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Revision of the Lower Ordovician (lower Floian; Tulean) pliomerid trilobite *Protopliomerella*, with new species from the Great Basin, western USA

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Abstract

New field sampling of classic Ibexian sections in the Great Basin has resulted in the discovery of several new species assignable to the pliomerid trilobite genus *Protopliomerella* Harrington, 1957. The genus was originally monotypic and based on *Protopliomerops contracta* Ross, 1951. *Protopliomerella pauca* Demeter, 1973, was later added, but it is shown herein to be a junior subjective synonym of *P. contracta*. The material originally assigned to *Protopliomerella contracta* by Ross belongs to as many as three distinct, stratigraphically separate species. New species include *P. stegneri*, *P. bowlesi*, *P. kerouaci*, *P. seegeri*, and *P. okeeffeae*. Two additional new species are not well enough known to name and are reported in open nomenclature. The phylogenetic status of *Protopliomerella*, as thus conceived, is ambiguous and the taxon may be rendered paraphyletic by the genera *Pseudocybele* Ross, 1951, and *Lemureops* McAdams and Adrain, 2009.

Key words: Silicified, biostratigraphy, taxonomy, Utah, Idaho, Nevada

Introduction

This is the fifth in a series of studies revising members of Pliomeridae Raymond, 1913, (McAdams and Adrain, 2009a, 2010, 2011a, 2011b) as part of a larger field-based description and revision of Ibexian (Tremadocian–Floian) and early Whiterockian (Dapingian) silicified trilobite faunas from the Great Basin. The faunas were originally described from northern Utah and southeastern Idaho by Ross (1951), and from western Utah and eastern Nevada by Hintze (1953). Adrain *et al.* (2009) summarized the history of study and established a revised and expanded trilobite-based biostratigraphic zonation for the Tulean and Blackhillsian stages which is followed herein.

This paper focuses on *Protopliomerella*, which Harrington (1957) erected as a monotypic genus with the type species *Protopliomerops contracta* Ross, 1951, from the Garden City Formation of northern Utah. Demeter (1973) later added a younger species, *P. pauca*, from the Fillmore Formation of western Utah, and these have been the only formally named members of the genus prior to the current study. Although members of this group are common at many horizons in early to late Tulean (lower Floian) strata (*Psalikilopsis cuspidicauda* Zone–*Heckethornia bowiei* Zone) of the Garden City and Fillmore formations, most of the species diversity has not been recognized. Sclerites belonging to new species have previously been misidentified mainly as *P. contracta* (Ross, 1951), but also as *P. pauca* Demeter, 1973. Indeed, material representing each named new species, as well as *Protopliomerella* n. sp. B, has been figured at some point by either Ross (1951), Hintze (1953), or Demeter (1973). Failure to properly discriminate species has vastly inflated the supposed stratigraphic thickness of Ross *et al.*'s (1997) *Protopliomerella contracta* Zone, which was recently restricted by Adrain *et al.* (2009).

The goals of this work are: 1) to revise and redescribe *Protopliomerella contracta*; 2) to name and describe five new species known from abundant silicified material from Idaho and Utah; 3) to describe two additional species from Utah and Nevada in open nomenclature; and 4) to diagnose *Protopliomerella* on the basis of putative synapo-

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morphies. Although the genus as thus understood consists of morphologically similar species, its monophyly is challenged by the younger clades *Pseudocybele* Ross, 1951, and *Lemureops* McAdams and Adrain, 2009. This issue can only be explored via comprehensive cladistic analysis of the entire group, which must await the description and revision of all of the remaining relevant species in our collections (primarily new and revised upper Floian [Blackhillsian] species of *Pseudocybele*). The present mainly descriptive work is a step toward facilitating such a broad analysis.

Localities and Stratigraphy

Adrain *et al.* (2009) summarized locality information for all Great Basin sections treated herein. Sections G, H, and YH were also recently discussed by McAdams and Adrain (2009a, b), and this information is not repeated here. Maps of field areas and sections in the Bear River Range of southeastern Idaho, and the Tule Valley of western Utah are shown in Figure 1. A map of the Yellow Hill locality was published by Adrain *et al.* (2009, fig. 2D), as was a map of Section D (2009, fig. 2C). The stratigraphic occurrence of species of *Protopliomerella* is shown on schematic depictions of sections YH, G, H, D, HC5, and HC6 in Figure 2.

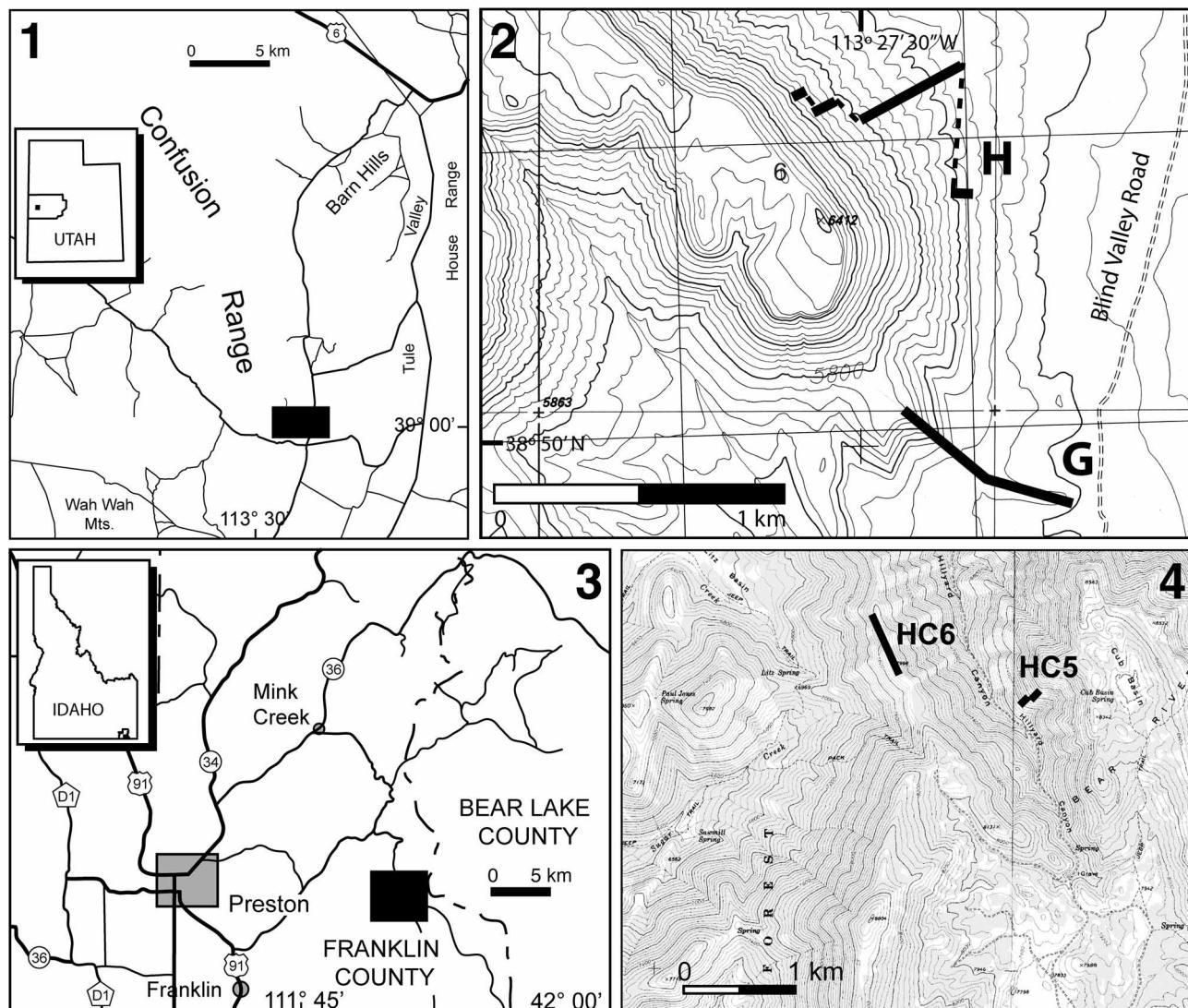


FIGURE 1. 1. Road map showing the Ibex area of the Tule Valley, Millard County, western Utah, and the location of sections G and H (black rectangle) in the southern Confusion Range. 2. Portion of U.S. Geological Survey 1: 24,000 Warm Point provisional 7.5' quadrangle topographical map (1991) depicting lines of Section G and Section H. 3. Road map with location of sections HC5 and HC6 (black box) in Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho. 4. Lines of sections HC6 and HC5 on areas of U.S. Geological Survey Mapleton (1988) and Egan Basin (2005) 1: 24,000 7.5' quadrangle topographical maps, respectively.

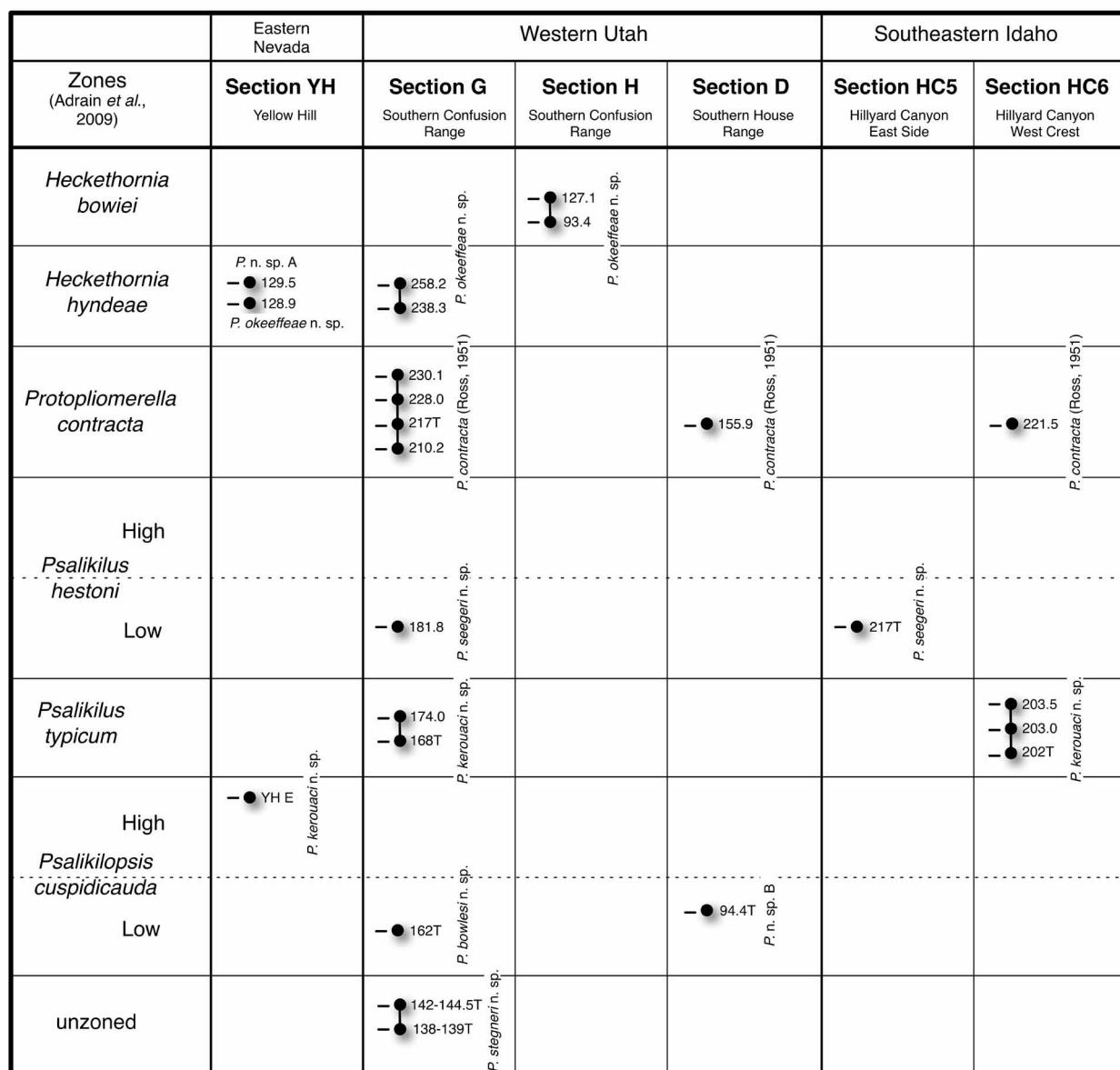


FIGURE 2. Schematic diagram of stratigraphic distribution of species of *Protoplomerella* in Tulean (lower Floian) sections of the Yellow Hill Limestone in eastern Nevada (Section YH), Fillmore Formation in western Utah (Sections G, H, D), and the Garden City Formation in southeastern Idaho (Sections HC5, HC6). Measurements are in metres. Metreages are not to scale. Zonation is that established by Adrain *et al.* (2009).

During the 2010 field season we resampled Section G in considerable detail, resulting in the discovery of several new fossiliferous horizons. These included two narrow intervals (G 138–139 m and 142–144.5 m) with abundant small talus lumps weathering apparently in place along strike. Once processed, these proved to be dominated by a single species of pliomerid, described herein as *P. stegneri*. This species is not known from elsewhere. Preservation is fairly coarse, and the only other taxa present are indeterminate sclerites of *Psalikilus* Ross, 1951, and *Aulacoparia* Hintze and Jaanusson, 1956. The lowest sampled occurrence of *Psalikilopsis cuspidicauda* Ross, 1953, is at G 148.2 m. Hence, the interval is of uncertain assignment in the biostratigraphic scheme of Adrain *et al.* (2009). It occurs just a few metres beneath the definite base of the *P. cuspidicauda* Zone. It could well prove to be part of that zone, given the poor preservation and rarity of anything other than the pliomerid. However, the only identifiable species is not known from the *P. cuspidicauda* Zone, nor from the underlying *Hintzeia celsaora* Zone, and the assemblage is as likely to represent a distinct, poorly known new zone. For the present it is shown on Fig-

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ure 2 as "unzoned." It is separated from the next lowest fossiliferous horizon, at G 118.6 m (*Hintzeia celsaora* Zone), by some 20 m of partially covered section which have not yielded any collections.

When we established the new biostratigraphic scheme, we were unable (Adrain *et al.*, 2009, fig. 4) to determine the zonal assignment of horizon D 155.9 m, in the southern House Range at Ibex, Utah. Identification of the relatively rare pliomerid occurring at this horizon as *Protopliomerella contracta* permits confident reference to that zone.

Systematics

Repository. All figured material is housed in the Paleontology Repository, Department of Geoscience, University of Iowa, Iowa City, with specimen number prefix SUI.

Terminology. Morphological terms follow Whittington and Kelly (1997). The term 'palpebro-ocular ridge' is used to describe the combined structure of the eye ridge and palpebral lobe, which are merged and indistinguishable in some pliomerid taxa, including members of *Protopliomerella*. The term palpebro-ocular furrow is used to describe the furrow running along the adaxial edge of this structure.

Family Pliomeridae Raymond, 1913

Protopliomerella Harrington, 1957

Type species. *Protopliomerops contracta* Ross, 1951 (lower Floian; Tulean; *Protopliomerella contracta* Zone).

Other species. *Protopliomerella stegneri* n. sp. (lower Floian; Tulean; unzoned interval beneath *Psalikilopsis cuspidicauda* Zone); *P. bowlesi* n. sp. (lower Floian; Tulean; low *Psalikilopsis cuspidicauda* Zone); *P. kerouaci* n. sp. (lower Floian; Tulean; high *Psalikilopsis cuspidicauda* Zone and *Psalikilus typicum* Zone); *P. seegeri* n. sp. (lower Floian; Tulean; low *Psalikilus hestoni* Zone); *P. okeeffae* n. sp. (lower Floian; Tulean; *Heckethornia hynedeae* Zone and *Heckethornia bowiei* Zone); *Protopliomerella* n. sp. A (lower Floian; Tulean; *Heckethornia hynedeae* Zone); *Protopliomerella* n. sp. B (lower Floian; Tulean; low *Psalikilopsis cuspidicauda* Zone).

Diagnosis. Anterior border narrow and very gently arcuate; anteroventral rim of anterior border with shallow median rostral suture arc about 1/3 total width of border; anterior margin of glabella bluntly truncated at anterior border furrow; palpebro-ocular ridges short, located opposite LF, but separated anteriorly from axial furrows by narrow strip of interocular fixigena; glabellar and axial furrows lined with granules; pygidium of five to seven segments with small, but elongated triangular terminal piece; tips of pygidial pleural spines very closely spaced but distinctly separate.

Discussion. Harrington (1957), in erecting his monotypic genus, considered the anteriorly tapered glabella, the positions of S3 and S4, the location of the palpebro-ocular ridges, shape of the genal angle, relative width of the pygidial axis to the pleurae, and shape of the posterior margin of the hypostome to be diagnostic features of *Protopliomerella*. In light of the seven new species described herein, as well as better knowledge of *Pseudocybele* Ross, 1951, and *Lemureops* McAdams and Adrain, 2009a, most of these characters are no longer diagnostic of either *P. contracta* or of the genus as a whole. Harrington based his work on the illustrated specimens of Ross (1951, pl. 33, figs 15–19, 22–32), but these do not all represent *Protopliomerella contracta* (see discussion under *P. contracta* below).

Lee and Chatterton (1997a) presented a new diagnosis for *Protopliomerella*, but it was largely composed of symplesiomorphic features, including the anteriorly tapered glabella with large palpebro-ocular ridges; the hypostome with an elliptical middle body, three pairs of lateral border spines and a median posterior border spine; and the five-segmented pygidium with short spines. These characters are common to many pliomerid taxa, including *Lemureops*, *Pseudocybele*, and *Hintzeia celsaora* (Ross, 1951).

Difficulty in diagnosing *Protopliomerella* in terms of synapomorphies may stem from the possibility that it is paraphyletic. A preliminary phylogenetic analysis (McAdams and Adrain, 2009c) of *Protopliomerella*, *Lemureops*, and *Pseudocybele* resulted in resolution of *Protopliomerella* (including some but not all of the species described herein) as a grade-group at the base of a well-supported *Lemureops*+*Pseudocybele* clade. Adjustment of

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the taxonomy may be necessary once cladistic analysis is complete, but this must await revision and description of all relevant taxa, which is in progress. We present a diagnosis which effectively separates the *Protopliomerella* group from taxa not part of the three genera considered here, but recognize that it may largely consist of basal synapomorphies of the broader clade. Again, the structure of *Protopliomerella* and its diagnosis must be revisited in the context of a broader analysis beyond the scope of the present descriptive study.

In any case, species presently grouped in *Protopliomerella* are undoubtedly closely related to *Pseudocybele* and to *Lemureops*. They are more morphologically similar to species of *Pseudocybele*, but the taxa are easily distinguished, as *Pseudocybele* possesses a medially pointed and recurved anterior border, rounded anterior glabellar margin, LF impressions, rounded genal angles, a long median posterior hypostomal spine, and an elongate pygidium with a very large, complexly impressed terminal piece. *Lemureops* is more morphologically derived, and notably possesses a very long, triangular anterior border, wide, lacunate cranidial axial furrows, very long genal angles, a short hypostome, and a pygidium with a large terminal piece and a distinctly tapered triangular posterior margin.

***Protopliomerella contracta* (Ross, 1951)**

(Plates 1–8)

- 1951 *Protopliomerops contracta* Ross, p. 136, pl. 33, figs 16, 17, 22 (only; pl. 33, fig 15 = *Protopliomerella seegeri*; pl. 33, figs 18, 19, 23–32 = *P. kerouaci*).
1953 *Protopliomerops contracta* Ross; Hintze, p. 31.
1953 *Protopliomerops contracta* Ross; Hintze, p. 35–36.
non 1963 *Protopliomerella contracta* (Ross); Hu, p. 89, pl. 13, figs 21–23.
1973 *Protopliomerella contracta* (Ross); Demeter, p. 59.
= 1973 *Protopliomerella pauca* Demeter, p. 59, pl. 4, figs 3, 13, 14.
? 1973 Genus and species undetermined (not described); Demeter, pl. 5, fig. 10 (only; pl. 5, figs 5, 16, 17 = gen. and sp. indet.).
1987 *Protopliomerella contracta* (Ross); Edgecombe and Chatterton, p. 345.
2009 *Protopliomerella contracta* (Ross); Adrain *et al.*, p. 563, fig. 13A, D.
2009a *Protopliomerella contracta* (Ross); McAdams and Adrain, p. 497, 499.

Material. Assigned specimens SUI 115229, 125997–126018 from Section HC6 221.5 m, Garden City Formation (lower Floian; Tulean; *Protopliomerella contracta* Zone), Bear River Range, Franklin County, southeastern Idaho, USA; SUI 115228, 126019–126051 from Section G 210.2 m and 230.1 m, Fillmore Formation (lower Floian; Tulean; *Protopliomerella contracta* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA. The species also occurs at Section D 155.9 m, Fillmore Formation (lower Floian; Tulean; *Protopliomerella contracta* Zone), southern House Range, Ibex area, Millard County, western Utah, USA.

Diagnosis. Median glabella and thoracic axial rings densely covered in fine tubercles; librigenae very long and narrow, with very strongly posterodorsally curved posterior projection; pygidial axis and pleurae strongly tuberculate.

Description. Cranidium narrow anteriorly and very wide posteriorly, relatively short, with sagittal length 49.2% (45.9–54.0%) width across genal angles, moderately vaulted axially and strongly vaulted pleurally; anterior border narrow, short, of even length axially and abaxially, very slightly anteriorly bowed, with dense sculpture of very small tubercles and transverse line of perforate tubercles at mid-length on some specimens (e.g., Pl. 1, figs 7, 9), slightly effaced anteriorly, and with shallow median arched rostral suture in ventral rim of border occupying about 1/3 total width (anterior view), anterior face of border slightly tapered at lateral corners; anterior border double expressed mainly as anterior face, only a rim ventrally; anterior border furrow short, incised, deepest in apodemal pits at meeting with axial furrows, with short (oblique) steeply posteromedially angled lateral branches along lateral limits of border, and very gently anteriorly bowed along broad median section; glabella moderately inflated (sag., tr.), lower anteriorly, long, narrow, widest posteriorly across L1 and gently tapered anteriorly, with width 91.4% (82.7–97.3%) length, and with three well defined, nearly equally sized posterior lateral lobes; L1 slightly narrower and more triangular, L2 and L3 slightly longer and wider, sub-square, lateral lobes nearly effaced except for rim of tiny tubercles around edges; L4 ill-defined, short, very narrow, triangular, LF ill-defined, as S4 reaches to anterior border with only a sliver of glabella exposed anterolaterally on each side; median lobe long, roughly evenly rectangular, slightly greater than 1/3 maximum glabellar width, densely covered in tiny tubercles

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and granules, some of which are perforate; glabellar sulci short, deep, slightly longer and deeper at abaxial ends and at posteriorly directed adaxial end of S1, generally anterolaterally angled at about 45° above horizontal (S1) or 30° above horizontal (S2 and S3); S4 branches anteromedially from exsagittal end of S3, very short, moderately deep, shallower anteromedially, with course about 45° above horizontal, about half as wide (tr.) as S3, better visible on large specimens (e.g., Pl. 4, fig. 1), partially obscured by anterior border and furrow in smaller specimens; SO very short medially for about half total width, slightly longer laterally, starting even with inner tip of S1, very deep, confluent with axial furrows and posterior border furrow, rimmed by tiny tubercles on anterior edge far abaxially and posterior edge of glabella; LO short, wide, slightly rounded and convex posteriorly, very slightly tapered laterally, gently inflated, very slightly posterodorsally raised (lateral view), granulose, with prominent median node located close to posterior margin, and flanked by tiny tubercles along margin, and more tiny tubercles along lateral margins; LO doublure short, lens-shaped, slightly longer medially than laterally, with sculpture of very fine transverse ridges; axial furrows moderately narrow, slightly wider along LF and slightly constricted along posterior half of L1, very deep, laterally bowed from base of glabella to mid-L2, then anteriorly convergent, lined with tiny tubercles on glabella and margin of fixigenae; palpebro-ocular ridges located across from LF, abutting anterior border, ridges comma-shaped, short, wide anteriorly, with strongly convex anterolateral margin, sharply tapered posterolaterally along short post-ocular ridge, steeply raised, with adaxial slope of about 50° above horizontal, with dense granulose sculpture; palpebro-ocular furrows very narrow, deep, incised along main part of palpebro-ocular ridge and suddenly shallower along post-ocular ridge, very shallowly sigmoid in course; interocular fixigena very short, narrow, nearly equilaterally triangular; posterior fixigena subrectangular, very long and very broad, slightly broader posteriorly, strongly downturned after fulcrum located roughly even with lateral edge of palpebro-ocular ridge, with dense sculpture of granules, small pits, and tiny tubercles (some perforate), except effaced along glabellar and posterior border margins, but with rim of tiny tubercles just inside those furrows; posterior border furrow short, especially near LO, deep, incised, transverse in course along most of border, but sharply anteriorly curved at genal angle; posterior border short adaxially, expanded ventrolaterally to maximum at genal angle, then suddenly tapered to a point, effaced but for anterior margin granules, tiny tubercles on posterior edge beginning at about half width, and small nubby genal spine; doublure short, turned posterodorsally until about half width, to form short articulating tongue set off by very short, moderately deep anterior furrow, then expanded toward genal angle, then cut by facial suture at genal angle.

Rostral plate unknown.

Hypostome long, narrow, with maximum width across spines midway between shoulders and posterolateral corners, and with width across shoulders 67.6% (62.8–71.9%) sagittal length; anterior border extremely short medially, expanded laterally into small, nearly equilaterally triangular wings with large, deep wing process pits located just anterolateral of center; anterior border furrow very short, moderately deep medially, shallowed laterally toward meeting with lateral border furrow; middle body long, ovoid, gently posteriorly tapered, with elliptical strongly ventrally inflated anterior lobe of about 3/4 total length, with sculpture of small tubercles overlying granules on about anterior third, posterior lobe roughly crescentic, moderately long medially, tapered laterally to a point at about half length of hypostome, moderately ventrally inflated, effaced; middle body furrow long, very shallow, strongly posteriorly bowed; lateral border furrows narrow, deep, incised, slightly shallower at junction with lateral branches of middle body furrow; lateral border moderately downturned, very narrow at long, shallow lateral notch, then expanded to shoulders and further expanded to widest point at posterolateral corners and merged with posterior border, granulose, with small nubby spines at shoulders, longer conical spines midway between shoulders and posterolateral corners, and longer, more robust conical spines at corners; posterior border furrow moderately deep, short; posterior border fairly narrow, long, downturned like lateral border, with wide, triangular median taper tipped with moderately long spine, granulose; lateral and posterior border doublure faces outward at lateral notch, then folds in medially, wide, and equally long along posterior border, slightly upturned along edges (lateral view), effaced.

Librigena long, narrow, crescentic, with width of field at midpoint of eye 14.0% (12.0–14.9%) length of lateral border furrow; anterior branch of facial suture very short along eye and field, meets lateral border at about 95° angle, segment along border about twice longer, anteroventrally directed at low angle; posterior branch of facial suture very long, with gently convex segment just after eye to about half length of field, then gradual slope down to lateral border, with junction of about 30°; eye small, ovoid, moderately inflated, highly elevated on tall, granulose socle (ventrolateral views), socle nearly contacts lateral border at anterolateral margin; librigenal field wedge-

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shaped, very narrow, especially posteriorly and at anterolateral corner of eye, strongly posteriorly tapered, densely covered in very small tubercles overlying granules, with scattered small pits concentrated along dorsal edge and under eye; lateral border furrow narrow, deep, incised, with very slightly posteriorly curved course; lateral border wide, equal to widest part of field, of roughly equal width until strongly tapered from end of librigenal field to pointed posterior tip, moderately ventrolaterally bowed, with curvature stronger posteriorly, with wide, rectangular, anteroventrally rotated anterior projection, and tapered posterior projection exposing slice of doublure in external view, and with dense sculpture of tiny tubercles with scattered granules; doublure wide, effaced, tapered to point at posterior end, truncated anteriorly even with beginning of anterior projection.

Thorax of at least 12 segments, but total number unknown; segments highly arched pleurally and axially, short and relatively broad, with relatively narrow axis 39.3% (31.4–55.6%) width across posterior pleural band; articulating half ring fairly long medially (about equal to axial ring), tapered laterally, semilunate, slightly inset posteriorly toward axial ring, laterally truncated in some specimens (Pl. 7, figs 9, 34), smooth; articulating furrow moderately long, deep, shallower medially and very deep laterally in apodemal pits just inside axial furrows, transverse to moderately posteriorly bowed in course; axial ring moderately long, wide, slightly anteriorly tapered but subrectangular, moderately inflated, posterodorsally raised (lateral view), with dense granulose sculpture overlain posteromedially by moderately (Pl. 2, figs 1, 3, 11) to very densely (Pl. 7, figs 4, 9, 19) concentrated tiny tubercles sometimes spilling over posteriorly (posterior view), with slightly larger tubercles marking each corner of ring, and with small tubercle protruding from posterior margin at posterolateral corners; doublure lens shaped, long medially, strongly tapered laterally, reaches most of way to posterior edge of articulating furrow, with sculpture of very fine transverse ridges; axial furrows narrow, expanded laterally at triangular junction with pleural furrow, very deep along posterior half of axial ring, shallower anteriorly, strongly anteriorly convergent, lined by tiny tubercles on edges of pleurae and axial ring of most segments; inner pleurae fairly narrow (wider on more anterior segments e.g., Pl. 2, figs 3, 11), roughly transverse, with dorsal surface gently ventrolaterally sloped due to lateral change in inflation of posterior band; fulcral angle moderate to steep, about 45–70° below horizontal (steeper on posterior segments); outer pleurae wide, from slightly more than half to about 80% of total pleural width (including spines); anterior pleural band wide, reaches to even with base of pleural spine, very short adaxially, slightly expanded abaxially, with extremely short articulating ridge on anterior edge of inner pleurae (best visible on Pl. 2, figs 3, 11) set off posteriorly by incised furrow, and with small anteriorly directed hook structure at ventrolateral tips (lateral view), finely granulose, rimmed posteriorly by slightly larger granules projecting into pleural furrow; pleural furrow very short and very deep for majority of course, abruptly shallowed at ventrolateral extremity (lateral view), course mainly transverse, with gentle anterior curvature far abaxially (lateral view); posterior pleural band moderately long, about three times longer than anterior band, ventrolaterally expanded, broad, moderately inflated, more so near axis (anterior or posterior view), with inflation decreasing ventrolaterally and band flattening toward pleural spine, with granulose sculpture overlain by tiny tubercles concentrated laterally and on posterior face (posterior view), also with coarse granules lining anterior margin; pleural spine long, wide, slightly anterolaterally rotated and flattened (lateral view), with single tip on some more anteriorly located specimens (Pl. 2, figs 16, 17) and with variably well developed notch separating spine into smaller anterior point and larger posterior point on more posterior segments, e.g., Pl. 2, fig. 2, Pl. 7, figs 2, 3, 18; doublure long and broad, covers spine from even with tip of anterior pleural band downward, with rounded notch along posterior pleural band, and with posterior margin twisted dorso-posteriorly to form short articulating shelf on posterior margin of posterior pleural band (ventral, posterior views).

Pygidium of five segments and terminal piece, relatively long and narrow, with width measured across anterior pleural band 107.5% (99.7–117.0%) sagittal length excluding articulating half ring, strongly axially and pleurally vaulted; articulating half ring wide, moderately long, laterally tapered, effaced anteriorly, but with dense granules on posterior half and projecting into articulating furrow; articulating furrow moderately long, deep, deepest just inside axial furrow in apodemal pits; axis very wide anteriorly, strongly tapered posteriorly to point at tip of terminal piece, highly vaulted anteriorly, with convexity decreasing posteriorly toward moderately inflated terminal piece; axial rings subrectangular with rounded lateral margins, first ring moderately long, wide, subsequent rings shorter and narrower, with fifth ring about half width of first, and a little more than half length, each ring individually moderately inflated, with sculpture of dense granules overlain by tiny tubercles concentrated on anterior and posterior margins of rings, with small tubercles, small perforated tubercles, and pits concentrated medially and roughly in a transverse line on each ring; inter-ring furrows deep, long between anterior rings, posterior furrows short, furrows increasingly longer medially and laterally tapered to form lens shape on larger specimens (e.g., Pl. 8,

fig. 1) terminal piece triangular, long, fairly wide anteriorly, strongly posteriorly tapered to a point, moderately inflated, with sculpture like that of axial rings except non-linear; axial furrows widely anteriorly divergent, fairly narrow, wider at intersections with inter-ring furrows, deep, lightly or not impressed over fifth pleurae, then merged with fifth interpleural furrow along terminal piece; pleurae individually moderately inflated, with narrow inner pleurae (decreases posteriorly) and very wide outer pleurae, very strongly backturned, with first pair nearly subparallel but slightly laterally bowed, and fourth and fifth pairs posteriorly convergent, and with large spines on posterior bands; interpleural furrows short, deep, incised, backturned like pleurae; anterior pleural band present only on first segment, very similar to that of thoracic segments, very strongly backturned, very short, wide, granulose, with small anteriorly facing hook articulating structure at ventrolateral tips; pleural furrow backturned like pleurae, short, deep; posterior pleural bands long and wide, with granulose sculpture topped by line of small tubercles just anterior to edge of interpleural furrow, and line of smaller tubercles on anterior edge of first 1–3 pleurae, also with tiny pits interspersed; pleural spines long, narrow, slightly laterally flattened, posteroventrally tapered, triangular (lateral view), with pointed and slightly dorsally recurved tips (lateral view), tips free and narrowly separated, spines granulose, with line of tiny tubercles on ventrolateral margin of first spine (lateral view), and with line of small pits near tips (posterior view); spine bases merged ventrally into short, granulose border with raised rim on anterolateral margin; doublure roughly triangular (anterior view), very long medially, steeply anterolaterally tapered, effaced.

Ontogeny. Cranidial ontogeny of *P. contracta* (cf. Pl. 4, fig. 1 and Pl. 5, fig. 16) involves broadening of the cranium overall; narrowing of the anterior border and development of the median notch in the anteriorly expressed doublure; reduction in size of the paleopbro-ocular ridges relative to overall cranidial dimensions; a slight decrease in the steepness of the fixigenae (anterior view); effacement of the strips of fixigena bordering the axial and posterior border furrows; overall decrease in coarseness of fixigenal granules and development of the pits; widening of the axial furrows; expansion of the posterior glabella and narrowing of the anterior; slight elongation of S1–S3; development of S4; lengthening of SO; reduction in coarseness of SO tubercles and size of median node; and reduction of the genal spines to nubs.

The hypostome becomes more elongate overall; the middle body lengthens, tapers posteriorly, and increases in inflation; the lateral border widens posteriorly; the posterior border lengthens; spines develop at the shoulders and the other three pairs of spines elongate slightly. Librigenal changes are subtle in these specimens because of their fairly close size, but it is possible to see that the platform supporting the eye grows taller (ventrolateral views); the librigenal field elongates slightly; the granules on the field decrease as deeper pits develop; and the lateral border widens slightly, especially toward the posterior tip.

The thorax is not sufficiently well known to discuss ontogenetic trends, as only segments from similar positions can be compared. Pygidial ontogenetic changes (cf. Pl. 8, figs 1, 17) include overall elongation of the pygidium relative to width; a slight decrease in the width of the axis compared to total width; relative decrease in size of the terminal piece, particularly in length; lengthening of inter-ring furrows; slight reduction in density of axial sculpture; and development of tubercles on the pleurae.

Discussion. *Protoplomerella pauca* Demeter, 1973, was based on three specimens (Demeter, 1973, pl. 4, figs. 3, 13, 14) from the Mesa Section in the southern House Range at Ibex. Two cranidia were collected from the same horizon, but the single pygidium was from a horizon 15.24 metres upsection. Demeter stated that the paratype cranium was a juvenile specimen, but it is almost exactly the same length (1.67 mm) as the holotype and both are juveniles. These cranidia fall in size between the smallest and second-smallest *P. contracta* cranidia illustrated herein (Pl. 5, figs 14, 16). The pygidium is the largest specimen at 1.92 mm sagittal length, which is very close to one of the smallest pygidia in this study, that of Pl. 8, fig. 20 (1.95 mm). Hence, it is also a small juvenile. The morphology of Demeter's specimens matches that of comparably sized *P. contracta* specimens, and the species appear to be synonyms. This is borne out by their stratigraphic occurrence. Conversion of the Mesa Section footages to correlative metreages at Section G shows that the cranidia occur at the equivalent of approximately G 206.8 m, and the pygidium at about G 222.1 m. Our samples containing sclerites of *Protoplomerella contracta* occur at G 210.2 m and G 230.1 m. Hence, the species are apparently morphologically identical (to the extent the morphology of *P. pauca* is known) and are from the same stratigraphic interval. Demeter stated (1973, p. 60) that a distinguishing feature of *P. pauca* was the "lack of accessory anterior glabellar furrows", i.e., lack of S4. This is ontogenetic; due to the small size of the figured cranidia, S4 is not visible (cf. Pl. 5, figs 14, 16).

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Protopliomerella contracta most closely resembles *P. okeeffeae*. The cranidia of *P. contracta* are distinguished by their shorter, less anteriorly convex anterior border; shorter SO, S1, and S2; narrower axial furrows; smaller, more anterolaterally located palpebro-ocular ridges; and longer posterior fixigenae. Hypostomes of *P. contracta* are more elongate; the anterior wings are narrower relative to width across the shoulders; the middle body is more elongate and less posteriorly tapered, with a larger patch of coarse granules anteriorly; the lateral border is wider; the posterior border is much longer; and the border spines are much longer and thicker. Librigenae of the two species differ in that those of *P. contracta* are longer; the anterior section of the librigenal field is longer, while the posterior section is wider; and the lateral border is narrower, somewhat less inflated, and more strongly laterally curved. Thoracic segments of the two species differ mainly in sculpture, as those of *P. contracta* possess densely tuberculate axial rings, while those of *P. okeeffeae* are more sparsely, but more complicatedly tuberculate (see description of latter species). Pygidia also differ prominently in sculpture; those of *P. contracta* are densely tuberculate, particularly on the axis and the posterior margin of the pleurae; they also have a wider axis; deeper, wider axial furrows; more elongate anterior inter-ring furrows; and more posteriorly directed, less ventrally curved pleural spines.

Although *Protopliomerella contracta* stratigraphically succeeds *P. seegeri*, the two taxa do not closely resemble each other. *Protopliomerella seegeri* is easily distinguished by its six-segmented, more posteriorly tapered pygidium; as well as its shorter, wider glabella; hypostome with a highly granulose anterior lobe of the middle body and border; and much more sparsely granulose and tuberculate cranidium, thoracic segments and pygidia.

Protopliomerella contracta and *P. kerouaci* share the unusual morphological feature of a transverse row of tiny pits on the anterior border, as do *P. bowlesi* and *P. seegeri*; this may be a synapomorphy. *Protopliomerella seegeri*, *P. contracta*, and *P. okeeffeae* bear small protruding tubercles from the lateral corners of the thoracic axial rings, and this unusual feature may also prove to be synapomorphic.

Ross (1951) reported *Protopliomerella contracta* from a 135 foot range (525–660 feet above base of the Garden City Formation) at his Locality 6 (= HC6). He also assigned specimens from his Locality 5 (= HC5) to the species, but noted that while the species occurred within the same interval, only approximate biostratigraphic zonation was possible because he had collected the samples prior to accurately measuring the section. The holotype cranidium (Ross, 1951, pl. 33, figs 17, 22) is from Locality 5. Further complicating matters, Ross's stratigraphic measurements and occurrence data contradict each other. His description of HC5 (1951, p. 15) notes the zone G(2), which was based on the appearance of *P. contracta*, from a 422 foot interval, and specifically lists *P. contracta* within a 215 foot span of this interval. This directly conflicts with the range of 135 feet given under the species description (p. 137). Adding the lithological thicknesses reported by Ross also gives the topmost appearance of *P. contracta* as 919 feet above the base of the formation at HC5; again, this directly contradicts the upper limit of 660 feet above base given in the species description.

Our measured sections HC5 and HC6 are at the same localities as Ross's localities 5 and 6 and sample the same faunas (see Adrain *et al.*, 2009, p. 547–548). We have collected two species of *Protopliomerella* from three horizons in a 19.5 m interval at the top of HC6, and a third species from a horizon at HC5 that correlates with HC6 between the topmost horizon and the lower two horizons. Only the uppermost horizon, at HC6 221.5 m, yields *Protopliomerella contracta*. Ross's reported 41.1 m range therefore undoubtedly conflates multiple species of *Protopliomerella*. These factors also make it almost certain that his figured specimens represent more than one species, which is borne out by their morphology. Ross did not give the specific collecting horizon for any of his figured specimens, assigning them only to subdivisions c–e of his zone G(2) (and this information is uncertain at HC5), so it is impossible to determine their provenance accurately.

Hintze (1953, tables 6, 7) listed occurrences of *Protopliomerella contracta*, as well as *Protopliomerella* aff. *P. contracta*, and several different numbered species of *Protopliomerella* (all as *Protopliomerops*) in his tables of species by horizon. He did not figure any specimens assigned to *P. contracta*, only those assigned to *Protopliomerella* sp. 6 (= *P. bowlesi* herein), and *Protopliomerella* aff. *P. contracta* (= a mixture of *P. bowlesi* and *P. okeeffeae* herein). The metreage of several cited horizons indicates the presence of true *P. contracta*, and those are cited in the synonymy. Occurrences of other species referred to as *P. contracta* or unnamed species of *Protopliomerella* are dealt with in the other synonymies and discussions.

Hu (1963) figured a somewhat damaged cranidium and a severely eroded pygidium from the Padre Formation of the El Paso Group, from the southern Franklin Mountains, western Texas, as *Protopliomerella contracta*. The specimens are too damaged and illustrated at too small a size for confident identification at the species level, but

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the morphology of the cranium is consistent with *Protopliomerella*. Hu noted that the glabella appears subquadrate, rather than anteriorly tapered. This could be due to the compaction of the specimen, or it may be a genuine feature distinguishing this specimen from named species of *Protopliomerella*, including *P. contracta*.

Demeter (1973) reported *P. contracta* from 21 horizons encompassing a range of 389 feet, but figured only four specimens from only three horizons (Demeter, 1973, pl. 4, figs. 2, 6, 11, 12). Of these four figured specimens, none represent *P. contracta*. They are assigned in synonymies of the appropriate species below. Demeter figured sclerites of *P. contracta* from Mesa Section (pl. 4, figs 3, 13, 14) which he misidentified as *P. pauca* (see discussion above), and an unidentified juvenile cranium (pl. 5, fig. 10) which is likely also *P. contracta*.

Lee and Chatterton (1997a) described protaspis and meraspid specimens which they assigned to *P. contracta* from their horizons R6-94 and R6-114, reported as 94 and 114 metres above the base of the Garden City formation at Ross's (1951) Locality 6. Only specimens from R6-94 were figured. These metreages are difficult to interpret. Section HC6 was also measured at Ross's Locality 6 and also began at the St. Charles–Garden City contact, which is distinctive. The section was measured using a Brunton compass coupled to a 1.5 m jacob staff, and while standard amounts of measurement error can be expected, our measurements are easily reconciled with those of Ross (1949, 1951) and we have considerable confidence in their accuracy. The Stairsian–Tulean boundary lies in the interval HC6 135–142 m (Adrain *et al.*, 2009). Hence, "R6-94" of Lee and Chatterton would be well down within the Stairsian, far below the appearance of any species of the exclusively Tulean *Protopliomerella*. Further, Lee and Chatterton (1997b) reported the distinctive Stairsian telephinid *Goniophrys* Ross, 1951, from R6-119 m, which is above the horizons cited as bearing *Protopliomerella*. Despite this, the larger specimens (Lee and Chatterton, 1997a, fig. 7.11, 7.12) definitely seem to represent a species of *Protopliomerella*, though they are too juvenile to assign at species level with any confidence.

This is not the only problematic aspect of Lee and Chatterton's (1997a) paper. They illustrated material (Lee and Chatterton, 1997a, fig. 6) which they assigned to *Rossaspis pliomeris* Demeter, 1973. This species is from near the very base of the Stairsian, and was described from the Fillmore Formation in the Ibex area. It has not been reported from the Garden City Formation and we have not encountered it there in our sampling. The basis for the identification was not discussed. Most of the illustrated specimens are larvae or early meraspides and their species affinity cannot be established without evidence from cooccurring mature specimens. The largest cranium (Lee and Chatterton, 1997a, fig. 6.10), termed a holaspis by Lee and Chatterton but almost certainly a meraspid, does not closely resemble those of *R. pliomeris* (either based on Demeter's [1973, pl. 2, figs. 1–4] illustrated material or our own work in progress).

Further, Lee and Chatterton (1997a) illustrated a single protaspis specimen which they assigned to *Kawina sexapugia* Ross, 1951. The specimen was said to be from their horizon R6-119. The age of this horizon was given as Zone G(2) (Lee and Chatterton, 1997a, fig. 2, 1997b, fig. 1.2), yet as noted above material assigned to the Stairsian (Zone F) species *Goniophrys prima* was also said to be from this horizon (in fact, it represents fault-repeated Stairsian rocks; see below). In any case, *Kawina sexapugia* is from much younger, upper Blackhillsian ("Zone J"), strata. Lee and Chatterton did not explain the basis for the species assignment, which represents an extreme range extension. Larvae definitely associated with holaspides of *Kawina sexapugia* have never been described, and larvae in isolation cannot be associated with confidence with any species known only from larger material at different horizons.

Measurements given by Lee and Chatterton (1997a) would place all of the horizons within the Stairsian by comparison to our measurements of the same section, yet the *Protopliomerella* and *Licnocephala* Ross, 1951, specimens illustrated certainly represent Tulean species. At the same time, a Stairsian species, *G. prima*, was illustrated and said to be from a stratigraphically higher horizon than the Tulean taxon *Licnocephala*. Section HC6 is terminated by an obvious fault which lies in a mostly covered interval at HC6 229.5–234.0 m in our measurements. Above this lie fault-repeated upper Stairsian strata with conspicuously different strike and dip than those of the main section. Lee and Chatterton appear not to have noticed this fault and to have assumed the Stairsian fault-repeated faunas above the fault stratigraphically succeeded the younger faunas below. Hence, they invoked a major range extension for *G. prima*. *Goniophrys prima*, however, occurs above the fault in association with a typical assemblage of other upper Stairsian species and no Tulean species. The mid-Tulean interval beneath the fault from which *Protopliomerella* and *Licnocephala* have been sampled at HC6 is 202–221.5 m in our measurements. This is almost double the measurement given by Lee and Chatterton (114 m), despite the sections ostensibly having been started from the same datum.

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Adrain *et al.* (2009) have discussed the implications of the true occurrence of *P. contracta* for the *Protopliomerella contracta* Zone *sensu* Ross *et al.* (1997) in the Great Basin. Ross (1951), Hintze (1953), and Demeter (1973), among other workers, misidentified other species of *Protopliomerella* as *P. contracta*, which vastly and inaccurately increased its range. That these misidentifications occurred when working with material from the type locality, and from the closely correlated Fillmore Formation, indicates that assignment of non-Great Basin material and faunas to *P. contracta* or the *P. contracta* Zone is likely problematic. Faunal correlation in particular should be critically reexamined, because it is now clear that the presence of a species of *Protopliomerella* in a fauna does not necessarily indicate the presence of, or correlation with, the *P. contracta* Zone, as has previously been widely assumed.

***Protopliomerella stegneri* n. sp.**

(Plates 9–13)

1973 *Hintzeia celsaora* (Ross); Demeter, p. 58, pl. 3, figs 9, 10, 14 (only; pl. 3, figs 11–13 = ? *Hintzeia celsaora*).

Material. Holotype, cranidium, SUI 126054, from Section G 138–139T m, and assigned specimens SUI 126052, 126053, 126055–126095, from Section G 138–139T m and 142–144.5T m, Fillmore Formation (lower Floian; Tulean; unzoned strata beneath *Psalikilopsis cuspidicauda* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

Etymology. After Wallace Stegner.

Diagnosis. Anterior border moderately broad; S4 barely impressed; hypostomal suture broad, with anterior wings long and much wider than shoulders; posterior section of librigenal field fairly wide; pygidial pleural spines well separated.

Description. Cranidium relatively short and wide, with sagittal length 48.4% (45.6–50.6%) maximum width across genal angles, highly vaulted (tr.) mainly because of strongly downturned fixigenae, axis moderately vaulted, cranidium covered in dense, finely granulose sculpture; anterior border moderately broad, short, gently anteriorly bowed, moderately inflated, densely granulose; doublure expressed as anterior face of border, exposes ventral half of inner wall of border, with very shallow median rostral suture arc of about 1/3 total border width; anterior border furrow very short, deep, incised, somewhat anteroventrally directed underneath posterior edge of anterior border, course gently anteriorly bowed over broad glabellar section, roughly transverse on narrow lateral sections in front of palpebro-ocular ridges, with deeper, longer apodemal pits at junctions with axial furrows; glabella relatively short and wide, gradually anteriorly tapered, with maximum width across L1 100.4% (94.7–106.5%) sagittal length, mildly vaulted (sag., tr.), with convexity highest posteriorly and falling anteriorly, with three well defined independently inflated lateral lobes, and with sculpture of fine granules, somewhat effaced in centers of L1–L3, denser medially, with lobes outlined by slightly larger granules on edges of furrows; L2 and L3 very similar, subrectangular, anterolaterally oriented at about 20° above horizontal, with L2 slightly longer and wider, L1 smaller, narrower, subtriangular, LF short, narrow, wedge-shaped, with very narrow, faint trace of S4 diverging anteromedially from S3 suggesting L4 (better visible on larger specimens, e.g., Pl. 9, figs 3, 21), S1 and S2 moderately long, very deep, with L1 slightly longer with inner end slightly posteriorly elongated, S3 shorter and shallower; SO short and deep medially, longer and deeper laterally in apodemal pits behind mid-L1, then constricted toward axial furrow, abaxial portions lined by small granules on margins of L1 and LO; LO wide, somewhat longer medially and tapered laterally, with very shallowly W-shaped anterior margin indented by apodemal pits in SO, moderately inflated, highest just posterior from mid-length (lateral view), densely granulose, with small median node and slightly larger granules on lateral margins; doublure fairly short, laterally tapered, lens-shaped; axial furrows deep, fairly narrow, wider at triangular junctions with glabellar furrows, anteriorly convergent along LO, then moderately laterally bowed around base of L1, then gradually anteriorly convergent; palpebro-ocular ridges fairly long, reaching from anterior border to anterior of L2, narrow, arcuate, tapered anteriorly and posteriorly, with widest point even with mid-L3, dorsolaterally raised (anterior view); palpebro-ocular furrows arcuate to gently sigmoid, very short, deep over most of course, shallow anteriorly and far posteriorly, anteromedially directed at about 45° above horizontal; interocular fixigenae short, fairly narrow, tapered anteriorly to point at junction of glabella and palpebro-ocular ridge, roughly equilaterally triangular; posterior fixigenae slightly longer, very wide, with broadly ante-

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riorly curved anterior margin, very strongly downturned from fulcrum, all areas of fixigenae with dense granulose sculpture and slightly less densely concentrated small pits; posterior border furrow roughly transverse until genal angle, then anteriorly curved (lateral view), deep, short, constricted adaxially, longer over most of course, then tapered anteriorly after genal angle; posterior border moderately long, expanded laterally toward maximum length at genal angle of not quite double adaxial length, then abruptly tapered to end, moderately inflated, granulose, with small nubby spine at genal angle; doublure very short adaxially, rotated posterodorsally into articulating device near axis, gradually expanded laterally to maximum just before genal angle, and terminated by cut of facial suture at and slightly anterior from genal angle.

Rostral plate unknown.

Hypostome long and narrow, widest across anterior wings, with width across shoulders 68.6% (65.9, 71.2%) sagittal length; hypostomal suture broad, very shallowly arcuate to nearly transverse; anterior border extremely short medially, abruptly expanded laterally into large triangular anterior wings of approximately equal width and length with small, deep wing process pits, densely covered in granules; anterior border furrow strongly anteriorly bowed, short, deep, incised medially, nearly effaced posterolaterally toward meeting with lateral border furrows; middle body long, narrow, ovoid; anterior lobe large, elongate, ovoid, about 80% total length of middle body, strongly ventrally inflated, with inflation decreasing slightly posteriorly, with dense sculpture of small tubercles over at least anterior half of lobe (entire lobe in some specimens); lateral branches of middle body furrow narrow, deep, incised, posteromedially sloped and gently laterally bowed in course, intersect lateral border furrows even with lateral notch, poorly impressed medially (longer and much shallower) on most specimens, but strongly posteriorly curved; posterior lobe of middle body U-shaped, with long, slender, anteriorly tapered arms and short, narrow midsection, lobe moderately inflated, effaced; lateral border furrows narrow, deep except over tips of lateral branches of posterior lobe of middle body and along anterior wings, incised, somewhat laterally bowed posterolaterally, subparallel for most of course and then anteriorly convergent with anterior border furrow; lateral border strongly downturned and inflated, narrow, gradually expanded posteriorly to maximum width at posterolateral corners, with dense sculpture of coarse granules and some anastomosing ridges, and with small nubby spines (just rounded angles in some specimens) at shoulders and slightly posterior from shoulders, and a longer, thicker, more pointed spine at posterolateral corners; posterior border furrow long, shallow, ill-defined, strongly posteriorly convex in course; posterior border long, fairly wide, moderately steeply ventrally angled (lateral view), with background sculpture like that of lateral border, and with small, broad-based, triangular median spine; doublure short and narrow, but reaches to lateral border furrow and about halfway to posterior border furrow, with anterior parts turned outward at lateral notch to form anterior wings, doublure moderately strongly upturned, with long, shallow lateral notch.

Librigena long and moderately wide, laterally convex but not well curved; anterior branch of facial suture short along eye and field, meets lateral border at slightly greater than 90°, branch along anterior projection of lateral border longer and strongly downturned; posterior branch of facial suture very long, with two major changes of slope, the first at about half length of field, changing from angle of about 45° to very gentle slope less than 10°, and the second at junction with lateral border, changing to posterodorsal curvature along posterior projection of lateral border; eye elliptical, narrow and elongate, elevated above librigenal field on socle about same height as eye (ventro-lateral view); librigenal field roughly wedge-shaped, fairly broad anteriorly, strongly tapered after about half field length, with width of field under midpoint of eye 22.9% (20.4–24.9%) length along lateral border furrow, moderately steeply ventrolaterally sloped, with sculpture of dense granules and fairly dense small pits concentrated under eye and near facial sutures; lateral border furrow narrow, deep, with short deeper segment at anterior end and slightly shallower toward posterior tip, curved, with slope steeper anteriorly; lateral border highly inflated, with inflation greater ventrolaterally, broad, gradually posteriorly tapered, rotated anteroventrally to form very long anterior projection with blunt termination, posterior projection short, triangular, strongly posteriorly tapered to point, with inner face of doublure protruding, border with dense sculpture of granules slightly coarser than those of field, but effaced far ventrolaterally; doublure wide, posteriorly tapered, with slight protrusion above tip in external view, bluntly terminated anteriorly even with edge of librigenal field, rotated anteroventrally outward into anterior projection of border.

Total number of thoracic segments unknown; segments highly arched axially and pleurally (varies somewhat with thoracic position), short and broad, with width of axis 34.4% (33.5, 35.2%) width across posterior pleural band, with dense finely granulose sculpture all over, including in furrows; articulating half ring short, laterally

tapered, semilunate, anteriorly upturned; articulating furrow deep, long medially, sharply constricted and deeper ventrolaterally, broadly arcuate and posteriorly convex in course; axial ring narrow, about same width as inner pleurae (may change depending on thoracic position), short, transverse medially with shallowly anterolaterally curved extremities, well inflated, slightly higher posteriorly; doublure short, laterally tapered, with fine transverse ridge at midlength; axial furrows fairly narrow, widest at junction with pleural furrow, deep, anteriorly convergent; inner pleurae and outer pleurae of roughly equal widths (may vary with thoracic position), inner pleurae nearly horizontal (anterior view), joined to steeply sloped outer pleurae by fulcral angle of about 115°; anterior pleural band very short, broad, uninflated, with extremely short articulating tongue on anterior margin set off posteriorly by incised furrow; pleural furrow very short and deep, slightly shallower near adaxial and abaxial ends, transverse for most of course, anteriorly curved at ventrolateral tip; posterior pleural band about twice length of anterior band dorsally, expanded ventrolaterally toward spine, broad, well inflated, higher near axis, laterally flattened and anterolaterally rotated to form broad-based spine, spine separated into two prongs by sharp notch in some specimens (Pl. 11, fig. 22); doublure on inner pleurae posterodorsally twisted into articulating ledge on posterior margin, long and wide ventrolaterally over spine, with deep notch at pleural furrow.

Pygidium highly vaulted pleurally and axially, composed of five segments and terminal piece, relatively short and wide, with width across tips of anterior pleural band of first segment 124.2% (117.7–133.1%) sagittal length excluding articulating half ring and free tips of spines, and with dense finely granulose sculpture; articulating half ring broad, short, laterally tapered; articulating furrow long and deep; axis conical, broad anteriorly, strongly posteriorly tapered to point at tip of terminal piece, highly vaulted anteriorly, decreasing posteriorly to barely inflated terminal piece; axial rings short and broad, with fifth ring a little shorter and slightly greater than half width of first, rings highly independently inflated, lined on all margins with small tubercles and granules, with small tubercles or pitted tubercles medially; inter-ring furrows long medially, shorter ventrolaterally into apodemal pits, deep, very deep in pits; terminal piece triangular, broad anteriorly, strongly tapered, long, with narrow posterior section extending almost to base of pygidial spines on some specimens (posterior view), mildly inflated, with impression of two short furrows projecting from anterior margin; axial furrows fairly narrow, wider at intersections with interpleural furrows, deep, widely anteriorly divergent, strong over fifth segment, then merged with fifth interpleural furrows along terminal piece; anterior pleural band present only on first segment, short, as wide as posterior band excluding its spine, strongly posterolaterally curved, with slightly flared tips (dorsal view), and with extremely short articulating tongue on anterior edge (best seen in lateral view, e.g., Pl. 12, fig. 7; Pl. 13, fig. 5), and small anteriorly directed hook structure at adaxial tip; pleural furrow short, deep, incised; posterior pleural bands long, broad, strongly independently inflated, increasingly backturned, with pleurae 1–4 approaching parallel and fifth pleurae medially convergent, granulose, with larger granules concentrated on margins of pleurae, and with small pits (some with slightly raised rims) on center of pleurae, and with large pleural spine; spines fairly short (posterior view), broad, tapered to blunt point, somewhat laterally flattened and blade-like, well separated at tips, projecting posteroventrally with gently curved ventral margin (lateral view) and slightly raised ridge at margin; interpleural furrows moderately long, anterior furrows very deep, furrows 4–5 relatively shallow but still well impressed, strongly backturned like pleurae, with 5th furrows posteriorly convergent into single furrow behind terminal piece; pygidial border located ventrally, formed of fused spine bases, with slightly raised rim anterolaterally, grading into doublure medially; doublure roughly triangular, moderately long medially and strongly anterolaterally tapered.

Ontogeny. *Protopliomerella stegneri* is not as well known as most other species of the genus. The small sample size and similar sizes of individual specimens hinder discussion of ontogenetic changes. However, it is possible to see that the glabella narrows and elongates slightly, all the cranidial furrows deepen, the palpebro-ocular ridges increase in anterolateral curvature, the coarseness of the pits and granules increases, and the genal angle widens. The hypostomes are very close in size, but it appears that larger hypostomes have coarser middle body tubercles and shorter lateral and posterior border spines. Librigenal ontogenetic changes include widening of the field, with a relative decrease in width of the lateral border, and with a less marked change in slope of the posterior branch of the facial suture. Thoracic segments are too poorly known to be informative. The pygidium elongates slightly, the axial ring sculpture is reduced, the inter-ring and interpleural furrows lengthen and deepen, and the terminal piece develops impressions.

Discussion. Two damaged hypostomes (Pl. 11, figs 11, 15) appear to have malformed lateral and posterior borders, although the deformation could be breakage. Demeter (1973, pl. 3, figs. 9, 10, 14) figured two pygidia and a cranidium of *P. stegneri* as *Hintzeia celsaora*.

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Protopliomerella stegneri is most morphologically similar to *P. kerouaci*, but can be distinguished by its wider anterior border, shorter and wider glabella, weakly developed S4, longer and more posterolaterally located palpebro-ocular ridges; a hypostome with much wider anterior wings, shorter border spines, shorter posterior lobe of the middle body, and coarser, more sparsely spaced tubercles on the anterior lobe of the middle body; a slightly shorter and much wider librigena with a lower eye and less raised eye socle area, longer anterior branch of the facial suture along the field, and less pitted field; and a relatively shorter and wider pygidium with a less tapered posterior margin, less posteromedially directed pleurae, wider and slightly more separated pleural spine tips, a less complex terminal piece impression, and finer sculpture.

Protopliomerella stegneri is stratigraphically closest to *P. bowlesi*, but the latter taxon possesses a narrower anterior border, a considerably longer and narrower glabella with a much more clearly impressed S4, narrower interocular fixigenae and more anteriorly located palpebro-ocular ridges, more steeply sloped fixigenae; a librigena with a more evenly sloped posterior branch of the facial suture and a narrower librigenal field, particularly posteriorly; and a distinctive six-segmented pygidium with less inflated axial rings and pleurae, a smaller, narrower terminal piece, and narrower, much more closely spaced pleural spines.

Protopliomerella stegneri is compared to *P. seegeri* in the discussion of the latter species.

***Protopliomerella bowlesi* n. sp.**

(Plates 14–19)

- 1953 *Protopliomerops* sp. 6; Hintze, p. 31, 209, pl. 22, fig. 12.
1953 *Protopliomerops* aff. *P. contracta* Ross; Hintze, p. 31, 207, pl. 22, figs 11, 19 (only; pl. 22, figs 18, 20 = *Protopliomerella okeeffeae*).
1973 *Protopliomerella contracta* (Ross); Demeter, p. 59, pl. 4, fig. 2 (only; pl. 4, figs 6, 11, 12 = *Protopliomerella okeeffeae*).
2009 *Protopliomerella* sp. nov. 1; Adrain *et al.*, p. 560, fig. 10V, Z.

Material. Holotype, cranium, SUI 115195, and assigned specimens SUI 115196, 126096–126145, from Section G 162T m, Fillmore Formation (lower Floian; Tulean; low *Psalikilopsis cuspidicauda* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

Etymology. After Paul Bowles.

Diagnosis. Glabella long and narrow; glabellar sculpture very fine and concentrated medially; palpebro-ocular ridges long, with posterior end even with S2; LO with very small median tubercle; effaced six-segmented pygidium, with very long first and second inter-ring furrows.

Description. Cranium long and very wide posteriorly, narrow anteriorly, with sagittal length 53.3% (48.0–57.4%) width across genal angles, strongly vaulted; anterior border short, moderately narrow, slightly anteriorly bowed, moderately inflated, with U-shaped cross-section, densely covered in fine granules; doublure expressed as anterior face of border, exposes roughly bottom 1/3 of outer face of inner wall of border, with broad, very shallow median rostral suture arc (anterior view), and doublure also present ventrally as very short rim; anterior border furrow short, very deep, with large, deep apodemal pits at junctions with axial furrows, somewhat overhung by inflation of anterior border, broad median section gently anteriorly bowed, lateral sections between border and palpebro-ocular ridges anterolaterally directed at about 30° above horizontal; glabella long, narrow, anteriorly tapered, with maximum width across L1 88.3% (79.5–100%) sagittal length, moderately arched (sag., tr.) with convexity decreasing anteriorly, formed of four distinct lateral lobes separated by sulci, densely granulose, with sculpture mostly confined to median lobe, but also branched into center of lateral lobes on some specimens (Pl. 14, figs 10, 15), and with a few very small perforate tubercles located at mid-length of each lateral lobe even with ends of sulci, additional tubercles scattered on some specimens, e.g., Pl. 15, fig. 2; Pl. 16, fig. 19; glabellar lobes weakly independently inflated, reach to about 1/3 glabellar width on each side, L1–L3 large, roughly equal in area, but L1 subtriangular, L2 and L3 sub-square, L4 less well defined, short, narrow, triangular, and LF present only as very short band echoing curvature of anterior border; S1–S3 short, deep, with courses about about 45°, 30°, and 45° above horizontal, with sagittal ends of S2 and especially S1 slightly posteriorly elongated, S4 very narrow, directed opposite other sulci, branches anteromedially from just inside abaxial end of S3, with junction angle of roughly 90°; SO short, moderately deep medially, very slightly longer and much deeper along L1, with course transverse

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medially and gently posteriorly bowed laterally; LO wide, moderately long, subrectangular, slightly inflated, with sculpture of dense granules concentrated medially, and small median node located slightly posterior from 2/3 length; LO doublure short, hardly laterally tapered, smooth; axial furrows narrow, a little wider at junctions with glabellar sulci, very deep, subparallel along LO, then steadily anteriorly convergent after bulge around L1; palpebro-ocular ridges long and moderately narrow, extend from anterior border to about even with base of L3, with widest part opposite S3, arcuate to gently sigmoid in shape, strongly raised laterally and steeply sloped anteroventrally (anterior view), with finely granulose rims; palpebro-ocular furrows narrow, deep, incised for most of course, effaced anteriorly from S3 forward and far posteriorly, shallowly sigmoid; interocular fixigenae small, triangular, anteriorly tapered, slightly longer than wide, with sculpture identical to posterior fixigenae; posterior fixigenae long and very wide, strongly downturned from fulcrum roughly even with posterolateral end of eye ridge (anterior view), with broadly anterolaterally bowed anterior margin, and with fairly dense sculpture of small pits and tiny granules, except for a border along glabella and in front of posterior border lacking pits, and a rim of granules on all furrows; posterior border furrow short, deep, incised, with broadly anterolateral course nearly transverse adaxially, and strongly anteriorly curved by genal angle; posterior border moderately short adaxially, expanded ventrolaterally to maximum length slightly before genal angle, then tapered anteriorly, with fine granulose sculpture and small, nubby genal spine; doublure fairly short laterally, cut by facial suture at anterior tip, very short medially, until slightly before genal angle, as doublure is posterodorsally rotated outward to form articulating tongue near LO.

Rostral plate unknown.

Hypostome long and narrow, widest across anterior wings, with width across shoulders 68.2% (67.2–68.6%) sagittal length; hypostomal suture fairly broad, slightly anteriorly bowed; anterior border extremely short medially, flared laterally into short, narrow, triangular anterior wings with relatively large, deep wing process pits; anterior border furrow very short, deep medially, shallowed laterally along posterior half of anterolateral wings, narrow, strongly anteriorly convex; middle body long, narrow, roughly ovoid but with gradual posterior taper; anterior lobe of middle body long (about 3/4 length of middle body), ovoid with rounded posterior margin, strongly ventrally inflated, inflation decreases slightly anteriorly and significantly posteriorly, with fairly dense sculpture of small tubercles concentrated on anterior half, and some scattered small pits (e.g., Pl. 16, fig. 2) on posterior half; anterolateral branches of middle body furrow overlapped with strongly impressed lateral border furrows, furrow ill-defined medially, mostly effaced and more present as break in slope between lobes of middle body, strongly posteriorly bowed; posterior lobe of middle body U-shaped, lateral branches long and very narrow, middle short and narrow, gradually posteriorly tapered in width, moderately ventrally inflated, effaced; lateral border furrows narrow, deep and incised, anterior part posteromedially directed, posterior part gently laterally bowed, with anterior portion separated from posterior portion by anterolateral tips of posterior middle body branches; lateral border narrowest anteriorly along lateral notch, gradually expanded posteriorly (as glabella also narrows) to maximum width at posterolateral corners, moderately downturned (lateral view), with dense sculpture of small granules, and with small nubby spines at shoulders, corners, and roughly halfway between those points; posterior border furrow narrow, moderately long and deep, posteriorly curved; posterior border moderately downturned (lateral view) short, but slightly longer than maximum width of lateral border, posteriorly tapered to tip of small, slightly elongated median spine; doublure turned outward into wings anteriorly from moderately long, shallow lateral notch, short and narrow posteriorly, but reaches nearly to lateral and posterior border furrows, gently dorsally raised, smooth.

Librigena long and narrow, moderately laterally convex (ventrolateral view); anterior branch of facial suture very short along eye and field, then about double length and anteroventrally directed along anterior projection of border; posterior branch of facial suture very long, posteroventrally sloped, with change from about 27° to about 10° below horizontal at a little less than half length, then upturned along posterior projection; eye small, ovoid, slightly raised above field (ventrolateral view); librigenal field long and narrow, posteriorly tapered, wedge-shaped, with width under midpoint of eye 20.8% (17.0–23.8%) length along lateral border, with sculpture of fairly densely spaced small pits, and small granules on raised area below eye (Pl. 16, fig. 26); lateral border furrow long, narrow, deep, slightly laterally bowed; lateral border wide, very slightly posteriorly tapered along field, then more strongly tapered to point along posterior projection, strongly inflated, with long, wide, ventrolaterally directed anterior projection with bluntly squared end, posterior projection slightly shorter, strongly tapered, triangular, with strongly upturned end; doublure moderately wide, tapered to sharp point posteriorly, with narrow strip visible behind tip of posterior projection in external view, slightly tapered and terminated anteriorly at anterior edge of librigenal field,

then anteroventrally rotated into anterior projection.

Total number of thoracic segments unknown; segments short and relatively wide, with width of axis 38.9% (33.1–50.5%) width across posterior pleural band, highly vaulted in axis and pleurae, with dense sculpture of fine granules all over, including in furrows; articulating half ring short, tapered laterally, relatively wide, raised to about even with axial ring (lateral view); articulating furrow moderately long, deep medially, deeper laterally, very broadly U-shaped in course; axial ring short, approximately same length as posterior pleural band, wide, slightly wider posteriorly than anteriorly, mildly inflated, granulose, with slightly larger granules medially and projecting into axial furrows from corners; doublure very short, very slightly laterally tapered, with extremely fine parallel transverse ridges; axial furrows narrow and very deep along axial ring, slightly wider and shallower after intersection with pleural furrow, anteriorly convergent, more steeply so over anterior pleural band; inner pleurae and outer pleurae approximately same width (excluding pleural spine) on more anterior segments (Pl. 17, fig. 22), outer pleurae longer on more vaulted posterior segments (Pl. 17, fig. 21), pleural angle steep, from about 45° below horizontal to subvertical; anterior pleural band very short medially, slightly expanded ventrolaterally, with extremely short articulating tongue on anterior edge defined by extremely short furrow, and with small anteriorly directed hook structure at tips of band; pleural furrow very short, deep, incised, course posterolateral until just before tips, then gently anteriorly curved; posterior pleural band fairly long, equally broad as anterior band (excluding pleural spine), gently inflated, highest just past fulcrum (anterior view), anterolaterally rotated and somewhat laterally flattened toward abaxial end and through spine, densely granulose, with long, wide, somewhat bladed genal spine, spine with notch separating two bluntly pointed tips in some specimens, and some specimens with concentration of coarser granules lining tip(s) (Pl. 17, figs 17, 27), spine anteriorly curved in most specimens, but posteriorly directed similar to pygidial spines in more posteriorly positioned segments (Pl. 17, fig. 17); doublure very short proximally, turned out posteriorly into very short articulating tongue, long and wide ventrolaterally over spine, with notch at pleural furrow.

Pygidium of six segments and terminal piece, relatively short and broad, with width across anterior pleural band 120.3% (111.9–132.1%) length, highly vaulted, more pleurally than axially, mostly effaced; articulating half ring short, wide, semilunate; articulating furrow short and deep; axis very wide anteriorly, strongly tapered posteriorly to point at tip of terminal piece, moderately vaulted anteriorly, with convexity decreasing toward nearly flat terminal piece; axial rings subrectangular with rounded margins, broad and long anteriorly, tapering to about half width and half length posteriorly, each independently moderately inflated, with paired tiny pits located at about 1/3 and 2/3 width (e.g., Pl. 18, fig. 4; Pl. 19, figs 2, 4), and with additional smaller pits and tiny tubercles on some smaller specimens (Pl. 19, fig. 22); terminal piece triangular, narrow, highly posteriorly tapered, long, very slightly inflated; inter-ring furrows deep, short laterally, longer medially, with first 2-3 furrows much longer; axial furrows narrow, wider at intersections with inter-ring furrows, deep, strongly anteriorly divergent, slightly laterally bowed, discontinuous over sixth pleurae on most but not all specimens (cf. Pl. 18, figs 3, 13), rapidly convergent toward tip of terminal piece, then merged into single sixth interpleural furrow; inner pleurae narrow and increasingly so posteriorly; fulcral angle very steep (anterior view); outer pleurae very wide and strongly downturned; anterior pleural band present only on first segment, broad, very short, with extremely short articulating tongue on inner half set off by extremely short, fairly shallow furrow (lateral view), and with small hook-like articulating structure at lateral tips; pleural furrow short, deep over most of course, but somewhat shallowed near tips of pleurae; posterior pleural bands long, wide, strongly backturned, with fourth pair roughly parallel, and fifth and sixth pairs increasingly posteriorly convergent, moderately inflated like axial rings, with inflation lessening toward tips, ventrolateral portion somewhat laterally compressed into buttress shape (lateral view), effaced except for tiny, widely spaced line of pits centered on ribs (posterior view); pleural spines long, tapered to blunt point, laterally flattened, triangular, gently posteroventrally curved, with very tips slightly recurved dorsally, effaced except for continuation of line of pits on pleurae, and with small tubercles lining ventral margin (lateral view); interpleural furrows short, deep, incised, posterior furrows slightly shallower, backturned to follow pleurae; ventral pygidial border short and narrow, with raised inner rim; doublure moderately long medially, strongly anterolaterally tapered (anterior view).

Ontogeny. Cranidial ontogenetic changes (cf. Pl. 14, figs 3, 15; Pl. 15, figs 10, 23) include overall reduction in coarseness and density of sculpture; narrowing of the anterior border; posterior expansion and anterior tapering of the glabella; lengthening of LF and development of S4; development of perforate glabellar tubercles; reduction of the median LO tubercle; and reduction of the genal spine.

Hypostomal changes (cf. Pl. 16, figs 2, 20) include overall shortening and widening; slight widening of the

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anterior wings; deepening of the lateral notch; shortening and widening of the anterior lobe of the middle body; shortening of the lateral branches of the posterior lobe of the middle body; reduction in coarseness and extent of middle body sculpture; and increased taper of the lateral border.

Librigenae (cf. Pl. 16, fig. 28; Pl. 17, fig. 1) elongate and widen anteriorly; the eye develops a slightly raised socle; the librigenal field pits spread and enlarge; and the lateral border curves more (especially posteriorly). Thoracic segments are not comparable due to variation based on thoracic position.

Pygidia (cf. Pl. 18, fig. 1; Pl. 19, fig. 22) elongate slightly; the pleurae become more posteromedially directed and create a rounded lateral margin overall; the axis widens and deflates slightly; the axial rings shorten medially as the inter-ring furrows lengthen; the axial furrows become deeper and wider; the pleural tips separate slightly; and the fine granules and tiny pits on the axis and pleurae become more effaced.

Discussion. The left S3 of one cranium (Pl. 14, fig. 1) does not reach the axial furrow. The posterior border of one hypostome (Pl. 16, fig. 14) is irregularly rounded and spineless; it may be a healed injury. One pygidium (Pl. 18, fig. 23) has a very small, irregularly shaped terminal piece. The axial furrow is impressed over the left side only of the sixth pleurae of one pygidium (Pl. 19, fig. 2).

Protopliomerella bowlesi most closely resembles *P. seegeri*, and they are compared in the differential discussion of the latter. The six-segmented pygidium differentiates this species from the older species *P. stegneri* and the younger species *P. kerouaci*, but other sclerites are more comparable. *Protopliomerella bowlesi* is also compared to *P. stegneri* in the discussion of that species.

Compared to *Protopliomerella kerouaci*, *P. bowlesi* has an overall narrower, less anteriorly tapered, more highly inflated (especially posteriorly) glabella with coarser granulose sculpture medially, fewer and smaller tubercles outlining the glabellar lobes, and shallower glabellar furrows, longer and narrower (especially anteriorly) palpebro-ocular ridges; a slightly wider hypostome (particularly across the lateral notch) with a longer posterior lobe of the middle body and narrower and shorter lateral and posterior borders; a wider librigena with a wider (anteriorly) and less pitted field; and a relatively wider six-segmented pygidium with a smaller terminal piece lacking a complex impression, shorter pleurae, and a shorter (anterior view) doublure.

Hintze figured specimens from Section G 158.1 m and G 238.3 m (1953, pl. 22, figs 11, 18–20) referred to as *Protopliomerops* aff. *P. contracta*. The two specimens from G 158.1 m are specimens of *P. bowlesi*. Hintze noted that the cranium (fig. 19) differed from that of *Protopliomerella contracta* in its less anteriorly tapered glabella, and lower palpebro-ocular ridges. He also stated that the hypostome (fig. 11) had smaller lateral border spines. The two stratigraphically higher specimens represent *P. okeeffeae* (see discussion). Hintze figured a six-segmented pygidium from G 158.1 m as *Protopliomerops* sp. 6 (1953, pl. 22, fig. 12), and this also belongs to *P. bowlesi*.

A single badly damaged pygidium from G 155.6 m likely represents *Protopliomerella bowlesi*. It is broken anteriorly, but evidence from a count of pleurae and damaged axial rings indicates six segments, which rules out assignment to *P. stegneri*. Demeter (1973, pl. 6, figs 10, 12) figured pygidia from approximately G 150.1 m, which have seven segments and are likely *Protopliomerella* n. sp. B (see discussion of that taxon). However, in lateral view (Pl. 19, fig. 23) the pygidium from G 155.6 m appears to include the ventrolateral portion of the anterior pleural band, suggesting that the damage has not removed additional anterior segments, and that the pygidium is that of *P. bowlesi*.

***Protopliomerella kerouaci* n. sp.**

(Plates 20–30)

- 1951 *Protopliomerops contracta* Ross, p. 136, pl. 33, figs 18, 19, 23–32 (only; pl. 33, fig. 15 = *Protopliomerella seegeri*; pl. 33, figs 16, 17, 22 = *P. contracta*).
1953 *Protopliomerops* sp. indet.; Hintze, p. 31.
1973 Genus and species undetermined A; Demeter, p. 64, pl. 5, fig. 15 (only; pl. 5, figs 2–4, 7, 8 = *Cybelopsis*? spp.; pl. 5, fig. 9 = *Protopliomerella seegeri*; pl. 5, fig. 13 = gen. and sp. indet.).
2009 *Protopliomerella* sp. nov. 2; Adrain *et al.*, p. 561, fig. 11M.

Material. Holotype, cranium, SUI 126209, from Section G 168T m, and assigned specimens SUI 126206–126208, 126210–126246 from Section G 168T m and 174.0 m, Fillmore Formation (lower Floian; Tulean; *Psalikilus typicum* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.; SUI 115214, 126146–126205 from Section HC6 202T m, 203.0 m, and 203.5 m, Garden City Formation (lower Floian; Tulean;

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Psalikilus typicum Zone), west side of Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho, USA. Also known from Locality YH E, Yellow Hill Limestone (lower Floian; Tulean; high *Psalikilopsis cuspida-cauda* Zone), Yellow Hill, near Pioche, Lincoln County, eastern Nevada, USA.

Etymology. After Jack Kerouac.

Diagnosis. Fixigenae with sparse granules concentrated around edges of pits; thoracic segments dorsally effaced; pygidium nearly effaced, with transverse line of pits on axial rings and down center of pleurae.

Description. Cranidium with strongly vaulted fixigenae, moderately vaulted axis, narrow anteriorly and very wide posteriorly, with sagittal length 48.4% (44.6–52.9%) width across genal angles; anterior border narrow, short, subrectangular, very slightly anteriorly curved, moderately inflated, with U-shaped cross-section, densely granulose, more effaced dorsally, with line of pits at mid-length echoing curvature; doublure expressed as anterior face, exposes bottom half of outer face of inner wall of border, scalloped with shallow median arc of rostral suture, only a rim ventrally; anterior border furrow short, very deep, incised, with short anterolateral branches angled at about 30° above horizontal and broad median section with slight anterior convexity; glabella long, narrow, strongly anteriorly tapered, with maximum width across L1 94.9% (81.6–106.1%) sagittal length, moderately arched, with convexity higher posteriorly, with four well-defined lateral lobes, and with dense granulose sculpture medially (effaced on larger specimens) and some perforate tubercles or pits, lateral lobes with sculpture extending exsagittally from middle lobe along mid-length and mid-width, but surrounded by short and narrow effaced rim on dorsal face (lobes totally effaced on larger specimens), lobes also outlined by granules on edge extending into lateral and axial furrows; L1 largest, subtriangular, with L2 and L3 slightly shorter and sub-square, L4 short, narrow, triangular, median lobe long, narrow, roughly rectangular, LF just a very short arc behind anterior border furrow; all lateral furrows short, deep, and incised, progressively narrower anteriorly, with S4 about 1/3 width of S1, S1–S3 strongly anterolaterally directed, about 30–40° above horizontal, S1 with slightly elongated adaxial end, S4 very strongly anteromedially directed about 50° above horizontal, branching from near exsagittal tip of S3; SO short, slightly longer medially and behind outer halves of L1, deep, shallower medially and deeper laterally, with gently wavy course curved behind L1, lined anteriorly and posteriorly with granules just inside rim; LO wide, about as long as L2, rectangular, with slightly wavy anterior margin, effaced; doublure fairly short, slightly laterally tapered, with a fine transverse ridge at midlength; axial furrows moderately wide, wider at triangular intersections with lateral glabellar furrows, very deep, subparallel along LO, bowed outward around L1, then steadily anteriorly convergent, framed by granulose margins of glabella and fixigenae; palpebro-ocular ridges opposite L3–LF, short, narrow, with strongly arcuate outer margin and very narrow, rapidly tapered posterior ridge, highly elevated at about 50–60° above horizontal (anterior view), densely granulose; palpebro-ocular furrows narrow, deep, incised, except effaced along extreme anteromedian section of ridge, with gently sigmoid course; interocular fixigenae triangular, narrow, short, a little less than 1/3 maximum length of fixigena; posterior fixigenae long, wide, subrectangular, with broadly curved anterior margin, all fixigena with fairly sparse sculpture of tiny granules, concentrated only on rims of pits in larger specimens, densely scattered small pits, and effaced zone along axial and posterior border furrows; posterior border furrow short, slightly longer toward genal angle, then constricted again, deep, incised, roughly transverse until mid-course, then anteriorly curved (lateral view), rimmed with granules anteriorly and posteriorly; posterior border short medially, expanded laterally to maximum at genal angle, then strongly tapered to point at tip, moderately inflated, mostly effaced, but with scattered granules on posterior edge (concentrated near genal angle), and small nubby spine at genal angle; doublure very short adaxially, turned outward into articulating tongue near axis, longer and wider toward genal angle, cut shallowly by facial suture at anterior corner of genal angle.

Rostral plate unknown.

Hypostome narrow and elongate, with width across shoulders 70.2% (65.8–73.0%) length; hypostomal suture broad, very slightly anteriorly convex; anterior border vanishingly short, especially medially, nearly overhung by middle body, expanded laterally into long, fairly wide, wedge-shaped anterior wings with small, deep wing process pits located very close to lateral margin, with granulose sculpture and some larger granules medially; anterior border furrow narrow arc, strongly anteriorly bowed, extremely short, especially medially, deep anteriorly, then abruptly shallowed at connection with lateral border furrow; anterior lobe of middle body long, wide, ovoid, strongly ventrally inflated, with inflation decreasing anteriorly and posteriorly from maximum about even with anterior end of lateral notch (lateral view), with sculpture of dense tiny tubercles over anterior half, becoming much less dense posteriorly; middle body furrow ill-defined, moderately long, shallow, strongly posteriorly convex, merged with lateral border furrow at about half length of middle body; posterior lobe of middle body U-shaped, short, tapered anterolaterally, somewhat inflated, with inflation decreasing posteriorly, effaced; lateral border fur-

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rows narrow, deep, gently laterally bowed, anteriorly and posteriorly convergent; lateral border very narrow at lateral notch, much expanded at shoulders, and gradually expanded posteriorly to maximum width at posterolateral corners, moderately downturned (lateral view), densely granulose, with small nubby spines at shoulders, small pointed spines between shoulders and posterolateral corners, and larger pointed spines at corners; posterior border furrow moderately long and deep medially, short and shallow laterally, strongly posteriorly convex; posterior border long, narrow, strongly downturned (lateral view), with granulose sculpture and short, triangular median spine; doublure long and wide, reaches slightly inside lateral border furrows and nearly to posterior border furrow, rotated anterolaterally at lateral notch out into anterior wings, posterior section moderately raised and posteroventrally sloped, lateral notch broad and moderately deep.

Librigena long and narrow, strongly posteriorly tapered, wedge-shaped with moderate lateral curvature (ventrolateral view); anterior branch of facial suture very short along eye and field, sharply posteriorly angled to make narrow angle with border, then long and steeply anteroventrally sloped to end of anterior projection of border; posterior branch of facial suture very long, steeply sloped from eye to about mid-length of librigenal field, then more shallowly sloped down to border (about 35° and 15° below horizontal, respectively); eye small, elliptical, moderately raised above field on socle (ventrolateral view); librigenal field fairly wide anteriorly, strongly tapered posteriorly, with width of field under midpoint of eye 17.0% (14.5–19.4%) length of lateral border furrow, moderately ventrolaterally and anteroposteriorly sloped, with dense sculpture of tiny granules and moderately densely distributed small pits; lateral border furrow narrow, deep, deeper anteriorly and slightly shallower near posterior end, very gently laterally bowed and posteriorly sloped in course; lateral border very wide, posteriorly tapered to fine point, with long anterior and posterior projections, anterior anteroventrally rotated, with bluntly squared termination, posterior triangular, rapidly tapered and strongly posterodorsally curved, border well inflated, with dense sculpture of medium granules; doublure wide, reaches about 3/4 to lateral border furrow, slightly tapered anteriorly, then terminated as border rotates to form anterior projection, with inner face exposed along tip of posterior projection in external view.

Total number of thoracic segments unknown; individual segments highly arched both axially and pleurally, generally short and broad, with width of axis 39.5% (31.3–80.7%) width across posterior pleural band, posterior segments narrower and more strongly arched, segments nearly effaced dorsally, very finely granulose on other surfaces; articulating half ring short, laterally tapered, somewhat lens-shaped, anterodorsally raised such that anterior margin is roughly equal in elevation with axial ring, anterior rim effaced, posterior half granulose (best seen as change in tone from bright light gray to medium gray in dorsal view); articulating furrow moderately long, very deep laterally in apodemal pits, shallower but still deep medially, transverse medially, with anterolaterally curved ends; axial ring short and broad, slightly wider posteriorly, with small, shallow indent at about midlength of each lateral margin, ring lightly inflated, with inflation stronger near axial furrows (posterior view), with clusters of coarse granules at each corner; doublure short, laterally tapered, semilunate, with several very fine transverse ridges; axial furrows narrow posteriorly, slightly wider at lateral indent of axial ring, and a little more than doubled in width after intersection with pleural furrow, deep, very deep posteriorly, anteriorly convergent in course; inner pleurae and outer pleurae (excluding spine) roughly equally wide in anterior segments, inner pleurae decrease in width posteriorly, joined by steep fulcral angle varying from approximately 45° to approaching subvertical; anterior pleural band as wide as posterior band (excluding spines), very short, with extremely short articulating shelf running along anterior margin and with small hook structure projecting anteriorly from ventral tip, with dense granulose sculpture concentrated posteriorly; pleural furrow very short and very deep, transverse to posterolaterally directed for most of course, anteriorly curved near tips; posterior pleural band slightly longer than axial ring, moderately inflated, higher near axial furrows and just past fulcrum, ventrolateral part of pleurae and pleural spine anterolaterally rotated and somewhat laterally flattened, with fine granules lining all edges and concentrated on anterior face just past fulcrum, and on edges of spine, spine wide (tr.), moderately long, tapered to single fine point on some specimens (Pl. 23, fig. 24; Pl. 28, fig. 21), split by small notch into two blunter tips on others (e.g., Pl. 23, fig. 15; Pl. 29, figs 4, 23), gently anteriorly curved except on far posterior segments (e.g., Pl. 28, fig. 21); doublure wide, covers all of spine, with rounded notch centered over posterior pleural band, posterior rim wider than anterior rim, folded posterodorsally to form very short articulating shelf on inner pleurae of posterior pleural band (posterior view).

Pygidium made of five segments and terminal piece, strongly pleurally vaulted and moderately axially vaulted, slightly longer than wide, with width measured across tips of anterior pleural band 107.9% (99.7–118.7%) sagittal length excluding articulating half ring; articulating half ring short, laterally tapered, semilunate, slightly narrower

than first axial ring, with anterior effaced strip and posterior finely granulose strip similar to thoracic articulating half rings; articulating furrow fairly short, deep, somewhat shallower medially; axis conical, broad anteriorly, strongly posteriorly tapered to point at end of terminal piece, moderately vaulted anteriorly, decreasing posteriorly to gently inflated terminal piece; anterior axial rings roughly equal in length, posterior rings slightly shorter, first ring very wide, fifth ring about 2/3 as wide, each ring independently inflated, shape of rings transverse to somewhat anteriorly bowed due to embayment by inter-ring furrows, mostly effaced dorsally, but with some dense granules (mainly on smaller specimens), and tiny pits in transverse line at midlength of rings, also outlined with small granules, especially noticeable at corners; inter-ring furrows lens-shaped, long medially and laterally constricted (anterior furrows) to moderately short (posterior furrows), very deep, especially laterally in apodemal pits; terminal piece triangular, long, wide anteriorly, gradually tapered to point even with or just above base of pleural spines, anterior portion gently inflated, falling along posterior taper, with pits and granules like axial rings, and with complex impression on most specimens varying from two furrows connected to last inter-ring furrow to large, roughly hexagonal pit; axial furrows fairly narrow, wider at intersections with inter-ring furrows, very deep, widely anteriorly divergent, well impressed over fifth segment, then overlapped with fifth interpleural furrows along terminal piece; anterior pleural band expressed on first segment only, extremely short in dorsal view, overhung laterally by posterior pleural band, longer ventrolaterally (lateral view), as wide as posterior pleural bands (without spine), with vanishingly short articulating tongue on anterior margin, and small anteriorly pointed hook at ventrolateral tips; pleural furrow also extremely short in dorsal view and overhung by posterior pleural band, very deep, backturned; posterior pleural bands long, wide, increasingly backturned, with pleurae 1–3 subparallel and 4–5 posteriorly convergent, each pleural rib moderately inflated near axis, increasingly inflated posteroventrally (lateral view), ribs somewhat laterally flattened toward base and spine, mostly effaced dorsally, rimmed with granules on anterior, posterior, and adaxial faces, and with line of widely spaced small pits on midline of each rib; spines with strongly posteroventrally curved ventral margin (lateral view), spines fairly short and wide, tapered to blunt point, closely spaced but with free tips, with granules on ventral margin, and small pit close to tip of spine; interpleural furrows short and very deep, posterior furrows shallower on smaller specimens, strongly backturned like pleurae; pygidial border located ventrally, formed from joined spine bases, short and narrow, with raised anterior rim; doublure seen best in anterior view, very long and pointed medially, sharply anterolaterally tapered, smooth.

Ontogeny. Cranidia of *Protopliomerella kerouaci* become wider overall, and all sculpture becomes increasingly effaced; the anterior border narrows and develops pits; the palpebro-ocular ridges move anteromedially, widen, and lose the slight postocular ridge; the glabella widens slightly posteriorly and tapers anteriorly; the lateral furrows lengthen and deepen, and S4 develops; LO lengthens, particularly laterally and becomes more rectangular; the median LO tubercle disappears; and the genal spine is reduced.

The hypostome lengthens; the anterior wings expand somewhat and rotate ventromedially to better expose the wing process pits in ventral view; the anterior border shortens to near absence medially; the lateral notch deepens (lateral view); the middle body furrow deepens anterolaterally and fades medially; the middle body sculpture reduces in coarseness and becomes restricted to the anterior part of the anterior lobe; the lateral border widens slightly and the posterior border lengthens; and the border spines become shorter and narrower.

Librigenal changes include overall elongation and increase in convexity (ventrolateral view); the anterior branch of the facial suture becomes slightly longer as the anterior part of the field widens and increases the distance between the eye and the lateral border; the librigenal field decreases in posterior taper and its pits enlarge and spread posteriorly; and the lateral border becomes more laterally curved. Thoracic ontogenetic changes cannot be accurately assessed because of variation in size and shape of pleurae by position.

The pygidium becomes longer and laterally rounded; the sculpture changes from coarse granules and small tubercles to nearly complete effacement; the axis narrows slightly relative to the pleurae; the axial rings become shorter medially as the inter-ring furrows lengthen; the axial furrows deepen and widen; the pleurae become longer, wider, and more posteromedially directed; and the tips of the pleural spines become blunter and more closely spaced.

Discussion. The terminal piece of one pygidium (Pl. 30, fig. 1) is marked with a large, deep, roughly hexagonal impression. One librigena (Pl. 28, fig. 1) has a small rounded excursion of the posterior librigenal field interrupting the slope of the posterior branch of the facial suture. Some cranidial specimens, e.g., those of Pl. 28, appear more effaced, and this is likely a combination of ontogenetic and preservational differences. The cranidia in question are both larger and more damaged overall than the more granulose specimens.

All but three sclerites figured by Ross (1951, pl. 33, figs 16–19, 22–32) as *Protopliomerella contracta* represent *P. kerouaci*, which we have also sampled from the Garden City Formation. *Protopliomerella kerouaci* is compared to *P. stegneri*, *P. bowlesi*, *P. seegeri*, and briefly to *P. contracta* in the discussion sections of those species.

***Protopliomerella seegeri* n. sp.**

(Plates 31–33)

- ? 1951 *Protopliomerops contracta* Ross, p. 136, pl. 33, fig. 15 (only; pl. 33, figs 16, 17, 22 = *Protopliomerella contracta*; pl. 33, figs 18, 19, 23–32 = *P. kerouaci*).
 1973 Genus and species undetermined A; Demeter, p. 64, pl. 5, fig. 9 (only; pl. 5, figs 2–4, 7, 8 = *Cybelopsis*? spp.; pl. 5, fig. 13 = gen. and sp. indet.; pl. 5, fig. 15 = *Protopliomerella kerouaci*).
 2009 *Protopliomerella contracta*; Adrain *et al.*, p. 561.

Material. Holotype, pygidium, SUI 126265, and assigned specimens SUI 126247–126254, 126257–126264, 126266–126268, 126270, from Section G 181.8 m, Fillmore Formation (lower Floian; Tulean; low *Psalikilus hestoni* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA; SUI 126255, 126256, 126269, 126271, from Section HC5 217.0T m, Garden City Formation (lower Floian; Tulean; low *Psalikilus hestoni* Zone), Bear River Range, Franklin County, southeastern Idaho, USA.

Etymology. After Pete Seeger.

Diagnosis. Glabella short and wide; hypostome with dense granules on entire anterior lobe of middle body; six-segmented pygidium with dense sculpture of small tubercles on axis and inner pleurae; pygidial spines very finely tapered.

Description. *Protopliomerella seegeri* is very morphologically similar to *P. bowlesi*, and is described with a differential discussion. Ratios are given for comparison to other species. Cranidia of *Protopliomerella seegeri* differ from those of *P. bowlesi* in being shorter and narrower overall; with shorter, more anteriorly positioned palpebro-ocular ridges; a slightly more arcuate palpebro-ocular furrow; a shorter, wider, less anteriorly tapered glabella; much wider LF with faint S4; longer posterior fixigenae; and having coarser granules lining the cranidial furrows. The sagittal length of the cranidium is 50.2% (42.5–56.1%) width across the genal angles, and the width of the glabella across L1 is 92.1% (79.5–101.9%) its sagittal length.

The hypostome of *P. seegeri* is relatively longer, narrower, and less posteriorly tapered than that of *P. bowlesi*, with a narrower hypostomal suture and anterior wings, more strongly inflated middle body with a more granulose anterior lobe, a wider lateral border, longer posterior border, and longer border spines. The width across the shoulders is 68.4% (66.5, 70.4%) the sagittal length.

The librigenae of *P. seegeri* are unknown for comparison, and the rostral plate is unknown for either species.

Thoracic segments of *P. seegeri* and *P. bowlesi* are very similar, but those of the former have shorter articulating furrows; slightly more inflated axial rings and posterior pleural bands; and tiny tubercles on the axial rings. The width of the axial ring is 41.7% (36.2–48.9%) the width of the posterior pleural band.

The pygidium of *P. seegeri* is slightly longer and narrower than that of *P. bowlesi*, with width across anterior pleural band 110.6% (104.7–117.4%) sagittal length; the pleurae are narrower; the axial rings are shorter; the elongate median areas of the inter-ring furrows are wider and a little shorter; the axial and overall pygidial sculpture is more coarsely granulose; the terminal piece is wider and longer; the pleural spines are slightly narrower at the tips (posterior view); and the doublure (anterior view) is shorter, more medially pointed, and more strongly anterolaterally tapered.

Ontogeny. Cranidial ontogenetic changes include effacement of the dense, coarsely granulose sculpture of the smallest specimens (e.g., Pl. 31, fig. 17) to mainly small granules lining furrows; development of fixigenal pitting; widening and shortening of the glabella; slight elongation of the eye ridges; widening and lengthening of all cranidial furrows; shortening and widening of LO; and reduction of the genal spines to small nubs.

Size ranges of hypostomes and thoracic segments are inappropriate for observation of ontogenetic changes. Librigenae are unknown.

Pygidial specimens are fairly close in size, and none are very large, but it is possible to observe some narrowing and elongation of the pygidium overall; lengthening of the inter-ring furrows, especially the median section of the first few furrows; slight widening of the axial furrows; deepening of the interpleural furrows; and development of the terminal piece impression.

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Discussion. The left half of one anterior border of one cranium (Pl. 31, fig. 6) is bent posterolaterally and partially obscures the frontal lobe of the glabella on that side. It is possible that this is taphonomic, but it may also represent a teratology or healed injury to the border or LF. The partial articulated specimen (Pl. 31, fig. 1), shows that the anteriormost thoracic segment has a single-tipped pleural spine. The spines of the disarticulated thoracic segments are not well preserved, but two (Pl. 32, figs 20, 26) appear to possess notched spines. One small pygidium (Pl. 33, fig. 24) shows the line of suture for the anteriormost segment as partially open ventrally, but undetectable dorsally. This may be an indication of the mechanism by which the pygidium develops six segments: the suture never fully separates to shed the anteriormost segment into the thorax.

Adrain *et al.* (2009, p. 561) reported the *Protopliomerella contracta* Zone from HC5 217.0T, but further investigation has revealed that *P. seegeri* occurs at this horizon, and that it represents the low *Psalikilus hestoni* Zone.

Compared to the older species *P. stegneri*, *P. seegeri* shares a mostly effaced cranium and a similar wide glabella, although it is relatively longer and more anteriorly tapered; the anterior border is narrower, and the palpebro-ocular ridges are shorter and more anteriorly located. The hypostome has shorter and much narrower anterior wings with smaller wing process pits, a more densely and extensively sculptured middle body, and longer and wider posterior and lateral borders with slightly larger spines. The pygidia are very distinct, as that of *P. seegeri* is longer and narrower, with six segments, longer and narrower pleurae, a tuberculate axis, a smaller terminal piece, and a much shorter (particularly laterally) doublure.

Protopliomerella seegeri differs from the stratigraphically closest species, *P. kerouaci*, in possessing a wider, somewhat shorter glabella with a much shorter (oblique) and less well impressed S4, palpebro-ocular ridges separated from the glabella and anterior border by a narrow section of interocular fixigena, and longer and less pitted fixigenae. The hypostome is longer and somewhat narrower, with a more tuberculate anterior lobe of the middle body. The pygidia are similar in proportion, but that of *P. seegeri* has six segments, a much smaller terminal piece without a complex indentation, is more posteriorly tapered, and has a tuberculate axis.

Protopliomerella seegeri is compared to *P. contracta* in the discussion section of that species.

***Protopliomerella okeeffae* n. sp.**

(Plates 34–40)

- 1953 *Protopliomerops* aff. *P. contracta* Ross; Hintze, p. 31, 207, pl. 22, figs 18, 20 (only; pl. 22, figs 11, 19 = *Protopliomerella bowlesi*).
? 1953 *Protopliomerops* sp.; Hintze, p. 35.
? 1953 *Protopliomerops contracta* Ross; Hintze, p. 35, 36.
1973 *Protopliomerella contracta* (Ross); Demeter, p. 59, pl. 4, figs 6, 11, 12 (only; pl. 4, fig. 2 = *Protopliomerella bowlesi*).
1973 *Pseudocybele* cf. *altinasuta* Hintze, 1953; Demeter, p. 62, pl. 4, fig. 7.
1973 *Pseudocybele* sp.; Demeter, p. 62, pl. 5, figs 1, 6, 11.
2009 *Protopliomerella* sp.; Adrain *et al.*, p. 567, fig. 14L.
2009 *Protopliomerella* sp. nov. 3; Adrain *et al.*, p. 567, fig. 15Y, CC.

Material. Holotype, cranium, SUI 126291, from Section G 258.2 m, and assigned specimens SUI 126290, 126292–126307, 126319, 126320, 126325–126336, from Section G 238.3 m and 258.2 m, Fillmore Formation (lower Floian; Tulean; *Heckethornia hyndeae* Zone), southern Confusion Range, Ibex area, Millard County, western Utah; SUI 115287, 115288, 126272–126289, 126308–126318, 126321–126324, 126337–126345, from Section H 93.4 m and H 127.1 m, Fillmore Formation (lower Floian; Tulean; *Heckethornia bowiei* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA; SUI 115263, from Section YH 128.9 m, Yellow Hill Limestone (lower Floian; Tulean; *Heckethornia hyndeae* Zone), Yellow Hill, near Pioche, Lincoln County, eastern Nevada, USA.

Etymology. After Georgia O'Keeffe.

Diagnosis. L1 smaller than L2 and L3; S3 short and shallow; axial furrows very wide and strongly laterally bowed around glabella; librigenae with relatively very narrow field and wide lateral border; terminal piece with complex W-shaped impression; pygidial pleural spines strongly ventrally directed, with small pit on posterior face marking angle.

Description. Cranium long medially, tapered laterally, narrow anteriorly, very wide posteriorly, with sagittal

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length 48.2% (43.0–53.1%) width across genal angles, highly vaulted pleurally and axially; anterior border moderately short, longer medially and slightly tapered laterally, with lateral edges truncated by palpebro-ocular ridges, narrow, gently anteriorly bowed, with posterior margin less curved than anterior margin, moderately inflated, very densely granulose; doublure present as a rim ventrally, mainly shown as anterior face of border, with narrow, shallow, semicircular median arc of rostral suture about 1/3 width of border, bottom half of anterior side of posterior wall of border exposed; anterior border furrow short, very deep, longer and deepest in apodemal pits at junctions with axial furrows, course gently anteriorly bowed medially, but with lateral branches projecting anterolaterally at about 30° above horizontal; palpebro-ocular lobes fairly short, narrow, posteriorly tapered, located opposite mid-L3–LF, steeply raised at about 50–60° (anterior view), granulose; palpebro-ocular furrows short, narrow, deep along most of course, but abruptly shallowed at anteromedial end of ridge, slightly sigmoidal in course, with inner end even with S4 on some cranidia (e.g., Pl. 34, figs 1, 2); interocular fixigenae triangular, very short, very narrow anteriorly and slightly expanded posteriorly; posterior fixigenae very long and wide, with gently anterolaterally curved anterior margin, steeply downturned post-fulcrum (occurs roughly in line with palpebro-ocular ridge; see anterior views), with dense sculpture of very fine granules and small pits, except effaced along axial and posterior border furrows; posterior border furrow moderately long, tapered adaxially and anterolaterally, deep, roughly transverse for most of course, then sharply anteriorly curved at genal angle, rimmed by tiny tubercles; posterior border very wide, short medially, expanded laterally to maximum length at genal angle, then anteriorly tapered, most of border effaced or with scattered tiny granules, but with some tiny tubercles on posterior margin, and with very short articulating tongue set off by extremely short, deep furrow on posteromedian margin (Pl. 34, fig. 19; ventral views); doublure very short proximally, with transverse furrow for articulation, lengthened toward genal angle, cut by facial suture at genal spine; axial furrows wide to very wide, somewhat lacunate in larger specimens, deep, anteriorly convergent, strongly laterally bowed around glabella, subparallel along LO, lined by granules on glabella, and inner margins of fixigenae, LO and posterior border; glabella long, narrow anteriorly and wide posteriorly, with width across L1 92.2% (80.8–103.8%) sagittal length, strongly inflated (sag., tr.), with convexity higher posteriorly, with three well-defined lateral lobes and less distinct L4, and with densely granulose sculpture, especially medially, but also on lateral lobes of some specimens; L1 ellipsoid, short, narrow, small, steeply anterolaterally directed; L2 and L3 small, subsquare, also anterolaterally directed but at lower angles, slightly larger than L1 in area; L4 more prominent in larger specimens (e.g., Pl. 34, fig. 2), small triangular, open-ended exsagittally; LF long, wide and nearly semicircular on cranidia without L4, just a short arc on cranidia with L4, has line of fine granules on anterior edge (e.g., Pl. 36, fig. 10, Pl. 37, fig. 17) hidden by anterior border in most specimens; S1 long, deep, anterolaterally directed, with posteriorly elongated inner end; L2 slightly shorter, deep, anterolaterally directed similarly to L1 at about 30° above horizontal; L3 short, moderately shallow, disconnected from axial furrows, anteromedially curved; S4 short, shallow, positioned far anterolaterally, disconnected from axial furrows, does not intersect S3; SO moderately long, deep, longer and deeper laterally in apodemal pits, lined by tubercles on posterior edge of glabella and far lateral edges of LO; LO wide, moderately long, slightly tapered laterally behind apodemal pits in SO, gently inflated, very slightly raised posteriorly (lateral view), with sculpture of small tubercles mainly on posterior edge, and with prominent median node nearly at posterior edge in small specimens (e.g., Pl. 36, figs 22, 27); doublure fairly long medially, nearly reaches SO, gently laterally tapered, semilunate.

Rostral plate unknown.

Hypostome long, narrow, widest across anterior wings, posteriorly tapered, with width across shoulders 72.1% (70.1–74.2%) sagittal length; anterior border sharply downturned (lateral view), short, laterally expanded into short, narrow, triangular anterior wings with deep, relatively large, wing process pits; anterior border furrow short, deep, incised, gently anteriorly convex; middle body long, narrow, posteriorly tapered, with lobes ill-defined by nearly effaced middle body furrow; anterior lobe ovoid, reaches to about 3/4 middle body length, strongly ventrally inflated, with inflation decreasing slightly anteriorly and posteriorly (lateral view), mostly effaced, with dense cluster of fine tubercles anteromedially; posterior lobe U-shaped, short and narrow, with anterolaterally tapered arms, moderately inflated anteriorly, nearly flat toward posterior border, effaced; lateral border furrows narrow, with alternating moderately deep and shallow segments: shallow far anteriorly along anterior wings, then deep opposite lateral notch, with shallow length near anterolateral limits of posterior lobe of middle body, then deep again from just past shoulders to junction with posterior border furrow; lateral border very narrow at lateral notch, slightly expanded at shoulders, then gradually further expanded (as middle body tapers) to maximum width at posterolateral corners, strongly downturned, with dense granulose sculpture and small nubby spines at shoulders, slightly

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larger and more conical spines at posterolateral corners, and small, spine in between; posterior border furrow very shallow, moderately short, U-shaped; posterior border short, narrow, strongly downturned (lateral view) with short median triangular spine; doublure slightly longer and wider than posterior and lateral borders, upturned, rotated anteroventrally over anterior part of very shallow lateral notch into anterior wings.

Librigena long, narrow, slightly anteroposteriorly curved (external view), strongly laterally curved (ventrolateral view); anterior branch of facial suture very short along eye and field, directed steeply ventroposteriorly to make angle of about 40° with lateral border, then somewhat longer and anteroventrally directed about 30° below horizontal along anterior projection of lateral border; posterior branch of facial suture very long, with break in slope at about half length of librigenal field, anterior slope about 35–40° below horizontal, posterior slope much shallower at about 5°; eye small, elliptical, highly inflated, raised above field on tall, narrow platform, with very shallow, narrow circumocular furrow (ventrolateral view); librigenal field very long and narrow, posteriorly tapered, with width at midpoint of eye 16.1% (12.1–19.4%) length along lateral border furrow; densely granulose, with small pits concentrated near eye and along posterior branch of facial suture; lateral border furrow narrow, deep, incised, nearly transverse to slightly ventrolaterally bowed in course; lateral border wide, sharply tapered along posterior projection to point with doublure showing, anterior projection roughly equal in length to posterior, ventrolaterally rotated, with blunt margin, border strongly inflated, densely covered in large granules; doublure moderately wide, gently anteriorly tapered near anterior edge of field, then truncated and turned anteroventrally into anterior projection.

Thorax with total number of segments unknown; segments highly arched both axially and pleurally, short, fairly wide (varies with thoracic position; posterior segments narrower), with relatively narrow axis of width 40.3% (34.0–54.2%) width across posterior pleural band; articulating half ring fairly long medially, laterally tapered, semilunate, anterodorsally raised, but not quite as high as axial ring (lateral view), anterior half of ring mostly effaced, posterior half densely granulose; articulating furrow fairly long and moderately deep medially, shorter and very deep anterolaterally in apodemal pits, broadly U-shaped in course; axial ring relatively short, slightly shorter than articulating half ring, wide, strongly inflated, slightly higher posteriorly, densely granulose, with line of small tubercles along posterior margin, small slightly elongate tubercles along sides and anterolateral corners, an elongate tubercle at each antero- and posterolateral corner (anterior and posterior view), and with arch of axial ring outlined posteriorly by slightly larger granules; axial furrows narrow and deep along axial ring, wider at meeting with pleural furrow, then narrow and very deep along articulating half ring, lined by tubercles and granules on axial ring and pleurae; inner pleurae and outer pleurae about same width on anterior segments, inner pleurae narrower on posterior segments, joined by steep fulcral angle of about 45–50°; anterior pleural band short, about half length of posterior band, as wide as posterior band excluding pleural spine, densely granulose, with extremely short articulating tongue and furrow on anterior margin, and small articulating hook structure at ventrolateral ends; pleural furrow short, deep, incised, abruptly shallowed and gently anteriorly curved near posterolateral tip; posterior pleural band about same length as axial ring, moderately inflated, highest near axis and just past fulcrum, densely finely granulose, with line of small tubercles at midlength, with larger granules and more tubercles scattered on some segments, and with large pleural spine; spine long, wide, laterally flattened, anterolaterally rotated, ventrally tapered, some spines with notch separating two pointed tips, with coarse granules along posterior edge and near spine tips.

Pygidium of five segments and terminal piece, relatively short and wide, with width across anterior pleural band of first segment 103.1% (91.2–114.1%) sagittal length from articulating furrow, strongly vaulted axially and pleurally; articulating half ring moderately long, laterally tapered, semilunate, anterior half effaced, posterior half finely granulose; articulating furrow short, deep, incised; axis moderately wide, conical and posteriorly tapered to point, strongly convexly vaulted anteriorly, convexity falling posteriorly to nearly flat terminal piece; axial rings each independently inflated, with first ring moderately well inflated, fifth ring very gently inflated, and terminal piece nearly uninflated, first ring moderately long and wide, fifth ring slightly shorter and a little less than 2/3 width of first, rings with rounded lateral margins, background sculpture finely granulose (specimens from H 93.4) to nearly effaced (specimens from G 258.2), rings rimmed by granules in furrows, and with some larger tubercles and pits in rough transverse line across midlength of ring; inter-ring furrows moderately long and deep, somewhat shallower and longer medially, with first and fifth inter-ring furrows particularly long; terminal piece triangular, fairly narrow anteriorly, long, tapered to point, with sculpture like axial rings and with complex W-shaped impression; axial furrows narrow, slightly wider at junctions with inter-ring furrows, deep anteriorly, not well impressed over fifth segment of most pygidia, unimpressed over fourth segment of some pygidia (e.g., Pl. 40, figs 5, 30, 33),

overlapped with fifth interpleural furrows along terminal piece; anterior pleural band strongly posterolaterally directed, very short, as wide as posterior pleural band excluding spine, but not well exposed in dorsal view, with extremely short articulating tongue on anterior edge and small hook-like articulating structure at ventrolateral limits; pleural furrow short, deep, incised, with slight anterior curvature near tip; posterior pleural bands very strongly backturned, subparallel to posteromedially convergent, long, wide, strongly independently inflated, somewhat laterally flattened, with inflation and flattening increasing posteroventrally into pleural spines, with granulose sculpture overlain by larger granules on margins and with some small pits running down middle of pleurae; spines fairly long, strongly posteroventrally curved, with small pit at angle (posterior view), laterally flattened, tapered to blunt points, granulose, with rim of coarser granules on ventrolateral margin (lateral view); interpleural furrows short, deep, incised, with posterior furrows shorter and shallower; pygidial border (ventral view) short and narrow, posteromedially tapered, with slight raised anterior margin near anterolateral corners, granulose; doublure moderately long in ventral view, tall medially, semilunate, strongly anterolaterally tapered in anterior view, smooth.

Ontogeny. Cranidial ontogenetic changes include relative shortening and widening of the cranidium overall (sagittal length:width across genal angles); lengthening, especially medially, and narrowing of the anterior border; narrowing of the interocular fixigenae and slight posteromedial movement of the palpebro-ocular ridges; widening of the posterior glabella (and LO) and development of the anterior taper; lengthening and deepening of the glabellar furrows, particularly S1 and S2; development of S4; widening of the axial furrows; effacement of the fixigenae bordering the axial and posterior border furrows; lengthening of SO and the posterior border furrow; shortening of the posterior fixigenae; reduction of the genal spine and median LO tubercle to nubs; and overall reduction in the coarseness of the granulose background sculpture.

Librigenae lengthen and narrow overall; the elevation of the eye increases (ventrolateral view); the anterior part of the posterior branch of the facial suture decreases in slope, and the posterior branch increases in slope; the anterior part of the field shortens (measured under the eye); the posterior part (after change in slope) widens slightly; the pits deepen; the lateral border furrow deepens; and the lateral border narrows, while the anterior and posterior projections increase in length. The two known hypostomes are too similarly sized to observe ontogenetic change, and the thoracic segments also lack the necessary range of sizes.

Pygidia are relatively close in size and less well preserved than the other sclerites. Major changes include overall lengthening relative to width; an increase in the angle of the backturned pleurae; elongation of the pleurae and inflation of the axis (lateral view); elongation and increased ventral direction of the pleural spines; and a decrease in tuberculate sculpture (cf. Pl. 40, figs 3, 30).

Discussion. The left first posterior pleural band of one pygidium (Pl. 39, fig. 15) has a furrow separating the inner pleural and outer pleural parts of the band. The fifth axial ring of one pygidium (Pl. 40, fig. 5) is split roughly in half by an excursion of the final inter-ring furrow. The posteromedian section of one pygidium (Pl. 40, fig. 1) seems to be merged and effaced.

Protopliomerella okeeffeae is compared to the most morphologically similar species, *P. contracta*, in the discussion section of the latter. It occurs with a new species of *Lemureops* McAdams and Adrain, 2009, at Section H 127.1 m. The taxa are somewhat morphologically similar, and both are relatively poorly preserved at this horizon. However, the species of *Lemureops* possesses a very wide, lacunate axial furrow which easily distinguishes it from *P. okeeffeae*, as well as a shorter and relatively wider hypostome with nubby spines, and a strongly posteriorly tapered pygidium.

Protopliomerella n. sp. A

(Plate 41, Plate 42, figs 1–13)

Material. Assigned specimens SUI 126346–126359, from Section YH 129.5 m, Yellow Hill Limestone (lower Floian; Tulean; *Heckethornia hyndaeae* Zone), Yellow Hill, near Pioche, Lincoln County, eastern Nevada.

Discussion. Specimens of *Protopliomerella* n. sp. A differ from those of *P. okeeffeae* in possessing more coarsely granulose cranidial sculpture, and more tuberculate dorsal thoracic and pygidial sculpture. Cranidia have a less anteriorly tapered glabella with a more faintly impressed S3, the interocular fixigenae are longer, and pygidia are slightly narrower and more elongate, with a narrower and more elongate terminal piece and longer, more strongly posteriorly directed pleurae. The librigena (Pl. 42, fig. 4) is not well preserved, but it shows coarser lateral

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border sculpture, and a possibly wider posterior section of the librigenal field. The species are otherwise very similar, but the sculptural difference between specimens of similar sizes is striking. *Protopliomerella okeeffeae* is known from a single cranium (Adrain *et al.*, 2009, fig. 14L) at Section YH 128.9 m, at which *Protopliomerella* n. sp. A does not occur.

***Protopliomerella* n. sp. B**

(Plate 42, figs 14–25)

1973 Genus and species undetermined (not described); Demeter, pl. 6, figs 10, 12 (only; pl. 6, figs 1–9, 11 = gen. and sp. indet.).

Material. Assigned specimens SUI 126360–126364, from Section D 94.4T m, Fillmore Formation (lower Floian; Tulean; low *Psalikilopsis cuspidicauda* Zone), southern House Range, Tule Valley, Millard County, western Utah, USA.

Discussion. *Protopliomerella* n. sp. B is known from only a few sclerites (two librigenae and three pygidia), but the unique pygidial morphology of seven segments demonstrates that it is a new species. The pygidium is somewhat similar to that of *P. bowlesi*, but in addition to possessing another segment, it is longer and wider overall; the axis is relatively wider anteriorly and narrower posteriorly; the pleurae are more laterally directed, not as tightly backturned, and less strongly vaulted; the inter-ring furrows are shorter; and the sculpture is slightly less effaced, with small tubercles or granules particularly noticeable running along the adaxial side of the pleurae just outside the interpleural furrows. Librigenae differ in that those of *P. bowlesi* are more strongly curved; much wider, particularly across the anterior part of the field; and possess a relatively narrower lateral border, with a shorter posterior projection and longer anterior projection.

The librigena of the younger species *P. kerouaci* more closely resembles that of *Protopliomerella* n. sp. B, but its librigenal field is somewhat wider anteriorly and narrower posteriorly, and it has a slightly narrower lateral border with a much longer and strongly posterodorsally directed posterior projection. The pygidia are not closely similar, as that of *P. kerouaci* has only five segments, and a large, complexly impressed terminal piece. The pygidium of the younger species *P. seegeri* somewhat more closely resembles that of *Protopliomerella* n. sp. B (in that it also resembles that of *P. bowlesi*), but again, it possesses only six segments, with strongly backturned and highly vaulted pleurae, and its axis is fairly densely covered in small tubercles.

Demeter (1973, pl. 6, figs 10, 12) figured two seven-segmented pygidia likely assignable to *Protopliomerella* n. sp. B from Section G at about 150.1 m. We have collected horizons G 148.2, 151T and 151.5T, but have not recovered any material assignable to this species.

Acknowledgements

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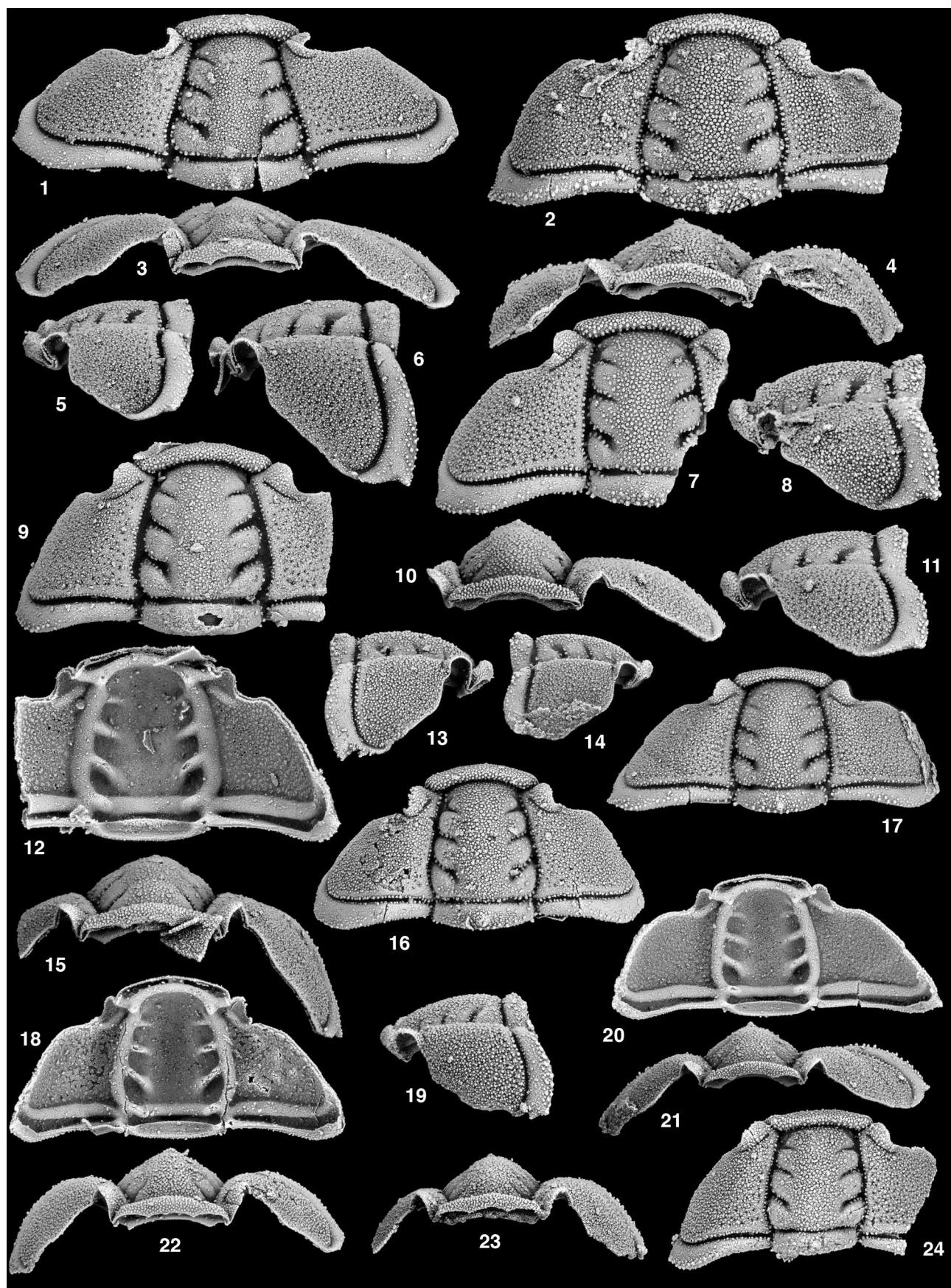


PLATE 1.

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PLATE 1. *Protopliomerella contracta* Ross, 1951, from Section HC6 221.5 m, Garden City Formation (lower Floian; Tulean; *Protopliomerella contracta* Zone), west side of Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho, USA. All magnifications are x12.

- 1, 3, 5. Cranidium, SUI 125997, dorsal, anterior, and left lateral views.
- 2, 4, 8. Cranidium, SUI 125998, dorsal, anterior, and left lateral views.
- 6, 9, 12, 15. Cranidium, SUI 125999, left lateral, dorsal, ventral, and anterior views.
- 7, 10, 11. Cranidium, SUI 126000, dorsal, anterior, and left lateral views.
- 13, 16, 18, 22. Cranidium, SUI 126001, right lateral, dorsal, ventral, and anterior views.
- 14, 17, 20, 21. Cranidium, SUI 126002, right lateral, dorsal, ventral, and anterior views.
- 19, 23, 24. Cranidium, SUI 126003, left lateral, anterior, and dorsal views.

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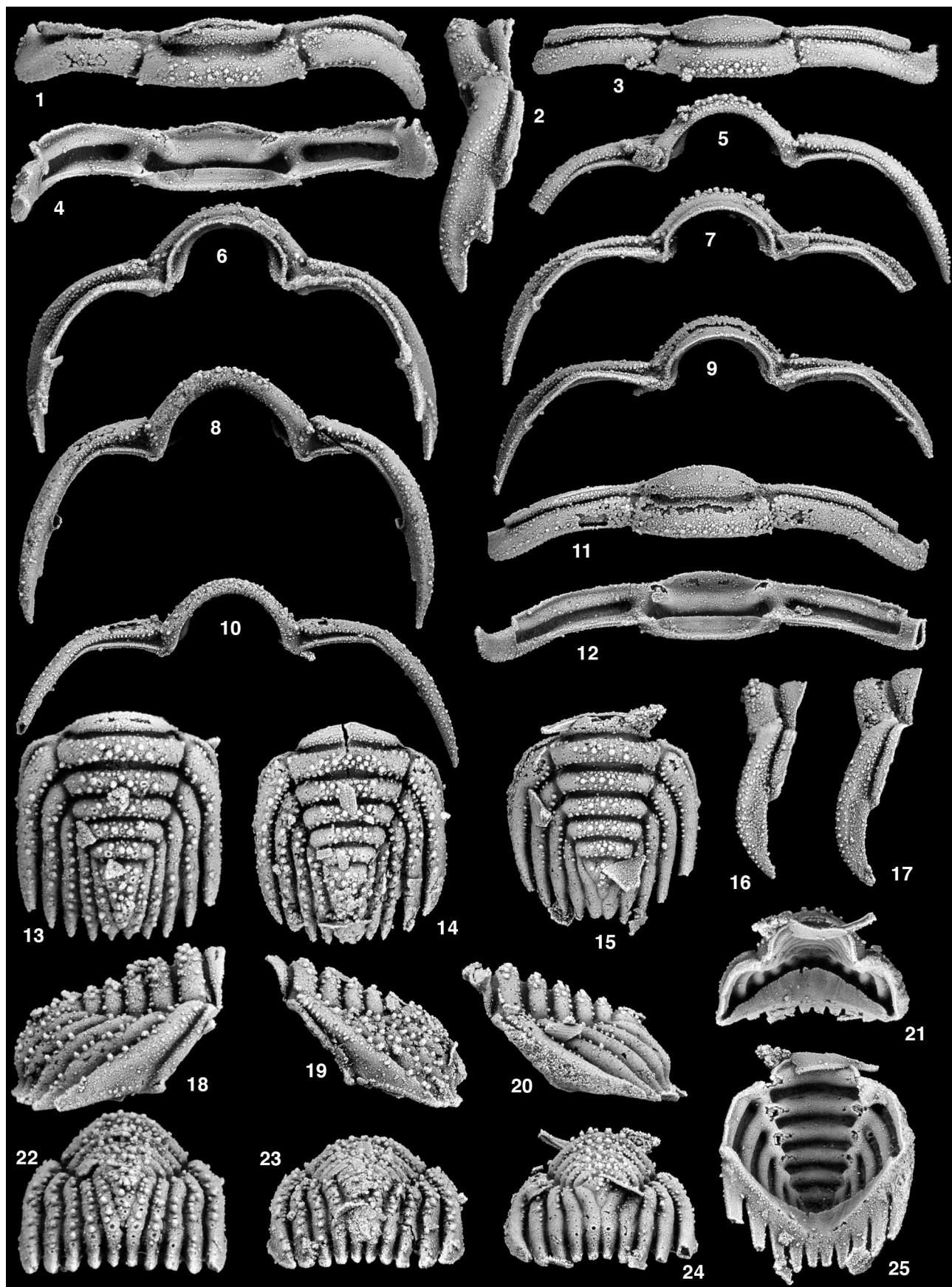


PLATE 2.

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PLATE 2. *Protopliomerella contracta* Ross, 1951, from Section HC6 221.5 m, Garden City Formation (lower Floian; Tulean; *Protopliomerella contracta* Zone), west side of Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho, USA.

- 1, 2, 4, 6, 8. Thoracic segment, SUI 126004, dorsal, right lateral, ventral, anterior, and posterior views, x15.
- 3, 5, 7, 16. Thoracic segment, SUI 126005, dorsal, posterior, anterior, and right lateral views, x15.
- 9–12, 17. Thoracic segment, SUI 126006, anterior, posterior, dorsal, ventral, and right lateral views, x12.
- 13, 18, 22. Pygidium, SUI 126007, dorsal, right lateral, and posterior views, x20.
- 14, 19, 23. Pygidium, SUI 115229, dorsal, left lateral, and posterior views, x15.
- 15, 20, 21, 24, 25. Pygidium, SUI 126008, dorsal, left lateral, anterior, posterior, and ventral views, x15.

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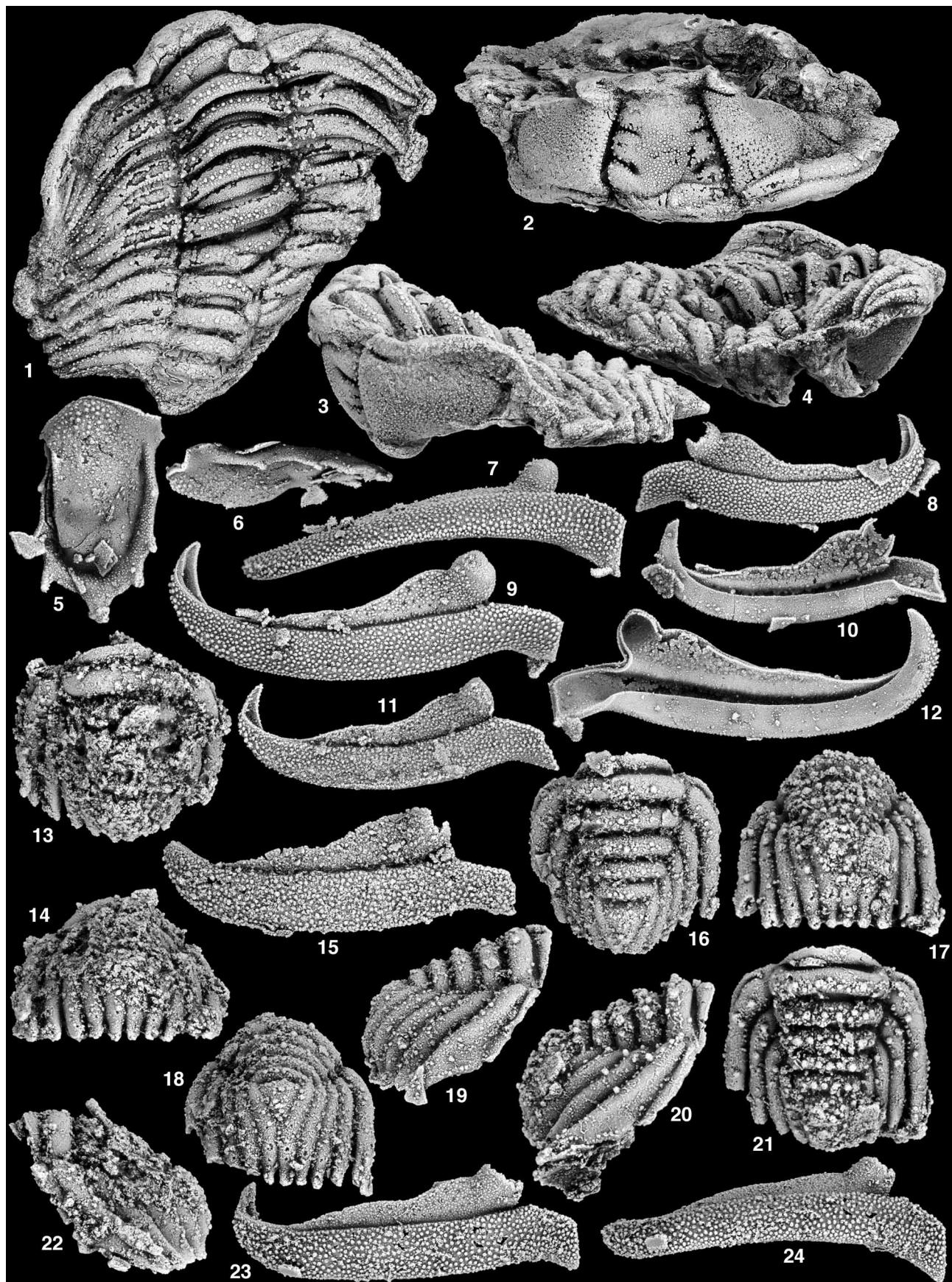


PLATE 3.

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◀ **PLATE 3.** 1–12. *Protopliomerella contracta* Ross, 1951, from Section HC6 221.5 m, Garden City Formation (lower Floian; Tulean; *Protopliomerella contracta* Zone), west side of Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho, USA.

1–4. Partial dorsal exoskeleton, SUI 126009, dorsal thoracic, dorsal cephalic, left lateral, and right lateral views, x10.

5, 6. Hypostome, SUI 126010, ventral and left lateral views, x15.

7, 9, 12. Right librigena, SUI 126011, ventrolateral, external, and internal views, x15.

8, 10. Left librigena, SUI 126012, external and internal views, x15.

11. Right librigena, SUI 126013, external view, x15.

13–24. *Protopliomerella contracta* Ross, 1951, from Section G 230.1 m, Fillmore Formation (Tulean; *Protopliomerella contracta* Zone), southern Confusion Range, Ibex area, Millard County, western Utah.

13, 14, 22. Pygidium, SUI 126014, dorsal, posterior, and left lateral views, x15.

15. Right librigena, SUI 126015, external view, x15.

16, 18, 19. Pygidium, SUI 126016, dorsal, posterior, and right lateral views, x15.

17, 20, 21. Pygidium, SUI 126017, posterior, right lateral, and dorsal views, x20.

23, 24. Right librigena, SUI 126018, external and ventrolateral views, x15.

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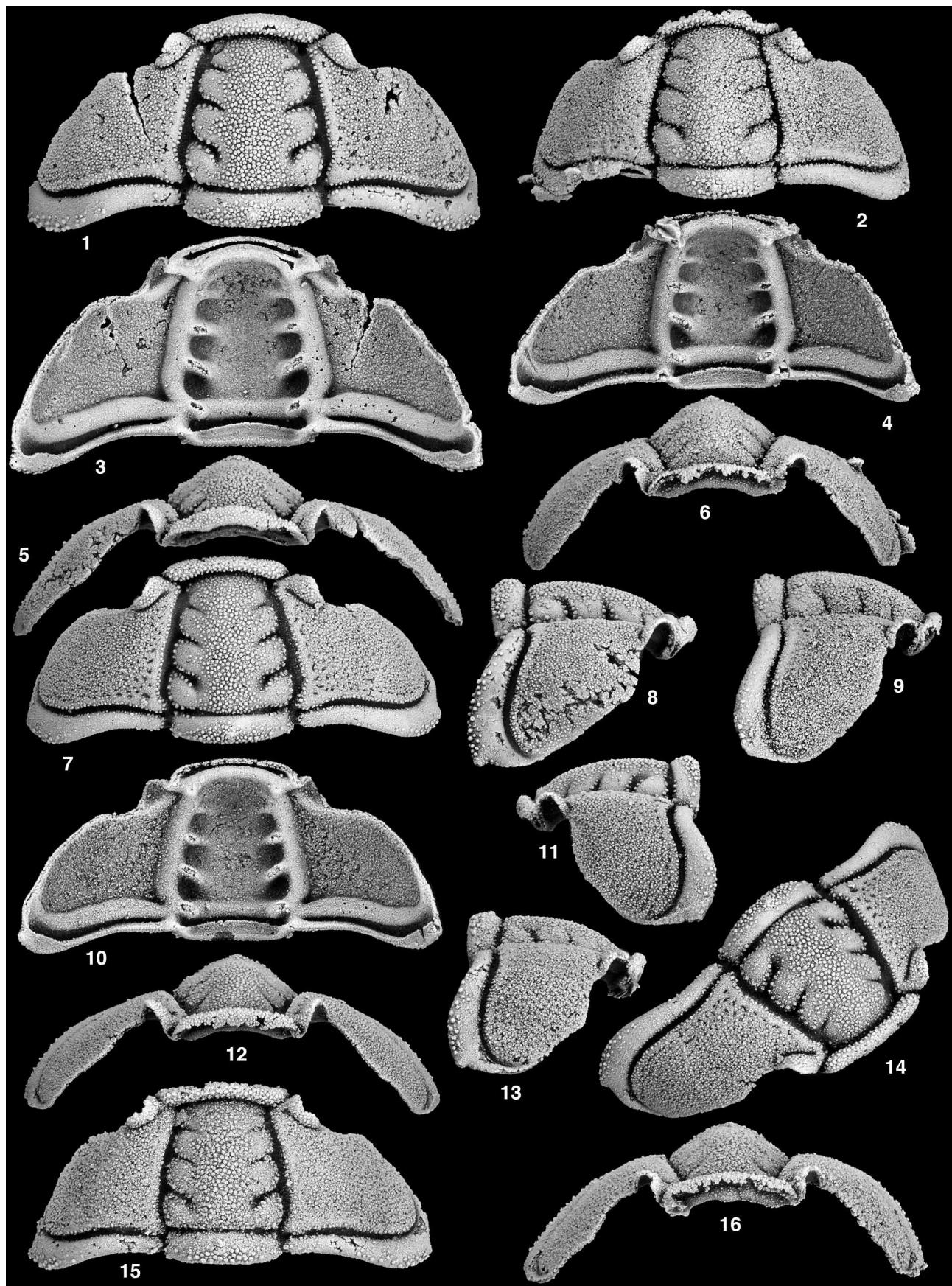


PLATE 4.

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◀—————
PLATE 4. *Protopliomerella contracta* Ross, 1951, from Section G 210.2 m, Fillmore Formation (lower Floian; Tulean; *Protopliomerella contracta* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA. All magnifications are x10.

- 1, 3, 5, 8. Cranium, SUI 126019, dorsal, ventral, anterior, and right lateral views.
- 2, 4, 6, 9. Cranium, SUI 126020, dorsal, ventral, anterior, and right lateral views.
- 7, 10–12, 14. Cranium, SUI 115228, dorsal, ventral, left lateral, anterior, and oblique views.
- 13, 15, 16. Cranium, SUI 126021, right lateral, dorsal, and anterior views.

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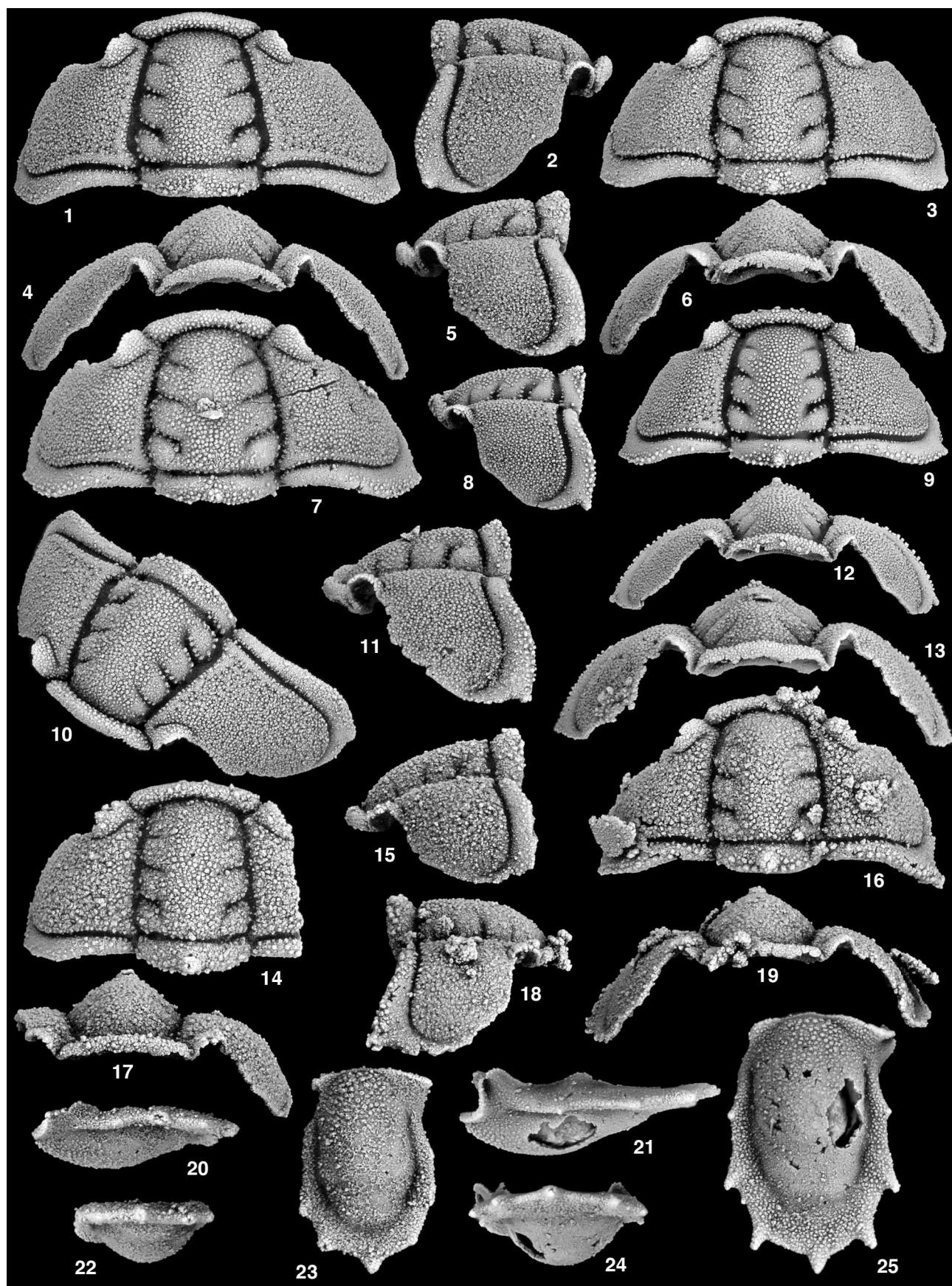


PLATE 5.

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PLATE 5. *Protopliomerella contracta* Ross, 1951, from Section G 210.2 m, Fillmore Formation (lower Floian; Tulean; *Protopliomerella contracta* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 2, 4, 10. Cranidium, SUI 126022, dorsal, right lateral, anterior, and oblique views, x12.
- 3, 5, 6. Cranidium, SUI 126023, dorsal, left lateral, and anterior views, x12.
- 7, 11, 13. Cranidium, SUI 126024, dorsal, left lateral, and anterior views, x15.
- 8, 9, 12. Cranidium, SUI 126025, left lateral, dorsal, and anterior views, x12.
- 14, 15, 17. Cranidium, SUI 126026, dorsal, left lateral, and anterior views, x20.
- 16, 18, 19. Cranidium, SUI 126027, dorsal, right lateral, and anterior views, x20.
- 20, 22, 23. Hypostome, SUI 126028, left lateral, posterior, and ventral views, x20.
- 21, 24, 25. Hypostome, SUI 126029, left lateral, posterior, and ventral views, x20.

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PLATE 6.

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PLATE 6. *Protopliomerella contracta* Ross, 1951, from Section G 210.2 m, Fillmore Formation (lower Floian; Tulean; *Protopliomerella contracta* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

1, 3, 5. Right librigena, SUI 126030, external, ventrolateral, and internal views, x12.

2, 4. Left librigena, SUI 126031, external and ventrolateral views, x20.

6, 7. Left librigena, SUI 126032, internal and external views, x15.

8, 9, 13. Hypostome, SUI 126033, ventral, posterior, and left lateral views, x15.

10, 11, 14, 17. Hypostome, SUI 126034, ventral, dorsal, left lateral, and posterior views, x20.

12, 15, 18. Hypostome, SUI 126035, ventral, posterior, and left lateral views, x20.

16, 19, 20. Hypostome, SUI 126036, ventral, posterior, and right lateral views, x20.

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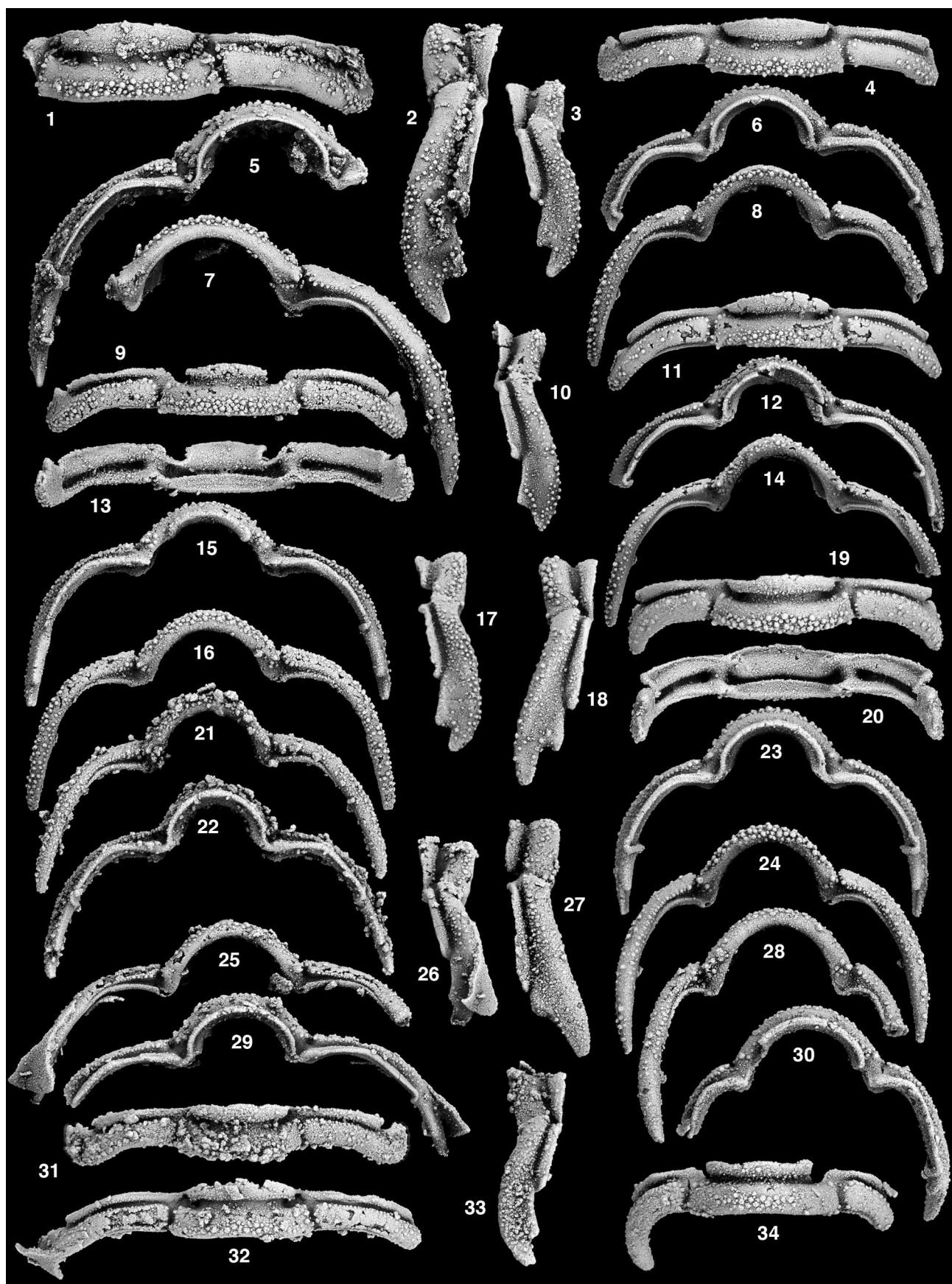


PLATE 7.

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PLATE 7. *Protopliomerella contracta* Ross, 1951, from Section G 210.2 m, Fillmore Formation (lower Floian; Tulean; *Protopliomerella contracta* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 2, 5, 7. Thoracic segment, SUI 126037, dorsal, right lateral, anterior, and posterior views, x10.
- 3, 4, 6, 8. Thoracic segment, SUI 126038, left lateral, dorsal, anterior, and posterior views, x10.
- 9, 13, 15–17. Thoracic segment, SUI 126039, dorsal, ventral, anterior, posterior, and left lateral views, x10.
- 10–12, 14. Thoracic segment, SUI 126040, left lateral, dorsal, anterior, and posterior views, x10.
- 18–20, 23, 24. Thoracic segment, SUI 126041, right lateral, dorsal, ventral, anterior, and posterior views, x12.
- 21, 22, 31, 33. Thoracic segment, SUI 126042, posterior, anterior, dorsal, and right lateral views, x12.
- 25, 26, 29, 32. Thoracic segment, SUI 126043, posterior, left lateral, anterior, and dorsal views, x10.
- 27, 28, 30, 34. Thoracic segment, SUI 126044, left lateral, posterior, anterior, and dorsal views, x12.

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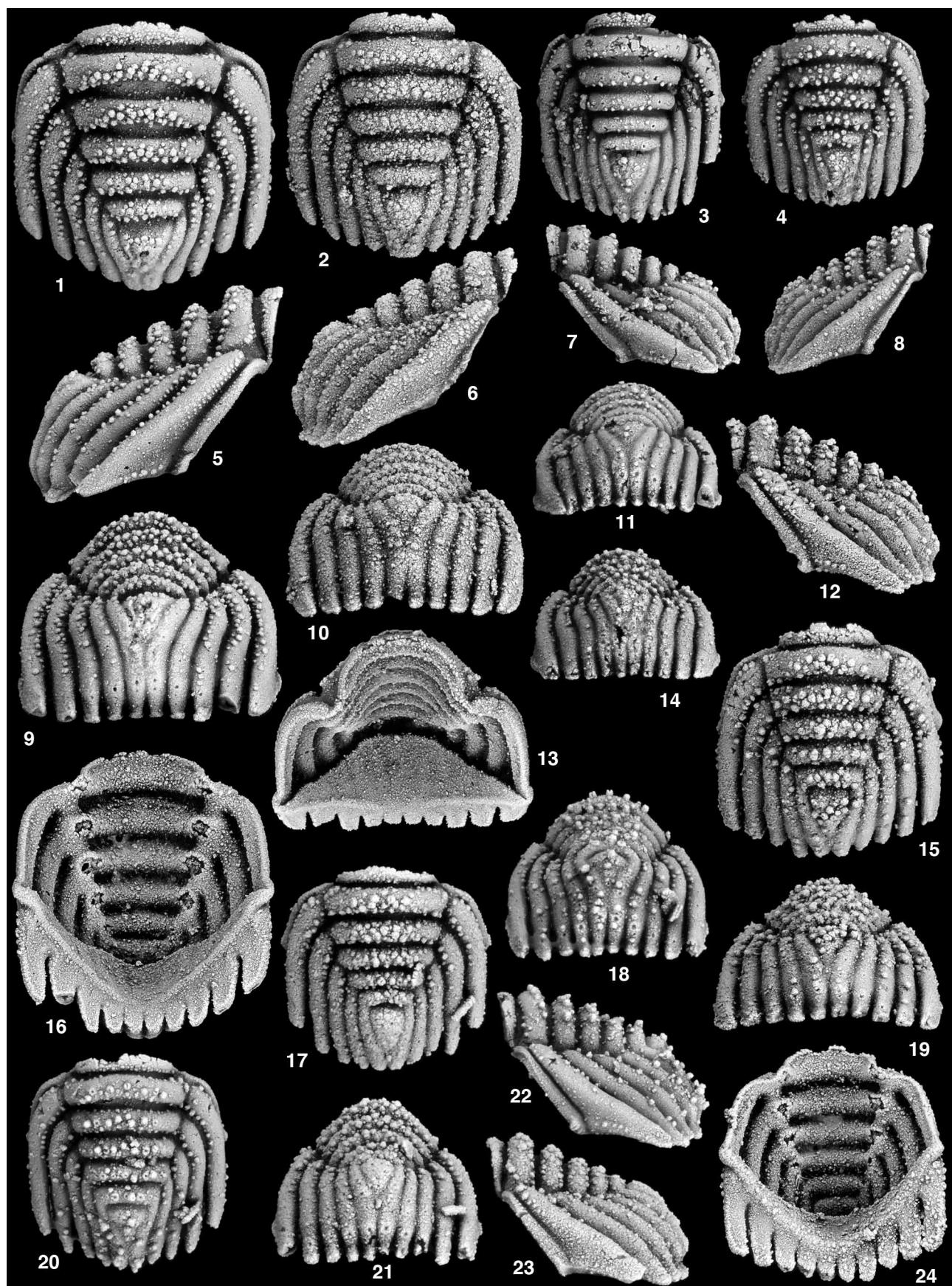


PLATE 8.

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PLATE 8. *Protopliomerella contracta* Ross, 1951, from Section G 210.2 m, Fillmore Formation (lower Floian; Tulean; *Protopliomerella contracta* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 5, 9, 13, 16. Pygidium, SUI 126045, dorsal, right lateral, posterior, anterior, and ventral views, x15.
- 2, 6, 10. Pygidium, SUI 126046, dorsal, right lateral, and posterior views, x15.
- 3, 7, 11. Pygidium, SUI 126047, dorsal, left lateral, and posterior views, x15.
- 4, 8, 14. Pygidium, SUI 126048, dorsal, right lateral, and posterior views, x15.
- 12, 15, 19, 24. Pygidium, SUI 126049, left lateral, dorsal, posterior, and ventral views, x15.
- 17, 21, 23. Pygidium, SUI 126050, dorsal, posterior, and left lateral views, x20.
- 18, 20, 22. Pygidium, SUI 126051, posterior, dorsal, and left lateral views, x20.

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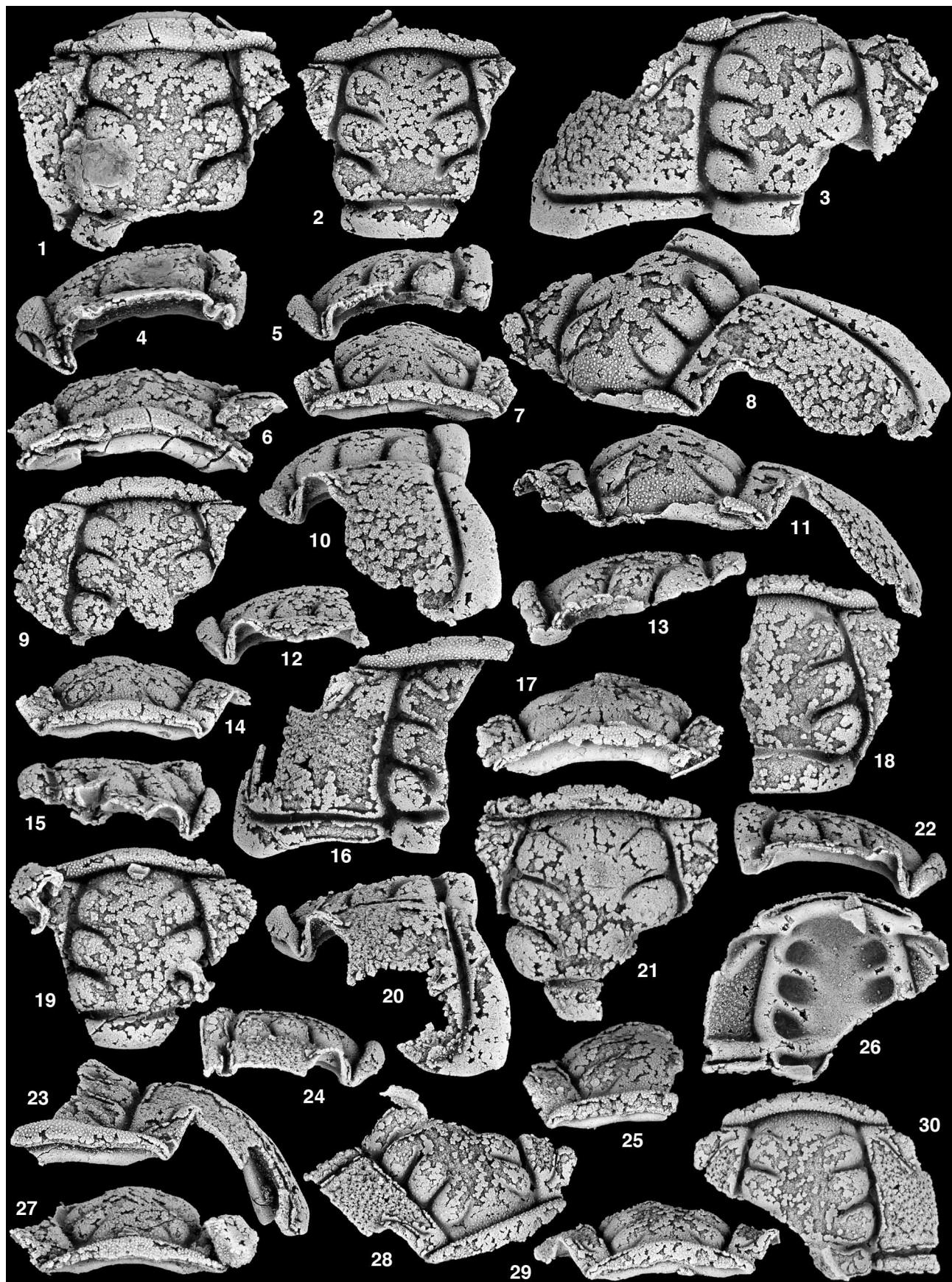


PLATE 9.

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◀

PLATE 9. *Protopliomerella stegneri* n. sp., from Section G 138–144.5T m, Fillmore Formation (lower Floian; Tulean; unzoned strata beneath *Psalikilopsis cuspidicauda* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 4, 6. Cranidium, SUI 126052, dorsal, left lateral, and anterior views, x7.5 (G 138–139T m).
- 2, 5, 7. Cranidium, SUI 126053, dorsal, left lateral, and anterior views, x7.5 (G 138–139T m).
- 3, 8, 10, 11. Cranidium, **holotype**, SUI 126054, dorsal, oblique, left lateral, and anterior views, x10 (G 138–139T m).
- 9, 12, 14. Cranidium, SUI 126055, dorsal, left lateral, and anterior views, x7.5 (G 138–139T m).
- 13, 17, 21. Cranidium, SUI 126056, left lateral, anterior, and dorsal views, x7.5 (G 142–144.5T m).
- 15, 19, 27. Cranidium, SUI 126057, right lateral, dorsal, and anterior views, x10 (G 138–139T m).
- 16, 20, 23. Cranidium, SUI 126058, dorsal, left lateral, and anterior views, x7.5 (G 138–139T m).
- 18, 22, 25. Cranidium, SUI 126059, dorsal, right lateral, and anterior views, x7.5 (G 142–144.5T m).
- 24, 26, 28–30. Cranidium, SUI 126060, right lateral, ventral, oblique, anterior, and dorsal views, x7.5 (G 142–144.5T m).

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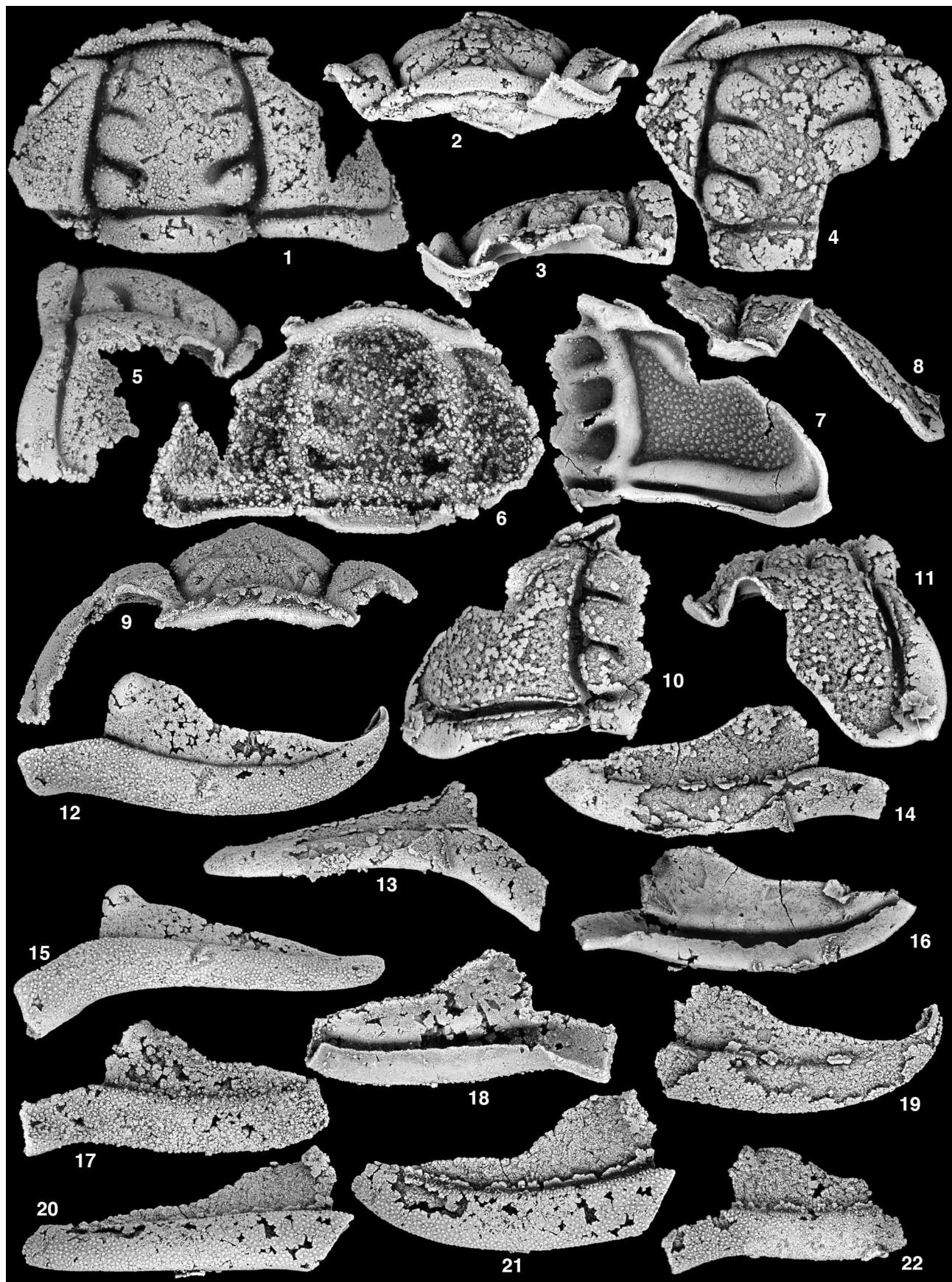


PLATE 10.

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PLATE 10. *Protopliomerella stegneri* n. sp., from Section G 138–144.5T m, Fillmore Formation (lower Floian; Tulean; unzoned strata beneath *Psalikilopsis cuspidicauda* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 5, 6, 9. Cranium, SUI 126061, dorsal, right lateral, ventral, and anterior views, x15 (G 142–144.5T m).
- 2–4. Cranium, SUI 126062, anterior, left lateral, and dorsal views, x10 (G 142–144.5T m).
- 7, 8, 10, 11. Cranium, SUI 126063, ventral, anterior, dorsal, and left lateral views, x7.5 (G 142–144.5T m).
- 12, 15. Left librigena, SUI 126064, external and ventrolateral views, x10 (G 138–139T m).
- 13, 14, 16. Right librigena, SUI 126065, ventrolateral, external, and internal views, x7.5 (G 142–144.5T m).
- 17, 18. Left librigena, SUI 126066, external and internal views, x12 (G 142–144.5T m).
19. Left librigena, SUI 126067, external view, x10 (G 138–139T m).
- 20, 21. Right librigena, SUI 126068, ventrolateral and external views, x10 (G 138–139T m).
22. Left librigena, SUI 126069, external view, x7.5 (G 142–144.5T m).

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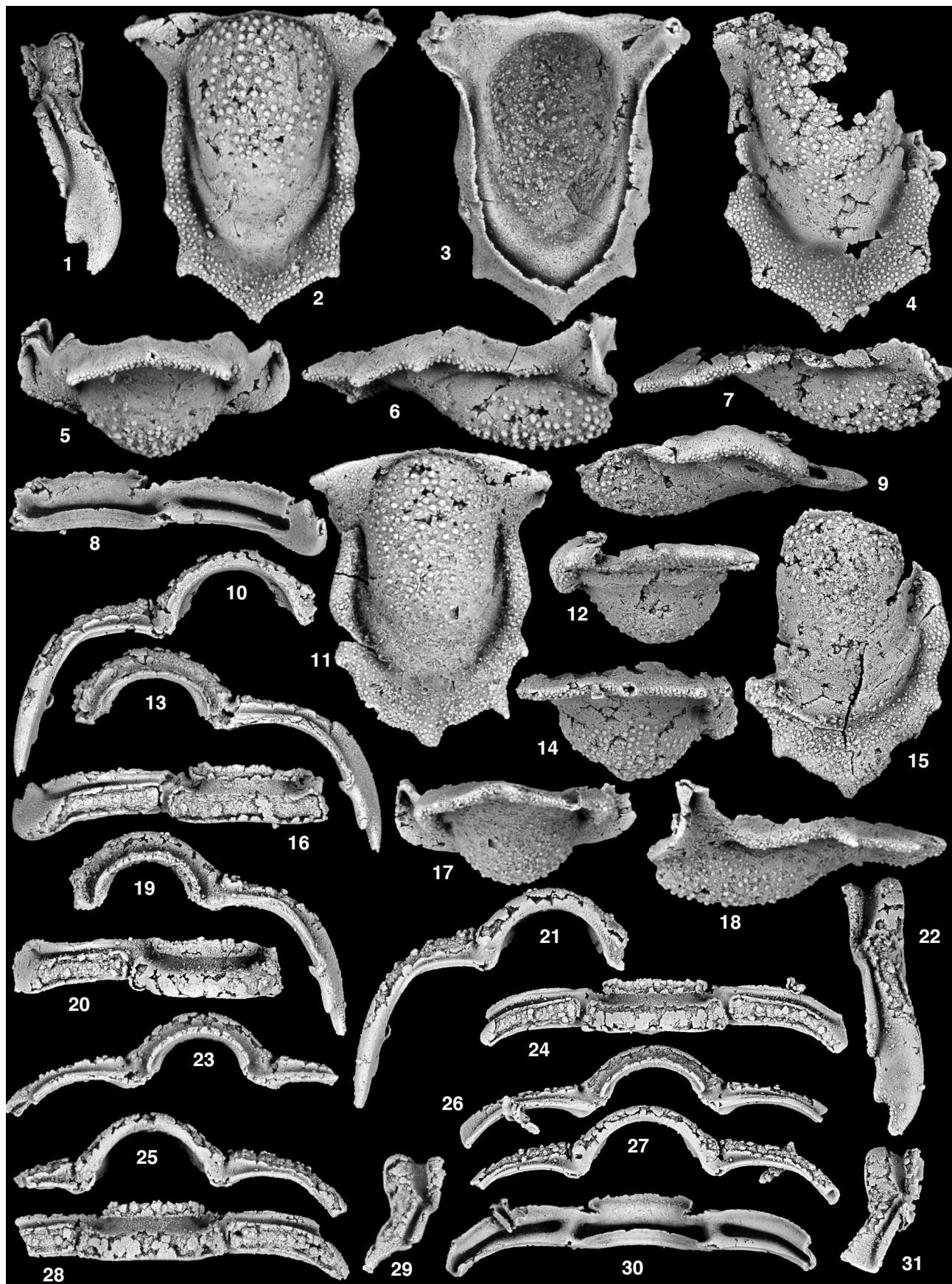


PLATE 11.

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PLATE 11. *Protopliomerella stegneri* n. sp., from Section G 138–144.5T m, Fillmore Formation (Tulean; unzoned strata beneath *Psalikilopsis cuspidicauda* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 8, 10, 13, 16. Thoracic segment, SUI 126070, left lateral, ventral, posterior, anterior, and dorsal views, x10 (G 142–144.5T m).
2, 3, 5, 6. Hypostome, SUI 126071, ventral, dorsal, posterior, and right lateral views, x15 (G 142–144.5T m).
4, 7, 14. Hypostome, SUI 126072, ventral, right lateral, and posterior views, x15 (G 142–144.5T m).
9, 12, 15. Hypostome, SUI 126073, left lateral, posterior, and ventral views, x15 (G 142–144.5T m).
11, 17, 18. Hypostome, SUI 126074, ventral, posterior, and left lateral views, x15 (G 138–139T m).
19–22. Thoracic segment, SUI 126075, anterior, dorsal, posterior, and left lateral views, x10 (G 142–144.5T m).
23, 25, 28, 29. Thoracic segment, SUI 126076, anterior, posterior, dorsal, and right lateral views, x12 (G 142–144.5T m).
24, 26, 27, 30, 31. Thoracic segment, SUI 126077, dorsal, anterior, posterior, ventral, and right lateral views, x7.5 (G 142–144.5T m).

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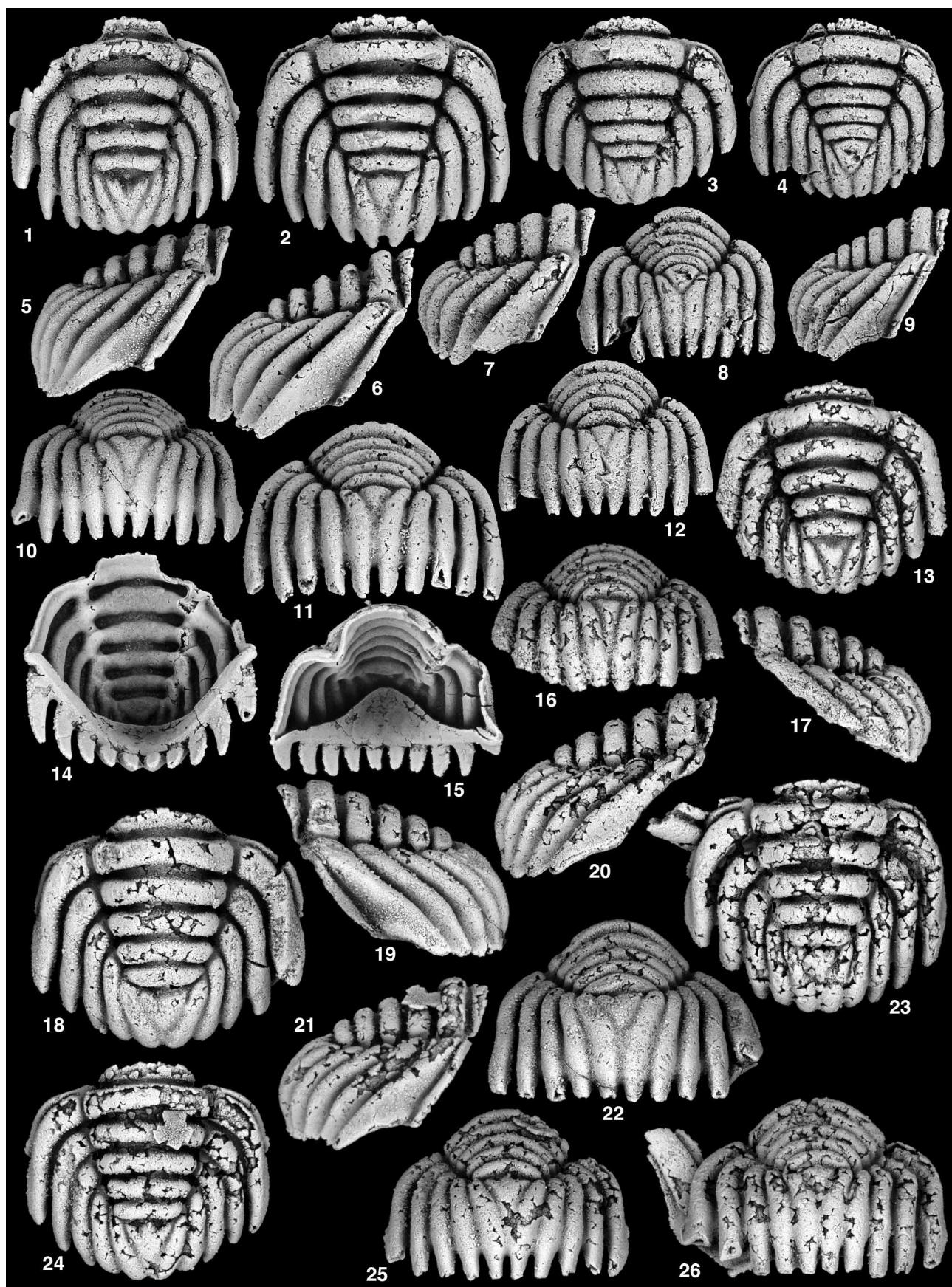


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PLATE 12. *Protopliomerella stegneri* n. sp., from Section G 138–144.5T m, Fillmore Formation (lower Floian; Tulean; unzoned strata beneath *Psalikilopsis cuspidicauda* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 5, 10, 14, 15. Pygidium, SUI 126078, dorsal, right lateral, posterior, ventral, and anterior views, x7.5 (G 142–144.5T m).
- 2, 6, 11. Pygidium, SUI 126079, dorsal, right lateral, and posterior views, x10 (G 138–139T m).
- 3, 7, 12. Pygidium, SUI 126080, dorsal, right lateral, and posterior views, x12 (G 138–139T m).
- 4, 8, 9. Pygidium, SUI 126081, dorsal, posterior, and right lateral views, x12 (G 138–139T m).
- 13, 16, 17. Pygidium, SUI 126082, dorsal, posterior, and left lateral views, x10 (G 142–144.5T m).
- 18, 19, 22. Pygidium, SUI 126083, dorsal, left lateral, and posterior views, x10 (G 142–144.5T m).
- 20, 23, 26. Pygidium, SUI 126084, right lateral, dorsal, and posterior views, x10 (G 142–144.5T m).
- 21, 24, 25. Pygidium, SUI 126085, right lateral, dorsal, and posterior views, x10 (G 142–144.5T m).

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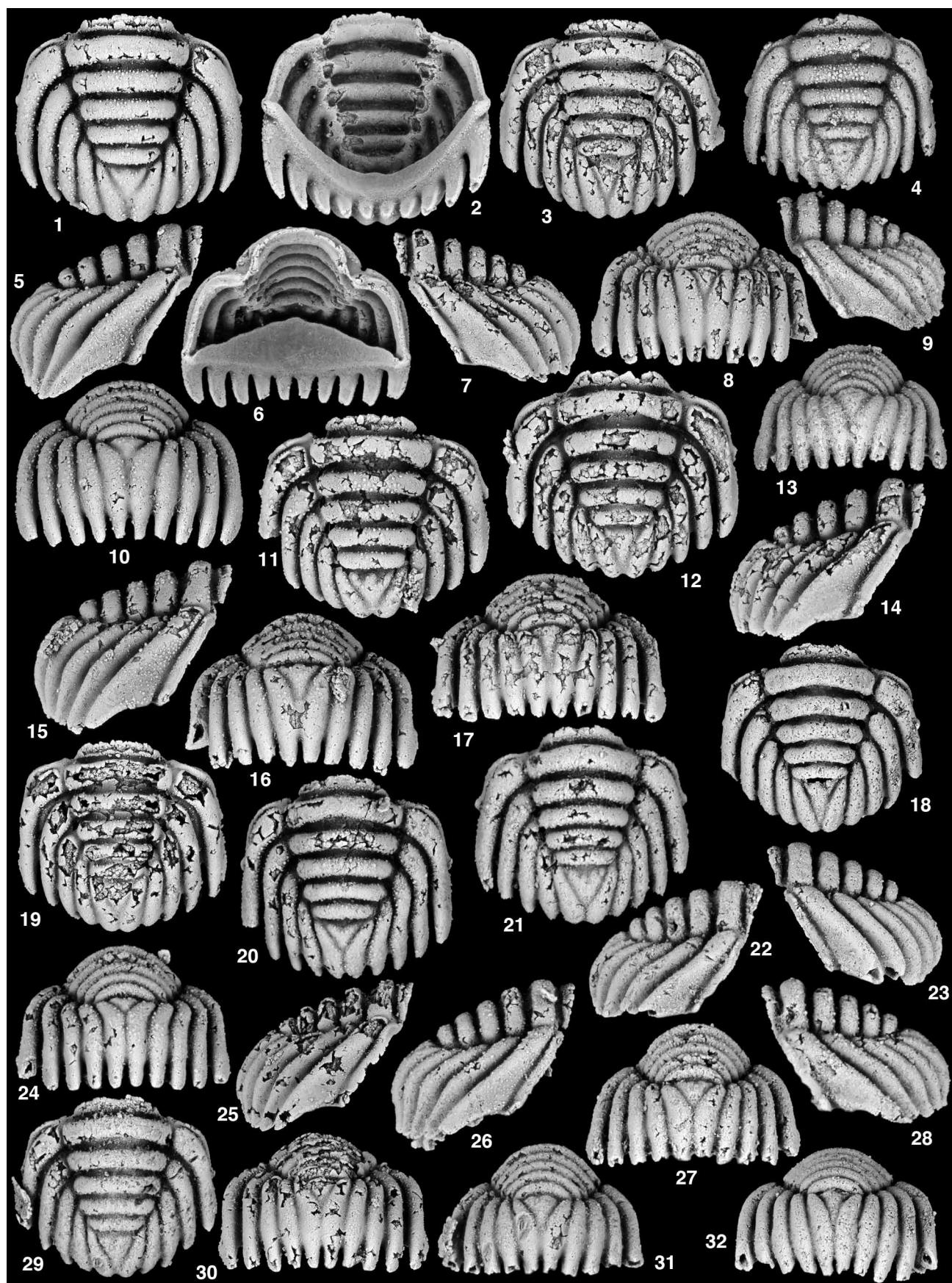


PLATE 13.

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PLATE 13. *Protopliomerella stegneri* n. sp., from Section G 142–144.5T m, Fillmore Formation (lower Floian; Tulean; unzoned strata beneath *Psalikilopsis cuspidicauda* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

1, 2, 5, 6, 10. Pygidium, SUI 126086, dorsal, ventral, right lateral, anterior, and posterior views, x10.

3, 7, 8. Pygidium, SUI 126087, dorsal, left lateral, and posterior views, x10.

4, 9, 13. Pygidium, SUI 126088, dorsal, left lateral, and posterior views, x15.

11, 15, 16. Pygidium, SUI 126089, dorsal, right lateral, and posterior views, x10.

12, 14, 17. Pygidium, SUI 126090, dorsal, right lateral, and posterior views, x10.

18, 23, 32. Pygidium, SUI 126091, dorsal, left lateral, and posterior views, x10.

19, 25, 30. Pygidium, SUI 126092, dorsal, right lateral, and posterior views, x10.

20, 24, 26. Pygidium, SUI 126093, dorsal, posterior, and right lateral views, x12.

21, 27, 28. Pygidium, SUI 126094, dorsal, posterior, and left lateral views, x15.

22, 29, 31. Pygidium, SUI 126095, right lateral, dorsal, and posterior views, x12.

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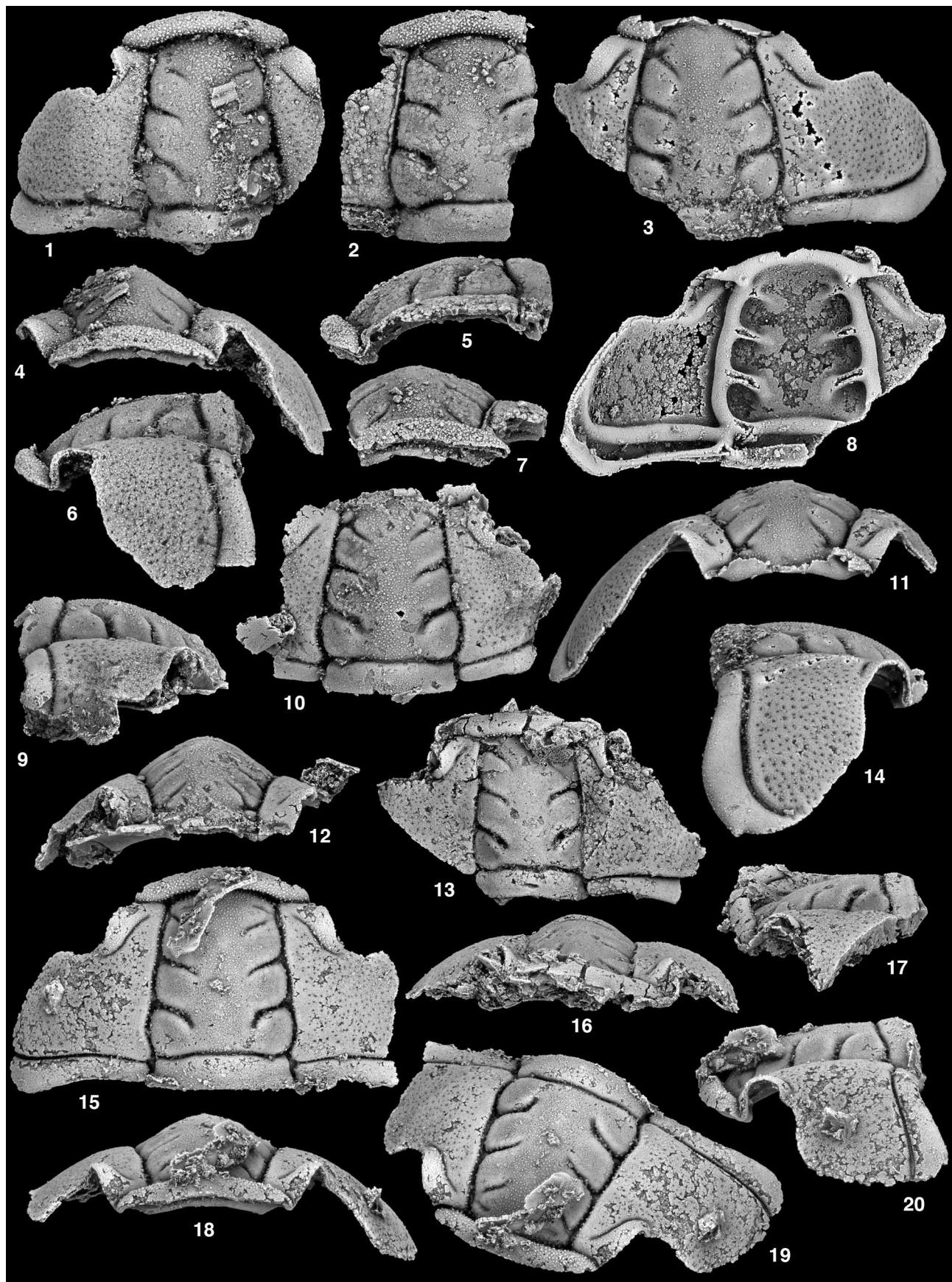


PLATE 14.

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◀ **PLATE 14.** *Protopliomerella bowlesi* **n. sp.**, from Section G 162T m, Fillmore Formation (lower Floian; Tulean; low *Psalikilopspis cuspidicauda* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 4, 6. Cranidium, SUI 126096, dorsal, anterior, and left lateral views, x12.
- 2, 5, 7. Cranidium, SUI 126097, dorsal, left lateral, and anterior views, x10.
- 3, 8, 11, 14. Cranidium, SUI 126098, dorsal, ventral, anterior, and right lateral views, x10.
- 9, 10, 12. Cranidium, SUI 126099, right lateral, dorsal, and anterior views, x10.
- 13, 16, 17. Cranidium, SUI 126100, dorsal, anterior, and left lateral views, x6.
- 15, 18–20. Cranidium, **holotype**, SUI 115195, dorsal, anterior, oblique, and left lateral views, x10.

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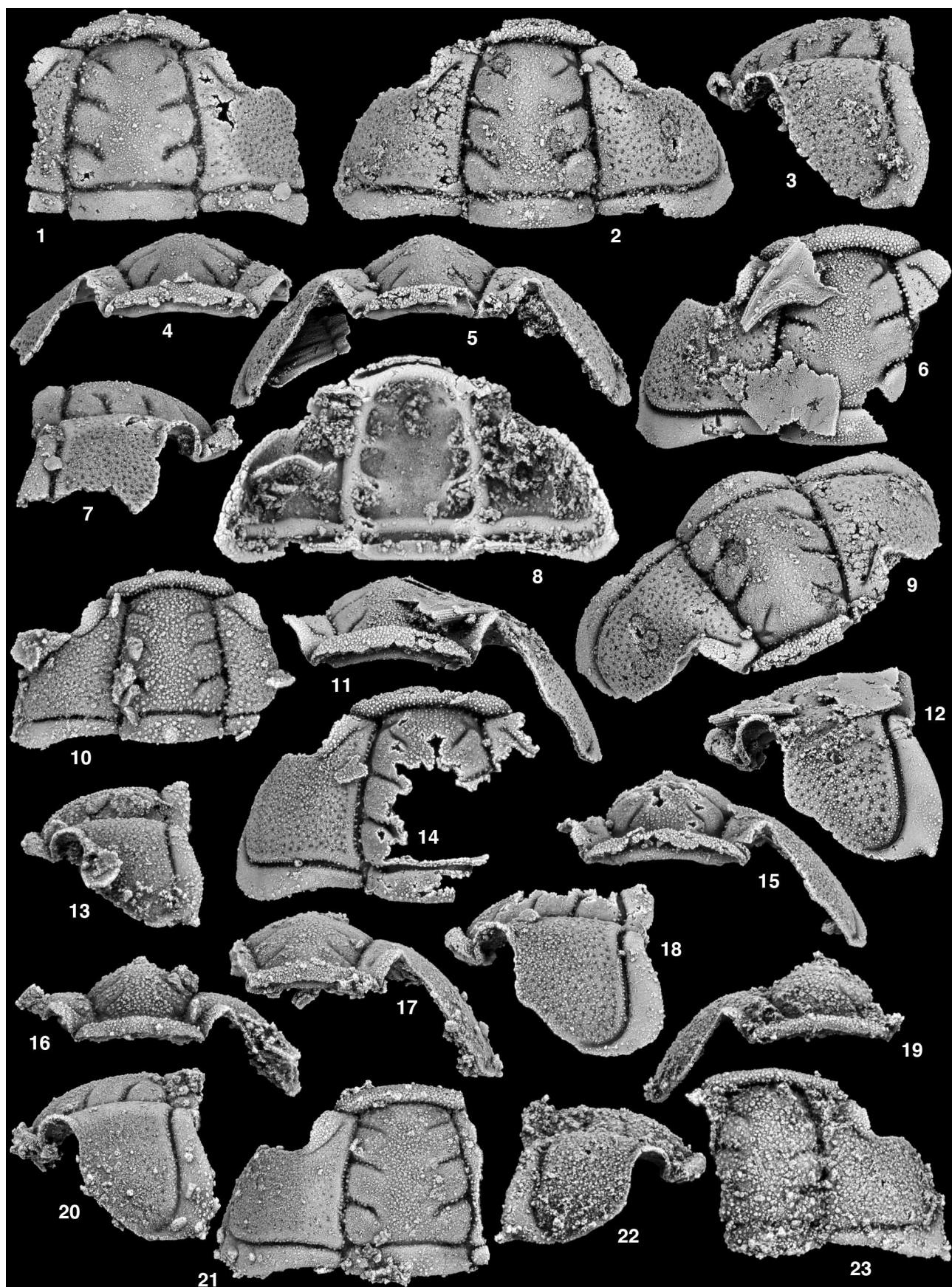


PLATE 15.

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PLATE 15. *Protopliomerella bowlesi* **n. sp.**, from Section G 162T m, Fillmore Formation (lower Floian; Tulean; low *Psalikilopspis cuspidicauda* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 4, 7. Cranidium, SUI 126101, dorsal, anterior, and right lateral views, x10.
- 2, 3, 5, 8, 9. Cranidium, SUI 126102, dorsal, left lateral, anterior, ventral, and oblique views, x12.
- 6, 11, 12. Cranidium, SUI 126103, dorsal, anterior, and left lateral views, x12.
- 10, 13, 16. Cranidium, SUI 126104, dorsal, left lateral, and anterior views, x15.
- 14, 15, 18. Cranidium, SUI 126105, dorsal, anterior, and left lateral views, x15.
- 17, 20, 21. Cranidium, SUI 126106, anterior, left lateral, and dorsal views, x12.
- 19, 22, 23. Cranidium, SUI 126107, anterior, right lateral, and dorsal views, x20.

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PLATE 16.

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PLATE 16. *Protopliomerella bowlesi* n. sp., from Section G 162T m, Fillmore Formation (lower Floian; Tulean; low *Psalikilopisis cuspidicauda* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 6, 10. Hypostome, SUI 126108, ventral, left lateral, and posterior views, x15.
- 2, 3, 7, 9, 11. Hypostome, SUI 126109, ventral, dorsal, right lateral, posterior, and left lateral views, x12.
- 4, 5, 8, 13. Hypostome, SUI 126110, dorsal, ventral, posterior, and left lateral views, x12.
- 12, 16, 20. Hypostome, SUI 126111, posterior, right lateral, and ventral views, x20.
- 14, 15, 17. Hypostome, SUI 126112, ventral, posterior, and left lateral views, x15.
- 18, 21, 22. Cranidium, SUI 126113, anterior, dorsal, and right lateral views, x7.5.
- 19, 23, 24. Cranidium, SUI 126114, dorsal, anterior, and left lateral views, x15.
- 25, 26. Left librigena, SUI 126115, ventrolateral and external views, x15.
- 27, 29, 31. Right librigena, SUI 126116, internal, external, and ventrolateral views, x10.
28. Right librigena, SUI 126117, external view, x15.
30. Left librigena, SUI 126118, external view, x12.

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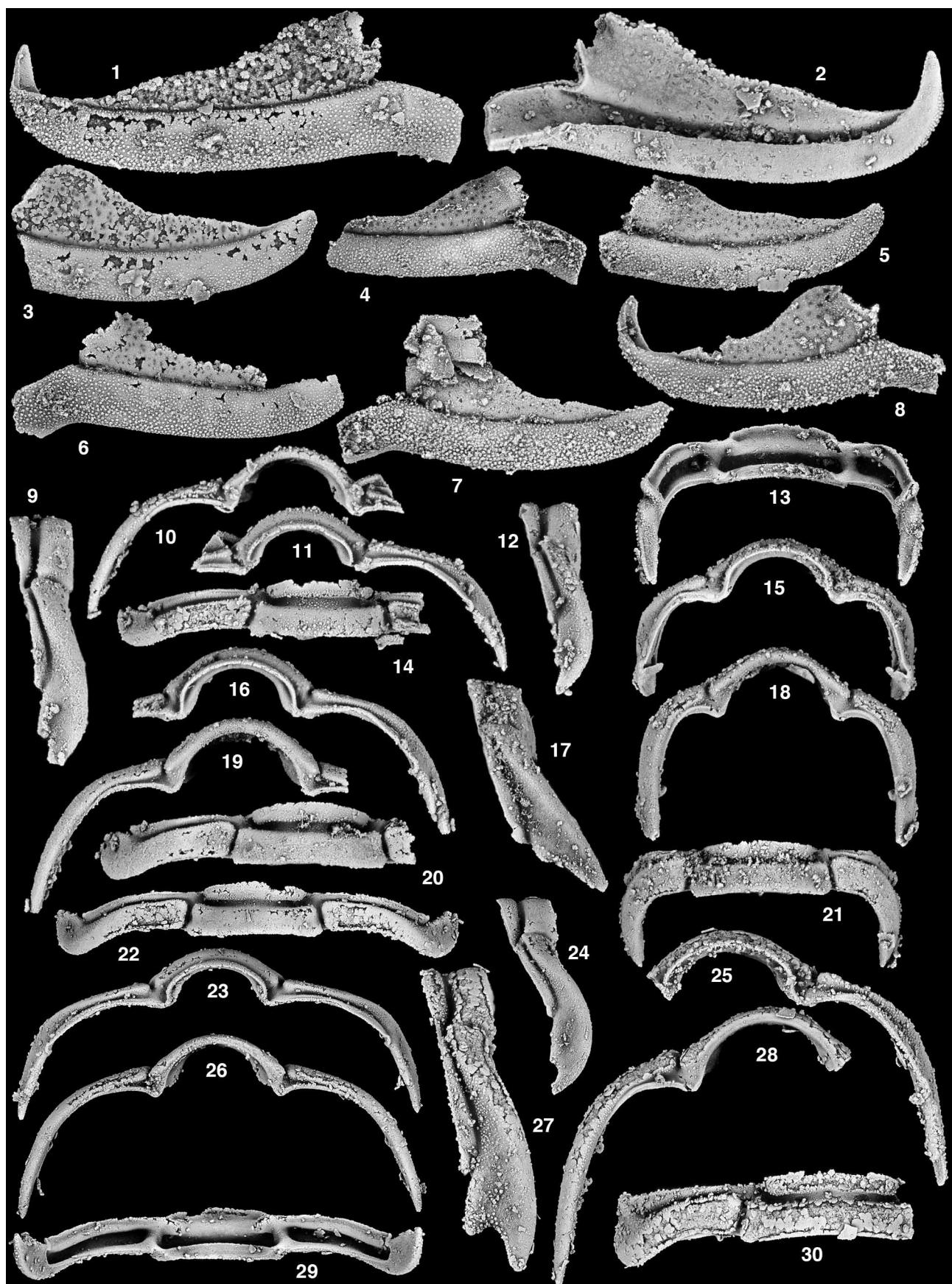


PLATE 17.

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PLATE 17. *Protopliomerella bowlesi* **n. sp.**, from Section G 162T m, Fillmore Formation (lower Floian; Tulean; low *Psalikilospis cuspidicauda* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 2. Right librigena, SUI 126119, external and internal views, x10.
3. Left librigena, SUI 126120, external view, x7.5.
4. Right librigena, SUI 126121, external view, x12.
5. Left librigena, SUI 126122, external view, x12.
6. Left librigena, SUI 126123, external view, x10.
7. Left librigena, SUI 126124, external view, x15.
8. Right librigena, SUI 126125, external view, x15.
- 9, 16, 19, 20. Thoracic segment, SUI 126126, left lateral, anterior, posterior, and dorsal views, x12.
- 10, 11, 12, 14. Thoracic segment, SUI 126127, posterior, anterior, left lateral, and dorsal views, x12.
- 13, 15, 17, 18, 21. Thoracic segment, SUI 126128, ventral, anterior, left lateral, posterior, and dorsal views, x12.
- 22–24, 26, 29. Thoracic segment, SUI 126129, dorsal, anterior, left lateral, posterior, and ventral views, x6.
- 25, 27, 28, 30. Thoracic segment, SUI 126130, anterior, left lateral, posterior, and dorsal views, x7.5.

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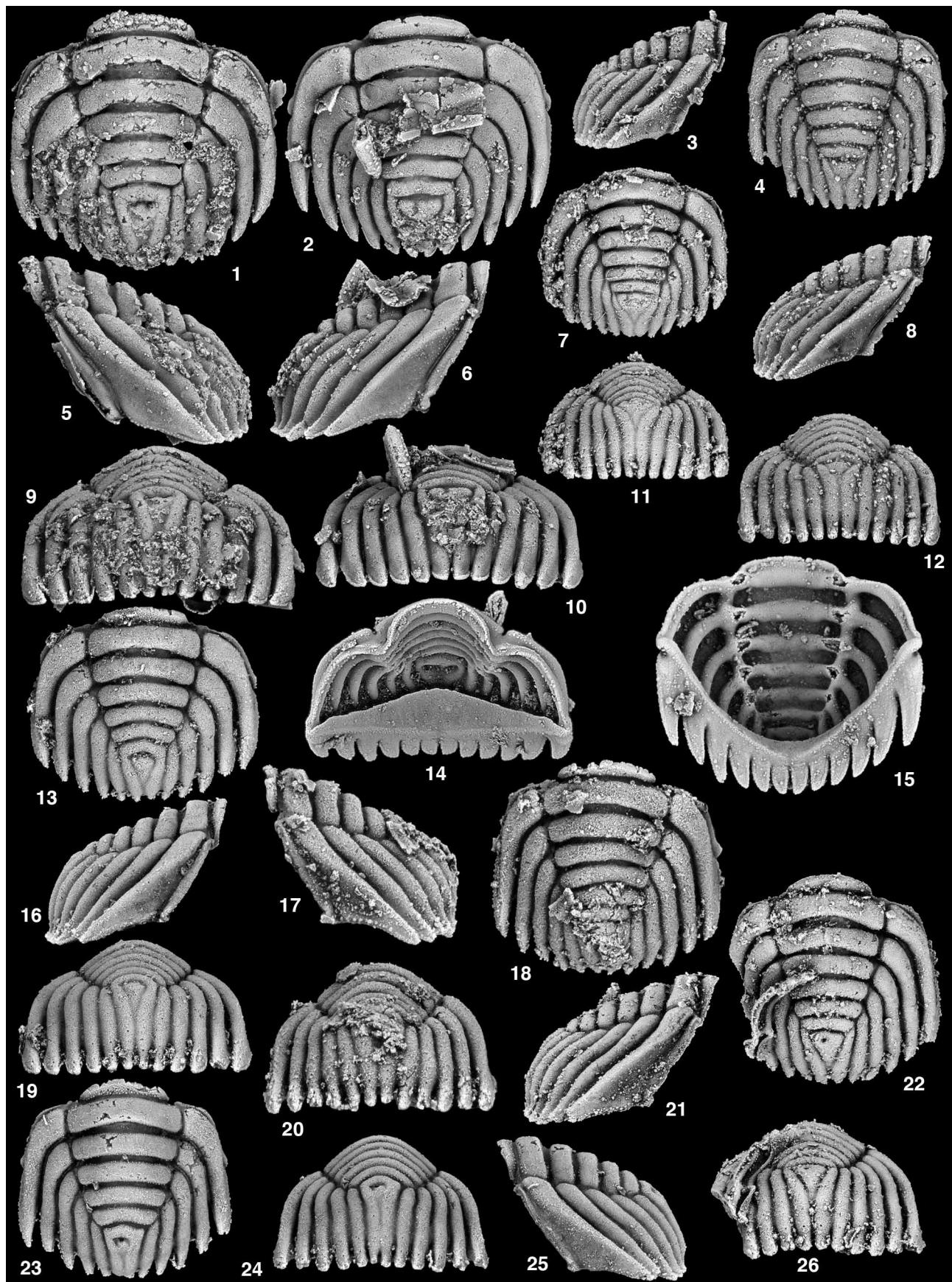


PLATE 18.

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PLATE 18. *Protopliomerella bowlesi* **n. sp.**, from Section G 162T m, Fillmore Formation (lower Floian; Tulean; low *Psalikilospis cuspidicauda* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 5, 9. Pygidium, SUI 126131, dorsal, left lateral, and posterior views, x10.
- 2, 6, 10, 14, 15. Pygidium, SUI 126132, dorsal, right lateral, posterior, anterior, and ventral views, x10.
- 3, 7, 11. Pygidium, SUI 126133, right lateral, dorsal, and posterior views, x12.
- 4, 8, 12. Pygidium, SUI 126134, dorsal, right lateral, and posterior views, x12.
- 13, 16, 19. Pygidium, SUI 126135, dorsal, right lateral, and posterior views, x12.
- 17, 18, 20. Pygidium, SUI 126136, left lateral, dorsal, and posterior views, x15.
- 21, 22, 26. Pygidium, SUI 126137, right lateral, dorsal, and posterior views, x10.
- 23–25. Pygidium, SUI 126138, dorsal, posterior, and left lateral views, x12.

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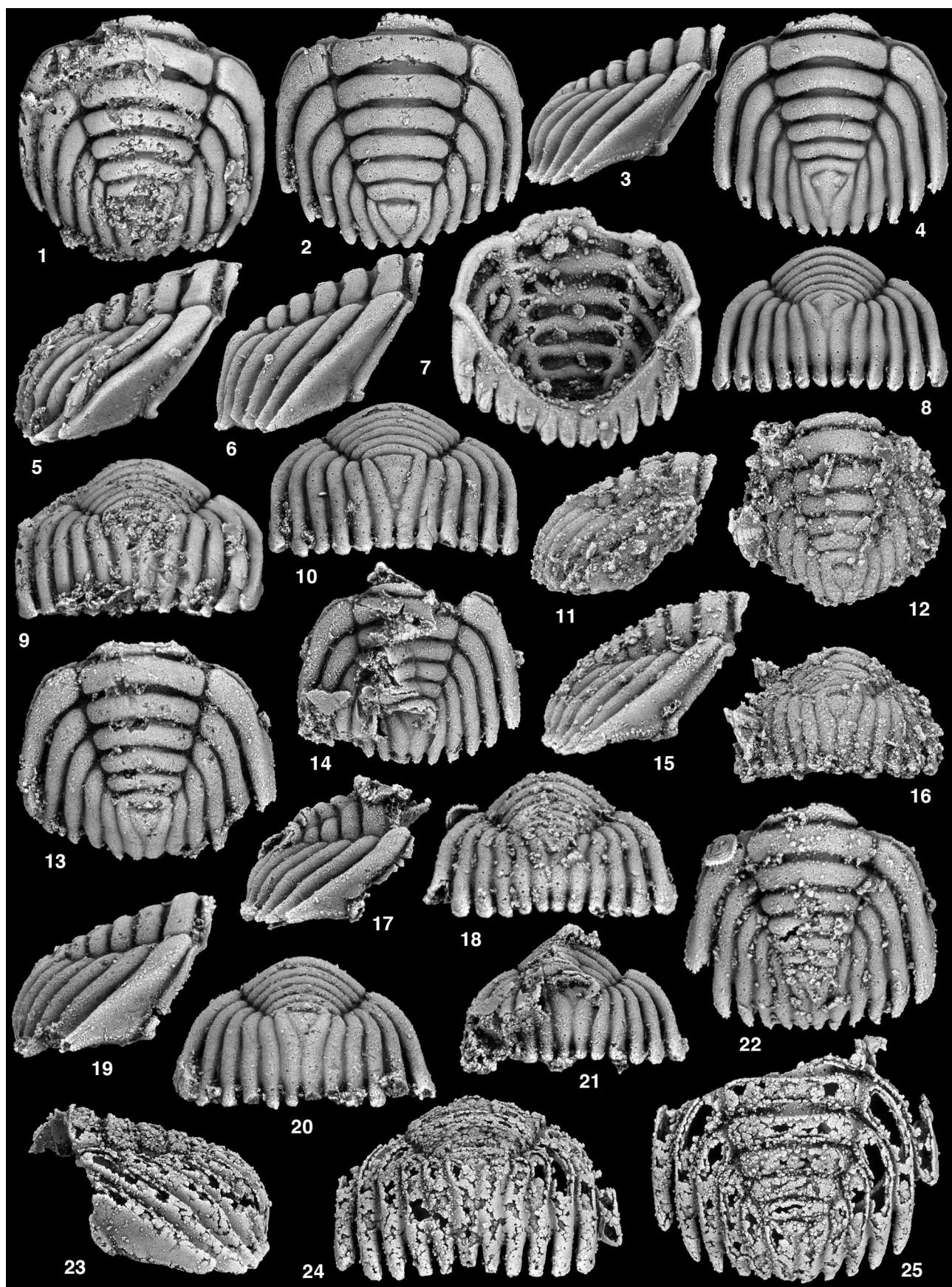


PLATE 19.

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PLATE 19. *Protopliomerella bowlesi* **n. sp.**, from Section G 162T m, Fillmore Formation (lower Floian; Tulean; low *Psalikilospis cuspidicauda* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 5, 9. Pygidium, SUI 126139, dorsal, right lateral, and posterior views, x10.
- 2, 6, 7, 10. Pygidium, SUI 126140, dorsal, right lateral, ventral, and posterior views, x10.
- 3, 4, 8. Pygidium, SUI 115196, right lateral, dorsal, and posterior views, x15.
- 11, 12, 16. Pygidium, SUI 126141, right lateral, dorsal, and posterior views, x10.
- 13, 19, 20. Pygidium, SUI 126142, dorsal, right lateral, and posterior views, x15.
- 14, 17, 21. Pygidium, SUI 126143, dorsal, right lateral, and posterior views, x15.
- 15, 18, 22. Pygidium, SUI 126144, right lateral, posterior, and dorsal views, x20.
- 23–25. Pygidium, SUI 126145, left lateral, posterior, and dorsal views, x10.

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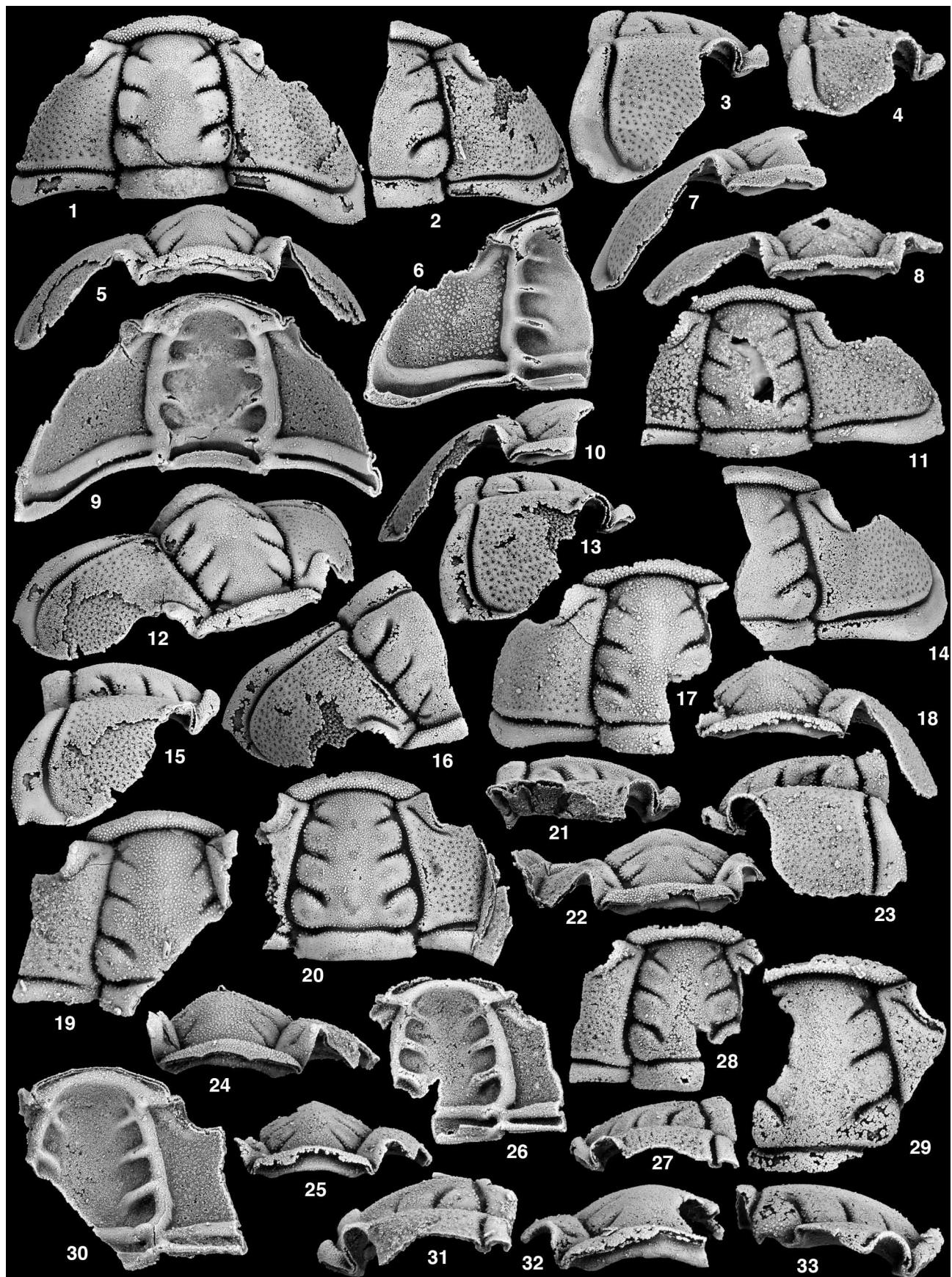


PLATE 20.

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PLATE 20. *Protopliomerella kerouaci* n. sp., from Section HC6 202T m and 203.5 m, Garden City Formation (lower Floian; Tulean; *Psalikilus typicum* Zone), west side of Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho, USA.

- 1, 5, 9, 12, 15. Cranidium, SUI 126146, dorsal, anterior, ventral, oblique, and right lateral views, x7.5 (HC6 202T m).
- 2, 6, 10, 13, 16. Cranidium, SUI 126147, dorsal, ventral, anterior, right lateral, and oblique views, x7.5 (HC6 203.5 m).
- 3, 7, 14. Cranidium, SUI 126148, right lateral, anterior, and dorsal views, x7.5 (HC6 202T m).
- 4, 8, 11. Cranidium, SUI 126149, right lateral, anterior, and dorsal views, x12 (HC6 202T m).
- 17, 18, 23. Cranidium, SUI 126150, dorsal, anterior, and left lateral views, x12 (HC6 202T m).
- 19, 24, 30, 31. Cranidium, SUI 126151, dorsal, anterior, ventral, and left lateral views, x10 (HC6 203.5 m).
- 20–22. Cranidium, SUI 126152, dorsal, right lateral, and anterior views, x7.5 (HC6 202T m).
- 25–28. Cranidium, SUI 126153, anterior, ventral, left lateral, and dorsal views, x10 (HC6 203.5 m).
- 29, 32, 33. Cranidium, SUI 126154, dorsal, anterior, and right lateral views, x10 (HC6 203.5 m).

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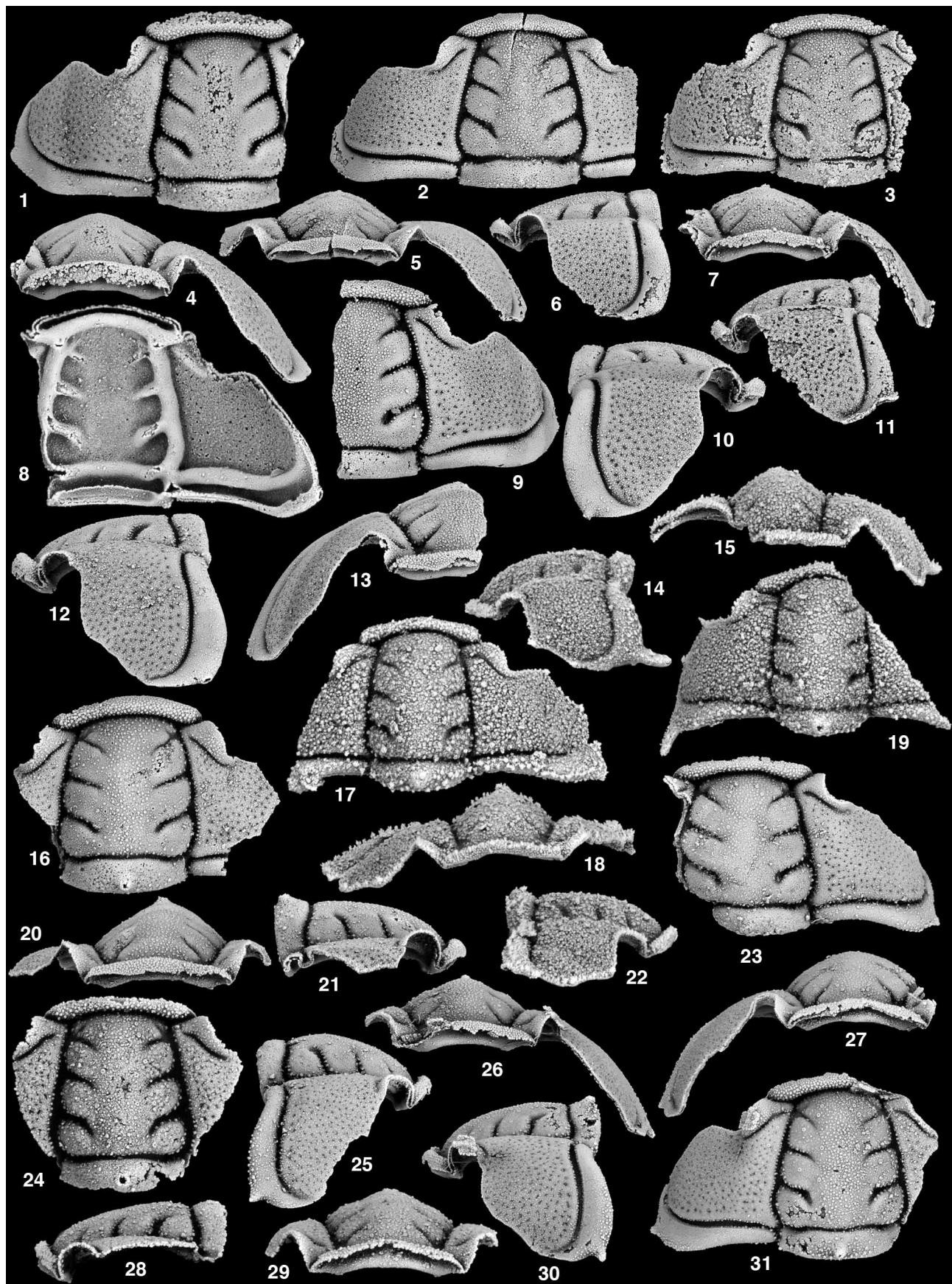


PLATE 21.

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PLATE 21. *Protopliomerella kerouaci* n. sp., from Section HC6 202T m, 203.0 m, and 203.5 m, Garden City Formation (lower Floian; Tulean; *Psalikilus typicum* Zone), west side of Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho, USA.

- 1, 4, 9, 12. Cranium, SUI 126155, dorsal, anterior, ventral, and left lateral view, x10 (HC6 203.0 m).
- 2, 5, 6. Cranium, SUI 126156, dorsal, anterior, and left lateral views, x10 (HC6 203.0 m).
- 3, 7, 11. Cranium, SUI 126157, dorsal, anterior, and left lateral views, x10 (HC6 203.0 m).
- 9, 10, 13. Cranium, SUI 126158, dorsal, right lateral, and anterior views, x10 (HC6 203.0 m).
- 14, 15, 19. Cranium, SUI 126159, left lateral, anterior, and dorsal views, x20 (HC6 203.0 m).
- 16, 20, 21. Cranium, SUI 126160, dorsal, anterior, and right lateral views, x12 (HC6 203.0 m).
- 17, 18, 22. Cranium, SUI 126161, dorsal, anterior, and right lateral views, x20 (HC6 203.0 m).
- 23, 25, 27. Cranium, SUI 126162, dorsal, right lateral, and anterior view, x12 (HC6 202T m).
- 24, 28, 29. Cranium, SUI 126163, dorsal, left lateral, and anterior views, x15 (HC6 203.5 m).
- 25, 26, 31. Cranium, SUI 126164, right lateral, anterior, and dorsal views, x12 (HC6 202T m).

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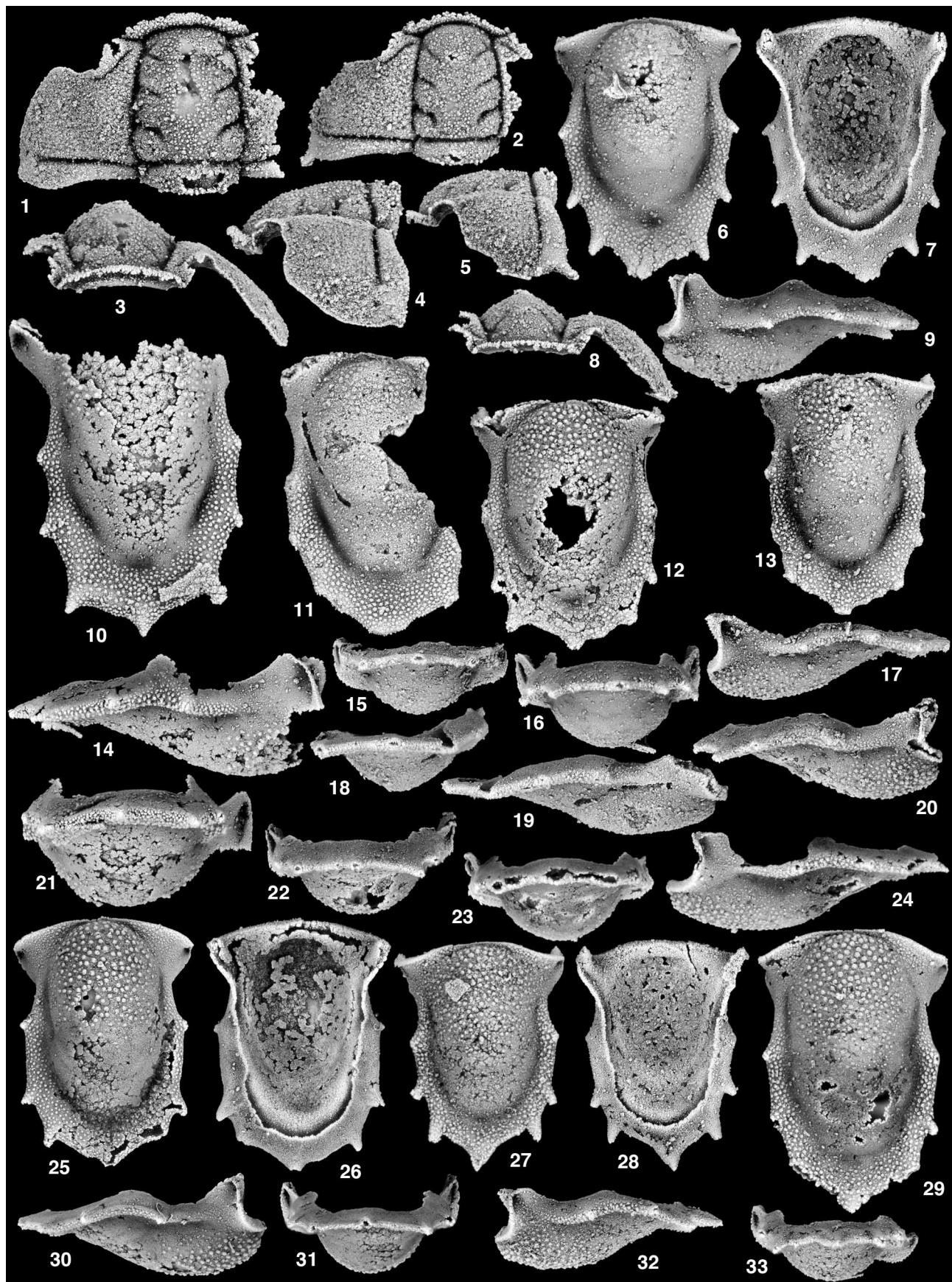


PLATE 22.

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PLATE 22. *Protopliomerella kerouaci* n. sp., from Section HC6 202T m and 203.0 m, Garden City Formation (lower Floian; Tulean; *Psalikilus typicum* Zone), west side of Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho, USA.

- 1, 3, 4. Cranium, SUI 126165, dorsal, anterior, and left lateral views, x15 (HC6 202T m).
- 2, 5, 8. Cranium, SUI 126166, dorsal, left lateral, and anterior views, x15 (HC6 202T m).
- 6, 7, 9, 16. Hypostome, SUI 126167, ventral, dorsal, right lateral, and posterior views, x15 (HC6 202T m).
- 10, 14, 21. Hypostome, SUI 126168, ventral, left lateral, and posterior views, x15 (HC6 202T m).
- 11, 18, 19. Hypostome, SUI 126169, ventral, posterior, and left lateral views, x15 (HC6 203.0 m).
- 12, 20, 22. Hypostome, SUI 126170, ventral, left lateral, and posterior views, x15 (HC6 203.0 m).
- 13, 15, 17. Hypostome, SUI 126171, ventral, posterior, and right lateral views, x15 (HC6 202T m).
- 23, 24, 29. Hypostome, SUI 126172, posterior, right lateral, and ventral views, x20 (HC6 203.0 m).
- 25, 26, 30, 31. Hypostome, SUI 126173, ventral, dorsal, left lateral, and posterior views, x15 (HC6 203.0 m).
- 27, 28, 32, 33. Hypostome, SUI 126174, ventral, dorsal, right lateral, and posterior views, x15 (HC6 203.0 m).

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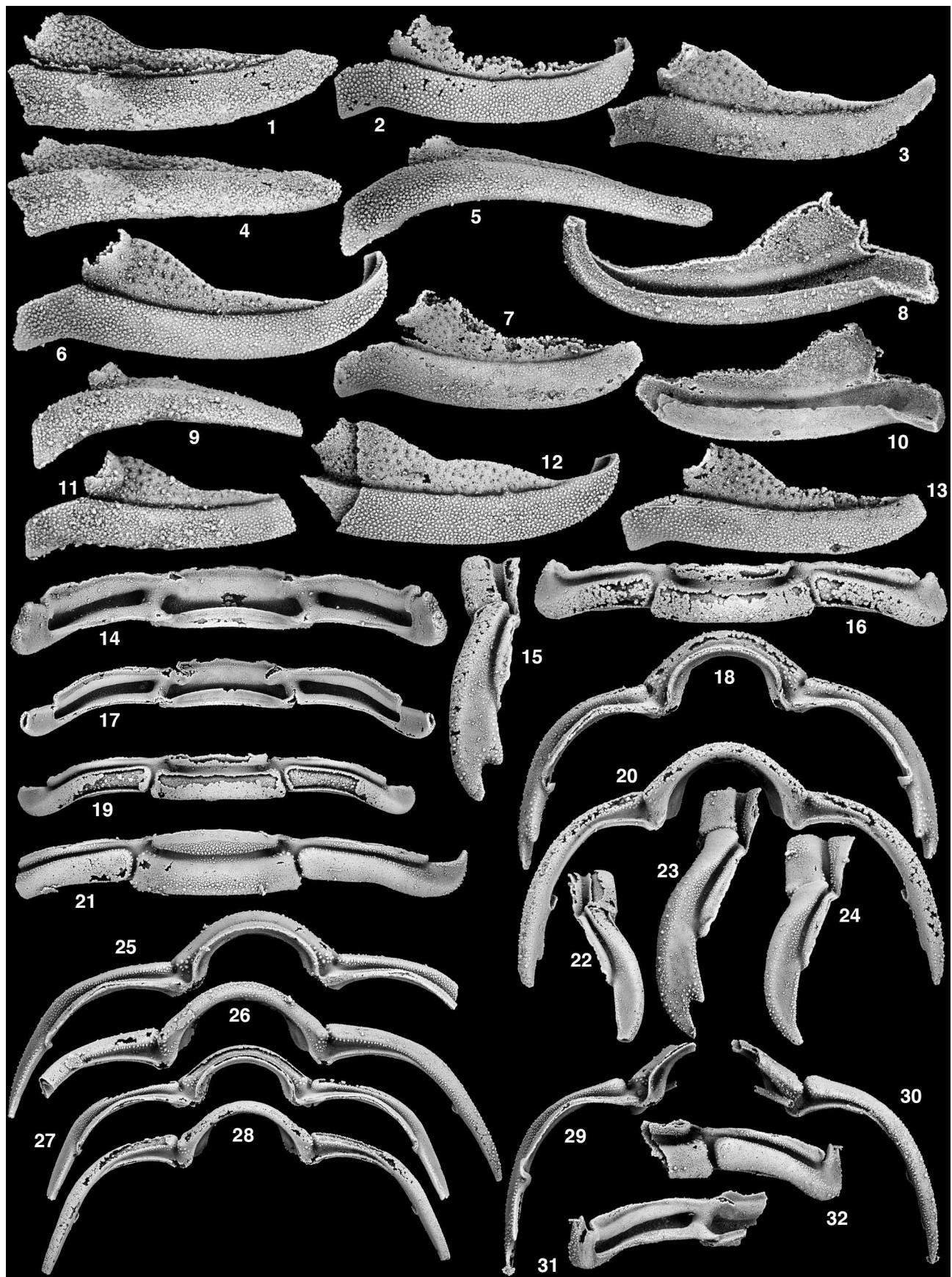


PLATE 23.

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PLATE 23. *Protopliomerella kerouaci* n. sp., from Section HC6 202T m, 203.0 m, and 203.5 m, Garden City Formation (lower Floian; Tulean; *Psalikilus typicum* Zone), west side of Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho, USA.

- 1, 4. Left librigena, SUI 126175, external and ventrolateral views, x12 (HC6 202T m).
2. Left librigena, SUI 126176, external view, x12 (HC6 203.5 m).
3. Left librigena, SUI 126177, external view, x12 (HC6 203.5 m).
- 5, 6, 8. Left librigena, SUI 126178, ventrolateral, external, and internal views, x15 (HC6 203.5 m).
- 7, 10. Left librigena, SUI 126179, external and internal views, x10 (HC6 203.5 m).
- 9, 11. Left librigena, SUI 126180, ventrolateral and external views, x15 (HC6 202T m).
12. Left librigena, SUI 126181, external view, x10 (HC6 203.5 m).
13. Left librigena, SUI 126182, external view, x12 (HC6 203.5 m).
- 14–16, 18, 20. Thoracic segment, SUI 126183, ventral, right lateral, dorsal, anterior, and posterior views, x10 (HC6 203.0 m).
- 17, 19, 22, 27, 28. Thoracic segment, SUI 126184, ventral, dorsal, left lateral, anterior, and posterior views, x7.5 (HC6 203.0 m).
- 21, 24–26. Thoracic segment, SUI 126185, dorsal, right lateral, anterior, and posterior views, x10 (HC6 203.0 m).
- 23, 29–32. Thoracic segment, SUI 126186, right lateral, anterior, posterior, ventral, and dorsal views, x7.5 (HC6 203.5 m).

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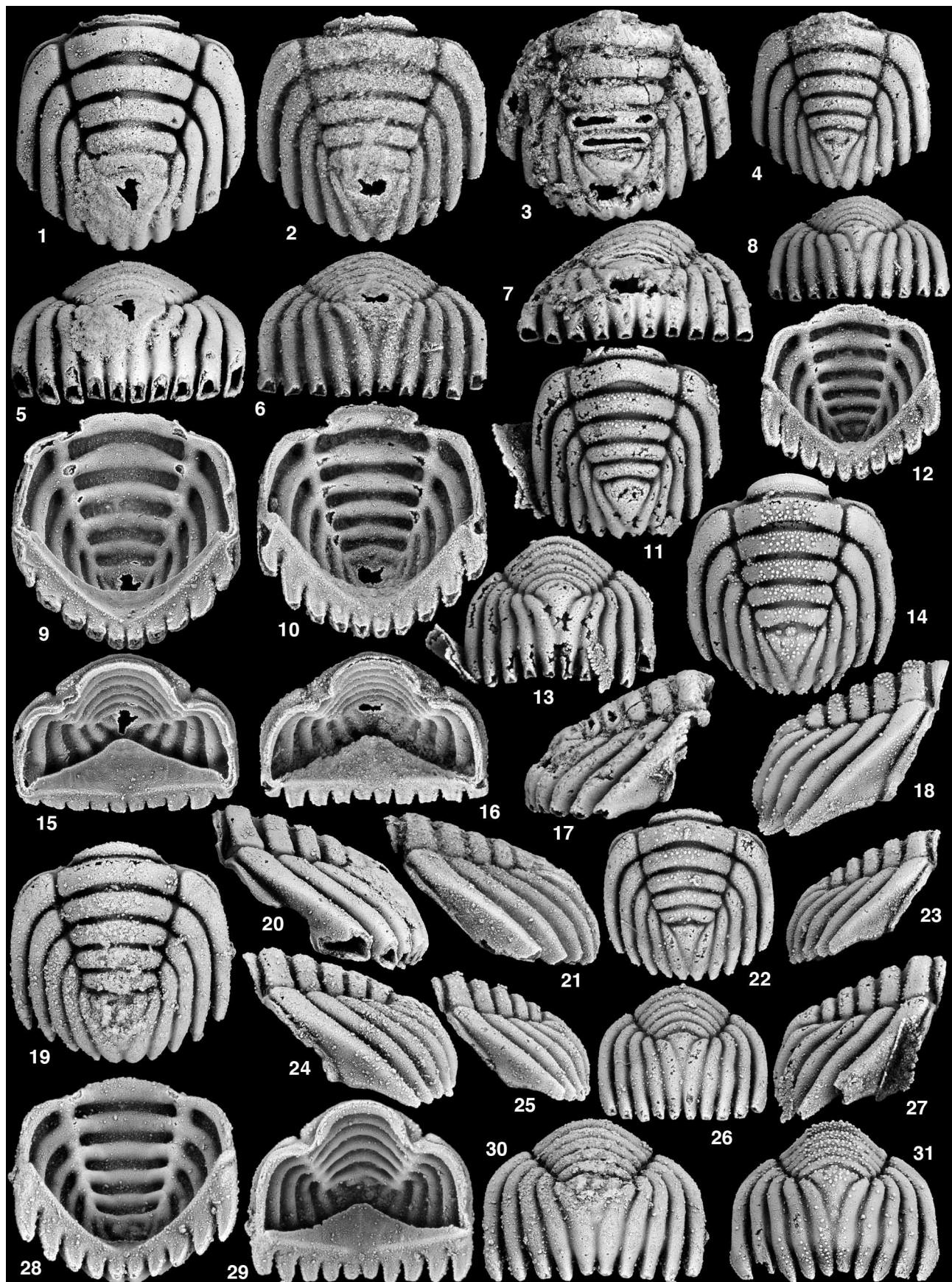


PLATE 24.

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PLATE 24. *Protopliomerella kerouaci* **n. sp.**, from Section HC6 203.5 m, Garden City Formation (lower Floian; Tulean; *Psalikilus typicum* Zone), west side of Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho, USA.

- 1, 5, 9, 15, 20. Pygidium, SUI 126187, x10 (HC6 203.5 m).
- 2, 6, 10, 16, 21. Pygidium, SUI 126188, dorsal, posterior, ventral, anterior, and left lateral views, x12 (HC6 203.0 m).
- 3, 7, 17. Pygidium, SUI 126189, dorsal, posterior, and right lateral views, x12 (HC6 203.0 m).
- 4, 8, 12, 23. Pygidium, SUI 126190, dorsal, posterior, ventral, and right lateral views, x12 (HC6 203.0 m).
- 11, 13, 27. Pygidium, SUI 126191, dorsal, posterior, and right lateral views, x15 (HC6 203.5 m).
- 14, 18, 31. Pygidium, SUI 126192, dorsal, right lateral, and posterior views, x10 (HC6 202T m).
- 19, 24, 28–30. Pygidium, SUI 126193, dorsal, left lateral, ventral, anterior, and posterior views, x12 (HC6 202T m).
- 22, 25, 26. Pygidium, SUI 126194, dorsal, left lateral, and posterior views, x12 (HC6 203.0 m).

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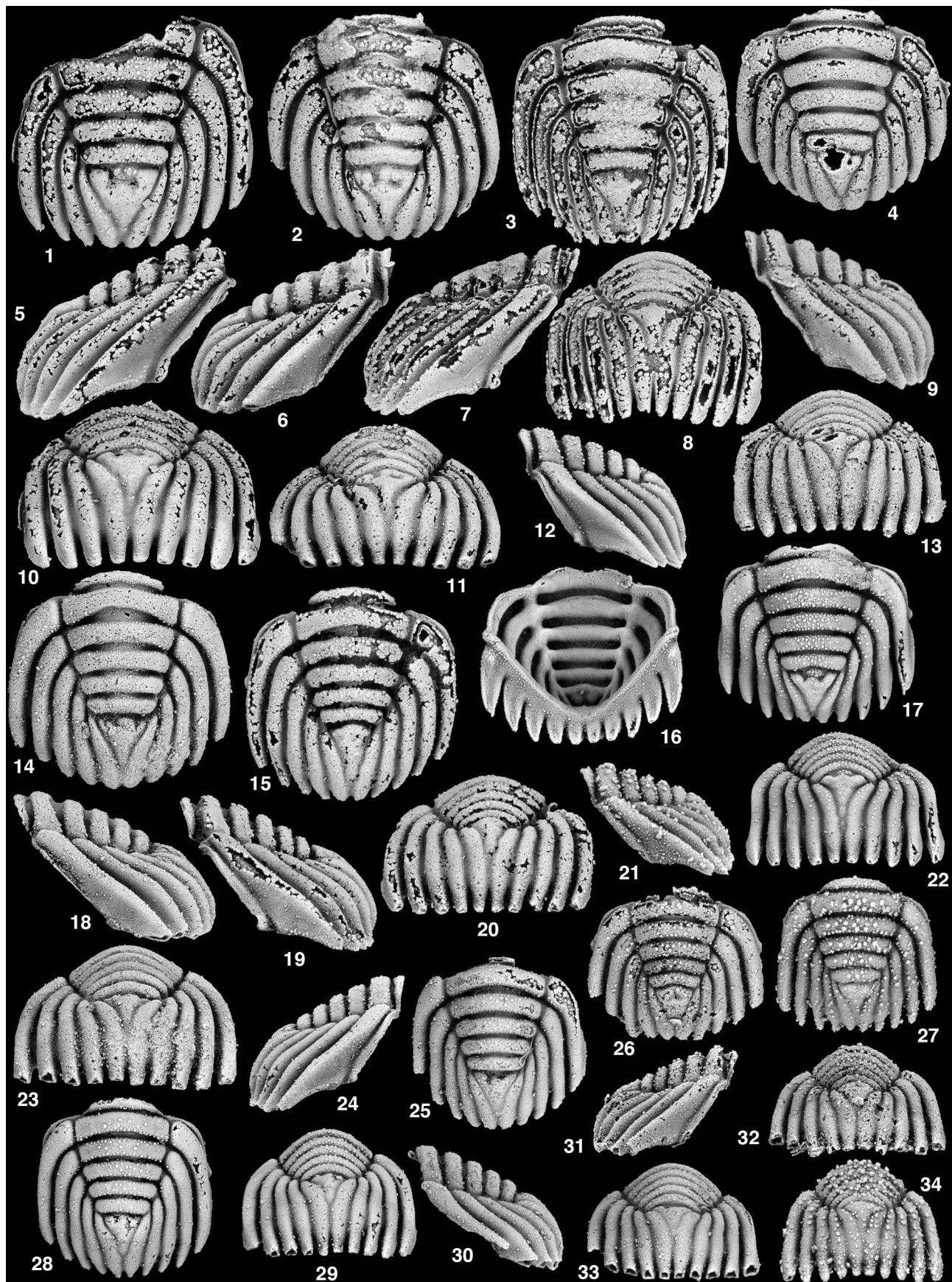


PLATE 25.

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PLATE 25. *Protopliomerella kerouaci* n. sp., from Section HC6 202T m and 203.0 m, Garden City Formation (lower Floian; Tulean; *Psalikilus typicum* Zone), west side of Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho, USA.

- 1, 5, 10. Pygidium, SUI 126195, dorsal, right lateral, and posterior views, x10 (HC6 203.0 m).
- 2, 6, 11. Pygidium, SUI 126196, dorsal, right lateral, and posterior views, x10 (HC6 203.0 m).
- 3, 7, 8. Pygidium, SUI 126197, dorsal, right lateral, and posterior views, x10 (HC6 203.0 m).
- 4, 9, 13. Pygidium, SUI 126198, dorsal, left lateral, and posterior views, x10 (HC6 203.0 m).
- 12, 16, 17, 22. Pygidium, SUI 126199, left lateral, ventral, dorsal, and posterior views, x10 (HC6 203.0 m).
- 14, 18, 23. Pygidium, SUI 126200, dorsal, left lateral, and posterior views, x10 (HC6 203.0 m).
- 15, 19, 20. Pygidium, SUI 126201, dorsal, left lateral, and posterior views, x12 (HC6 203.0 m).
- 21, 27, 34. Pygidium, SUI 126202, left lateral, dorsal, and posterior views, x15 (HC6 202T m).
- 24, 28, 29. Pygidium, SUI 126203, right lateral, dorsal, and posterior views, x12 (HC6 203.0 m).
- 25, 30, 33. Pygidium, SUI 126204, dorsal, left lateral, and posterior views, x12 (HC6 203.0 m).
- 26, 31, 32. Pygidium, SUI 126205, dorsal, right lateral, and posterior views, x12 (HC6 203.0 m).

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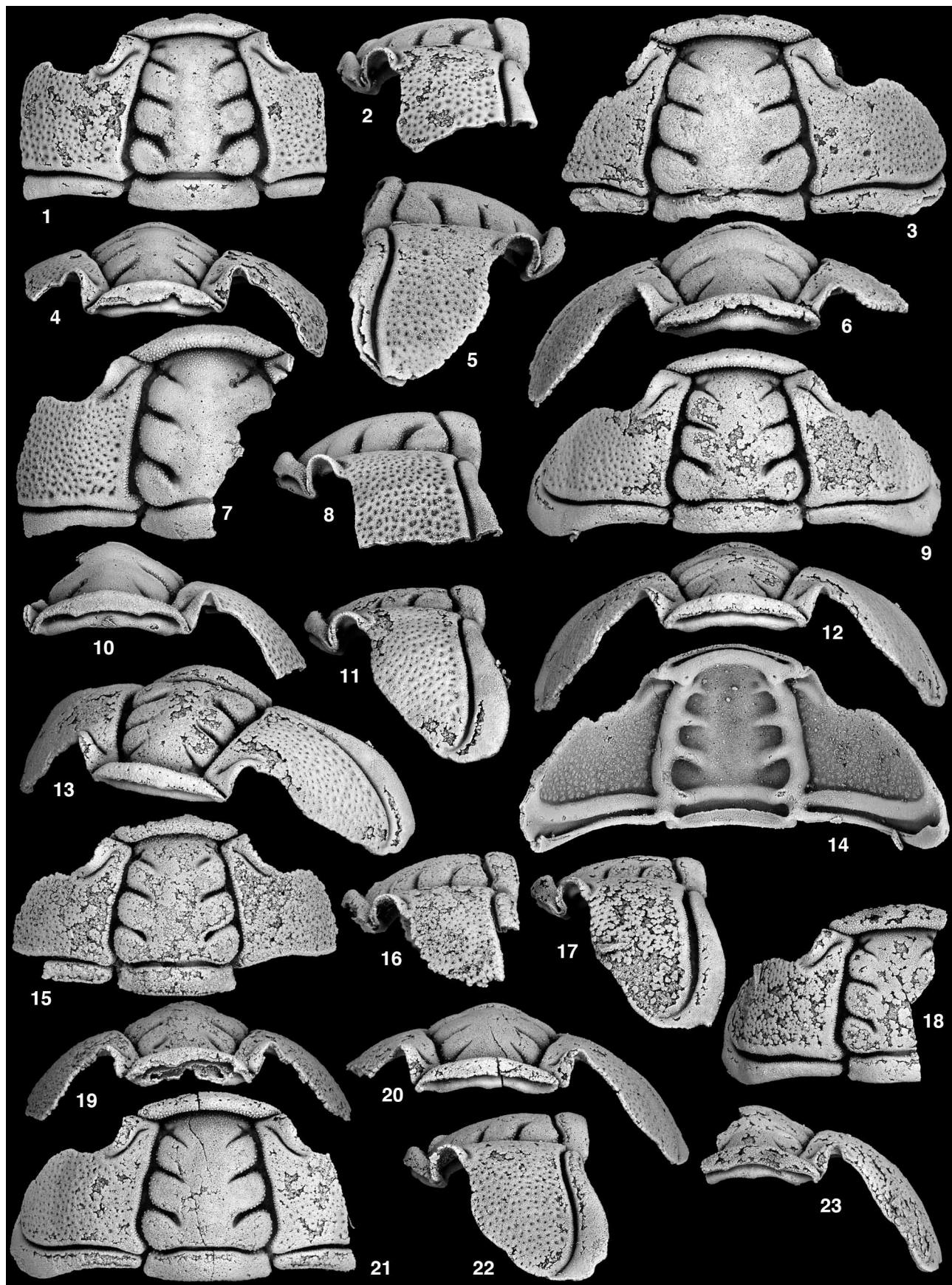


PLATE 26.

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PLATE 26. *Protopliomerella kerouaci* n. sp., from Section G 168T m, Fillmore Formation (lower Floian; Tulean; *Psalikilus typicum* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 2, 4. Cranidium, SUI 126206, dorsal, left lateral, and anterior views, x6.
- 3, 5, 6. Cranidium, SUI 126207, dorsal, right lateral, and anterior views, x7.5.
- 7, 8, 10. Cranidium, SUI 126208, dorsal, left lateral, and anterior views, x6.
- 9, 11–14. Cranidium, **holotype**, SUI 126209, dorsal, left lateral, anterior, oblique, and ventral views, x7.5.
- 15, 16, 19. Cranidium, SUI 126210, dorsal, left lateral, and anterior views, x7.5.
- 17, 18, 23. Cranidium, SUI 126211, left lateral, dorsal, and anterior views, x6.
- 20–22. Cranidium, SUI 126212, anterior, dorsal, and left lateral views, x7.5.

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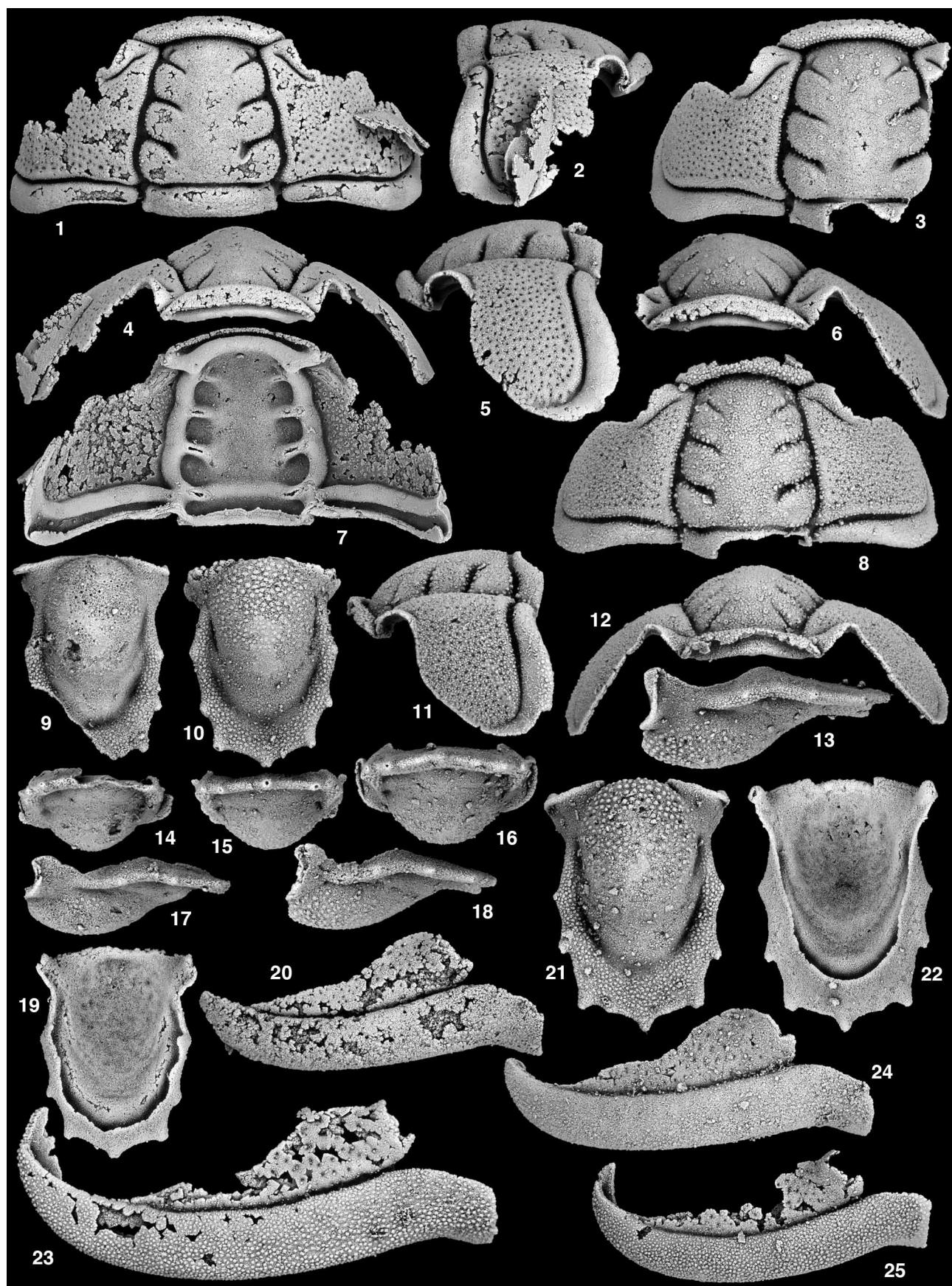


PLATE 27.

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PLATE 27. *Protopliomerella kerouaci* n. sp., from Section G 168T m, Fillmore Formation (lower Floian; Tulean; *Psalikilus typicum* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 2, 4, 7. Cranium, SUI 126213, dorsal, right lateral, anterior, and ventral views, x7.5.
- 3, 5, 6. Cranium, SUI 126214, dorsal, left lateral, and anterior views, x12.
- 8, 11, 12. Cranium, SUI 126215, dorsal, left lateral, and anterior views, x15.
- 9, 14, 17. Hypostome, SUI 126216, ventral, posterior, and right lateral views, x12.
- 10, 15, 18, 19. Hypostome, SUI 126217, ventral, posterior, right lateral, and dorsal views, x12.
- 13, 16, 21, 22. Hypostome, SUI 126218, right lateral, posterior, ventral, and dorsal views, x12.
20. Right librigena, SUI 126219, external view, x12.
23. Right librigena, SUI 126220, external view, x10.
24. Right librigena, SUI 126221, external view, x12.
25. Right librigena, SUI 126222, external view, x12.

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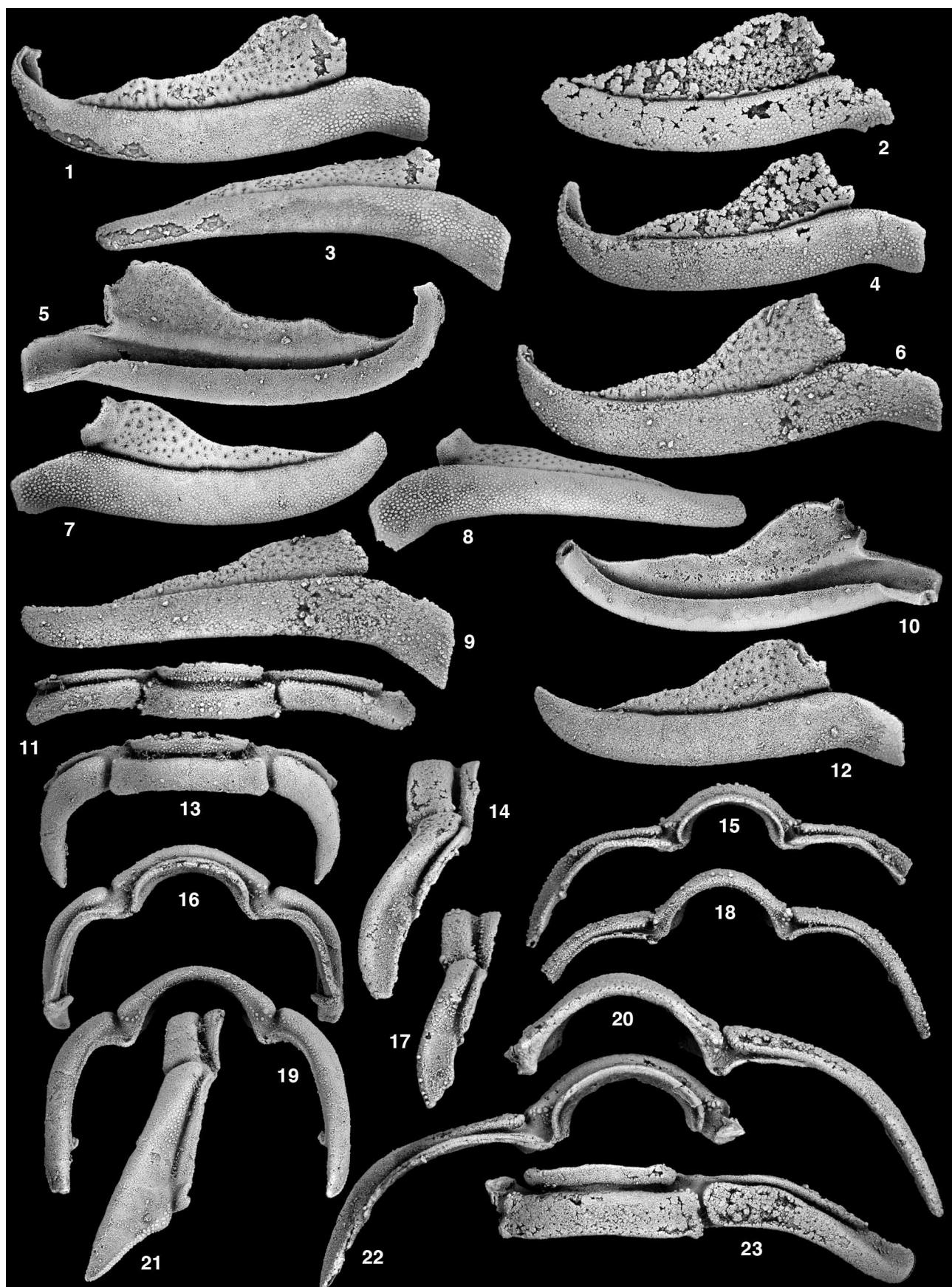


PLATE 28.

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PLATE 28. *Protopliomerella kerouaci* n. sp., from Section G 168T m, Fillmore Formation (lower Floian; Tulean; *Psalikilus typicum* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 3, 5. Right librigena, SUI 126223, external, ventrolateral, and internal views, x10.
2. Right librigena, SUI 126224, external view, x10.
4. Right librigena, SUI 126225, external view, x10.
- 6, 9. Right librigena, SUI 126226, external and ventrolateral views, x10.
- 7, 8, 10. Left librigena, SUI 126227, external, ventrolateral, and internal views, x10.
- 11, 15, 17, 18. Thoracic segment, SUI 126228, dorsal, anterior, right lateral, and posterior views, x15.
12. Right librigena, SUI 126229, external view, x10.
- 13, 16, 19, 21. Thoracic segment, SUI 126230, dorsal, anterior, posterior, and right lateral views, x12.
- 14, 20, 22, 23. Thoracic segment, SUI 126231, right lateral, posterior, anterior, and dorsal views, x10.

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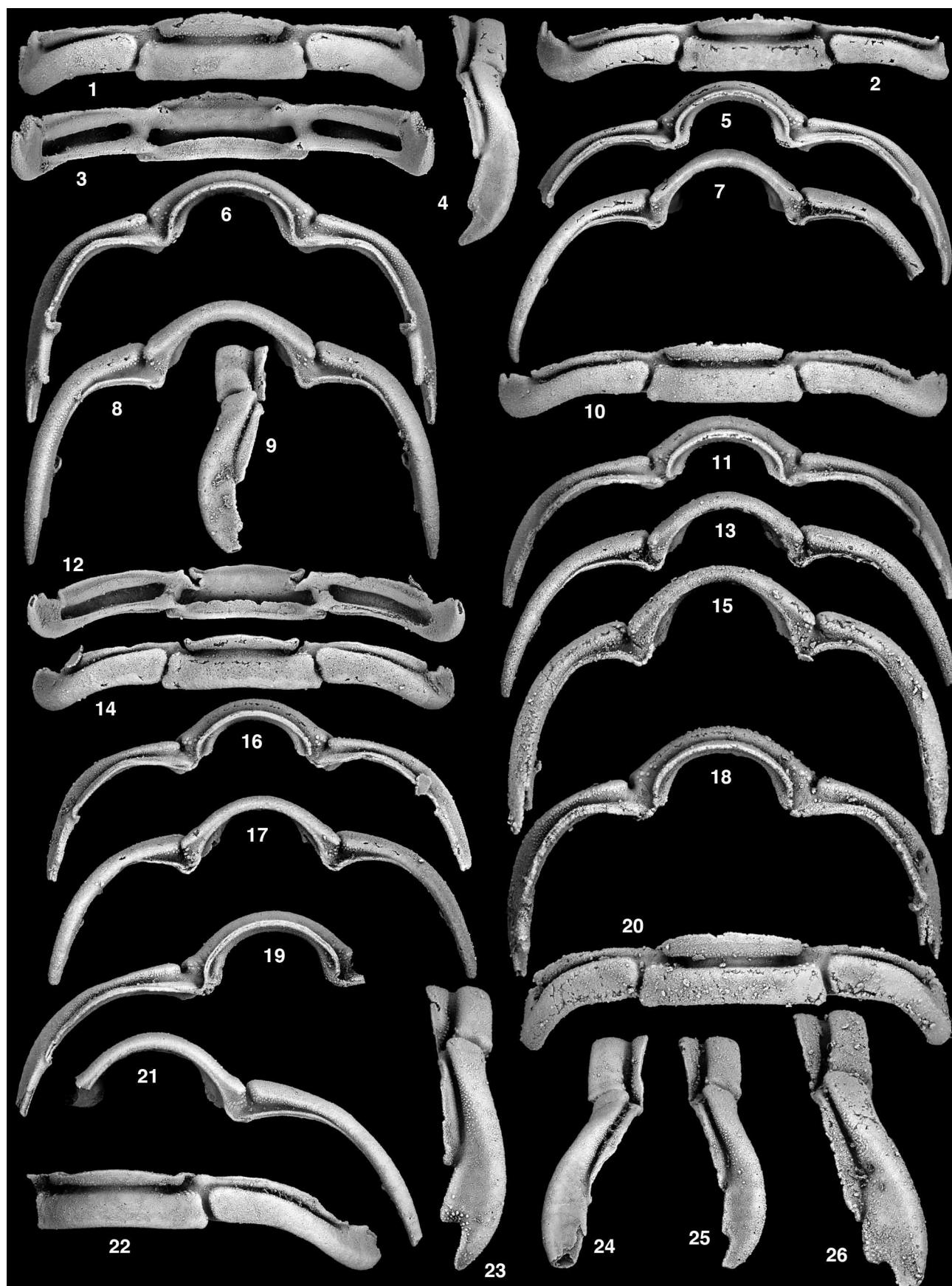


PLATE 29.

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◀ **PLATE 29.** *Protopliomerella kerouaci* n. sp., from Section G 168T m, Fillmore Formation (lower Floian; Tulean; *Psalikilus typicum* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 3, 6, 8, 23. Thoracic segment, SUI 126232, dorsal, ventral, anterior, posterior, and left lateral views, x10.
- 2, 4, 5, 7. Thoracic segment, SUI 126233, dorsal, left lateral, anterior, and posterior views, x7.5.
- 9, 12, 14, 16, 17. Thoracic segment, SUI 126234, right lateral, ventral, dorsal, anterior, and posterior views, x7.5.
- 10, 11, 13, 25. Thoracic segment, SUI 126235, dorsal, anterior, posterior, and left lateral views, x10.
- 15, 18, 20, 26. Thoracic segment, SUI 126236, posterior, anterior, dorsal, and left lateral views, x10.
- 19, 21, 22, 24. Thoracic segment, SUI 126237, anterior, posterior, dorsal, and right lateral views, x7.5.

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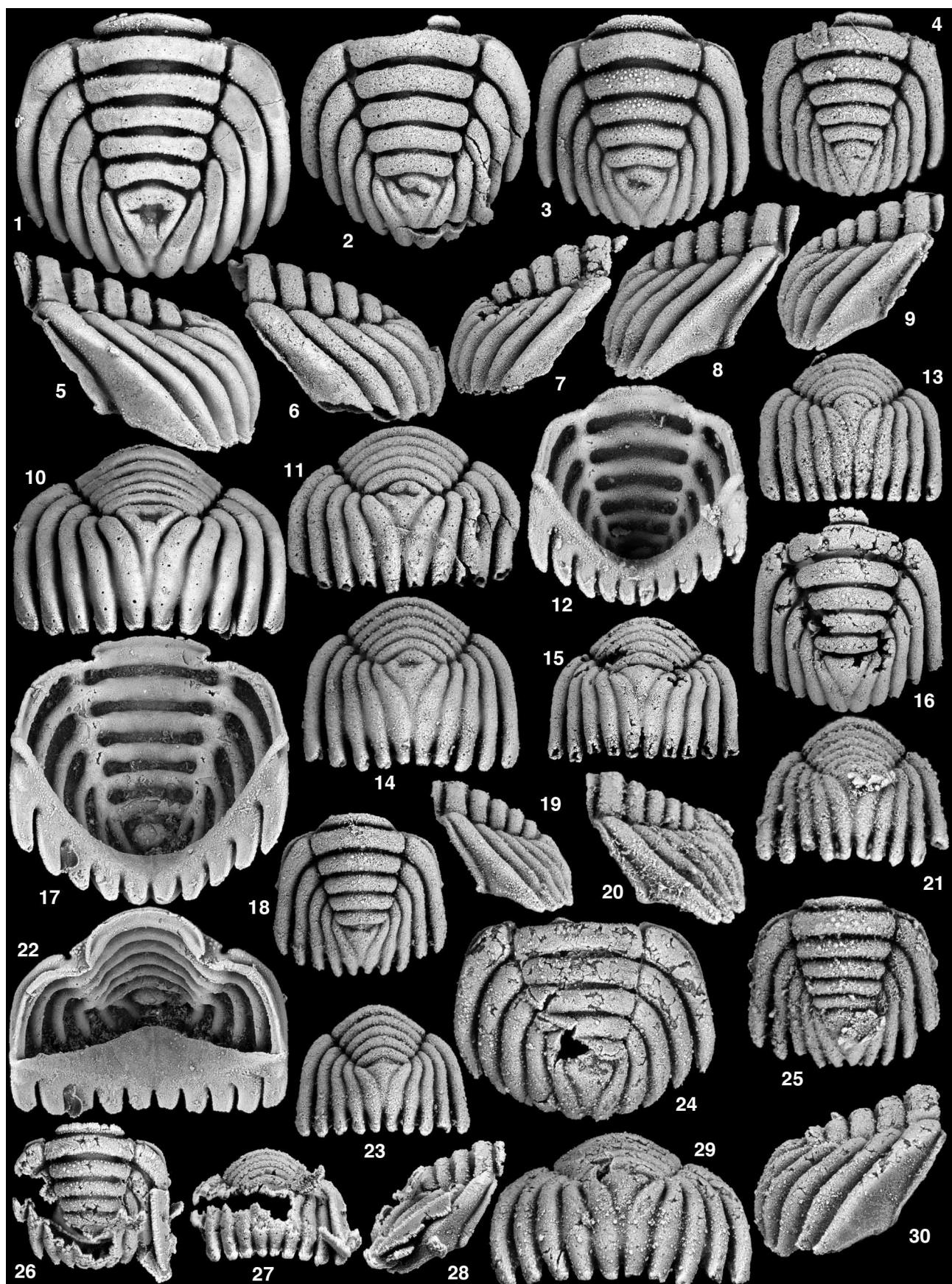


PLATE 30.

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◀

PLATE 30. *Protopliomerella kerouaci* n. sp., from Section G 168T m and G 174.0 m, Fillmore Formation (lower Floian; Tulean; *Psalikilus typicum* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 5, 10, 17, 22. Pygidium, SUI 126238, dorsal, left lateral, posterior, ventral, and anterior views, x10.
- 2, 6, 11. Pygidium, SUI 126239, dorsal, left lateral, and posterior views, x10 (G 168T m).
- 3, 8, 12, 14. Pygidium, SUI 126240, dorsal, right lateral, ventral, and posterior views, x15 (G 168T m).
- 4, 9, 13. Pygidium, SUI 126241, dorsal, right lateral, and posterior views, x15 (G 168T m).
- 7, 15, 16. Pygidium, SUI 126242, right lateral, posterior, and dorsal views, x12 (G 168T m).
- 18, 19, 23. Pygidium, SUI 126243, dorsal, left lateral, and posterior views, x15 (G 168T m).
- 20, 21, 25. Pygidium, SUI 126244, left lateral, posterior, and dorsal views, x20 (G 168T m).
- 24, 29, 30. Pygidium, SUI 126245, dorsal, posterior, and right lateral views, x10 (G 174.0 m).
- 26–28. Pygidium, SUI 126246, dorsal, posterior, and right lateral views, x12 (G 174.0 m).

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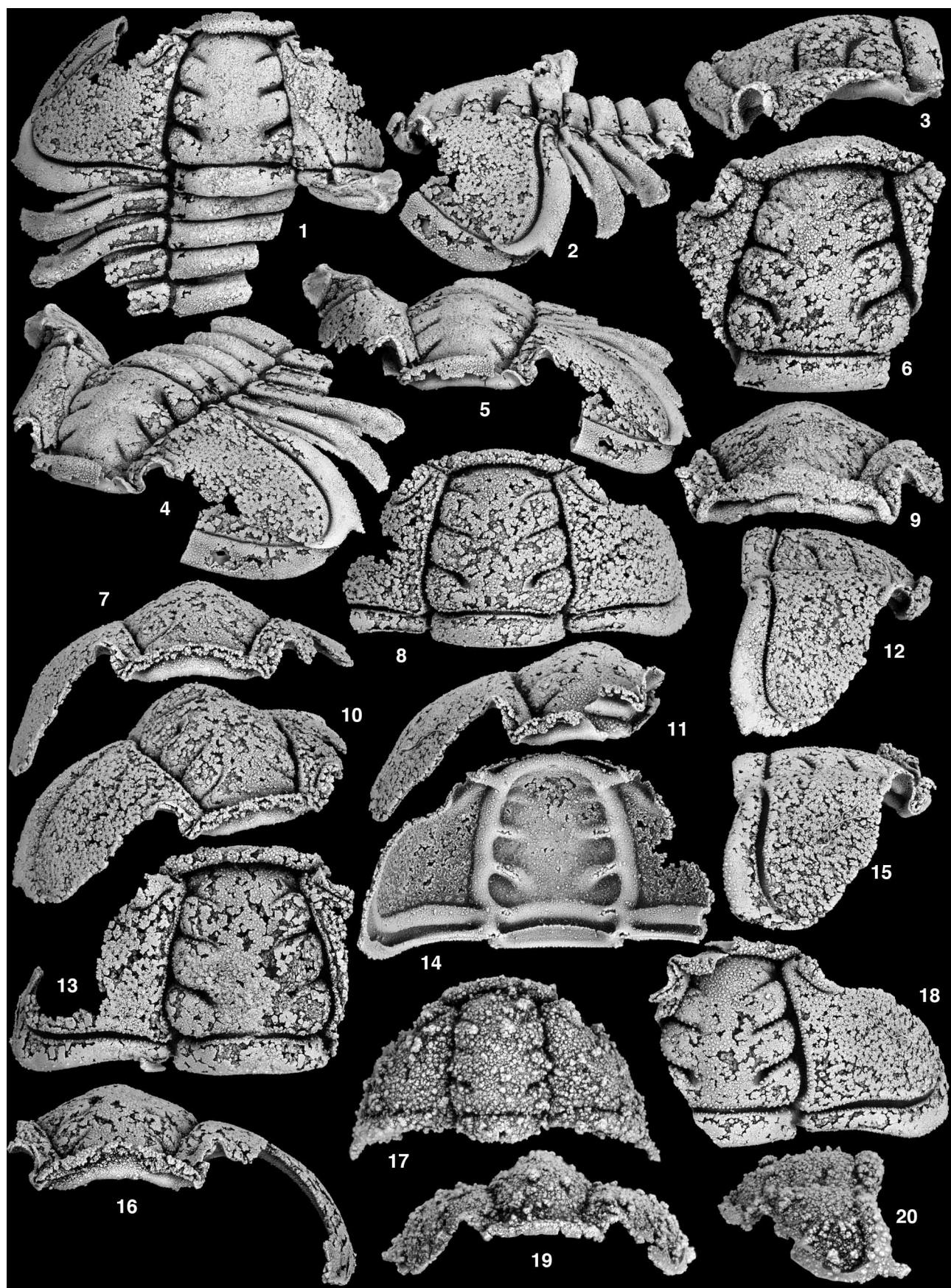


PLATE 31.

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◀ **PLATE 31.** *Protopliomerella seegeri* n. sp., from Section G 181.8 m, Fillmore Formation (lower Floian; Tulean; low *Psalikilus hestoni* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 2, 4, 5. Partial cephalon and anterior thorax, SUI 126247, dorsal, left lateral, oblique, and anterior views, x7.5.
- 3, 6, 9. Cranidium, SUI 126248, left lateral, dorsal, and anterior views, x10.
- 7, 8, 10, 12, 14. Cranidium, SUI 126249, anterior, dorsal, oblique, right lateral, and ventral views, x10.
- 11, 15, 18. Cranidium, SUI 126250, anterior, right lateral, and dorsal views, x10.
- 13, 16. Cranidium, SUI 126251, dorsal and anterior views, x10.
- 17, 19, 20. Cranidium, SUI 126252, dorsal, anterior, and left lateral views, x20.

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◀

PLATE 32. *Protopliomerella seegeri* n. sp., from Section G 181.8 m, Fillmore Formation (lower Floian; Tulean; low *Psalikilus hestoni* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA, and Section HC5 217T m, Garden City Formation (lower Floian; Tulean; low *Psalikilus hestoni* Zone), east side of Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho, USA.

- 1, 3, 6. Cranium, SUI 126253, dorsal, right lateral, and anterior views, x12 (G 181.8 m).
- 2, 4, 5. Cranium, SUI 126254, anterior, dorsal, and right lateral views, x7.5 (G 181.8 m).
- 7, 9, 12. Cranium, SUI 126255, left lateral, dorsal, and anterior views, x15 (HC5 217T m).
- 8, 10, 13. Cranium, SUI 126256, right lateral, dorsal, and anterior views, x20 (HC6 217T m).
- 11, 15, 34. Hypostome, SUI 126257, ventral, posterior, and left lateral views, x12 (G 181.8 m).
- 14, 16–18. Hypostome, SUI 126258, left lateral, ventral, dorsal, and posterior views, x12 (G 181.8 m).
- 19, 20, 28, 35, 36. Thoracic segment, SUI 126259, ventral, right lateral, dorsal, anterior, and posterior views, x12 (G 181.8 m).
- 21, 23, 27, 29. Thoracic segment, SUI 126260, left lateral, dorsal, anterior, and posterior views, x10 (G 181.8 m).
- 22, 24–26. Thoracic segment, SUI 126261, dorsal, anterior, posterior, and left lateral views, x10 (G 181.8 m).
- 30–33. Thoracic segment, SUI 126262, left lateral, posterior, anterior, and dorsal views, x12 (G 181.8 m).

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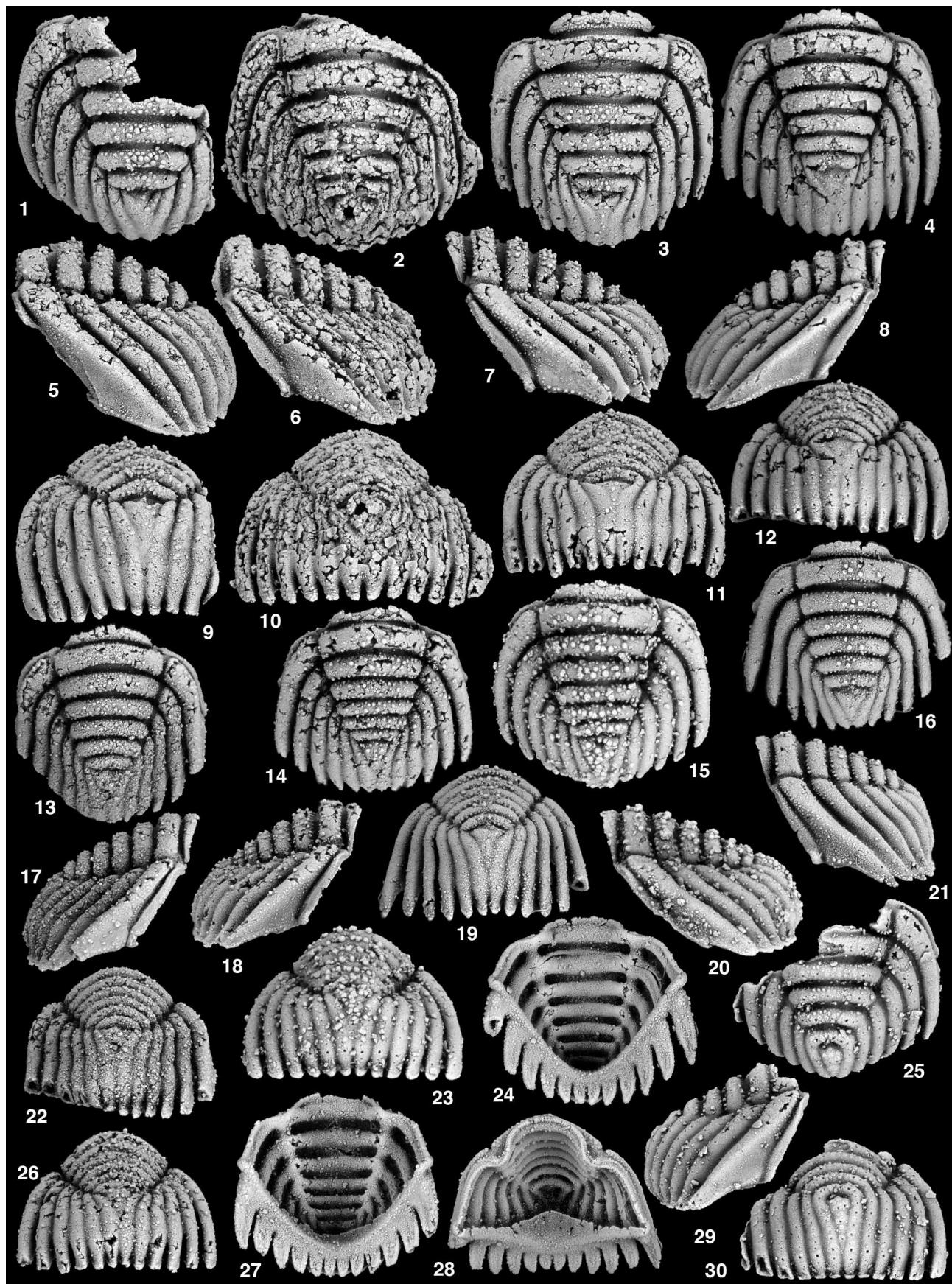


PLATE 33.

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PLATE 33. *Protopliomerella seegeri* n. sp., from Section G 181.8 m, Fillmore Formation (lower Floian; Tulean; low *Psalikilus hestoni* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA, and Section HC5 217T m, Garden City Formation (lower Floian; Tulean; low *Psalikilus hestoni* Zone), east side of Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho, USA.

- 1, 5, 9. Pygidium, SUI 126263, dorsal, left lateral, and posterior views, x12 (G 181.8 m)
- 2, 6, 10. Pygidium, SUI 126264, dorsal, left lateral, and posterior views, x12 (G 181.8 m).
- 3, 7, 11. Pygidium, **holotype**, SUI 126265, dorsal, left lateral, and posterior views, x12 (G 181.8 m).
- 4, 8, 12. Pygidium, SUI 126266, dorsal, right lateral, and posterior views, x15 (G 181.8 m).
- 13, 17, 22. Pygidium, SUI 126267, dorsal, right lateral, and posterior views, x12 (G 181.8 m).
- 14, 18, 16, 17. Pygidium, SUI 126268, dorsal, right lateral, posterior, and ventral views, x15 (G 181.8 m).
- 15, 20, 23. Pygidium, SUI 126269, dorsal, left lateral, and posterior views, x15 (HC5 217T m).
- 16, 19, 21, 24, 28. Pygidium, SUI 126270, dorsal, posterior, left lateral, ventral, and anterior views, x15 (G 181.8 m).
- 25, 29, 30. Pygidium, SUI 126271, dorsal, right lateral, and posterior views, x12 (HC5 217T m).

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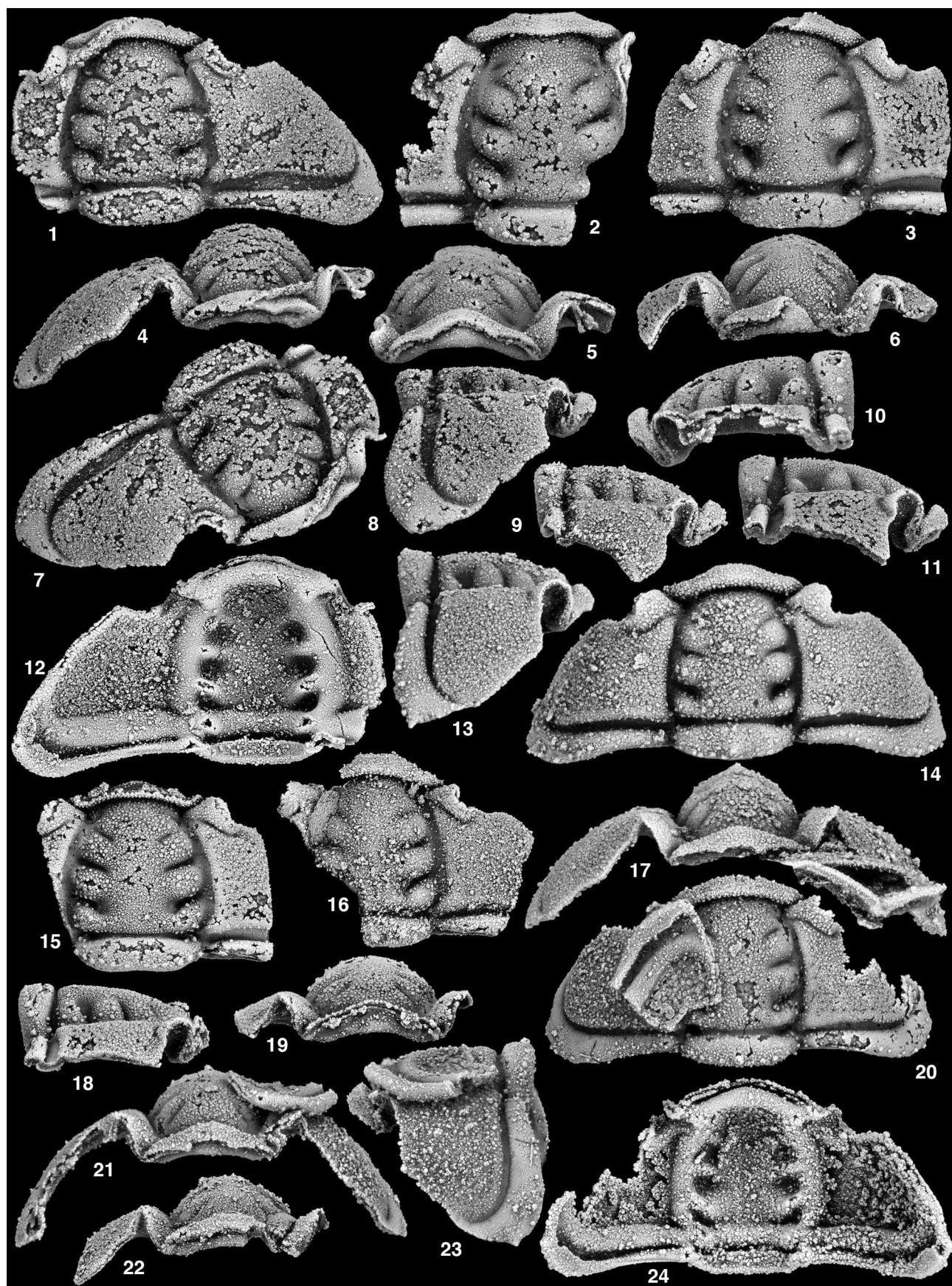


PLATE 34.

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PLATE 34. *Protopliomerella okeeffae* n. sp., from Section H 93.4 m, Fillmore Formation (lower Floian; Tulean; *Heckethornia bowiei* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 4, 7, 8, 12. Cranidium, SUI 126272, dorsal, anterior, oblique, right lateral, and ventral views, x10.
- 2, 5, 10. Cranidium, SUI 126273, dorsal, anterior, and left lateral views, x10.
- 3, 6, 11. Cranidium, SUI 126274, dorsal, anterior, and right lateral views, x10.
- 9, 16, 22. Cranidium, SUI 126275, right lateral, dorsal, and anterior views, x10.
- 13, 14, 17. Cranidium, SUI 126276, right lateral, dorsal, and anterior views, x15.
- 15, 18, 19. Cranidium, SUI 126277, dorsal, right lateral, and anterior views, x10.
- 20, 21, 23, 24. Cranidium, SUI 126278, dorsal, anterior, left lateral, and ventral views, x12.

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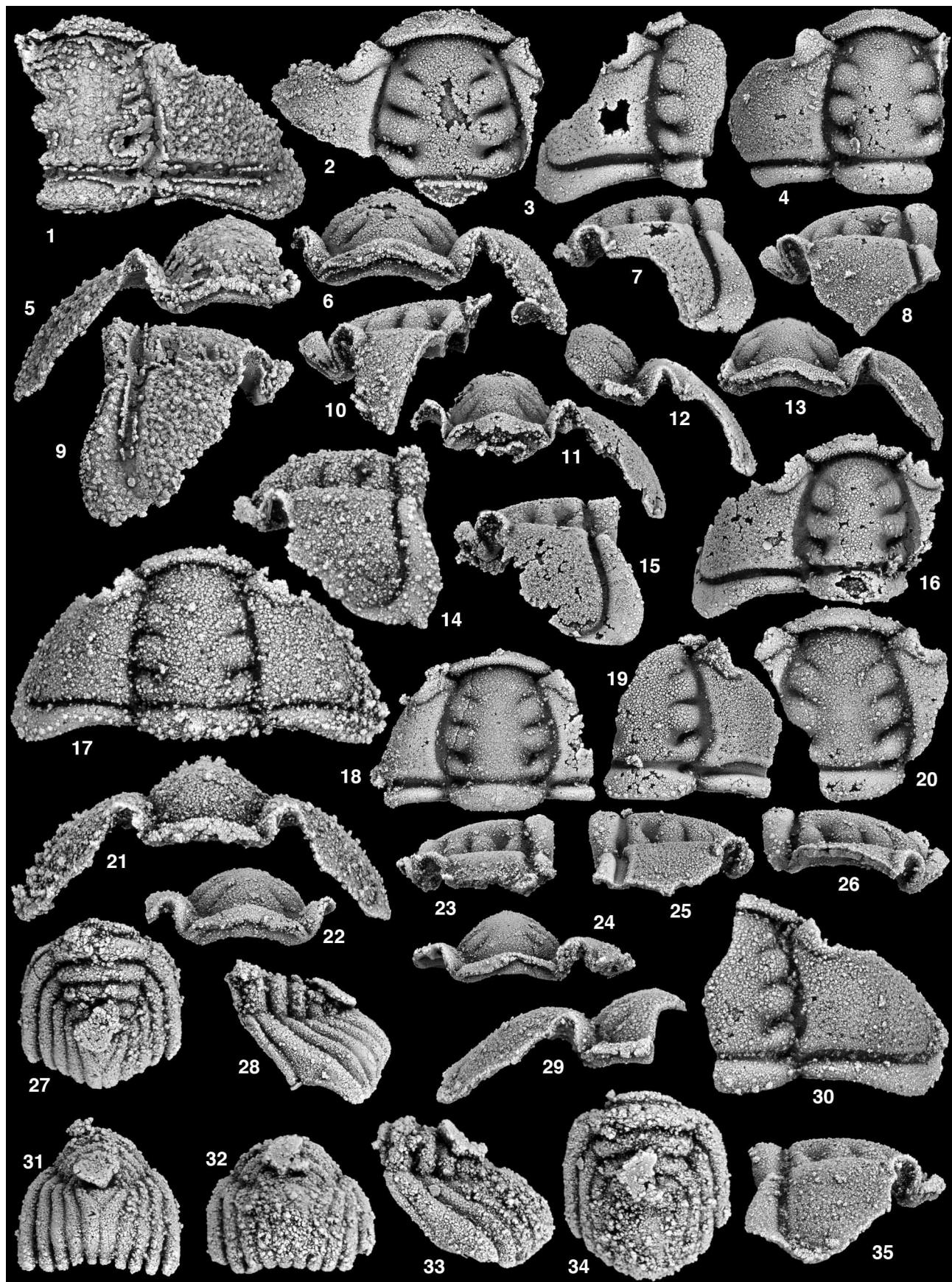


PLATE 35.

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PLATE 35. *Protopliomerella okeeffae* n. sp., from Section H 93.4 m and H 127.1 m, Fillmore Formation (lower Floian; Tulean; *Heckethornia bowiei* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 5, 9. Cranidium, SUI 126279, dorsal, anterior, and right lateral views, x10 (H 127.1 m).
- 2, 6, 10. Cranidium, SUI 126280, dorsal, anterior, and left lateral views, x10 (H 93.4 m).
- 3, 7, 12. Cranidium, SUI 126281, dorsal, left lateral, and anterior views, x12 (H 93.4 m).
- 4, 8, 13. Cranidium, SUI 115287, dorsal, left lateral, and anterior views, x10 (H 93.4 m).
- 11, 15, 16. Cranidium, SUI 126282, anterior, left lateral, and dorsal views, x12 (H 127.1 m).
- 14, 17, 21. Cranidium, SUI 126283, left lateral, dorsal, and anterior views, x15 (H 93.4 m).
- 18, 23, 24. Cranidium, SUI 126284, dorsal, left lateral, and anterior views, x10 (H 93.4 m).
- 19, 25. Cranidium, SUI 126285, dorsal and right lateral views, x10 (H 93.4 m).
- 20, 22, 26. Cranidium, SUI 126286, dorsal, anterior, and right lateral views, x10 (H 93.4 m).
- 27, 28, 31. Pygidium, SUI 126287, dorsal, left lateral, and posterior views, x15 (H 93.4 m).
- 29, 30, 35. Cranidium, SUI 126288, anterior, dorsal, and right lateral views, x15 (H 93.4 m).
- 32–24. Pygidium, SUI 126289, dorsal, left lateral, and posterior views, x20 (H 93.4 m).

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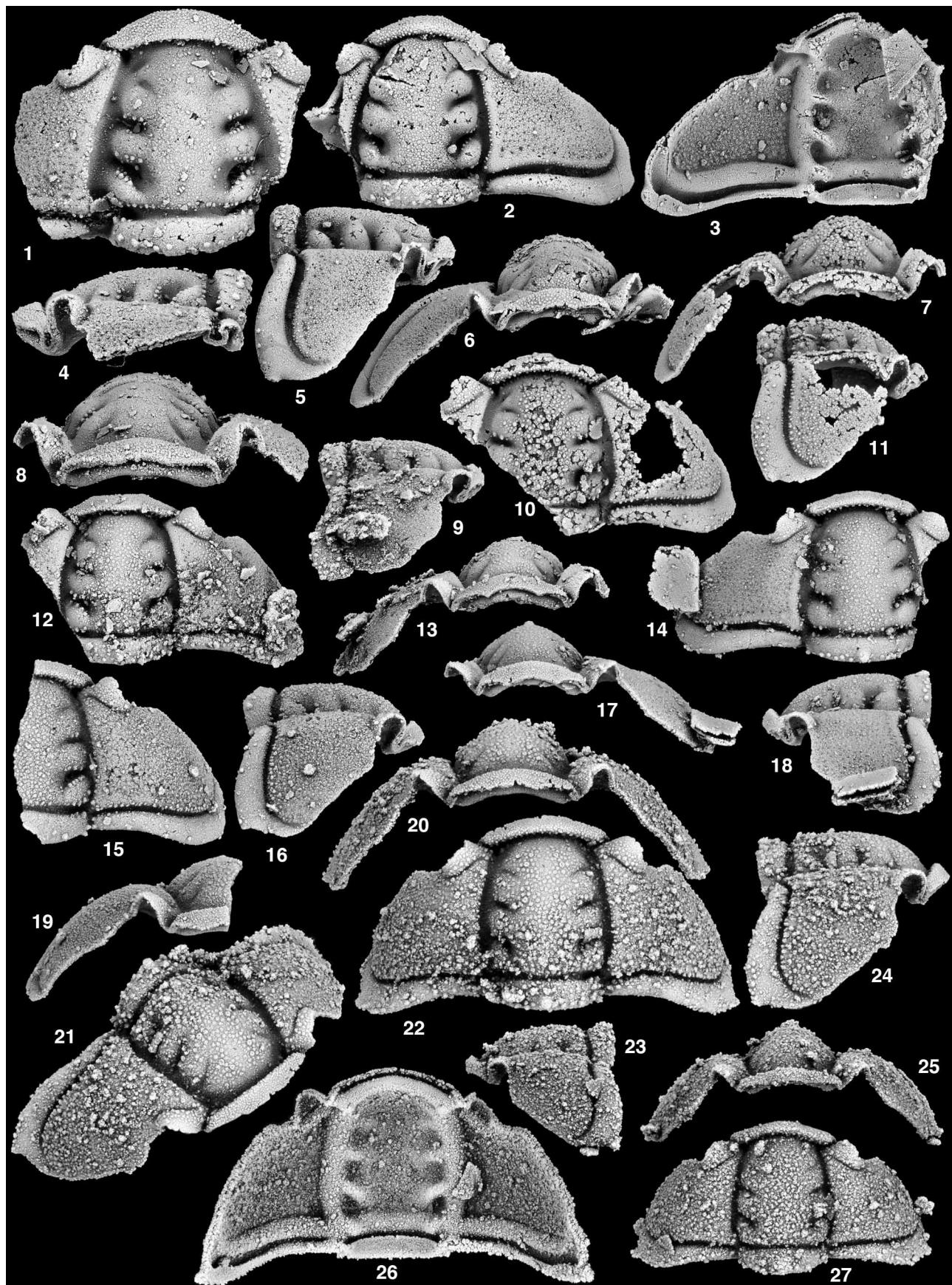


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PLATE 36. *Protopliomerella okeeffae n. sp.*, from Section G 258.2 m, Fillmore Formation (lower Floian; Tulean; *Heckethornia hyndae* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 4, 8. Cranidium, SUI 126290, dorsal, left lateral, and anterior views, x10.
- 2, 3, 5, 6. Cranidium, **holotype**, SUI 126291, dorsal, ventral, right lateral, and anterior views, x10.
- 7, 10, 11. Cranidium, SUI 126292, anterior, dorsal, and right lateral views, x12.
- 9, 12, 13. Cranidium, SUI 126293, right lateral, dorsal, and anterior views, x10.
- 14, 17, 18. Cranidium, SUI 126294, dorsal, anterior, and left lateral views, x12.
- 15, 16, 19. Cranidium, SUI 126295, dorsal, right lateral, and anterior views, x12.
- 20–22, 24, 26. Cranidium, SUI 126296, anterior, oblique, dorsal, right lateral, and ventral views, x15.
- 23, 25, 27. Cranidium, SUI 126297, left lateral, anterior, and dorsal views, x15.

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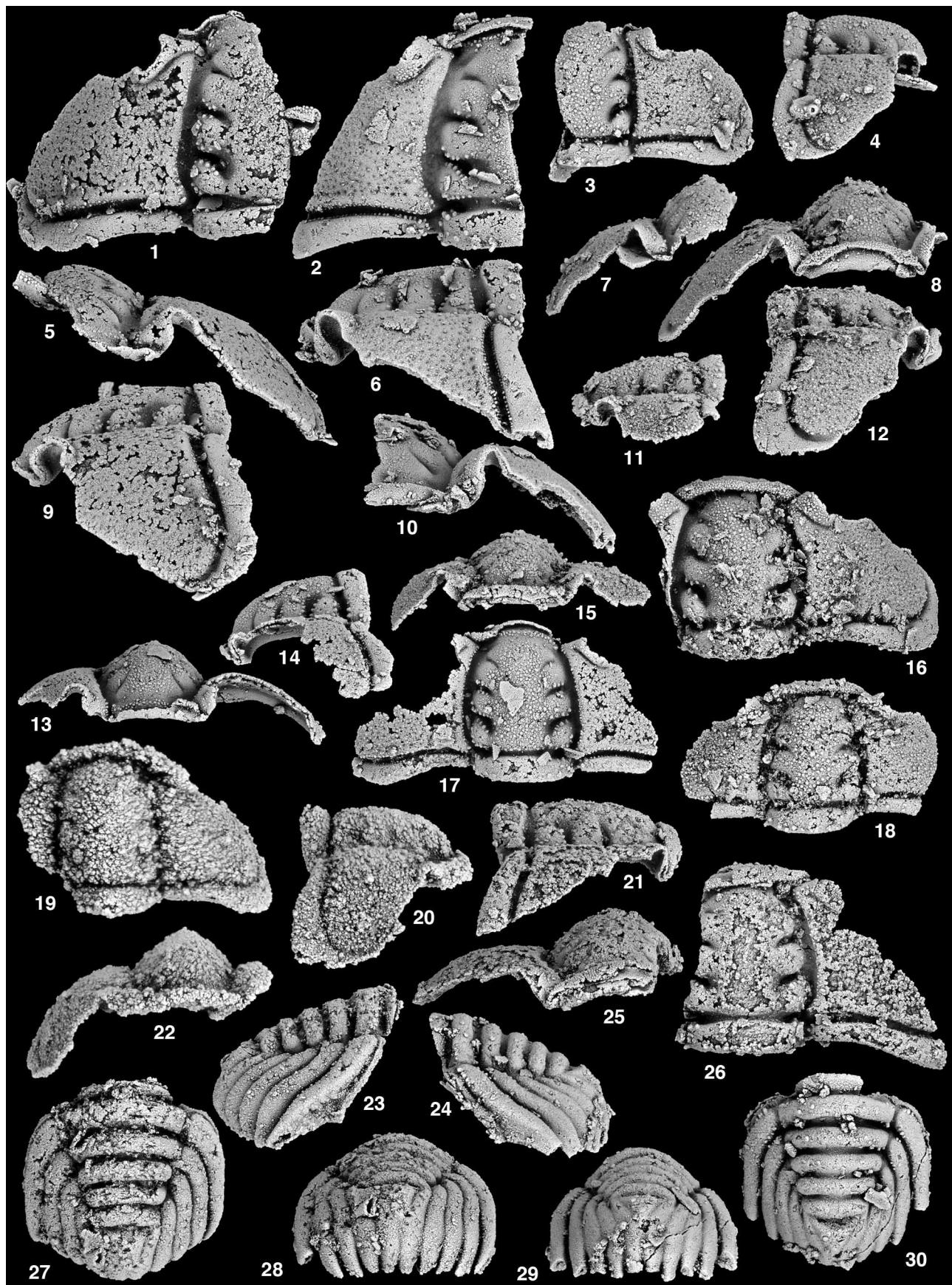


PLATE 37.

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PLATE 37. *Protopliomerella okeeffae n. sp.*, from Section G 238.3 m, Fillmore Formation (lower Floian; Tulean; *Heckethornia hyndae* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 5, 9. Cranium, SUI 126298, dorsal, anterior, and left lateral views, x10.
- 2, 6, 10. Cranium, SUI 126299, dorsal, left lateral, and anterior views, x10.
- 3, 4, 7. Cranium, SUI 126300, dorsal, right lateral, and anterior views, x12.
- 8, 12, 16. Cranium, SUI 126301, anterior, right lateral, and dorsal views, x10.
- 11, 15, 18. Cranium, SUI 126302, left lateral, anterior, and dorsal views, x12.
- 13, 14, 17. Cranium, SUI 126303, anterior, left lateral, and dorsal views, x10.
- 19, 20, 22. Cranium, SUI 126304, dorsal, right lateral, and anterior views, x20.
- 21, 25, 26. Cranium, SUI 126305, right lateral, anterior, and dorsal views, x10.
- 23, 27, 28. Pygidium, SUI 126306, right lateral, dorsal, and posterior views, x12.
- 24, 29, 30. Pygidium, SUI 126307, left lateral, posterior, and dorsal views, x12.

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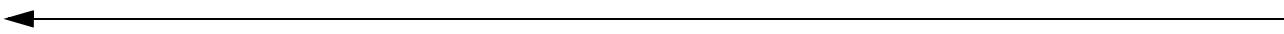


PLATE 38. *Protopliomerella okeeffae* n. sp., from Section G 238.3 m (lower Floian; Tulean; *Heckethornia hyndae* Zone) and Section H 93.4 m (lower Floian; Tulean; *Heckethornia bowiei* Zone), Fillmore Formation, southern Confusion Range, Ibex area, Millard County, western Utah, USA.

1. Right librigena, SUI 126308, external view, x12 (H 93.4 m).
2. Left librigena, SUI 126309, external view, x10 (H 93.4 m).
- 3, 6. Left librigena, SUI 126310, external and ventrolateral views, x12 (H 93.4 m).
4. Left librigena, SUI 126311, external view, x12 (H 93.4 m).
5. Left librigena, SUI 126312, external view, x12 (H 93.4 m).
7. Right librigena, SUI 126313, external view, x12 (H 93.4 m).
- 8, 10. Right librigena, SUI 126314, external and internal views, x10 (H 93.4 m).
9. Left librigena, SUI 126315, external view, x10 (H 93.4 m).
- 11, 13, 17. Left librigena, SUI 126316, external, internal, and ventrolateral views, x10 (H 93.4 m).
- 12, 15. Right librigena, SUI 126317, external and ventrolateral views, x15 (H 93.4 m).
- 14, 16. Right librigena, SUI 126318, external and ventrolateral views, x10 (H 93.4 m).
- 18, 24. Right librigena, SUI 126319, external and ventrolateral views, x12 (G 238.3 m).
19. Right librigena, SUI 126320, external view, x12 (G 238.3 m).
20. Left librigena, SUI 126321, external view, x10 (H 93.4 m).
- 21, 22, 27, 28. Thoracic segment, SUI 126322, dorsal, right lateral, anterior, and posterior views, x12 (H 93.4 m).
- 23, 25, 29, 33. Thoracic segment, SUI 126323, right lateral, dorsal, anterior, and posterior views, x7.5. (H 93.4 m).
- 26, 30, 34, 39. Thoracic segment, SUI 126324, dorsal, anterior, posterior, and left lateral views, x12 (H 93.4 m).
- 31, 32, 35, 40. Thoracic segment, SUI 126325, dorsal, right lateral, anterior, and posterior views, x12 (G 238.3 m).
- 36–38, 42. Thoracic segment, SUI 126326, posterior, anterior, left lateral, and dorsal views, x12 (G 238.3 m).
- 41, 43–45. Thoracic segment, SUI 126327, anterior, right lateral, posterior, and dorsal views, x12 (G 238.3 m).

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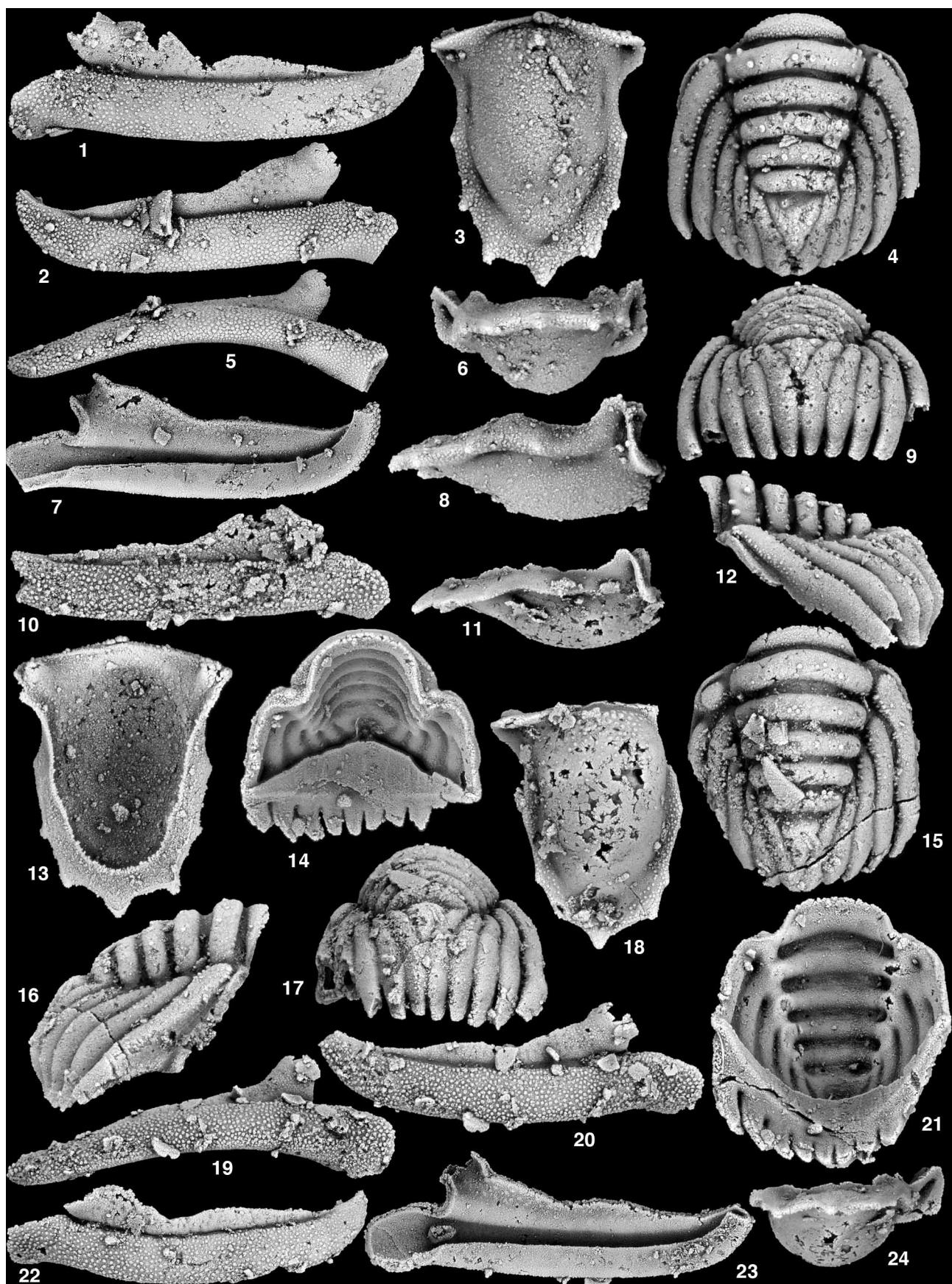


PLATE 39.

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PLATE 39. *Protopliomerella okeeffae n. sp.*, from Section G 258.2 m, Fillmore Formation (lower Floian; Tulean; *Heckethornia hyndae* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

1. Left librigena, SUI 126328, external view, x12.
- 2, 5, 7. Right librigena, SUI 126329, external, ventrolateral, and internal views, x12.
- 3, 6, 8, 13. Hypostome, SUI 126330, ventral, posterior, right lateral, and dorsal views, x20.
- 4, 9, 12. Pygidium, SUI 126331, dorsal, posterior, and left lateral views, x20.
10. Right librigena, SUI 126332, external view, x15.
- 11, 18, 24. Hypostome, SUI 126333, right lateral, ventral, and posterior views, x15.
- 14–17, 21. Pygidium, SUI 126334, anterior, dorsal, right lateral, posterior, and ventral views, x15.
- 19, 20, 23. Right librigena, SUI 126335, ventrolateral, external, and internal views, x15.
22. Left librigena, SUI 126336, external view, x12.

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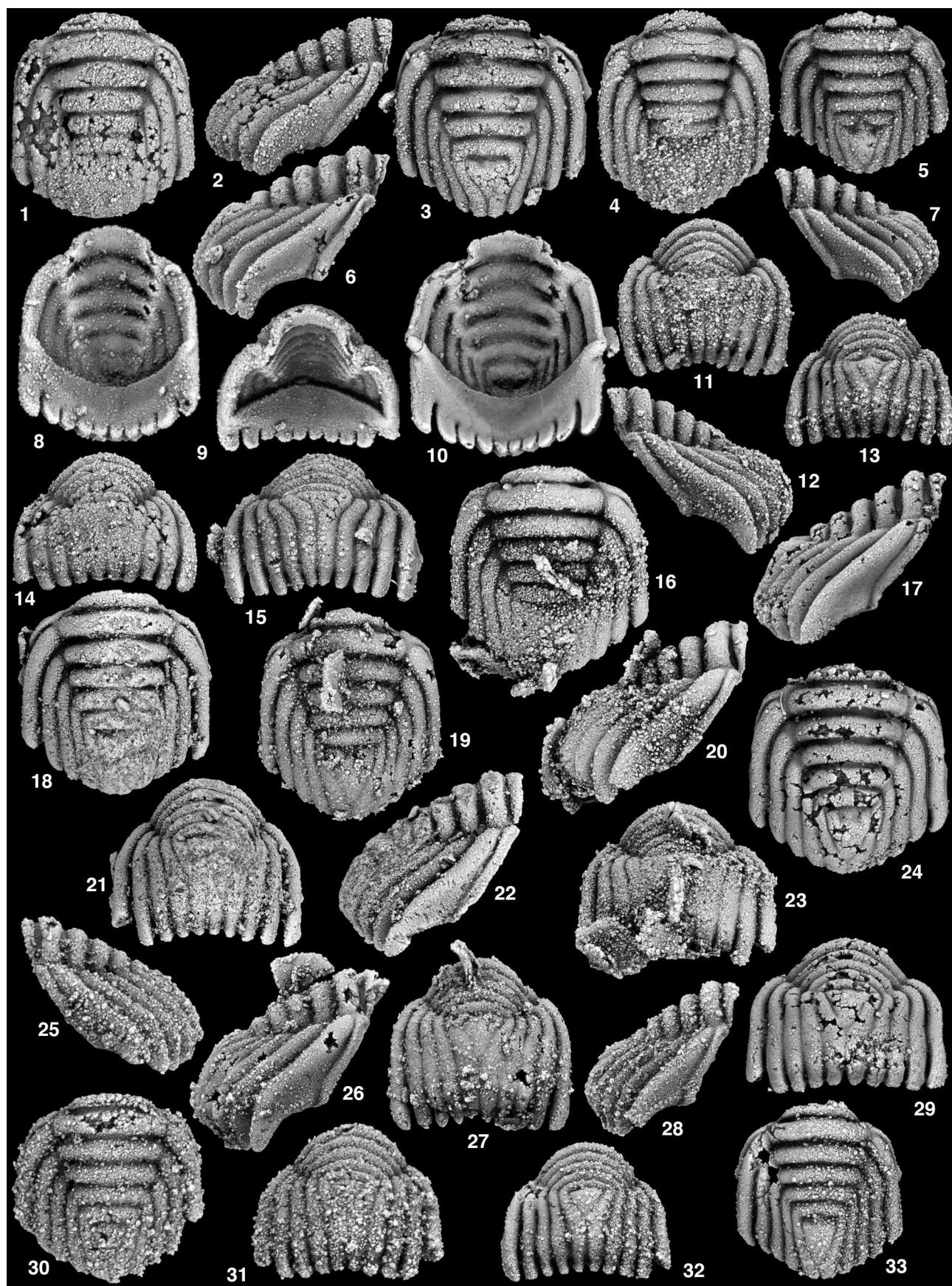


PLATE 40.

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PLATE 40. *Protopliomerella okeeffae n. sp.*, from Section H 93.4 m, Fillmore Formation (lower Floian; Tulean; *Heckethornia bowiei* Zone), southern Confusion Range, Ibex area, Millard County, western Utah, USA.

- 1, 2, 8, 9, 14. Pygidium, SUI 115288, dorsal, right lateral, ventral, anterior, and posterior views, x12.
- 3, 6, 10, 15. Pygidium, SUI 126337, dorsal, right lateral, ventral, and posterior views, x12.
- 4, 11, 12. Pygidium, SUI 126338, dorsal, posterior, and left lateral views, x15.
- 5, 7, 13. Pygidium, SUI 126339, dorsal, left lateral, and posterior views, x15.
- 16, 20, 23. Pygidium, SUI 126340, dorsal, right lateral, and posterior views, x15.
- 18, 21, 22. Pygidium, SUI 126341, dorsal, posterior, and right lateral views, x15.
- 19, 26, 27. Pygidium, SUI 126342, dorsal, right lateral, and posterior views, x15.
- 24, 26, 29. Pygidium, SUI 126343, dorsal, right lateral, and posterior views, x15.
- 25, 30, 31. Pygidium, SUI 126344, left lateral, dorsal, and posterior views, x20.
- 28, 32, 33. Pygidium, SUI 126345, right lateral, posterior, and dorsal views, x15.

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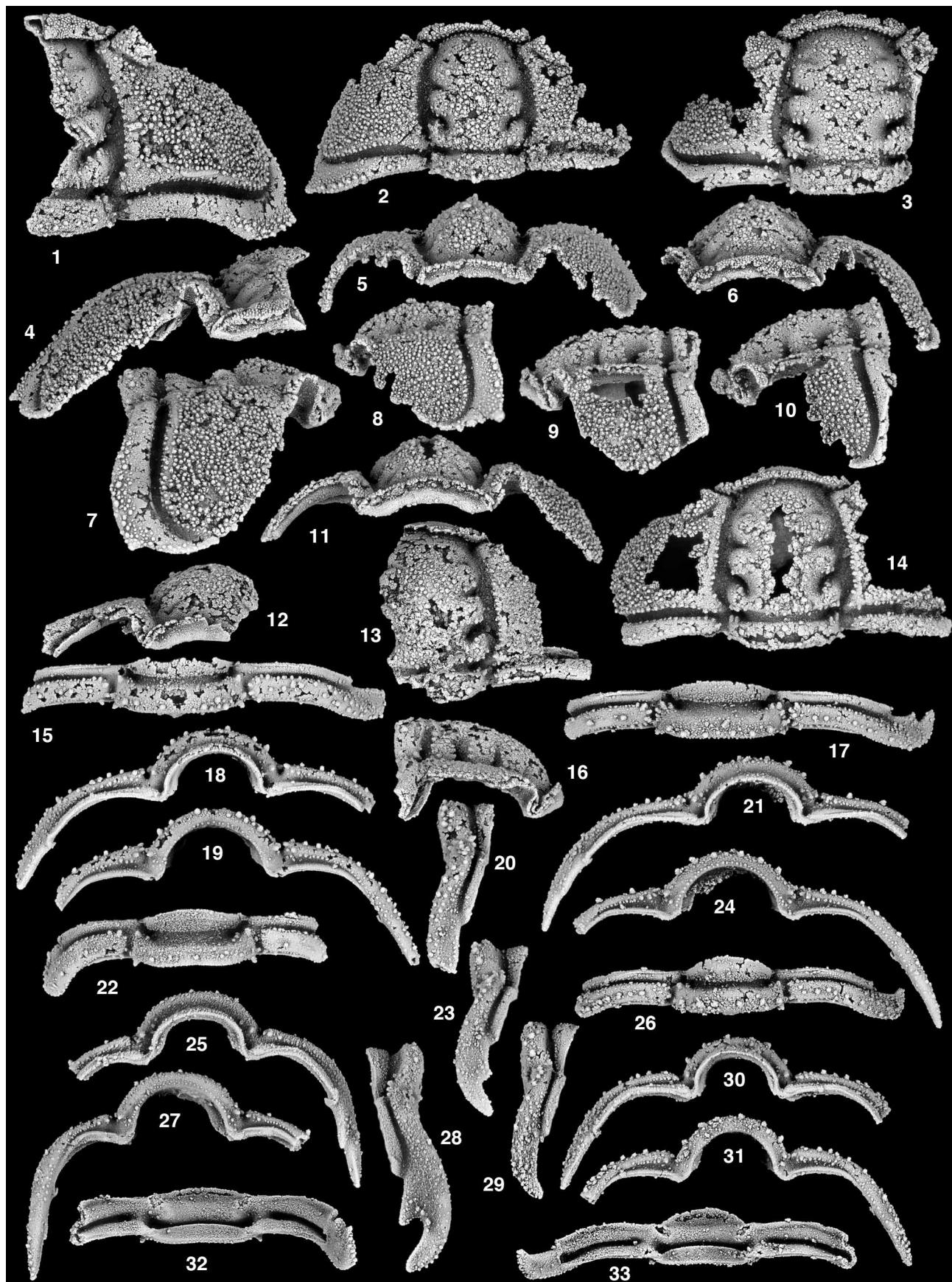


PLATE 41.

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PLATE 41. *Protopliomerella* n. sp. A, from Section YH 129.5 m, Yellow Hill Limestone (lower Floian; Tulean; *Heckethornia hyndae* Zone), Yellow Hill, near Pioche, Lincoln County, eastern Nevada, USA.

- 1, 4, 7. Cranidium, SUI 126346, dorsal, anterior, and right lateral views, x10.
- 2, 5, 8. Cranidium, SUI 126347, dorsal, anterior, and left lateral views, x15.
- 3, 6, 10. Cranidium, SUI 126348, dorsal, anterior, and left lateral views, x12.
- 9, 11, 14. Cranidium, SUI 126349, left lateral, anterior, and dorsal views, x12.
- 12, 13, 16. Cranidium, SUI 126350, anterior, dorsal, and right lateral views, x10.
- 15, 18, 19, 20. Thoracic segment, SUI 126351, dorsal, anterior, posterior, and right lateral views, x10.
- 17, 21, 23, 24. Thoracic segment, SUI 126352, dorsal, anterior, right lateral, and posterior views, x10.
- 22, 25, 27, 28, 32. Thoracic segment, SUI 126353, dorsal, anterior, posterior, left lateral, and ventral views, x10.
- 26, 29–31, 33. Thoracic segment, SUI 126354, dorsal, right lateral, anterior, posterior, and ventral views, x10.

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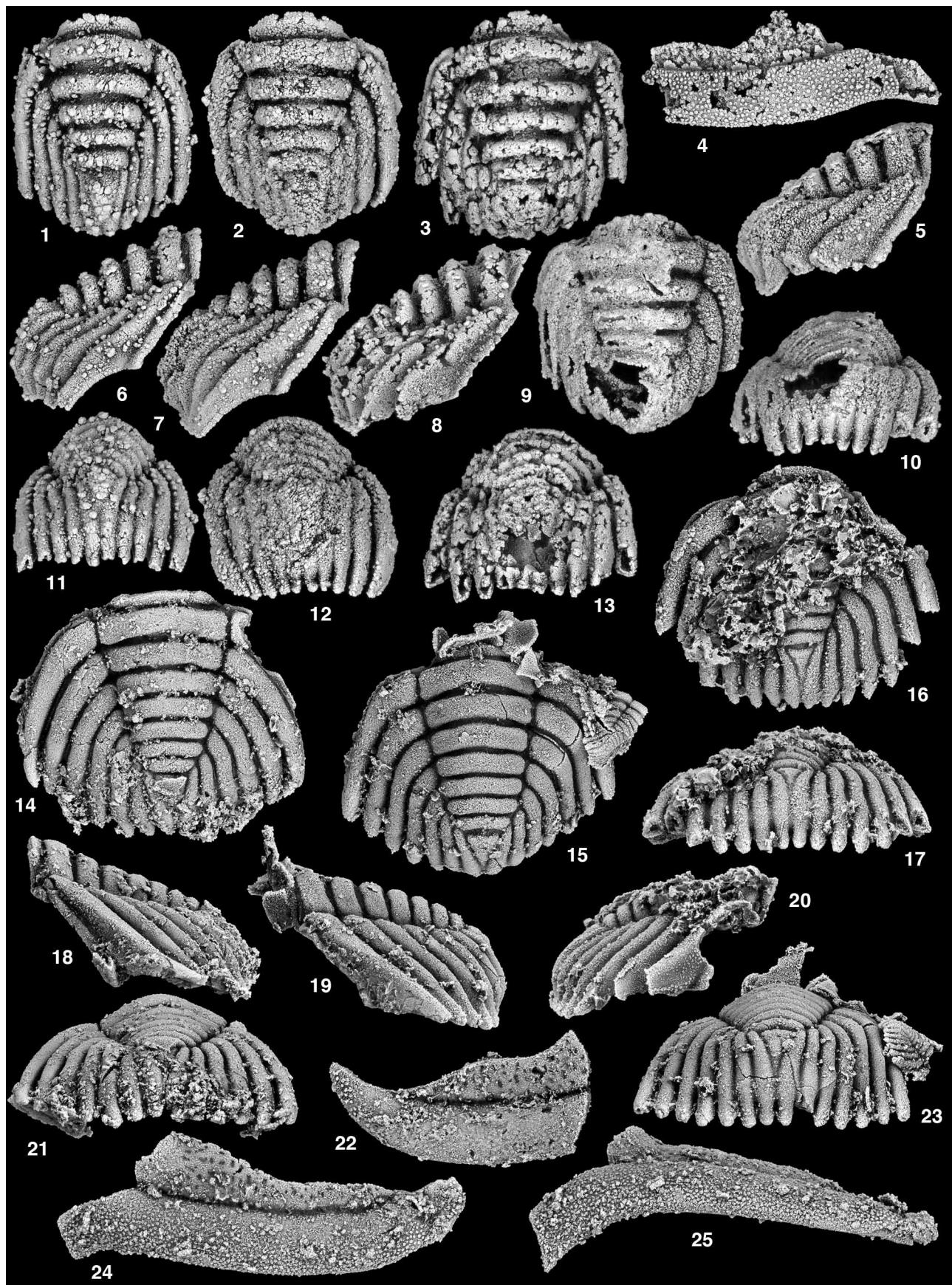


PLATE 42.

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PLATE 42. 1–13. *Protopliomerella* n. sp. A, from Section YH 129.5 m, Yellow Hill Limestone (lower Floian; Tulean; *Heckethornia hyndae* Zone), Yellow Hill, near Pioche, Lincoln County, eastern Nevada, USA.

- 1, 6, 11. Pygidium, SUI 126355, dorsal, right lateral, and posterior views, x15.
2, 7, 12. Pygidium, SUI 126356, dorsal, right lateral, and posterior views, x15.
3, 8, 13. Pygidium, SUI 126357, dorsal, right lateral, and posterior views, x15.
4. Right librigena, SUI 126358, external view, x12.
5, 9, 10. Pygidium, SUI 126359, right lateral, dorsal, and posterior views, x20.

14–25. *Protopliomerella* n. sp. B, from Section D 94.5T m, Fillmore Formation (Tulean; low *Psalikilopsis cuspidicauda* Zone), southern House Range, Ibex area, Millard County, western Utah.

- 14, 18, 21. Pygidium, SUI 126360, dorsal, left lateral, and posterior views, x10.
15, 19, 23. Pygidium, SUI 126361, dorsal, left lateral, and posterior views, x10.
16, 17, 20. Pygidium, SUI 126362, dorsal, posterior, and right lateral views, x12.
22. Right librigena, SUI 126363, external view, x12.
24, 25. Left librigena, SUI 126364, external and ventrolateral views, x12.