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## Monograph

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# Middle Permian ostracods (Crustacea) from the Guadalupe Mountains, West Texas, USA

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**Abstract.** Middle Permian (Guadalupian) ostracods are described from the Williams Ranch Member of the Cutoff Formation (Roadian) and the McKittrick Canyon Member of the Bell Canyon Formation (Capitanian) from two sections exposed in Culberson County, Guadalupe Mountains, West Texas. Their taxonomy is discussed and adds to the scientific understanding of marine ostracod biodiversity and palaeobiogeography during the Middle Permian. Ostracod assemblages are represented by 51 species of 26 genera and 15 families. Eleven species are newly described: *Healdia mckittrickensis* Crasquin sp. nov., *Healdia cutoffella* Crasquin sp. nov., *Aurikirkbya guadalupensis* Crasquin sp. nov., *Hollinella (Hollinella) williamsranchensis* Crasquin sp. nov., *Geisina culbersonensis* Crasquin sp. nov., *Paraparchites pecosensis* Crasquin sp. nov., *Bairdia elcapitanensis* Forel sp. nov., *Ceratobairdia mescaleroella* Forel sp. nov., *Ceratobairdia sexagintaduella* Forel sp. nov., *Ceratobairdia pratti* Forel sp. nov., and *Denticupachydomella bellcanyonensis* Forel sp. nov. The diagnosis of the genus *Denticupachydomella* is emended. The palaeobiogeographic distribution of the species is analyzed and exemplifies the taxon exchanges between Tethyan and Panthalassic localities in the Permian. The eastern margin of the Palaeo-Tethyan realm is shown to have played a major role in radiation of taxa in the Permian.

**Keywords.** Ostracods, Roadian, Capitanian, Guadalupe Mountains.

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## Introduction

The Guadalupian Epoch, Middle Permian, witnessed major global changes, including the formation of the Pangaea supercontinent, the end of the Late Palaeozoic Ice Age, and sea-level changes as well as major biotic events (e.g., Shen *et al.* 2020 and references therein). Ostracods are millimetre-size crustaceans that are significant components of the meiofauna known from the Early Palaeozoic (e.g., Salas *et al.* 2007) to the present time. It is now acknowledged that Permian marine ostracod communities went through significant changes up to the end-Permian extinction (see Crasquin & Forel 2014 and Forel & Crasquin 2020 for reviews) but their response to the so-called end-Guadalupian mass extinction remains enigmatic. The evolution of meiobenthic biodiversity through this key interval can only be understood by first characterizing the taxonomic structure of Middle Permian communities worldwide. Guadalupian marine ostracods have been reported, for instance, from Greece (Crasquin-Soleau & Baud 1998), Turkey (Kozur *et al.* 2000; Crasquin-Soleau *et al.* 2004), Sultanate of Oman (Crasquin-Soleau *et al.* 1999), the Russian Platform and Far East in Russia (e.g., Khivintseva 1969; Gramm 1997), Thailand (e.g., Chitnarin *et al.* 2012, 2017), China (Zazzali *et al.* 2015), Japan (Ishizaki 1964; Tanaka *et al.* 2013), Afghanistan (Forel 2018), and North America (e.g., Girty 1908, 1910; Sohn 1954, 1960, 1982).

In North America, Middle Permian ostracods have been described from the Guadalupian outcrops that are widespread in the Delaware Basin: in the Guadalupe, Apache and Glass mountains (Fig. 1). The Guadalupe Mountains are the World stratotype area for the Middle Permian and the Guadalupe Mountains National Park contains the GSSPs for the Roadian, Wordian and Capitanian stages (Glenister *et al.* 1999). The first appearance of the conodonts *Jinogondolella nankingensis* (Jin, 1960), *J. aserrata* (Clark & Behnken, 1979) and *J. postserrata* (Behnken, 1975), respectively, define the lower boundary of the Roadian, Wordian and Capitanian stages. The Guadalupian strata present in the Delaware Basin represent various palaeoenvironments from back reef, reef, fore reef to basinal.

The ostracods from the Delaware Basin are known from the Guadalupe and Glass Mountains. In the Guadalupe Mountains, the first ostracods were mentioned by Girty (1908) who described and illustrated (drawings) three species of silicified ostracods: *Cythere?* sp. from the “dark limestone” of Pine Spring (= Goat Seep Limestone), *Bairdia* aff. *plebeia* Reuss, 1854 from basal black limestone (= Bone Spring Limestone of King that includes members of the Cutoff Formation, Lambert *et al.* 2000) of Guadalupe Point, both from the Guadalupe Mountains, and *Argilloecia* sp. from the Delaware Mountain Formation of the southern Delaware Mountains. Sohn (1954) included Girty’s species *Argilloecia* sp. in his species *Miltonella shupeii* Sohn, 1950 and reillustrated it in Sohn (1954: pl. 5 fig. 19). Later, Sohn (1960: pl. 1 fig. 22) reillustrated another of Girty’s species, *Bairdia* aff. *plebeia*, and assigned it to the species *Bairdia pecosensis* Delo, 1930. According to Sohn (1982: 105), the third of Girty’s species *Cythere?* sp. is “an unidentifiable broken smooth valve on limestone.” Sohn (1961a) listed 23 species of ostracods from the Getaway Limestone Member of the Cherry Canyon Formation in the Guadalupe Mountains. Almost all species were identified in open nomenclature, except for six: *Amphissites* aff. *centronotus* (Ulrich & Bassler, 1906), *Aurikirkbya* aff. *wordensis* (Hamilton, 1942), *Ceratobairdia wordensis* (Hamilton, 1942), *Healdia?* *vidriensis* Hamilton, 1942, *Polytylites digitatus?* Sohn, 1954, and *Roundyella dorsopapillosa?* Sohn, 1954.

In the Glass Mountains, Guadalupian age ostracods have been studied from the Word # 1 limestone of the Word Formation (Hamilton 1942). According to Cooper & Grant (1964), this limestone is assigned to the Road Canyon Formation, which is of Roadian age (Wardlaw 2002). Also, ostracods have been described by Sohn (1950, 1954, 1962) from the upper part of the Leonardian or lower part of the Word Formation (USNM 703c locality that is assigned to the Road Canyon Formation) and the Road Canyon Formation (Sohn 1972). Hamilton (1942) and Sohn (1950, 1954, 1962) described 29 new species, some of which occur in the material studied herein.

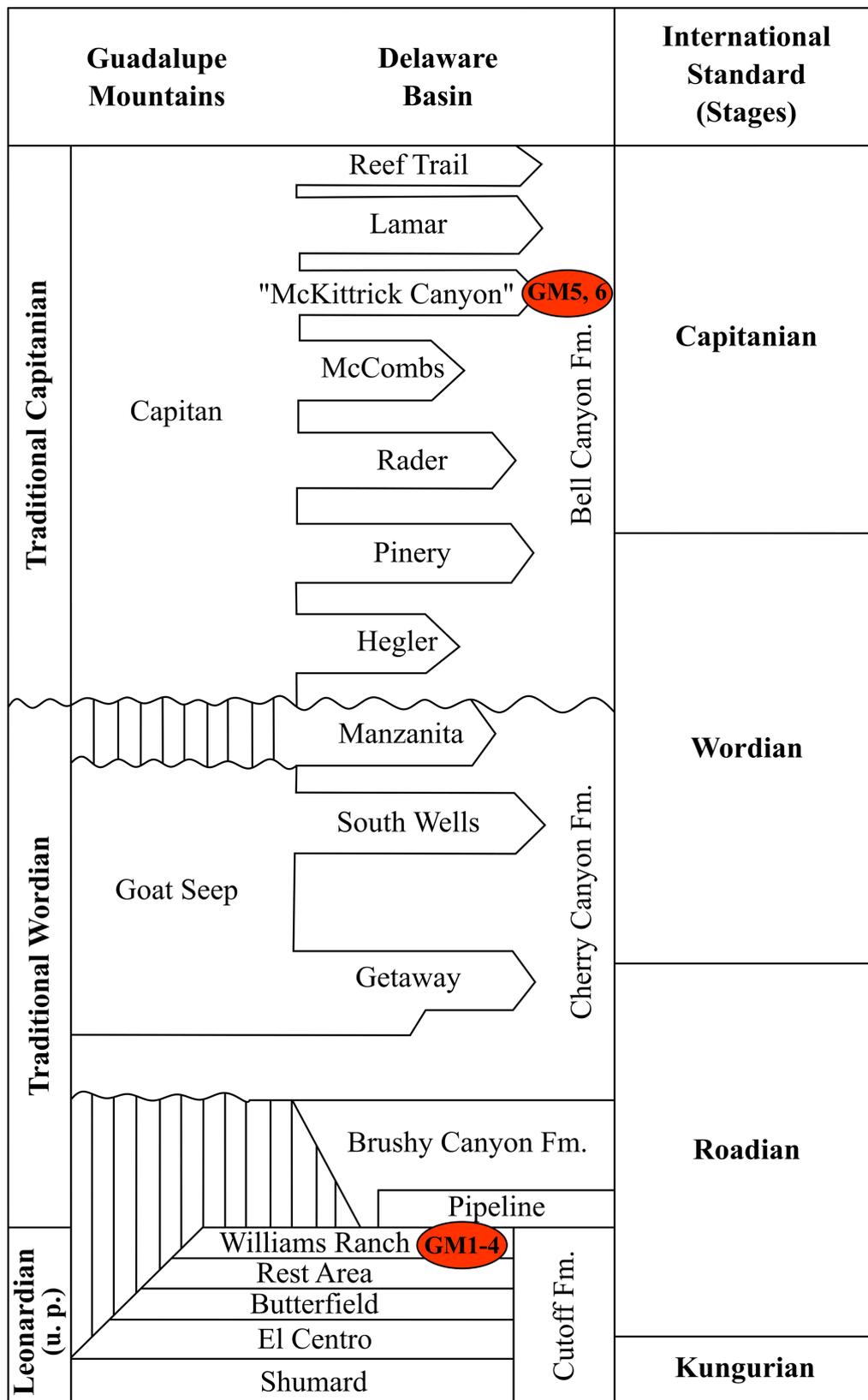


**Fig. 1.** Major structural features of the Permian Basin region in West Texas, USA showing the location of the Delaware Basin and surrounding mountains (modified from Harris 2000). Black lines indicate the boundaries of provinces of Permian time.

Herein, we analyse ostracod assemblages obtained from two sections in the Guadalupe Mountains area of West Texas: the Quarry section exposing the upper part of the Cutoff Formation (Roadian) and the MKCS1 section exposing the middle part of the Bell Canyon Formation (Capitanian). Ostracods are described and taxonomy is discussed, adding important information to better constraint the Middle Permian biodiversity of ostracod assemblages along the eastern Panthalassa margin. The palaeogeographical links with coeval assemblages are also analysed and provide evidence of Tethyan-Panthalassic exchanges through the Permian.

### Geological setting

The Guadalupian strata of basinal setting exposed in the Delaware Basin are subdivided into the Cutoff, Brushy Canyon, Cherry Canyon and Bell Canyon Formations (Fig. 2).



**Fig. 2.** Stratigraphical units of the Guadalupian in the Delaware Basin area (modified from Wardlaw 2004) and position of the studied Quarry section (samples GM1-GM4) and MKCS1 section (samples GM5, GM6). Abbreviations: u. p. = upper part; Fm. = formation.

### Cutoff Formation

The history and stratigraphical nomenclature of the Cutoff Formation in the Guadalupe Mountains is discussed in Harris (2000), Lambert *et al.* (2000), Hurd *et al.* (2018), and Nestell & Nestell (2020). The Cutoff Formation is a succession of alternating carbonate and siliciclastic rocks and recently has been subdivided into 5 members (Hurd *et al.* 2016, 2018): Shumard, El Centro, Butterfield, Rest Area, and Williams Ranch, in ascending order (Fig. 2). The lower boundary of the Roadian is in the middle of the El Centro Member as shown by the first appearance of the conodont *J. nankingensis* (Glenister *et al.* 1999; Lambert *et al.* 2000). The Williams Ranch Member is the uppermost member of the Cutoff Formation that unconformably overlies the Rest Area Member and is unconformably overlain by the Brushy Canyon Formation (Hurd *et al.* 2018). It ranges from 10 to 47 m in thickness and consists of deformed soft-sediments, thin-bedded carbonate mudstone, wackstone and packstone.

The Williams Ranch Member recently has been restudied and resampled by Nestell & Nestell (2020) for the radiolarian analysis in the Quarry section. Besides radiolarians, the studied samples contain conodonts, foraminifers, fish teeth and ostracods, the latter are investigated herein. The Quarry section is located along US Highway 62/180 3 km northeast of its junction with Texas Highway 54 (Fig. 3). The strata of the Williams Ranch Member of the Cutoff Formation are exposed as two roadcuts on both sides of the U.S. Highway 62/180. The ostracod fauna is studied from samples taken on the northwestern side of the highway in a small quarry that exposes about 13 m of limestone beds (Nestell & Nestell 2020). The bottom of the section is composed of thin-bedded black carbonate mudstone with small black pebbles of packstone with soft-sediment deformation. A zone of debris with exposures in some places of thin- to medium-bedded black carbonate mudstone with lenses of mollusc-bearing packstone occur higher in the section. The packstone lenses contain ammonoids, a very rich assemblage of fish remains, small foraminifers, rare fusulinids, conodonts, diverse radiolarians, scolecodonts, holothurian sclerites, and ostracods (Spinosa *et al.* 1975; Lambert *et al.* 2000; Nestell *et al.* 2015; Nestell & Nestell 2020).

### Bell Canyon Formation

In the Guadalupe Mountains, the Bell Canyon Formation is subdivided into seven limestone members (in ascending order): Hegler, Pinery, Rader, McCombs, 'McKittrick Canyon' (its status is not formalised yet), Lamar and Reef Trail (Fig. 2). The ostracods were studied from the 'McKittrick Canyon' Member exposed in one section (MKSC1) at the locality GUMO GEO 00252 in the Patterson Hills area (Ivanov *et al.* 2020). Strata of this locality are represented by thin-bedded limestone about 3 m thick with several thin beds of debris flow. Eight samples were taken from this locality, but ostracods have been found only in two samples. It is worthy to note that fish remains have recently been described from this locality (Ivanov *et al.* 2020).

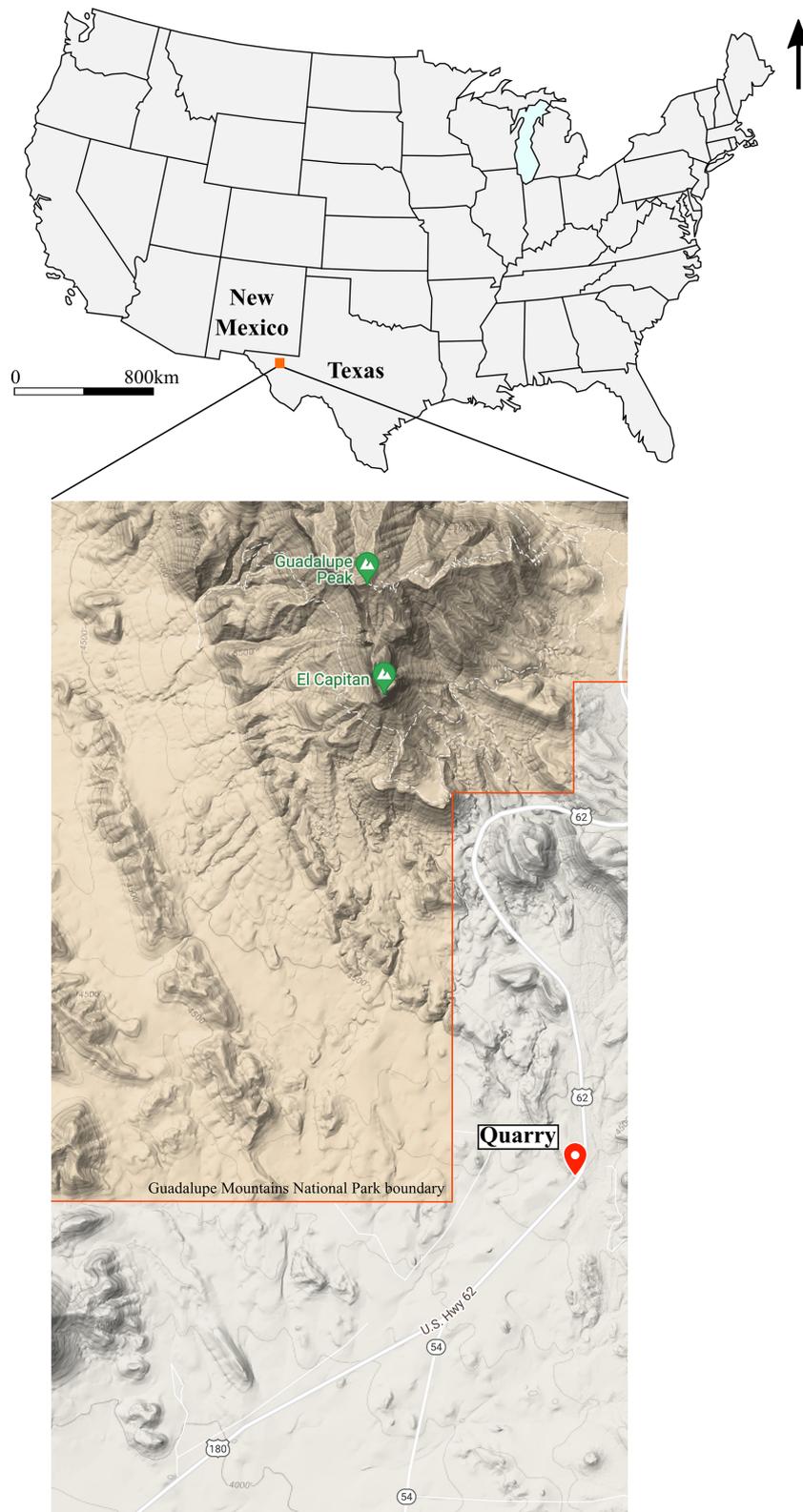
### Material and methods

Six samples processed by diluted acid used for conodont analysis are studied herein (Fig. 2). Four samples from the Williams Ranch Member, Cutoff Formation (Roadian; GM1, GM2, GM3 and GM4) and two samples from the 'McKittrick Canyon' Member, Bell Canyon Formation (Capitanian; samples GM5, GM6) have been studied for ostracod analysis (Fig. 3). All of the recovered specimens of ostracods are silicified. 1662 specimens were mounted on stubs and photographed with SEM. 943 specimens have been identified: they belong to 15 families, 26 genera and 51 species. 23 species are kept in open nomenclature or compared to previously known species.

We follow herein the general ostracod classification of Moore (1961) and Horne *et al.* (2002).

### Material repository

All type and figured specimens from the Roadian and Capitanian of the Guadalupe Mountains are temporarily deposited in the Micropalaeontology collections of the Muséum national d'histoire naturelle, Paris, France (MNHN) under catalogue numbers MNHN.F.F63365–MNHN.F.F63500 and



**Fig. 3.** A. Location of Texas in the USA. B. Location of the studied sections along US Highway 62/180 in the Guadalupe Mountains, West Texas (Google Maps 2021). The orange area shows the Park and its boundary. The section MKSC1 is located within the park but its precise position cannot be disclosed because of park regulations.

MNHN.F.F63653–MNHN.F.F63660. Individual collection numbers are only provided for type and figured specimens, other mentioned materials are given lot numbers.

Two specimens from the late Capitanian, Middle Permian, Penglaitan section, Guangxi, South China are deposited in the collections of the Sorbonne Université, Paris, France under catalogue numbers P6M 3778 and P6M 3779.

### Anatomical abbreviations

AB	=	anterior border
ACA	=	anterior cardinal angle
ADB	=	antero-dorsal border
AVB	=	antero-ventral border
DB	=	dorsal border
H	=	height
Hmax	=	maximal height
Hmean	=	mean height
L	=	length
L <sub>1</sub> , L <sub>2</sub> , L <sub>3</sub>	=	lobers
Lmax	=	maximal length
Lmean	=	mean length
LV	=	left valve
PB	=	posterior border
PCA	=	posterior cardinal angle
PDB	=	postero-dorsal border
PVB	=	postero-ventral border
RV	=	right valve
S <sub>2</sub>	=	median sulcus
VB	=	ventral border
W	=	width
Wmax	=	maximal width

### Results

#### *Systematic palaeontology* (M.-B. Forel & S. Crasquin)

Class Ostracoda Latreille, 1806  
 Subclass Podocopa Müller, 1894  
 Order Metacopida Sylvester-Bradley, 1961  
 Suborder Metacopina Sylvester-Bradley, 1961  
 Superfamily Healdioidea Harlton, 1933  
 Family Healdiidae Harlton, 1933

Genus *Healdia* Roundy, 1926

#### Type species

*Healdia simplex* Roundy, 1926 by original designation.

*Healdia mckittrickensis* Crasquin sp. nov.

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Fig. 4A–C

#### Diagnosis

A species of *Healdia* with a stocky carapace, a massive overlap of LV on RV, thick posterior spines; a curved ridge extends in front of the spines.

### Etymology

In reference to the ‘McKittrick Canyon’ Member, Bell Canyon Formation, Guadalupe Mountains, West Texas, where this species has been discovered.

### Material examined

#### Holotype

USA • complete carapace, (Fig. 4A); Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample GM5; Capitanian, Middle Permian; MNHN.F.F63365.

#### Paratype

USA • 1 incomplete carapace (DB and PVB of LV are missing), (Fig. 4B); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63366.

#### Additional material

USA • 1 right valve; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample GM5; Capitanian, Middle Permian; MNHN.F.F63367 • 3 complete carapaces; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM4; Roadian, Middle Permian; MNHN.F.F63473.

### Dimensions

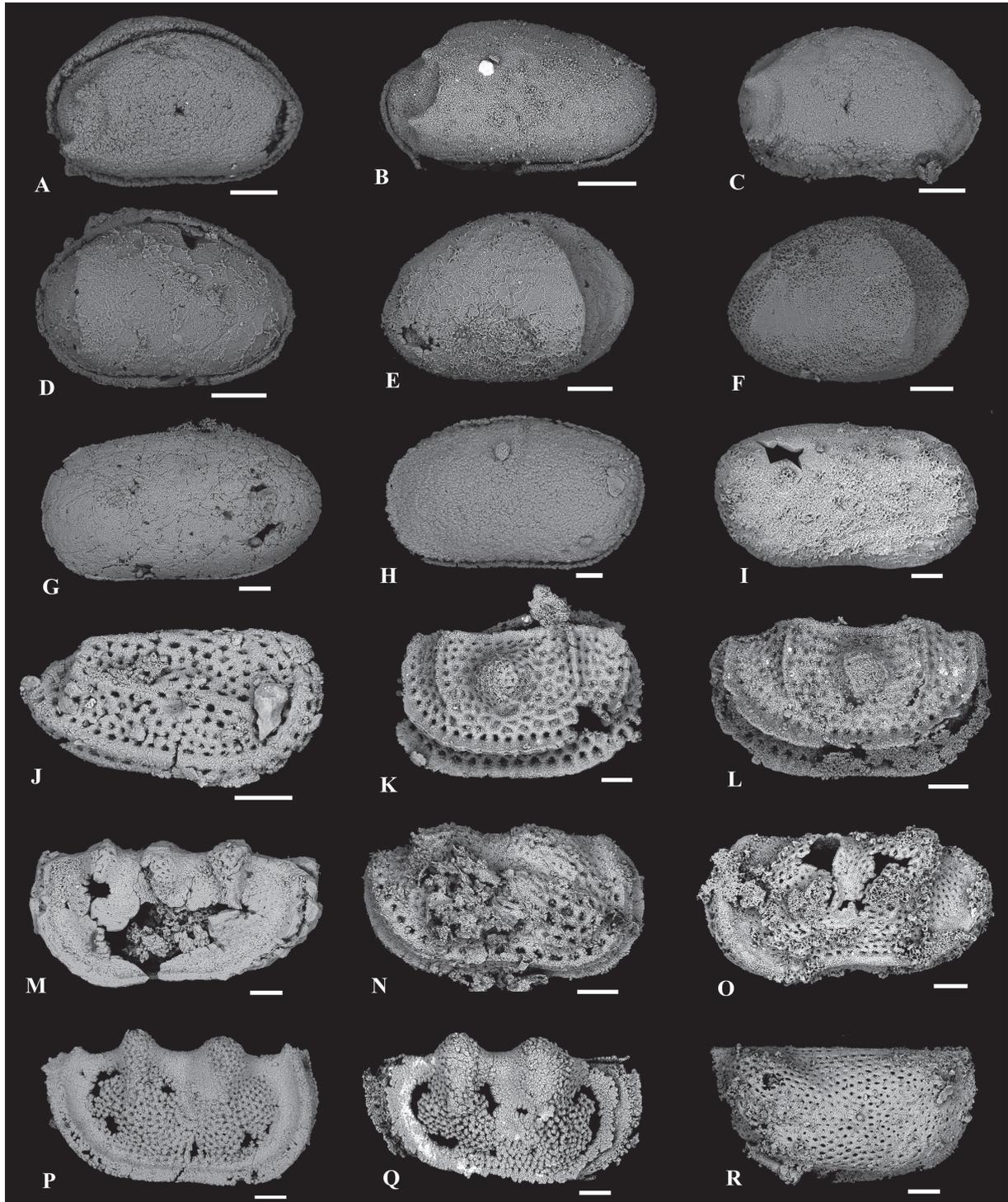
L=224–807 µm; H=139–489 µm.

### Description

Carapace stocky, subtriangular to ovoid in lateral view; important overlap of RV by LV with maximum along PDB; dorsal margin of LV regularly arched with Hmax at posterior 1/3 of L; dorsal margin of

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**Fig. 4** (next page). SEM micrographs of ostracods from the Middle Permian (Roadian, Quarry section, samples GM1, GM2, and GM4; Capitanian, MKCS1 section, samples 4 (GM5) and sample 2 (GM6)) of the Guadalupe Mountains (West Texas, USA). All specimens are temporarily housed in the collections of the Muséum national d’histoire naturelle, Paris, France (MNHN). **A–C.** *Healdia mckittrickensis* Crasquin sp. nov. **A.** Holotype, right lateral view of a carapace, sample 4 (GM5) (MNHN.F.F63365). **B.** Paratype, right lateral view of a carapace, sample GM1 (MNHN.F.F63366). **C.** External view of a right valve, sample 4 (GM5) (MNHN.F.F63367). – **D–F.** *Healdia cutoffella* Crasquin sp. nov. **D.** Holotype, right lateral view of a carapace, sample GM4 (MNHN.F.F63368). **E.** Paratype, external view of a left valve, sample GM1 (MNHN.F.F63369). **F.** External view of a left valve, sample GM4 (MNHN.F.F63370). – **G–I.** *Sulcella mesopermiana* Kozur, 1991. **G.** External view of a left valve, sample GM1 (MNHN.F.F63371). **H.** Left lateral view of a carapace, sample 2 (GM6) (MNHN.F.F63372). **I.** External view of a left valve, sample GM2 (MNHN.F.F63373). – **J.** Kirkbyidae gen. et sp. indet., right lateral view of a carapace, sample 4 (GM5) (MNHN.F.F63374). – **K–L.** *Amphissites centronotus* (Ulrich & Bassler, 1906). **K.** External view of a right valve, sample GM1 (MNHN.F.F63375). **L.** External view of a right valve, sample GM1 (MNHN.F.F63376). – **M.** *Polytylites?* sp., external view of a left valve, sample GM4 (MNHN.F.F63377). – **N.** *Kindlella fissiloba* Sohn, 1954, external view of a right valve, sample GM1 (MNHN.F.F63378). – **O.** *Kindlella* sp., external view of a left valve, sample GM1 (MNHN.F.F63379). – **P–Q.** *Kindlella bellsundi* Olempska & Błaszyk, 1996. **P.** External view of a right valve, sample 4 (GM5) (MNHN.F.F63380). **Q.** External view of a right valve, sample 4 (GM5) (MNHN.F.F63381) – **R.** *Kirkbya* sp., external view of a right valve, sample GM1 (MNHN.F.F63382). Scale bars: 100 µm.



RV with Hmax at mid-L; AB with maximum of convexity located slightly below Hmax; VB slightly concave at both valves; PB large and close to vertical; presence of two posterior spines quite large, their bases are linked by an intra-spines tenuous ridge; in front of the spines, presence of a curved ridge, more developed than the intra-spines one; surface smooth.

### Occurrence

Samples GM1, 4 (GM5), Quarry section, Williams Ranch Member, Cutoff Formation, Roadian; MKCS1 section, sample GM5, ‘McKittrick Canyon’ Member, Bell Canyon Formation, Capitanian; Middle Permian, Guadalupe Mountains, West Texas, USA (this work).

### Remarks

*Healdia mckittrickensis* sp. nov. has a unique morphology. The general outline is reminiscent of *Healdia subtrangua* Kotschetkova, 1959 from the Kazanian (Roadian) of Bashkiria, SW of the Ural Mts (Kotschetkova 1959) but *H. mckittrickensis* sp. nov. has a less triangular lateral outline with thicker spines.

### *Healdia cutoffella* Crasquin sp. nov.

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Figs 4D–F, 5A

### Diagnosis

A species of *Healdia* with a short and stocky carapace and a posterior ridge more or less vertical without spines, ADB longer than PDB in both valves.

### Etymology

After the Cutoff Formation, Roadian, Middle Permian, West Texas that contains this species.

### Material examined

#### Holotype

USA • complete carapace, (Fig. 4D); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM4; Roadian, Middle Permian; MNHN.F.F63368.

#### Paratype

USA • 1 complete carapace, (Fig. 4E); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63369.

#### Additional material

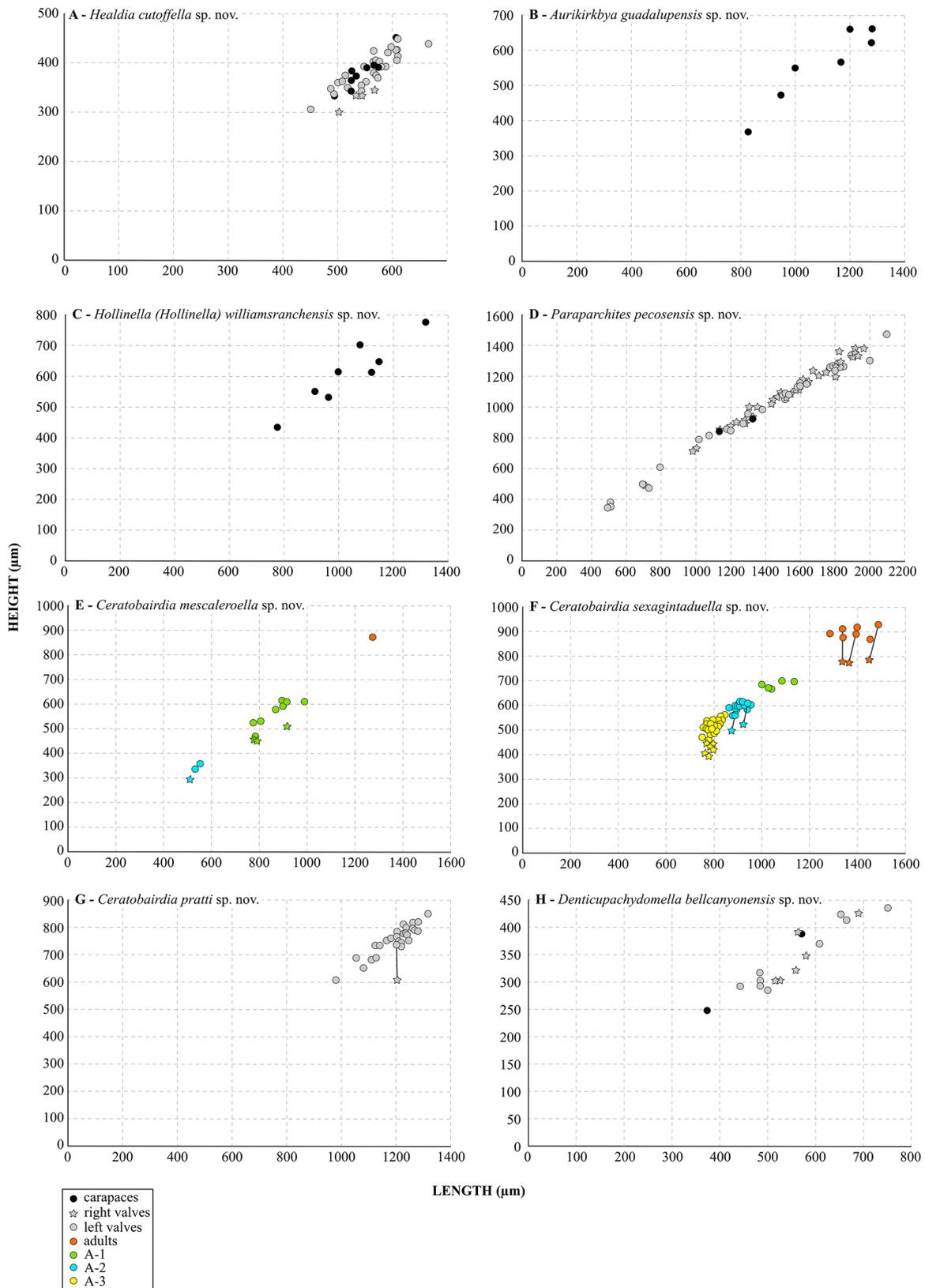
USA • 1 left valve, (Fig. 4F); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM4; Roadian, Middle Permian; MNHN.F.F63370 • 10 complete carapaces, 32 valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM4; Roadian, Middle Permian; MNHN.F.F63474.

### Dimensions

L=452–667 µm; H=300–448 µm (Fig. 5A)

### Description

Short and stocky carapace, egg-shaped in lateral view; LV strongly overlaps RV all around the carapace; ADB longer than PDB at both valves; AB large with maximum of curvature located around mid-H;



**Fig. 5.** Height/length scatter plots of species from the Middle Permian (Roadian, Capitanian) of the Guadalupe Mountains (West Texas, USA). A-1, A-2, A-3. Three last juvenile stages before adult.

PB quite equivalent to AB; presence of a posterior vertical to slightly tilted ridge, without spines; carapace laterally compressed posterior to ridge, more strongly at LV.

### Occurrence

Samples GM1, GM4, Quarry section, Williams Ranch Member, Cutoff Formation, Roadian; sample 4 (GM5), MKCS1 section, ‘McKittrick Canyon’ Member, Bell Canyon Formation, Capitanian; Middle Permian, Guadalupe Mountains, West Texas, USA (this work).

### Remarks

*Healdia cutoffella* sp. nov. is very similar to *Healdia simplissima* Harlton, 1933 from the Pennsylvanian of Texas and Oklahoma (Harlton 1933; Hoare & Merrill 2004). Both species have the same ridge without spines, equivalent AB and PB, but mainly differ by PB being longer than AB in *H. simplissima* (herein AB is longer than PB).

Order Platycopida Sars, 1866  
Family Cavellinidae Egorov, 1950

Genus *Sulcella* Coryell & Sample, 1932

### Type species

*Sulcella sulcata* Coryell & Sample, 1932 by original designation.

*Sulcella mesopermiana* Kozur, 1991  
Fig. 4G–I

*Sulcella mesopermiana* Kozur, 1991: 22, pl. 5 figs 3–4.

*Sulcella mesopermiana* – Crasquin-Soleau & Baud 1998: 139, pl. 3 figs 3, 5, 6, 9. — Zazzali *et al.* 2015: 306, fig. 17a. — Chitnarin *et al.* 2017: 681, figs 24o–r.

### Material examined

USA • 1 left valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63371 • 1 complete carapace; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 2 (GM6); Capitanian, Middle Permian; MNHN.F.F63372 • 1 left valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM2; Roadian, Middle Permian; MNHN.F.F63373 • 3 complete carapaces, 10 valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM3, GM4; Roadian; MNHN.F.F63653 • 2 complete carapaces, 7 valves; same locality as for preceding; ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, samples 4 (GM5) and 2 (GM6); Capitanian, Middle Permian; MNHN.F.F63475.

### Occurrence

Bükk Mountains, Hungary, Capitanian–Wuchiapingian, Middle–Late Permian (Kozur 1991); Hydra Island, Greece, Capitanian–Wuchiapingian, Middle–Late Permian (Crasquin-Soleau & Baud 1998); Chaotian section, Sichuan, South China, Wuchiapingian, Late Permian (Zazzali *et al.* 2015); Pha Nok Khao Formation, Khao Kana section, Phetchabun Province, central Thailand, Sakmarian–Artinskian, Early Permian (Chitnarin *et al.* 2017); Quarry section, samples GM1, GM3, GM4, Williams Ranch Member, Cutoff Formation, Roadian; MKCS1 section, samples 4 (GM5) and 2 (GM6), ‘McKittrick Canyon’ Member, Bell Canyon Formation, Capitanian; Guadalupe Mountains, West Texas, USA, Middle Permian (this work).

Order Palaeocopida Henningsmoen, 1953  
Suborder Kloedenellocopina Scott, 1961  
Superfamily Kirkbyoidea Ulrich & Bassler, 1906

**Kirkbyidae** gen. et sp. indet.

Fig. 4J

**Material examined**

USA • 1 complete carapace; Guadalupe Mountains, West Texas, 'McKittrick Canyon' Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63374.

**Remarks**

This specimen shows a clear oval kirkbyan pit in the middle part of the valve. The right valve has PB and AB with a different radius of curvature, whereas they are quite equivalent in Kirkbyidae. Herein, the PB has a very small radius of curvature and AB a large one. The ornamentation is coarse.

**Occurrence**

Sample 4 (GM5), MKCS1 section, 'McKittrick Canyon' Member, Bell Canyon Formation, Guadalupe Mountains, West Texas, USA, Capitanian, Middle Permian (this work).

Family Amphissitidae Knight, 1928

Genus *Amphissites* Girty, 1910

**Type species**

*Amphissites rugosus* Girty, 1910 by original designation.

*Amphissites centronotus* (Ulrich & Bassler, 1906)

Fig. 4K–L

*Kirkbya centronota* Ulrich & Bassler 1906: 159, pl. 11, figs 16, 17.

*Amphissites centronota* – Harlton 1927: 207, pl. 32 figs 10a–b (new combination). — Knight 1928: 259, pl. 32 figs 6a–e. — Sohn 1961b: 118–119, pl. 7 figs 8–10. — Kellett 1933: pl. 95, pl. 16 figs 16–22. — Ishizaki 1964: pl. 17 figs 4–5. — Thompson & Shaver 1964: fig. 2. — Schneider 1966: 110. — Shaver & Smith 1974: 35, pl. 1 figs 1–5. — Sanchez de Posada 1977: 416, pl. 2 figs 9–11. — Shi 1982: 301, pl. 1 figs 4–6. — Kozur 1991: pl. 1 fig. 1. — Zhang & Liang 1987: 301, pl. 2 fig. 5. — Burke 1985: fig. 4.12. — Jones 1988: 260, text fig. 1a, pl. 1 figs 1–4, 7; 1989: 44, pl. 10, figs 1a–2d, text fig. 19b. — Melnyk & Maddocks 1988: pl. 2 fig. 9. — Christopher *et al.* 1990: 979, figs 4.16–4.20. — Fohrer 1991: 22, pl. 7 figs 1–3; 1997: 114–115, pl. 10, figs 7–8. — Becker & Wang 1992: 12, pl. 1 fig. 5. — Crasquin-Soleau & Orchard 1994: pl. 3 fig. 2. — Crasquin-Soleau 1997: 51, pl. 2 figs 9–11. — Becker 1997: pl. 3 figs 1–2. — Ferdinando 2001: 43–44, pl. 1 figs 29–30, pl. 2 figs 1–8. *Amphissites (Amphissites) centronotus* – Olempska 1999: 406, figs 14a–b.

**Material examined**

USA • 1 right valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63375 • 1 right valve; same locality as preceding; Roadian, Middle Permian; MNHN.F.F63376 • 24 valves; Guadalupe Mountains, West

Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM4; Roadian, Middle Permian; MNHN.F.F63476.

### Occurrence

Kansas, USA, Carboniferous (Ulrich & Bassler 1906); Oklahoma, USA, Pennsylvanian (Harlton 1927); Texas, USA, Pennsylvanian (Coryell & Billings 1932); USA, Gzhelian, Pennsylvanian, Sakmarian–Artinskian, Early Permian (Kellett 1933); Kansas, USA, Carboniferous–Permian (Sohn 1961b); Japan, Capitanian, Middle Permian (Ishizaki 1964); Illinois, USA, Early Pennsylvanian (Thompson & Shaver 1964); Russian Platform, Late Permian (Schneider 1966); Illinois, USA, Pennsylvanian (Shaver & Smith 1974); Asturias, Spain, Late Carboniferous (Sanchez de Posada 1977); Ohio, USA, Pennsylvanian (Burke 1985); Bükk Mountains, Hungary, Moscovian, Late Carboniferous (Kozur 1991); Henan Province, East China, Late Carboniferous (Zhang & Liang 1987); Texas, USA, Pennsylvanian–Kungurian (Melnik & Maddocks 1988); Bonaparte Basin, Australia, Early Carboniferous (Jones 1988, 1989); Appalachian Basin, USA, Pennsylvanian (Christopher *et al.* 1990); South China, Tournaisian, Early Carboniferous (Becker & Wang 1992; Olempska 1999); British Columbia, Canada, Sakmarian–Artinskian, Early Permian (Crasquin-Soleau & Orchard 1994; Crasquin-Soleau 1997); Cantabrian Mountains, Spain, Pennsylvanian (Becker 1997); Carnic Alps, Austria, Asselian, Early Permian (Fohrer 1997); Perth Basin, Australia, Sakmarian, Early Permian (Ferdinando 2001); West Texas, USA, Middle Permian, Roadian, Quarry section, samples GM1, GM4, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains (this work).

Family Kelletinidae Sohn, 1954

Genus *Kindlella* Sohn, 1954

### Type species

*Kindlella fissiloba* Sohn, 1954 by original designation.

*Kindlella fissiloba* Sohn, 1954

Fig. 4N

*Kindlella fissiloba* Sohn, 1954: 16–17, pl. 2 fig. 12, pl. 3 figs 22–27, pl. 4 fig. 13.

### Material examined

USA • 1 right valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63378 • 3 valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM4; Roadian, Middle Permian; MNHN.F.F63477.

### Occurrence

Texas, USA, Roadian, Middle Permian (Sohn 1954); samples GM1, GM4, Quarry section, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains, West Texas, USA, Roadian, Middle Permian (this work).

*Kindlella bellsundi* Olempska & Błaszyk, 1996

Fig. 4P–Q

*Kindlella bellsundi* Olempska & Błaszyk, 1996: 11–12, pl. 2 figs 3–4, pl. 3 figs 1–4.

**Material examined**

USA • 1 right valve; Guadalupe Mountains, West Texas, 'McKittrick Canyon' Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63380 • 1 right valve; same locality as for preceding; Capitanian, Middle Permian; MNHN.F.F63381.

**Remarks**

The specimens have a transitional morphology between *Kindlella* Sohn, 1954 and *Kelletina* Swartz, 1936. They have the carapace outline and characters of *Kindlella* and lobes overpassing the DB as in *Kelletina*.

**Occurrence**

West Spitzbergen, Norway, Wuchiapingian, Late Permian (Olempska & Błaszyk 1996); sample 4 (GM5), MKCS1 section, 'McKittrick Canyon' Member, Bell Canyon Formation, Guadalupe Mountains, West Texas, USA, Capitanian, Middle Permian (this work).

*Kindlella* sp.

Fig. 4O

**Material examined**

USA • 1 right valve; Guadalupe Mountains, West Texas, Quarry section, sample GM1, Williams Ranch Member, Cutoff Formation; Roadian, Middle Permian (this work); MNHN.F.F63379.

**Occurrence**

Sample GM1, Quarry section, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains, West Texas, USA, Roadian, Middle Permian (this work).

Family Kirkbyidae Ulrich & Bassler, 1906

Genus *Kirkbya* Jones, 1859

**Type species**

*Dithyrocaris permiana* Jones, 1850 subsequently designated by Jones (1859).

*Kirkbya* sp.

Fig. 4R

**Material examined**

USA • 1 right valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63382.

**Remarks**

The general outline of *Kirkbya* sp. is close to that of *Kirkbya permiana* (Jones, 1850) in Woszczyńska, 1987 from the Late Permian of Poland (Woszczyńska 1987) and to *Kirkbya bendensis* Harlton, 1933 from the Pennsylvanian of USA (Harlton 1933) but the ornamentation in the Texan specimens is very different by a very fine reticulation.

## Occurrence

Sample GM1, Quarry section, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains, West Texas, USA, Roadian, Middle Permian (this work).

Genus *Aurikirkbya* Sohn, 1950

## Type species

*Kindlella wordensis* Hamilton, 1942 subsequently designated by Sohn (1950).

*Aurikirkbya guadalupensis* Crasquin sp. nov.

[urn:lsid:zoobank.org:act:FD8EB2E1-3BDB-4A75-ADA2-4FB287EB27AA](https://zoobank.org/act:FD8EB2E1-3BDB-4A75-ADA2-4FB287EB27AA)

Figs 5B, 6A–B

## Diagnosis

A species of *Aurikirkbya* with an additional ventral ridge parallel to the adventral ridge, extending from mid-H in the anterior part to mid-H in the posterior part of the carapace.

## Etymology

After the Guadalupe Mountains, West Texas, USA, where this species has been discovered.

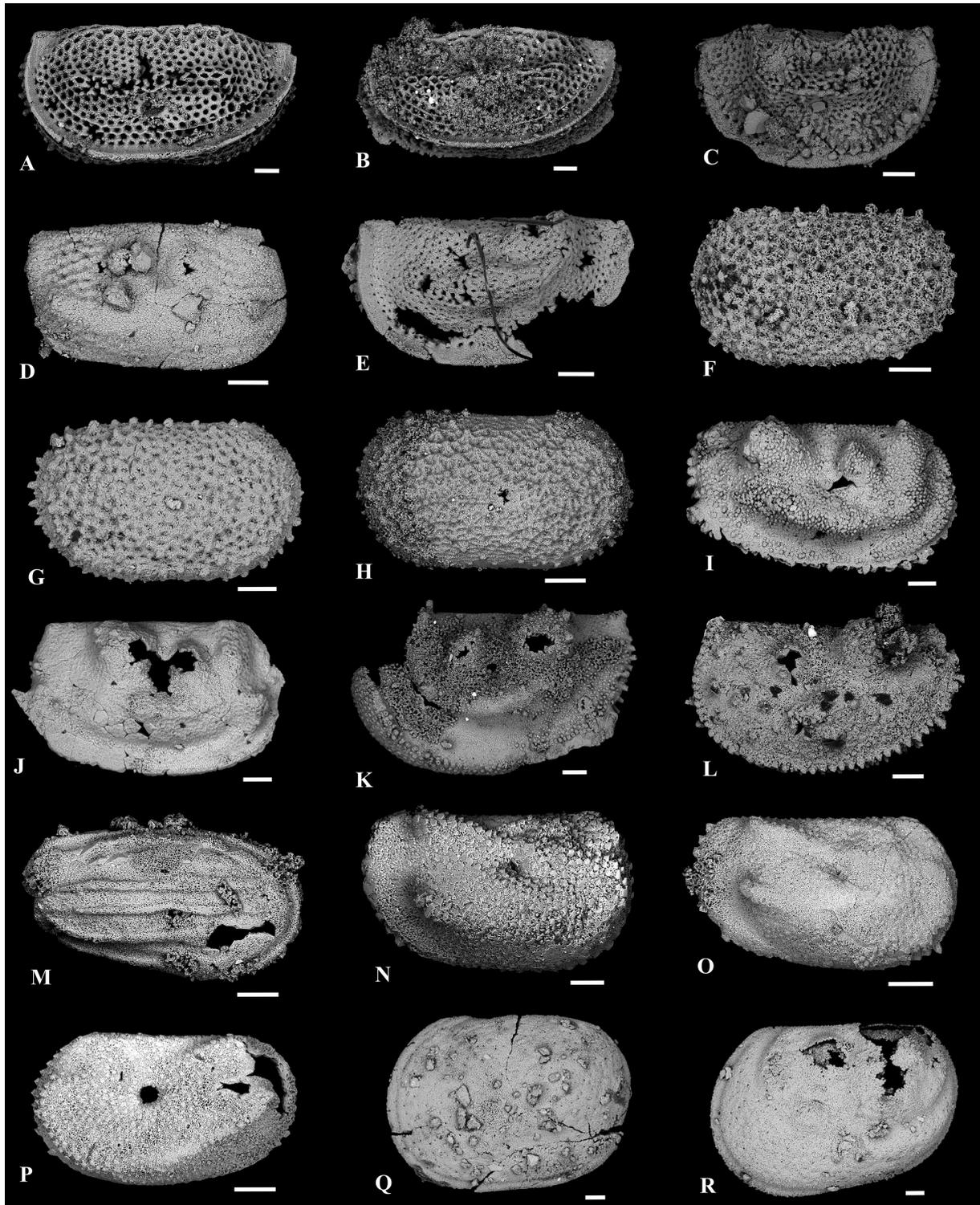
## Material examined

### Holotype

USA • complete carapace, (Fig. 6A); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM2; Roadian, Middle Permian; MNHN.F.F63383.

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**Fig. 6** (next page). SEM micrographs of ostracods from the Middle Permian (Roadian, Quarry section, samples GM1, GM2, and GM4; Capitanian, MKCS1 section, samples 4 (GM5) and 2 (GM6)) of the Guadalupe Mountains (West Texas, USA). All specimens are temporarily housed in the collections of the Muséum national d'histoire naturelle, Paris, France (MNHN). **A–B.** *Aurikirkbya guadalupensis* Crasquin sp. nov. **A.** Holotype, left lateral view of a carapace, sample GM2 (MNHN.F.F63383). **B.** Paratype, left lateral view of a carapace, sample GM1 (MNHN.F.F63384). – **C, E.** *Aurikirkbya wordensis* (Hamilton, 1942). **C.** External view of a left valve, sample 2 (GM6) (MNHN.F.F63385). **E.** External view of a left valve, sample GM4 (MNHN.F.F63387). – **D.** *Kirkbyella (Berdanella) cf. quadrata* Croneis & Gutke, 1939, external view of a right valve, sample 4 (GM5) (MNHN.F.F63386). – **F–H.** *Roundyella lebaensis* Krömmelbein, 1958. **F.** External view of a left valve, sample GM4 (MNHN.F.F63388). **G.** External view of a right valve, sample GM4 (MNHN.F.F63389). **H.** External view of a right valve, sample GM1 (MNHN.F.F63390). – **I–L.** *Hollinella (Hollinella) williamsranchensis* Crasquin sp. nov. **I.** Holotype, external view of a right valve, sample GM1 (MNHN.F.F63391). **J.** External view of a right valve, sample GM1 (MNHN.F.F63392). **K.** Paratype, external view of a left valve, sample GM1 (MNHN.F.F63393). **L.** External view of a left valve, sample GM4 (MNHN.F.F63394). – **M.** *Glyptopleura* sp., external view of a right valve, sample GM1 (MNHN.F.F63395). – **N–P.** *Geisina culbersonensis* Crasquin sp. nov. **N.** Holotype, external view of a right valve, sample GM1 (MNHN.F.F63396). **O.** Paratype, external view of a right valve, sample GM1 (MNHN.F.F63397). **P.** External view of a left valve, sample GM2 (MNHN.F.F63398). – **Q–R.** *Miltonella cf. shupei* Sohn, 1950. **Q.** External view of a left valve, sample 4 (GM5) (MNHN.F.F63399). **R.** External view of a left valve, sample 4 (GM5) (MNHN.F.F63400). Scale bars: 100 µm.



### Paratype

USA • 1 complete carapace, (Fig. 6B); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63384.

### Additional material

USA • 8 valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM2, and GM3; Roadian, Middle Permian; MNHN.F.F63478.

### Dimensions

L=829–1280 µm; H=368–660 µm (Fig. 5B).

### Description

Carapace sub-rectangular in lateral view with Hmax located in anterior half; Lmax located in dorsal part of Hmax; DB long and straight; posterior shoulder clearly expressed, ACA close to 90° or slightly obtuse; PCA close to 90° or slightly acute; AB with large radius of curvature with maximum located around mid-H; VB almost straight with weak median concavity, parallel to DB; PB with small radius of curvature and maximum located close to DB; 2 vertical lobes connected above kirkbyan pit by small sub-horizontal lobe; kirkbyan pit located at mid-L and below mid-H; two important ridges along free margins, one ventral and one adventral; marginal structure underlined by tubercles; adventral ridge smooth as well as areas around cardinal angles; additional ridge parallel to adventral one, extending from mid-H in anterior part up to mid-H in posterior part of the carapace; presence of a dorsal shield characteristic of the genus; surface reticulate.

### Occurrence

Samples GM1, GM2, and GM3, Quarry section, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains, West Texas, USA, Roadian, Middle Permian (this work).

### Remarks

*Aurikirkbya guadalupensis* sp. nov. differs from the three species described by Sohn (1950) (*A. wordensis* (Hamilton, 1942), *A. barbarae* Sohn, 1950 and *A. auriformis* Sohn, 1950) from the Roadian (upper Leonardian or lower Wordian in the sense of Sohn 1950) of the Glass Mountains, Texas by a smaller PB and a diagnostic ridge. *Aurikirkbya kelleetae* (Harlton, 1929) from the Pennsylvanian of Texas and *Aurikirkbya miyakei* Yanaka & Ono in Tanaka *et al.*, 2012 from the Early Permian of Japan (Tanaka *et al.* 2012) have a similar carapace shape but differ by the diagnostic ridge.

*Aurikirkbya wordensis* (Hamilton, 1942)

Fig. 6C, E

*Kirkbya wordensis* Hamilton, 1942: 713–714, pl. 110 fig. 13.

*Aurikirkbya wordensis* – Sohn 1950: pl. 7, figs 1–13.

### Material examined

USA • 1 left valve; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 2 (GM6); Capitanian, Middle Permian; MNHN.F.F63385 • 1 valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM4; Roadian; MNHN.F.F63387 • 1 valve; same locality as for preceding; ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63479.

### Occurrence

Texas, USA, Roadian, Middle Permian (Hamilton 1942; Sohn 1950); sample GM4, Quarry section, Williams Ranch Member, Cutoff Formation, Roadian; samples GM5 and GM6, MKCS1 section, 'McKittrick Canyon' Member, Bell Canyon Formation, Guadalupe Mountains, West Texas, USA, Capitanian, Middle Permian (this work).

Family Kirkbyellidae Sohn, 1961

Genus *Kirkbyella* Coryell & Booth, 1933

### Type species

*Kirkbyella typa* Coryell & Booth, 1933 by original designation.

*Kirkbyella (Berdanella) cf. quadrata* Croneis & Gutke, 1939

Fig. 6D

### Material examined

USA • 1 right valve; Guadalupe Mountains, West Texas, 'McKittrick Canyon' Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63386.

### Remarks

This specimen could belong to a new species with regard to the ornamentation of the carapace that consists of small ridges on the anterior part and a reticulation on the posterior part. The general shape is similar to that of *Kirkbyella (Berdanella) quadrata* Croneis & Gutke, 1939 sensu Hoare & Mapes 2000 from the Mississippian of Arkansas (Hoare & Mapes 2000) but in this species the reticulation is organised quite horizontally and here it is more oblique.

### Occurrence

Sample 4 (GM5), MKCS1 section, 'McKittrick Canyon' Member, Bell Canyon Formation, Guadalupe Mountains, West Texas, USA, Capitanian, Middle Permian (this work).

Family Scrobiculidae Posner, 1951

Genus *Roundyella* Bradfield, 1935

### Type species

*Amphissites simplicissimus* Knight, 1928 subsequently designated by Bradfield (1935).

*Roundyella lebaensis* Krömmelbein, 1958

Fig. 6F–H

*Roundyella lebaensis* Krömmelbein, 1958: 118, pl. 1 figs 11–15, pl. 3 figs 45–46.

*Roundyella krommelbeini* sp. nov. Kozur, 1991: 15, 16, pl. 7, fig. 2.

*Roundyella lebaensis wangi* n. subsp. Kozur, 1991: 15, 16, pl. 8, figs 2, 13.

*Roundyella lebaensis* — Knüpfer 1967: 76, pl. 1 fig. 1. — Ivanov 1975: 164, pl. 33 fig. 34, pl. 39 fig. 4.

— Woszczyńska 1987: 188, pl. 9 figs 1–2, 8. — Olempska & Błaszyk 1996: 15, pl. 2 fig. 5, pl. 4 fig. 1.

### Material examined

USA • 1 left valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM4; Roadian, Middle Permian; MNHN.F.F63388 • 1 right valve; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F63389 • 1 right valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1; Roadian, Middle Permian; MNHN.F.F63390 • 5 valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM4; Roadian; MNHN.F.F63654 • 3 valves; same locality as for preceding; ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5) Capitanian; Middle Permian; MNHN.F.F63480.

### Occurrence

German basin, Werrakarbonate, Zechstein (Knüpfner 1967); USSR, Baltic region, Novoakmyanskaya svita (Ivanov 1975); Polish lowlands, cyclothem PZ1, Zechstein (Woszczyńska 1987); Bükk Mountain, Hungary, Wuchiapingian, Late Permian (Kozur 1991); southwest Spitzbergen, Norway, Wuchiapingian, Late Permian (Olempska & Błaszyk 1996); samples GM1, GM4, Quarry section, Williams Ranch Member, Cutoff Formation, Roadian; sample 4 (GM5), MKCS1 section, ‘McKittrick Canyon’ Member, Bell Canyon Formation, Capitanian, Guadalupe Mountains, West Texas, USA, Middle Permian (this work).

Superfamily Hollinoidea Swartz, 1936  
Family Hollinellidae Bless & Jordan, 1971

Genus *Hollinella* Coryell, 1928

### Type species

*Hollinella dentata* Coryell, 1928 by original designation.

*Hollinella (Hollinella) williamsranchensis* Crasquin sp. nov.  
[urn:lsid:zoobank.org:act:2A663FBA-1BBF-481E-B29E-1EF99A05F293](https://zoobank.org/urn:lsid:zoobank.org:act:2A663FBA-1BBF-481E-B29E-1EF99A05F293)  
Figs 5C, 6I–L

### Diagnosis

A species of *Hollinella (Hollinella)* with a subvertical  $L_1$  in continuation of the ventral lobe and dorsally ended by a small nodule/spine; spine at the posterior part of the velum.

### Etymology

After Williams Ranch Member, Bell Canyon Formation, Capitanian, West Texas where this species has been discovered.

### Material examined

#### Holotype

USA • right valve, (Fig. 6I); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63391.

#### Paratype

USA • 1 left valve, (Fig. 6K); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63393.

**Additional material**

USA • 1 right valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63392 • 1 left valve; same locality as for preceding but sample GM4; Roadian, Middle Permian; MNHN.F.F63394 • 2 valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM4, Roadian; MNHN.F.F63655 • 6 valves; same locality as for preceding; ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5), Capitanian; Middle Permian; MNHN.F.F63481.

**Dimensions**

L=776–1318 µm; H=434–773 µm (Fig. 5C).

**Description**

Carapace auriform and elongate in lateral view; Hmax at ACA; Lmax at mid-L; DB long and straight; presence of cardinal spine at PCA; AB with maximum of curvature at or below mid-H; VB straight; PB with quite large radius of curvature underlined by nodules; presence of a granular velum that ends by posterior spine; L<sub>1</sub> well expressed, vertical and in continuation of ventral lobe, ended dorsally by small nodule/spine; L<sub>2</sub> well expressed, peaked, with small nodule; L<sub>3</sub> covered by nodules, higher than DB; surface granular; intraspecific variations observed in velum formed by small spines (Fig. 6L) and blade (Fig. 6I).

**Occurrence**

Samples GM1, GM4, Quarry section, Williams Ranch Member, Cutoff Formation, Roadian; sample 4 (GM5) MKCS1 section, ‘McKittrick Canyon’ Member, Bell Canyon Formation, Capitanian; Guadalupe Mountains, West Texas, USA, Middle Permian (this work).

**Remarks**

*Hollinella (Hollinella) williamsranchensis* sp. nov. is reminiscent of *H. warthini* Cooper, 1946 from the Missourian–Virgilian (Late Pennsylvanian) of USA (see synthesis in Christopher *et al.* 1990) by the carapace shape, spines at PCA and posterior part of the velum and the granular surface. However, in *H. warthini*, L<sub>1</sub> is not visible and L<sub>2</sub> and L<sub>3</sub> are more bulbous. *Hollinella (Hollinella) williamsranchensis* sp. nov. has the same ornamentation on L<sub>3</sub> as *H. (H.) lungcamensis* Crasquin, 2018 from the Permian–Triassic boundary of North Vietnam (Crasquin *et al.* 2018), which is stockier (H/L=0.55–0.65 herein, 0.65–0.75 for *H. (H.) lungcamensis*).

Superfamily Kloedenelloidea Ulrich & Bassler, 1908

Family Glyptopleuridae Girty, 1910

Genus *Glyptopleura* Girty, 1910

**Type species**

*Glyptopleura inopinata* Girty, 1910 by original designation.

*Glyptopleura* sp.

Fig. 6M

**Material examined**

USA • 1 right valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63395 • 7 valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM2, and GM3; Roadian, Middle Permian; MNHN.F.F63482.

### Remarks

A species of *Glyptopleura* with 6 thick ridges on the lateral surface, the upper two ridges are shorter than the others and end before PB. This species may be new, but the material is poorly preserved. So far, this species is the youngest representative of *Glyptopleura*.

### Occurrence

Samples GM1, GM2, and GM3, Quarry section, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains, West Texas, USA, Roadian, Middle Permian (this work).

Family Geisinidae Sohn, 1961b

Genus *Geisina* Johnson, 1936

### Type species

*Beyrichiella gregaria* Ulrich & Bassler, 1906 subsequently designated by Johnson (1936).

*Geisina culbersonensis* Crasquin sp. nov.

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Fig. 6N–P

### Diagnosis

A species of *Geisina* with a pustulose carapace, two large spines in the posterior part of the carapace and free margins bordered with small spines.

### Etymology

From Culberson County, West Texas, USA, where the studied samples have been collected.

### Material examined

#### Holotype

USA • 1 complete carapace, (Fig. 6N); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63396.

#### Paratype

USA • 1 complete carapace, (Fig. 6O); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63397.

#### Additional material

USA • 1 complete carapace; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM2; Roadian, Middle Permian; MNHN.F.F63398 • 1 complete carapace, 4 valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM2, GM4; Roadian, Middle Permian; MNHN.F.F63483.

### Dimensions

L=602–676 µm; H=430–548 µm; H/L=0.53–0.64.

### Description

Carapace sub-rectangular in lateral view with Hmax in anterior 1/3<sup>rd</sup> of L and Lmax slightly below mid-H; DB long and straight; ACA=115°–130°, PCA=105°–115°; AB with large radius of curvature with maximum at lower 1/3<sup>rd</sup> H; VB nearly straight; PB laterally compressed, large with maximum of curvature located at mid-H; free margins bordered by small spines; L<sub>2</sub> not well visible; S<sub>2</sub> round and

clearly marked; L<sub>3</sub> underlined by two large spines, one dorsal and one medio-ventral, pointing upward; surface completely covered with pustules.

### Occurrence

Samples GM1, GM2, GM4, Quarry section, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains, Western Texas, USA, Roadian, Middle Permian (this work).

### Remarks

*Geisina culbersonensis* sp. nov. has a very particular shape and primary ornamentation. It can be compared with *Geisina* sp. in Chitnarin *et al.* 2012 from the Asselian–Sakmarian, Early Permian of Thailand (Chitnarin *et al.* 2012), which has a smaller PB and a smooth surface.

Family Miltonellidae Sohn, 1950

Genus *Miltonella* Sohn, 1950

### Type species

*Miltonella shupei* Sohn, 1950 by original designation.

*Miltonella cf. shupei* Sohn, 1950  
Fig. 6Q–R

### Material examined

USA • 1 left valve; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63399 • 1 left valve; same locality as for preceding; Capitanian, Middle Permian; MNHN.F.F63400 • 2 right valves; same locality as for preceding; Capitanian, Middle Permian; MNHN.F.F63484.

### Occurrence

Sample 4 (GM5), MKCS1 section, ‘McKittrick Canyon’ Member, Bell Canyon Formation, Guadalupe Mountains, West Texas, USA, Capitanian, Middle Permian (this work).

### Remarks

This species is similar to *Miltonella shupei* Sohn, 1950 from the Middle Permian of Texas (Sohn 1950). Herein, the specimens are shorter and the characteristic ridge of the genus begins at ACA and finishes at PCA (instead of PB in type species).

?Family Miltonellidae Sohn, 1950

Genus *Libumella* Rozhdestvenskaya, 1959

### Type species

*Libumella discoides* Rozhdestvenskaya, 1959 by original designation.

*Libumella cf. athabascensis* Green, 1963  
Fig. 7A

### Material examined

USA • 1 complete carapace; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63401.

### Occurrence

Sample GM1, Quarry section, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains, West Texas, USA, Roadian, Middle Permian (this work).

### Remarks

The specimen is similar to *Libumella athabascensis* Green, 1963 from the Mississippian of the Rocky Mountains, Canada (Green 1963; Crasquin 1985) and from the Late Permian of South China (Yuan *et al.* 2007). Nevertheless, it differs by the presence of a nodule in the dorso-median part of the carapace.

Order Leiocopa Schallreuter, 1973  
Superfamily Paraparchitoidea Scott, 1959  
Family Paraparchitidae Scott, 1959

Genus *Paraparchites* Ulrich & Bassler, 1906

### Type species

*Paraparchites humerosus* Ulrich & Bassler, 1906 by original designation.

*Paraparchites texanus* Delo, 1930  
Fig. 7C

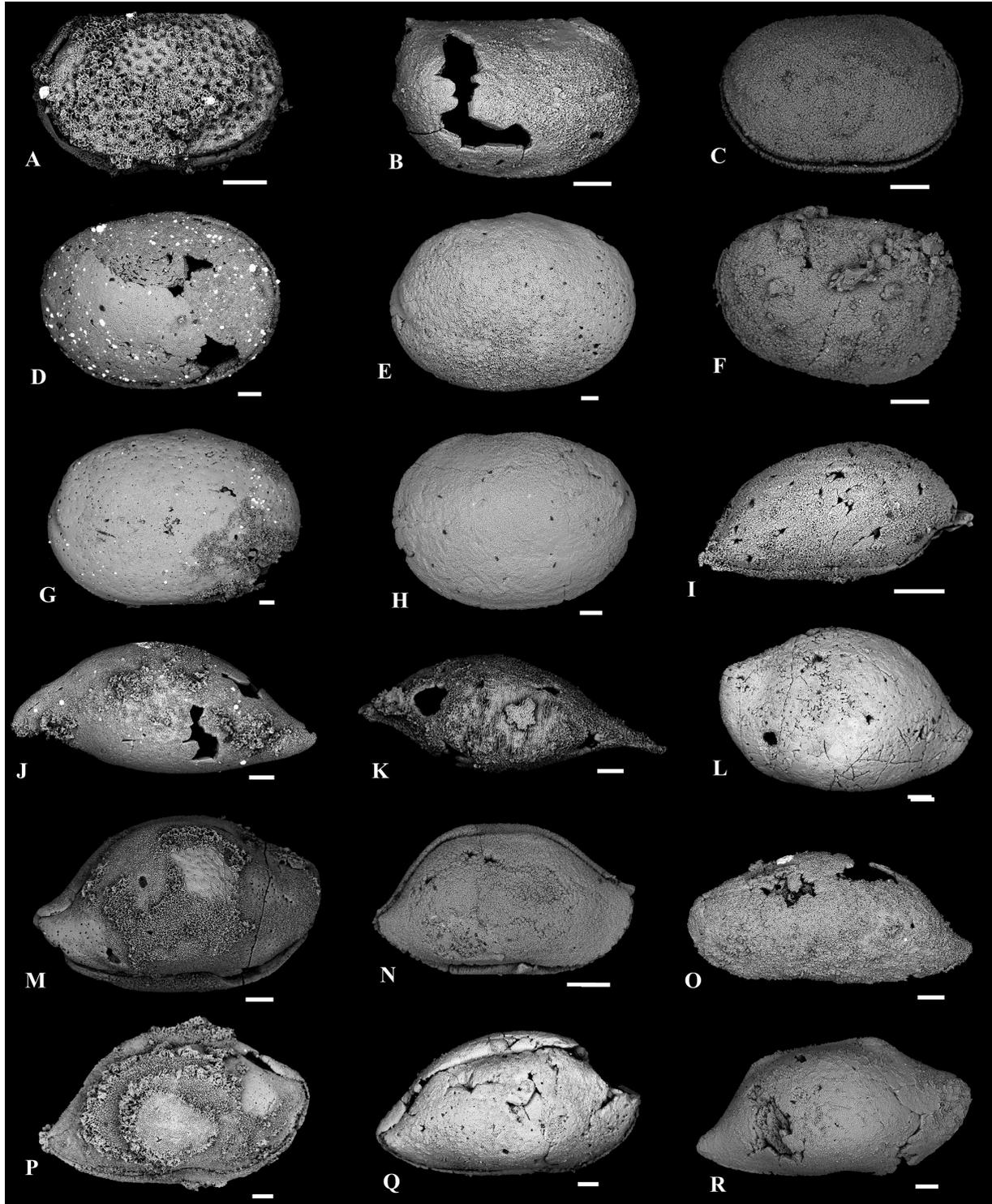
*Paraparchites humerosus* var. *texana* Delo, 1930: 153, pl. 12 fig. 1.

*Paraparchites texanus* – Sohn 1971: A8, pl. 2 figs 1–2, 7–10, 13–15, with all previous synonyms therein.

non *Paraparchites texanus* – Crasquin-Soleau & Orchard 1994: 59, 60, pl. 4 fig. 12. — Yi 2004: pl. 2 fig. 13.

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**Fig. 7** (next page). SEM micrographs of ostracods from the Middle Permian (Roadian, Quarry section, samples GM1 and GM2; Capitanian, MKCS1 section, samples 4 (GM5) and 2 (GM6)) of the Guadalupe Mountains (West Texas, USA). All specimens are temporarily housed in the collections of the Muséum national d'histoire naturelle, Paris, France (MNHN). **A.** *Libumella* cf. *athabascensis* Green, 1963, left lateral view of a carapace, sample GM1 (MNHN.F.F63401). – **B.** *Fellerites?* sp., external view of a right valve, sample GM1 (MNHN.F.F63402). – **C.** *Paraparchites texanus* Delo, 1930, right lateral view of a carapace, sample 4 (GM5) (MNHN.F.F63403). – **D–H.** *Paraparchites pecosensis* Crasquin sp. nov. **D.** Holotype, right lateral view of a carapace, sample GM1 (MNHN.F.F63404). **E.** Right lateral view of a carapace, sample GM1 (MNHN.F.F63405). **F.** External view of a right valve, sample 2 (GM6) (MNHN.F.F63406). **G.** External view of a right valve, sample GM1 (MNHN.F.F63407). **H.** Paratype, left lateral view of a carapace, sample GM1 (MNHN.F.F63408). – **I.** *Acratia* sp., right lateral view of a carapace, sample GM2 (MNHN.F.F63409). – **J.** *Acratia* cf. *sinuata* (Kozur, 1991), external view of a left valve, sample GM1 (MNHN.F.F63410). – **K.** *Acratia sinuata* (Kozur, 1991), external view of a left valve, sample GM1 (MNHN.F.F63411). – **L–M.** *Bairdia radlerae* Kellett, 1934. **L.** External view of a left valve, sample GM1 (MNHN.F.F63412). **M.** Right lateral view of a carapace, sample GM1 (MNHN.F.F63413). – **N.** *Bairdia rhomboidalis* Hamilton, 1942, right lateral view of a carapace, sample 2 (GM6) (MNHN.F.F63414). – **O.** *Bairdia subfusiformis* Hamilton, 1942, external view of a left valve, sample GM1 (MNHN.F.F63415). – **P–R.** *Bairdia elcapitanensis* Forel sp. nov. **P.** Right lateral view of a carapace, sample GM1 (MNHN.F.F63416). **Q.** Right lateral view of a carapace, sample GM1 (MNHN.F.F63417). **R.** Paratype, external view of a right valve, sample GM1 (MNHN.F.F63418). Scale bars: 100 µm.



### Material examined

USA • 1 complete carapace; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63403  
• 2 complete carapaces; same locality as for preceding; Capitanian, Middle Permian; MNHN.F.F63485.

### Occurrence

Menar and Tom Green Counties, Texas, USA, Kungurian (Arroyo Formation), Early Permian (Sohn 1971 and all references therein); sample 4 (GM5), MKCS1 section, ‘McKittrick Canyon’ Member, Bell Canyon Formation, Capitanian; Guadalupe Mountains, West Texas, USA, Guadalupian, Middle Permian (this work).

*Paraparchites pecosensis* Crasquin sp. nov.

[urn:lsid:zoobank.org:act:E76693E7-FD8A-4E7B-9328-6D3248AC584F](https://zoobank.org/urn:lsid:zoobank.org:act:E76693E7-FD8A-4E7B-9328-6D3248AC584F)

Figs 5D, 7D–H

### Diagnosis

A species of *Paraparchites* with a small hemi-circular ridge at mid-H of PB on both valves and a weak overreach of RV above hinge-line.

### Etymology

In reference to the Pecos River, West Texas, USA.

### Material examined

#### Holotype

USA • complete carapace, (Fig. 7D); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63404.

#### Paratype

USA • 1 complete carapace, (Fig. 7H); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63408.

#### Additional material

USA • 1 complete carapace; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63405 • 1 right valve; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F63407 • 1 right valve; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample GM6; Capitanian, Middle Permian; MNHN.F.F63406 • 1 complete carapace, 52 valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM2, GM3; Roadian; MNHN.F.F63656 • 15 valves; same locality as for preceding; ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 2 (GM6), Capitanian; Middle Permian; MNHN.F.F63486.

### Dimensions

L=503–2100 µm; H=341–1467 µm (Fig. 5D).

### Description

Carapace stocky (H/L=0.69–0.75) sub-rectangular in lateral outline; DB straight at LV; DB a little convex with weak overreach of RV above hinge-line; AB and PB quite equivalent with large radius of curvature, maximum of curvature around mid-H; VB nearly straight; LV overlaps RV all around free margins; presence of small hemi-circular ridge at mid-H of PB on both valves.

**Occurrence**

Samples GM1, GM2, and GM3, Quarry section, Williams Ranch Member, Cutoff Formation, Roadian; sample 2 (GM6), MKCS1 section, 'McKittrick Canyon' Member, Bell Canyon Formation, Capitanian; Guadalupe Mountains, West Texas, USA, Middle Permian (this work).

**Remarks**

*Paraparchites pecosensis* sp. nov. has a lateral outline similar to that of *Paraparchites texanus* Ulrich & Bassler, 1906 emend. Scott, 1959 from the Early Permian of Texas (Scott 1959). The main difference between the two species is the small hemi-circular ridge at PB in the new species.

Order Podocopida Sars, 1866  
Suborder Podocopina Sars, 1866  
Superfamily Bairdioidea Sars, 1888

Family **Bairdiidae** Sars, 1888

**Preliminary remarks**

The classification of ornate Bairdiidae is complex and still disputed mainly because of the difficulty to unravel the taxonomic significance of their lateral ornamentation features. As detailed in Forel & Grădinaru (2020), the revision of their classification requires the addition of new characters to avoid producing another classification system that would only be a new point of view further complicating the current situation. The peak of diversity of ornate Bairdiidae occurred in the Late Triassic but they were already present in the Permian (see Forel & Crasquin 2020 and references therein for a review) as illustrated for instance by the material described herein from the Middle Permian of the Guadalupe Mountains. Specifically, the confusion and instability of the conceptions of *Petasobairdia* Chen, 1982 and *Praelobobairdia* Kozur, 1991 have recently been described and discussed in Forel & Grădinaru (2020). Herein, we follow the view that *Praelobobairdia* is a junior synonym of *Petasobairdia*, as was first introduced by Becker (2001).

Genus *Acratia* Delo, 1930

**Type species**

*Acratia typica* Delo, 1930 by original designation.

*Acratia sinuata* (Kozur, 1991)  
Fig. 7K

*Cooperuna sinuata* Kozur, 1991: 107–108, pl. 21 fig. 2.

**Material examined**

USA • 1 left valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63411 • 1 complete carapace, 2 valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM4; Roadian, Middle Permian; MNHN.F.F63487.

**Occurrence**

Bükk Mountains, Hungary, Early Wuchiapingian, Late Permian (Kozur 1991); samples GM1, GM4, Quarry section, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains, West Texas, USA, Roadian, Middle Permian (this work).

Genus *Bairdia* McCoy, 1844

**Type species**

*Bairdia curta* McCoy, 1844 subsequently designated by Ulrich & Bassler (1923).

*Bairdia radlerae* Kellett, 1934

Fig. 7L–M

*Bairdia radlerae* Kellett, 1934: 125, pl. 14 figs 3a–c.

*Bairdia radlerae* – Sohn 1960: 31.

**Material examined**

USA • 1 left valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63412 • 1 complete carapace; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F63413 • 78 valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM2, and GM4; Roadian; MNHN.F.F63657 • 27 valves; same locality as for preceding; ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, samples 4 (GM5) and 2 (GM6), Capitanian; Middle Permian; MNHN.F.F63488.

**Occurrence**

Kansas, USA, Asselian, Sakmarian, Early Permian (Kellett 1934); samples GM1, GM2, GM4, Quarry section, Williams Ranch Member, Cutoff Formation, Roadian; samples 4 (GM5) and 2 (GM6), MKCS1 section, ‘McKittrick Canyon’ Member, Bell Canyon Formation, Capitanian; Middle Permian, Guadalupe Mountains, West Texas, USA (this work).

*Bairdia rhomboidalis* Hamilton, 1942

Fig. 7N

*Bairdia rhomboidalis* Hamilton, 1942: 715, pl. 110 figs 11a–b.

*Bairdia rhomboidalis* – Sohn 1960: 31, pl. 1 figs 26–27.

**Material examined**

USA • 1 complete carapace; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 2 (GM6); Capitanian, Middle Permian; MNHN.F.F63414 • 1 complete carapace; same locality as for preceding but sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63489.

**Occurrence**

Texas, USA, Roadian, Middle Permian (Hamilton 1942); samples 4 (GM5) and 2 (GM6), MKCS1 section, ‘McKittrick Canyon’ Member, Bell Canyon Formation, Guadalupe Mountains, West Texas, USA, Capitanian, Middle Permian (this work).

*Bairdia subfusiformis* Hamilton, 1942

Fig. 7O

*Bairdia subfusiformis* Hamilton, 1942: pl. 110, figs 8a–b.

*Bairdia subfusiformis* – Sohn 1960: 32.

### Material examined

USA • 1 left valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63415 • 1 left valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1, Roadian; MNHN.F.F63658 • 1 left valve; same locality as for preceding; 'McKittrick Canyon' Member, Bell Canyon Formation, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63490.

### Occurrence

Glass Mountains, West Texas, USA, Roadian, Middle Permian (Hamilton 1942); sample GM1, Quarry section, Williams Ranch Member, Cutoff Formation, Roadian; sample 4 (GM5), MKCS1 section, 'McKittrick Canyon' Member, Bell Canyon Formation, Capitanian; Guadalupe Mountains, West Texas, USA, Middle Permian (this work).

*Bairdia elcapitanensis* Forel sp. nov.

[urn:lsid:zoobank.org:act:4DDDDDD5C-6D2B-45E5-8B59-427C19C96DD7](https://zoobank.org/act:4DDDDDD5C-6D2B-45E5-8B59-427C19C96DD7)

Figs 7P–R, 8A–B

### Diagnosis

A species of *Bairdia* with asymmetric valves and with a strong overlap along DB; ADB concave at RV and dorsal margin uniformly convex; PD and AD angles laterally compressed at RV.

### Etymology

In reference to the El Capitan Peak located within the Guadalupe Mountains National Park, Guadalupe Mountains, West Texas, USA.

### Material examined

#### Holotype

USA • right valve, (Fig. 8B); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63420.

#### Paratype

USA • 1 right valve, (Fig. 7R); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63418.

#### Additional material

USA • 1 complete carapace; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63416 • 1 carapace; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F63417 • 1 right valve; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F634119 • 16 right valves; same locality as for preceding but samples GM1, GM2; Roadian, Middle Permian; MNHN.F.F63491.

### Dimensions

L=1250–1386 µm; H=635–761 µm.

### Description

Carapace sub-triangular in lateral view with asymmetric valves and overlap of LV all around RV with maximum along DB; lateral surface smooth.

LV: Hmax around mid-L; dorsal margin uniformly convex with PDB and ADB almost straight; AB with small radius of curvature located above mid-H; VB straight to only gently concave; PB narrow with maximum of convexity located very ventrally.

RV: Hmax located at AD angulation; DB long and straight, gently bent posteriorly; PDB straight with terminal concavity; ADB concave; PD angle (130–135°) and AD angle (135–140°) laterally compressed; AB with relatively small radius of curvature, located above mid-H; oral concavity in front of mid-L at ventral margin; PB slighted.

### Occurrence

Samples GM1 and GM2, Quarry section, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains, West Texas, USA, Roadian, Middle Permian (this work).

### Remarks

*Bairdia girtyi* Sohn, 1960 sensu Hoare & Merrill, 2004 from the Pennsylvanian of Texas (Hoare & Merrill 2004) is similar to *Bairdia elcapitanensis* sp. nov. by its lateral morphology, but lacks the AD and PD angulations at RV. It is worth noting that the specimens of Hoare & Merrill (2004) do not belong to *Bairdia girtyi* Sohn, 1960 from the Late Mississippian of USA (Sohn 1960), because *Bairdia girtyi* is more elongate, with PB located higher and Hmax located slightly behind mid-H.

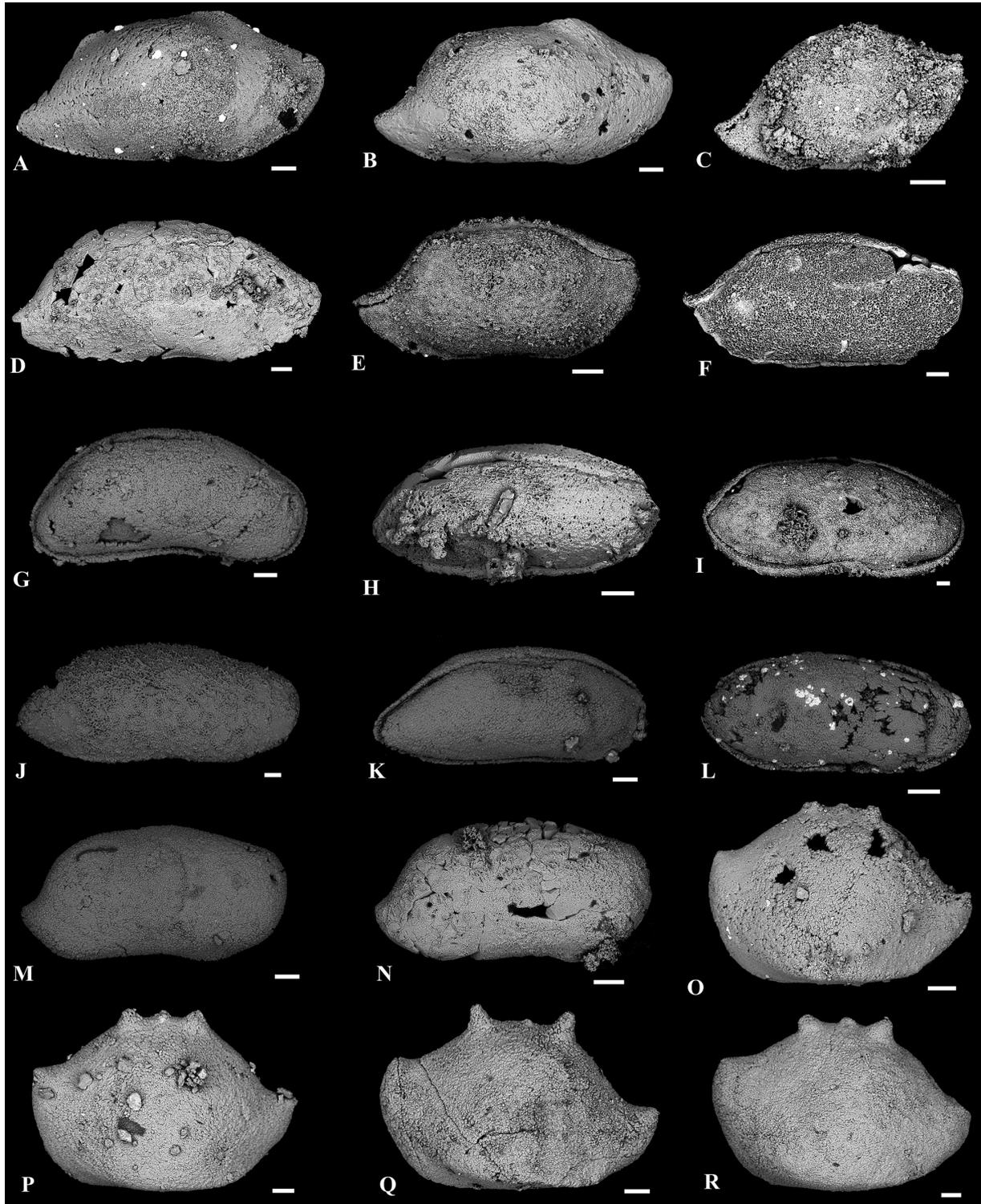
### *Bairdia* sp. A Fig. 8D

### Material examined

USA • 1 complete carapace; Guadalupe Mountains, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63422 • 1 complete carapace, 4 valves; same locality as for preceding; Roadian, Guadalupe, Middle Permian; MNHN.F.F63492.

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**Fig. 8** (next page). SEM micrographs of ostracods from the Middle Permian (Roadian, Quarry section, samples GM1 and GM4; Capitanian, MKCS1 section, samples 4 (GM5) and 2 (GM6)) of the Guadalupe Mountains (West Texas, USA). All specimens are temporarily housed in the collections of the Muséum national d'histoire naturelle, Paris, France (MNHN). **A–B.** *Bairdia elcapitanensis* Forel sp. nov. **A.** External view of a right valve, sample GM1 (MNHN.F.F63419). **B.** Holotype, external view of a right valve, sample GM1 (MNHN.F.F63420). – **C.** *Bairdia* cf. *postacuta* Chen, 1958, right lateral view of a carapace, sample GM1 (MNHN.F.F63421). – **D.** *Bairdia* sp. A, right lateral view of a carapace, sample GM1 (MNHN.F.F63422). – **E.** *Bairdia* sp. B, right lateral view of a carapace, sample GM1 (MNHN.F.F63423). – **F.** *Bairdia* sp. C, right lateral view of a carapace, sample GM1 (MNHN.F.F63424). – **G.** *Bairdiacypris* sp. B, right lateral view of a carapace, sample 2 (GM6) (MNHN.F.F63425). – **H.** *Bairdiacypris* sp. C, right lateral view of a carapace, sample GM1 (MNHN.F.F63426). – **I–J.** *Fabalitypris acetalata* (Coryell & Billings, 1932). **I.** Right lateral view of a carapace, sample GM1 (MNHN.F.F63427). **J.** External right of a right valve, sample GM4 (MNHN.F.F63428). – **K.** *Fabalitypris glennensis* (Harlton, 1927), right lateral view of a carapace, sample 4 (GM5) (MNHN.F.F63429). – **L.** *Fabalitypris* sp., right lateral view of a carapace, sample GM4 (MNHN.F.F63430). – **M–N.** *Orthobairdia texana* (Harlton, 1927). **M.** External right of a right valve, sample 4 (GM5) (MNHN.F.F63431). **N.** External view of a right valve, sample GM1 (MNHN.F.F63432). – **O–R.** *Ceratobairdia mescaleroella* Forel sp. nov. **O.** Holotype, adult, external view of a left valve, sample 4 (GM5) (MNHN.F.F63433). **P.** A-1, external view of a left valve, sample 4 (GM5) (MNHN.F.F63434). **Q.** Paratype, A-1, external view of a left valve, sample 4 (GM5) (MNHN.F.F63435). **R.** A-1, external view of a left valve, sample 4 (GM5) (MNHN.F.F63436). Scale bars: 100 µm.



### Remarks

*Bairdia* sp. A is extremely similar to *Bairdia salemensis* Geis, 1932 from the Mississippian of Indiana (Geis 1932) that was later considered as a junior synonym of *Bairdia permagna* Geis, 1932 by Sohn (1960). Sohn (1960) more precisely stated that the type specimens of *Bairdia salemensis* are young juveniles of *Bairdia permagna*, although dimensions provided by Geis for *Bairdia salemensis* are of Lmean=1450 µm, Hmean=685 µm. In the present analysis, *Bairdia* sp. A is morphologically closer to specimens considered as young juveniles of *Bairdia permagna* than to adults and their dimensions are very similar to those reported for *Bairdia salemensis* with Lmean=1500 µm, Hmean=500 µm. Herein, however, all specimens at hand assigned to *Bairdia* sp. A are not abundant enough to discuss their ontogenetic development and verify the conspecificity of the species.

### Occurrence

Sample GM1, Quarry section, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains, West Texas, USA, Roadian, Middle Permian (this work).

Genus *Fabalicypriis* Cooper, 1946

### Type species

*Fabalicypriis wileyensis* Cooper, 1946 by original designation.

*Fabalicypriis acetalata* (Coryell & Billings, 1932)

Fig. 8I–J

*Bairdia acetalata* Coryell & Billings, 1932: 173, pl. 17 fig. 5.

*Fabalicypriis acetalata* – Sohn 1960 (with all previous synonymy therein): 62.

### Material examined

USA • 1 complete carapace; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63427 • 1 right valve; same locality as for preceding but sample GM4; Roadian, Middle Permian; MNHN.F.F63428 • 9 valves; same locality as for preceding but samples GM1, GM2, and GM4; Roadian, Middle Permian; MNHN.F.F63493.

### Occurrence

Kansas, Texas, Illinois, USA, Pennsylvanian (Coryell & Billings 1932; Sohn 1960); Nebraska, USA, Permian (Sohn 1960); samples GM1, GM2, and GM4, Quarry section, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains, West Texas, USA, Roadian, Middle Permian (this work).

*Fabalicypriis glennensis* (Harlton, 1927)

Fig. 8K

*Bairdia glennensis* Harlton, 1927: 210, pl. 33 fig. 10.

*Bairdia glennensis* – Kellett 1935: 133, pl. 18 figs 4a–e.

*Fabalicypriis glennensis* – Sohn 1960: pl. 3 figs 9–10. — Yi 1993: 62, pl. 3 figs 9–10. — Shi & Chen 2002: 86, pl. 23 figs 1–2.

### Material examined

USA • 1 complete carapace; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63429.

### Occurrence

Kansas, Oklahoma, USA, Kasimovian, Pennsylvanian (Harlton 1927; Kellett 1935; Sohn 1960); Hubei, China, Kungurian, Early Permian (Yi 1993); Sichuan, China, Changhsingian, Late Permian (Shi & Chen 2002); sample 4 (GM5), MKCS1 section, ‘McKittrick Canyon’ Member, Bell Canyon Formation, Guadalupe Mountains, West Texas, USA, Capitanian, Middle Permian (this work).

Genus *Orthobairdia* Sohn, 1960

### Type species

*Bairdia cestriensis* Ulrich, 1891 subsequently designated by Sohn (1960).

*Orthobairdia texana* (Harlton, 1927)

Fig. 8M–N

*Bairdia texana* Harlton, 1927: 210, pl. 33 fig. 9.

*Bairdia chasae* Kellett, 1934: pl. 18 figs 5a–d, pl. 19 figs 5a–d.

*Bairdia guadalupiana* Hamilton, 1942: 714, pl. 110 figs 5a–b.

*Orthobairdia texana* – Sohn 1960: 68, 69, pl. 3 fig. 29 with all the previous references therein. — Hoare *et al.* 1999: 444, figs 3.22–3.25.

### Material examined

USA • 1 right valve; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63431 • 1 right valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63432 • 3 valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian; MNHN.F.F63659 • 10 valves; same locality as for preceding; ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, samples 4 (GM5) and 2 (GM6), Capitanian; Middle Permian; MNHN.F.F63494.

### Occurrence

Kansas, Texas, Missouri, Oklahoma, Nebraska, Illinois, Ohio, USA, Pennsylvanian (Sohn 1960 and all references therein); Glass Mountains, West Texas, USA, Roadian, Middle Permian (Hamilton 1942); Ischimbaev District (North Ural?), Russia, Early Permian (Sohn 1960); Germany, Permian (Sohn 1960); Appalachian Basin, USA, Pennsylvanian (Hoare *et al.* 1999); sample GM1, Quarry section, Williams Ranch Member, Cutoff Formation, Roadian; samples 4 (GM5) and 2 (GM6), MKCS1 section, ‘McKittrick Canyon’ Member, Bell Canyon Formation, Capitanian; Guadalupe Mountains, West Texas, USA, Middle Permian (this work).

Genus *Ceratobairdia* Sohn, 1954

### Type species

*Ceratobairdia dorsospinosa* Sohn, 1954 by original designation.

*Ceratobairdia mescaleroella* Forel sp. nov.

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Figs 5E, 8O–R, 9A–C

**Diagnosis**

A species of *Ceratobairdia* with three spines, two long and one short, along the dorsal margin of LV and the ventro-lateral ala not terminated by spine.

**Etymology**

From the tribe of Mescalero Apaches who inhabited parts of the Southwest US and Northwest Mexico.

**Material examined**

**Holotype**

USA • left valve, (Fig. 8O); Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63433.

**Paratypes**

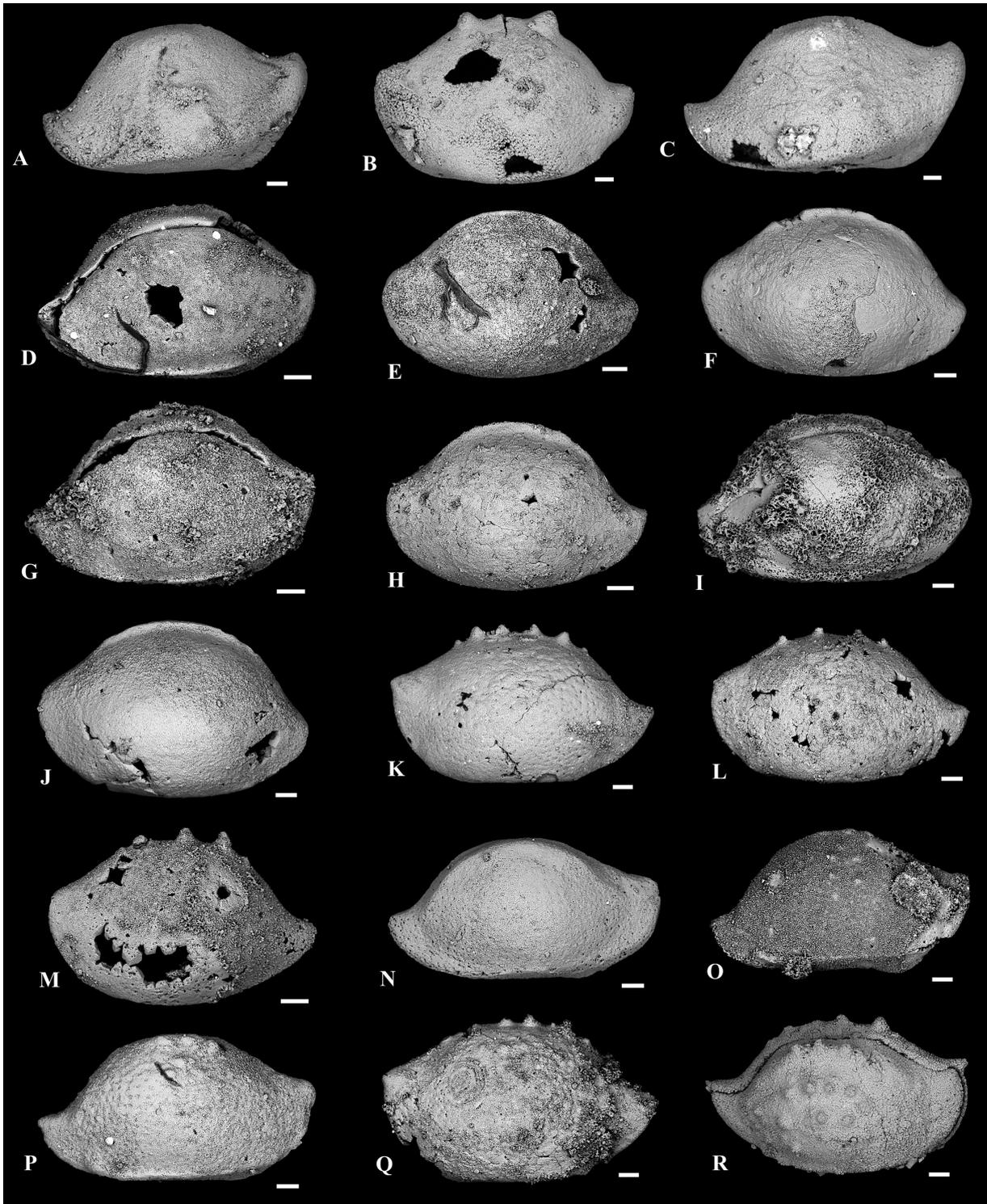
USA • 1 left valve (Fig. 9A); Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63435 (Fig. 8Q) • 1 right valve; same locality and sample as for preceding; Capitanian, Middle Permian; MNHN.F.F63437.

**Additional material**

USA • 1 left valve; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63434 • 1 left valve; same locality and sample as for preceding; Capitanian, Middle Permian; MNHN.F.F63436 • 1 left valve; same locality as for preceding but sample 2 (GM6); Capitanian, Middle Permian; MNHN.F.F63438 • 1 left valve; same locality and sample as for preceding; Capitanian, Middle Permian; MNHN.F.F63439

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**Fig. 9** (next page). SEM micrographs of ostracods from the Middle Permian (Roadian, Quarry section, samples GM1; Capitanian, MKCS1 section, samples 4 (GM5) and 2 (GM6)) of the Guadalupe Mountains (West Texas, USA). All specimens are temporarily housed in the collections of the Muséum national d’histoire naturelle, Paris, France (MNHN). **A–C.** *Ceratobairdia mescaleroella* Forel sp. nov. **A.** Paratype, A-1, external view of a right valve, sample 4 (GM5) (MNHN.F.F63437). **B.** External view of a left valve, A-2, sample 2 (GM6) (MNHN.F.F63438). **C.** External view of a right valve, A-2, sample 2 (GM6) (MNHN.F.F63439). – **D–J.** *Ceratobairdia sexagintaduella* Forel sp. nov. **D.** Holotype, right lateral view of a carapace, adult, sample GM1 (MNHN.F.F63440). **E.** Paratype, external view of a left valve, adult, sample GM1 (MNHN.F.F63441). **F.** External view of a left valve, A-1, sample GM1 (MNHN.F.F63442). **G.** Right lateral view of a carapace, A-2, sample GM1 (MNHN.F.F63443). **H.** External view of a left valve, A-2, sample GM1 (MNHN.F.F63444). **I.** Right lateral view of a carapace, A-3, sample GM1 (MNHN.F.F63445). **J.** External view of a left valve, A-3, sample GM1 (MNHN.F.F63446). – **K–R.** *Ceratobairdia wordensis* (Hamilton, 1942). **K.** External view of a left valve, adult, sample GM1 (MNHN.F.F63447). **L.** External view of a left valve, adult, sample GM1 (MNHN.F.F63448). **M.** External view of a left valve, A-2?, sample GM1 (MNHN.F.F63449). **N.** External view of a right valve, sample 4 (GM5) (MNHN.F.F63450). **O.** External view of a right valve, sample GM1 (MNHN.F.F63497). **P.** External view of a right valve, sample GM1 (MNHN.F.F63451). **Q.** External view of a left valve, sample GM1 (MNHN.F.F63452). **R.** Right lateral view of a carapace, sample 4 (GM5) (MNHN.F.F63453). Scale bars: 100 µm.



• 13 valves; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, samples 4 (GM5) and 2 (GM6); Capitanian, Middle Permian; MNHN.F.F63495.

### Dimensions

See Fig. 5E.

### Description

LV: stocky, subtriangular in lateral view with Hmax along DB and Lmax in lower half of H; dorsal margin uniformly arched with concave ADB and PDB, and apex of curvature with 3 equidistant spines; the 3 spines triangular in shape and thickest at base, central spine sub-vertical, external spines biggest, anterior one oriented anteriorly and posterior one oriented posteriorly; AB beak-like located in upper fourth of H with long and subvertical AVB; ventral margin uniformly convex; PB beak-like, located below mid-H; anterior and posterior margins laterally compressed; ventro-lateral ala delimited by smooth subhorizontal ridge lacking terminal spine.

RV: elongate, subtriangular in lateral view with Hmax at AD angulation and Lmax below mid-H; dorsal margin tripartite with DB slightly convex, very concave ADB and PDB; AB beak-like located in upper fourth of H with AVB long and straight; PB beak-like located in lower third of H; ventral margin long and straight except for tenuous oral concavity in anterior part; anterior and posterior margins laterally compressed; lateral surface inflated dorsally into narrow platform and ventrally delimited by latero-ventral ala lacking terminal spine and raising upward anteriorly.

### Occurrence

Samples 4 (GM5) and 2 (GM6), MKCS1 section, ‘McKittrick Canyon’ Member, Bell Canyon Formation, Guadalupe Mountains, West Texas, USA, Capitanian, Middle Permian (this work).

### Remarks

*Ceratobairdia dorsospinosa* Sohn, 1954 from the Roadian, Middle Permian of Texas (Sohn 1954) is morphologically very similar to *Ceratobairdia mescaleroella* sp. nov., but the new species differs by its relatively smaller dimensions, three thicker dorsal spines, lack of a terminal sharp spine at the latero-ventral ridge and PB located higher and more upturned. Sohn (1954) observed that specimens of *Ceratobairdia dorsospinosa* Sohn, 1954 have one or two spines along the dorsal margin of LV. However, all other characters of the carapaces and valves are very similar, so he suggested that all specimens are conspecific. Although very similar morphologically, *Ceratobairdia mescaleroella* sp. nov. cannot be considered as another degree in the variability of *Ceratobairdia dorsospinosa* Sohn, 1954 as the lateral morphologies of the two species are significantly different as detailed above. Contrary to what was shown for *Ceratobairdia dorsospinosa* Sohn, 1954, *Ceratobairdia mescaleroella* sp. nov. has a conservative number and position of dorsal spines, the only difference observed is in the expression of the central spine.

*Ceratobairdia sexagintaduella* Forel sp. nov.

[urn:lsid:zoobank.org:act:E353B465-EF88-46B2-A3E0-5C7C3B2AB411](https://doi.org/10.3897/zoobank.org/E353B465-EF88-46B2-A3E0-5C7C3B2AB411)

Figs 5F, 9D–J

### Diagnosis

A species of *Ceratobairdia* with a lamellar overlap of LV over RV and a curved latero-ventral ridge delimiting a flat venter lacking a posterior spine.

**Etymology**

From the Latin ‘*sexaginta duo*’, meaning ‘62’, referring to the location of the studied sections along the Highway 62.

**Material examined****Holotype**

USA • complete carapace, (Fig. 9D); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63440.

**Paratype**

USA • 1 left valve, (Fig. 9E); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63441.

**Additional material**

USA • 1 left valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63442 • 1 complete carapace; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F63443 • 1 left valve; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F63444 • 1 complete carapace; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F63445 • 1 left valve; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F63446 • 29 complete carapaces, 368 valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM2; Roadian, Middle Permian; MNHN.F.F63496.

**Dimensions**

L=753–1488 µm; H=389–925 µm (Fig. 5F, not all valves measured, all RV correspond to complete carapaces).

**Description**

Massive carapace (H/L=0.58–0.71); AB with small radius of curvature and maximum located at mid-H, dorsal part of AB forms a right angle with ADB at RV; VB straight at RV and convex at LV; PB short, with small radius of curvature located in lower 1/3<sup>rd</sup> of Hmax; latero-ventral ridge developed along the VB; strong overlap of LV on RV particularly at DB developed into blade; surface smooth.

**Occurrence**

Samples GM1, GM2, Quarry section, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains, West Texas, USA, Roadian, Middle Permian (this work).

**Remarks**

*Ceratobairdia sexagintaduella* sp. nov. is similar to *Bairdia monstrabilis* Cooper, 1946 from the Pennsylvanian of Illinois (Cooper 1946) but differs by a shorter carapace, a shorter latero-ventral ridge and the presence of a blade along the dorsal overlap at LV. Noteworthy, Sohn (1954) considered that *Bairdia monstrabilis* Cooper, 1946 does not belong to *Ceratobairdia* mainly because of the lack of a dorsal structure at LV. *Lobobairdia ventriconcava* (Chen, 1958) in Chen & Bao, 1986 from the Early Permian of South China (Chen & Bao 1986) is similar to *Ceratobairdia sexagintaduella* sp. nov., but has an even shorter latero-ventral ridge and lacks the dorsal blade at LV. The morphology of the latero-ventral ridge in *Ceratobairdia sexagintaduella* sp. nov. is similar to that of *Ceratobairdia sinensis* Wang, 1978 from the Changhsingian, Late Permian of South China (Wang 1978) by the morphology of the latero-ventral ridge but differs by lamellar DB at LV, PB less upturned and AB located lower. *Ceratobairdia sexagintaduella* sp. nov. is very similar to *Bairdia permiana* Hamilton, 1942 from the Kungurian of the

Glass Mountains (Hamilton 1942): this species has later been shown to be a junior synonym of *Bairdia pecosensis* Delo, 1930 by Sohn (1960), who additionally mentioned that the ridge on the ventral part of the RV is not as pronounced as shown in the original drawing of Hamilton (1942).

*Ceratobairdia wordensis* (Hamilton, 1942)  
Figs 9K–R, 10

*Bairdia wordensis* Hamilton, 1942: 716, pl. 110 fig. 4.

*Ceratobairdia wordensis* – Sohn 1954: 5; 1960: 69, pl. 4 figs 8–17.

**Material examined**

USA • 1 left valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63447 • 1 left valve; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F63448 • 1 left valve; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F63449 • 1 right valve; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63450 • 1 right valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63497 • 1 right valve; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F63451 • 1 left valve; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F63452 • 1 complete carapace; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63453 • 1 broken carapace, 20 left valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM2, and GM3; Roadian; MNHN.F.F63660 • 3 broken carapaces, 15 left valves; same locality as for preceding; ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, samples 4 (GM5) and 2 (GM6), Capitanian; Middle Permian; MNHN.F.F63498.

**Dimensions**

L=727–1450 µm; H=397–920 µm (Fig. 10, not considering spines).

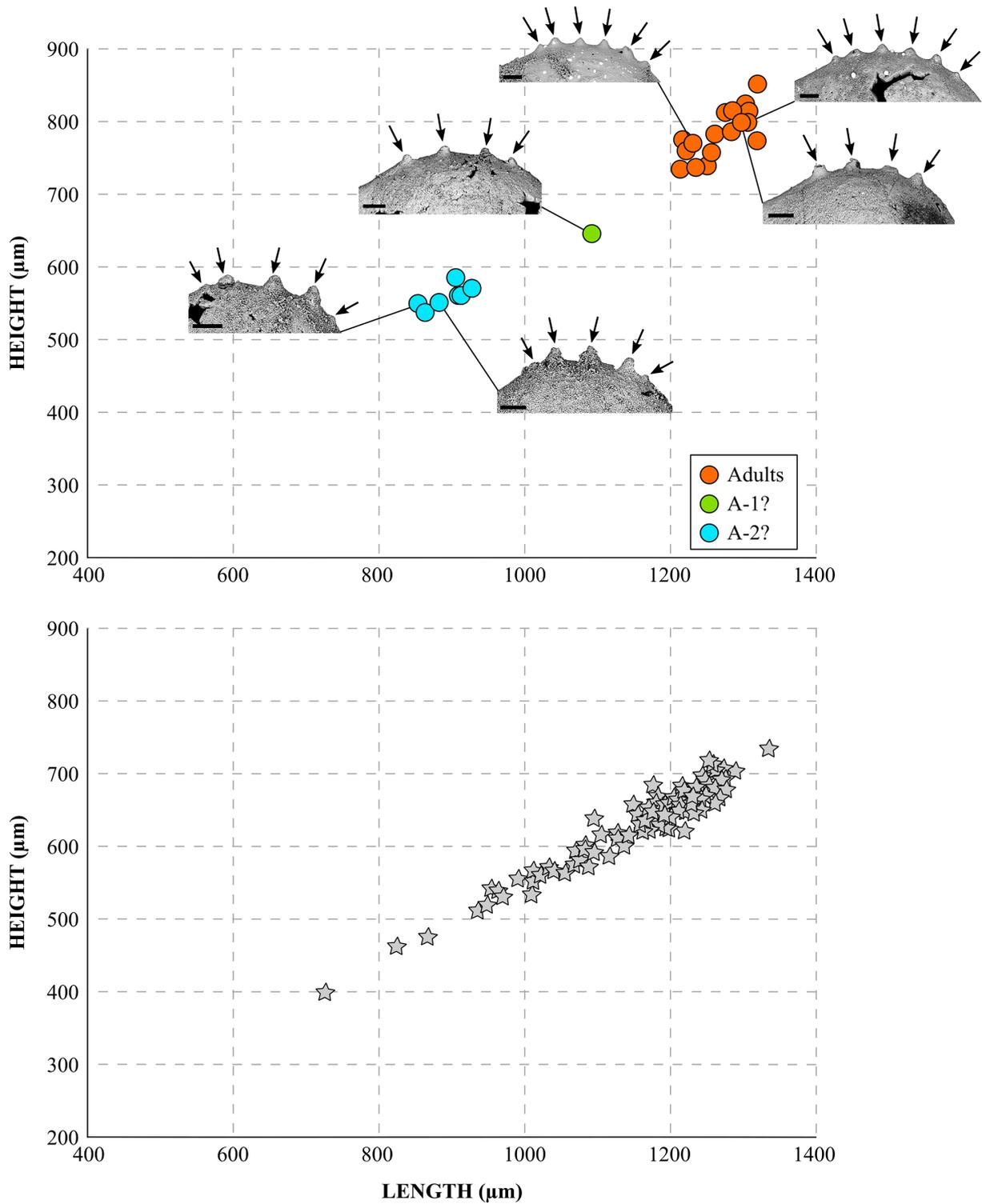
**Occurrence**

Glass Mountains, Texas, USA, Roadian, Middle Permian (Hamilton 1942; Sohn 1954, 1960); samples GM1, GM2, and GM3, Quarry section, Williams Ranch Member, Cutoff Formation, Roadian; samples 4 (GM5) and 2 (GM6), MKCS1 section, ‘McKittrick Canyon’ Member, Bell Canyon Formation, Capitanian; Guadalupe Mountains, West Texas, USA, Middle Permian (this work).

**Remarks**

Most of the specimens of *Ceratobairdia wordensis* (Hamilton, 1942) in the present work occur as isolated valves and LV are relatively easily assigned to this species based on their unique dorsal ornamentation. The identification of RV is more complex and has been possible because of the description provided by Hamilton (1942: 716) of “the centrodorsal portion of the right valve flattens abruptly to hingeline, expressed as a flat terrace in dorsal bi and as a rather prominent ridge in lateral view; [...] the ventral portion of the right valve sharply infolded, forming a sharp downward projecting ridge terminating in mature molds as a backward projecting spine.”

Hamilton (1942: 716) described the dorsal margin of LV of *Ceratobairdia wordensis* as “usually ornamented by two to seven short strong spines equally spaced and concentrated dorsally on the middle third or more.” The present material provided LV with 4 to 6 spines, but all other characters leave no doubt on the conspecificity of the specimens. Is the number of spines related to ontogeny? Although



**Fig. 10.** Height/length scatter plots of *Ceratobairdia wordensis* (Hamilton, 1942) from the Middle Permian (Roadian, Capitanian) of the Guadalupe Mountains (West Texas, USA). Top: left valves (arrows pointing to dorsal spines), bottom: right valves.

Hamilton (1942) mentioned 2 to 7 dorsal spines on LV, the unique specimen illustrated displays 6 spines and no discussion is provided on the possible link between size and number of the spines. Conversely, Sohn (1960: pl. 4 figs 12, 14, 17) illustrated specimens with 8 to 10 dorsal spines and at least one of them shows spines organized into 2 overlapping rows. For the present material, the number of spines along the dorsal margin of LV of *Ceratobairdia wordensis* ranges from 4 to 6 without pattern related to ontogeny (Fig. 10):

- most of the smallest specimens, assigned to A-2?, are weathered but the two sufficiently well preserved at dorsal margin show 5 spines, the 2 external being ‘embryonic’,
- the only known specimen of A-1? stage displays 4 dorsal spines,
- the adult specimens display from 4 to 6 spines, the external ones being the smallest.

It is worth noting that in A-2? specimens, the external spines are very small and may be overlooked, leading to the wrong identification of only 3 dorsal spines. However, these specimens cannot be confused with *Petasobairdia tricornuta* Chen in Shi & Chen, 2002 from the Late Permian of South China (Shi & Chen 2002) which is more elongate, larger, and with only 3 spines for specimens of a size slightly larger than the adults of *Ceratobairdia wordensis*.

A significant morphological trend is observed in *Ceratobairdia wordensis* from the Guadalupe Mountains: whereas the majority of specimens have a relatively smooth surface, several show the development of scattered nodules in the dorsal area of their lateral surface (Fig. 9O–Q). This trend culminates in very rare specimens with the entire lateral surface of the valves covered by nodules (Fig. 9R). This nodular surface is reminiscent of *Pustulobairdia* Sohn, 1960 but all characters of *Ceratobairdia wordensis* and the morphological trend observed from smooth to nodular leave no doubt that these specimens belong to *Ceratobairdia wordensis*.

*Ceratobairdia pratti* Forel sp. nov.

[urn:lsid:zoobank.org:act:97132C11-D593-4D25-AFA4-05B453873EA4](https://zoobank.org/act:97132C11-D593-4D25-AFA4-05B453873EA4)

Figs 5G, 11C–G

**Diagnosis**

A species of *Ceratobairdia* with a nodular dorsal blade at LV displaying 6 very small triangular nodules?, AB and PB prolonged by short horizontal spines, posterior end reduced.

**Etymology**

Named after the geologist Wallace Pratt who donated a part of the McKittrick Canyon which became part of the Guadalupe Mountains National Park, Guadalupe Mountains, West Texas, USA.

**Material examined**

**Holotype**

USA • complete carapace (Fig. 11C); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63456.

**Paratype**

USA • 1 left valve, (Fig. 11D); Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63457.

**Additional material**

USA • 1 left valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM1; Roadian, Middle Permian; MNHN.F.F63458 • 1 left valve; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F63459 • 1 left valve; same locality as for preceding; Roadian, Middle Permian; MNHN.F.F63460 • 43 left valves; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, samples GM1, GM2; Roadian, Middle Permian; MNHN.F.F63499.

**Dimensions**

L=981–1317 µm; H=607–846 µm (Fig. 5G, only complete left valves measured, not considering spines).

**Description**

Sub-rectangular in lateral outline with Hmax around mid-L and Lmax around mid-H; dorsal margin uniformly convex with ADB straight and short; strong overlap of LV on RV along entire dorsal margin, much narrower along venter; PB steep, short and concave; dorsal margin transformed into nodular blade with 6 small triangular nodules; AB large with maximum of curvature around upper 1/3<sup>rd</sup> and AVB plump, very convex; ventral margin straightly to slightly concave around mid-L; PB reduced, relatively large with maximum of curvature around mid-H; AB and PB slightly compressed laterally, prolonged by thick, short horizontal spines; surface smooth.

**Occurrence**

Samples GM1, GM2, Quarry section, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains, West Texas, USA, Roadian, Middle Permian (this work).

**Remarks**

*Ceratobairdia pratti* sp. nov. is unique among species of *Ceratobairdia* known to date by the disposition of nodules along a nodular blade at LV and by the spines terminating AB and PB.

Genus *Petasobairdia* Chen in Chen & Shi, 1982

*Praelobobairdia* Kozur, 1991: 66.

**Type species**

*Petasobairdia bicornuta* Chen in Chen & Shi, 1982 by original designation.

*Petasobairdia campbelli* Chitnarin in Chitnarin *et al.*, 2017  
Fig. 11H–I

*Petasobairdia campbelli* Chitnarin in Chitnarin *et al.*, 2017: 670, figs 12j–p.

**Material examined**

USA • 1 left valve; Guadalupe Mountains, West Texas, Williams Ranch Member, Cutoff Formation, Quarry section, sample GM2; Roadian, Middle Permian; MNHN.F.F63461 • 1 left valve; same locality as for preceding but sample GM4; Roadian, Middle Permian; MNHN.F.F63462.

**Occurrence**

Central Thailand, Artinskian, Roadian?, Early–Middle Permian (Chitnarin *et al.* 2017); samples GM2, GM4, Quarry section, Williams Ranch Member, Cutoff Formation, Guadalupe Mountains, West Texas, USA, Roadian, Middle Permian (this work).

Superfamily Sigillioidea Mandelstam, 1960  
Family Microcheilinellidae Gramm, 1975

Genus *Microcheilinella* Geis, 1933

### Type species

*Microcheilus distortus* Geis, 1932 by original designation.

*Microcheilinella postspinosa* Chen, 1958  
Fig. 11L

*Microcheilinella postspinosa* Chen, 1958: 254, pl. 2 figs 1–6.

*Microcheilinella postspinosa* – Chen & Bao 1986: 110.

non *Microcheilinella postspinosa* – Crasquin-Soleau & Baud 1998: 146, pl. 7 figs 5–9.

### Material examined

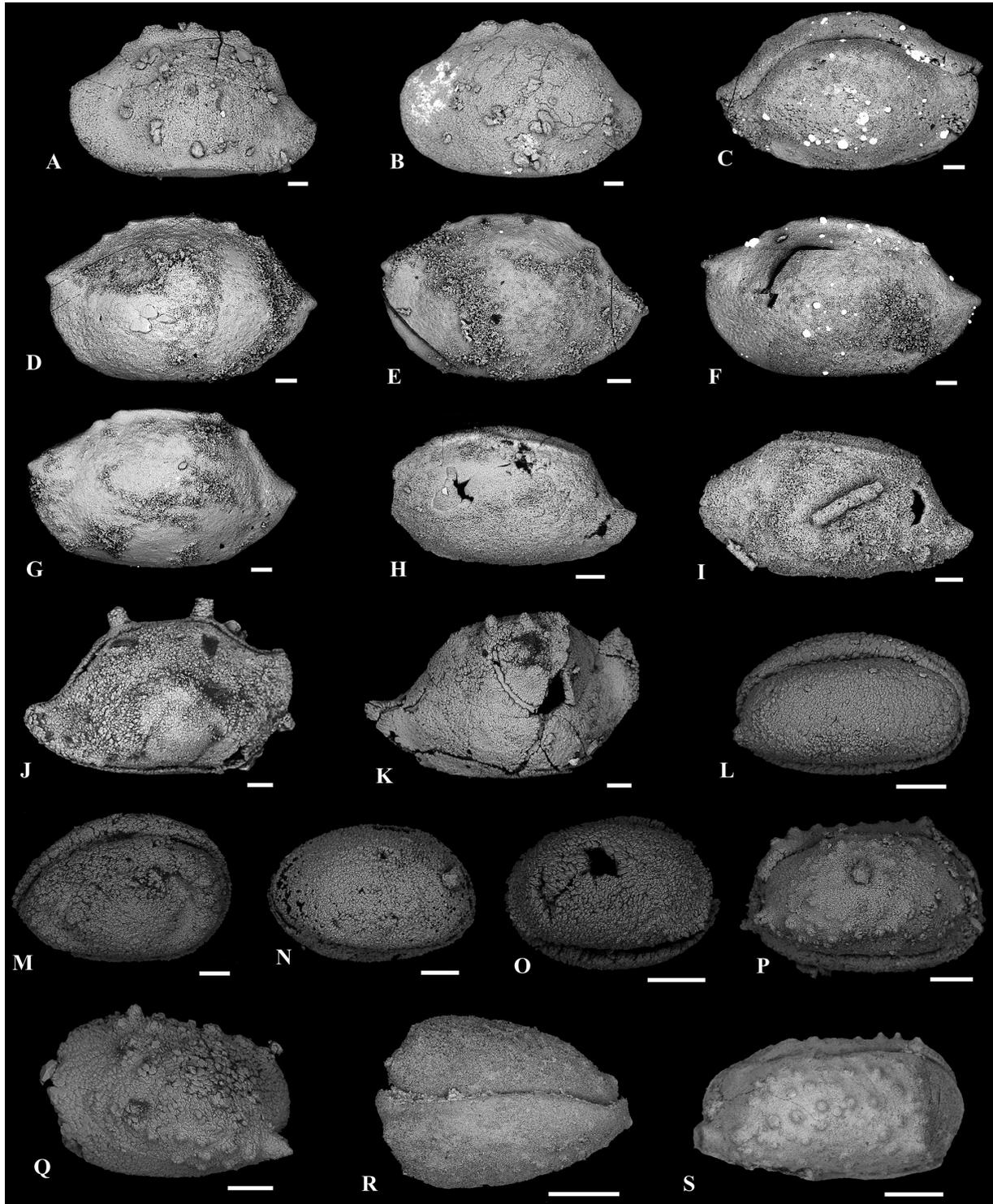
USA • 1 complete carapace; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 2 (GM6); Capitanian, Middle Permian; MNHN.F.F63465  
• 1 left valve; same locality as for preceding but sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63472.

### Occurrence

Chishia Limestone, Kwanshan, Lungtan, China, Kungurian, Early Permian (Chen 1958); Jurong, China, Kungurian, Early Permian (Chen & Bao 1986); samples 4 (GM5) and 2 (GM6), MKCS1 section,

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**Fig. 11** (next page). SEM micrographs of ostracods from the Middle Permian (Roadian, Quarry section, samples GM1, GM2 and GM4; Capitanian, MKCS1 section, samples 4 (GM5) and 2 (GM6)) of the Guadalupe Mountains (West Texas, USA), except R and S from the late Capitanian, Middle Permian, Penglaitan section, Guangxi, South China (Zazzali 2016, unpublished PhD thesis). All specimens from A–Q are temporarily housed in the collections of the Muséum national d’histoire naturelle, Paris, France (MNHN), specimens R and S are housed in the collections of the Sorbonne University, Paris, France. **A–B.** *Ceratobairdia* cf. *ventrocostata* Wang, 1978. **A.** External view of a left valve, sample 4 (GM5) (MNHN.F.F63454). **B.** External view of a left valve, sample 2 (GM6) (MNHN.F.F63455). – **C–G.** *Ceratobairdia pratti* Forel sp. nov. **C.** Holotype, right lateral view of a carapace, sample GM1 (MNHN.F.F63456). **D.** Paratype, external view of a left valve, sample GM1 (MNHN.F.F63457). **E.** External view of a left valve, sample GM1 (MNHN.F.F63458). **F.** External view of a left valve, sample GM1 (MNHN.F.F63459). **G.** External view of a left valve, sample GM1 (MNHN.F.F63460). – **H–I.** *Petasobairdia campbelli* Chitnarin in Chitnarin *et al.*, 2017. **H.** External view of a left valve, sample GM2 (MNHN.F.F63461). **I.** External view of a left valve, sample GM4 (MNHN.F.F63462). – **J.** *Petasobairdia* cf. *bicornuta* Chen in Chen & Shi, 1982, right lateral view of a carapace, sample 4 (GM5) (MNHN.F.F63463). – **K.** *Petasobairdia?* sp., external view of a right valve, sample 4 (GM5) (MNHN.F.F63464). – **L.** *Microcheilinella postspinosa* Chen, 1958, right lateral view of a carapace, sample 2 (GM6) (MNHN.F.F63465). – **M.** *Microcheilinella* sp. 15 in Zazzali *et al.* (2015), right lateral view of a carapace, sample 4 (GM5) (MNHN.F.F63466). – **N–O.** *Microcheilinella* sp. **N.** Right lateral view of a carapace, sample 2 (GM6) (MNHN.F.F63467). **O.** Right lateral view of a carapace, sample 4 (GM5) (MNHN.F.F63468). – **P–Q.** *Denticupachydomella bellcanyonensis* Forel sp. nov. **P.** Holotype, right lateral view of a carapace, sample 4 (GM5) (MNHN.F.F63469). **Q.** Paratype, external left of a right valve, sample 2 (GM6) (MNHN.F.F63470). – **R–S.** *Microcheilinella* sp. D in Zazzali (2016). **R.** Dorsal view of a carapace (P6M 3778). **S.** Right lateral view of a carapace (P6M 3779). Scale bars: 100 µm.



‘McKittrick Canyon’ Member, Bell Canyon Formation, Guadalupe Mountains, West Texas, USA, Capitanian, Middle Permian (this work).

*Microcheilinella* sp. 15 in Zazzali *et al.* 2015

Fig. 11M

*Microcheilinella* sp. 15 – Zazzali *et al.* 2015: fig. 12m.

### Material examined

USA • 1 complete carapace; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63466  
• 1 complete carapace, 3 left valves; same locality as for preceding but samples 4 (GM5) and 2 (GM6); Capitanian, Middle Permian; MNHN.F.F63471.

### Occurrence

Chaotian section, Sichuan, China, Wuchiapingian, Late Permian (Zazzali *et al.* 2015); samples 4 (GM5) and 2 (GM6), MKCS1 section, ‘McKittrick Canyon’ Member, Bell Canyon Formation, Guadalupe Mountains, West Texas, USA, Capitanian, Middle Permian (this work).

### Remarks

The carapace of this species is subtriangular in lateral view, with large AB and strong overlap of LV on RV, hemi-circular furrows are visible on the medio-anterior and medio-posterior parts of the carapace in both valves.

Genus *Denticupachydomella* Yuan in Yuan *et al.*, 2009

### Type species

*Denticupachydomella spinosa* Yuan in Yuan *et al.*, 2009 by original designation.

### Original diagnosis

“A new Pachydomellidae genus with left valve having straight dorsal border, two horny dorsal spines erecting at the anterior cardinal angle, one stronger spine at the posterior cardinal angle, three denticles along dorsal border, one posteroventral spine and pustulous lateral surface.” (from Yuan *et al.* 2009: 392–393).

### Emended diagnosis

A new genus with a relatively massive postero-ventral spine, spines of various morphology and strength developed along the dorsal margin of the left valve and surface pustulose.

### Assigned species

The following species are herein re-assigned to the genus *Denticupachydomella*:

*Microcheilinella?* *multinodosa* Forel in Crasquin *et al.*, 2010 from the Changhsingian, Late Permian of the Meishan section, Zhejiang Province, China (Crasquin *et al.* 2010);

*Microcheilinella* sp. D in Zazzali (2016: 208–209, pl. 14f–g, unpublished material, PhD thesis), Late Capitanian, Middle Permian, Penglaitan section, Guangxi, South China (Fig. 11R–S).

## Remarks

The thorough comparison of ornate Microcheilinellidae revealed that all the above-mentioned species share postero-ventral spines on both valves and spines/nodules/pustules along the dorsal margin and over the lateral surface. Conversely, the two horny dorsal spines and the three denticles along the dorsal border originally described by Yuan *et al.* (2009) as of generic significance to the newly erected genus *Denticupachydomella* rather appear as variations of the morphology and strength of the spines, thus being of specific significance. The diagnosis of *Denticupachydomella* Yuan in Yuan *et al.*, 2009 is here emended to clarify this issue of generic versus specific characters.

*Denticupachydomella bellcanyonensis* Forel sp. nov.

[urn:lsid:zoobank.org:act:89B99A6B-AD6C-43DD-BAAD-D85F291FCBD3](https://zoobank.org/urn:lsid:zoobank.org:act:89B99A6B-AD6C-43DD-BAAD-D85F291FCBD3)

Fig 5H, 11P–Q

## Diagnosis

A species of *Denticupachydomella* with a row of nodules uniform in size along DB of LV and a surface ornamented by nodules.

## Etymology

After the Bell Canyon Formation (Middle Permian, West Texas) that yielded this new species.

## Material examined

### Holotype

USA • complete carapace, (Fig. 11P); Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 4 (GM5); Capitanian, Middle Permian; MNHN.F.F63469.

### Paratype

USA • 1 left valve, (Fig. 11Q); Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, sample 2 (GM6); Capitanian, Middle Permian; MNHN.F.F63470.

### Additional material

USA • 1 complete carapace, 13 valves; Guadalupe Mountains, West Texas, ‘McKittrick Canyon’ Member, Bell Canyon Formation, MKCS1 section, samples 4 (GM5) and 2 (GM6); Capitanian, Middle Permian; MNHN.F.F63500.

## Dimensions

L=387–756 µm; H=247–433 µm (Fig. 5H).

## Description

Small carapace sub-rectangular, H/L=0.57–0.69; DB straight on both valves; row of nodules long DB of LV; AB with quite large radius of curvature with maximum located below mid-H; VB almost straight at both valves; PB with large radius of curvature for genus with maximum of curvature located in lower part of H; presence of spine in posteroventral part of carapace; overlap of LV on RV all around carapace; presence of nodules on surface of both valves.

## Occurrence

Samples 4 (GM5) and 2 (GM6), MKCS1 section, ‘McKittrick Canyon’ Member, Bell Canyon Formation, Guadalupe Mountains, West Texas, USA, Capitanian, Middle Permian (this work).

## Remarks

*Denticupachydomella bellcanyonensis* sp. nov. is very similar to the type species *Denticupachydomella spinosa* Yuan in Yuan *et al.*, 2009 from the Changhsingian of South China (Yuan *et al.* 2009) but is larger and lacks the two horny spines at the anterior and posterior cardinal angles. *Denticupachydomella bellcanyonensis* sp. nov. differs from *Denticupachydomella multinodosa* (Forel in Crasquin *et al.* 2010) from the Changhsingian (Late Permian) of Sichuan, south-west China (Crasquin *et al.* 2010) by the presence of a postero-ventral spine and by the organisation of nodules along dorsal and ventral margins at both valves. Herein, the dorso-central shoulder at RV is absent and the surface is covered by nodules. The species from the Late Capitanian of the Penglaitan section (Guadalupuan–Lopingian GSSP) in Guangxi, South China (Zazzali 2016: fig. 13o–p, unpublished material) differs from *Denticupachydomella bellcanyonensis* sp. nov. by a more elongate carapace and a PB with smaller radius of curvature. The species from the Penglaitan section is also new and has to be described.

## Discussion

### Diversity and taxonomic composition of ostracod assemblages

Each of the 6 samples studied from the Middle Permian (Roadian and Capitanian) of the Guadalupe Mountains, West Texas, USA, yielded identifiable ostracods. In total, 51 species have been identified, belonging to 26 genera and 15 families. Seventeen species were previously known from the Permian, 11 are new and 23 are kept in open nomenclature due to poor preservation and/or paucity of material (including *Microcheilinella* sp. 15 in Zazzali *et al.* 2015, which occurs in the Wuchiapingian, Late Permian of South China). Table 1 provides a complete taxonomic list of the two assemblages from the Middle Permian (Roadian and Capitanian) of the Guadalupe Mountains. The assemblages described in the present contribution are obtained from two continuous bedded sections.

The diversity level of the Roadian assemblage is slightly higher with 34 species, 21 genera, and 13 families whereas in the Capitanian assemblage, the ostracods are represented by 26 species, 18 genera, and 11 families. Across the studied area, 23 species are restricted to the Roadian (including *Healdia mckittrickensis* sp. nov., *Amphissites centronotus* (Ulrich & Bassler, 1906), *Kindlella fissiloba* Sohn, 1954, *Aurikirkbya guadalupensis* sp. nov., *Geisina culbersonensis* sp. nov., *Acratia sinuata* (Kozur, 1991), *Bairdia subfusiformis* Hamilton, 1942, *B. elcapitanensis* sp. nov., *Fabalitypris acetalata* (Coryell & Billings, 1932), *Ceratobairdia sexagintaduella* sp. nov., *C. pratti* sp. nov., and *Petasobairdia campbelli* Chitnarin in Chitnarin *et al.*, 2017) and 15 are restricted to the Capitanian (including *Kindlella bellsundi* Olempska & Błaszzyk, 1996, *Paraparchites texanus* Delo, 1930, *Bairdia rhomboidalis* Hamilton, 1942, *Fabalitypris glennensis* (Harlton, 1927), *Ceratobairdia mescaleroella* sp. nov., *Microcheilinella postspinosa* Chen, 1958, and *Denticupachydomella bellcanyonensis* sp. nov.). Conversely, eight genera are restricted to the Roadian (*Amphissites*, *Polytylites*, *Kirkbya*, *Glyptopleura*, *Geisina*, *Libumella*, *Fellerites*, *Acratia*) and five are only found in the Capitanian (*Kirkbyidae* gen. et sp. indet., *Kirkbyella*, *Miltonella*, *Microcheilinella*, *Denticupachydomella*). At the family level, *Amphissitidae*, *Glyptopleuridae*, *Geisinidae*, *Rozhdestvenskaytidae* are restricted to the Roadian whereas *Microcheilinidae* and *Kirkbyellidae* are restricted to the Capitanian.

In terms of family composition (Fig. 12), both assemblages are dominated by *Bairdiidae* (*Acratia*, *Bairdia*, *Bairdiacypris*, *Ceratobairdia*, *Fabalitypris*, *Orthobairdia*, *Petasobairdia*) that account for 53% and 42% of the species in the Roadian and the Capitanian, respectively. The Roadian and Capitanian assemblages differ by their respective composition in secondary and accessory families. In the Roadian, all families except *Bairdiidae* account for less than 10% of the species. Of them, *Kirkbyidae* (*Aurikirkbya*, *Kirkbya*) is the most diverse with 9% of the species. *Amphissitidae* (*Amphissites*, *Polytylites*) and *Healdiidae* (*Healdia*) each account for 6% of the species. Accessory families are *Paraparchitidae* (*Paraparchites*), *Cavellinidae* (*Sulcella*), *Kelletinidae* (*Kindlella*), *Scrobiculidae*

**Table 1** (continued on next page). Taxonomic list of all ostracod species identified from the Roadian and Capitanian of the Guadalupe Mountains, West Texas, USA.

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Class Ostracoda Latreille, 1806

Subclass Podocopa Müller, 1894

Order Metacopida Sylvester-Bradley, 1961

Suborder Metacopina Sylvester-Bradley, 1961

Superfamily Healdioidea Harlton, 1933

Family Healdiidae Harlton, 1933

*Healdia mckittrickensis* Crasquin sp. nov. [Fig. 4A–C; GM1, GM4]

*Healdia cutoffella* Crasquin sp. nov. [Fig. 4D–F; GM1-GM5]

Family Cavellinidae Egorov, 1950

*Sulcella mesopermiana* Kozur, 1991 [Fig. 4G–I; GM1, GM3-GM6]

Order Palaeocopida Henningsmoen, 1953

Suborder Kloedenellocopina Scott, 1961

Superfamily Kirkbyoidea Ulrich & Bassler, 1906

Kirkbyidae gen. et sp. indet. [Fig. 4J; GM5]

Family Amphissitidae Knight, 1928

*Amphissites centronotus* (Ulrich & Bassler, 1906) [Fig. 4K–L; GM1, GM4]

*Polytylites?* sp. [Fig. 4M; sample GM4]

Family Kelletinidae Sohn, 1954

*Kindlella fissiloba* Sohn, 1954 [Fig. 4N; GM1, GM4]

*Kindlella bellsundi* Olempska & Błaszyk, 1996 [Fig. 4P–Q; GM5]

*Kindlella* sp. [Fig. 4O, GM1]

Family Kirkbyidae Ulrich & Bassler, 1906

*Kirkbya* sp. [Fig. 4R; GM1]

*Aurikirkbya guadalupensis* Crasquin sp. nov. [Fig. 6A–B; GM1-GM3]

*Aurikirkbya wordensis* (Hamilton, 1942) [Fig. 6C, E; GM4-GM6]

Family Kirkbyellidae Sohn, 1961

*Kirkbyella (Berdanella) cf. quadrata* Croneis & Gutke, 1939 [Fig. 6D; GM5]

Family Scrobiculidae Posner, 1951

*Roundyella lebaensis* Krömmelbein, 1958 [Fig. 6F–H; GM1, GM4, GM5]

Superfamily Hollinoidea Swartz, 1936

Family Hollinellidae Bless & Jordan, 1971

*Hollinella (Hollinella) williamsranchensis* Crasquin sp. nov. [Fig. 6I–L; GM1, GM4, GM5]

Superfamily Kloedenelloidea Ulrich & Bassler, 1908

Family Glyptopleuridae Girty, 1910

*Glyptopleura* sp. [Fig. 6M; GM1-GM3]

Family Geisinidae Sohn, 1961b

*Geisina culbersonensis* Crasquin sp. nov. [Fig. 6N–P; GM1, GM2, GM4]

Family Miltonellidae Sohn, 1950

*Miltonella cf. shupei* Sohn, 1950 [Fig. 6Q–R; GM5]

?Family Miltonellidae Sohn, 1950

*Libumella cf. athabascensis* Green, 1963 [Fig. 7A; GM1]

Superfamily Primitiopsioidea Swartz, 1936

Family Rozhdestvenskaytidae McGill, 1966

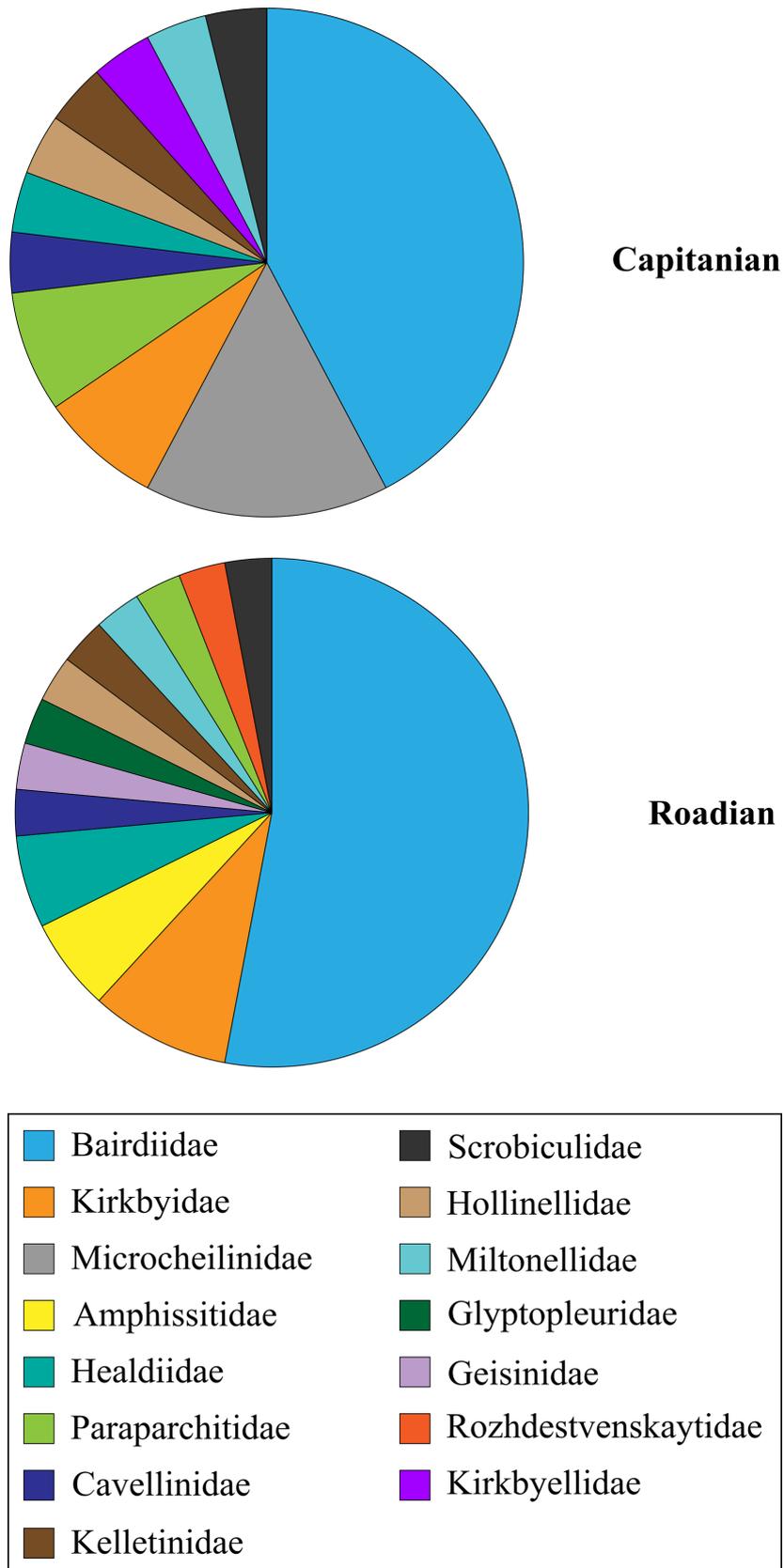
*Fellerites?* sp. [Fig. 7B; GM1]

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**Table 1** (continued). Taxonomic list of all ostracod species identified from the Roadian and Capitanian of the Guadalupe Mountains, West Texas, USA.

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- Order Leiocopa Schallreuter, 1973  
  Superfamily Paraparchitoidea Scott, 1959  
    Family Paraparchitidae Scott, 1959  
      *Paraparchites texanus* Delo, 1930 [Fig. 7C; GM5]  
      *Paraparchites pecosensis* Crasquin sp. nov. [Fig. 7D–H; GM1–GM3, GM6]
- Order Podocopida Sars, 1866  
  Suborder Podocopina Sars, 1866  
    Superfamily Bairdioidea Sars, 1887  
      Family Bairdiidae Sars, 1865  
        *Acratia* sp. [Fig. 7I; GM2]  
        *Acratia* cf. *sinuata* (Kozur, 1991) [Fig. 7J; GM1]  
        *Acratia sinuata* (Kozur, 1991) [Fig. 7K; GM1, GM4]  
        *Bairdia radlerae* Kellett, 1934 [Fig. 7L–M; GM1, GM2, GM4–GM6]  
        *Bairdia rhomboidalis* Hamilton, 1942 [Fig. 7N; GM5, GM6]  
        *Bairdia subfusiformis* Hamilton, 1942 [Fig. 7O; GM1]  
        *Bairdia elcapitanensis* Forel sp. nov. [Figs 7P–R, 8A–B; GM1]  
        *Bairdia* cf. *postacuta* Chen, 1958 [Fig. 8C; GM1, GM2, GM5, GM6]  
        *Bairdia* sp. A [Fig. 8D; GM1]  
        *Bairdia* sp. B [Fig. 8E; GM1]  
        *Bairdia* sp. C [Fig. 8F; GM1]  
        *Bairdiacypris* sp. B [Fig. 8G; GM1–GM6]  
        *Bairdiacypris* sp. C [Fig. 8H; GM1]  
        *Fabalitypris acetalata* (Coryell & Billings, 1932) [Fig. 8I–J; GM1, GM2, GM4]  
        *Fabalitypris glennensis* (Harlton, 1927) [Fig. 8K; GM5]  
        *Fabalitypris* sp. [Fig. 8L; GM1, GM2, GM4]  
        *Orthobairdia texana* (Harlton, 1927) [Fig. 8M, N; GM1, GM5, GM6]  
        *Ceratobairdia mescaleroella* Forel sp. nov. [Fig. 8O–R, 9A–C; GM5, GM6]  
        *Ceratobairdia sexagintaduella* Forel sp. nov. [Fig. 9D–J; GM1, GM2]  
        *Ceratobairdia wordensis* (Hamilton, 1942) [Fig. 9K–R; GM1–GM3, GM5, GM6]  
        *Ceratobairdia* cf. *ventrocostata* Wang, 1978 [Fig. 11A, B; GM5, GM6]  
        *Ceratobairdia pratti* Forel sp. nov. [Fig. 11C–G; GM1, GM2]  
        *Petasobairdia campbelli* Chitnarin in Chitnarin *et al.*, 2017 [Fig. 11H, I; GM2, GM4]  
        *Petasobairdia* cf. *bicornuta* Chen in Shi & Chen, 2002 [Fig. 11J; GM5]  
        *Petasobairdia?* sp. [Fig. 11K; GM5]
- Superfamily Sigillioidea Mandelstam, 1960  
    Family Microcheilinellidae Gramm, 1975  
      *Microcheilinella postspinosa* Chen, 1958 [Fig. 11L; GM5, GM6]  
      *Microcheilinella* sp. 15 in Zazzali *et al.* 2015 [Fig. 11M; GM5, GM6]  
      *Microcheilinella* sp. [Fig. 11N, O; GM5, GM6]  
      *Denticupachydomella bellocanyonensis* Forel sp. nov. [Fig. 11P, Q; GM5, GM6]
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**Fig. 12.** Circular diagrams of faunal composition of ostracod assemblages by number of species in the Roadian and Capitanian of the Guadalupe Mountains, West Texas, USA.

(*Roundyella*), Hollinellidae (*Hollinella*), ?Miltonellidae (*Libumella*), Glyptopleuridae (*Glyptopleura*), Geisiniidae (*Geisina*) and Rozhdestvenskaytidae (*Fellerites*), each being 3% of the species. The Capitanian assemblage shows a slightly different structure with relatively diverse Microcheilinellidae (*Microcheilinella*, *Denticupachydomella*) accounting for 15% of the species. Secondary components are Kirkbyidae (*Aurikirkbya*, Kirkbyidae gen. et sp. indet.) and Paraparchitidae (*Paraparchites*) each with 8% of the species. Accessory families each account for less than 4% of the species: Healdiidae (*Healdia*), Cavellinidae (*Sulcella*), Kelletinidae (*Kindlella*), Scrobiculidae (*Roundyella*), Hollinellidae (*Hollinella*), Miltonellidae (*Miltonella*), Kirkbyellidae (*Kirkbyella*).

The autochthonous or allochthonous nature of ostracod assemblages can be assessed by considering the proportion of complete carapaces versus isolated valves and the demographic structure of populations (e.g., Oertli 1971; Boomer *et al.* 2003). As visible in all H/L scatter plots shown in Fig. 5 and Fig. 10, both assemblages are composed of a mixture of adults and juveniles, but very small juveniles are significantly lacking. Specimens were picked prior to this analysis and it is possible that only the largest specimens have been collected from the residues. In both assemblages, disarticulated valves are much more abundant than complete carapaces (Fig. 5 and Fig. 10), indicating that relatively important transportation occurred, in line with the lithological information pointing to deep-water downslope deposits in the Roadian Quarry section (Amerman 2009; Hurd & Kerans 2014; Scholle *et al.* 2015). It is worth noting that none of the typical Palaeozoic off-shelf taxa (Beecherellidae Ulrich, 1894, Bythocytheridae Sars, 1866, Rectoriidae Gründel, 1962, Tricorninidae Blumenstengel, 1965) is present, which further confirms that these taxa may have been purely Palaeo-Tethyan in the Permian and the Triassic (Forel in press).

### Stratigraphical and palaeobiogeographical distributions

#### Species restricted to the USA

Several of the species reported from the present analysis were already known from other North American localities. Several species previously known only from the Early Permian are herein extended to the Middle Permian:

- *Kindlella fissiloba* Sohn, 1954 previously only known from the Kungurian, Early Permian of Texas is herein shown to extend to the Roadian,
- *Bairdia rhomboidalis* Hamilton, 1942 documented from the Kungurian, Early Permian of Texas extends to the Capitanian,
- *Aurikirkbya wordensis* (Hamilton, 1942), *Bairdia subfusiformis* Hamilton, 1942 and *Ceratobairdia wordensis* (Hamilton, 1942) were only known from the Kungurian, Early Permian of Texas and are herein shown to occur in the Roadian and Capitanian,
- *Bairdia radlerae* Kellett, 1934 known from the Asselian and Sakmarian, Early Permian of Kansas herein is documented from the Roadian and Capitanian.

#### Taxa with worldwide distributions

Of the species recognized in the Middle Permian of the Guadalupe Mountains, several have been previously documented outside of this area during the Permian (Fig. 13). The present work extends the stratigraphical range of *Microcheilinella postspinosa* that was only known from the Kungurian, to the Capitanian. Conversely, *Acratia sinuata*, *Roundyella lebaensis*, *Kindlella bellsundi* and *Microcheilinella* sp. 15 in Zazzali *et al.* 2015 were only known from the Changhsingian, Late Permian, worldwide and herein are shown to have radiated in the Middle Permian. It is important to mention that stratigraphical updates are also observed at the generic level: until now *Denticupachydomella* was only known from the Late Permian but we show that it radiated in the Capitanian.

In terms of palaeobiogeographical distribution of taxa through time, several patterns are also visible. The species *Sulcella mesopermiana*, *Petasobairdia campbelli*, *Fabalicypriis glennensis* and *Microcheilimella postspinosa* had a purely Palaeo-Tethyan distribution until the present contribution but their occurrence

		<i>Amphissites centronotus</i>	<i>Sulcella mesopermiana</i>	<i>Petasobairdia campbelli</i>	<i>Fabalicypriis glennensis</i>	<i>Microcheilimella postspinosa</i>	<i>Acratia sinuata</i>	<i>Roundyella lebaensis</i>	<i>Kindtella bellsundi</i>	<i>Microcheilimella</i> sp. 15	
<b>PERMIAN</b>	Late	Changhsingian				China					
		Wuchiapingian		China Greece Hung.				Hung.	Hung. Russia Lith. Spitzb.	Spitzb.	China
	Middle	Capitanian	Japan	Greece Hung. USA	USA	USA	USA		USA	USA	USA
		Wordian									
		Roadian	USA	USA	USA Thail.			USA	USA		
	Early	Kungurian	USA			China	China				
		Artinskian	USA Canada	Thail.	Thail.						
		Sakmarian	USA Austr. Canada	Thail.							
		Asselian	Austria USA Canada								

**Fig. 13.** Stratigraphical (Permian only) and palaeogeographic ranges of ostracod species recorded outside of the USA in the Permian; stage durations not to scale. Abbreviations: Hung. =Hungary; Spitzb. =Spitzbergen.; Lith. =Lithuania; Thail. =Thailand; Austr. =Australia. Orange colour underlined =species found in this study; light grey =supposed occurrences; dark grey =occurrences of species in common with this study.

in the Middle Permian of the Guadalupe Mountains documents a transpanthalassic dispersal of species in the Permian. In the present state of our knowledge, these species all appear to have radiated on the eastern margin of Palaeo-Tethys sensu lato in the Early Permian (Fig. 13), but their dispersal patterns show significant discrepancies. *Sulcella mesopermiana* was restricted to the Indochina Block, Thailand (Chitnarin *et al.* 2017) and later spread westward to the eastern Palaeo-Tethys (Greece, Hungary) and eastward across the Panthalassa to the Guadalupe Mountains area in the Middle Permian. Conversely, *Petasobairdia campbelli*, *Fabalicypriis glennensis* and *Microcheilinella postspinosa* only record a transpanthalassic eastward migration trend, but this feature may change with more data from diverse localities worldwide. A second group of species documents the opposite trend: *Acratia sinuata*, *Roundyella lebaensis*, *Kindlella bellsundi* and *Microcheilinella* sp. 15 in Zazzali *et al.* 2015 radiated in the Middle Permian of the Guadalupe Mountains area as revealed by the present assemblages and migrated westward to the Palaeo-Tethyan area in the Late Permian. These two migration ways herein illustrated for the first time show that exchanges of taxa between Palaeo-Tethys sensu lato and Panthalassa were strong in the Permian prior to the end-Permian extinction. The strong relationship of the northern America ostracod assemblages with the eastern Tethyan area, more precisely the South China Block, was already reported in Forel (2018). A second observation is that the eastern Palaeo-Tethys has been a zone of major importance in radiation of ostracod taxa in the Permian, as it was in the Triassic (Bate 1977; Kristan-Tollmann 1983, 1993; Lord 1988; Ketmuangmoon *et al.* 2018; Forel *et al.* 2019; Forel & Moix 2020).

## Conclusion

Ostracods of Roadian and Capitanian (Middle Permian) age have been extracted from samples collected from the Quarry and MKCS1 sections in the Guadalupe Mountains area in West Texas, USA. In total, the ostracod assemblages are composed of 49 species, which represent 26 genera and 15 families. Eleven new species are described: *Healdia mckittrickensis* Crasquin sp. nov., *Healdia cutoffella* Crasquin sp. nov., *Aurikirkbya guadalupensis* Crasquin sp. nov., *Hollinella* (*Hollinella*) *williamsranchensis* Crasquin sp. nov., *Geisina culbersonensis* Crasquin sp. nov., *Paraparchites pecosensis* Crasquin sp. nov., *Bairdia elcapitanensis* Forel sp. nov., *Ceratobairdia mescaleroella* Forel sp. nov., *Ceratobairdia sexagintaduella* Forel sp. nov., *Ceratobairdia pratti* Forel sp. nov., and *Denticupachydomella bellcanyonensis* Forel sp. nov. The Roadian and Capitanian assemblages are largely dominated by isolated valves that document transportation, in line with other proxies indicating deep-water downslope deposition. The stratigraphical and palaeobiogeographic distribution of taxa indicate transpanthalassic exchanges of taxa in the Permian as well as the importance of the eastern Palaeo-Tethys margin for radiation of ostracod species.

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