above base of section in m*
J-19	Basal layers

4. One mile southwest of Landusky, Sec. 2, T. 25N., R. 24E., Little Rocky Mountains, Phillips County, Montana (Locality 4 on Fig. 1, after Swain and Peterson, 1952).

Sample	*Position above base of section in m*
J-22a	0.3
J-22b	1.2
J-22c	2.7
J-22d	4.0
J-22f	6.7
J-22g	7.6
J-22h	8.8
J-22j	11.3
J-22l	15.2

5. Gorge of Shoshone River, 2 miles W. of Cody, Wyoming (Locality 5 on Fig. 1, after Swain and Peterson, 1952).

Sample	*Position above base of section in m*
5-43b	1.5-3.0
5-43c	3.0-4.6

The species described in this paper and their known stratigraphic ranges are given in Table 1.

AGE OF THE SWIFT FORMATION

The Swift Formation is predominantly Oxfordian, early upper Jurassic, on the basis of the presence

Species	*Bathonian*	*Callovian*	*Oxfordian*	*Kimmeridgian*
Aparchitocythere typica	---	--- ----------	----------	--- - -
Cytherella paramuensteri		--- ----------	----------	--- - -
Macrocypris minutus		--- ----------	----------	--- - -
Bythocypris petersoni		--- ----------	----------	--- - -
Monoceratina sundancensis		--- ----------	----------	--- - -
Procytheridea cf. *crassa*		---- --------	----------	--- - -
Fuhrbergiella (P.) heiroglyphica		---------	----------	--- - -
Fuhrbergiella (P.) crowcreekensis		----	----------	--- - -
Cytherelloidea recurvoidea			----------	--- - -
Macrocypris? sp.			----------	--- - -
Cytherura? sp.			----------	--- - -
Cytherura? lanceolata			----------	--- - -
Ektyphocythere? sp.			----------	--- - -
Aparchitocythere loeblichorum			----------	--- - -
Limnocythere? aff. *climaxia*			----------	--- - -
Leptocythere imlayi			----------	--- - -
Procytheridea aff. *exempla*			--- -------	--- - -
Protocythere aff. *quadricarinata*			--- -------	--- - -
Progonocythere? aff. *cristata*			--- -------	--- - -
Galliaecytheridea? aff. *subquadrata*			--- -------	--- - -

Table 1. Stratigraphic distribution of species described in this paper.

of the ammonites *Cardioceras* and *Quenstedtoceras (Pavloviceras)* of early Oxfordian age in the Bearpaw and Little Rocky Mountains, Montana (Imlay, 1980). The basal beds of the formation contain the late Callovian ammonites *Quenstedtoceras (Lamberticeras) collieri* Reeside (Imlay, 1980). A specimen of *Buchia concentrica* (Sowerby), a late Oxfordian bivalve, has been found in the basal Swift in Montana (Imlay, 1980). The age of the upper Swift may be late Oxfordian or early Kimmeridgian according to Imlay (1980) based on its stratigraphic position, but has not yielded diagnostic mollusks.

Brooke and Braun (1972) used the ostracode species *Fuhrbergiella (Praefuhrbergiella) crowcreekensis*, and *F. (P.) heiroglyphica* to characterize the Swift Formation of Montana and the upper Vanguard Formation of Saskatchewan. Both species occur in the present collection, but both have been suggested to occur additionally in underlying Callovian equivalents by other authors (Wall, 1960; Loranger, 1955). Among the present species, the following are characteristic of the Swift Formation and are more than rare in occurrence: *Cytherura? lanceolata* Swain and Peterson, *Aparchitocythere loeblichorum* Swain and Peterson and *Leptocythere? imlayi* Swain and Peterson. All three species also occur in the Redwater Shale member of the Upper Sundance Formation of South Dakota, and in the upper Sundance of Wyoming (Swain and Peterson, 1951, 1952). Other aspects of the late Jurassic ostracode biostratigraphy of the Western Interior United States are discussed by Peterson (1954b).

The illustrated specimens are housed in the University of Minnesota Paleontological Collections.

Suborder PLATYCOPIDA Sars, 1866
Family CYTHERELLIDAE Sars, 1866
Genus ***Cytherella*** Jones, 1849

Cytherella paramuensteri Swain and Peterson
Plate 1 Figs. 1-3

Cytherella paramuensteri Swain and Peterson, 1952, p. 9, Pl. 1, Figs. 1-7. Peterson, 1954, p. 160, Pl. 1, Figs. 5-6.

Summary of shell characters: This species is characterized by sub-elliptical lateral outline, moderate overlap of left valve by right valve, broad dorsomedian depression of valves, small dorsomedian pit, posteromedian inflated shell in female dimorphs, smooth surface except for submarginal pits, simple lophodont hinge groove in right valve, and dorsomedian muscle scar consisting of four or five longitudinally elongate spots.

Length of figured specimen (Pl. 1, Figs. 1, 2) 0.78 mm; Height 0.40 mm; Width 0.33 mm.

Occurrence: The species occurs in the Swift Formation (Oxfordian-Kimmeridgian) localities J-11a-d, J-12b, J-14, and J-43c. It also occurs in the lower and upper (Redwater Member) Sundance Formation (Oxfordian-Kimmeridgian) of Wyoming (Swain and Peterson, 1952) and in the Rierdon Formation (lower Sundance) (Callovian) of Montana (Peterson, 1954) the lower (Callovian) Vanguard Formation of Saskatchewan (Wall, 1960; Brooke and Braun, 1972).

N.° of specimens studied: 38.

Genus ***Cytherelloidea*** Alexander, 1929

Cytherelloidea recurvoidea n. sp.
Plate 1 Figs. 4-6

Diagnosis: A *Cytherelloidea* having anterior submarginal narrow rim that continues along venter and posterior margin to position one-fourth from posterodorsal angle where it bends anteriorly and ventrally near midheight one-fourth from anterior end; general surface within rim coarsely pitted.

Description: Shell subelliptical in side view, highest anteromedially; dorsal margin nearly straight, slightly concave medially with broadly obtuse cardinal marginal bends; ventral margin slightly concave; anterior margin broadly rounded; posterior margin less broadly rounded, subtruncate above. Right valve larger than left valve, overlapping and extending beyond edge of left most noticeably along posterior, ventral and dorsal margins. Valves relatively compressed, parallelsided in edge view, greatest width posteromedian.

A narrow-crested broad submarginal ridge begins near anterodorsal angle and continues along anterior, ventral and ventral two-thirds of posterior margin where it bends sharply toward anterior to midlength where it loops toward venter to venterad of midheight, continues anteriorly to one-third of length from anterior where it merges with valve surface; in mid-dorsal area are several irregular short ridges defining a large rounded median pit; general valve surface other than ridges and median pit, coarsely pitted. Internal shell structures not observed.

Length of holotype right valve (Pl. 1, Fig. 6) 0.68 mm; Height 0.37 mm; Width of valve 0.10 mm. The holotype is from the Swift Formation, Locality J-43h.

Relationships: This species differs from *C. recurvata* Peterson 1954 from the Rierdon Formation of Montana and Wyoming in that the main ridge in that species terminates posterodorsally rather than continuing from that position ventrally and anteriorly as in the present species. In addition *recurvata* has a large node dorsal to the median pit in this right valve that is absent in the new species. Both forms are coarsely pitted on the general surface, neither species has exhibited dimorphism in known specimens.

Occurrence: Swift Formation, Localities J-19 and J-43h.

N.° of specimens studied: 6.

Superfamily BAIRDIACEA Sars, 1888
Order PODOCOPIDA Müller, 1894
Suborder PODOCOPINA Sars, 1866
Family MACROCYPRIDIDAE Müller, 1912
Genus ***Macrocypris*** Brady, 1867

Macrocypris minutus Swain and Peterson
Plate 1 Figs. 7, 8

Macrocypris minutus Swain and Peterson, 1952, p. 9, Pl. 1, Figs. 13-16. Peterson, 1954, p. 164, Pl. 18, Fig. 22.

Summary of shell characters: Shell sublanceolate in lateral outline: highest anteromedially; dorsum moderately convex, venter nearly straight; anterior rounded, extended below; posterior subacuminate, strongly extended below. Right valve larger than left, overlapping and extending beyond edge of left most noticeably anterodorsally and ventrally; medially, right valve overlaps left; valves compressed, greatest width anteromedian. General surface smooth. Hinge margin of left valve beveled above for reception of edge or right valve; inner lamellae fairly broad, vestibule absent; adductor scar a dorsomedian group of four or more spots.

Length of figured shell 0.52 mm; Height 0.24 mm; Width 0.13 mm.

Ocurrence: Swift Formation, Localities J-14, J-19, J-22c, J-22f. Previously the species was recorded from the Redwater Shale Member of the upper Sundance Formation, Sheridan County, Wyoming (Swain and Peterson, 1952), the Rierdon Formation of Carbon County, Montana (Peterson, 1954), and from the lower and middle Vanguard Formation of Saskatchewan and the Rierdon Formation, Little Rocky Mountains, Montana (Brooke and Braun, 1972).

N.° of specimens studied: 4.

Macrocypris? sp.
Plate 1 Figs. 11, 12

Summary of shell characters: Shell elongate sublanceolate, highest one-third from anterior end; dorsum gently convex with slight depression posteriorly, venter slightly concave, anterior margin rounded, posterior margin acuminate, but not pointed, strongly produced below; antero-ventrally is a weak marginal notch; right valve larger than left valve, overlapping and extending beyond edge of left most noticeably along venter and dorsal slopes; general surface apparently smooth.

Length of figured specimens 0.40 mm; Height 0.14 mm; Width 0.08 mm.

Remarks: This form is considerably more elongate than *M. minutus* Swain and Peterson, 1952, recorded above. It bears some resemblance to *M. terraefullonicae* Jones and Sherborne, 1888 from

the Bathonian (Middle Jurassic) of England but that species is more equal-ended than the present one.

Occurrence: Swift Formation, Locality 14a.

N.° of specimens studied: 3.

Family BAIRDIIDAE Sars, 1888
Genus ***Bythocypris*** Brady, 1880

Bythocypris petersoni, new name
Plate 1 Figs. 9, 10

Bythocypris sp. Swain and Peterson, 1952, p. 7
Bythocypris jurassica Peterson, 1954a, p. 163, Pl. 17, Figs. 12, 13, not *B.? jurassica* Chapman, 1900, p. 325, text Figs. 1a-c.

Summary of shell characters: Shell elongate, subelliptical-subreniform, dorsum slightly convex, venter weakly concave, ends rounded, the anterior slightly narrower than posterior; left valve slightly larger than right valve; surface appears unornamanted.

Length of figured specimen 0.43 mm; Height 0.20 mm; Width 0.20 mm.

Remarks: This form is more elongate with respect to height than *B. ambitruncata* Peterson, 1954 which also has a more convex dorsum.

Occurrence: Swift Formation, Locality J-11d. The species was described from the Rierdon Formation of south-central Montana and north-central Wyoming (Peterson, 1954) and was recorded from the Swift Formation, Locality J-22a (Swain and Peterson, 1952).

N.° of specimens studied: 2.

Superfamily CYTHERACEA Baird, 1850
Family CYTHERURIDAE G. W. Müller, 1894
Genus ***Cytherura*** Sars, 1866

Cytherura? sp.
Plate 1 Figs. 13, 14

Summary of shell characters: Shell small, subpyriform-sublanceolate in side view, highest slightly anteriormedially, dorsum gently convex; venter slightly convex with slight notch posteriorly due to projecting alae; anterior margin broadly rounded; posterior margin narrowly rounded, subacuminate, extended medially. Valves subequal, right valve overlaps left along hinge margin left valve overlaps right along dorsal slopes. Ventral surface of each valve expanded as a short ala; ventral marginal surfaces of alae bear narrow ridges; posterior fifth of shell compressed and smooth-surfaced; anterior marginal zone of shell also smooth; general shell surface bears closely spaced pits and low sinuous ridges, medially a slightly larger pit is defined by ridges. Internal shell structures not observed.

Length of figured specimen (Pl. 1, Fig. 13) 0.27 mm; Height 0.17 mm; Width 0.15 mm.

Remarks: The outline and ventral weak alation of this form resemble features of many species of *Cytherura*. The species resembles *Monoceratina sundancensis* Swain and Peterson, 1952 in general form but lacks the dorsomedian sulcus and is more densely pitted than that species. Too little material is available here for further treatment of the species.

Occurrence: Swift Formation, Localities J-11b, J-43c?

N.° of specimens studied: 3.

Cytherura? lanceolata Swain and Peterson
Plate 2 Figs. 3-6, 12, 13

Cytherura? lanceolata Swain and Peterson, 1952, p. 802, Pl. 114, Figs. 5, 6, 27; text Fig. 1b,c.

Summary of shell characters: Shell of male dimorphs small, subovate-subacuminate, highest anterior to middle; dorsum moderately convex, venter slightly convex to nearly straight with slight notch posteriorly due to overhanging alae; anterior broadly rounded extended below, truncate above; posterior narrowly rounded to subacuminate, strongly extended below. Valves nearly equal in size, right valve overlaps left along hinge margin;

left valve extends slightly beyond right along dorsal slopes. Ventral surface of each valve expanded to form low alae that terminate posteroventally as blunt points and overhang ventral margin. General surface smooth. Internal valve structures described previously.

Shells of female? dimorphs more elongate and with flatter dorsal margins than male shells.

Length of figured specimen (Pl. 2, Fig. 5) 0.31 mm; Height 0.21 mm; Width 0.13 mm.

Remarks: The specimens referable to this species show dimorphism with relatively shorter and higher males? and more elongate female? shells, not previously reported.

Occurrence: Swift Formation, Localities J-11c, J-11d, J-14, J-22f. Elsewhere the species occurs in the Redwater shale member, Sundance Formation, northwestern South Dakota (Swain and Peterson, 1951) and north central Wyoming (Swain and Peterson, 1952) and the Swift Formation of Montana (*ibid.*). It has not been recorded in pre-Oxfordian deposits in the north central United States or Saskatchewan, Canada.

N.° of specimens studied: 33.

Family BYTHOCYTHERIDAE Sars, 1926
Genus ***Monoceratina*** Roth, 1928

Monoceratina sundancensis Swain and Peterson
Plate 1 Figs. 15-17
Plate 2 Figs. 1, 2

Monoceratina sundancensis Swain and Peterson, 1951, p. 803, Pl. 114, Figs. 7-15; text Fig. 1a.

Summary of shell characters: Shell small, elongate-subpyriform, highest about one-third of length from anterior end; dorsum slightly convex, notched medially at position of median sulcus; venter gently concave; anterior broadly rounded slightly extended below; posterior narrowly rounded, subcaudate, strongly extended medially; valves subequal, the right valve overlaps the left along hinge; dorsomedially is a shallow, narrow, subvertical, sulcus; general surface weakly reticulated, some of the sinous ridges dorsally and terminally are more prominent than others ridges of the reticulum; midventral surface in each valve expanded as short posteriorly directed alate; alate surface overhangs valve margin; posterior sixth of shell compressed. Hinge consists of simple terminal notchlike depressions in left valve corresponding projections in right valve; interterminal edge of left valve rabbeted below, that of right valved rabbeted above; abductor muscle scar a slightly anteromedian vertical row of four small spots; inner lamellae of moderate width, sloping steeply inward, narrow vestibules occur terminally.

Length of figured specimen (Pl. 1, Fig. 17) 0.37 mm; Height 0.20 mm; Width 0.16 mm.

Occurrence: In the present collection, the species occurs in the Swift Formation, Localities J-11a-d, J-14a, J-19, J-22f, J-22j. Previously the species was recorded in the Sundance Formation, Redwater Shale Member of South Dakota (Swain and Peterson, 1951); the Redwater Shale of Wyoming and the Swift Formation of Montana (Swain and Peterson, 1952); the Rierdon Formation of Montana and Wyoming (Peterson, 1954), and the Lower Member of the Vanguard Formation of Saskatchewan (Brooke and Braun, 1972). Thus the species appears to range throughout the Callovian and Oxfordian Rierdon and Swift Formations (= Sundance Formation) in Montana, Wyoming, and South Dakota, but is found only in the Callovian lower member of the Vanguard Formation in Saskatchewan.

N.° of specimens studied: 17.

Family PROGONOCYTHERIDAE Sylvester-Bradley, 1948
Subfamily PROTOCYTHERINAE Lyubimova, 1955
Genus ***Procytheridea*** Peterson, 1954

Procytheridea of *P. crassa* Peterson
Plate 2 Figs. 7, 8

Procytheridea crassa Peterson, 1954, p. 172, Pl. 19, Figs. 1-5.

Summary of shell characters: Shell of male? dimorphs, elongate subquadrate in side view, hig-

hest posteromedially; dorsum nearly straight, cardinal angles obtuse; venter slightly convex, straightened in anterior half; anterior broadly rounded; posterior pointed, extended medially, truncate above and below, left valve slightly larger than right valve; in edge view valves relatively compressed and parallel-sided. Anterodorsally is a low lobe or eye tubercle; anterior marginal zone compressed; concentric narrow ridges lie in ventral half and anterior two-thirds; a second set of oblique narrow ridges lies in posterior third, ventral surface expanded and overhangs ventral margin. Internal shell structures not observed.

Length of figured specimen (Pl. 2, Fig. 7) 0.65 mm; Height 0.40 mm; Width of compressed shell 0.23 mm.

Remarks: These forms resemble male forms of *P. crassa* in general shape and ornamentation but are distorted and are difficult to identify with certainty. It also resembles *Fuhrbergiella (Praefuhrbergiella)* sp. 60 of Brooke and Braun from the middle and upper Vanguard Formation of Saskatchewan and the Swift Formation of Little Rocky Mountains, Montana (1972, Pl. 2, Figs. 14-25) in surface ornamentation but is much more compressed in edge view than that species.

Occurrence: Swift Formation, Locality J-22a.

N.° of specimens studied: 2.

Procytheridea sp. aff. *exempla* Peterson
Plate 2 Figs. 9-11

?Procytheridea exempla Peterson, 1954 of Brooke and Braun, 1972, Pl. 3, Figs. 15, 16.

Summary of shell characters: Shell subpyriform in side view, highest about two-fifths of length from anterior end; dorsum moderately convex, venter gently convex; anterior broadly rounded, extended below; posterior narrowly rounded, strongly extended medially; left valve larger than right valve, overlapping and extending beyond right dorsally. Valves moderately convex, greatest width posteromedian.

Anterodorsally in each valve is a low oblique swelling bordered ventrally by an oblique shallow sulcus; dorsomedially each valve bears two or more ridges arched toward dorsum; in medial half are two narrow longitudinal ridges; surface medially bears a few small pits in some specimens. Hinge of right valve consists of terminal elongate crenulate teeth that fit into corresponding sockets in left valve.

Length of figured specimen (Pl. 2, Fig. 9) 0.60 mm; Height 0.37 mm; Width 0.29 mm.

Remarks: This form most clearly resembles Peterson's Pl. 19, Fig. 9, among the specimens originally illustrated, but differs in being much more weakly, ornamented than that specimen especially in the strong pitting in the holotype of *P. exempla* (Peterson, 1954, Pl. 19, Fig. 6) has a more uniform pattern of pitting and a more strongly elevated mid-dorsal ridge than any of the present specimens. Brooke and Braun (1972, Pl. 3, Figs. 15, 16) illustrate two forms that they assign to *P. exempla* which resemble the present Swift specimens, but which are larger than the type specimens as well as the present specimens. The latter are about the same size as the types. The much weaker surface ornamentation of the present specimens may be due to interspecific variation, but are left here in affinitive status.

Occurrence: Swift Formation, Locality J-22a.

N.° of specimens studied: 38.

Genus ***Protocythere*** Triebel, 1938

Protocythere? sp. aff. *P. quadricarinata* Swain and Peterson
Plate 2 Figs. 14, 15
Plate 3 Figs. 8, 9

?Procytheridea sp. A. of Wall, 1960; Brooke and Braun, 1972, Pl. 3, Figs. 45-49 (not Wall, 1960).

Summary of shell characters: Shell subtriangular-subpyriform (female) to sublanceolate (male), in side view, highest medially; dorsum moderately convex, venter gently convex; anterior rounded, extended below, subtruncate above; posterior narrowly rounded, strongly extended medially. Left

valve larger than right valve and shells vary from compressed to tumid in edge view. Valves bear median longitudinal furrows that separate four longitudinal ridges in approximately middle half of valves; anterodorsal quarter of valves somewhat compressed. Internal shell structure not observed.

Elongate forms of the species are less convex than the shorter subtriangular specimens and probably represent male specimens.

Length of figured left valve 0.60 mm; Height 0.37 mm; Width of valve 0.13 mm.

Remarks: These forms are more triangular in lateral outline than *P. quadricarinata* Swain and Peterson, 1952 from the upper Jurassic Redwater Shale member, upper Sundance Formation of Wyoming. They are similar if not identical to *Procytheridea* sp. A of Wall (1960) as illustrated by Brooke and Braun, 1972, but *P.* sp. A of Wall (1960) has broader ridges, narrower intergrooves and a narrow subvertical anterior furrow as compared to the present form.

Occurrence: Swift Formation, Localities J-10b, c y J-22f, g.

N.° of specimens studied: 17.

Genus ***Fuhrbergiella*** Brand and Malz, 1962
Subgenus *Praefuhrbergiella* Brand and Malz, 1962

Fuhrbergiella? (Praefuhrbergiella) heiroglyphica (Swain and Peterson)
Plate 2 Figs. 16, 17
Plate 3 Figs. 1, 2

Progonocythere heiroglyphica Swain and Peterson, 1951, p. 800, Pl. 113, Figs. 10-18; 1952, p. 12, Pl. 2, Figs. 18-20. Wall, 1960, p. 148, Pl. 28, Figs. 8, 9.
Fuhrbergiella (Praefuhrbergiella) heiroglyphica (Swain and Peterson); Brooke and Braun, 1972, p. 28, Pl. 2, Figs. 1-13; p. 74, Pl. 25, Figs. 4-11.

Summary of shell characters: Shell subquadrate to subelliptical, highest near anterior end; dorsum and venter nearly straight and subparallel; anterior broadly rounded, slightly extended below in some specimens; posterior margin more narrowly rounded, extended above in most specimens. Left valve slightly larger than right valve; greatest width slightly posteromedian; male dimorphs less wide than females, an oblique eye tubercle occurs anterodorsally; anteromedially is an irregular median tubercle nearly surrounded by a curved ridge; two or three conventric ridges lie anterior to median tubercle, and 7 or 8 subvertical ridges occur posterior to tubercle; two or three additional narrow ridges lie along dorsal and ventral borders and connect to the ends of some of the other ridges. Left valve hinge consists of terminal elongate denticulate sockets, separated by a weakly crenulate interterminal bar.

Length of figured specimen (Pl. 2, Fig. 16) 0.53 mm; Height 0.30 mm; Width 0.30 mm.

Remarks: There is considerable doubt that this species belongs in *Fuhrbergiella*, which typically has a rather pronounced ventral longitudinal ridge and a reticulate or nodose general surface. The writer believes the species may represent a new genus.

Occurrence: Swift Formation, Localities J-10a, J-19, J-22b, c, d, f, g y J-43b. The species is widespread in the Redwater Shale, upper Sundance Formation of South Dakota (Swain and Peterson, 1951, 1952) and in the Swift Formation of Montana (Swain and Peterson, 1952; Brooke and Braun, 1972) and in the upper Vanguard Formation of Saskatchewan (Wall, 1960; Brooke and Braun, 1972). Loranger (1955) recorded it from a well in lower Vanguard of Saskatchewan, but Wall (1960) suggested that this occurrence might be the result of caving well samples.

N.° of specimens studied: 74.

Fuhrbergiella (Praefuhrbergiella) crowcreekensis (Swain and Peterson)
Plate 3 Figs. 3, 4?, 5-7
Plate 4 Figs. 7, 8

Progonocythere crowcreekensis Swain and Peterson, 1951, p. 802, Pl. 114, Figs. 1-4.

Fuhrbergiella (Praefuhrbergiella) crowcreekensis (Swain and Peterson); Brooke and Braun, 1972, p. 26, Pl. 1, Figs. 56-62.

Summary of shell characters: Shell elliptical to subquadrate, dorsum nearly straight, venter concave medially, but subparallel to dorsum, anterior broadly rounded, posterior more narrowly rounded; left valve slightly larger than right valve, valves strongly convex; anterior marginal zone compressed; anterodorsally oblique furrow extends from near dorsal margin to about midheight; anteromiddorsally a short narrow sulcus extends from margin to venterad of midheight; a concentric submarginal ridge parallel free margins in well preserved specimens; general surface coarsely reticulate; hinge of right valve with terminal slightly elevated transversely weakly crenulate dental areas and interterminal crenulate bar. Males? slightly shorter and higher than females?

Length of figured male? shell (Pl. 3, Figs. 5, 6) 0.87 mm; Height 0.47 mm; Width 0.47 mm.

Remarks: As figured by various authors this species is variable in coarseness of reticulation and in degree of development of sulci.

Occurrence: Swift Formation, Localities J-10a-c, J-19, J-43c and J-22b, h. Previously the species was recorded from the Redwater Shale, Sundance Formation, South Dakota (Swain and Peterson, 1951), the Redwater Shale of Wyoming and the Swift Formation of Montana (Swain and Peterson,

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PLATE 1

All paired pictures are stereo pairs.

Figs. 1-2. *Cytherella paramuensteri* Swain and Peterson. Left side, X 66 and dorsal view, X 75 of two male shells. Locality J-11b, Swift Formation.

Fig. 3. *Cytherella paramuensteri* Swain and Peterson. Left side of female shell, X 84. Locality J-11b, Swift Formation.

Figs. 4-5. *Cytherelloidea recurvoidea* n. sp. Left side, X 72 and dorsal view, X 66 of male paratype shell. Locality J-19, Swift Formation.

Fig. 6. *Cytherelloidea recurvoidea* n. sp. Right side of holotype shell, X 66. Locality J-43h, Swift Formation.

Figs. 7-8. *Macrocypris? minutus* Swain and Peterson. Left side, X 106 and dorsal view, X 100 of poorly reserved shell. Locality J-19, Swift Formation.

Figs. 9-10. *Bythocypris petersoni*, new name. Right? side, X 114 and dorsal view, X 121 of shell. Locality J-11d, Swift Formation.

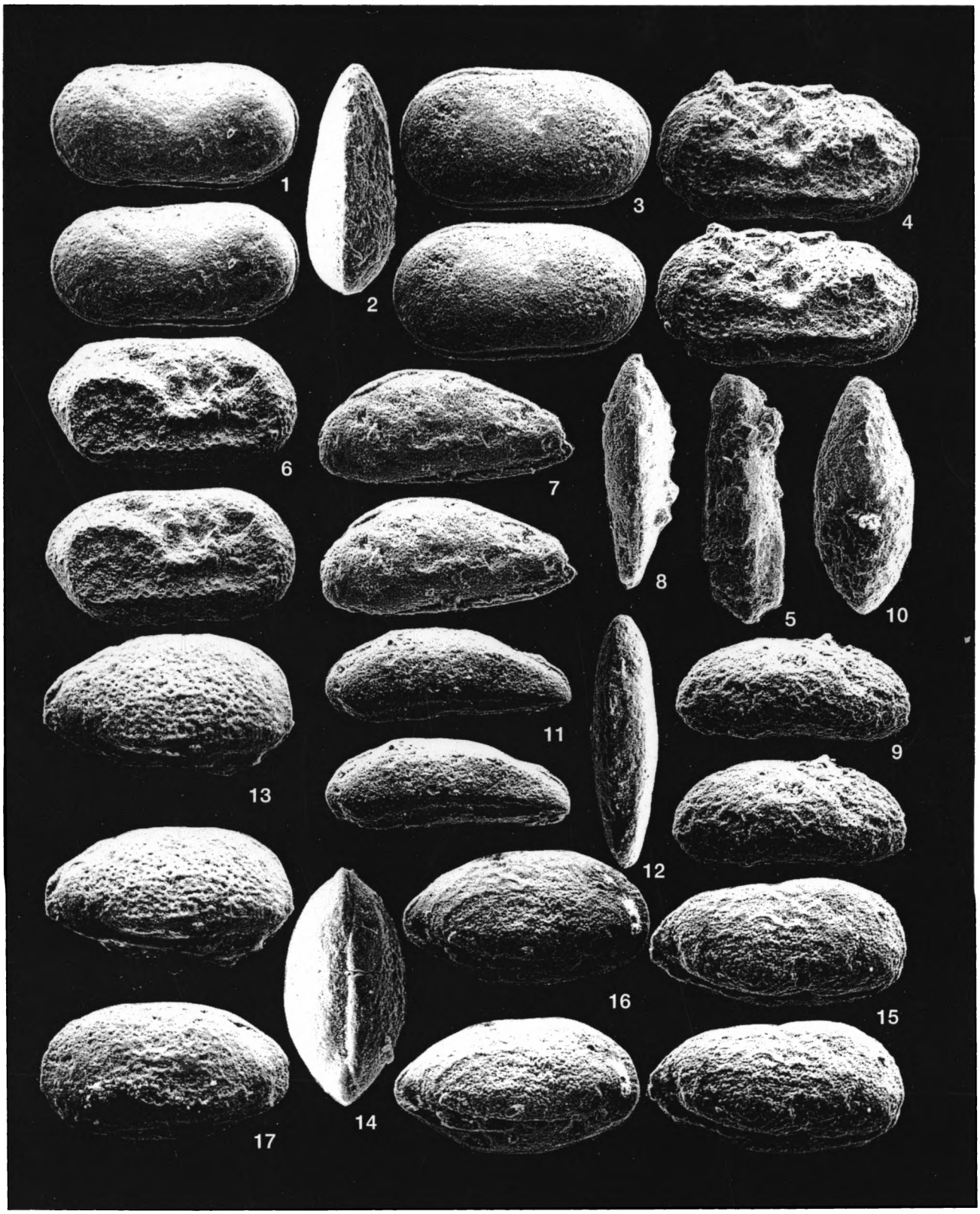
Figs. 11-12. *Paracypris* sp. aff. *P. projecta* Peterson. Left side, X 127 and dorsal view, X 139 of two shells. Locality J-14a, Swift Formation.

Figs. 13-14. *Monoceratina sundancensis* Swain and Peterson. Right side, X 163 and dorsal view, X 151 of two shells. Locality J-11b, Swift Formation.

Fig. 15. *Monoceratina?* cf. *sundancensis* Swain and Peterson. Right side of shell, X 145. Locality J-19, Swift Formation.

Fig. 16. *Monoceratina?* cf. *sundancensis* Swain and Peterson. Right side of shell, X 145. Locality J-19, Swift Formation.

Fig. 17. *Monoceratina?* cf. *sundancensis* Swain and Peterson. Left side of shell, X 163. Locality J-14a, Swift Formation.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1952), the middle and upper Vanguard Formation of Saskatchewan (Wall, 1960), and the upper Vanguard of Saskatchewan and the Swift Formation of Montana (Brooke and Braun, 1972).

N.° of specimens studied: 46.

Genus ***Ektyphocythere*** Bates, 1963

Ectyphocythere? sp.
Plate 3 Figs. 10, 11, 15

Summary of shell characters: Shell subpyriform in side view, highest submedially; dorsum gently convex, venter more strongly convex, anterior broadly rounded; posterior narrowly rounded, strongly extended dorsad of midheight. Left valve slightly larger than right valve, valves moderately convex, more or less parallel-sided in edge view; ends compressed. An anterior and ventral submarginal ridge originates in a slightly enlarged condition near anterodorsal angle, overhangs midventral margin and terminates posteroventrally by merging with shell surface; one limb of inverted V-shaped narrow ridge extends from mid-dorsal position anteroventrally and terminates dorsad of midheight; the others limb extends posteroventrally to near midheight, then bends sharply back toward mid-shell area; a node-like swelling occurs anteromedventrally; hinge margin of left valve bears a prominent accommodation groove, interterminal bar and terminal furrows; right valve hinge bears terminal elongate dental elements and intervening furrow.

Length of figured left valve (Pl. 3, Fig. 10) 0.51 mm; Height 0.33 mm; Width of valve 0.20 mm.

Remarks: The outline and surface ornamentation of this form ally it to *Ektyphocythere* Bate, such as *E. triangula* (Brand) from the middle Jurassic of Linconshire England (Bate, 1983). Preservation of the specimens at hand is too poor to provide a basis for certain comparison.

PLATE 2

Figs. 1-2. *Monoceratina sundancensis* Swain and Peterson. Right side, X 151 and dorsal view, X 134 of shell. Locality J-14a, Swift Formation.

Figs. 3-4. *Cytherura? lanceolata* Swain and Peterson. Right side and dorsal views of male? shell, X 136. Locality J-11c, Swift Formation.

Figs. 5-6. *Cytherura? lanceolata* Swain and Peterson. Left side, X 139 and dorsal view, X 133 of male? shell. Locality J-11c, Swift Formation.

Figs. 7-8. *Procytheridea crassa* Peterson. Right side, X 75 and dorsal view, X 72 of two shells. Locality J-22a, Swift Formation.

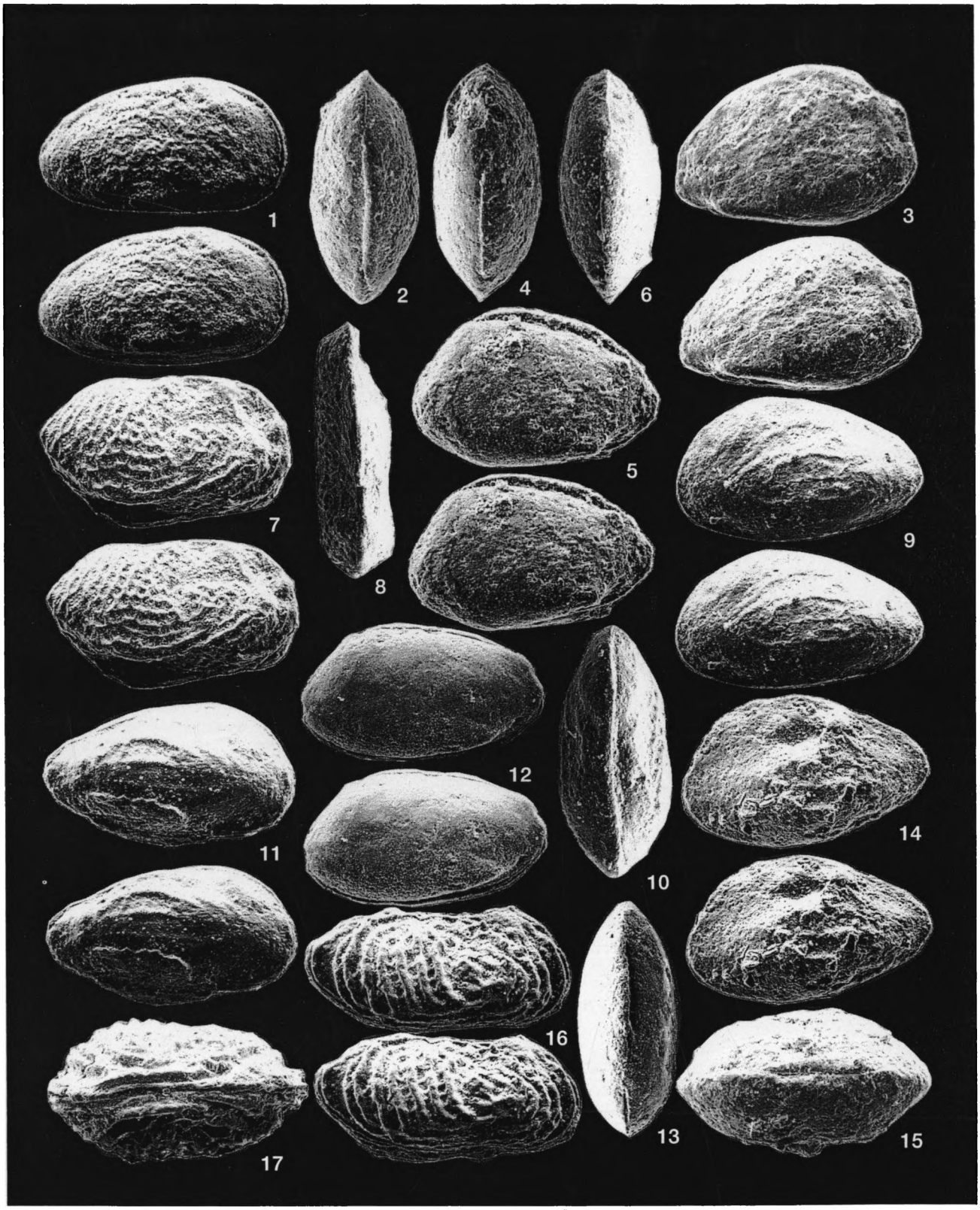
Figs. 9-10. *Procytheridea* sp. aff. *P. exempla* Peterson. Left side, X 78 and dorsal view, X 96 of two shells. Locality J-22a, Swift Formation.

Fig. 11. *Procytheridea* sp. aff. *P. exempla* Peterson. Right side of shell, X 84. Locality J-22a, Swift Formation.

Figs. 12-13. *Cytherura? lanceolata* Swain and Peterson. Left side and dorsal view, X 127 of two female? shells. Locality J-61c, Swift Formation.

Figs. 14-15. *Protocythere* sp. aff. *P. quadricarinata* Swain and Peterson. Left side, X 84 and dorsal view, X 90 of two shells. Locality J-11c, Swift Formation.

Figs. 16-17. *Fuhrbergiella (Praefuhrbergiella) heiroglyphica* (Swain and Peterson). Right side, X 111 and dorsal view, X 96 of two male? shells. Locality J-19, Swift Formation.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Occurrence: Swift Formation, Locality J-22g.

N.° of specimens studied: 4.

Genus ***Aparchitocythere*** Swain and Peterson, 1952

Aparchitocythere typica Swain and Peterson
Plate 3 Figs. 12-14

Aparchitocythere typica Swain and Peterson, 1952, p. 10, Pl. 1, Figs. 8, 9, 17, 18, 21, 22.

Summary of shell characters: Shell subquadrate to subrhombohedral in side view, highest anteromedially; dorsum nearly straight to slightly convex, more than half of shell length with broadly obtuse cardinal marginal bends; venter slightly concave medially; anterior broadly rounded, slightly extended below; posterior more narrowly rounded; left valve slightly larger than right valve, but dorsally right valve slightly overlaps left valve; anterior marginal zone compressed, an oblique very weak narrow depression extends from mid-dorsal margins anteroventrally to near midheight; general surface smooth except for scattered weak pits and some specimens faint dense finer pits. Hinge of right valve consists of terminal elongate slightly elevated dental areas and an interterminal groove; adductor muscle scar visible on exterior in some specimens, consists of median vertical row of three or four spots and a more anterior pair of frontal spots. Male dimorphs shorter and higher than females.

Length of figured female shell (Pl. 3, Fig. 12) 0.63 mm; Height 0.40 mm; Width 0.33 mm.

Occurrence: Swift Formation, Localities J-10b, c, J-11c, d, J-12a, J-14a and J-22l. The species was recorded earlier from the upper Sundance (Redwater Shale) of Wyoming, the Swift Formation of Montana and Wyoming. (Swain and Peterson, 1952), all upper Jurassic (Oxfordian, Kimmeridgian) and questionably from the upper Shaunavon

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PLATE 3

Figs. 1-2. *Fuhrbergiella (Praefuhrbergiella) heiroglyphica* (Swain and Peterson). Right side, X 106 and dorsal view, X 90 of two female shells. Locality J-19, Swift Formation.

Figs. 3-4. *Fuhrbergiella (Praefuhrbergiella) crowcreekensis* (Swain and Peterson). Right side, X 75 and dorsal view, X 69 of poorly preserved shell. Locality J-43-c, Swift Formation.

Figs. 5-6. *Fuhrbergiella (Praefuhrbergiella?)* sp. aff. *F. (P.) crowcreekensis* (Swain and Peterson). Left side, X 60 and dorsal view, X 54 of shell. Locality J-10a, Swift Formation.

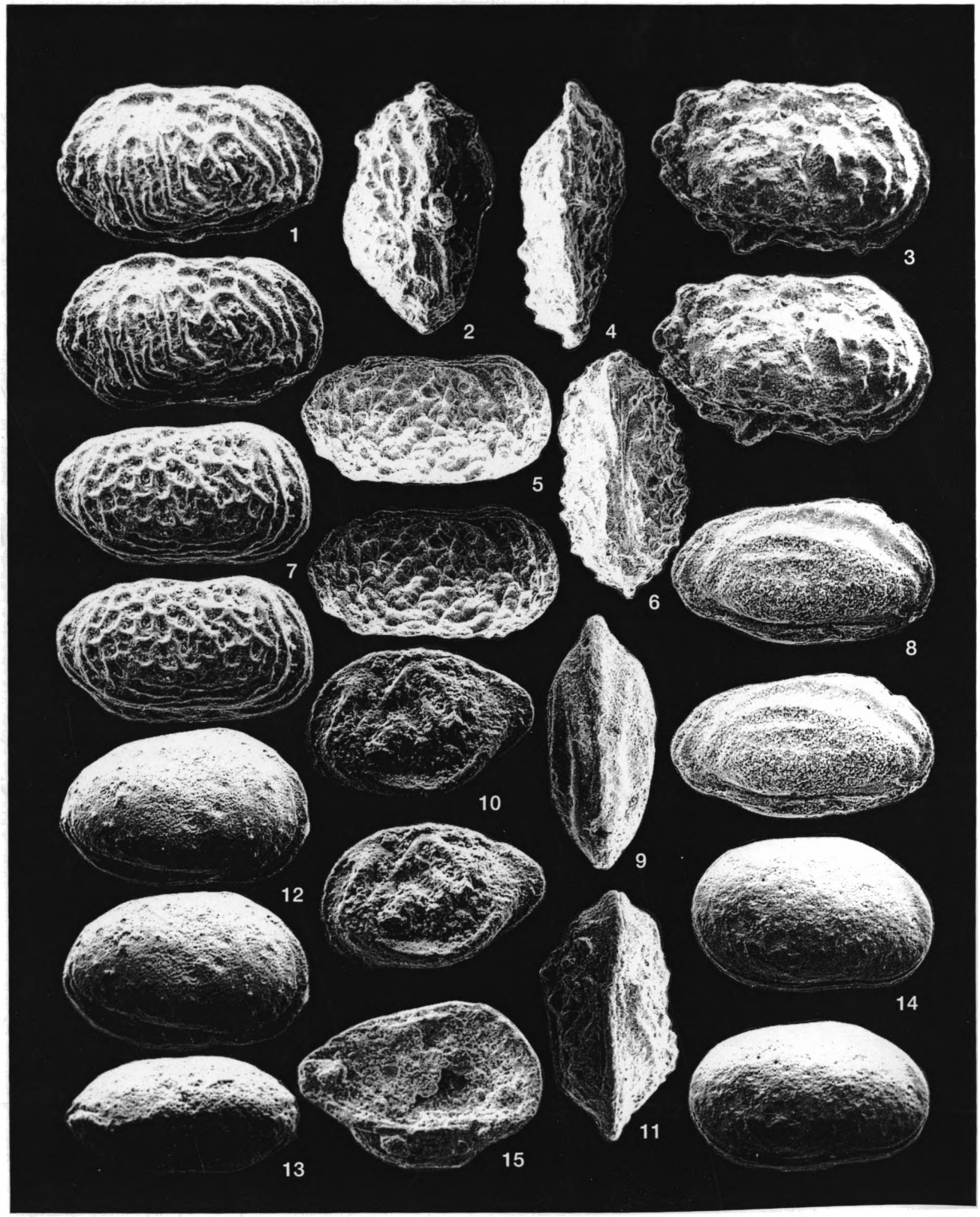
Fig. 7. *Fuhrbergiella (Praefuhrbergiella) crowcreekensis* (Swain and Peterson). Right side of shell, X 118. Swift Formation.

Figs. 8-9. *Protocythere* sp. aff. *P. quadricarinata* Swain and Peterson. Right side and dorsal view, X 81 of shell. Locality J-43c, Swift Formation.

Figs. 10-11 y 15. *Ektyphocythere?* sp. Left side, X 96, dorsal view, X 90, and left valve interior, X 90 of three specimens. Locality J-22g, Swift Formation.

Figs. 12-13. *Aparchitocythere typica* Swain and Peterson. Right side and dorsal views, X 78 of two immature specimens. Locality J-22l, Swift Formation.

Fig. 14. *Aparchitocythere typica* Swain and Peterson. Left side of shell, X 57. Locality J-14a, Swift Formation.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Formation (Middle Bathonian) of Saskatchewan (Brooke and Braun, 1972).

N.° of specimens studied: 12.

Aparchitocythere loeblichorum (Swain and Peterson)
Plate 4 Figs. 1-3

Aparchitocythere loeblichorum Swain and Peterson, 1951, p. 799, Pl. 113, Figs. 3-5.

Summary of shell characters: Shell subovate to subpyriform in side view, highest slightly anterior to middle, dorsum moderately convex, venter nearly straight to slightly convex; anterior broadly rounded, slightly extended below; posterior more narrowly rounded, extended below; left valve slightly larger than right valve but along hinge margin, right slightly overlaps left; valves moderately convex, greatest width slightly posteromedian. Anterior narrow marginal and postventral marginal zones compressed; a joint oblique broad furrow or depression extends from middorsum to slightly anterior of midheight; general surface smooth except for scattered large pits and in some specimens dense finer pits. Hinge of right valve consists of terminal elongate elevated dental areas and an interterminal furrow overhung by valve margin; adductor muscle scar an anteromedian subvertical row of four spots and one frontal spot; the latter lies at ventral end of faint interior ridge represented exteriorly by a furrow.

Length of figured specimen (Pl. 4, Fig. 2) 0.65 mm; Height 0.47 mm; Width 0.33 mm.

Occurrence: Swift Formation, Localities J-14a, J-19, J-22d, J-22j and J-43c. Previously this species was recorded from the Upper Sundance Forma-

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PLATE 4

Fig. 1. *Aparchitocythere loeblichorum* Swain and Peterson. Interior of right valve, X 90. Locality J-43c, Swift Formation.

Figs. 2-3. *Aparchitocythere loeblichorum* Swain and Peterson. Right side and dorsal views of shell, X 75. Locality J-14a, Swift Formation.

Figs. 4-5. *Galliaecytheridea?* sp. aff. *G.? subquadrata* Swain and Anderson. Left side, X 133 and dorsal view, X 131 of shell. Locality J-11c, Swift Formation.

Fig. 6. *Progonocythere?* sp. aff. *P. cristata* Bate. Right side of shell, X 90. Locality J-22g, Swift Formation.

Figs. 7-8. *Fuhrbergiella (Praefuhrbergiella?) crowcreekensis* (Swain and Peterson). Left side, X 121 and dorsal view, X 113 of shell. Locality J-10a, Swift Formation.

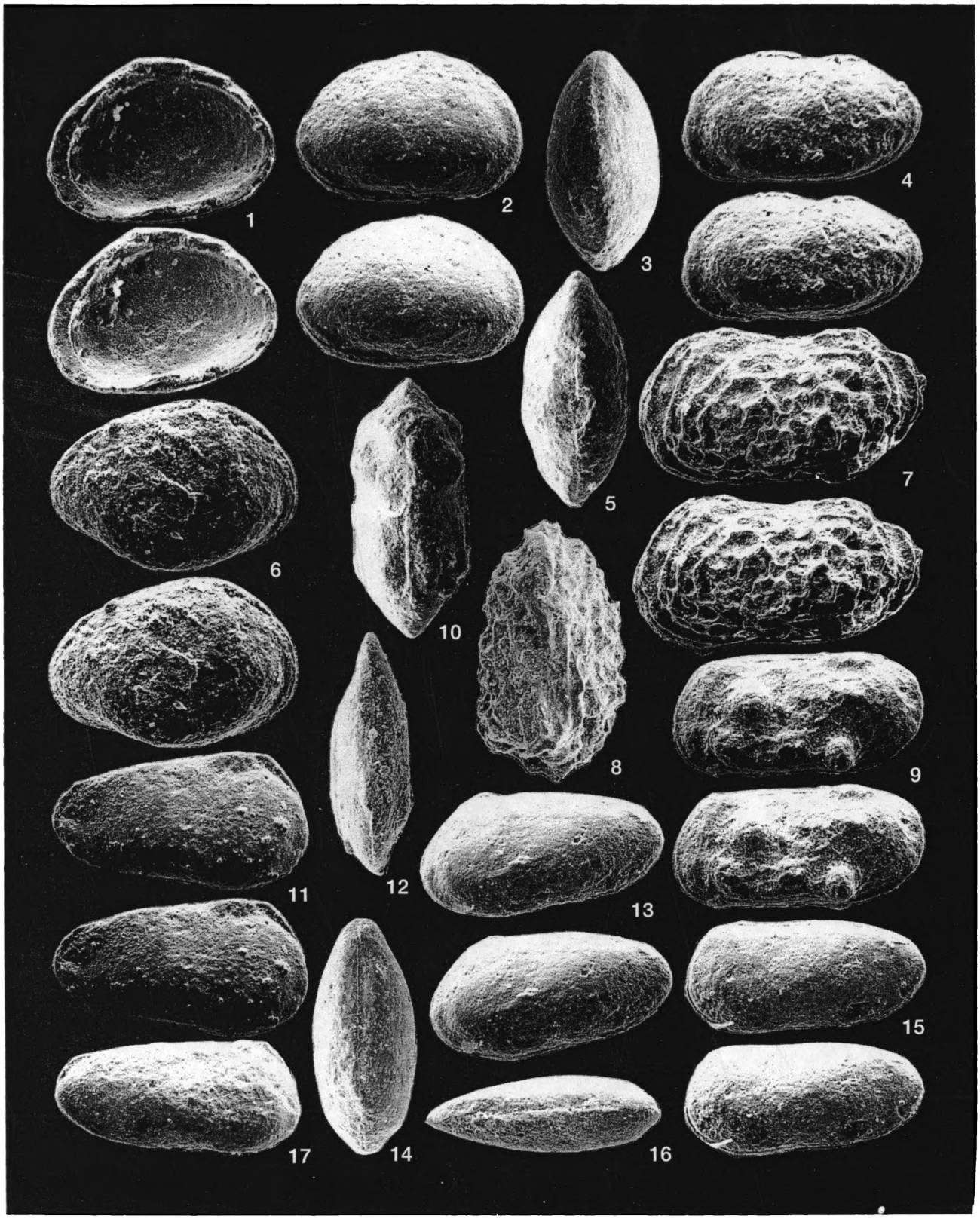
Figs. 9-10. *Limnocythere? climaxia* (Loranger). Left side and dorsal views, X 145 of two shells. Locality J-14a, Swift Formation.

Figs. 11-12. *Leptocythere imlayi* Swain and Peterson. Right side, X 96 and dorsal view, X 94 of shell. Locality J-19, Swift Formation.

Figs. 13-14. *Leptocythere imlayi* Swain and Peterson. Left side, X 144 and dorsal view, X 90 a distorted shell questionably belonging to this species. Locality J-14a, Swift Formation.

Figs. 15-16. *Leptocythere imlayi* Swain and Peterson. Left side, X 100 and dorsal view, X 95 of shell. Locality J-14a, Swift Formation.

Fig. 17. *Leptocythere imlayi* Swain and Peterson. Right side of shell, X 84. Locality J-14a, Swift Formation.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tion, Redwater Shale Member of South Dakota and Wyoming; Swift Formation of Montana (Swain and Peterson, 1951, 1952), and questionably from the Upper Vanguard Formation of Saskatchewan (Brooke and Braun, 1972).

N.° of specimens studied: 124.

Family PROGONOCYTHERIDAE Sylvester-Bradley, 1948
Subfamily PROGONOCYTHERINAE Sylvester-Bradley, 1948
Genus ***Progonocythere*** Sylvester-Bradley, 1948

Progonocythere? sp. aff. *P. cristata* Bate
Plate 4 Fig. 6

Summary of shell characters: Shell subovate in side view, highest about one-third of length from anterior end; dorsum moderately convex, venter also moderately convex, owing to strongly overhanging mid-ventral surface; anterior broadly rounded; posterior more narrowly rounded extended medially; left valve larger than right valve overlapping right most noticeably at cardinal angles; anterior marginal zone compressed; midventral surface swollen, with rounded crest, and strongly overhangs ventral margin; general surface smooth. Internal shell structures not observed in specimens at hand.

Length of figured specimen 0.53 mm; Height 0.37 mm; Width 0.33 mm.

Remarks: The shape and surface features of this form resemble *Progonocythere stilla* Sylvester-Bradlye, 1948 from the Bathonian (Middle Jurassic) of England and *P. cristata* Bate, 1963 from the Bajocian (Middle) Jurassic of England. The former species is more rounded posteriorly than the present form. The latter species is more pointed posteriorly and has a sharper mid-ventral crest than the present one.

Occurrence: Swift Formation, Locality J-22g.

N.° of specimens studied: 4.

Family CYTHERIDEIDAE Sars, 1925
Subfamily CYTHERIDEIDAE Sars, 1925
Genus ***Galliaecytheridea*** Oertli, 1957

Galliaecytheridea? sp. aff. *G.? subquadrata* Swain and Anderson
Plate 4 Figs. 4, 5

Summary of shell characters: Shell elongate subpyriform in side view, highest about onethird of length from anterior end; dorsum sinuous, concave medially; venter slightly convex, but with weak concavity anteromedially; anterior broadly rounded, slightly extended below; posterior margin more narrowly rounded, extended medially. Left valve slightly larger than right valve, but along hinge margin right valve slightly overlaps left; valves moderately convex, greatest width slightly posteromedian. Anterior marginal zone compressed; dorsomedian surface broadly depressed; ventomedian surface inflated and slightly overhangs ventral margin; general surface smooth. Internal shell structures not observed in material at hand.

Length of figured specimen 0.40 mm; Height 0.23 mm; Width 0.20 mm.

Remarks: The general outline end surface ornamentation of this species resembles features of *Galliaecytheridea* Oertli. *G? subquadrata* Swain and Anderson, 1991 from the Upper Jurassic of Louisiana is similar in outline and compressed anterior and dorsomedian depression of shell, but is more concave ventrally and less pointed posteriorly than the present species.

Occurrence: Swift Formation, Locality J-11c.

N.° of specimens studied: 1.

Family LIMNOCYTHEREIDAE Klie, 1938
Genus ***Limnocythere*** Brady, 1868

Limnocythere? sp. aff. *L. climaxia* (Loranger)
Plate 4 Figs. 9, 10

Summary of shell characters: Shell subquadrate to subelliptical in side view, highest about onethird of length from posterior end; dorsum and venter nearly straight and subparallel; anterior margin rounded slightly extended below; posterior margin a little more narrowly rounded than anterior and extended above; left valve slightly larger

than right valve; but along hinge margin right valve appears to overlap left; greatest width submedian valves; parallel-sided in edge view. An anteromedian shallow sulcus extends from dorsal margin to near midheight; an anterodorsal short sulcus is defined anteriorly by a short ridge; two large rounded nodes lie anterior to median sulcus; another large rounded node lies in posteroventral quadrant postjacent to node, surface is depressed in posterodorsal quadrant; a short ridge lies near posterodorsal angle; a second short ridge lies venterad of preceding ridge; a low elevation occurs venterad of median sulcus; general surface faintly and coarsely reticulate. Internal valve structures not observed.

Length of figured specimen (Pl. 4, Fig. 9) 0.37 mm; Height 0.19 mm; Width 0.16 mm.

Remarks: The outline, sucation, reticulate surface and posteromedian nodes and swellings resemble features prescribed for *Limnocythere? climaxia* (Loranger, 1955). The present specimen is like that figured for *L.? climaxia* by Brooke and Braun, 1972 (Pl. 6, Figs. 41, 42, 46) in that they show two anteromedian nodes. Whether the species, due to environmental variations can be expanded to include forms like those figured by Brooke and Braun is uncertain.

Occurrence: Swift Formation, Locality J-14a.

N.° of specimens studied: 2.

Family LEPTOCYTHERIDAE Hanai, 1957
Genus ***Leptocythere*** Sars, 1925

Leptocythere imlayi Swain and Peterson
Plate 4 Figs. 11-17

Leptocythere imlayi Swain and Peterson, 1951, p. 804, Pl. 114, Figs. 16-24.

Summary of shell characters: Shell subelliptical-subquadrate in side view, highest near anterior end; dorsum nearly straight, with slight obtuse anterior, and broadly obtuse posterior cardinal angles; venter nearly straight, slightly concave medially, and converging posteriorly with respect to dorsum; anterior broadly rounded, slightly extended below; posterior narrowly rounded, extended a little dorsad of midheight. Left valve slightly larger than right valve, but along hinge right valve overlaps left; valves compressed in male shells (Pl. 4, Figs. 11, 12, 15, 16), moderately convex in female shells (Pl. 4, Figs. 13, 14). Anterior marginal zone of female shells compressed; that of male shells only slightly compressed; dorsomedian shell surface faintly sulcate; anteroventral quadrant of female shells inflated and shell as a result, is somewhat produced ventrally. General surface smooth. Hinge of right valve consists of terminal rounded or elongate teeth and an interterminal weakly crenulate groove.

Length of figured shell (Pl. 4, Fig. 15) 0.56 mm; Height 0.27 mm; Width 0.20 mm.

Occurrence: Swift Formation, Localities J-14a, J-19 and J-22j. Previously the species was recorded from the Upper Sundance Formation, Redwater Shale Member of South Dakota and Wyoming (Swain and Peterson, 1951, 1952) and from the Swift Formation of Montana (Swain and Peterson, 1952).

N.° of specimens studied: 23.

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Manuscrito recibido el 05-VII-1996
Manuscrito aceptado el 12-VII-1996