

TRILOBITES OF THE LOWER MIDDLE CAMBRIAN *POLIELLA DENTICULATA* BIOZONE (NEW) OF SOUTHEASTERN NEVADA

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ABSTRACT—Two new genera, *Poliellaites* and *Piochella*, and six new species, *Eokochaspis? cabinensis*, *Nyella? plana*, *Poliellaites gloriosa*, *Piochella peasleensis*, *Poliella ovala*, and *Stephenaspis highlandensis*, are described from the Susan Duster Limestone and Log Cabin members, Pioche Shale. *Kochaspis* Resser, 1935, and *Kochaspis liliana* (Walcott, 1886) are redescribed based on new material. In addition, several species from the Pioche Shale, that are not addressed in our previous reports are discussed in relationship to existing species and local occurrence. The trilobite diversity of the *Poliella denticulata* Biozone (new) within the study area is 17 genera and 35 species, occurring in five faunal assemblages.

INTRODUCTION

THIS IS THE fifth (Eddy and McCollum, 1998; Sundberg and McCollum, 1997, 2000, 2002) and final contribution on the taxonomy of early Middle Cambrian trilobites of the Pioche Shale within the type region of eastern Nevada and equivalent-age faunas from the Carrara Formation in the northern Groom Range, central Nevada (Fig. 1). Seventeen genera and 35 species of trilobites occur within the *Poliella denticulata* Biozone (new; Fig. 2) in the southern Great Basin and represent five faunal assemblages (Fig. 3). They are the *Poliella denticulata*, *Fieldaspis celer*, *Syspacephalus longus*, *Poliellaites gloriosa*, and *Kochiella augusta* assemblages.

LITHOSTRATIGRAPHY

The trilobite faunas discussed in this report were recovered from the Susan Duster Limestone Member and the overlying Log Cabin Member of the Pioche Shale and the correlative interval in the Pyramid Shale Member of the Carrara Formation, northern Groom Range (Figs. 3–7). The study interval ranges in thickness from 85 m in the Highland Range to 55 m in the Pioche Hills (Fig. 4), and is bounded by regional disconformities.

The 4.5-to-6.8-meter-thick Susan Duster Limestone Member is the first regionally extensive carbonate above the Lower Cambrian Combined Metals Member (Beaver et al., 2001). The thin-bedded nature of this member is somewhat masked by the massive, ledge-forming appearance in outcrop. Bedding plane partings are uncommon, even though bedding surfaces weather in relief and are compositionally distinct, consisting of a mixture of siliciclastic clays and silts with variable amounts of lime mud and microspar. Outcrop exposures and polished sections show that the bedding surfaces are often disrupted, probably due to compaction and dewatering, causing the beds to be annealed. There was no evidence of bioturbation, either within or upon the bedding surfaces in the Susan Duster Limestone Member.

In the southern sections within the Delamar Mountains and the Antelope Canyon section of the southern Chief Range, the Susan Duster Limestone Member is a uniformly thin-bedded carbonate that has been recrystallized. In the northern sections within the Highland Range, Pioche Hills, and the Klondike Gap section in the Chief Range, an influx of siliciclastic mud in the middle of the Susan Duster Limestone Member gives a distinctive tripartite division, beginning with a lower, two-meter-thick ledge of limestone, overlain by a meter or two of shale and limestone nodules, capped by another meter or more of thin to nodular bedded limestone.

In the northern part of the study area, which includes the type section of the Pioche Shale, Merriam (1964) observed that although the Susan Duster Limestone Member appeared to be medium grained, it had a fine-grained matrix that had seams and

spots of crystalline calcite. Merriam (1964, p. 22) also noted that bioclastic beds occurred in the Susan Duster Limestone Member, and that the shell fragments were so numerous as to constitute a coquina. He was probably referring to the basal beds of the member, which are composed of light-colored, bioclastic and microspar layers that contain granule-to-pebble size noncarbonate and carbonate clasts. Tangential cross-bedding is common in the basal beds.

The Susan Duster Limestone Member was deposited on top of an erosional surface, resulting in a sharp contact with progressively lower horizons to the east (toward the craton) within the underlying Comet Shale Member. Rapid deposition of individual beds can be inferred from the presence of tangential cross-stratification, the chaotic mixture of mud and larger grains, the presence of sediment injection from one bed to another, and the absence of bioturbation. The overall fining upward nature of the sequence is in keeping with a deepening environment where the carbonate source area was becoming more distal.

The Log Cabin Member is predominantly a bioturbated mudstone to sandstone, with thin limestone intervals. The member ranges in thickness from 80 m in the Highland Range to approximately 50 m in the Pioche Hills to the east. The thinning is due to an erosional unconformity at the top of the member (Sundberg and McCollum, 2000).

The Highland Range has one of the thickest and most complete sections of the Log Cabin Member (Fig. 4). The lower 30-m interval consists of a bioturbated, silty, dusky yellow mudstone with an ichnofauna that includes abundant *Teichichnus rectus* and *Bifungites* sp.; common *Planolites beverleyensis*; and occasional *Cruziana* and *Skolithos*. A meter-thick, stenotheconid-rich limestone separates this unit from the overlying 22-meter-thick, bioturbated silty mudstone interval with several quartz arenite beds containing an ichnofauna including *Skolithos* and *Psammichnites*. A two-meter-thick, oncolitic limestone separates the middle clastic interval from the upper 23-meter-thick, bioturbated silty mudstone, with thin interbedded sandstone and limestone beds. The sandier facies contains an ichnofauna consisting of *Psammichnites*, *Rusophycos*, *Cruziana*, *Scolicia*, and *Skolithos*.

Together, the Susan Duster Limestone and Log Cabin members constitute a fourth- or fifth-order cycle bounded by erosional surfaces. The fining- and deepening-upward nature of the Susan Duster Limestone Member is consistent with a transgressive systems tract deposit. The overall lithostratigraphic package of the Log Cabin Member is of a coarsening and shallowing upward succession, consistent with a highstand systems tract deposit. The maximum flooding surface or interval is within the dark siltshales containing the *Fieldaspis celer* assemblage, at the base of the Log Cabin Member.

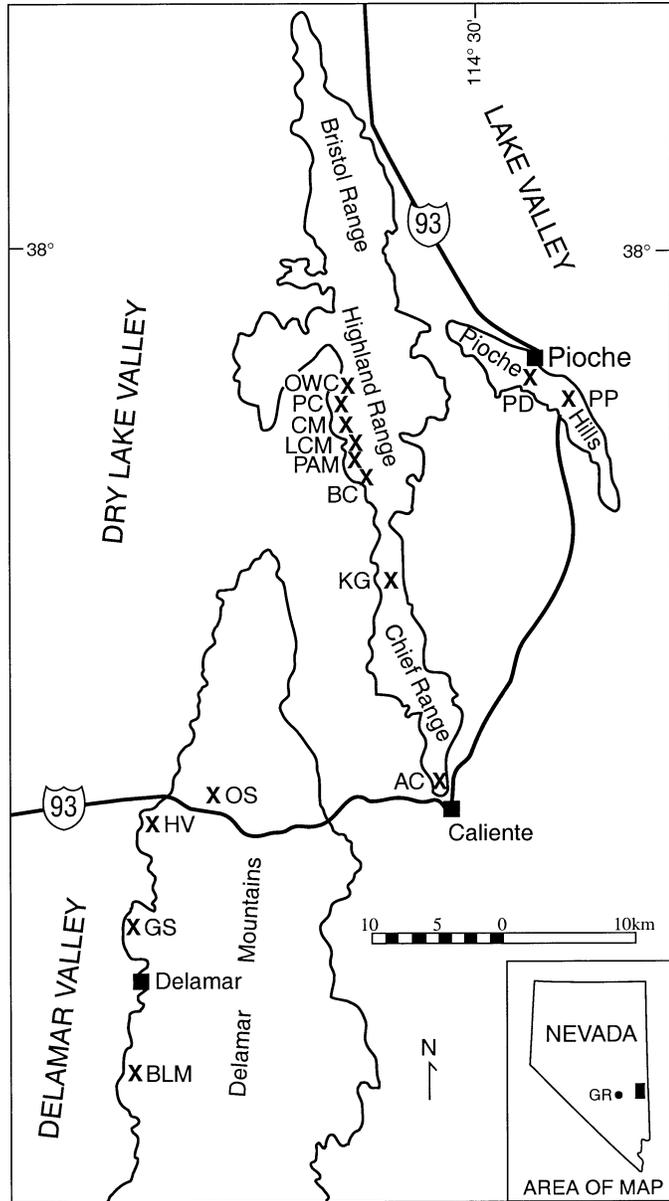


FIGURE 1—Location map of the stratigraphic sections and faunas of the Susan Duster Limestone and Log Cabin members, Pioche Shale, and Pyramid Shale Member, Carrara Formation, Lincoln County, Nevada. Sections: AC = Antelope Canyon; BC = Black Canyon; BLM = Big Lime Mountain; CM = Comet Mine; GR = Groom Range; GS = Grassy Spring and Grassy Springs Wash; HV = Hidden Valley; KG = Klondike Gap; LCM = Log Cabin Mine; OS = Oak Springs; OWC = One Wheel Canyon; PAM = Pan American Mine and Lyndon Gulch; PC = Peaslee Canyon; PD = Pioche Divide; and PP = Old Pioche-Panaca Road and Highway 93 Roadcut.

Biozones This Paper	Deiss 1939	Howell 1944	Rasetti 1951	Lochman-Balk & Wilson 1958
<i>Albertella</i>	<i>Albertella</i>	<i>Albertella</i>	<i>Albertella</i>	<i>Albertella</i>
<i>Poliella denticulata</i>	Kochaspis Zone	Kochaspis liliana Zone	Plagiura-Kochaspis Zone	Plagiura-Poliella Zone
	Plagiura Zone			
<i>Amecephalus arjosensis</i>		Syspacephalus Zone	Wenkchemnia-Stephenaspis Zone	
<i>Eokochaspis nodosa</i>				
<i>Olenellus</i>	<i>Olenellus</i>	<i>Olenellus</i>	<i>Olenellus</i>	<i>Olenellus</i>

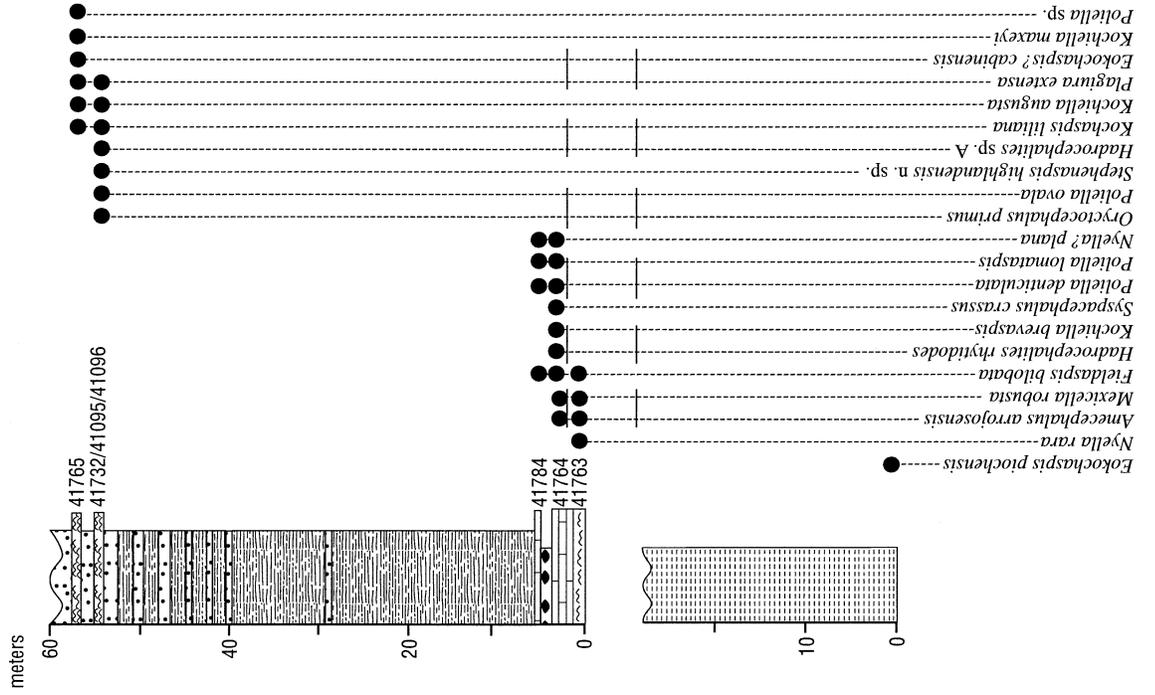
FIGURE 2—Generalized biostratigraphic correlation chart of the biozones proposed here and those previously named for interval between the *Olenellus* and *Albertella* biozones. The thick dashed lines represent where various authors placed the Lower-Middle Cambrian boundary. The biozones of Rasetti represent, in part, biofacies based on the dominance of shales in the *Wenkchemnia-Stephenaspis* Zone and limestone in the *Plagiura-Kochaspis* Zone and preliminary work on the deeper-water faunas in Nevada and California (unpublished data).

Biozones	Assemblages	Pioche Shale	Carrara Fm.	Assemblages
<i>Albertella</i>		Grassy Spring	Red Pass Limestone	
<i>Poliella denticulata</i>	<i>Kochiella augusta</i>	Log Cabin	Pyramid Shale	<i>Kochiella augusta</i>
	<i>Poliellaites gloriosa</i>			
	<i>Fieldaspis celer</i>			
	<i>Poliella denticulata</i>			<i>Syspacephalus longus</i>
<i>Amecephalus arjosensis</i>		Susan Duster Lms.		<i>Poliella denticulata</i>
<i>Eokochaspis nodosa</i>		Comet Shale		
<i>Olenellus</i>		Combined Metals	Gold Ace Limestone	

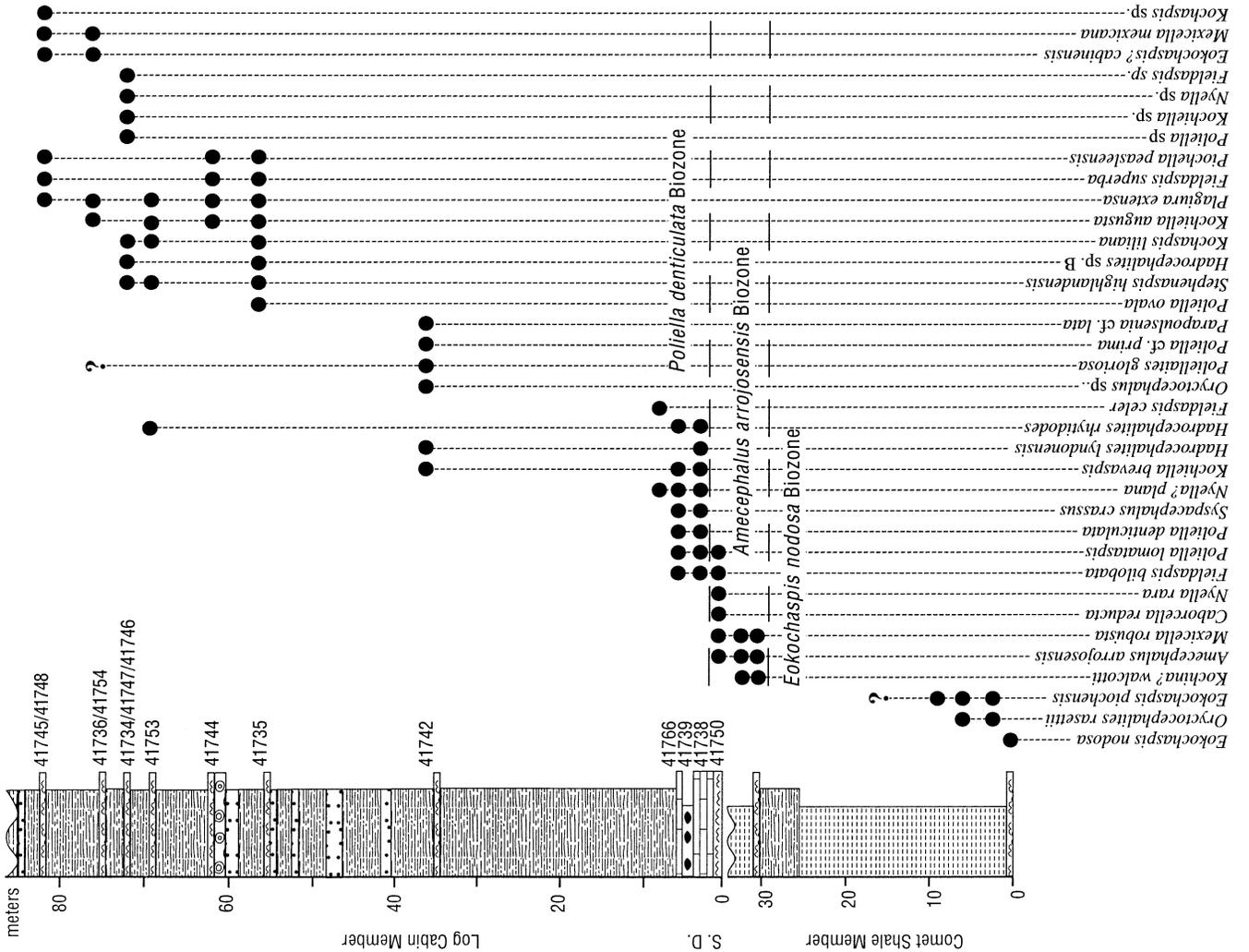
FIGURE 3—Biozones, faunal assemblages, and stratigraphic nomenclature of the Pioche Shale (from Sundberg and McCollum, 2000; here in) and part of the Carrara Formation (from Palmer and Halley, 1979) showing lithologic and chronostratigraphic equivalency of the units. The *Kochiella augusta* assemblage from the Carrara Formation is based on collections reported by Palmer and Halley, 1979. A. R. Palmer (personal commun., 2002) no longer believes that the Carrara Formation should be used in the Groom and Belted Range sections, and that a new formational scheme in this region is warranted. Therefore the use of the Carrara members in this chart is tentative.

FIGURE 4—Composite columnar stratigraphic sections of the Comet Shale, Susan Duster Limestone, and Log Cabin members, Pioche Shale, in the Highland Range and Pioche Hills, Nevada, and occurrence of trilobites (dots). Construction of the Highland Range composite section is based on data from several measured sections along the west side of the range from just south of the Pan American Mine northward 5.5 km to One Wheel Canyon. The Pioche Hills composite section is constructed from the type section of the Pioche Shale at Pioche Divide and partial sections to the west and south of Gray Cone, along U.S. Highway 93 and in the vicinity of the old Pioche-Panaca road. Lithologic key is given in Figure 7.

Pioche Hills



Highland Range



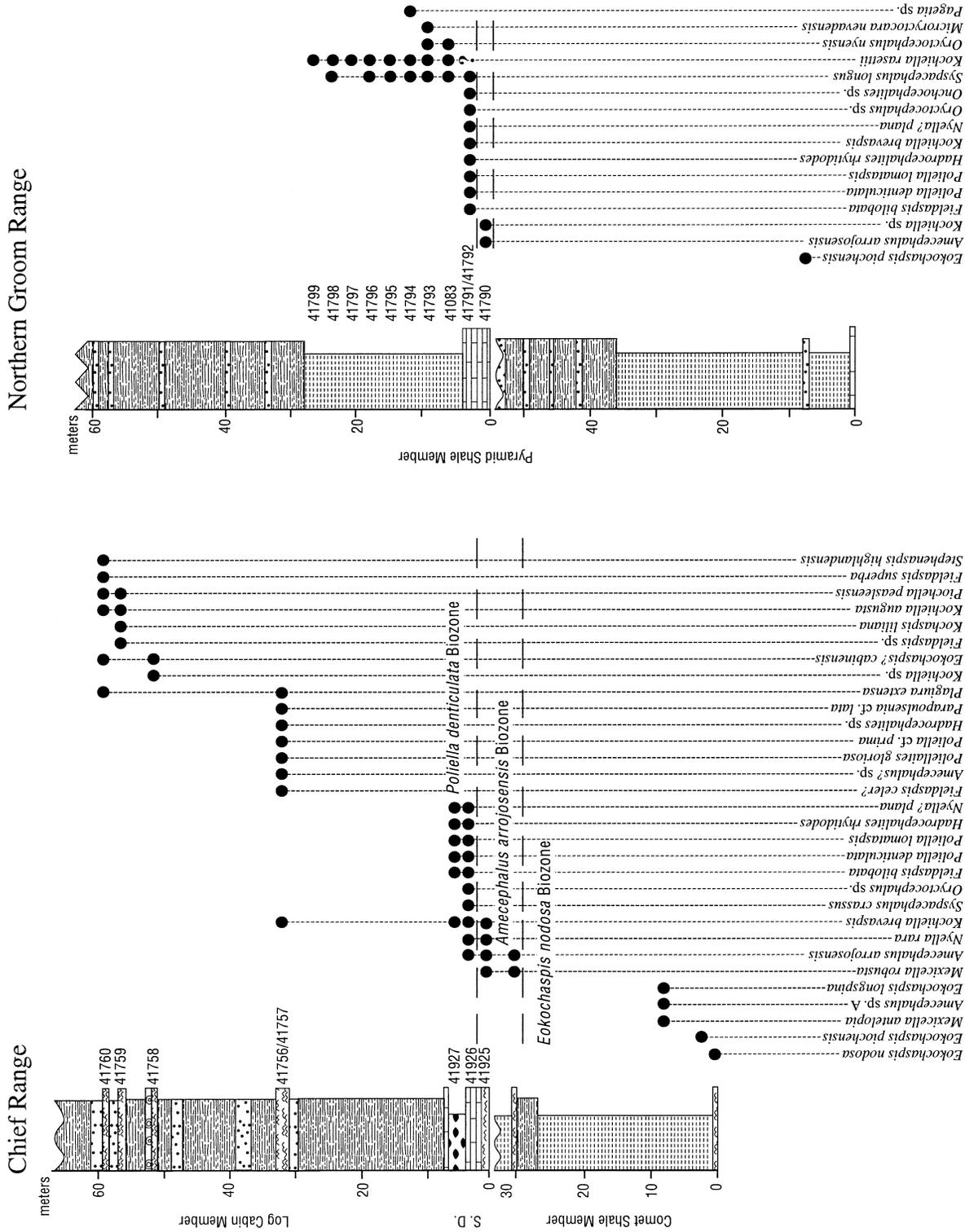


FIGURE 5.—Composite columnar stratigraphic section of the Comet Shale, Susan Duster Limestone, and Log Cabin members, Pioche Shale, in the Chief Range, Nevada, and occurrence of trilobites (dots). Construction of the Chief Range composite section is based on data from the upper and lower Klondike Gap measured sections. The columnar stratigraphic section of the Pyramid Shale Member, Carrara Formation, northern Groom Range, is from a single measured section. Lithologic key is given in Figure 7.

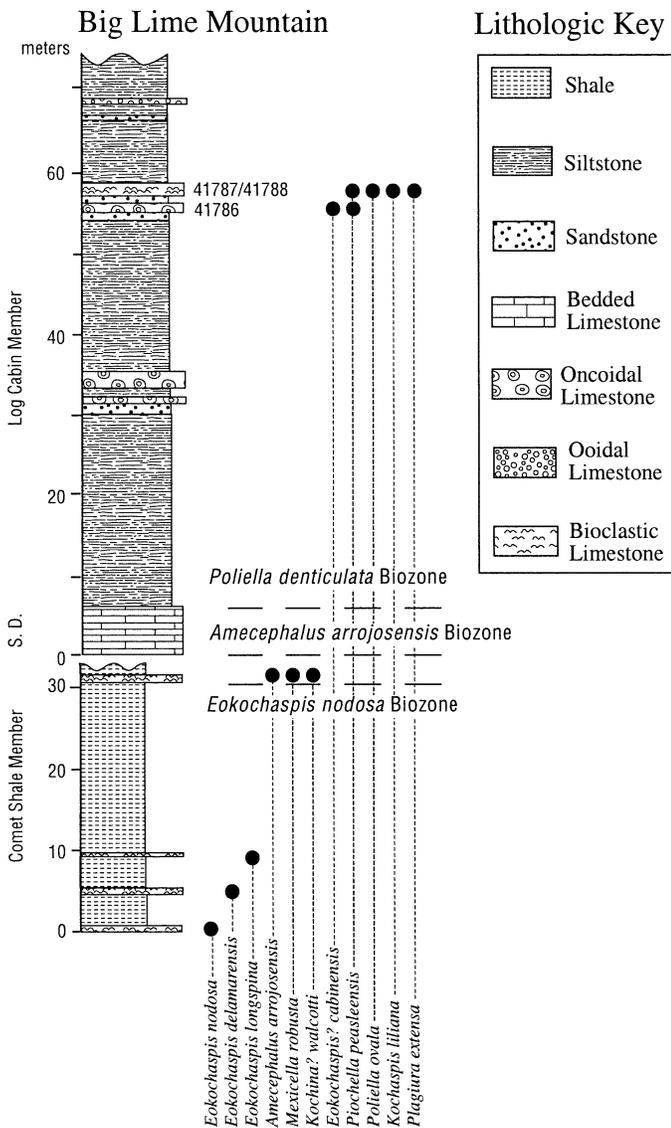


FIGURE 7—Columnar stratigraphic section of the Comet Shale, Susan Duster Limestone, and Log Cabin members, Pioche Shale, at Big Lime Mountain, Delamar Mountains, Nevada, and occurrence of trilobites (dots).

BIOSTRATIGRAPHY

The biostratigraphic interval between the *Olenellus* Zone of Walcott (1890) and the *Albertella* Zone of Deiss (1939) has variably been referred to as the *Plagiura* Zone (Deiss, 1939), *Syspacephalus* and *Kochaspis liliana* zones (Howell, 1944), *Wenkchennia-Stephenaspis* and *Plagiura-Kochaspis* zones (Rasetti, 1951), and *Plagiura-Poliella* Zone (Lochman-Balk and Wilson, 1958). Each of these range zones was primarily based on one or more genera and do not meet the criteria currently recommended for establishing biozones (Salvador, 1994). Three species-based biozones are now recognized by Sundberg and McCollum (2000, herein; Figs. 2, 3) in the post-*Olenellus*, pre-*Albertella* interval of the southern Great Basin. These biozones are the *Eokochaspis nodosa*, *Amecephalus arrojensis*, and *Poliella denticulata* (new) biozones.

Poliella denticulata Rasetti, 1951, is the oldest known species of that genus and has a wide geographic extent, from the southern

Great Basin to the southern Canadian Rocky Mountains (Rasetti, 1951). The first appearance datum of this species, which occurs in the basal meter of the Susan Duster Limestone Member, is used to define the base of the *Poliella denticulata* Biozone, which lies immediately above the *Amecephalus arrojensis* Biozone and is overlain by the *Albertella aspinosa* Subbiozone of the *Albertella* Biozone in the southern Great Basin (Eddy and McCollum, 1998). The reference section for the *P. denticulata* Biozone is in the type section of the Pioche Shale at Pioche Divide in the Pioche Hills.

The *Poliella denticulata* Biozone contains five faunal assemblages, that have a stratigraphically and geographically limited distribution (Fig. 3). The lowest assemblage is the *Poliella denticulata* assemblage, found in the Susan Duster Limestone Member and in an equivalent limestone within the Pyramid Shale Member of the northern Groom and Belted ranges. This assemblage is characterized by numerous specimens of this species, as well as *Poliella lomataspis* Palmer (in Palmer and Halley, 1979) and *Fieldaspis bilobata* Rasetti, 1951. Less common trilobites in this assemblage include *Amecephalus arrojensis* (Lochman, 1952); *Kochiella brevaspis* Sundberg and McCollum, 2002; *Hadrocephalites rhytidodes* Sundberg and McCollum, 2002; *Nyella? plana* n. sp.; and *Syspacephalus crassus* Rasetti, 1951, and rare occurrences of *Caborcella reducta* Palmer (in Palmer and Halley, 1979), and *Oryctocephalus* sp. This assemblage is equivalent to the *Poliella lomataspis* "zonule" of Palmer and Halley (1979).

The *Fieldaspis celer* assemblage occurs in a thin (<0.5-m-thick), dark siltstone interval at the base of the Log Cabin Member, Pioche Shale. This assemblage is characterized by large articulated specimens of *Fieldaspis celer* (Walcott, 1917b) and specimens of *Hadrocephalites* sp., *Kochiella* sp., and *Nyella? plana*.

The *Syspacephalus longus* assemblage occurs within a 20-to-25 m thick, dark shale interval that overlies the Susan Duster Limestone Member equivalent within the Pyramid Shale Member of the northern Groom and Belted ranges. This assemblage begins at about the same stratigraphic position as the *Fieldaspis celer* assemblage, but occurs in a more oceanward position. The relatively large size of *S. longus* Palmer (in Palmer and Halley, 1979), its common occurrence within the shale, and the limonitic infillings of the often complete carapaces makes this an easily recognizable faunal interval. Rarer faunal elements include *Kochiella rasettii* Sundberg and McCollum, 2002; *Microrhyctocara nevadensis* Sundberg and McCollum, 1997; *Oryctocephalus nyensis* Palmer (in Palmer and Halley, 1979); and *Pagetia* sp.

The *Poliellaites gloriosa* assemblage occurs in *Stenothecoides*-rich limestones occurring 24-to-30 m above the base of the Log Cabin Member. The dark gray limestone contains numerous *Stenothecoides elongata* (Walcott, 1886) and *Latouchella arguta* (Resser, 1939b), along with the trilobites *Poliellaites gloriosa* n. gen. and sp.; *Poliella* cf. *prima* (Walcott, 1908); *Kochiella brevaspis*; *Hadrocephalites lyndonensis* Sundberg and McCollum, 2002; *Parapoulsenia* cf. *lata* Rasetti, 1957; and *Plagiura extensa* Palmer (in Palmer and Halley, 1979).

The *Kochiella augusta* assemblage occurs in sandy bioclastic limestones in the upper portion of the Log Cabin Member. Common taxa are *Kochiella augusta* (Walcott, 1886), *Kochaspis liliana* (Walcott, 1886), *Piochella peasleensis* n. gen. and sp., *Plagiura extensa*, and *Fieldaspis superba* Rasetti, 1951. Rarer taxa are *Stephenaspis highlandensis* n. sp., *Eokochaspis? cabinensis* n. sp., *Poliella ovata* n. sp., and *Oryctocephalus primus* Walcott, 1886. This assemblage is equivalent to the *kochaspis* "zonule" of Palmer and Halley (1979).

ABBREVIATIONS AND MEASUREMENTS

Described specimens are deposited in the U.S. National Museum of Natural History, Washington, D.C. (USNM). Measurements used are illustrated in Figure 8. Terminology and abbreviations are derived from Shaw (1957), Whittington and Kelly (in

Kaesler, 1997), and Sundberg and McCollum (1997, 2000). Sagittal (sag.) and exsagittal (exsag.) measurements are referred to as lengths and transverse (trans.) measurements are referred to as widths. Only larger holaspids were used for measurements. Measurements are given as averages plus one standard deviation when five or more specimens are measured. Ranges of percentages are given if two to four specimens were measured, and these ranges are rounded off to the nearest five percent (e.g., 54 percent would be listed as 55 percent). The term approximately is given when only one specimen was measured, or if two to four specimens were measured, but their range rounded to a single 5 percentage (e.g., 54 to 57 percent is listed as approximately 55 percent). Under "Material examined," illustrated and measured specimens are listed by their USNM numbers, but unfigured specimens are listed by the number of cranidia and librigenae from each locality.

All photographed specimens were coated with colloidal graphite (except previous USNM type specimens) and ammonium chloride sublimate.

SYSTEMATIC PALEONTOLOGY

Discussion of previously named taxa is limited to those that either have not been recently documented (Sundberg and McCollum, 1997, 2000, 2002) or for which new materials have provided additional information. *Mexicella mexicana* Lochman, 1948, and *Kochiella janglensis* Palmer (in Palmer and Halley, 1979) have been thoroughly illustrated and discussed by Lochman (1948, 1952) and Palmer and Halley (1979). Taxa listed as "sp." in the locality register and Figures 4–7 are probably conspecific with other taxa found at the same stratigraphic horizon in other sections; but these specimens lack sufficient, well-preserved material to allow specific assignment. Some taxa were also left in open nomenclature because of the lack of sufficient, well-preserved material to provide adequate descriptions.

Class TRILOBITA Walch, 1771

Order CORYNEXOCHIDA Kobayashi, 1935

Family DOLICHOMETOPIDAE Walcott, 1916

POLIELLAITES new genus

Type species.—*Poliellaites gloriosa* n. gen. and sp.

Diagnosis.—Cranidium with slightly expanding glabella, palpebral lobes moderately short, and posterior area of the fixigena tapered. Pygidium subrectangular with maximum width near anterior end of axis; pleural and axial ring furrows moderately strong; anterior border poorly defined, anterior border furrow absent; margin upturned; each anterior pleural band with long, upturned spines.

Etymology.—Greek, *ites* = likeness, for the cranidial likeness to *Poliella*.

Discussion.—*Poliellaites* can be distinguished from *Poliella* Walcott, 1916, by its distinctive pygidium with an upturned margin, long upturned spines, and moderately developed pleural bands and furrows. The cranidia are similar to *Poliella*, but can be distinguished from *Poliella* in having stronger lateral glabellar furrows, slightly expanded glabella, and shorter palpebral lobes. *Poliellaites* can be distinguished from *Wenkchemnia* Rasetti, 1951, by its less expanding glabella, upturned pygidial margin, better developed and upturned pygidial spines, and more poorly defined anterior border and border furrow.

POLIELLAITES GLORIOSA new species

Figure 9.1–9.9

Diagnosis.—Same as for genus.

Description.—Cranidium moderate size, length 7.5 ± 0.6 mm ($n = 5$); subtrapezoidal; moderate convexity (sag. and trans.); anterior margin moderately curved, straight laterally; posterior margin, excluding occipital ring, straight to distally directed

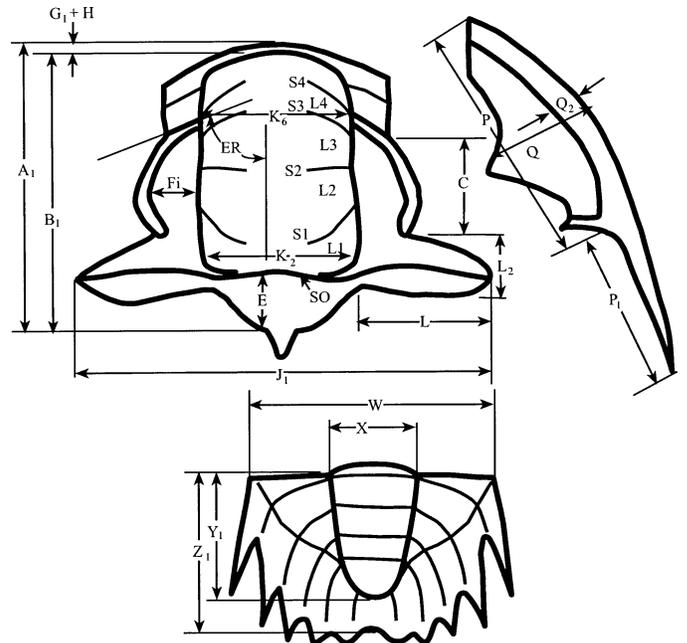


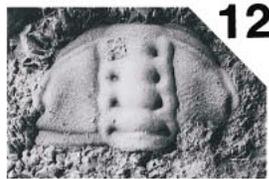
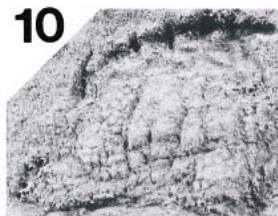
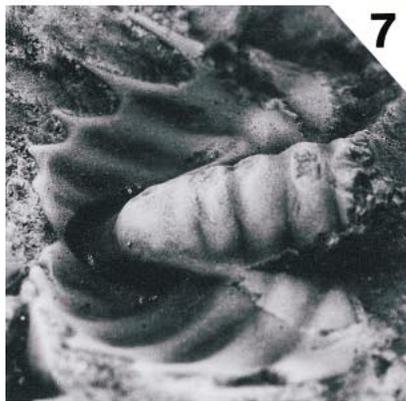
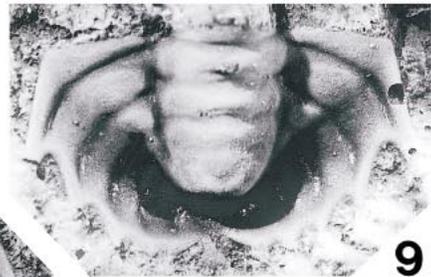
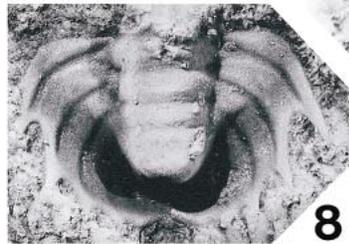
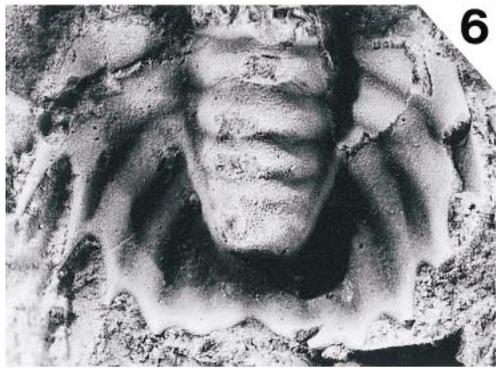
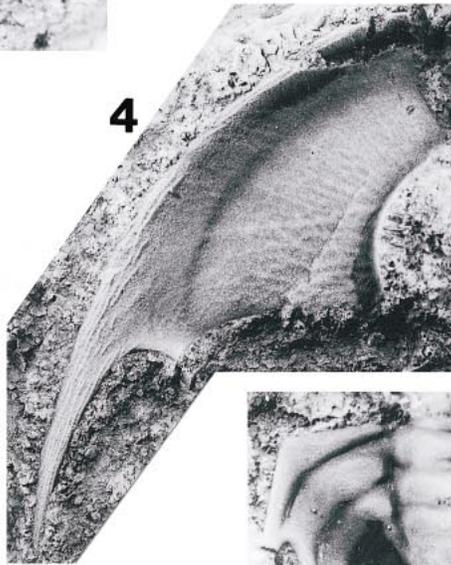
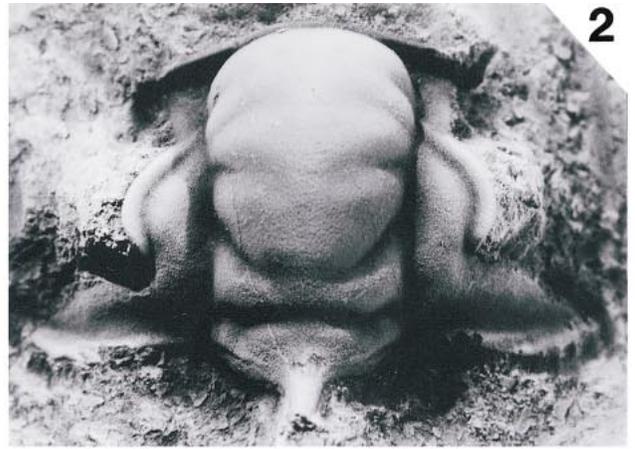
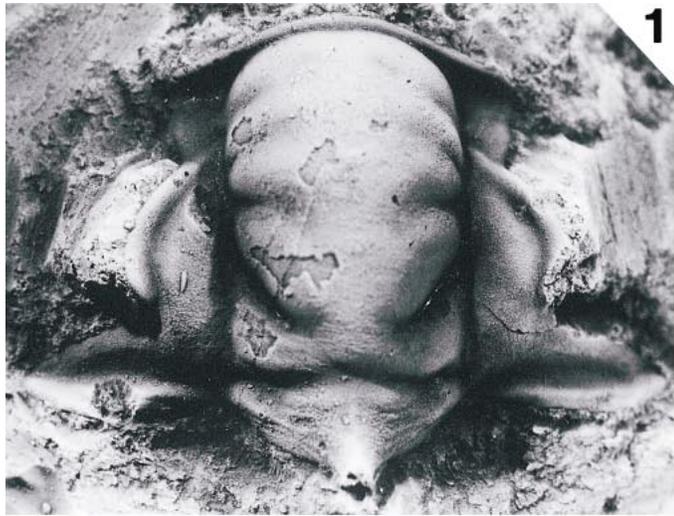
FIGURE 8—Measurements and lobe and furrow labels used in the trilobite descriptions.

slightly anterolateral. Anterior branches of facial sutures slightly to moderately divergent to border furrow and then moderately convergent to anterior margin; posterior branches strongly divergent to posterior margin. Glabella elongated, slightly expanding, width at anterior end 110 ± 9 percent glabellar width (K_2); moderate convexity (sag. and trans.); frontal lobe rounded; length 97 ± 1 percent cranidial length; width 34 ± 2 percent cranidial width. Axial furrow shallow, slightly concave in outline; preglabellar furrow moderately shallow. Lateral glabellar furrows deep to moderately deep, S1 directed posteriorly, S2 directed laterally, S3 and S4 directed anteriorly. Occipital ring moderately convex, length 21 ± 2 percent glabellar length; occipital spine present; posterior margin convex. SO forms a broad "W" shape; deep, shallower medially. Anterior border flat, longer laterally, upturned. Anterior border furrow absent. Fixigena flat to slightly concave, level, width 37 ± 2 percent glabellar width (K_2). Palpebral lobes crescent shape, level to slightly upturned, narrow and moderately long, length 33 ± 2 percent glabellar length; anterior margin located opposite S3 or L3. Ocular ridge short, moderately strong, straight, directed strongly posterolaterally from glabella at 45 to 50 degrees to axis. Posterior area of fixigena strap-like, downsloping, narrowing laterally, sharply terminated; length 25 ± 2 percent glabellar length; width 100 to 105 percent glabella length.

Librigena moderate size, length 4.4 to 7.4 mm ($n = 3$); moderately wide, width approximately 50 percent length without spine; lateral margin moderately curved. Genal field moderately convex. Border concave to flat posteriorly, upturned anteriorly; width 25 to 30 percent librigenal width; border furrows moderately shallow. Genal spine narrow, curved, moderately long, 45 to 50 percent librigenal length.

Rostral plate, hypostoma, and thorax unknown.

Pygidium moderate size, length 4.2 ± 1.1 mm ($n = 5$); subrectangular, length 68 ± 4 percent width; moderately concave (sag. and trans.); posteromedial notch present. Margin with four to five spines, narrow, flattened, shorter posteriorly, posteriorly directed, upturned. Axis slightly tapered, anterior width 38 ± 4 percent pygidial width, length 80 ± 5 percent pygidial length,



postaxial ridge weak; three to four axial rings, strongly convex, node on anterior segment; terminal axial piece small, rounded; axial ring furrows moderately deep. Pleural regions with five anterior pleural furrows moderately wide and moderately deep to shallow, extending to near posterior of spine base; interpleural furrows faint; first anterior pleural band moderately well developed, others moderately convex, posterior pleural bands poorly separated from anterior bands. Border widens posteriorly, poorly separated from pleural fields, turned upward.

Margin-parallel ridges on the occipital ring and librigenal border. Genal caeca on genal area of the librigena.

Etymology.—Latin, *gloriosus*, for its glorious development of upturned pygidial spines.

Types.—Holotype, complete pygidium USNM 510170 from USNM locality 41742; paratypes USNM 510161–510169, 510171–510173 from USNM locality 41742.

Occurrence.—*Poliella denticulata* Biozone, Susan Duster Limestone and Log Cabin members, Pioche Shale, eastern Nevada. USNM localities 41734?, 41742, 41756, and 41757.

Discussion.—Cranidia and pygidia are common at the type locality.

Genus POLIELLA Walcott, 1916

Bathyriscus (*Poliella*) Walcott, 1916, p. 349.

Poliella WALCOTT. RAYMOND, 1928, p. 310; RESSER, 1935, p. 43; KOBAYASHI, 1942, p. 153; POULSEN, C. in MOORE (ED.), 1959, p. 226; FRITZ, 1968, p. 206; PALMER in PALMER and HALLEY, 1979, p. 79.

Type species.—*Bathyriscus* (*Poliella*) *anteros* Walcott, 1916.

Discussion.—Rasetti (1951) emphasized the shape of the “posterior limb” (posterior portion of the fixigena), length of the palpebral lobes, and the last thoracic segment enveloping the pygidium as important in distinguishing *Poliella* from *Wenkchemnia*. In the Susan Duster Limestone Member, basal Log Cabin Member, and age-equivalent portions of the Pyramid Shale Member in the Groom Range, there are several representatives of the Dolichometopidae that differ in the shape of the posterior portion of the fixigena, but are similar overall in their cranial and/or pygidial construction. This suggests that the parallel nature of the posterior portion of the fixigena is not relevant in defining genera. All of these similar taxa reported here are assigned to *Poliella*, with the shape of the posterior area of the fixigena, presence of punctae, presence of occipital spines/nodes, and/or pygidial characteristics used to identify species.

POLIELLA DENTICULATA Rasetti, 1951 Figure 10.1–10.7

Poliella denticulata RASETTI, 1951, p. 173–174, pl. 12, figs. 6–9; FRITZ, 1968, p. 208, pl. 38, figs. 14–18.

Poliella cf. *P. denticulata* RASETTI, 1951, p. 174, pl. 9, figs. 7, 8.

Material examined.—USNM 510149–510154 from USNM locality 41767; USNM 510155, 510156 from USNM locality 41748.

Occurrence.—*Poliella denticulata* Biozone, Susan Duster

Limestone Member, Pioche Shale, eastern Nevada. USNM localities 41738, 41739, 41751, 41752, 41762, 41764, 41767, 41768, 41774, 41776?, 41784, 41923, 41926, 41927, and 41930. Pyramid Shale Member, Carrara Formation, central Nevada. USNM localities 41791 and 41792. *Albertella* Biozone, Pioche Shale, east-central Nevada (Fritz, 1968). *Wenkchemnia-Stephenaspis* Biozone, Mount Whyte Formation, British Columbia (Rasetti, 1951).

Discussion.—Several specimens of *Poliella denticulata* in the Susan Duster Limestone Member compare well to the flattened specimens illustrated by Rasetti (1951). Larger pygidia from the Pioche Shale have a more sagittally elongated outline and a stronger posteromedial notch (Fig. 10.7). *Poliella denticulata* can be differentiated from the co-occurring *P. lomataspis* by having parallel-sided or expanding posterior area of fixigena, upturned anterior border, less pronounced occipital spine, less punctate surface, and spinose pygidium with stronger pleural and axial ring furrows. Fritz (1968) reported this species from the *Albertella* Biozone of the Pioche Shale northwest of the study area.

POLIELLA LOMATASPIS Palmer (in Palmer and Halley, 1979) Figure 10.13–10.16

Poliella lomataspis PALMER in PALMER and HALLEY, 1979, p. 80, pl. 6, figs. 1–5, 12.

Material examined.—USNM 510157–510160 from USNM locality 41792.

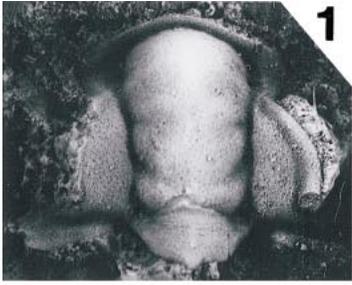
Occurrence.—*Poliella denticulata* Biozone, Susan Duster Limestone Member, Pioche Shale, eastern Nevada. USNM localities 41739, 41750, 41762, 41767, 41769, 41772, 41776, 41784, 41924, 41926, and 41927. Pyramid Shale Member, Carrara Formation, central and western Nevada (Palmer and Halley, 1979). USNM localities 41789, 41791, and 41792.

Discussion.—Palmer gave a complete description of *Poliella lomataspis*. Specimens from the Groom Range are illustrated here for comparison to the other small *Poliella* species. Of potential confusion is the slightly bilobed nature of the pygidium (Palmer and Halley, 1979, pl. 6, figs. 4, 5; Fig. 10.15, 10.16), which is similar to the co-occurring *Fieldaspis bilobata*. However, the pygidium of *P. lomataspis* differs from a similar-sized pygidium of *F. bilobata* in having a more tapered axis, higher width to length ratio, and being only slightly bilobate. *Poliella lomataspis* from USNM locality 41750 is associated with a typical *Amecephalus arjosensis* Biozone assemblage. Locality 41750 is an earlier collection made from the basal meter of the Susan Duster Limestone Member and probably represents a mixed assemblage of two biozones.

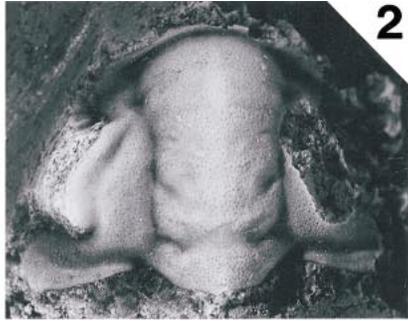
POLIELLA OVALA new species Figure 10.17–10.21

Diagnosis.—Cranidium with glabella that has poorly defined lateral glabellar furrows and small occipital spine; anterior border with flat lateral margins, narrows in front of glabella; posterior portions of fixigena parallel-sided. Surface punctate. Pygidium elliptical shape with maximum width near posterior end of axis,

FIGURE 9—*Poliellaites gloriosa* n. gen. and sp., and oryctocephalids. 1–9, *Poliellaites gloriosa*, all are paratypes, $\times 7.5$, testate, and from the Log Cabin Member, Pioche Shale (USNM locality 41742) unless otherwise mentioned; 1, 3, cranidium (USNM 510161); 2, cranidium (USNM 510162); 4, librigena (USNM 510166); 5, librigena (USNM 510167); 6, 7, pygidium (USNM 510169), 7 is an oblique view showing upturned marginal spines; 8, latex cast of pygidium (USNM 510172); 9, latex cast of holotype pygidium (USNM 510170). 10, 11, *Microrhyctocara nevadensis* from the Pyramid Shale, Carrara Formation, USNM locality 41793, $\times 10.0$. 10, partial cranidium (USNM 510137); 11, partial shield (USNM 510138). 12–14, *Oryctocephalus* sp. 12, latex cast of a partial cranidium (USNM 510147) from the Pyramid Shale, Carrara Formation, USNM locality 41792, $\times 7.5$; 13, latex cast of a partial cranidium (USNM 510148) from the Log Cabin Member, Pioche Shale, USNM locality 41742, $\times 7.5$; 14, mostly testate, partial cranidium (USNM 509468) for the Susan Duster Limestone Member, Pioche Shale, USNM locality 41936, $\times 7.0$.



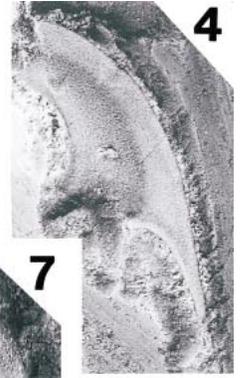
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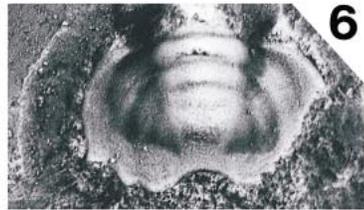
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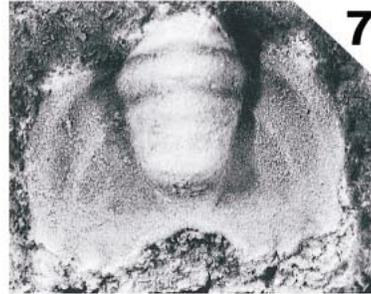
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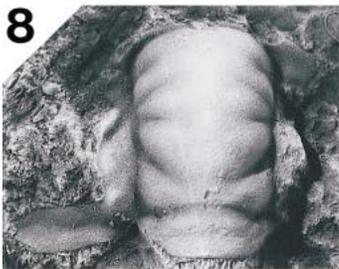
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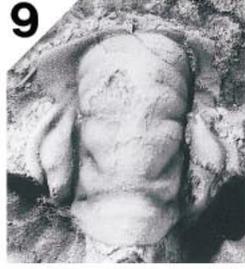
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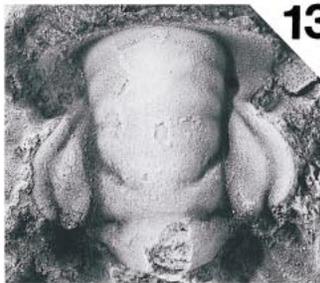
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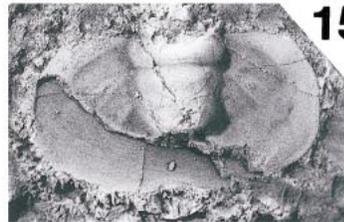
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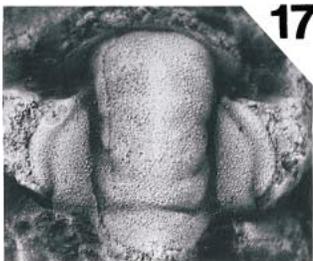
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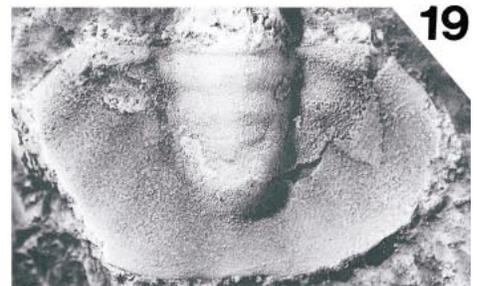
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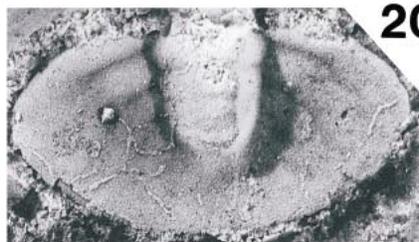
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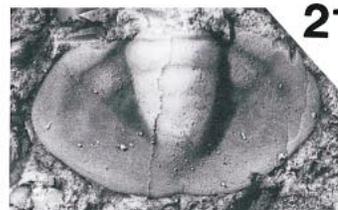
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pleural and axial ring furrows weak to effaced, posteromedial notch weak to absent, marginal spines absent.

Description.—Cranidium small, length 2.5 to 3.0 mm ($n = 3$); subtrapezoidal; moderate convexity (sag. and trans.); anterior margin moderately and evenly curved; posterior margin, excluding occipital ring, straight. Anterior branches of facial sutures slightly divergent to border furrow and then moderately convergent to anterior margin; posterior branches strongly divergent. Glabella elongated, slightly expanding, width at anterior end 100 to 120 percent glabellar width (K_2); moderate convexity (sag. and trans.); frontal lobe rounded; length 96 to 98 percent cranial length; width approximately 40 percent cranial width. Axial furrow moderately deep, slightly concave in outline; preglabellar furrow shallow. Lateral glabellar furrows moderately deep to shallow, S1 directed posteriorly, S2 directed laterally to slightly anteriorly, S3 and S4 directed anteriorly. Occipital ring moderately convex, length 20 to 25 percent glabellar length; occipital spine small; posterior margin convex. SO straight and moderately deep. Anterior border flat, uniform length, level. Anterior border furrow defined by change in slope. Fixigena flat to slightly concave, level, width 40 to 45 percent glabellar width (K_2). Palpebral lobes crescent shape, slightly upturned, narrow and long, length 35 to 45 percent glabellar length; anterior margin located about opposite of S3 or L3. Ocular ridge short, moderately weak, straight, directed very strongly posterolaterally from glabella at 50 to 55 degrees to axis. Posterior area of fixigena strap-like, downsloping, parallel-sided or slightly expanding laterally, termination round; length approximately 20 percent glabellar length; width 35 to 40 percent glabella length.

Librigena, rostral plate, hypostoma, and thorax unknown.

Pygidium small, length 2.9 ± 0.8 mm ($n = 7$); oval, length 67 ± 4 percent width; moderately convex (sag. and trans.); maximum width near posterior end of axis; posteromedial notch slight or absent. Marginal spines absent. Axis slightly tapered, anterior width 29 ± 2 percent pygidial width; length 67 ± 4 percent pygidial length, weak postaxial ridge; three axial rings, strongly convex, axial nodes absent; terminal axial piece small, rounded; axial ring furrows moderately deep to shallow. Pleural regions with three anterior pleural furrows moderately wide and shallow, extending to near posterior margin, moderately curved posterolaterally; interpleural furrows faint to absent; first anterior pleural band moderately developed, others weakly convex, posterior pleural bands poorly separated from anterior bands. Border wide, poorly defined by shallow furrow, level to slightly upsloping.

Surface of all known parts smooth.

Etymology.—Named for its oval-shaped pygidium.

Types.—Holotype, complete pygidium USNM 510182 from USNM locality 41787; paratypes USNM 510174–510180 from USNM locality 41771; USNM 510181–510183 from USNM locality 41787, USNM 510184, 510185 from USNM locality 41782.

Occurrence.—*Poliella denticulata* Biozone, Log Cabin Member, Pioche Shale, eastern Nevada. USNM localities 41132, 41735, 41771, 41782, and 41787.

Discussion.—The cranidia of this species are known only from small specimens that cannot be differentiated from *P. cf. prima*. The pygidia are easily recognized by their more oval shape and the posteromedial notch absent or slight. These characters can be used to separate *P. ovala* from *P. prima*, *P. cf. prima*, and *P. lomataspis*. The species is relatively rare.

POLIELLA cf. PRIMA (Walcott, 1908)

Figure 10.8–10.12

Material examined.—USNM 510186–510189 from USNM locality 41742.

Occurrence.—*Poliella denticulata* Biozone, Log Cabin Member, Pioche Shale, eastern Nevada. USNM localities 41742 and 41757.

Discussion.—Cranidia and pygidia assigned to *Poliella cf. prima* are preserved in limestone, whereas specimens of *Poliella prima* illustrated by Rasetti (1951, pl. 12, figs. 10–13) are flattened in shales. Thus, comparison of the two taxa is difficult. However, the two forms are similar in lacking an occipital node or spine and having flat lateral margins of the anterior border, parallel-sided posterior portions of the fixigena, and a subrectangular, transversely elongated pygidium with the maximum width about equal to the posterior end of the axis. *Poliella cf. prima* differs from *P. prima* in having better-defined lateral glabellar furrows and narrower anterior border in front of the glabella. This species differs from the slightly older *P. lomataspis* in the shape of the posterior area of the fixigena.

Family ZACANTHOIDIDAE Swinnerton, 1915

Genus FIELDASPIS Rasetti, 1951

Type species.—*Fieldaspis furcata* Rasetti, 1951.

FIELDASPIS BILOBATA Rasetti, 1951

Figure 11.1–11.4

Fieldaspis bilobata RASETTI, 1951, p. 161, pl. 16, figs. 1–7.

Material examined.—USNM 509449 from USNM locality 41926, USNM 509458 from USNM locality 41767, USNM 509461 from USNM locality 41738, USNM 510136 from USNM locality 41764.

Occurrence.—*Amecephalus arjosensis* and *Poliella denticulata* biozones, Susan Duster Limestone Member, Pioche Shale, eastern Nevada. USNM localities 41738, 41739, 41740, 41750, 41751, 41752, 41762, 41763, 41764, 41767, 41768, 41774, 41784, 41922, 41923, 41924, 41926, 41927, and 41930. Pyramid Shale Member, Carrara Formation, central Nevada. USNM locality 41791. *Plagiura-Kochaspis* Biozone, Mount Whyte Formation, British Columbia (Rasetti, 1951).

FIGURE 10—*Poliella* species from the Pioche Shale and Carrara Formation. 1–7, *Poliella denticulata*, all testate and from the Susan Duster Limestone Member, Pioche Shale (USNM locality 41767). 1, mostly complete cranidium (USNM 510150), $\times 7.5$; 2–3, partial cranidium (USNM 510149), $\times 7.5$; 4, librigena (USNM 510151), $\times 7.5$; 5, pygidium (USNM 510152), $\times 10.0$; 6, partial pygidium (USNM 510154), $\times 10.0$; 7, larger pygidium (USNM 510153) with more elongated outline and pronounced posteromedial notch, $\times 10.0$. 8–12, *Poliella cf. prima*, all testate and from the Log Cabin Member, Pioche Shale (USNM locality 41742); 8, partial cranidium (USNM 510187), $\times 7.5$; 9, 10, partial cranidium (USNM 510186), $\times 7.5$; 11, librigena (USNM 510188), $\times 8.5$; pygidium (USNM 510189), $\times 7.5$. 13–16, *Poliella lomataspis*, all material testate and from the Susan Duster Limestone Member equivalent of the Pyramid Shale Member, Carrara Formation (USNM locality 41792); 13, partial cranidium (USNM 510157), $\times 7.5$; 14, librigena (USNM 510158), $\times 7.5$; 15, damaged pygidium (USNM 510159), $\times 7.5$; 16, small pygidium (USNM 510160), $\times 7.5$. 17–21, *Poliella ovala* n. sp., all specimens are paratypes, testate, and from the Log Cabin Member, Pioche Shale unless otherwise mentioned; 17, partial cranidium (USNM 510175) from USNM locality 41771, $\times 10.0$; 18, pygidium (USNM 510183) from USNM locality 41787, $\times 7.5$; 19, partial pygidium (USNM 510184) from USNM locality 41787, $\times 8.0$; 20, partial pygidium (USNM 510177) from USNM locality 41771, $\times 8.0$; 21, holotype pygidium (USNM 510182) from USNM locality 41787, $\times 7.5$.

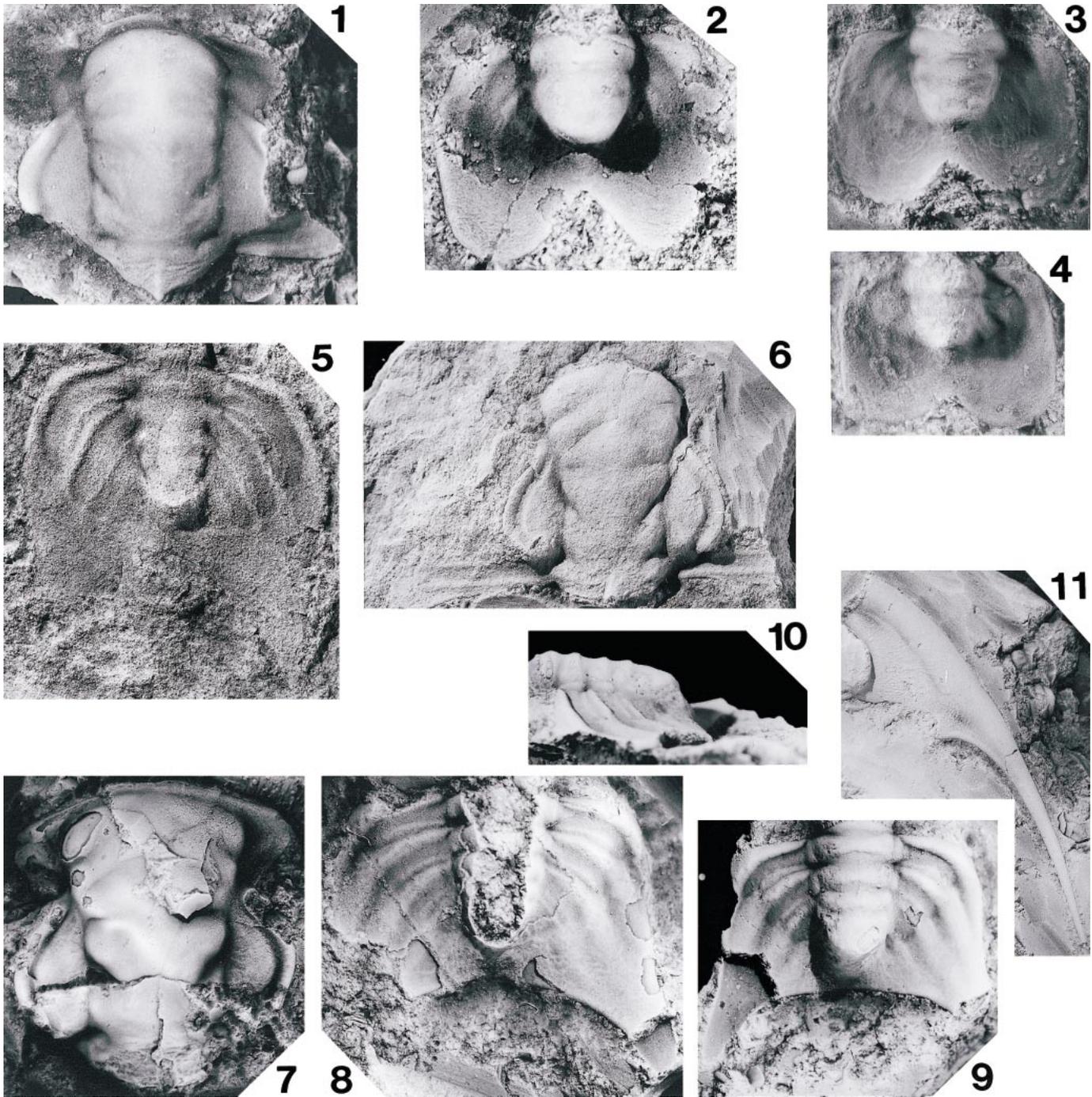


FIGURE 11—*Fieldaspis* species from the Pioche Shale. 1–4, *Fieldaspis bilobata*, all specimens testate; 1, partial cranidium (USNM 510136), from USNM locality 41764, $\times 7.5$; 2, pygidium (USNM 509458), from USNM locality 41767, $\times 7.5$; 3, pygidium (USNM 509449), from USNM locality 41926, $\times 7.0$; 4, pygidium (USNM 509461), from USNM locality 41738, $\times 7.0$. 5, 6, *Fieldaspis celer*, all from USNM locality 41773, non-testate material preserved in siltstone, and $\times 2.0$; 5 pygidium (USNM 510142); 6, nearly complete cranidium (USNM 510141). 7–11, *Fieldaspis superba*; 7, partial, crushed cranidium (USNM 510143), from USNM locality 41760, $\times 3.0$; 8, partial pygidium (USNM 510146) with broad-based spines, from USNM locality 41749, $\times 5.0$; 9, 10, partial pygidium (USNM 510145) with narrow-based spines, from USNM locality 41735, $\times 5.0$; 11, librigena (USNM 510144), from USNM locality 41760, $\times 1.7$.

Discussion.—The specimens from the Susan Duster Limestone Member are smaller but similar to *Fieldaspis bilobata* illustrated by Rasetti (1951). The pygidia reported here differ from those of Rasetti's in having a shorter axis, less pronounced pleural bands and furrows, and longer lobes, especially in larger specimens. In

these aspects, the Pioche Shale material is similar to *F. furcata* Rasetti, 1951. Rasetti (1957) suggested that *F. bilobata* was ancestral to *F. furcata*, an interpretation this material appears to support. The presence of depressions at the base of the lobes is variable in the type material of *F. bilobata*. These depressions in

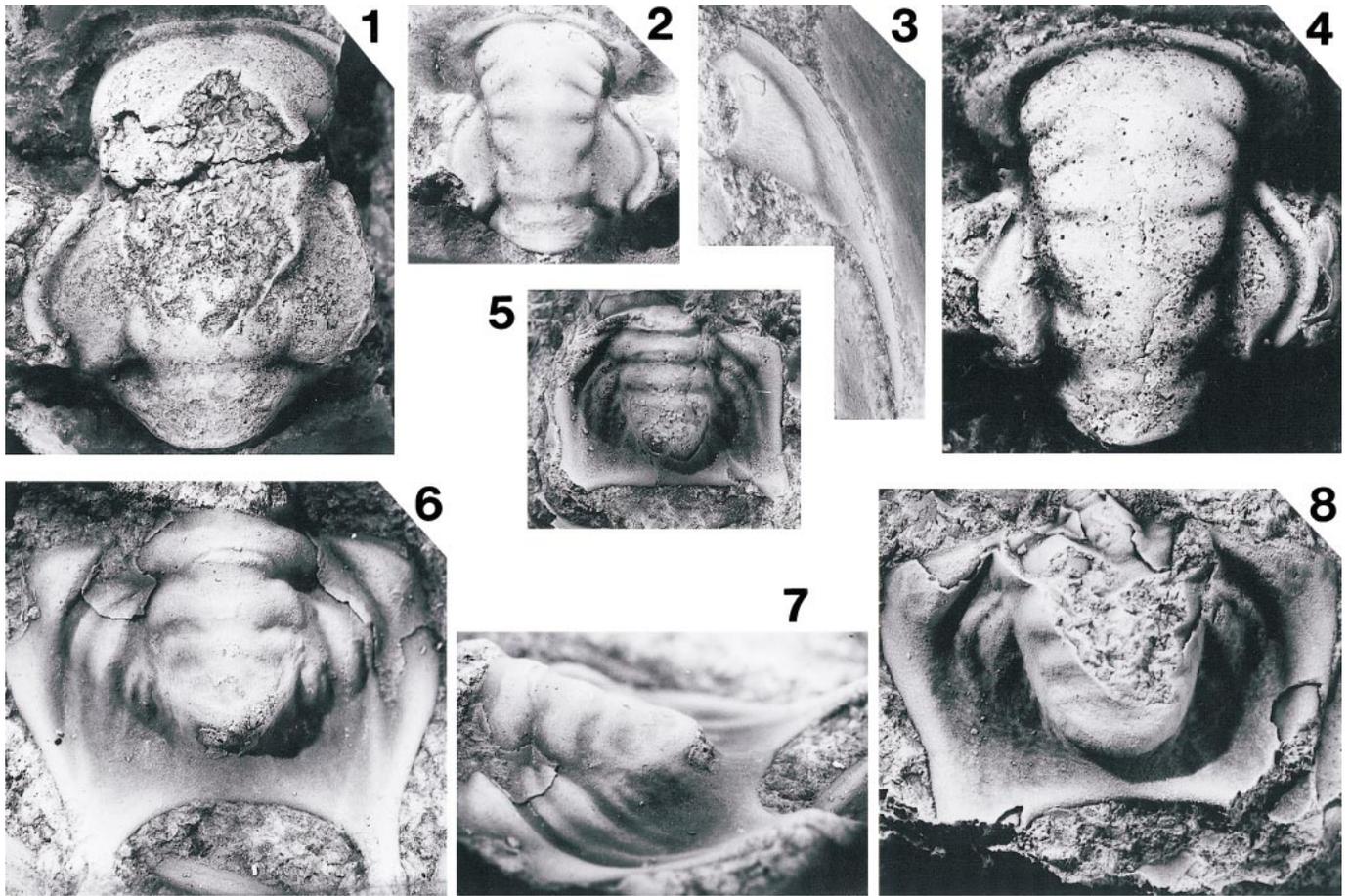


FIGURE 12—1–8, *Stephenaspis highlandensis* n. sp., all from the Log Cabin Member, Pioche Shale (USNM locality 41735), and paratypes unless otherwise mentioned; 1, exfoliated partial cranidium (USNM 510159), $\times 2.5$; 2, partial testate cranidium (USNM 510191), $\times 5.0$; 3, testate librigena (USNM 510197) from USNM locality 41132, $\times 5.0$; 4, partial exfoliated cranidium (USNM 510191), $\times 5.0$; 5, testate holotype pygidium (USNM 510196), $\times 6.0$; 6, 7, latex cast of mostly exfoliated pygidium (USNM 540498) from USNM locality 41749, $\times 6.0$; 9, partial testate pygidium (USNM 510195), $\times 6.0$.

the Pioche material are commonly more pronounced than those in *F. bilobata*.

FIELDASPIS CELER (Walcott, 1917b)

Figure 11.5–11.6

Crepicephalus celer WALCOTT, 1917b, p. 1010, pl. 11, fig. 2.

Kochaspis celer (WALCOTT). RESSER (part), 1935, p. 36.

Fieldaspis celer (WALCOTT). RASETTI, 1951, p. 110; RASETTI, 1957, p. 957–958, pl. 118, figs. 1–8, text-fig. 4.

Material examined.—USNM 510141, 510142 from USNM locality 41773.

Occurrence.—*Poliella denticulata* Biozone, Log Cabin Member, Pioche Shale, eastern Nevada. USNM locality 41766, 41773, 41775, and 41756?. *Plagiura-Kochaspis* Biozone, Mount Whyte Formation, British Columbia (Rasetti, 1957).

Discussion.—The specimens from the basal few cm of the Log Cabin Member are preserved in silty, hackly shales, but agree well with those illustrated by Rasetti (1957) from limestone.

FIELDASPIS SUPERBA Rasetti, 1951

Figure 11.7–11.11

Fieldaspis superba RASETTI, 1951, p. 162–163, pl. 16, figs. 10–18.

Material examined.—USNM 510143, 510144 from USNM locality 41760; USNM 510145 from USNM locality 41735; USNM 510145 from USNM locality 41749.

Occurrence.—*Poliella denticulata* Biozone, Log Cabin Member, Pioche Shale, eastern Nevada. USNM locality 41735, 41744, 41745, 41749, and 41760. *Plagiura-Kochaspis* Biozone, Mount Whyte Formation, British Columbia (Rasetti, 1951).

Discussion.—The specimens from the Log Cabin Member are preserved in limestone and agree well with those illustrated by Rasetti (1951) except for the lack of an occipital spine. The Pioche specimens show variation in the basal width of the pygidial spines from relatively narrow (Fig. 11.8) to broad (Fig. 11.9). This variation makes the posterior margin of the pygidium either relatively broad and nearly straight or narrow and nearly V-shaped similar to *F. celer*. Rasetti (1957) suggested a lineage *F. bilobata*-*F. furcata*-*F. celer*-*F. superba*, which is supported by this morphological gradation and the sequential appearance of three *Fieldaspis* species in the Pioche Shale.

Genus STEPHENASPIS Rasetti, 1951

Type species.—*Stephenaspis bispinosa* Rasetti, 1951.

STEPHENASPIS HIGHLANDENSIS new species

Figure 12.1–12.8

Diagnosis.—Cranidium possibly with a small occipital node. Pygidial spines at posterolateral corners, straight or slightly curved posterior margin, posteromedial notch absent; axis wide; pleural bands distinct.

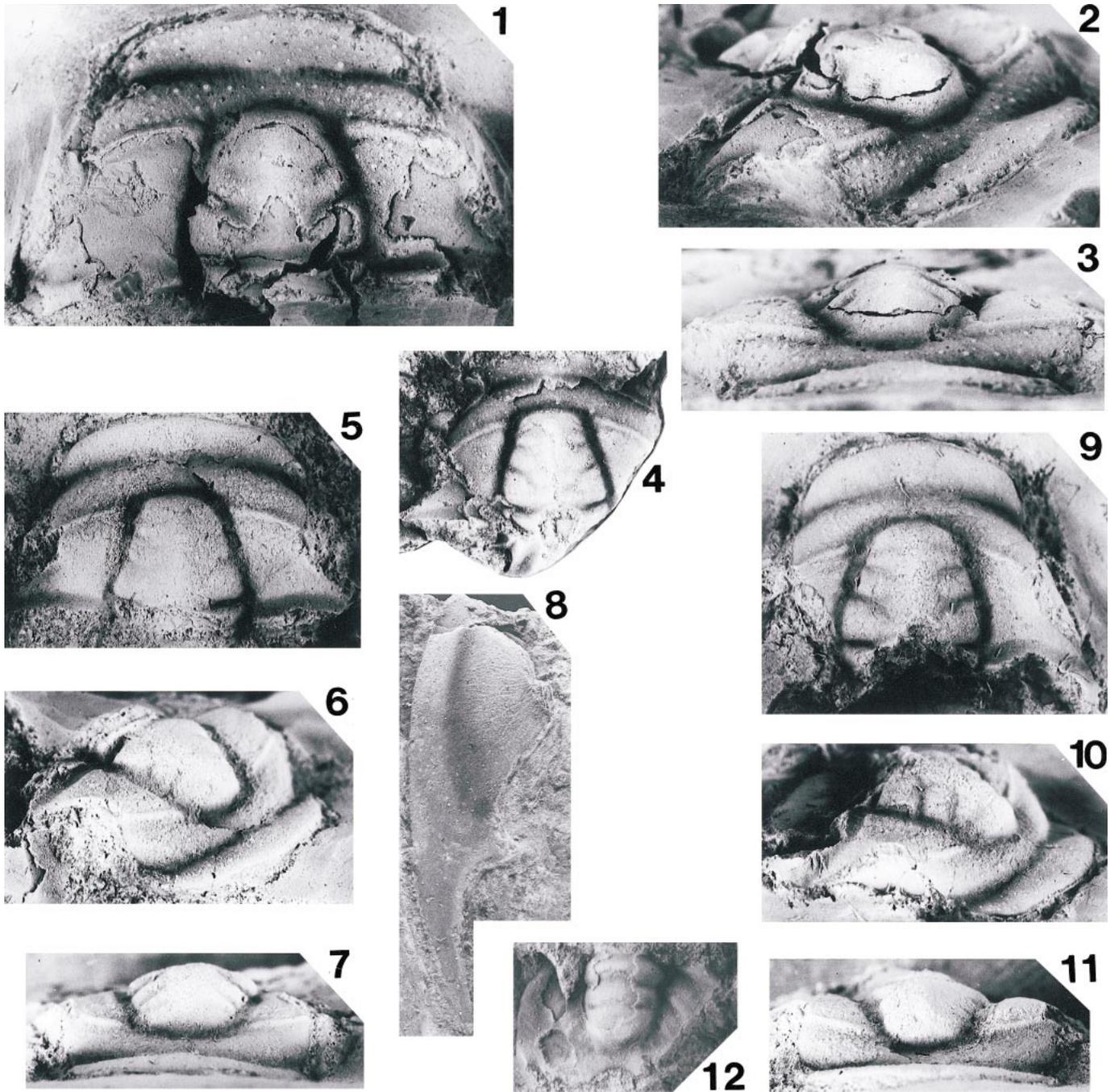


FIGURE 13—1–12, Type specimens of previously named species of *Kochaspis*, all $\times 3.0$, unless otherwise mentioned. 1–4, *Kochaspis liliana* from USNM locality 31a in the Pioche Shale, Nevada; 1–3, partially testate holotype cranidium (USNM 15428); 4, associated, partial, partially testate cranidium (USNM 15428b). 5–8, 12, *Kochaspis highlandensis*, from USNM locality 30 in the Pioche Shale, Nevada; 5–7, testate holotype cranidium (USNM 61640); 8, testate paratype librigena (USNM 61641), $\times 5.0$; 12, mostly testate, paratype pygidium (USNM 510201) probably belonging to *Poliella denticulata*, $\times 8.2$. 8–11, exfoliated holotype, partial cranidium of *Kochaspis nevadensis* (USNM 61643) from USNM locality 30.

Description.—Cranidium moderate size to large, length 6.8 to 22.8 mm ($n = 4$); subtrapezoidal; moderate convexity (sag. and trans.); anterior margin moderately curved, straight laterally; posterior margin unknown. Anterior branches of facial sutures moderately to strongly divergent to border furrow and then moderately convergent to anterior margin; posterior branches unknown. Glabella elongated, moderately expanding, frontal lobe maximum expansion 135 to 150 percent glabellar width (K_2);

moderate convexity (sag. and trans.); frontal lobe moderately rounded; length 95 to 98 percent cranial length. Axial furrow moderately deep, concave in outline; preglabellar furrow shallow. Lateral glabellar furrows deep to moderately deep, S1 directed posteriorly, S2 directed laterally, S3 and S4 directed anteriorly. Occipital ring moderately convex, length 20 to 25 percent glabellar length; possible small occipital node; posterior margin convex. SO straight and moderately deep. Anterior border flat,

longer laterally, level. Anterior border furrow absent at corners. Fixigena flat to slightly concave, level, width 35 to 50 percent glabella width (K_2). Palpebral lobes crescent shape, level, narrow and long, length 40 to 50 percent glabella length; anterior margin located opposite S3 or L3. Ocular ridge short, weak, straight, directed very strongly posterolaterally from glabella at 35 to 40 degrees to axis. Posterior area of fixigena unknown.

Librigena moderate to large sized, length 6.1 to 9.7 mm ($n = 2$); wide, width 50 to 65 percent length without spine; lateral margin slightly curved. Genal field moderately convex. Border moderately convex, width approximately 25 percent librigenal width; border furrows moderately deep. Genal spine narrow, slightly curved, long, approximately 90 percent librigenal length.

Rostral plate, hypostoma, and thorax unknown.

Pygidium moderate size, length 4.3 to 6.0 mm ($n = 3$); subrectangular, length 75 to 85 percent width; moderately convex (sag. and trans.); posteromedial notch absent. Spines developed from lateral margin, narrow, sharp, directed posteriorly, upturned. Axis slightly tapered, anterior width approximately 45 percent pygidial width; length 75 to 85 percent pygidial length, postaxial ridge absent; three axial rings, strongly convex, axial nodes absent; terminal axial piece small size, rounded; axial ring furrows moderately deep. Pleural regions with three anterior pleural furrows moderately wide, deep to shallow, extending to near posterior margin, interpleural furrows moderately strong to faint; first anterior pleural band moderately well developed, others moderately convex, posterior pleural bands weakly developed. Border defined as smooth area.

Margin-parallel ridges on the occipital ring and librigenal border. Genal caeca on genal area of the librigena and pleural area of pygidium.

Etymology.—Named for the type locality of the species in the Highland Range, Nevada.

Types.—Holotype, nearly complete pygidium USNM 510196 from USNM locality 41735; USNM 510190–510195 from USNM locality 41735; USNM 510197 from USNM locality 41132; USNM 510198 from USNM locality 41749.

Occurrence.—*Poliella denticulata* Biozone, Log Cabin Member, Pioche Shale, eastern Nevada. USNM localities 31a, 41132, 41734, 41735, 41749, 41753, and 41760.

Discussion.—This species is assigned to *Stephenaspis* based on general cranial characteristics and the derivation of the pygidial spine from the anterior pleural band. It can be differentiated from the type species of the genus, *S. bispinosa*, by the more posterior location of the pygidial spines, relatively wider axis, more poorly defined pleural bands, and lacking a posteromedial notch. Cranidia of *S. highlandensis* can be differentiated from cranidia of *S. bispinosa* by the absence of an occipital spine.

Family ORYCTOCEPHALIDAE Beecher, 1897
Subfamily ORYCTOCEPHALINAE Beecher, 1897
Genus ORYCTOCEPHALUS Walcott, 1886

Type species.—*Oryctocephalus primus* Walcott, 1886.

ORYCTOCEPHALUS sp.
Figure 9.12–9.14

Material examined.—USNM 510147 from USNM locality 41792, USNM 510148 from USNM locality 41742, and USNM 509468 from USNM locality 41926.

Occurrence.—*Poliella denticulata* Biozone, Susan Duster Limestone and Log Cabin members, Pioche Shale, eastern Nevada. USNM localities 41742 and 41926. Pyramid Shale Member, Carrara Formation, central Nevada. USNM locality 41792.

Discussion.—Three incomplete cranidia were found in limestones. Due to their incompleteness, the small size of one specimen, and the lack of pygidia, these specimens are not assigned

to a species. They have only one faint transglabellar furrow, unlike most *Oryctocephalus* species, and they do not have the expanded frontal lobe typical of the coeval *O. nyensis*.

Subfamily ORYCTOCARINAE Hupé, 1953
Genus MICRORYCTOCARA Sundberg and McCollum, 1997

Type species.—*Microroryctocara nevadensis* Sundberg and McCollum, 1997.

MICRORYCTOCARA NEVADENSIS Sundberg and McCollum, 1997
Figure 9.10–9.11

Microroryctocara nevadensis SUNDBERG AND MCCOLLUM, 1997, p. 1085–1086, fig. 15.1–15.10.

Material examined.—USNM 510137 and 510138 from USNM locality 41793.

Occurrence.—*Poliella denticulata* Biozone, Pyramid Shale Member, Carrara Formation, Nevada. USNM locality 41793.

Discussion.—Poorly preserved or fragmentary specimens were found in the soft shales overlying the limestone horizon in the Pyramid Shale Member that is equivalent to the Susan Duster Limestone Member, Pioche Shale. Despite their poor preservation, these specimens show the cranial and pygidial characteristics of the open-shelf species.

Order PTYCHOPARIIDA Swinnerton, 1915
Suborder PTYCHOPARIINA Richter, 1933
Superfamily PTYCHOPARIACEA Matthew, 1887
Family unassigned
Genus KOCHASPIS Resser, 1935

Kochaspis RESSER, 1935, p. 36; RASETTI, 1951, p. 225; PALMER, 1954, p. 79; LOCHMAN in MOORE, 1959, p. O250; PALMER AND HALLEY, 1979, p. 105.

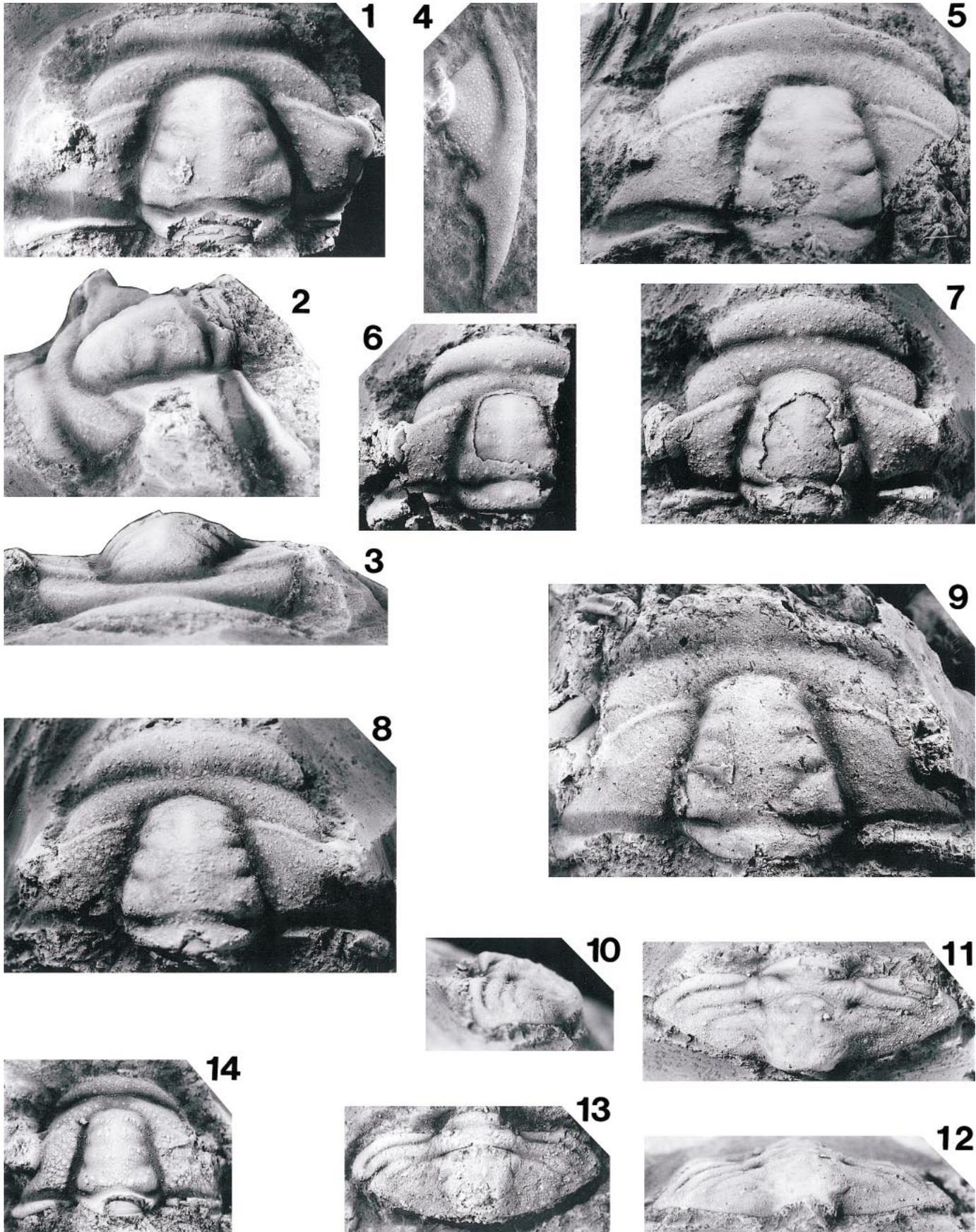
Type species.—*Crepicephalus liliana* (Walcott, 1886).

Emended diagnosis.—Cranidium with glabella moderately elongated, moderately convex, moderately tapered (K_6 averages 67 ± 3 basal glabella width [K_2]), deep axial and occipital ring furrows; preglabellar area short; anterior border convex, level, straight to slightly curved, border well defined; palpebral lobes short (length 28 ± 5 percent glabella length), strongly curved; anterior branches of facial suture strongly convergent, strongly bowed outward. Pygidium transversely elongated, posterior border gently curved, wide, anterior corners adjacent to axial mid-length; spines absent; border narrow; pleural bands strong, posteromedial notch present.

Discussion.—The most significant change to the concept of *Kochaspis* is its pleisomorphic pygidium instead of the spinous forms previously assigned to the genus by Resser (1935; see Sundberg and McCollum, 2002).

Kochaspis differs from *Caborcella* in its less tapered and convex glabella, convex anterior border with a well defined border; and strongly convergent and bowed anterior branches of the facial sutures. *Kochaspis* differs from *Nyella* in its stronger glabella tapering, deeper axial and occipital ring furrows, and shorter and more curved palpebral lobes.

Palmer (1954) considered *Kochaspis liliana* and *K. highlandensis* Resser, 1935 (Fig. 13.5–13.8), as synonymous and *K. nevadensis* Resser, 1935 (Fig. 13.9–13.11), as a distinct species, which is followed here. The pygidium of *K. highlandensis* (Fig. 13.12) is probably *Poliella denticulata* Rasetti, 1951 (see Fig. 10.5, 10.6). Other species assigned to *Kochaspis* by Resser (1935, 1939b) belong to a variety of genera. *Kochaspis cecinna* (Walcott, 1917b) and *K. carina* (Walcott, 1917b) belong to *Hadrocephalites* (see Sundberg and McCollum, 2002); *K. chares* (Walcott, 1917a) belongs to *Kochiella* (see Sundberg and McCollum, 2002); *K. celer* (Walcott, 1917b) is probably *Fieldaspis*; and *K. maladensis*



Resser, 1939b, and the pygidium of *K. dispar* Resser, 1939b, are corynexochids. *Kochaspis kobayashi* Resser, 1937, is based on a small specimen reported by Kobayashi (1936) as *Chancia? clusia* (Walcott, 1917b). This specimen has straight palpebral lobes that are anteriorly placed and does not belong in *Kochaspis*, although its affinity is unknown. *Kochaspis upis* (Walcott, 1916) should be placed back into *Crepicephalus* given its long, slightly crescent shaped palpebral lobes, nearly effaced eye ridges, strongly convex fixigena, strongly rounded frontal lobe, and short and wide posterior areas of the fixigenae. *Kochaspis unzia* (Walcott, 1916) occurs with *K. upis* and is probably conspecific. *Kochaspis eif-felensis* Rasetti, 1951, belongs to *Kochiella* (see Sundberg and McCollum, 2002). *Kochaspis cooperi* Lochman, 1952, is a corynexochid pygidium.

KOCHASPIS LILIANA (Walcott, 1886)

Figures 13.1–13.8, 14.1–14.13

Crepicephalus liliana WALCOTT [part], 1886, p. 207–208, fig. 28, fig. 3; WALCOTT, 1890, p. 653, pl. 96, fig. 7, 7b–7c; WALCOTT, 1916, p. 209, pl. 29, fig. 5, 5a–5b; SHIMER AND SHROCK, 1944, p. 611, pl. 257, fig. 16.

Kochaspis liliana (Walcott). RESSER, 1935, p. 37; PALMER, 1954, p. 80, pl. 17, figs. 8, 10, 11; LOCHMAN in MOORE, 1959, p. O250, figs. 187, 7a, 7b (only); PALMER AND HALLEY, 1979, p. 105–106, pl. 8, fig. 8.

Kochaspis highlandensis RESSER, 1935, p. 37.

Kochaspis? sp. unident PALMER AND HALLEY, 1979, p. 106, pl. 8, figs. 10, 11.

Emended diagnosis.—Anterior border moderate length (54 ± 5 percent of frontal area) and fixigena wide (52 ± 4 percent of glabellar width).

Emended description.—Cranidium moderate size, length 10.0 ± 2.9 mm ($n = 27$); subtrapezoidal, moderately convex (sag. and trans.); anterior margin nearly straight to moderately and evenly curved, arched dorsally; posterior margin, excluding occipital ring, distally curved slightly posterolaterally. Anterior branches of facial sutures moderately convergent to anterior border, less convergent to anterior margin; posterior branches moderately divergent. Glabella moderately elongated, strongly tapered, width at anterior end 67 ± 3 percent glabellar width (K_2); moderately convex (sag. and trans.); frontal lobe moderately to bluntly rounded; length 69 ± 2 percent cranial length; width 37 ± 2 percent cranial width. Axial furrow deep, straight in outline and convergent from SO to S2 then slightly less convergent; preglabellar furrow moderately deep. Lateral glabellar furrows moderately deep, S1 bifurcated directed posteriorly, S2 bifurcated directed laterally to slightly posterior, S3 faint, directed moderately anteriorly, S4 faint or absent. Occipital ring strongly elevated above glabella, moderately convex; prominent occipital node; length 21 ± 2 percent glabellar length; posterior margin convex posteriorly, straight medially. SO curved anteriorly and deep. Frontal area subequally divided; length 30 ± 2 percent cranial length. Preglabellar field convex, moderately downsloping, length 46 ± 5 percent frontal area length. Anterior border moderately convex, level, uniform length, faint medial inbend, length 16 ± 2 percent cranial length. Anterior border furrow moderately wide and

deep, shallower medially, shallower than axial furrows. Fixigena slightly convex, slightly upsloping, anterior area moderately downsloping, lateral portions strongly downsloping; width 52 ± 5 percent glabellar width (K_2). Palpebral lobes strongly arcuate, moderately upturned, moderately wide to wide and moderately short to moderately long, length 28 ± 5 percent glabellar length; anterior margin located opposite L3. Ocular ridge moderately strong, straight to slightly arched, directed moderately posterolaterally from glabella at 71 ± 6 degrees to axis. Posterior area of fixigena triangular, terminated sharply; length 38 ± 4 percent glabellar length; width 73 ± 6 percent glabella length.

Librigena moderate size, length approximately 5.0–13.5 mm ($n = 4$); moderately wide, width 40 to 50 percent length without spine; lateral margin moderately curved. Genal field moderately convex. Border strongly convex, wider posteriorly, width 25 to 30 percent librigenal width; border furrows deep. Librigenal spine moderately long, 75 to 85 percent librigenal length, slightly curved and flattened.

Rostral plate, hypostoma, and thorax unknown.

Pygidium small, length 1.6 to 3.3 mm ($n = 11$); suboval, length 32 ± 4 percent width; margin smooth, anterior margin slightly to moderately curved posterolaterally; anterolateral corners sharply rounded, adjacent to axial midlength; posteromedial notch well to moderately developed; moderately convex (sag.). Axis moderately to not tapered, anterior width 35 ± 3 percent pygidial width; length 91 ± 5 percent pygidial length, postaxial ridge absent; two axial rings, moderately convex; terminal axial piece moderate size, rounded; axial ring furrows shallow. Pleural regions moderately convex, downsloping; anterior pleural furrow narrow and moderately deep, extending to border; one additional pleural furrow, shallow; interpleural furrows moderately deep to shallow, not joining with pleural furrows; first anterior and posterior pleural bands moderately to weakly developed, second set weakly developed. Border narrow, wider at anterolateral corners, level; absent next to terminal piece; border furrow absent.

Coarse pustules on all parts. Genal caeca on preocular and preglabellar regions of exfoliated specimens.

Type.—Holotype cranidium USNM 15428 from USNM locality 31a.

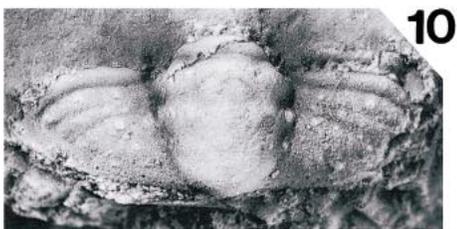
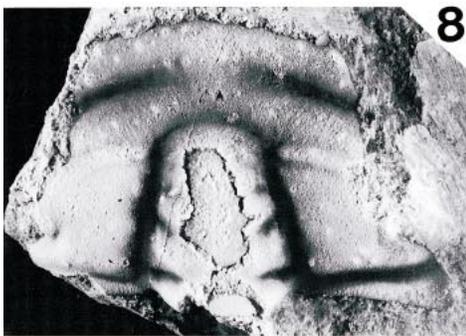
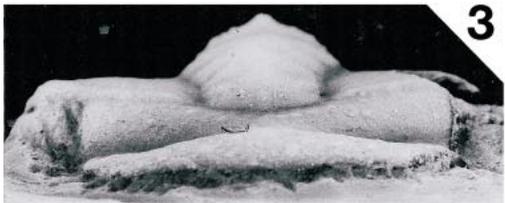
Material examined.—USNM 509985, 509986, and six cranidia, two librigenae, and three pygidia from USNM locality 41132; USNM 509987–509993 and 11 cranidia and two pygidia and from USNM locality 41765; one librigena from USNM locality 41132; four pygidia from USNM locality 41753.

Occurrence.—*Poliella denticulata* Biozone, Log Cabin Member, Pioche Shale, eastern Nevada. USNM localities 30, 31a, 41096, 41132, 41734, 41735, 41741, 41743, 41753, 41749, 41759, 41765, 41771, 41785, 41787, and 41788. Red Pass Limestone Member, Carrara Formation, western Nevada (Palmer and Halley, 1979).

Discussion.—*Kochaspis liliana* morphology is variable when compared to the other kochaspids (as defined by Palmer and Halley, 1979). Variation occurs in the depth of the axial furrows, convexity of the cranidium, curvature of the anterior border, length of the anterior border, curvature of the frontal lobe, and

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FIGURE 14—1–13, *Kochaspis liliana*, all specimens are from the Log Cabin Member, Pioche Shale; 1–3, nearly complete, exfoliated cranidium (USNM 509987) with a narrow (trans.) anterior border, from USNM locality 41765, $\times 5.0$; 4, testate librigena (USNM 509991) from USNM locality 41765, $\times 5.0$; 5, exfoliated cranidium (USNM 509986) from USNM locality 41132, $\times 5.0$; 6, mostly testate, partial cranidium (USNM 509990) from USNM locality 41765, $\times 5.0$; 7, mostly testate, partial cranidium (USNM 509989) from USNM locality 41765, $\times 5.0$; 8, mostly testate cranidium (USNM 509988) from USNM locality 41765, $\times 5.0$; 9, exfoliated cranidium (USNM 509985) from USNM locality 41132, $\times 4.0$; 10–12, testate pygidium (USNM 509993) from USNM locality 41753, $\times 7.5$; 13, testate, small pygidium with partly fused thoracic segment (USNM 509992) from USNM locality 41753, $\times 7.5$. 14, Testate, small cranidium of *Nyella rara* (USNM 510037) from the Susan Duster Limestone Member, Pioche Shale, USNM locality 41750, $\times 7.0$.



the coarseness of the granules. The type specimen of *K. liliana* (Fig. 13.1–13.3) and *K. highlandensis* (Fig. 13.5–13.7) illustrate many of these differences. However, specimens from other localities, as well as topotype material, span the range between and beyond that displayed by the two type species. Due to the lack of consistent differences, *K. highlandensis* is considered a junior synonym of *K. liliana*.

Kochaspis liliana and *K. nevadensis* (Fig. 13.9–13.11) are similar in their glabellar structure, facial sutures, granular ornamentation, and the downsloping of the anterior portions of the fixigena. *Kochaspis liliana* differs from *K. nevadensis* in a shorter anterior border (54 ± 5 vs. 60 percent [estimated]) and wider fixigena (52 ± 5 vs. 37 percent).

Palmer (in Palmer and Halley, 1979, pl. 8, figs. 10, 11) illustrates a cranium and librigena that are also similar to some forms of *K. liliana*. However, these specimens are too poorly preserved to determine if granular ornamentation is present; the specimens are questionably assigned to *K. liliana*.

Genus NYELLA Palmer (in Palmer and Halley, 1979)

Nyella PALMER in PALMER AND HALLEY, 1979, p. 110.

Type species.—*Poulsenia granosa* Resser, 1939b.

NYELLA RARA (Rasetti, 1951)

Figure 14.14

Caborcella rara RASETTI, 1951, p. 211–212, pl. 15, figs. 21–23.

Nyella rara (RASETTI, 1951). PALMER AND HALLEY, 1979, p. 110.

Material examined.—USNM 510037 from locality 41750.

Occurrence.—*Amecephalus arrosensis* Biozone, Susan Duster Limestone Member, Pioche Shale, eastern Nevada. USNM localities 41750, 41761, 41763, 41922, 41925, and 41926. *Kochaspis-Poliella* Biozone, Mt. Whyte Formation, British Columbia, Canada (Rasetti, 1951).

Discussion.—Several small cranidia (3.2 to 3.8 mm in length) match the larger, incomplete cranium (>7 mm in length) illustrated by Rasetti.

NYELLA? PLANA new species

Figure 15.1–15.13

Diagnosis.—Cranidium with anterior border moderately wide (width 63 ± 4 percent cranial width), moderately long, moderate curved, not arched dorsally, and moderately convex; ocular ridges slightly posterolaterally directed; fixigena moderately wide (width 66 ± 6 percent glabellar width); palpebral lobes moderately long (length 40 ± 3 percent glabellar length). Pygidium wide (length 29 ± 3 percent width).

Description.—Cranidium moderate size, length 9.0 ± 2.1 mm ($n = 14$); subtrapezoidal; moderately convex (sag. and trans.); anterior margin moderately and evenly curved, slightly arched dorsally; posterior margin, excluding occipital ring, curved slightly distally. Anterior branches of facial sutures slightly bowed and convergent to anterior border, more convergent to anterior margin; posterior branches moderately divergent. Glabella moderately elongated, strongly tapered, width at anterior end 69 ± 3 percent glabellar width (K_2); moderately convex (sag. and trans.); frontal

lobe moderately rounded; length 68 ± 3 percent cranial length; width 33 ± 2 percent cranial width. Axial furrow moderately deep, slightly concave in outline and convergent from SO to S2 then slightly less convergent; preglabellar furrow moderately deep. Lateral glabellar furrows moderately deep, S1 bifurcated directed posteriorly, S2 bifurcated directed laterally to slightly posterior, S3 faint, directed moderately anteriorly, S4 absent. Occipital ring elevated above glabella, moderately convex; prominent occipital node; length 21 ± 2 percent glabellar length; posterior margin convex posteriorly, straight medially. SO straight and moderately deep. Frontal area equally divided; length 32 ± 2 percent cranial length. Preglabellar field slightly convex, slightly downsloping, length 52 ± 3 percent frontal area length. Anterior border moderately convex, level, uniform length, medial bend, length 15 ± 2 percent cranial length. Anterior border furrow moderately wide and moderately deep, shallower medially, laterally as deep as axial furrows. Fixigena slightly convex, level, anterior area moderately downsloping, lateral portions moderately downsloping; width 66 ± 6 percent glabellar width (K_2). Palpebral lobes slightly arcuate, level, moderately wide and moderately short to moderately long, length 40 ± 3 percent glabellar length; anterior margin located opposite S3 or L4. Ocular ridge moderately strong, straight, directed slightly posterolateral from glabella at 75 to 80 degrees to axis. Posterior area of fixigena triangular, terminated sharply; length 37 ± 5 percent glabellar length; width 75 ± 6 percent glabella length.

Librigena moderate size, length approximately 10.2 ± 2.6 mm ($n = 7$); moderately wide, width 42 ± 3 percent length without spine; lateral margin moderately curved. Genal field moderately convex, width 38 ± 5 percent librigenal width. Border moderately convex, wider posteriorly; border furrows deep. Librigenal spine long, 65 ± 10 percent librigenal length, slightly curved, flattened, and bent ventrally.

Rostral plate, hypostoma, and thorax unknown.

Thoracic segment with axial furrows poorly defined, shallow and uniform depth. Thoracic pleura projecting slightly posterolaterally to fulcrum and then more posterolaterally to distal end, width approximately 125 percent of axial width; distal end rounded; anterior and posterior pleural bands uniform length, posterior pleural band approximately equal in length to anterior pleural band; pleural furrow deep extending into pleural spines. Facet developed on outer portion of pleura; fulcral sockets or processes not apparent.

Pygidium small to moderate size, length 2.1 ± 0.6 mm ($n = 5$); suboval, length 29 ± 3 percent width; margin smooth, anterolateral corners sharply rounded, adjacent to axial midlength; postmedial notch poorly developed; moderately convex (sag.). Axis moderately to not tapered, anterior width 34 ± 4 percent pygidial width; length 96 ± 1 percent pygidial length, postaxial ridge absent; two to possibly three axial rings, moderately convex; terminal axial piece moderate size, rounded; axial ring furrows shallow. Pleural regions well defined, slightly transversely elongate; moderately convex, downsloping laterally; anterior pleural furrow narrow and moderately deep, extending to border, curved slightly posterolaterally; one additional pleural furrow, shallow;

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FIGURE 15—1–13, *Nyella? plana* n. sp. from the Susan Duster Limestone Member, Pioche Shale, Nevada, all are testate material and paratypes unless otherwise mentioned; 1–3, holotype cranium (USNM 510013) from USNM locality 41764, $\times 4.5$; 4, cranium (USNM 510012) from USNM locality 41739, $\times 4.5$; 5, librigena (USNM 510005) from USNM locality 41738, $\times 4.0$; 6, smaller cranium (USNM 510011) from USNM locality 41739, $\times 6.0$, $\times 10.0$; 7, small cranium (USNM 510000) from USNM locality 41738, $\times 5.5$; 8, cranium (USNM 509997) from USNM locality 41738, $\times 4.5$; 9, small cranium (USNM 509999) from USNM locality 41738, $\times 5.5$; 10, pygidium (USNM 510008) from USNM locality 41738, $\times 7.5$; 11–13, larger pygidium with partial thoracic segment (USNM 510015) from USNM locality 41764, $\times 7.5$.

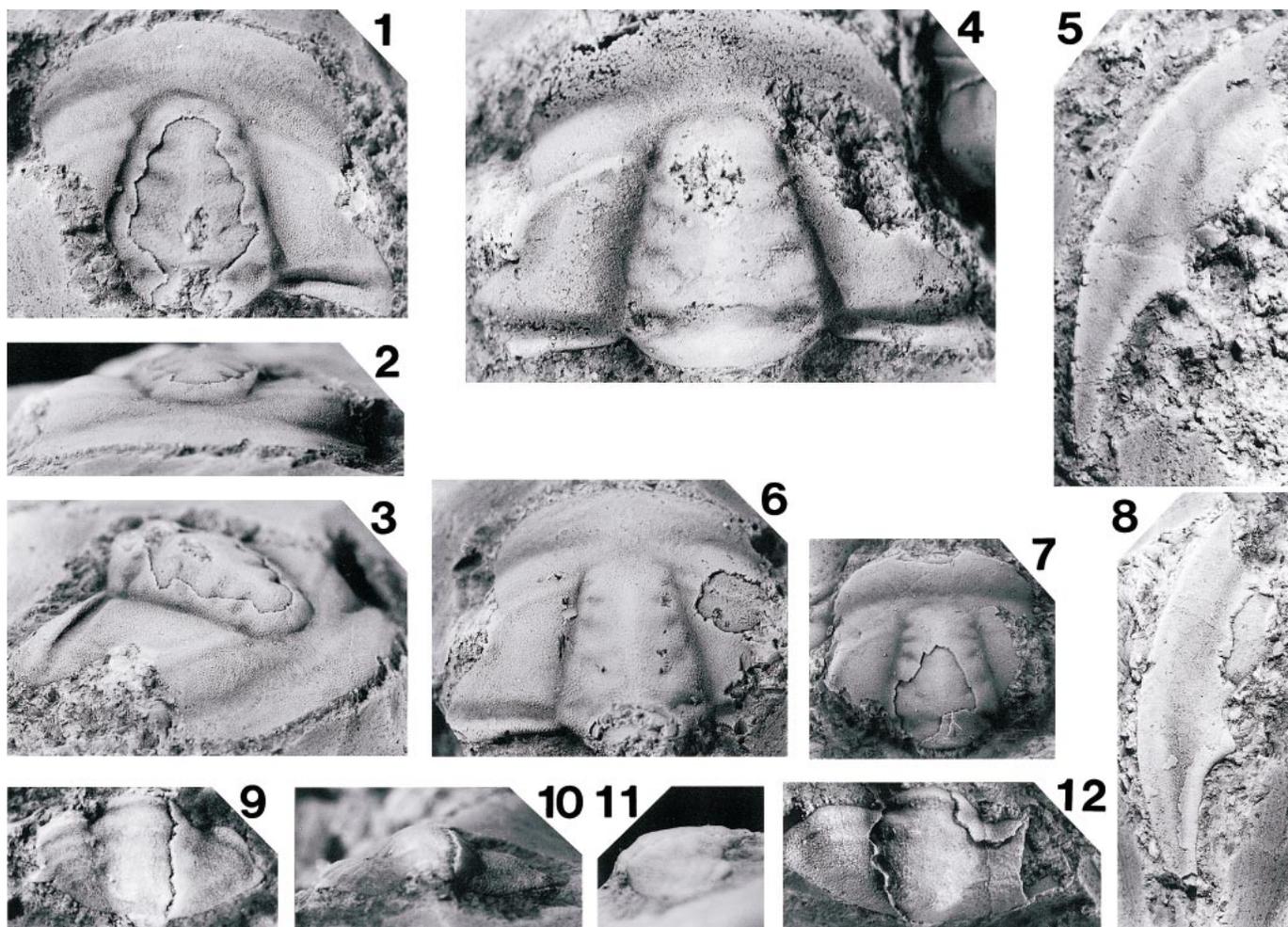


FIGURE 16—1–12, *Eokochaspis? cabinensis* n. sp. from the Log Cabin Member, Pioche Shale, Nevada, all specimens are paratypes, and mostly testate unless otherwise mentioned; 1–3, partial holotype cranidium (USNM 510030) from USNM locality 41754, $\times 5.0$; 4, exfoliated, large, partial cranidium (USNM 510029) from USNM locality 41781, $\times 5.4$; 5, complete librigena (USNM 510036) from USNM locality 41785, $\times 5.0$; 6, partial cranidium (USNM 510031) from USNM locality 41785, $\times 5.3$; 7, small cranidium (USNM 510023) from USNM locality 41765, $\times 5.6$; 8, complete librigena (USNM 510034) from USNM locality 41785, $\times 5.1$; 9–11, partially exfoliated, partial pygidium (USNM 510027) from USNM locality 41765, $\times 10.0$; 12, partially exfoliated, partial pygidium (USNM 510026) from USNM locality 41765, $\times 10.0$.

interpleural furrows moderately deep, not joining with pleural furrows; first anterior and posterior pleural bands moderately developed, second set weakly developed. Border narrow, wider at anterolateral corners, downsloping; absent next to terminal piece; border furrow absent.

Pustules and fine granules on all parts. Faint genal caeca on preocular and preglabellar regions.

Etymology.—Latin, *plana* = level, for the nearly level frontal area.

Types.—Holotype, nearly complete cranidium USNM 510013 from USNM locality 41764; paratypes USNM 509994–510009 from USNM locality 41738; USNM 510010–510012 from USNM locality 41739, USNM 510014–510021 from USNM locality 41767.

Occurrence.—*Poliella denticulata* Biozone, Susan Duster Limestone Member, Pioche Shale, eastern Nevada: USNM localities 41726, 41735, 41738, 41739, 41751, 41764, 41767–41769, 41774, 41776–41778, 41784, 41923, 41924, 41926, and 41927. Log Cabin Member, Pioche Shale, eastern Nevada: USNM localities 41766, 41773?, and 41775. Pyramid Shale Member, Carrara

Formation, central Nevada: USNM localities 41789, 41791, and 41792.

Discussion.—*Nyella? plana* from the Groom Range have slightly upsloping and convex fixigena and are slightly more granular than other specimens of the species. The description of the thoracic segment is based on a single specimen attached to a pygidium (USNM 510015, Fig. 15.12).

Nyella? plana differs from *N. granosa* in its narrower and less convex anterior border, slightly posterolaterally directed ocular ridges, wider fixigena, longer palpebral lobes, and wider pygidium. *Nyella? plana* differs from *N. rara* in its narrower, longer, less curved, and less convex anterior border, slightly posterolaterally directed ocular ridges; and wider fixigena. *Nyella? plana* is questionably assigned based on its similarity to both *Nyella granosa* and *Kochaspis liliana*. *Nyella? plana* is similar to *K. liliana* in its glabellar length, moderately convex anterior border, width of fixigena, posterior length of fixigena, slight bowing of the anterior branch of the facial suture, and slightly posterolateral directed ocular ridges.

Genus *EOKOCHASPIS* SUNDBERG AND McCOLLUM, 2000*Eokochaspis* SUNDBERG AND McCOLLUM, 2000, p. 610–611.*Type species.*—*Eokochaspis nodosa* Sundberg and McCollum, 2000, by original designation.*EOKOCHASPIS?* *CABINENSIS* new species
Figure 16.1–16.12

Diagnosis.—Cranidium slightly convex; anterior margin moderately narrow (67 ± 12 percent cranial width); preglabellar area short (30 ± 5 percent frontal area length); anterior border slightly convex, furrow without inbending, medial swelling absent; anterior branches of facial suture relatively short; glabellar length 70 ± 2 percent cranial length, convexity low, lateral glabellar furrows moderately defined; axial furrows straight; occipital node absent; ocular ridge moderately defined; posterior area of fixigena sharply terminated, directed slightly posteriorly; posterior border convex. Librigena with moderately narrow genal area, moderately defined border furrows, interborder furrow present, librigenal spine long (55 to 60 percent librigenal length), and recurved. Pygidium suboval, moderately arched, axis has two axial rings, plural bands poorly defined, anterolateral corners moderately rounded, and posteromedial notch well developed. Fine granular ornamentation on glabella, fixigena, and pygidium.

Description.—Cranidium moderate size, length 6.9 ± 1.7 mm ($n = 10$); subsquare; moderately convex (sag. and trans.); anterior margin moderately and evenly curved, slightly arched dorsally; posterior margin, excluding occipital ring, distally curved slightly posterolaterally. Anterior branches of facial sutures parallel to slightly convergent to midlength (exsag.) of anterior border, moderately convergent to anterior margin; posterior branches moderately divergent, directed posteriorly at distal end. Glabella elongated, strongly tapered, width at anterior end 67 ± 8 percent glabellar width (K_2); moderately convex (sag. and trans.); frontal lobe moderately rounded; length 70 ± 2 percent cranial length; width 36 ± 4 percent cranial width. Axial furrow moderately deep, slightly concave in outline and convergent from S0 to S2 then less convergent anteriorly; preglabellar furrow shallow. Lateral glabellar furrows moderately deep, S1 bifurcated directed posteriorly, S2 directed slightly posterior, S3 directed laterally to moderately anteriorly, S4 directed anteriorly, shallow on larger specimens. Occipital ring slightly elevated above glabella, moderately convex; low occipital node; length 22 ± 1 percent glabellar length; posterior margin convex posteriorly. SO slightly curved posteriorly and moderately deep. Frontal area unequally divided, length 29 ± 2 percent cranial length. Preglabellar field convex, moderately downsloping, length 30 ± 5 percent frontal area length. Anterior border slightly convex, downsloping, shorter laterally to uniform in length, posteromedial notch absent, length 20 ± 2 percent cranial length. Anterior border furrow narrow, moderately deep, shallow medially, shallower than axial furrows, possible shallow boss medially. Fixigena moderately convex, level, anterior area moderately downsloping; width 50 ± 8 percent glabellar width (K_2). Palpebral lobes slightly arcuate, slightly upturned, moderately narrow to moderately wide and moderately short, length 26 ± 3 percent glabellar length; anterior margin located opposite S2 to L3. Ocular ridge moderately strong, straight to slightly arched, directed strongly to moderately posterolateral from glabella at 60 to 70 degrees to axis. Posterior area of fixigena triangular, sharply terminated; length 41 ± 5 percent glabellar length; width 64 ± 8 percent glabella length.

Librigena moderate size, length approximately 6.5–7.0 mm ($n = 3$); moderately narrow, width 40 to 50 percent length without spine; lateral margin moderately curved. Genal field gently convex. Border slightly convex to slightly concave, wider posteriorly, width 45 to 50 percent librigenal width; border furrows shallow;

interborder furrow shallow, forming deeper depressed area at base of genal spine, extends into spine. Librigenal spine moderately long, 55 to 60 percent librigenal length, slightly curved and flattened. Doublure forms triangular ridge underneath interborder furrow, terrace lines on anterior edge of ridge.

Rostral plate, hypostoma, and thorax unknown.

Pygidium small, length approximately 2 mm ($n = 2$); suboval, length approximately 45 percent width; margin smooth; anterolateral corners sharply rounded, adjacent to axial midlength; posteromedial notch well developed; moderately convex (sag.). Axis moderately to slightly tapered, anterior width approximately 42 percent pygidial width; length approximately 90 percent pygidial length, postaxial ridge absent; three axial rings, moderately convex; terminal axial piece moderate size, posteriorly rounded; axial ring furrows shallow. Pleural regions moderately convex, level to downsloping distally; anterior pleural furrow narrow and moderately deep, extending to border; one or two additional pleural furrows, shallow; interpleural furrows shallow, not joining with pleural furrows; first anterior and posterior pleural bands moderately well developed, second set weakly developed. Border narrow, wider at anterolateral corners, slightly downsloping; absent next to terminal piece; border furrow absent.

Fine granules on all parts of the cranidia, librigenae, and pygidia. Genal caeca on anterior area of fixigena and frontal area.

Etymology.—Named for its occurrence in the Log Cabin Member, Pioche Shale.

Types.—Holotype, nearly complete cranidium USNM 510030 from USNM locality 41785; paratypes USNM 510022–510027 from USNM locality 41765; USNM 510028–510029 from USNM locality 41781, USNM 510031–510032 from USNM locality 41785.

Occurrence.—*Poliella denticulata* Biozone, Log Cabin Member, Pioche Shale, eastern Nevada. USNM localities 41748, 41754, 41758, 41760, 41765, 41781, 41782, 41785, and 41786.

Discussion.—The material collected during this study is fragmented, probably due to wave action during the deposition of the sandy bioclastic limestone in which they are found. The tails were assigned because they are associated with the cranidia and have similar granulation.

Eokochaspis? cabinensis is questionably added to this genus because of its straight axial furrows and interborder furrow in the genal spine. *Eokochaspis? cabinensis* is most similar to *E. longispina* Sundberg and McCollum, 2000, but differs in having straight axial furrows, lower convexity of the cranidium, narrower anterior margin, shorter preglabellar area, no medial swelling, shorter anterior branch of facial suture, interborder furrow, and granular surface. *Eokochaspis? cabinensis* differs from the other species of *Eokochaspis* in having straight axial furrows, lower convexity of the cranidium, shorter preglabellar area, no medial swelling, no medial inbend of the anterior border, shorter anterior branch of facial suture, interborder furrow, long genal spine, and/or granular surface.

ONCHOCEPHALITES Rasetti, 1957

Type species.—*Onchocephalites laevis* Rasetti, 1957.

ONCHOCEPHALITES sp.

Figure 17.1

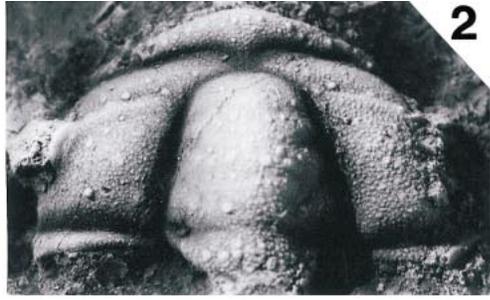
Material examined.—USNM 510101 from USNM locality 41777.

Occurrence.—*Poliella denticulata* Biozone, Susan Duster Limestone Member, Pioche Shale, eastern Nevada. USNM locality 41777. Pyramid Shale Member, Carrara Formation, central Nevada. USNM locality 41792.

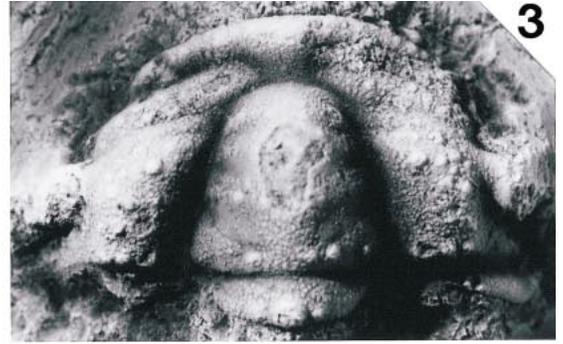
Discussion.—Three fragmented cranidia have the general outline and effacement typical of *Onchocephalites*. The specimens



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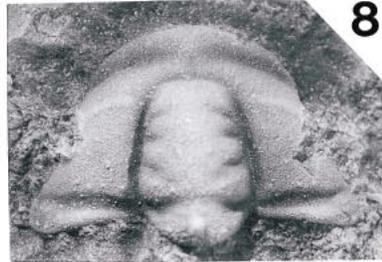
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differ from *O. laevis* in their non-tapering anterior border and wider posterior area of the fixigena.

PARAPOULSENIA Rasetti, 1957

Type species.—*Parapoulsenia lata* Rasetti, 1957.

PARAPOULSENIA cf. LATA Rasetti, 1957
Figure 17.2–17.7

Material examined.—USNM 510102–510104 from USNM locality 41742.

Occurrence.—*Poliella denticulata* Biozone, Log Cabin Member, Pioche Shale, eastern Nevada. USNM localities 41742 and 41756.

Discussion.—This small, generalized ptychopariid is similar to *Parapoulsenia lata* and *P. cf. P. lata* of Rasetti (1957) in its small, anteriorly placed palpebral lobes; granular surface; and wide fixigenae. The Pioche Shale specimens differ from Rasetti's material in having a more tapered glabella; an anterior border that is more tapered, dorsally arched, and curved. Some specimens also have more strongly arched palpebral areas of the fixigena and less angularly curved anterior border (Fig. 17.3, 17.6) than do Rasetti's (1957) specimens.

PIOCHELLA new genus

Type species.—*Piochella peasleensis* n. gen. and sp.

Diagnosis.—Cranidium pentagonal in outline with moderately low relief; anterior branches of facial suture parallel to moderately convergent; posterior branch slightly divergent, nearly parallel; glabella moderately to strongly tapered, frontal lobe bluntly rounded, straight or slightly convex glabellar outline, lateral glabellar furrows and axial furrows nearly effaced; anterior border narrow, upturned; border furrow wide; palpebral lobes moderately long, posteriorly placed; fixigena slightly convex, level; anterior area moderately downsloping, posterior area extending slightly past palpebral lobes. Exoskeleton smooth.

Etymology.—Named for the Pioche Shale in which it occurs.

Discussion.—This small ptychopariid is known from cranidia, which are common in the Log Cabin Member, Pioche Shale. The unique features that separate it from co-occurring taxa include its flat profile; pentagonal outline; long, posteriorly placed palpebral lobes; upturned, thin anterior border; and smooth surface. *Piochella* is most similar to the younger *Bythicheilus* Resser, 1939a, from the Spence Shale of Utah, which occurs in the *Albertella* Biozone. *Piochella* differs in having a flatter profile, pentagonal outline of the cranidium, straight to convex glabellar outline, and shallower axial furrows.

PIOCHELLA PEASLEENSIS new species
Figure 17.10–17.15

Diagnosis.—Same as for genus.

Description.—Cranidium small, length 3.0 ± 0.7 mm ($n = 17$); subtrapezoidal; moderate convexity (sag. and trans.); anterior margin strongly curved, straight laterally, nearly V-shaped, slightly arched dorsally; posterior margin, excluding occipital ring,

straight. Anterior branches of facial sutures moderately convergent to parallel to anterior border, moderately convergent to anterior margin; posterior branches slightly divergent, nearly parallel. Glabella moderately elongated, moderately to strongly tapered, width at anterior end 75 ± 5 percent glabellar width (K_2); moderate convexity (sag. and trans.); frontal lobe bluntly rounded; length 76 ± 2 percent cranial length; width 39 ± 2 percent cranial width. Axial furrow shallow, straight to slightly convex in outline and convergent; preglabellar furrow shallow. Lateral glabellar furrows shallow, S1 bifurcated directed posteriorly, S2 bifurcated directed laterally, S3 faint, directed laterally, S4 faint or absent, directed laterally. Occipital ring slightly elevated above glabella, moderate convexity; occipital node faint; length 27 ± 2 percent glabellar length; posterior margin moderately to strongly convex posteriorly, straight medially. SO straight and shallow to effaced. Frontal area unequally divided; length 25 ± 2 percent cranial length. Preglabellar field slightly convex, slightly downsloping, length 63 ± 6 percent frontal area length. Anterior border slightly convex, strongly upturned, slightly tapered, medial in bend absent, length 9 ± 2 percent cranial length. Anterior border furrow moderately wide and shallow, deeper than axial furrows. Fixigena slightly convex, level, anterior area slightly downsloping, lateral portions slightly more downsloping; width 65 ± 5 percent glabellar width (K_2). Palpebral lobes slightly arcuate, upturned, moderately wide to wide and moderately long, length 37 ± 4 percent glabellar length; anterior margin located opposite L2. Ocular ridge moderately weak, curved, directed moderately posterolaterally from glabella at 65 to 70 degrees to axis. Posterior area of fixigena small, triangular, terminated sharply; length 20 ± 3 percent glabellar length; width 58 ± 6 percent glabella length.

Rostral plate, hypostoma, librigena, thorax, and pygidium unknown.

Faint genal caeca on preocular and preglabellar regions.

Etymology.—Named for the type locality in the Peaslee Canyon, Nevada.

Types.—Holotype, complete cranidium USNM 510105 from USNM locality 41735; paratypes USNM 510106–510114 from USNM locality 41735; USNM 510115–510121 from USNM locality 41782.

Occurrence.—*Poliella denticulata* Biozone, Log Cabin Member, Pioche Shale, eastern Nevada. USNM localities 41735, 41741, 41743, 41744, 41745, 41749, 41759, 41760, 41771, 41780, 41782, 41786, and 41787.

Discussion.—See genus discussion.

PLAGIURA Resser, 1935

Type species.—*Ptychoparia? cercops* Walcott, 1917b.

PLAGIURA EXTENSA Palmer (in Palmer and Halley, 1979)
Figure 18.1–18.6, 18.8–18.10

Plagiura extensa PALMER (in PALMER AND HALLEY, 1979), p. 113, pl. 6, figs. 17–20, 23.

Material examined.—USNM 510122–510126 and five cranidia

FIGURE 17—Ptychopariids from the Pioche Shale, all testate material and $\times 10.0$ unless otherwise mentioned. 1, small cranidium of *Onchocephalites* sp. (USNM 510101) from the Log Cabin Member, USNM locality 41777. 2–7, *Parapoulsenia cf. lata*, all from the Log Cabin Member (USNM locality 41742); 2, 4, 5, cranidium (USNM 510102) that has more angularly curved anterior border and relatively level and less inflated fixigenae; 3, 6, cranidium (USNM 510103) with a less angular anterior border and upsloping and more inflated fixigenae; 7, smaller cranidium (USNM 510104). 8, 9, *Syspacephalus crassus*, all from the Susan Duster Limestone Member (USNM 41767); 8, cranidium (USNM 510132); 9, larger cranidium (USNM 510131). 10–15, *Piochella peasleensis* new genus and species, all from the Log Cabin Member and paratypes unless otherwise mentioned; 10, 11, 13, holotype cranidium (USNM 510105) from USNM locality 41735; 12, small cranidium (USNM 510119) from USNM locality 41782; 14, cranidium (USNM 510118) from USNM locality 41782; 15, exfoliated cranidium (USNM 510111) from USNM locality 41735.

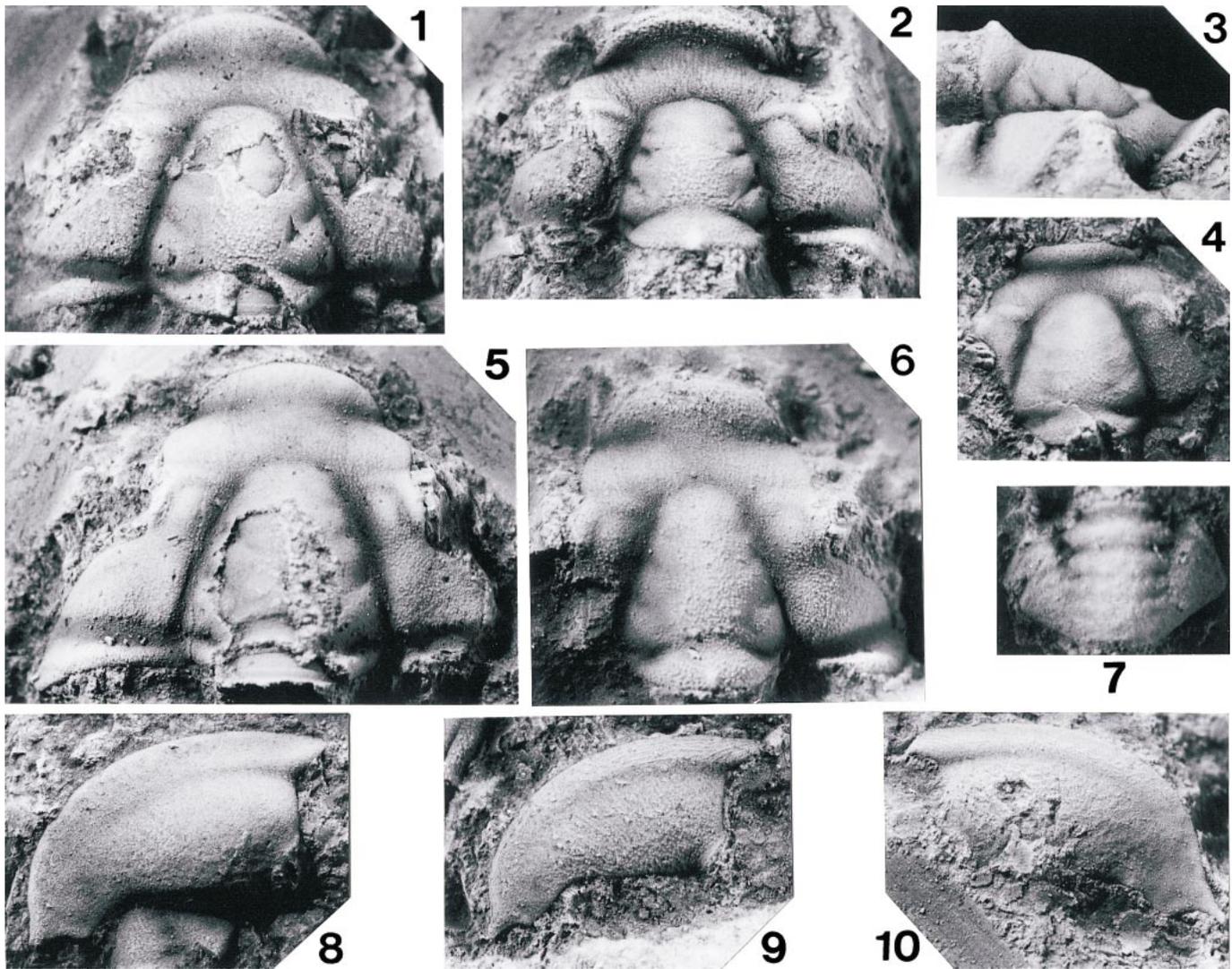


FIGURE 18—Ptychopariids from the Log Cabin Member, Pioche Shale, all testate and $\times 10.0$ unless otherwise mentioned. 1–6, 8–10, *Plagiura extensa*; 1, damaged cranidium (USNM 510125) from USNM locality 41753; 2, 3, cranidium (USNM 510122) with shorter glabella, deeper anterior border furrow, and upturned anterior border, from USNM locality 41753; 4, small cranidium (USNM 510123) with shorter anterior border and with a uniform depth anterior border furrow, from USNM locality 41753; 5, cranidium (USNM 510124) with a longer preglabellar field and smooth surface, from USNM locality 41753; 6, cranidium (USNM 510127) with a narrower glabella, from USNM locality 41132; 8, librigena (USNM 510128) with a non-deflected genal spine, from USNM locality 41132; 9, librigena (USNM 510129) with a slightly deflected genal spine, from USNM locality 41132; 10, librigena (USNM 510126) with a more deflected genal spine, from USNM locality 41753. 7, Ptychopariid pygidium (USNM 510130) from USNM locality 41132.

from USNM locality 41753; USNM 510127–510129 and four librigenae from USNM locality 41132.

Occurrence.—*Poliella denticulata* Biozone, Log Cabin Member, Pioche Shale, eastern Nevada. USNM localities 31a, 41095, 41096, 41132, 41735, 41736, 41741, 41744, 41745, 41749, 41753, 41756, 41760, 41765, and 41788. Red Pass Limestone Member, Carrara Formation, western Nevada (Palmer and Halley, 1979).

Discussion.—Palmer separated *Plagiura extensa* from *P. cercops* and *P. retracta* Palmer (in Palmer and Halley, 1979) based on its strongly upturned anterior border, longer preglabellar area, shallower border furrow, larger palpebral lobes, more convex posterior branch of the facial suture, occipital spine, granular ornamentation, a genal spine whose lateral margin continues the curvature of the librigenal border, and/or narrower librigenal border. The limited type material shows variation in the slope of the anterior border.

The specimens from the Pioche Shale show variability in the upturned nature of the anterior border (strongly upturned to level), as well as the length, curvature, and width of the anterior border; the depth of anterior border furrow (deeper for more upturned borders); ornamentation (granular to smooth, the latter of which is most common); the amount of curvature of the posterior branch of the facial suture; and the glabellar outline. However, given this variability, *P. extensa* can still be separated from similar-sized cranidia of *P. cercops* (see Rasetti, 1951, pl. 13, figs. 11–13, 16) by its longer preglabellar area, occipital spine, and stronger convexity. *Plagiura extensa* can also be separated from *P. retracta* by its longer palpebral lobes, longer preglabellar area, and transversely elongated librigena. The Pioche Shale specimens differ from the Carrara Formation material in having shorter genal spines. Some specimens have slightly deflected spines, but they are not considered significant enough to define a new species.

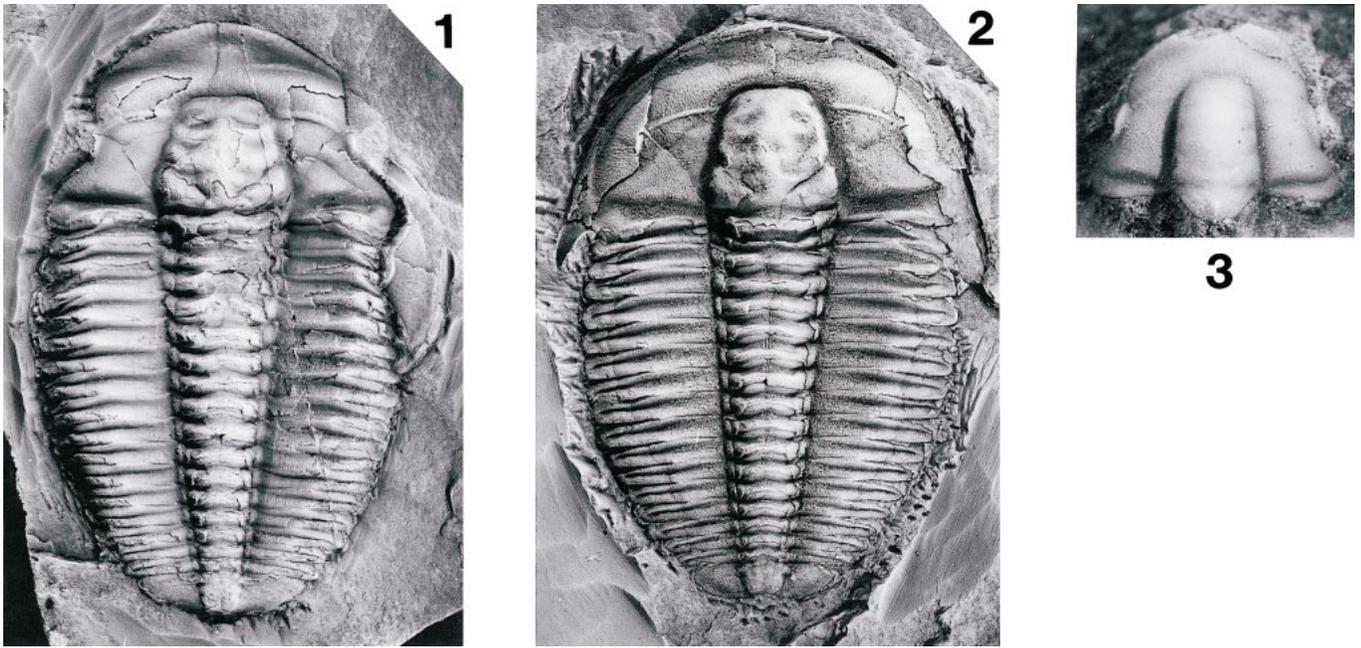


FIGURE 19—1–3, *Syspacephalus longus* from the Pyramid Shale, Carrara Formation; 1, nearly complete shield with disarticulated librigena (USNM 510135) preserved in shale from USNM locality 41793, $\times 3.2$; 2, complete shield (USNM 510134) preserved in shale from USNM locality 41796, $\times 3.2$; 3, small cranium (USNM 510133) preserved in limestone from USNM locality 41791, $\times 10.0$.

SYSPLACEPHALUS Resser, 1936

Type species.—*Agraulos charops* Walcott, 1917b.

Discussion.—Revision of *Syspacephalus* Resser, 1936, and related taxa is needed. Robison (1976) and Babcock (1994) have suggested that *Syspacephalus* and *Elrathina* Resser, 1937 are synonymous. Blaker and Peel (1997) synonymized *Elrathina*, *Syspacephalus*, and *Eoptychoparia* Rasetti, 1955, with *Ptychoparella*

Poulsen, 1927, based on the morphological variation seen in *Ptychoparella* sp. A. However, *Ptychoparella* sp. A was not compared to the type species, *P. brevicauda* Poulsen, 1927, which has more posteriorly placed palpebral lobes. A phylogenetic analysis of these four genera needs to be done before they are synonymized. Such an analysis is beyond the scope of this paper.

SYSPLACEPHALUS CRASSUS Rasetti, 1951

Figure 17.8–17.9

Syspacephalus crassus RASETTI, 1951, p. 246–247, pl. 9, figs. 12–16.

Material examined.—USNM 510131 and 510132 from USNM locality 41767.

Occurrence.—*Poliella denticulata* Biozone, Susan Duster Limestone Member, Pioche Shale, eastern Nevada. USNM localities 41738, 41739, 41764, 41767, 41768, 41923, and 41926. *Wenkchemnia-Stephenaspis* Biozone, Mount Whyte Formation, British Columbia (Rasetti, 1951).

Discussion.—The material from the Pioche Shale compares well to that from British Columbia, but differs in having a slightly tapered glabella. Some Pioche Shale specimens have a few coarse granules, an occipital spine instead of a node, a flatter fixigena, and/or deeper glabellar furrows.

SYSPLACEPHALUS LONGUS Palmer (in Palmer and Halley, 1979)

Figure 19.1–19.3

Syspacephalus longus PALMER (in PALMER AND HALLEY, 1979), p. 115, pl. 7, figs. 14, 16–18.

Material examined.—USNM 510135 and 28 cranidia from USNM locality 41793; four cranidia from USNM locality 41794; six cranidia from USNM locality 41795; USNM 510134 and 15 cranidia from USNM locality 41796; USNM 510133 from USNM locality 41791.

Occurrence.—*Poliella denticulata* Biozone, Pyramid Shale Member, Carrara Formation, central Nevada. USNM localities

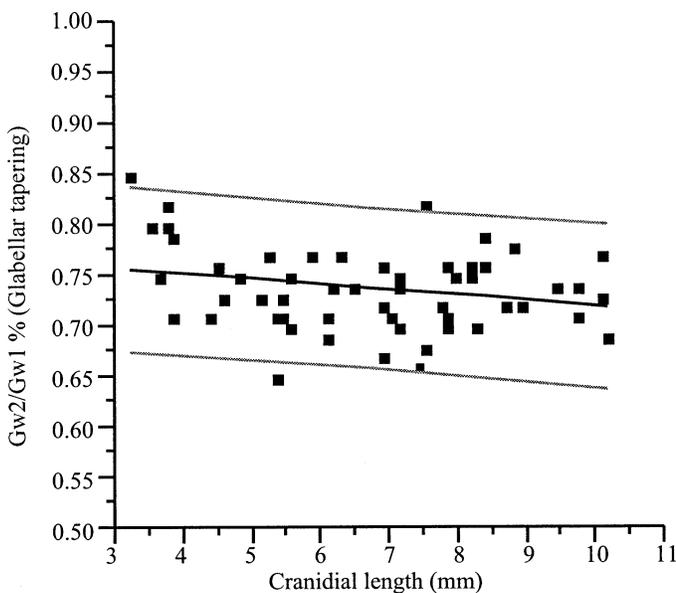


FIGURE 20—Bivariate plot of glabellar tapering versus cranial length showing the increased tapering of the glabella in the larger specimens of *Syspacephalus longus* from the Pyramid Shale, Carrara Formation, Groom Range, Nevada. Black line at center is regression line, gray lines at the sides are 95% confidence levels.

41083, 41791, and 41793–41796, 41798 (also see Palmer and Halley, 1979).

Discussion.—Palmer (in Palmer and Halley, 1979) characterized *Syspacephalus longus* as having a glabella that is obscurely furrowed and slightly tapered. The larger specimens illustrated here have moderately defined lateral glabellar furrows and a more tapered glabella. The distribution of these characters and other characters for 56 measured specimens show a continuum between the smaller specimens with nearly parallel-sided, obscured furrowed glabellae and the larger specimens with tapered, distinctly furrowed glabellae (Fig. 20). Part of the furrow enhancement and greater tapering is probably the result of greater compression of the larger specimens in the shales, as seen in other trilobites that have been preserved in shales (Hughes, 1995). A few small, uncompact specimens have been also found in limestones in the northern Groom Range, Nevada (Fig. 19.3). These specimens compare well with the small shale specimens.

PTYCHOPARIID PYGIDIUM

Figure 18.7

Material examined.—USNM 510130 from USNM locality 41132.

Occurrence.—*Poliella denticulata* Biozone, Log Cabin Member, Pioche Shale, eastern Nevada. USNM locality 41132.

Discussion.—A single small pygidium that has relatively strong relief, a wide axis with four axial rings, and nearly effaced pleural regions was found in the diverse assemblages at USNM locality 41132. A possible affinity of the pygidium might belong to *Plagiura extensa*, which is common at this locality, but cannot be confidently assigned because of its rarity and the lack of articulated specimens.

ACKNOWLEDGMENTS

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- ACCEPTED 13 JUNE 2002
- APPENDIX
Locality register
- All localities are USNM and are from either the Susan Duster Limestone and Log Cabin members of the Pioche Shale or from the Pyramid Shale Member, Carrara Formation, in the northern Groom Range. Alphabetical listing of trilobites is by locality with corynexochids first and ptychopariids second. Locality information in this register supersedes previous information about the same localities published by Sundberg and McCollum (1997, 2000, 2002).
- HIGHLAND RANGE.—
- 30.—12.8 km (8 mi) “north of Bennetts Spring, on the west slope of the Highland Range, Lincoln County, Nev. (C.D. Walcott and J. E. W., 1885)” (Walcott, 1912, p. 189). Most likely from the Log Cabin Member, Pioche Shale. *Kochaspis highlandensis*.
- One Wheel Canyon*.—SE¼, NW¼, sec. 29, T1N, R66E, 37°55'03", 114°36'15", Highland Peak 7.5' quadrangle, Nevada (1969). 41734—At 68 m above the base of the Log Cabin Member. *Poliellaites gloriosa?*, *Poliella* sp., *Stephenaspis highlandensis*, *Kochaspis liliana*, *Kochiella* sp.
- Peaslee Canyon North*.—SW¼, NW¼, sec. 32, T1N, R66E, 37°54'22", 114°36'25". Highland Peak 7.5' quadrangle, Nevada (1969). Small quarry in roadbed near powerline crossing, no measured section. 41766—Basal 10 cm of the Log Cabin Member. *Fieldaspis celer*, *Nyella?* *plana*.
- Peaslee Canyon South Section*.—SW¼, SW¼, sec. 32, T1N, R66E, 37°53'52", 114°36'25", Highland Peak 7.5' quadrangle, Nevada (1969). 41736—At 70 m above the base of the Log Cabin Member. *Plagiura extensa*, *Mexicella mexicana*. 41735—At 49 m above the base of the Log Cabin Member. *Poliella ovala*, *Fieldaspis superba*, *Stephenaspis highlandensis*, *Hadrocephalites* sp. B, *Kochaspis liliana*, *Kochiella augusta*, *Plagiura extensa*, *Piochella peasleensis*.
- Log Cabin Mine Section*.—SW¼, SW¼, sec. 32, T. 1 N., R.66E, 37°53'53", 114°36'29", Highland Peak 7.5' quadrangle, Nevada (1969). Roadcut south of the mine. 41738—From 1.0–2.0 m above base of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Poliella denticulata*, *Hadrocephalites rhytidodes*, *Kochiella brevaspis*, *Nyella?* *plana*, *Syspacephalus crassus*. 41737—Basal meter of the Susan Duster Limestone Member. *Amecephalus arrosensis*.
- COMET MINE.—
- Shallow adit*.—NW¼, NW¼, unsurveyed sec. 4, T1S, R66E, 37°53'32", 114°36'23", Highland Peak 7.5' quadrangle, Nevada (1969). Collection from shallow adit 0.6 km northeast of Comet Mine. 41924—From 3.5–5.2 m above the base of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Poliella lomataspis*, *Kochiella brevaspis*, *Nyella?* *plana*. 41739—Lower meter of limestone and shale interval, 2.5–3.5 m above base of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Poliella denticulata*, *Poliella lomataspis*, *Hadrocephalites rhytidodes*, *Kochiella brevaspis*, *Nyella?* *plana*, *Syspacephalus crassus*. 41923—From 1–2.5 m above the base of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Poliella denticulata*, *Kochiella brevaspis*, *Nyella?* *plana*, *Syspacephalus crassus*. 41922—Basal meter of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Amecephalus arrosensis*, *Caborcella reducta*, *Nyella rara*.
- Comet Mine Section*.—0.5 km east of Comet Mine, just west of range-front powerline. SW¼, NW¼, unsurveyed sec. 4, T1S, R66E, 37°53'27", 114°36'23", Highland Peak 7.5' quadrangle, Nevada (1969). 41741—Float material from near 50 m above base of the Log Cabin Member. *Kochiella augusta*, *Kochaspis liliana*, *Piochella peasleensis*, *Plagiura extensa*. 41740—Basal meter of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Amecephalus arrosensis*.
- Lyndon Gulch North*.—NW¼, NW¼, unsurveyed sec. 9, T1S, R66E, 37°52'47", 114°36'13", Highland Peak 7.5' quadrangle, Nevada (1969). 41745—At 78 m above the base of the Log Cabin Member. *Fieldaspis superba*, *Kochaspis* sp., *Mexicella mexicana*, *Piochella peasleensis*, *Plagiura extensa*. 41744—At 60 m above the base of the Log Cabin Member. *Fieldaspis superba*, *Kochiella augusta*, *Piochella peasleensis*, *Plagiura extensa*. 41743—Uncertain horizon near top of Log Cabin Member. South of Lyndon Gulch near Pan American Mine section. *Kochaspis liliana*, *Piochella peasleensis*. 41742—*Stenothecoides* Limestone. A one-meter-thick bioclastic limestone exposed in a roadcut just north of Lyndon Gulch. NW¼, NW¼, unsurveyed sec. 9, T1S, R66E, 37°52'47", 114°36'15", Highland Peak 7.5' quadrangle, Nevada (1969). At 30 m above the base of the Log Cabin Member. *Oryctocephalus* sp., *Poliellaites gloriosa*, *Poliella* cf. *prima*, *Kochiella brevaspis*, *Hadrocephalites lyndonensis*, *Parapoulsonia* cf. *lata*.
- Pan American Mine Section*.—Faunal collections made approximately 300 m east of the Pan American Mine buildings. NE¼, SW¼, unsurveyed sec. 9, T1S, R66E, 37°52'20", 114°36'08", Bennett Pass 7.5' quadrangle, Nevada (1970). 41748—At 78 m above the base of the Log Cabin Member. *Eokochaspis?* *cabinensis*. 41747—At 67 m above the base of the Log Cabin Member. *Poliella* sp., *Hadrocephalites* sp. B, *Kochiella* sp., *Nyella* sp. 41746—At 63 m above the base of the Log Cabin Member. *Fieldaspis?* sp., *Nyella* sp.
- Pan American Mine section*.—NE¼, NW¼, unsurveyed sec. 16, T1S, R66E, 37°51'57", 114°36'07", Bennett Pass 7.5' quadrangle, Nevada (1970). Roadcut exposure at the junction of the southern entrance to the Pan American Mine and the range-front road.

41752—1.0–2.0 m above base of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Poliella denticulata*, *Hadrocephalites lyndonensis*, *Kochiella brevaspis*.

North of Pan American Mine Section.—SE¼, SW¼, unsurveyed sec. 9, T1S, R66E, 37°52'10", 114°36'11", Bennett Pass 7.5' quadrangle, Nevada (1970). Just west of the range-front road, 100 m north of the north entrance of the Pan American Mine.

41751—1.0–2.0 m above base of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Poliella denticulata*, *Nyella? plana*.

41750—Basal meter of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Poliella lomataspis*, *Nyella rara*, *Amecephalus arrojensis*, *Mexicella robusta*.

Black Canyon North #4 Section.—NE¼, SW¼, unsurveyed sec. 16, T1S, R66E, 37°51'21", 114°36'05", Bennett Pass 7.5' quadrangle, Nevada (1970).

41754—At 70 m above the base of the Log Cabin Member. *Eokochaspis? cabinensis*, *Kochiella augusta*.

41753—At 63 m above the base of the Log Cabin Member. *Stephenaspis highlandensis*, *Hadrocephalites rhytidodes*, *Kochaspis liliana*, *Kochiella augusta*, *Plagiura extensa*.

CHIEF RANGE.—

Upper Klondike Gap Section.—SW¼, SW¼, unsurveyed sec. 24, T2S, R66E, 37°45'18", 114°33'00", Bennett Pass 7.5' quadrangle, Nevada (1970).

41760—At 51 m above the base of the Log Cabin Member. *Fieldaspis superba*, *Stephenaspis highlandensis*, *Eokochaspis? cabinensis*, *Kochiella augusta*, *Piochella peasleensis*, *Plagiura extensa*.

41759—At 48 m above the base of the Log Cabin Member. *Fieldaspis* sp., *Kochaspis liliana*, *Kochiella augusta*, *Piochella peasleensis*.

41758—At 45 m above the base of the Log Cabin Member. *Eokochaspis? cabinensis*, *Kochiella* sp.

41757—At 25 m above the base of the Log Cabin Member. *Poliellaites gloriosa*, *Poliella* cf. *prima*, *Hadrocephalites* sp., *Kochiella brevaspis*.

41756—At 24 m above the base of the Log Cabin Member. *Fieldaspis celer?*, *Poliellaites gloriosa*, *Amecephalus? sp.*, *Kochiella brevaspis*, *Parapoulsenia* cf. *lata*, *Plagiura extensa*.

Lower Klondike Gap Section.—SE¼, SE¼, unsurveyed sec. 3, T2S, R66E, 37°45'18", 114°33'13", Bennett Pass 7.5' quadrangle, Nevada (1970).

41927—From 4–6.8 m above the base of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Poliella denticulata*, *Poliella lomataspis*, *Hadrocephalites rhytidodes*, *Kochiella brevaspis*, *Nyella? plana*.

41926—From 0.7–4 m above the base of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Oryctocephalus* sp., *Poliella denticulata*, *Poliella lomataspis*, *Amecephalus arrojensis*, *Hadrocephalites rhytidodes*, *Kochiella brevaspis*, *Nyella? plana*, *Nyella rara*, *Syspacephalus crassus*.

41925—Basal 0.7 m of the Susan Duster Limestone Member. *Amecephalus arrojensis*, *Kochiella brevaspis*, *Mexicella robusta*, *Nyella rara*.

Antelope Canyon Section.—NW¼, NW¼, unsurveyed sec. 5, T4S, R67E, 37°38'00", 114°30'53", Chief Mountain 7.5' quadrangle, Nevada (1970).

41762—From 1–5 m above base of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Poliella denticulata*, *Poliella lomataspis*, *Hadrocephalites rhytidodes*, *Kochiella brevaspis*, *Nyella? plana*.

41761—Basal 0.7 m of the Susan Duster Limestone Member. *Amecephalus arrojensis*, *Kochiella* sp., *Nyella rara*.

PIOCHE HILLS.—

Upper Pioche Divide Section.—NW¼, NE¼, sec. 27, T1N, R67E, 37°55'15", 114°27'12", Pioche 7.5' quadrangle, Nevada (1969).

41765—At 50 m above the base of the Log Cabin Member. *Poliella* sp., *Eokochaspis? cabinensis*, *Kochaspis liliana*, *Kochiella augusta*, *Kochiella maxeyi*, *Plagiura extensa*.

Lower Pioche Divide Section.—NW¼, NE¼, sec. 27, T1N, R67E, 37°55'11", 114°27'11", Pioche 7.5' quadrangle, Nevada (1969).

41784—From 3–4.5 m above base of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Poliella denticulata*, *Poliella lomataspis*, *Nyella? plana*.

41764—From 1.0–2.0 m above base of the Susan Duster Limestone

Member. *Fieldaspis bilobata*, *Poliella denticulata*, *Kochiella brevaspis*, *Nyella? plana*, *Syspacephalus crassus*.

41763—Basal meter of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Amecephalus arrojensis*, *Mexicella robusta*, *Nyella rara*.

Old Pioche-Panaca Road.—E ½, sec. 36, T1N, R67E, Pioche 7.5' quadrangle, Nevada (1969).

31a.—“Lower Cambrian: Limestone and interbedded siliceous shales of the Pioche formation [Walcott, 1908a, p. 11], just above the quartzite on the east side of the anticline, near Pioche, Lincoln County, Nev. (C.D. Walcott and J.E.W., 1885).” (Walcott, 1912, p. 192). Uppermost Log Cabin Member. Walcott's original collection includes *Oryctocephalus primus*, *Stephenaspis highlandensis*, *Kochiella augusta*, *Hadrocephalites* sp. A., *Kochaspis liliana*, *Plagiura extensa*.

Highway 93 Roadcut Section #1.—SW¼, NE¼, sec. 36, T1N, R67E, 37°54'19", 114°24'53", Pioche 7.5' quadrangle, Nevada (1969).

41132—At 50 m above the base of the Log Cabin Member. *Oryctocephalus primus*, *Poliella ovala*, *Stephenaspis highlandensis*, *Hadrocephalites* sp. A, *Kochaspis liliana*, *Kochiella augusta*, *Plagiura extensa*, ptychopariid pygidium.

41095—This locality and USNM Localities 41096 and 41132 are the same stratigraphic interval and contain same trilobites in an outcrop belt that is discontinuously exposed from a roadcut of U.S. Highway 93 to approximately 500 m to the east. *Oryctocephalus primus*, *Kochiella augusta*, *Plagiura extensa*.

41096—See USNM Locality 41095. Four hundred meters east of U.S. Highway 93, elevation 6,000'. *Oryctocephalus primus*, *Kochaspis liliana*, *Kochiella augusta*, *Plagiura extensa*.

Highway 93 Roadcut Section #2.—SW¼, NE¼, sec. 36, T1N, R67E, 37°54'15", 114°24'53", Pioche 7.5' quadrangle, Nevada (1969).

41767—From 1–2 m above base of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Poliella denticulata*, *Poliella lomataspis*, *Amecephalus arrojensis*, *Hadrocephalites rhytidodes*, *Kochiella brevaspis*, *Nyella? plana*, *Syspacephalus crassus*.

Old Pioche-Panaca Road Section.—NE¼, SE¼, sec. 36, T1N, R67E, 37°54'05", 114°24'34", Pioche 7.5' quadrangle, Nevada (1969).

41768—From 1–2 m above base of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Poliella denticulata*, *Nyella? plana*, *Syspacephalus crassus*.

DELAMAR MOUNTAINS.—

Upper Oak Springs Section.—SE¼, NE¼, unsurveyed sec. 8, T4S, R65E, 37°37'00", 114°42'52", Chokecherry Mountain 7.5' quadrangle, Nevada (1970).

41771—At 56 m above the base of the Log Cabin Member. *Poliella ovala*, *Amecephalus* sp., *Hadrocephalites? sp.*, *Kochaspis liliana*, *Kochiella augusta*, *Piochella peasleensis*, *Syspacephalus* sp. unident.

Middle Oak Springs Section.—NE¼, NE¼, unsurveyed sec. 8, T4S, R65E, 37°37'17", 114°43'05", Chokecherry Mountain 7.5' quadrangle, Nevada (1970).

41770—At 25 m above the base of the Log Cabin Member. *Poliella* sp.

Lower Oak Springs Section.—NE¼, NE¼, unsurveyed sec. 8, T4S, R65E, 37°37'12", 114°43'05", Chokecherry Mountain 7.5' quadrangle, Nevada (1970).

41769—From 2–3 m above base of the Susan Duster Limestone Member. *Poliella lomataspis*, *Hadrocephalites rhytidodes*, *Kochiella? sp.*, *Nyella? plana*.

41930—From 0.7–2 m above base of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Poliella denticulata*, *Hadrocephalites rhytidodes*, *Kochiella brevaspis*.

41929—Basal 0.7 m of the Susan Duster Limestone Member. *Amecephalus arrojensis*.

SOUTHERN BURNT SPRINGS RANGE.—

Hidden Valley Section.—SE¼, SW¼, sec. 12, T4S, R64E, 37°36'36", 114°45'38", Pahroc Spring SE 7.5' quadrangle, Nevada (1970).

41773—Basal 0.2 m of the Log Cabin Member. *Fieldaspis celer*, *Hadrocephalites* sp., *Kochiella* sp., *Nyella? plana?*

41772—At 1 m above the base of the Susan Duster Limestone Member. *Poliella lomataspis*.

Grassy Spring Section.—NW¼, NW¼, sec. 14 and SW¼, SW¼, sec. 11,

T5S, R64E, 37°31'17", 114°47'26", Pahroc Spring SE 7.5' quadrangle, Nevada (1970).

41783—A 0.75 m thick, echinodermal bioclastic limestone 62–63 m above the base of the Log Cabin Member. *Fieldaspis?* sp., *Stephenaspis* sp., *Hadrocephalites lyndonensis*, *Kochaspis* sp., *Kochiella* sp., *Plagiura* sp.

41782—From 51–53 m above the base of the Log Cabin Member. *Poliella ovala*, *Eokochaspis?* *cabinensis*, *Kochiella augusta*, *Kochiellina janglensis*, *Piochella peasleensis*.

41781—From 51–51.5 m above base of the Log Cabin Member. *Eokochaspis?* *cabinensis*.

41780—At 51 m above the base of the Log Cabin Member. *Fieldaspis* sp., *Kochiella augusta*, *Piochella peasleensis*.

41779—At 50 m above the base of the Log Cabin Member. *Kochiella augusta*.

41775—Basal 0.25 m of the Log Cabin Member. *Fieldaspis celer*, *Nyella?* *plana*.

41776—From 3–4.5 m above the base of the Susan Duster Limestone Member. *Poliella denticulata?*, *Poliella lomataspis*, *Hadrocephalites* sp., *Nyella?* *plana*.

41777—From 2–3 m above base of the Susan Duster Limestone Member. *Poliella* sp., *Hadrocephalites rhytidodes*, *Kochiella brevaspis*, *Nyella?* *plana*, *Onchocephalites* sp.

41774—From 0.7–2.0 m above base of the Susan Duster Limestone Member. *Fieldaspis bilobata*, *Poliella denticulata*, *Amecephalus arrojosisensis*, *Hadrocephalites rhytidodes*, *Kochiella brevaspis*, *Nyella?* *plana*, *Syspacephalus* sp.

41778—Basal 0.7 m of the Susan Duster Limestone Member. *Amecephalus arrojosisensis*, *Hadrocephalites rhytidodes*, *Nyella?* *plana*.

Grassy Spring Wash Section.—SE¼, NW¼, sec. 14, T5S, R64E, 37°31'03", 114°47'20", Pahroc Spring SE 7.5' quadrangle, Nevada (1970).

41749—At 52 m above the base of the Log Cabin Member. *Fieldaspis superba*, *Stephenaspis highlandensis*, *Kochaspis liliana*, *Kochiella augusta*, *Piochella peasleensis*, *Plagiura extensa*.

41785—At 50 m above the base of the Log Cabin Member. *Eokochaspis?* *cabinensis*, *Kochaspis liliana*, *Kochiella* sp.

Big Lime Mountain Section.—NE¼, SW¼, sec. 23, T6S, R64E, 37°24'35", 114°47'13", Delamar 7.5' quadrangle, Nevada (1969).

41788—At 53 m above the base of the Log Cabin Member. *Kochaspis liliana*, *Plagiura extensa*.

41787—At 51 m above the base of the Log Cabin Member. *Poliella ovala*, *Kochaspis liliana*, *Kochiella* sp., *Piochella peasleensis*.

41786—At 48 m above the base of the Log Cabin Member. *Eokochaspis?* *cabinensis*, *Piochella peasleensis*.

NORTHERN GROOM RANGE.—

Groom Range Section.—NW¼, SE¼, unsurveyed sec. 26, T4S, R55E, 37°34'07", 115°45'23", White Blotch Springs SE 7.5' quadrangle, Nevada (1987). All localities are in the Pyramid Shale Member, Carrara Formation. Stratigraphic thicknesses are given above the base of the Pyramid Shale Member.

Log Cabin Member equivalent begins at 220 m above the base of the Carrara Formation and 103 m above the base of the Pyramid Shale Member.

41799—At 124 m. *Kochiella rasettii*.

41798—At 121 m. *Kochiella rasettii*, *Syspacephalus longus*.

41797—At 113.5 m. *Kochiella rasettii*.

41796—At 109 m. *Kochiella rasettii*, *Syspacephalus longus*.

41795—At 108 m. *Kochiella rasettii*, *Syspacephalus longus*.

41794—At 107 m. *Kochiella rasettii*, *Syspacephalus longus*, *Pagetia* sp.

41793—From 104.5–106 m. *Microroyctocara nevadensis*, *Oryctocephalus nyensis*, *Poliella* sp., *Kochiella rasettii*, *Syspacephalus longus*.

41083—At 103 m above the base of the Pyramid Shale Member within the several meters of dark shale starting directly above the Susan Duster Member equivalent. *Oryctocephalus nyensis*, *Kochiella rasettii*, *Syspacephalus longus*.

Susan Duster Limestone equivalent begins at 216 m above the base of the Carrara Formation and 99 m above the base of the Pyramid Shale Member.

41792—From 102.5–103 m, upper 0.5 m of limestone. *Oryctocephalus* sp., *Poliella denticulata*, *Poliella lomataspis*, *Hadrocephalites rhytidodes*, *Kochiella brevaspis*, *Nyella?* *plana*, *Onchocephalites* sp.

41791—From 99.5–101 m, 0.5–2 m above base of limestone. *Fieldaspis bilobata*, *Poliella denticulata*, *Poliella lomataspis*, *Hadrocephalites rhytidodes*, *Kochiella brevaspis*, *Nyella?* *plana*, *Syspacephalus longus*.

41790—From 99–99.5 m, basal 0.5 m of limestone. *Amecephalus arrojosisensis*, *Kochiella* sp.

41789—Student collection, within the limestone unit. *Poliella lomataspis*, *Hadrocephalites rhytidodes*, *Nyella?* *plana*, *Syspacephalus* sp.