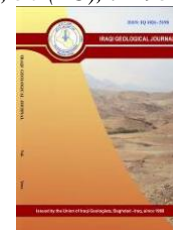




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Campanian-Maastrichtian Ostracods (Crustacea) From the Shiranish Formation, Dukan Area, Kurdistan Province, Northern Iraq

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Abstract

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The present study represents a detailed systematic study of obtained ostracods in sixty three samples from an outcrop section of the Shiranish Formation (Campanian – Maastrichtian), Dukan area, Kurdistan, northern Iraq. Thirty ostracod species belonging to twenty one genera are found, whereas nineteen species are previously recorded. Eleven new described species are detected, which three new species represented in *Bairdia dukanensis* sp. nov., *Bairdoppilata shiranishensis* sp. nov. and *Hornibrookella nudosa* sp. nov. are newly renamed by the authors according to the scientific roles of nomenclature, and nine species are systemacilly described as (sp.) due to the lack of satisfied specimens.

Keywords: Ostracods; Shiranish Formation; Species; Systematic study; Dukan area; Campanian – Maastrichtian

1. Introduction

The present study represents a detailed taxonomic study of all Ostracod fossils assemblages that are found in an outcropped section of the Shiranish Formation (Campanian-Maastrichtian) in Dukan area, northern Iraq (Fig.1a and b). Although this formation has been studied in various geological disciplines, the current study represents the first in terms of dealing with Ostracod fossils. In the type section of the Shiranish Formation in Shiranish Islam Village Northeastern Iraq, the Formation is about 225 m thick (Henson, 1940, in Belen et.al., 1959), while in the studied outcropped section in Dukan, its thickness is about 218 m, which is almost the same as in the type locality.

The previous paleo environmental studies indicate that the Shiranish Formation was deposited in middle-outer shelf and upper-middle bathyal depositional environments (Malak, 2015). According to the field observations, the formation consists mainly of successions of marly limestone with thin beds of marl and occasionally (5-20 cm) thick limestone beds (Fig.2). The lower contact of the formation is unconformable lying above Kometan Formation (Turonian) indicated by the presence of conglomerate, while the upper contact gradually changes to the Tanjero Formation (Maastrichtian age).

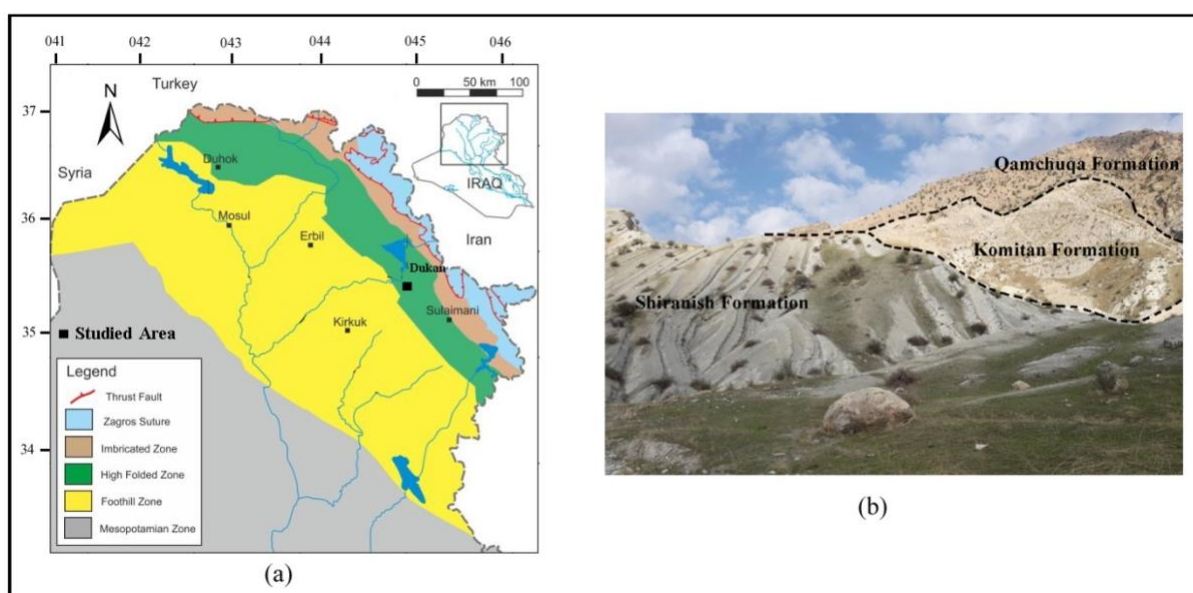


Fig.1. (a) Tectonic map of North Iraq show the location of studied area; (b) Photographic picture of the Shiranish Formation outcropped section

The Shiranish Formation in the field is very easy to identify because of its distinctive blueish grey color that distinguish the formation from the surrounding formations (Fig.1). Tectonically, the formation is exposed in the Imbricated, High Folded Thrust Zones and within subsurface sections of the Low Folded Thrust Zone (Kirkuk embayment) (Jassim and Goff, 2006; Aqrawi et al., 2010; Sharland et al., 2004; Lawa et al., 2013). Lithologically, this formation consists of a very homogeneous successions of bluish grey to dark grey hemiplegic/pelagic marl and marly limestone, glauconitic at the upper and lower boundaries (Lawa, 2018). Generally, the main aim of the current study is to systematically identifying of all ostracodes fauna that obtained from the outcropped section of the Shiranish Formation, where it is a new scientific addition for the ostracod assemblages that recorded in the Late Cretaceous of Iraq. There is only one study that dealt with the ostracod of Shiranish Formation by Taha (2020), who systematically mentioned only eight species of ostracods, while the present study shows that there are much more diversity in ostracods assemblages, represented in thirty species and twenty one genera.

2. Materials and Methods

Sixty three rock specimens are collected across an outcrop of the Shiranish Formation (218 m) in Dukan area (latitude: 35° 54' 22" N, longitude: 045° 00' 40" E) (Fig. 2). They are prepared according to the established method of Moore and Pitrat (1961). The samples are soaked in water for 24 hours or more (according to the lithology), then boiled on the hot plate; after that, the boiled fragments are washed under the water tap with 100 mesh sieve; then, the residue passing through arranged sieves (20, 40, 60 and 80 mesh size) are dried to make the picking process better and easier, picking the ostracod specimens. Finally, they are put in suitable slides. The specimens are studied by binocular microscope (brand: KERN OSE) and photographed by digital microscope adapter camera (brand: UCMOS05100KPA). The Ostracod specimens are reposted in Sulaimani Polytechnic University, Technical College of Applied Sciences in Halabja with abbreviation of Sh.Fm.Du. (Shiranish Formation Dukan). The abbreviation given to the rock samples is Sh.S.No. (Shiranish Sample Number).

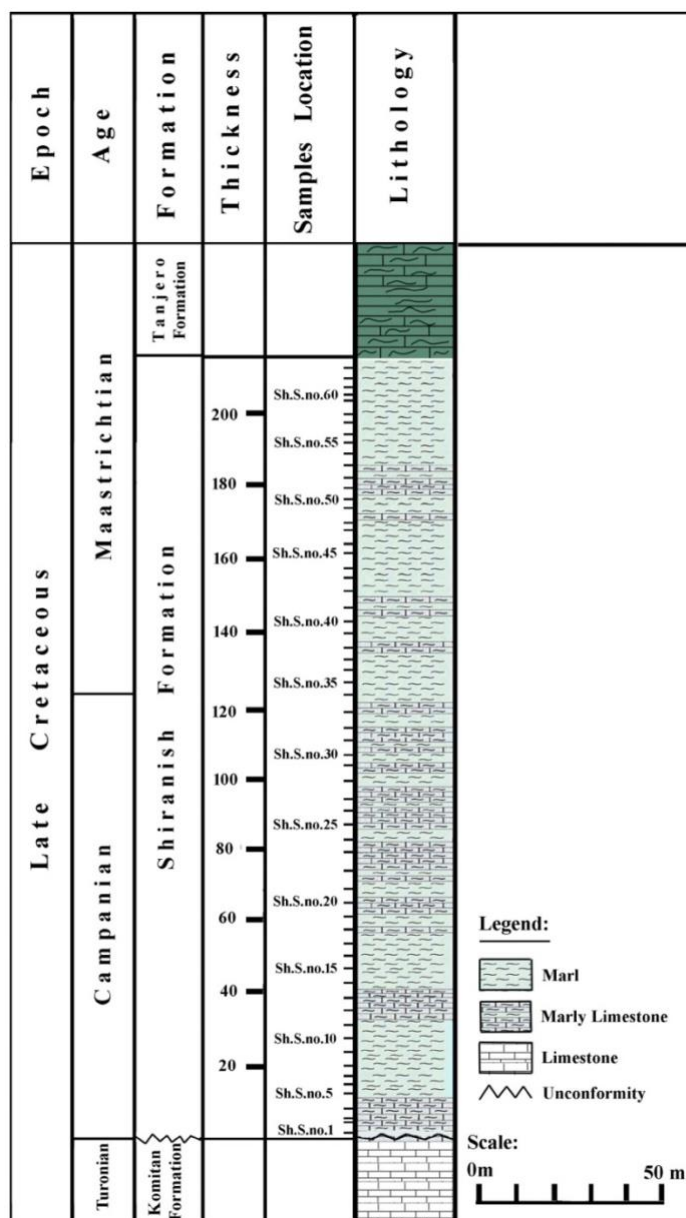


Fig.2. Lithological section of the Shiranish Formation in Dukan area

3. Systematic Descriptions

Classification systems of Hartman and Puri (1974) and Morkhoven (1963) are applied in the present study in order to classify the obtained ostracods. With considering that numbers were given for the newly described genera due to the lack of specimens. The ranges of all species across the studied section are shown in Fig. 3.

Phylum :	Crustacea	(Pennant, 1777)
Class :	Ostracoda	(Latreille, 1806)
Order :	Podocopida	(Muller, 1896)
Suborder :	Podocopina	(Sars, 1866)
Family :	Cytherellidae	(Sars, 1866)
Genus :	<i>Cytherella</i>	(Jones, 1849)
Type species :	<i>Cytherina ovata</i>	(Roemer, 1840)

Cytherella cf. *C. ovata* (Roemer, 1840)

(Pl.1, Fig.1)

1840. - *Cytherina ovata* n. sp. - Roemer, p. 104, pl. 16, fig. 21.1841 - *Cytherina ovata*, Roemer: Norddeutsches Kreidegebirge, p. 104, pl. 16, fig. 21.1841. - *Cytherella ovata* (Roemer, 1840) Bonnema, p. 93, pl. 1, fig. 1-16.

Figured specimen: Sh.Fm.Du.1

Materials: Five carapaces and one valve

Dimensions (µm): Length: 738, Height: 504

Type Horizon: Sh.S.No.4

Remarks: the present species has the same description of *Cytherella ovata* (Roemer, 1840), but somewhat has more straight dorsal margin.*Cytherella tawaica* (Tewari and Sing, 1966)

(Pl.1, Figs.2a,b)

1966 *Cytherella tawaica* Tewari and Sing, p. 127, pl.2, figs 3 a-d Figured specimen: Sh.Fm.Du.2 , Sh.Fm.Du.3

Materials: Forty carapaces.

Dimensions (µm): Length: 777, Height: 502

Type Horizon: Sh.S.No.4

Remarks: the present species is totally matches the outline of *Cytherella tawaica* species that described from India. also *Cytherella tawaica* species described by (Khalaf and Aziz, 2011) from Avana formation, Dohuk area, Northern Iraq (pl.2, figs.3a-d) but larger size.*Cytherella aegyptiensis* (Colin & El-Dakkak, 1975)

(Pl.1, Figs.3a,b)

1974 *Cytherella* gr. *ovata* (Roemer); Rosenfeld & Raab, p. 3, pl. 1, figs 3–5.1975 *Cytherella aegyptiensis*, Colin & El-Dakkak, p. 50, pl. 1, figs 2–3.

Figured specimen: Sh.Fm.Du.4, Sh.Fm.Du.5

Materials: Three carapaces.

Dimensions (µm): Length: 573, Height: 433, Width: 295

Type Horizon: Sh.S.No.4

Remarks: the present species is confirmed with *Cytherella aegyptiensis* that described from Egypt.*Cytherella suranensis* (Aziz, 2018)

(Pl.1, Fig. 4)

2018 *Cytherella suranensis* Aziz, pl. 1, figs. c1- c2.

Figured specimen: Sh.Fm.Du.6

Materials: One carapace.

Dimensions (µm): Length: 657, Height: 400

Type Horizon: Sh.S.No.4

Remarks: the present species has the same diagnostics of *Cytherella suranensis* that described from northern Iraq.*Cytherella* cf. *C. araucana* (Bertels, 1974)

(Pl.1, Figs. 5a-c)

1974 cf. *Cytherella araucana* – Bertels, p. 388, pl. 1, figs. 1a, b, 2a, b.

Figured specimen: Sh.Fm.Du.7, Sh.Fm.Du.8, Sh.Fm.Du.9

Materials: ninety carapaces.

Dimensions (μm): Length: 574, Height: 427, Width: 295

Type Horizon: Sh.S.No.7

Remarks: the present species is very related to the Argentinian species *Cytherella araucana* but somewhat the Iraqi species is wider posteriorly.*Cytherella* sp.3 (Andreu et al., 2008)

(Pl.1, Figs. 6a,b)

2008 *Cytherella* sp.3 Andreu, Colin and Singh, , pl. 1, figs. 8-9.

Figured specimen: Sh.Fm.Du.10, Sh.Fm.Du.11

Materials: nine carapaces.

Dimensions (μm): Length: 740, Height: 420, Width: 358

Type Horizon: Sh.S.No.7

Remarks: the present species is firstly observed by Andreu et al. (2008) in India as *C. sp.3*, they left it under open nomenclature.

Family:	Cytheridae	(Baird, 1850)
Genus:	<i>Sulcostocythere</i>	(Benson and Maddocks, 1964)
Type species:	<i>Sulcostocythere knysnaensis</i>	(Benson and Maddocks, 1964)

Sulcostocythere sp.1

(Pl.1, Figs. 7a-c)

Figured specimen: Sh.Fm.Du.12, Sh.Fm.Du.13, Sh.Fm.Du.14

Materials: Two carapaces.

Dimensions (μm): Length: 606, Height: 430, Width: 324

Type Horizon: Sh.S.No.24

Description: a species with sub quadrate carapace in the lateral side, maximum length passes under the center, while the maximum height passes through the anterodorsal angle. The anterior is rounded and extremely wide relative to the carapace, Posterior narrow and subrounded. booth of dorsal and ventral margins are straight and merge slightly with the anterior, while they merge with the posterior by a subrounded angle. The carapace is inflated in the behind the middle, and acuminate in the anterior half, therefore, the carapace has a wedge appearance in the dorsal view. Left valve is bigger than the right, the overlapping is eminent at the posterior.

The outer surface is covered with fine pores; there is a small longitudinal ridge above the ventral margin extending from the middle and ends near the posteroventral angle. The eye tubercle is small and slightly presence.

Remarks: *Sulcostocythere* sp.1 differs in the distinctive outline from all genera that described within *Sulcostocythere*, therefor, it could be a new species. It left as sp. due to the lack of materials.

Family:	Leptocytheridae	(Hanai, 1957)
Genus:	<i>Leptocythere</i>	(Sars, 1925)
Type species:	<i>Cythere pellucida</i>	(Baird, 1850)

Leptocythere sp.1

(Pl.1, Figs.8a-c)

Figured specimen: Sh.Fm.Du.15, Sh.Fm.Du.16, Sh.Fm.Du.17

Materials: Two carapaces.

Dimensions (μm): Length: 673, Height: 414, Width: 299

Type Horizon: Sh.S.No.29

Description: Carapace is sub quadrate in the side view, maximum length locates near the dorsal margin, maximum height passes through the anterodorsal angle. Anterior is wide, rounded and tilted toward the ventral margin, while the posterior is subtruncated. Dorsal margin is substraight and merges gradually with the anterior, also it merges by subrounded angle with the posterior. Ventral margin is slightly curved inward, which gives the carapace an arched appearance in the lateral view, it merges gradually with the anterior and posterior. The left valve is bigger than the right; the overlapping appears at the anterior and the posterior. The outer surface has no ornamentation but very fine pores.

Remarks: the species differs from all genera that belong to *Leptocythere* by its featured outline, it could be a new species. This species left under open name due to the lack of materials.

Family: Bairdiidae (Sars, 1866)
 Genus: *Bairdia* (McCoy, 1844)
 Type species: *Bairdia curtus* (Hartmann, 1962)

Bairdia dukanensis sp. nov.

(Pl.1, Figs.9a-c)

Derivation of the name: after the city of the studied section.

Diagnosis: a species of *Bairdia* moderately have large carapace and extremely rounded outline.

Holotype: One carapace (Sh.Fm.Du.18)

Paratype: Tow carapaces (Sh.Fm.Du.19) and (Sh.Fm.Du.20)

Type Locality: Dukan area.

Type Horizon: Shiranish Formation, Sh.S.No.4

Materials: Eleven carapaces.

Dimensions (μm): Length: 930, Height: 765, Width: 451

Description: Carapace is rounded in the lateral view, maximum length locates nearly below the middle, while the maximum height passes through the middle. Anterior is widely rounded and slightly tilted downward. Posterior is narrowly rounded and slightly towed backward having a convex dorsal margin that gradually merges with the anterior and the posterior. Ventral margin is striate and also gradually merges with the anterior and the posterior.

The outer surface has no clear ornamentation, but covered with very fine pores. The carapace is moderately calcified, distended in the middle. The left valve is larger than the right, and the overlapping is present at the posterior region.

Affinities: The present species is very similar to *Bairdia bassoni* Crasquin, (in Crasquin et. al., 2010) from China, but it differs in having much wider anterior. *Bairdia eoacaenica* (Khalaf and Aziz, 1994) from the Eocene of western Iraq is closely similar to the present species, but the present species has more rounded outline. Generally the *Bairdia dukanensis* is different from all genera that described with *Bairdia* in its featured rounded outline in the side view; for that, the present species is established.

Genus: *Neonesidea* (Maddocks, 1969)
 Type species: *Triebelina schulzi* (Hartmann, 1962)

Neonesidea cymbula (Deltel, 1964)

(Pl.1, Figs.10a-c)

1964 *Bairdia cymbula* Deltel, p. 139–140, pl.2, Figs. 21, 22.2012 *Neonesidea cymbula* (Deltel, 1964), Yamaguchi and Norris, pl. 3, figs. 14,15.

Figured specimen: Sh.Fm.Du.24, Sh.Fm.Du.25, Sh.Fm.Du.26

Materials: Twelve carapaces.

Dimensions (μm): Length: 996, Height: 616, Width: 435

Type Horizon: Sh.S.No.7

Remarks: *Neonesidea cymbula* was described in the first time from France in the upper Eocene age as *Bairdia cymbula* and was reported by Yamaguchi and Norris (2012) from the Paleogene sediments in the North Atlantic. They observed that *N. cymbula* did not have teeth in their hinge line, therefore, they combined the species with the *Neonesidea* genera.

Genus: *Bairdoppilata* (Coryll, Sample and Jennings, 1935)Type species: *Bairdoppilata maryni* (Coryll, Sample and Jennings, 1935)*Bairdoppilata shiranishensis* sp. nov.

(Pl.1, Figs.11a-c)

Derivation of the name: after the formation where the species is found.

Diagnosis: a species of *Bairdoppilata* with large sized and thick carapace, distinctively convex dorsal margin and clearly overlapped valves.

Holotype: One carapace (Sh.Fm.Du.21)

Paratype: Two carapaces (Sh.Fm.Du.22) and (Sh.Fm.Du.23)

Type Locality: Dukan area.

Type Horizon: Shiranish Formation, Sh.S.No.7

Materials: Six carapaces and one valve.

Dimensions (μm): Length: 1213, Height: 806, Width: 612

Description: Carapace is sub pyramidal to sub triangular in the side view; maximum length and height pass through the middle. Anterior is rounded, but a kind of narrow relative to the carapace. The posterior is subrounded, narrow and drawn backward. Dorsal margin is symmetrically convex, and gradually combined with the anterior and the posterior. Ventral margin slightly arcuates outward, and it merges gradually with the anterior and the posterior. Left valve is larger than the right; the overlapping is extremely clear at all the margins. The carapace is well calcified, and inflated in the dorsal view, in which the thickness of the carapace is about a half of the length. The outer surface is smoothly ornamented, and very fine pores observed all over.

Affinities: *Bairdoppilata shiranishensis* is very similar to *Bairdoppilata rakhdensis* Knosla and Pant 1988 from Eocene of India, but it differs in having more convex dorsal margin. Also it has some similarity to *Bairdoppilata rajanathi* (Tewari and Tandon, 1960) from Lower Miocene of India, but have differences in the anterior and dorsal margins. The outline of the present species and the other diagnostic characteristics make it different from all the previously described species.

Bairdoppilata sp.1

(Pl.1, Figs.12a-c)

Figured specimen: Sh.Fm.Du.27, Sh.Fm.Du.28, Sh.Fm.Du.29

Materials: Two carapaces.

Dimensions (μm): Length: 1065, Height: 669, Width: 542

Type Horizon: Sh.S.No.4

Description: Carapace is sub rectangular in the lateral view; bigger length locates near the middle, and bigger height locates at the middle. Anterior subtruncated to subrounded, narrow relatively, somewhat recumbent ventrally. Posterior is sub angular, narrow and slightly tilted upward. Dorsal margin is straight at the middle, curved like a quarter circles in the front third, while sloped sub straight in the posterior third. Ventral margin is sub sinuous and merges gradually with the anterior and posterior. The carapace is well calcified and inflated in the dorsal view. The outer surface is covered with medium sized pores which gives a coarse appearance to the carapace. The right valve is bigger than the left; the overlapping occurs at the anterior and dorsal margins.

Remarks: the present species is different from all species that previously describe with in *Bairdoppilata* by its diagnostic characteristics; may be it's a new species; it left as sp. due to the lack of materials.

Family:	Cytheridae	(Sars, 1925)
Genus:	<i>Asciocythere</i>	(Swain, 1952)
Type species:	<i>Bythocypris rotundus</i>	(Vanderpool, 1928)

Asciocythere daiaensis (Damotte, 1984)
(Pl.1, Figs.13a-c)

1984 *Asciocythere daiaensis*, R. Damotte, Géologie Méditerranéenne pl. 1, fig. 1-3.

Figured specimen: Sh.Fm.Du.30, Sh.Fm.Du.31, Sh.Fm.Du.32

Materials: Five carapaces.

Dimensions (µm): Length: 563, Height: 376, Width: 323

Type Horizon: Sh.S.No.33

Remarks: the present species is confirmed with *Asciocythere daiaensis* from Algeria.

Family:	Krithidae	Mandelstam, 1960
Genus:	<i>Krithe</i>	Brady et al., 1874
Type species:	<i>Ilyobates praetexta</i>	Sars, 1866

Krithe cf. *K. solomoni* Honigstein, 1984
(Pl.1, Fig.14)

Figured specimen: Sh.Fm.Du.33

Materials: One carapaces.

Dimensions (µm): Length: 620, Height: 370

Type Horizon: Sh.S.No.4

Remarks: The present species is very related to *Krithe solomoni* that described from the Senonian of Palestine, but the Iraqi species has more inclined posterior.

Krithe cf. *K. langhiana* Oertli (1961)
(Pl.1, Figs.15a-c)

1961 *Krithe langhiana* Oertli, Riv. Ital. Palaeonto. Strat. 67(1), 17-44, Milano.

Figured specimen: Sh.Fm.Du.34, Sh.Fm.Du.35, Sh.Fm.Du.36

Materials: Six carapaces.

Dimensions (µm): Length: 789, Height: 451, Width: 327

Type Horizon: Sh.S.No.7

Remarks: the present species agrees in its characteristics with *Krithe langhiana* Oertli 1961 from Italy, but the present species has slightly a wider anterior.

Family : Hemicytheridae (Puri, 1953)
 Genus : *Hornibrookella* (Moos, 1965)
 Type species : *Cythere anna* (Lienenklaus, 1894)

Hornibrookella speijeri (Morsi & Scheibner, 2009)

(Pl.2, Fig. 1)

2009 *Hornibrookella speijeri* nov. sp. : Morsi, and Scheibner, pp. 163, pl. 3, figs. 6-8.

Figured specimen: Sh.Fm.Du.37

Materials: One carapace.

Dimensions (µm): Length: 623, Height: 404

Type Horizon: Sh.S.No.4

Remarks: the present species is matched the Egyptian *Hornibrookella speijeri* from Paleocene – Eocene of the Eastern Desert.

Hornibrookella nudosa sp. nov.

(Pl.2, Figs. 2a-c)

Derivation of the name: after the scattered nodules on the outer surface.

Diagnosis: a medium sized species of *Hornibrookella* that have many nodules at the outer surface of the carapace.

Holotype: One carapace (Sh.Fm.Du.38)

Paratype: Two carapaces (Sh.Fm.Du.39) and (Sh.Fm.Du.40)

Type Locality: Dukan area.

Type Horizon: Shiranish Formation, Sh.S.No.7

Materials: Four carapaces.

Dimensions (µm): Length: 723, Height: 450, Width: 391

Description: Carapace is sub quadrate in the lateral view, longest length passes slightly beneath the center; longest height passes through the anterior cardinal angle. Anterior is wide, rounded, thick edged, and slightly arched near the anterodorsal angle; and it has small marginal denticulations in the lower part. Posterior is narrow, sub rounded and has few marginal denticulations in the ventral part. Dorsal margin is straight and merges with the anterior and posterior by a rounded angle. Ventral margin is sinuous due to the swelling above it, merging gradually with the anterior and the posterior. Both of the eye tubercle and the sub central tubercle are clearly present. Presence of longitudinal swelling is above the ventral margin, started in front of the middle and ends near the posteroventral angle. The outer surface is ornamented by fine reticulations, with presence of many small nodules separated all over the carapace. The carapace is well calcified; the left valve is bigger than the right; the overlapping somewhat occurs at the ventral margin.

Affinities: *Hornibrookella nudosa* differs from *Hornibrookella speijeri* Morsi & Scheibner (2009) and the other species of *Hornibrookella* in the distinctive outline and surface ornamentation, which is characterized by fine reticulations and small sized nodules.

Family : Trachyleberididae Sylvester & Bradley (1947)
 Genus : *Acanthocythereis* Howe (1963)
 Type species: *Acanthocythereis araneosa* Howe (1963)

Acanthocythereis sinjarensis (Khalaf and Yousif, 2008)

(Pl.2, Figs. 3a,b)

2008 *Acanthocythereis sinjarensis* Khalaf S. K. and Yousif, M. S., pl.1 figs. 1,2.

Figured specimen: Sh.Fm.Du.41, Sh.Fm.Du.42

Materials: three carapaces.

Dimensions (μm): Length: 861, Height: 386, Width: 286

Type Horizon: Sh.S.No.4

Remarks: The species has exactly the same description of the species that described by Khalaf and Yousif (2008) in northern Iraq.

Acanthocythereis posterotriangulata (Morsi and Scheibner, 2009)

(Pl.2, Figs. 4a-d)

1990. *Oertliella?* sp. Bassiouni & Luger, p. 831, pl. 18, figs 6-10.

1995. *Oertliella?* cf. *frescoensis* (Apostolescu), Honigstein & Rosenfeld, p. 58, pl. 3, fig. 8.

1999. *Oertliella posterotriangulata* Morsi, p. 41, pl. 3, figs 1-5.

2009. *Acanthocythereis posterotriangulata* Morsi and Scheibner, pl4, fig. 6.

Figured specimen: Sh.Fm.Du.43, Sh.Fm.Du.44, Sh.Fm.Du.45, Sh.Fm.Du.46

Materials: Three carapaces.

Dimensions (μm):

	Length	Height
Male	714	387
Female	657	410

Type Horizon: Sh.S.No.9

Remarks: The present species is firstly recorded as *Oertliella?* sp. by Bassiouni & Luger (1990), but according to the outline similarity, Morsi and Scheibner (2009) assigned this species to the genus *Acanthocythereis*, taking into account this transfer remains questionable until it is based on internal features.

Genus *Aegyptoleberis* (Boukhary et al., 2013)

Type species: *Cythereis coronata* (Esler, 1968)

Aegyptoleberis sp.1

(Pl.2, Figs. 5a-c)

Figured specimen: Sh.Fm.Du.47, Sh.Fm.Du.48, Sh.Fm.Du.49

Materials: Four carapaces.

Dimensions (μm): Length: 623, Height: 396, Width: 315

Type Horizon: Sh.S.No.4

Description: Carapace is sub quadrate in the lateral view; maximum length sites at the middle, maximum height passes at the anterior cardinal angle. Anterior is widely rounded having a thickened margin and decorated with fine marginal denticulations. The posterior is sub triangular looking like a wedge. Dorsal margin is sinuous and merges steeply with the posterior, while it merges with the anterior by sub rounded cardinal angle. Ventral margin is straight and merges steeply with the both ends. Eye tubercle is rounded and moderately prominent, and the sub central tubercle is slightly prominent. The ornamentation of the outer surface is represented by fine reticulations and somehow a numbers of small nodules near the dorsal margin. The left valve is bigger than the right, and the overlapping is present at the posterior.

Remarks: the genus *Aegyptoleberis* was firstly established by Bukhary et al. (2013) from the Maastrichtian of Egypt; the present species is closely related to the previously described genera of this genus but however differs in its significant characteristics. It left for open nomenclature due to the lack of materials.

Genus *Cristaeleberis* (Bassiouni, 1970)

Type species: *Cristaeleberis reticulate* (Bassiouni, 1970)

Cristaeleberis fornicata (Bassiouni, 1970)

(Pl.2, Figs. 6a,b)

1970. *Cristaeleberis fornicata* n. sp.- Bassiouni, P. 29, Pl. 3, Figs. 9-10.

Figured specimen: Sh.Fm.Du.50, Sh.Fm.Du.51

Materials: Six carapaces.

Dimensions (μm): Length: 747, Height: 487, Width: 357

Type Horizon: Sh.S.No.4

Remarks: the present species has the same description of the Egypt species *Cristaeleberis fornicata* but the Iraqi species is slightly wider anteriorly.

Genus : *Phacorhabdotus* (Alexander, 1933)

Type species : *Phacorhabdotus texanus* (Howe and Laurencich, 1958)

Phacorhabdotus inaequicostatus Colin and Donze (in Donze et al., 1982)

(Pl.2, Figs. 7a-c)

1982. *Phacorhabdotus inaequicostatus* nov. sp. Colin and Donze–Donze et al., p. 296, Pl. 13, Fig. 11.

Figured specimen: Sh.Fm.Du.52, Sh.Fm.Du.53, Sh.Fm.Du.54

Materials: Three carapaces.

Dimensions (μm): Length: 774, Height: 520, Width: 338

Type Horizon: Sh.S.No.2

Remarks: the present species is totally compatible with the Tunisian species.

Genus: *Occultocythereis* (Howe, 1951)

Type species: *Occultocythereis delumbata* (Howe, 1951)

Occultocythereis peristicta (Siddiqui, 1971)

(Pl.2, Fig. 8)

1971 *Occultocythereis peristicta* Siddiqui, pp. 50-53, pl. 25, figs. 13-17; pl. 26, figs. 1-15; pl. 27, figs. 1-2.

Figured specimen: Sh.Fm.Du.55

Materials: Two carapaces.

Dimensions (μm): Length: 861, Height: 502

Type Horizon: Sh.S.No.2

Remarks: the present species is very related to the Pakistani species *Occultocythereis peristicta* in the outline but the Iraqi species has a less height.

Genus: *Oertliella* (Pokorney, 1964)

Type species: *Cythere reticulate* (Kafka, 1886)

Oertliella donzei (Weaver, 1982)

(Pl.2, Figs. 9a-c)

1982 *Oertliella donzei* Weaver: 74, Pl. 15, figs 6-1 1, text fig. 14

Figured specimen: Sh.Fm.Du.56, Sh.Fm.Du.57, Sh.Fm.Du.58

Materials: one carapace.

Dimensions (μm): Length: 618, Height: 397, Width: 283

Type Horizon: Sh.S.No.4

Remarks: This species was recorded from the Early and Middle Cenomanian of England (Weaver, 1982); is very similar to the Iraqi species.

Genus: *Rahacythereis* (Grundel, 1973)

Type species: *Cythereis leurmannae* (Triebel, 1940)

Rehacythereis libanensis (Bischoff, 1963)

(Pl.2, Fig. 10)

1963 *Cythereis libanensis* n. sp. – Bischoff, p. 33, pl. 13, fig. 95-102.

1991 *Rehacythereis libanensis* (Bischoff, 1963); (Szczechura, 1991) Abd-Elshafy and Babinot, pl.8, figs. 4-8.

Figured specimen: Sh.Fm.Du.59

Materials: Three carapaces.

Dimensions (µm): Length: 596, Height: 421

Type Horizon: Sh.S.No.4

Remarks: the present species resembles totally the Lebanon species *Rehacythereis libanensis* but slightly differs in length and height ratio.

Family : *Loxoconchidae* (Sars, 1926)

Genus : *Loxoconcha* (Sars, 1866)

Type species : *Cythere impressa* (Baird, 1850)

Loxoconcha sp.1

(Pl.2, Figs. 11a-b)

Figured specimen: Sh.Fm.Du.60, Sh.Fm.Du.61, Sh.Fm.Du.62

Materials: Two carapaces.

Dimensions (µm): Length: 595, Height: 431, Width: 303

Type Horizon: Sh.S.No.7

Description: Carapace is sub ovate in the lateral view; maximum length passes through the middle, and the maximum height locates at the anterior cardinal angle. Anterior is broadly rounded, while the posterior is narrow, sited at the dorsal half of the carapace. Dorsal margin is sub sinuous converging with the anterior by rounded angle, merges steeply with the posterior. Ventral margin is sub straight and gradually linked to the anterior and posterior. The eye tubercle is present and slightly prominent. The outer surface is covered with fine pores or may be very fine reticulations. The posterior half of the carapace is more swollen than the anterior half in the dorsal view. The left valve is bigger than the right; the overlapping presence is near the posterodorsal angle.

Remarks: *Loxoconcha* sp.1 is very similar to *L. hamrinensis* (Khalaf, 1998) from Miocene of northern Iraq, but it has a wider anterior. The present species left sp.1 due to the lack of the materials.

Family : *Xestoleberididae* (Sars, 1928)

Genus: *Xestoleberis* (Sars, 1866)

Type species: *Cythere aurantia* (Baird, 1838)

Xestoleberis sp.1

(Pl.2, Figs. 12a-c)

Figured specimen: Sh.Fm.Du.63, Sh.Fm.Du.64, Sh.Fm.Du.65

Materials: Six carapaces.

Dimensions (µm): Length: 616, Height: 385, Width: 328

Type Horizon: Sh.S.No.35

Description: Carapace is sub ovate in the lateral view; bigger length locates beneath the center, and longest height locates behind the center. The anterior is relatively narrow and rounded; the posterior is rounded and slightly narrower than the anterior. Dorsal margin is moderately convex, and merges steeply with the anterior and posterior. The ventral margin is sub straight and also merges steeply with the anterior and posterior. The outer surface is smooth having small normal pores. The left valve is bigger than the right; the overlapping is clear at the dorsal margin.

Remarks: *Xestoleberis* sp.1 has significant properties differring from other *Xestoleberis* genera; therefore, it (may be) a new species described as sp. due to the lack of good specimens.

Genus: *Uroleberis* (Sars,1928)
Type species: *Eocytheropteron parnensis* (Apostolescu,1955)

Uroleberis sp.1
(Pl.2, Figs. 13a-c)

Figured specimen: Sh.Fm.Du.66, Sh.Fm.Du.67, Sh.Fm.Du.68

Materials: Three carapaces.

Dimensions (μm): Length: 729, Height: 614, Width: 513

Type Horizon: Sh.S.No.31

Description: The carapace is sub spheroid in both lateral and dorsal views; maximum length passes beneath the center, and the biggest height locates behind the center. The anterior is narrowly rounded and sited downward. The posterior is perfectly rounded, and very wide related to the carapace. Convex dorsal margin has been seen, while ventral margin is straight, but both merge steeply with the anterior and posterior. The carapace is moderately calcified; the left valve is bigger than the right; the overlapping is present somewhat at the dorsal margin. The outer surface is covered with normal pores.

Remarks: The present species is left under open nomenclature due to the lack of the specimens.

Uroleberis sp.2
(Pl.2, Figs. 14a-c)

Figured specimen: Sh.Fm.Du.69, Sh.Fm.Du.70, Sh.Fm.Du.71

Materials: One carapace.

Dimensions (μm): Length: 759, Height: 435, Width: 345

Type Horizon: Sh.S.No.4

Description: Carapace is sub ovate in the lateral view; longest length and height locate at the center. The anterior is narrow relative to the posterior, rounded and sited at the ventral half of the carapace. The posterior is wide and nearly sub truncated. Dorsal margin is curved merging steeply with the anterior but it merges with the posterior by a rounded angle. Ventral margin is straight merging with the anterior and posterior by a wide angle. The left valve is bigger than the right; the overlapping is present at the dorsal margin. The outer surface is covered by normal pores.

Remarks: *Uroleberis* sp.2 is left under open nomenclature because of the lack of the materials.

Family : Cytheruridae (Müller, 1894)
Genus: *Cytheropteron* (Sars, 1966)
Type species: *Cythere latissima* (Norman,1865)
Cytheropteron cf. *C. rameshi* (Singh and Misra, 1968)

(Pl.2, Fig. 15)

1968 *Cytherura rameshi* Singh and Misra, pp. 31-32, pl. 8, figs. 4-6.

1972 *Semicytherura rameshi* (Singh and Misra, 1968). Khosla, p. 495, pl. 3, fig. 11.

1988 *Cytheropteron rameshi* (Singh and Misra, 1968). Khosla and Pant, p. 331.

Figured specimen: Sh.Fm.Du.72

Materials: One carapace.

Dimensions (µm): Length: 1089, Height: 644

Type Horizon: Sh.S.No.7

Remarks: the present species has the same diagnostics of the Indian species *Cytheropteron rameshi* but some how the Iraqi species has less appeared reticulat ornamentation.

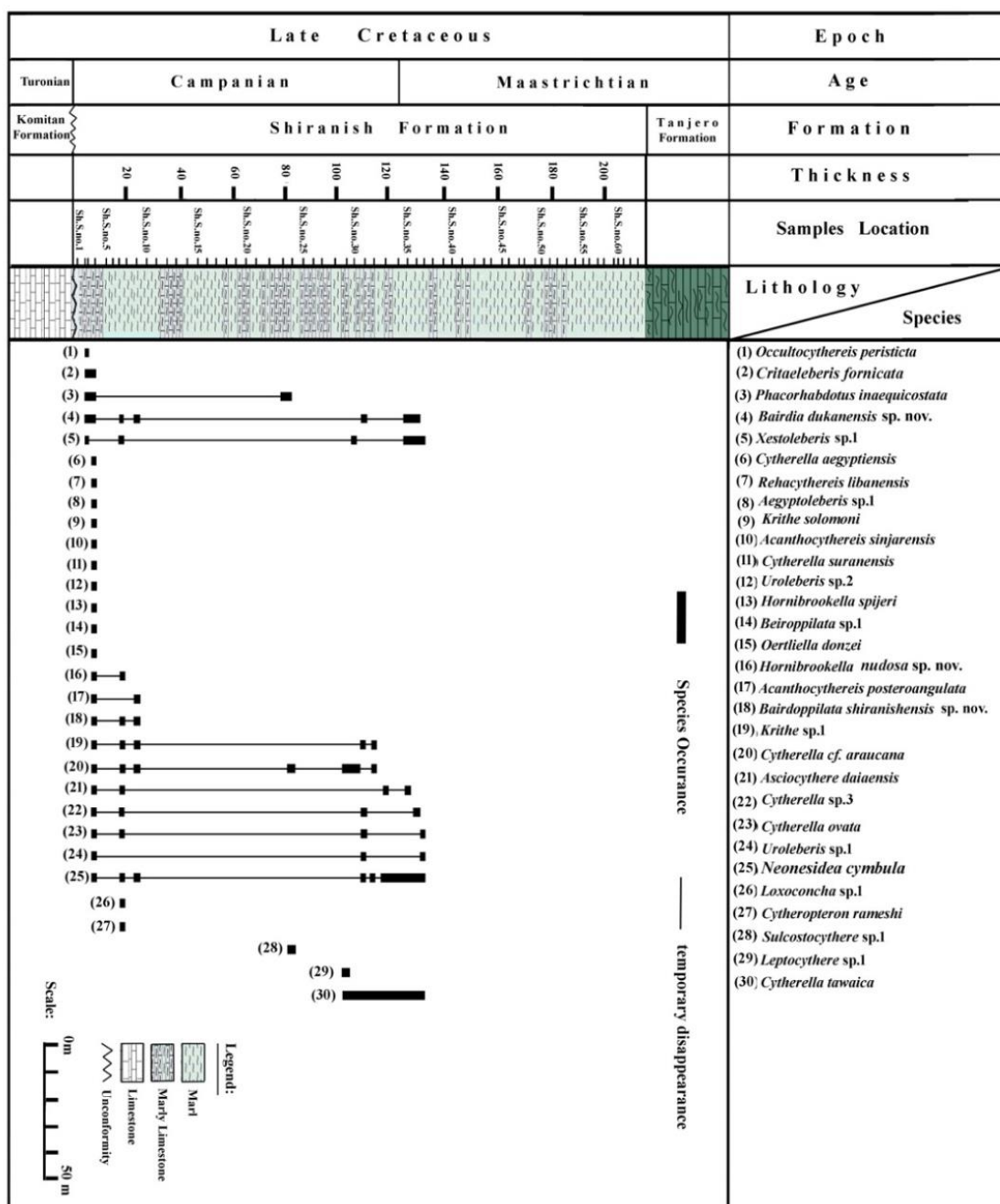


Fig.3. Distribution of the obtained ostracods in the studied section

Explanation of plate 1:

(1) *Cytherella* cf. *C. ovata* (Roemer, 1840), lateral view of the L.V., (2) *Cytherella tawaica* Sing and Tewari (1966), a. lateral view of the R.V., b. lateral view of the L.V., (3) *Cytherella aegyptiensis* (Colin & El-Dakkak, 1975), a. lateral view of the R.V., b. dorsal view, (4) *Cytherella suranensis* (Aziz, 2018), lateral view of the L.V., (5) *Cytherella* cf. *C. araucana* (Bertels, 1974), a. lateral view of the L.V.,

b. dorsal view, c. lateral view of the R.V., (6) *Cytherella* sp.3 (Andreu et.al., 2008), a. lateral view of the L.V., b. dorsal view. (7) *Sulcostocythere* sp.1, a. lateral view of the R.V., b. dorsal view, c. lateral view of the L.V., (8) *Leptocythere* sp.1, a. lateral view of the R.V., b. dorsal view, c. lateral view of the L.V., (9) *Bairdia dukanensis* sp. nov., a holotype lateral view of the R.V., b. Paratype lateral view of the L.V., c. Paratype dorsal view. (10) *Neonesidea cymbula* (Deltel, 1964), a. lateral view of the R.V., b. lateral view of the L.V., c. dorsal view. (11) *Bairdoppilata shiranishensis* sp. nov. a holotype lateral view of the R.V., b. Paratype lateral view of the L.V., c. Paratype dorsal view. (12) *Bairdoppilata* sp.1, a. lateral view of the R.V., b. lateral view of the L.V., c. dorsal view. (13) *Asciocythere daiaensis* Damotte.1984, a. lateral view of the R.V., b. lateral view of the L.V., c. dorsal view. (14) *Krithe* cf. *K. solomoni* (Honigstein, 1984), lateral view of the R.V., (15) *Krithe* cf. *K. langhiana* (Oertli 1961), a. lateral view of the R.V., b. lateral view of the L.V., c. dorsal view.

Explanation of plate 2:

(1) *Hornibrookella speijeri* (Morsi & Scheibner, 2009), lateral view of the L.V., (2) *Hornibrookella nudosa* sp. nov. a. holotype, lateral view of the R.V., b. paratype, lateral view of the L.V., c. paratype, dorsal view. (3) *Acanthocythereis sinjarensis* (Khalaf and Yousif, 2008), a. lateral view of the L.V., b. dorsal view. (4) *Acanthocythereis posterotriangulata* (Morsi, 1999), a, male, lateral view of the R.V., b. male, , lateral view of the R.V., c. female, lateral view of the R.V., d. , lateral view of the L.V., (5) *Aegyptoleberis* sp.1, a. lateral view of the R.V., b. lateral view of the L.V., c. dorsal view, (6) *Cristaeleberis fornicata* (Bassiouni, 1970), a. lateral view of the R.V., b. lateral view of the L.V., (7) *Phacorhabdotus inaequicostatus* (Colin and Donze, 1982), a. lateral view of the R.V., b. lateral view of the L.V., c. dorsal view, (8) *Occultocythereis peristicta* (Siddiqui, 1971), lateral view of the R.V., (9) *Oertliella donzei* (Weaver, 1982), a. lateral view of the R.V., b. lateral view of the L.V., c. dorsal view, (10) *Rehacythereis libanensis* (Bischoff, 1963), lateral view of the R.V., (11) *Loxoconcha* sp.1, a. lateral view of the R.V., b. lateral view of the L.V., c. dorsal view, (12) *Xestoleberis* sp.1, a. lateral view of the R.V., b. lateral view of the L.V., c. dorsal view, (13) *Uroleberis* sp.1, a. lateral view of the R.V., b. lateral view of the L.V., c. dorsal view, (14) *Uroleberis* sp.2, a. lateral view of the R.V., b. lateral view of the L.V., c. dorsal view, (15) *Cytheropteron* cf. *C. rameshi* (Singh and Misra, 1968), lateral view of the R.V.

L.V. = Left Valve

R.V. = Right Valve



Plate 1



Plate 2

4. Conclusions

The present study is based on sixty three rock samples of the Shiranis Formation (218 m) in Dukan area, Kurdistan province. It systematically dealt with the microfounas (Ostracode) and yielded thirty species belonging to twenty one genera, whose distribution refers to the Late Campanian–Early Maastrichtian. The inferred environmental deposition fluctuates between middle-outer shelf and

upper-middle bathyal showing increasing of the water depth upwards with worm water conditions, in which these fauna shows good affinities with Southern Tethyan Margin (North Africa and Middle East). The present study deals with nineteen species in which previously described, and eleven new described species including three new named species *Bairdia dukanensis* sp. nov. , *Bairdoppilata shiranishensis* sp. nov. and *Hornibrookella nudosa* sp. nov.

The good diversity of the obtained ostracodes and the decreasing of numbers of the individual indicate that the lack of the suitable environmental conditions for living ostracodes in the study area. On the other hand, the alternative change in the layer's lithology and thickness indicates rapid changes in the sedimentary environment. This gives the reason of why the numbers of the individual are too low to be counted as abundant.

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References

- Andreu, B., Colin, J. P., and Singh, J., 2008. Cretaceous (Albian to Coniacian) Ostracodes from the subsurface of the Jaisalmer Basin, Rajasthan, India, *Micropaleontology*, 53 (5), 245-370.
- Aziz, N. M., 2018. Some Ostracoda Species of Tanjero Formation (Late Campanian-Maastrichtian) of Diana Area, NE Iraq. *Iraqi National Journal of Earth Sciences*, 18(1), 27-40.
- Bassiouni, M.A.A., 1970. Ostracoda (Mauritsininae und Trachyleberidinae) und ihre Bedeutung die Biostratigraphie des Maastrichts und Alttertiars von Jordanien. *Beih. Geol. Jb.* 106, 5,52.
- Bassiouni, M.A.A., Luger, P., 1990. Maastrichtian to Early Eocene Ostracoda from southern Egypt. *Palaeontology, palaeoecology, palaeobiogeography and biostratigraphy*. *Berliner Geowiss. Abh. A* 120, 755-928.
- Benson, R. H. and Maddocks, 1964. Recent Ostracodes of Kansas estuary, cape, provens, Union of South Africa , *Univ. of Kansas Paleon. Contr. (Arthropoda) Art*, 5, 1-39 .
- Bertels, A., 1974. Upper Cretaceous (lower Maastrichtian?) ostracodes from Argentina. *Micropaleontology*, 20 (4), 385–397.
- Bischoff, G., 1963. Ostracoden-Studien im Libanon. 1. Die Gattung Cythereis in der Unterkreide. *Senckenb. Leth.* 44, 1,77.
- Boukhary, M., Bassiouni, M.E.A., Issawi, B., Sharabi, S. and Mansour, H., 2013. Maastrichtian–Early Paleogene Ostracoda from the Kharga Oasis and the Nile Valley, Egypt. *micropaleontology*, 223-248.
- Crasquin, S., Forel, M.B., Qinglai, F., Aihua, Y., Baudin, F. and Collin, P.Y., 2010. Ostracods (Crustacea) through the Permian-Triassic boundary in South China: the Meishan stratotype (Zhejiang Province). *Journal of Systematic Palaeontology*, 8(3), 331-370.
- Colin, J.P., El Dakkak, N.W., 1975. Quelques ostracodes du Cenomanien du Djebel Nezzazat, Sinai, Egypte. *Rev. Esp. Micropaleontol. (No. Extraord.)* 1975, 49-60.
- Damotte, R., 1984. Ostracodes barremiens- cenomaniens en Algerie occidentale (coupe du Djebel Cheguiga, Monts deDaia, Oranie). *Ge.ol. Me.dit.* 11, 155-172.
- Deltel, M. B., 1964. Nouveaux ostracodes de L'Eocene et de l'Oligocene de l'Aquitaine Meridionale. *Acres de la SociitP Lineenne de Bordeaux*, 100 127-221.
- Donze, P., Colin, J.P., Damotte, R., Oertli, H.J., Peypouquet, J.P. & Said, R., 1982. Les ostracodes du Campanien terminal h l'Eocene terminalde lacoupe d'Kef, Tunisie Nord occidentale. *Bull. Cent. Rech. Pau*, 6 (2), 272-335, 1-13.
- Esker, G.L., 1968. Danian Ostracodes from Tunisia. *Micropaleontology* 14, 319, 333.
- Gründel, J., 1973. Zur Entwicklung der Trachyleberididae (Ostracoda) in der Unterkreide und in der tieferen Oberkreide. Teil 1 Taxonomie. *Zeitschrift für Geologischen Wissenschaft* 1 (11), 1463–1474.

- Hanai, T., 1957. Studies on the Ostracoda from Japan, Subfamily Leptocytherininae. n. subfam., Jour. Fac. Sci. Univ. Tokyo Sec.11, x , 431-468 , 3.
- Hartman, G., 1962. Abh. Verh. Naturw. Ver. Hamburg, 7, 137-143.
- Hartmann, G., and Puri, H. S., 1974. Summary of Neontological and Paleontological classification of Ostracoda, Mitt Hammdurg, Zool. Mus. Inst.,Band. 70, 7-37 , Hambury .
- Honigstein, A., 1984. Senonian Ostracodes from Israel. Bull. Geol. Surv. Isr. 78, 148.
- Honigstein, A. and Rosenfeld, A., 1995. Paleocene Ostracods from Southern Israel. Revue de Micropaléontology, 38, 1, 49 - 62.
- Howe, H.V. 1951. New Paleogene ostracode fauna from Levy ountry, Florida. Bulletin Florida Geological Survey, Tallahassee, 34, 1-43.
- Jassim, S. Z. and Goff, J. C., 2006. Geology of Iraq , Published by Dolin, Prague and Moravian Museum, Brno, 179-181 .
- Khalaf, S.K., 1998. The Ostracode family loxoconchidae from the Middle Miocene of Northern Iraq. Iraqi Geological Journal, 31(1), 83-89.
- Khalaf, S.K. and Aziz, N.M., 1994. The ostracoda genus Bairdla from the Tertiary of west and north west Iraq. Journal Education Science, 23, 235-245.
- Khalaf, S.K. and Yousif, M.S., 2008. On some Ostracode species of the Family Trachyleberididae from Tertiary of NW. Iraq. *Tikrit Journal of Pure Science*, 13(3).
- Khosla, S.C., 1972. Ostracoda from the Eocene beds of Rajasthan .India, Micropal, 18 (4), 476-507.
- Khosla, S. C. and Pant, P. C., 1988. Ostracoda from the Eocene and Oligocene beds of Kachchh, Gujarat, Part I - Families Cytherellidae, Bairdiidae and Trachyleberididae. Indian Journal of Earth Sciences, 15(4), 325-346.
- Malak, Z. A., 2015. Sequence stratigraphy of Shiranish Formation in Dokan area, Northern Iraq. Arabian Journal Geoscience, 8, 9489–9499.
- Maddocks, R.F., 1969. Revision of Recent Bairdiidae (Ostracoda). Bulletin of the United States National Museum.
- Moos, B., 1965. Die Ostracoden-Fauna des Unteroligocenans von bun (Bi. Herford-West,3817) und einige., verwandte jungere Arten (Ostr. Crust.) 1. Geol, 82, 593-630.
- Moore, R.C. And Pitrat, G. W., 1961. Treatise on invertebrate. Paleontology, Part Q Arthropoda 3 Crustacea Ostracoda . Geol. Soc. of America and University of Kansas press, Lawrance Kansas, 442 .
- Morkhoven, F. P., Van, C. M., 1963. Post Paleozoic Ostracoda. Their Morphology, Taxonomy and Economic Use . Amsterdam, Elsevier Public, Com. 2: 478. General Description.
- Morsi, A. M., 1999. Paleocene to Early Eocene ostracodes from the area of east central Sinai, Egypt. Revue de Paléobiologie, Genève, 18 (1), 31-55.
- Morsi, A. M. M. and Scheibner, C., 2009. Paleocene–Early Eocene ostracodes from the Southern Galala Plateau (Eastern Desert, Egypt): Taxonomy, impact of paleobathymetric changes, Revue de micropaléontologie 52, 149–192.
- Oertli, H. J., 1961. Ostracodes du Langhian Type Riv. Italy, Paleont. Strat. 67(1),17-44.
- Oertli, H.J., Grosdidier, E., 1961. Ostracodes des quelques sondages du Lias du Bassin de Paris. MeÂm. Bur. Rech. geÂol. Min. 4, 459-461.
- Pokorny, V., 1964. Oertliella and Spinicythereis, new otracode genera from the Upper Cretaceous. Vestnik Ustredniho Ustavu Geologickeho, 39 (4), 283–284.
- Puri, H. S., 1953. Contribution to the study of the Miocene of the Florida Panhandle, Bull. Fla. St. Geol. Surv.,215-309, Pl. 5, 1-17, Figs. 1-13 .
- Rosenfeld, A., and Raab, M., 1974. Cenomanian-Turonian ostracods from the Judea Group in Israel. Bulletin of the Geological Survey of Israel, 62, 1-64.
- Siddiqui, Q.A., 1971. Early Tertiary Ostracoda of the family Trachyleberididae from West Pakistan. Bull. Br. Mus. Nat. hist. (Geol.), Supple. 9, 98., 42.
- Singh, S. N., and Misra, P. C., 1968. New genus and species of ostracodes from Fuller's Earth, Kolayatji, Bikaner, Rajasthan, India. Pal. Soc. India Journal, 11 (26-37), 7-11.
- Swain, F.M., 1952. Ostracoda from wells in North Carolina: Part 2 - Mesozoic Ostracoda. U.S. Geological Survey Professional Paper No. 234B, 1-75.

- Sylvester-Bradley, P. C., 1947. Some ostracod genotypes. *Annals and Magazine of Natural History, Series 11*, 13 (23), 192–199.
- Szczuchura, J., Abd-Elshafy, E. & Babinot, J.-F., 1991. Late Albian to Early/Mid-Cenomanian Ostracods from Northern Galala Plateau, Egypt, *Acta Palaeontol. Polon*, 36/1, 3–38.
- Taha, Z.A., 2020. Late Cretaceous Ostracoda in the Shiranish Formation Dokan Area, Kurdistan Region-NE Iraq., *JZS– 1 (Part-A)*, 77-87.
- Tewari, B. S., and Singh, P., 1966. Ostracoda from the Nummulitic beds of Kalakot, Jammu and Kashmir State. *Panjab Univ., Centre Advanced Study Geol., Publ.*, 3, 117-1 30, pls. 1-3.
- Tewari, B. S., and Tandon, K. K., 1960. Kutch microfauna- Lower Tertiary Ostracoda. *India, Nat. Inst. Sci., Proc.*, ser. B, 26, 4, 148-167, text-figs. 1-6.
- Weaver P.P.E., 1982. Ostracoda from the British Chalk and Plenus Marls.- *Palaeontographical Society (Monographs)*, London, 562, 127.
- Yamaguchi, T. and Norris, R.D., 2012. Deep-sea ostracode turnovers through the Paleocene–Eocene thermal maximum in DSDP Site 401, Bay of Biscay, North Atlantic. *Marine Micropaleontology*, 86, 32-44.