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Miocene decapod crustacean faunas from Cyprus – Part 1. Geographical-stratigraphical setting and Anomura

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ABSTRACT

Study of high-diversity Miocene decapod crustacean faunas has resulted in the recognition of several new species from a range of localities across Cyprus. Anomuran taxa collected comprise *Paguristes joecollinsi, Dardanus cyprioticus* sp. nov., *Dardanus plevrotos* sp. nov., *Galathea weinfurteri, Palmunidopsis muelleri, Petrolisthes haydni, Petrolisthes magnus* and *Petrolisthes mitseroensis* sp. nov. The presence of *Petrolisthes magnus* in upper Chattian–middle Burdigalian strata documents the oldest stratigraphical occurrence of that species to date. Anomuran taxa recognised in the lower Miocene are also present in upper Miocene reefal facies; the latter illustrate the highest anomuran diversity.

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INTRODUCTION

Miocene sedimentary basins on the island of Cyprus came into existence during a period of regional tectonic instability associated with the onset of uplift (Kinnaird, 2008). Reefal strata of Miocene age comprise the Terra Limestone Member (Aquitanian–Burdigalian) and the Koronia Limestone Member (Tortonian–early Messinian) of the Pakhna Formation. The reefs formed by colonisation of faulted blocks along the margins of subbasins (Follows et al., 1996). In Cyprus reefs of Middle Miocene (Langhian) age are absent, which is linked to drowning of earlier reefs, in response to a rapid sea level rise (Robertson et al., 1991). Depositional environments in the area during the Late Miocene were characterised by a progressive shallowing, from approximately 500 m depth to very shallow-water conditions (Krijgsman et al., 2002).

During the Miocene, conditions conducive to reef building prevailed across the Mediterranean, but coral diversity decreased from the Early to Late Miocene (Esteban, 1996). From several of these reefal deposits decapod crustaceans have been recorded in recent decades (e.g., Müller, 1984b, 1993; Georgiades-Dikeoulia and Müller, 1984; Garcia Socias, 1990; Gatt and De Angeli, 2010; De Angeli et al., 2011, Ossó and Hammann-Yelo, 2021). Interestingly, decapod crustacean faunas from such strata exhibit marked taxonomic similarities to those from the Central Paratethys (e.g., Müller, 1984a; Górka, 2002; Radwański et al., 2006; Ossó and Stalennuy, 2011; Collins, 2014; Hyžný and Dulai, 2021) and even those from the Pacific region (e.g., Müller, 1979, 1984a; De Angeli et al., 2011; Ossó and Gagnaison, 2019; Ossó et al., 2022).

Regional Geology and Stratigraphy

Sedimentary basins in the southern part of Cyprus formed during a period (early to Middle Miocene) of palaeogeographical reorganisation that was linked to the onset of the final phase of subduction in the easternmost Mediterranean (Follows et al., 1996). Three depositional centres developed to the south of the Troodos Massif (Figure 1), namely the Polemi, Pissouri and Maroni-Psematismenos basins. In these basins, patch reefs of Early and Late Miocene age are exposed. Reef growth followed early Cenozoic deep-water sedimentation and localised tectonic uplift (Kinnaird, 2008). The Miocene reefs were dominated by the coral genus *Porites* Link, 1807 and at first were largely domal in structure, but later occurred mainly as sheet-like encrustations (Follows, 1992). Reef growth finally came to halt as a result of the desiccation of the Mediterranean Sea during the Messinian, with the deposition of large evaporites (e.g., Krijgsman et al., 2002; Cannings et al., 2021).

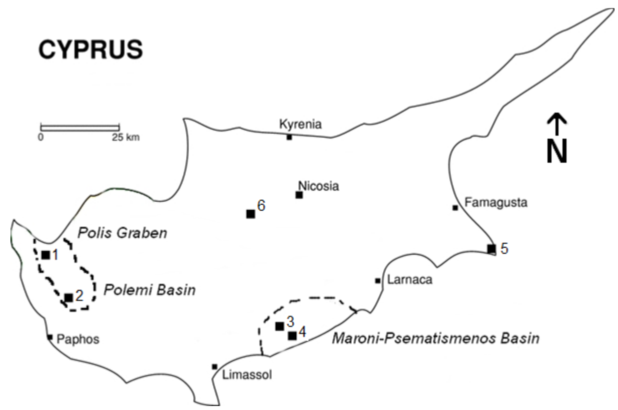

FIGURE 1. Miocene basins and localities yielding decapod crustaceans studied herein: 1 – Prodromi; 2 – Kamares; 3 – Tochni; 4 – Maroni; 5 – Cap Greco; 6 – Mitsero.

1. Pakhna Formation (late Chattian–early Messinian)

The Pakhna Formation (Figure 2) consists mainly of chalks, with some marls, limestones, gypsum lenses, calcareous sandstones and polymictic conglomerates interspersed (Morse, 1996). The reefal limestones of the Terra and Koronia members constitute prominent horizons, at or near the base and top of this formation (e.g., Follows and Robertson, 1990; Follows et al., 1996). The chalks in this unit have variable thicknesses (60-500 m) and are cream to buff-coloured, their composition, texture and faunal assemblage being indicative of deposition in an open-marine to hemipelagic environment (Gass et al., 1994). The alternating relative rise and fall of sea level, caused by regional uplift, during deposition may be responsible for the irregular cyclic sequence of chalk, marl and limestones (Gass et al., 1994).

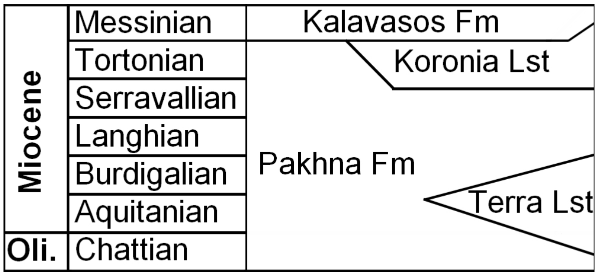

FIGURE 2. Stratigraphy of Miocene strata in Cyprus (based on Robertson et al., 1991; Morse, 1996; Cannings et al., 2021 and personal observations).

1A. Terra Limestone Member (Aquitanian–Burdigalian). This unit crops out both in the southwest (Morse, 1996) and the southeast of Cyprus (Greensmith, 1994; Follows et al., 1996). In the latter area (Cap Greco), the Terra Limestone Member is developed as a coral framestone, consisting of diverse species of occasionally very large corals (Follows et al. 1996). This diverse fauna and the presence of corals, often metre sized, suggest that deposition occurred under shallow-marine conditions with normal salinity (Follows and Robertson, 1990). Stratigraphically, this member is situated at or near the base of the Pakhna Formation. Follows and Robertson (1990) summarised earlier studies and dated this unit as Aquitanian to Burdigalian (calcareous nannofossil zones NN1–NN4), at least in south-east Cyprus. According to Robertson et al. (1991: 337, figure 3) the Terra Limestone Member ranges in age from the Chattian (Late Oligocene) to the middle Burdigalian (Early Miocene). Cannings et al. (2021) dated this member as Aquitanian-Burdigalian. In a road cutting at Prodromi-Drousaei and at a small quarry about 50 m to the west of that spot, a coral limestone that is like the one at Cap Greco is exposed, but coral colonies are considerably smaller (decimetre sized) and possibly represent remnants of a coral carpet or patch reef.

In the outcrop near the village of Kamares, about 100 m north-east of the tennis court, decapod crustaceans were collected from redeposited reefal detritus in between down-slope bioclastic turbidites. Fragments of coral patch reefs are interstratified by beds of gravity-deposited shallow-water carbonates; these are interpreted as storm-dominated mid-ramp deposits.

1B. Koronia Limestone Member (late Serravallian-early Messinian). This unit is seen as discontinuous outcrops along all margins of the Troodos Massif. Along the northern margin, poritid corals predominate, with less abundant benthic foraminifera than in the Terra Limestone Member in south-east Cyprus, indicating that deposition occurred in a more turbulent and shallow-marine setting (Follows and Robertson, 1990). Stratigraphically, this member constitutes the uppermost unit of the Pakhna Formation; it has been reported to overstep the Pakhna Formation chalks (Morse, 1996). Follows and Robertson (1990) summarised earlier data and inferred a Tortonian to early Messinian age for this member along the northern margin of the Troodos Massif. Morse (1996) dated the Koronia Member in south-west Cyprus as Tortonian on the basis of calcareous nannoplankton, while, on the basis of strontium isotopes, Cannings et al. (2021) favoured a late Serravallian to early Messinian date for the Koronia Member. At Maroni and Tochni (Figure 1), small patch reefs are preceded and surrounded by reefal debris, usually within a conglomeratic facies with pebbles of pelagic chalk and of crystalline, ophiolite-derived (Troodos) provenance. The decapod crustaceans are accompanied by remains of bivalves, coralline algae, bryozoans, echinoids, benthic foraminifera, serpulids, sponges and corals. There are far fewer corals than in the reefal limestones of the Terra Member, whereas decapod crustacean diversity is much higher in this unit. Voids within the reefal sediments are often filled with celestine and at Tochni, large-sized oysters are usually completely selenitised.

2. Kalavasos Formation (Messinian)

Outcrops of this unit comprise mostly evaporites and are located within synclinal structures, south-west of the Troodos Massif, for instance in the Polemi, Pissouri, Mesaoria and Psematismenos basins (Orszag-Sperber et at., 1989; Robertson et al., 1995). Krasheninnikov and Kaleda (1994) noted an evaporitic sequence of the Kalavasos Formation with three distinct members near the village of Pissouri, which is typical of other localities in Cyprus and the Mediterranean region as a whole. These members comprised a lower unit of marls and diatomites, with intercalated limestone beds, a middle unit of fine-grained, bedded to coarse crystalline gypsums, with a polygenetic breccia at the base and a gypsiferous breccia within the member, and an upper unit comprising intercalated conglomerates/breccias, limestone and marls, in lens-shaped layers of variable thickness. The Kalavasos Formation usually conformably overlies the Pakhna Formation and is associated with the salinity crisis in the Mediterranean region during the Messinian (e.g., Follows and Robertson, 1990). A prominent change in palaeoenvironmental conditions occurred, as has been demonstrated on the basis of a change from open-marine, deeper-water taxa to more restricted, shallower-water taxa amongst microfossils (Kouwenhoven et al., 2006).

Earlier Work and Localities

Heller (1863) was the first to record extant decapod crustaceans from Cyprus, listing six marine and one freshwater species. More than a century later, Lewinsohn and Holthuis (1986) increased the number of known extant Cypriotic taxa considerably, by recording 39 macrurans, 15 anomurans and 60 brachyurans. Until recently (Fraaije, 2014a; Wallaard et al., 2020), there were no records of fossil decapod crustaceans from Cyprus. During fieldwork in western and southern Cyprus, from 1995 onwards, several localities with decapod-rich Miocene reefal limestones have been discovered and studied.

Six localities were visited at irregular intervals between 1995 and 2021 (Figure 1). In 1995, one of us (PMM, deceased) discovered the rich localities of Cap Greco on the east coast and Prodromi, south-west of Polis, in the western part of Cyprus (Figure 1; localities 1 and 5). The other localities, Kamares (village), Maroni,Tochni and Mitsero (Figure 1; localities 2–4 and 6), were first recognised by the second author (RF), during fieldtrips from 1995 onwards.

This part of our study of decapod crustacean assemblages collected from the Pakhna Formation (Terra and Koronia limestone members) is devoted to the Anomura. All specimens are housed in the Oertijdmuseum at Boxtel (MAB), numbers with '.' followed by another number indicate the presence of more than one specimen on the same piece of matrix.

Locality 1. Prodromi, Prodromi-Drouseia road cutting (Polis Graben); exposed is the Terra Limestone Member. Anomurans collected: *Galathea weinfurteri* (MAB13488).

Locality 2. Village of Kamares, road cutting near tennis court (Polemi Basin); exposed is the Terra Limestone Member. Anomurans collected: *Galathea weinfurteri* (MAB10336).

Locality 3. Tochni (Tochni hill, Maroni-Psematismenos Basin); exposed is the Koronia Member. Material was collected about 100 m north-west of the local quarry of Tochni. Anomurans collected: *Galathea weinfurteri* (MAB6669.1, 10868–10870.1, 10871.1, 10872, 10873, 11851, 13498.2) and *Petrolisthes haydni* (MAB11856–11858).

Locality 4. Maroni (Maroni-Psematismenos Basin); exposed is the Koronia Member. Material was recovered from an outcrop along an unhardened road a few hundred metres north-west of the village of Maroni. Around celestite mounds of bioclastic limestones rich in molluscs and serpulids, a diverse fauna of decapod crustaceans was collected during a field trip in 1999. Anomurans collected: *Galathea weinfurteri* (MAB9439, 9440, 9511.2, 9530.2, 9530.3, 11852, 11853) and *Palmunidopsis muelleri* (MAB839, 13686).

Locality 5. Cap Greco; exposed is the Terra Limestone Member. Anomurans collected: *Galathea weinfurteri* (MAB9687.2, 10335) and *Petrolisthes magnus* (MAB10343)

Locality 6. Mitsero; exposed is the Koronia Member. Material was collected to the west of Kreatos Hill, about one kilometre to the north-north-west of the village of Mitsero, in coral-reef talus of Koronia Member. Anomurans collected: *Paguristes joecollinsi* (MAB10456), *Dardanus cyprioticus* sp. nov. (MAB13511, 13512), *Dardanus plevrotos* sp. nov. (MAB13510), *Galathea weinfurteri* (MAB10864–10866, 10867.2, 10897.3, 10931.2, 10932, 13501, 13503-13507, 13508.3, 13509.2), *Petrolisthes magnus* (MAB879, 10905.1, 10906, 10908, 10909.1, 10913, 10914, 10915.1, 10934.2, 13530.3, 13530.4, 13532-13534.1, 13535.1, 13536.1, 13537.1, 13538-13540.1, 13541, 13542.1, 13543-13548, 13549.2, 13550.1, 13551-13554, 13587.1, 13823.1), *Petrolisthes haydni* (MAB10907, 10910-10912, 10916–10930.1, 10931.1, 10934.1, 11854, 11855, 11865.1, 13508.1, 13534.2, 13563, 13564.2, 13565.1, 13566-13568.1, 13569-13571.1, 13572-13574.2, 13575-13586.1, 13587.2, 13822.2, 13993.3, 13994, 13995) and *Petrolisthes mitseroensis* sp. nov. (MAB13531, MAB13996).

SYSTEMATIC PALAEONTOLOGY

Order Decapoda Latreille, 1802
Infraorder Anomura MacLeay, 1838
Superfamily Paguroidea Latreille, 1802
Family Annuntidiogenidae Fraaije, 2014b
Genus *Paguristes* Dana, 1851
Paguristes joecollinsi Wallaard, Fraaije, Jagt, Klompmaker and Van Bakel, 2020
Figure 3

2020 *Paguristes joecollinsi* Wallaard et al., page 38, figure 3.

Material. A single carapace (holotype), part and counterpart (MAB10456).

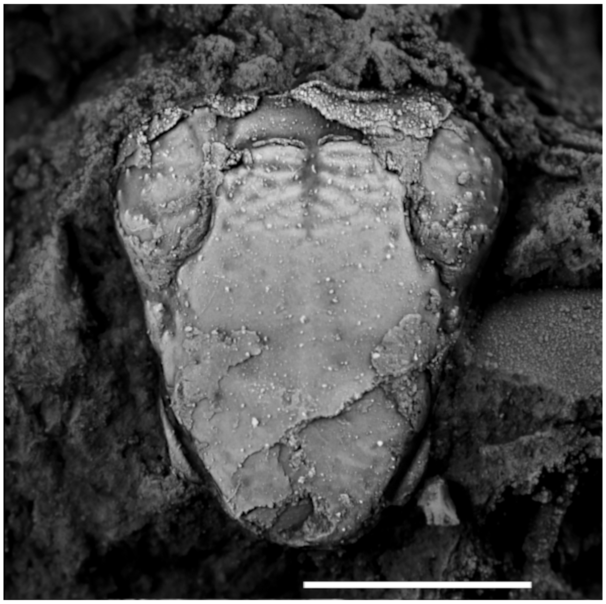

FIGURE 3. *Paguristes joecollinsi*, holotype (MAB10456). Scale bar is 2 mm.

Locality and stratigraphy. Mitsero; Koronia Member (Pakhna Formation, late Serravallian-early Messinian).

Description. Elongated, triangular carapace covered with grooves. The orbital area is broad, rimmed and shallow. The postrostral ridges are indented by a central gastric furrow, which extends posteriorly into a faint central line. Spinose and globose massetic region, posteriorly covered with spinose ridges. The carapace is decorated with a V-shaped cervical groove and large irregular pores.

Remarks. This small carapace, described in detail by Wallaard et al. (2020), constitutes the first, and sole, record of a paguroid shield from the Miocene of Cyprus.

Family Diogenidae Ortmann, 1892

Genus *Dardanus* Paul'son, 1875

Dardanus cyprioticus sp. nov.

Figure 4A, B

zoobank.org/7830BD18-EBE7-4380-930F-44A2FEE639CD

Material. A single, near-complete right chela, as part and counterpart in matrix (MAB13511) (holotype); a damaged fragment of a chela (MAB13512) is here considered conspecific.

Locality and stratigraphy. Mitsero; Koronia Member (Pakhna Formation, late Serravallian-early Messinian).

Etymology. The species is named after the island of Cyprus.

Description. Only the lateral surface of the right chela is visible in the matrix. Part of the proximal medial palm is missing. The lower edge of the chela is convex, rounded and covered with striae. The edges of the striae are steep on both sides. The striae on the proximal side are almost the same length and every second ridge is stronger. The striae become shorter near the fixed finger. The upper half of the fixed finger is covered with tubercles, which extend onto the beginning of the palm and cover the upper half of the palm. The

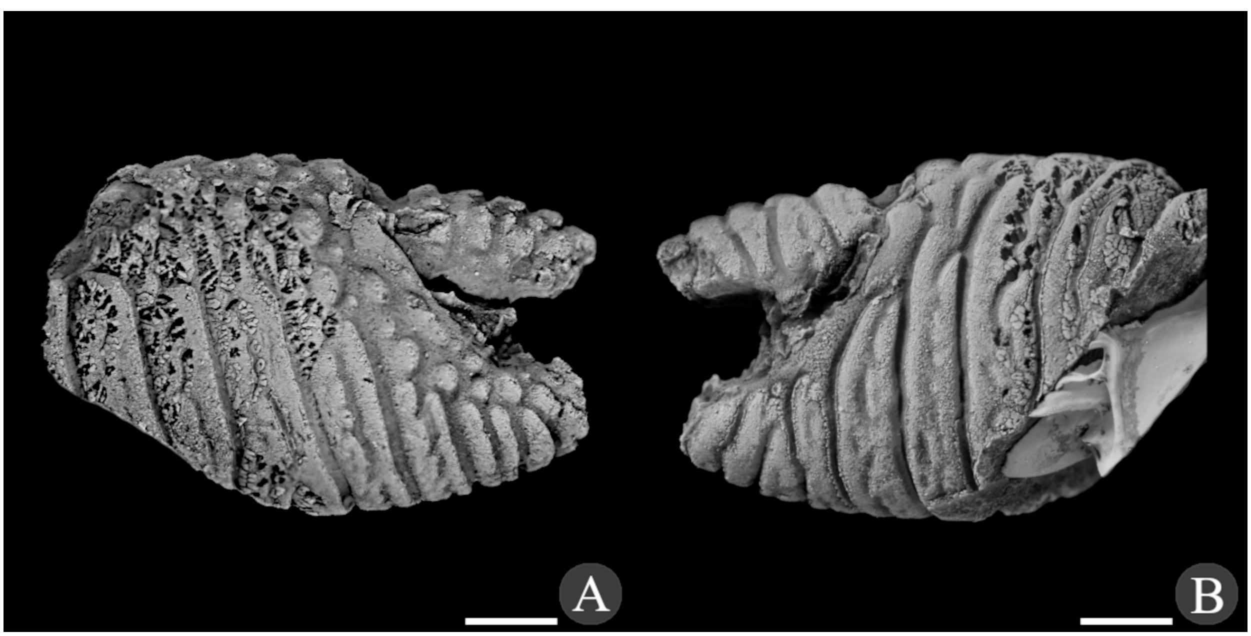

FIGURE 4. Right chela of *Dardanus cyprioticus* sp. nov., holotype (MAB13511). Scale bars are 2 mm.

moveable finger is completely covered with tubercles.

Remarks. *Dardanus cyprioticus* sp. nov. closely resembles *D. hungaricus* (Lőrenthey *in* Lőrenthey and Beurlen, 1929), but differs in the length of the striae, every other stria being deeper, and in the position of the tubercles on the upper half of the fixed finger.

Dardanus plevrotos sp. nov.
Figure 5A, B

zoobank.org/13ED9B8B-2AB3-482F-8719-5B40145901BA

Material. A single, partial right chela (MAB13510) (holotype).

Locality and stratigraphy. Mitsero; Koronia Member (Pakhna Formation, late Serravallian-early Messinian).

Etymology. Greek plevrotós (*πλευρωτός*), meaning ribbed, in allusion to the large grooves on the outer surface.

Description. Inner and outer surfaces are covered with large striae; upper edge is keeled and slightly convex, the lower edge rounded and straight. The striae are perpendicular to the longitudinal axis and are gently sinusoid. The medial striae have a steep edge at the proximal side, and a smooth edge on the distal side of edge groove. This is present, but less pronounced at the lateral side of the chela. The fixed finger is broken off.

Remarks. *Dardanus plevrotos* sp. nov. closely resembles *Ciliopagurus substriatiformis* (Lőrenthey *in* Lőrenthey and Beurlen, 1929) with the major differences found in the sinusoid shape of the striae in the latter, while the former has a rounded lower edge and the striae continue onto the distal side.

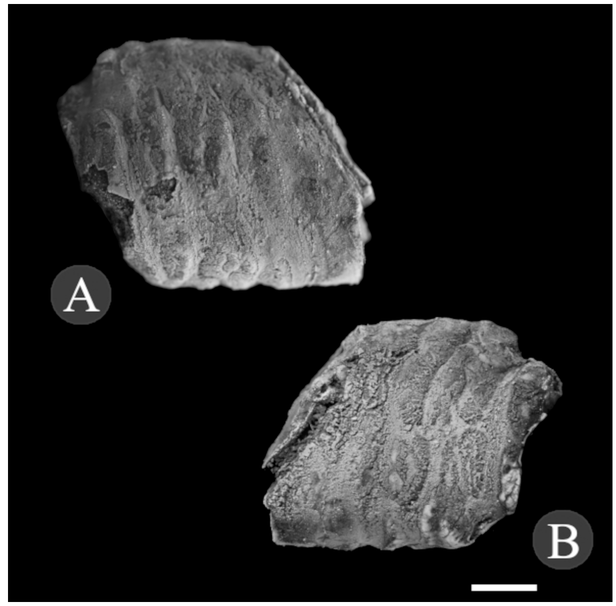

FIGURE 5. Fragment of chela of *Dardanus plevrotos* sp. nov., holotype (MAB13510). Scale bar is 2 mm.

Superfamily Galatheoidea Samouelle, 1819
Family Galatheidae Samouelle, 1819
Genus *Galathea* Fabricius, 1793
Galathea weinfurteri Bachmayer, 1950
Figure 6

1928 *Galathea* sp. Glaessner, page 164, 206, plate 3, figure 1

1950 *Galathea weinfurteri* Bachmayer – Bachmayer, page 135, plate 1, figure 2-4.

1953 *Galathea weinfurteri* Bachmayer – Bachmayer, page 242, 243 plate 5, figures 3, 4, 6.

1984a *Galathea weinfurteri* Bachmayer – Müller, page 60, plate 21, figures 4, 5, plate 22, figures 1-5.

1996 *Galathea weinfurteri* Bachmayer – Müller, page 8.

2002 *Galathea weinfurteri* Bachmayer – Górka, page 528.

2002 *Galathea* cfr. *G. weinfurteri* Bachmayer – De Angeli and Garassino, page 10, figure 7.

2006 *Galathea weinfurteri* Bachmayer – Radwański et al., page 96-97, plate 2, figure 1.

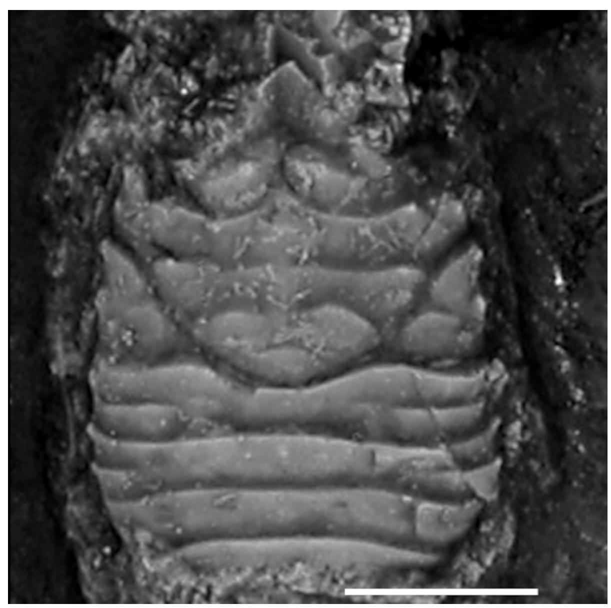

FIGURE 6. Carapace of *Galathea weinfurteri* (MAB11853). Scale bar is 2 mm.

2010 *Galathea weinfurteri* Bachmayer – Gatt and De Angeli, page 1326, plate 2, figure 4.

2010 *Galathea* sp. – Gatt and De Angeli, page 1326, text-figure 3, plate 2, figure 3.

2011 *Galathea weinfurteri* Bachmayer – Ossó and Stalennuy, figures 3.7, 3.13.

2014 *Galathea weinfurteri* Bachmayer – Collins, page 33, plate 1, figures 3, 4.

2014 *Galathea weinfurteri* Bachmayer – Hyžný et al., page 243-244, figures 1, 7A, plates 1-2.

2018 *Galathea weinfurteri* Bachmayer – Górka, page 515, text-figure 3.1.

2021 *Galathea weinfurteri* Bachmayer – Hyžný and Dulai, page 126, 128, figure 44.1-14

Material. 15 carapaces (MAB6669.1, 10868–10870.1, 10871.1, 10872, 10873, 11851, 13498.2) from Tochni; 12 carapaces (MAB9439, 9440, 9511.2, 9530.2, 9530.3, 11852, 11853) from Maroni; 1 carapace (MAB10336) from Kamares; 2 carapaces (MAB9687.2, 10335) from Cap Greco; 38 carapaces (MAB10864–10866, 10867.2, 10897.3, 10931.2, 10932, 13501, 13503-13507, 13508.3, 13509.2) from Mitsero, 1 carapace (MAB13488) from Podromi.

Locality and stratigraphy. Kamares, Podromi and Cap Greco; Terra Limestone Member (Pakhna Formation, Aquitanian-Burdigalian); Tochni, Maroni and Mitsero; Koronia Limestone Member (Pakhna Formation, late Serravallian-early Messinian).

Remarks. This common and widely distributed species has been recorded to date from Miocene levels in the Paratethys: Austria, Hungary, Poland and Ukraine – see Müller (1984a, b, 1993, 1996), Radwański et al., (2006) and Ossó and Stalennuy (2011), as well as from the Oligocene of northern Italy (De Angeli et al., 2010), the Middle Miocene from France (Ossó et al., 2022) and the Upper Miocene of Malta (Gatt and De Angeli, 2010).

Family Munidopsidae Ortmann, 1898
Genus *Palmunidopsis* Fraaije, 2014a
Palmunidopsis muelleri Fraaije, 2014a
Figure 7

2014a *Palmunidopsis muelleri* Fraaije, page 235, plate 1.

Material. A carapace with pereiopod fragments (MAB13686, holotype, old collection number MAB k. 3284), and two incomplete carapaces and fragments of pereiopods (MAB839, paratype, old collection number MAB k. 3285) from Maroni.

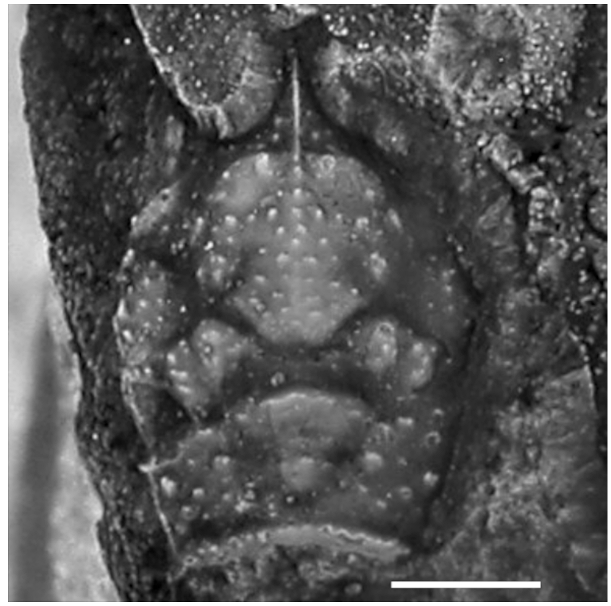

FIGURE 7. Carapace of *Palmunidopsis muelleri*, holotype (MAB13686). Scale bar is 2 mm.

Locality and stratigraphy. Maroni; Koronia Member (Pakhna Formation, late Serravallian-early Messinian).

Remarks. The occurrence of this shallow-marine munidopsid in the Upper Miocene of Cyprus just prior to the desiccation of the Mediterranean Sea, suggests that this species was probably able to adapt and migrate from deep to very shallow-marine environments within a geologically short time span (Fraaije, 2014a).

Family Porcellanidae Haworth, 1825
Genus *Petrolisthes* Stimpson, 1858
Petrolisthes haydni Müller, 1984a
Figure 8A-F

1984a *Petrolisthes haydni* – Müller, Page 61, Plate 26, figures 1-5.

1996 *Petrolisthes haydni* Müller – Müller, page 8.

1998 *Petrolisthes haydni* Müller – Müller, page 16.

2006 *Petrolisthes* cf. *haydni* Müller – Radwański et al., page 96.

2012 *Petrolisthes haydni* Müller – Górka et al., page 171.

2014 *Petrolisthes haydni* Müller – Collins, page 34, plate 1 figures 5-8.

2014 *Pagurus retznensis* – Collins, page 35, plate 2, figures 3-5 (junior synonym).

2018 *Petrolisthes haydni* Müller – Górka, page 516, text-figure 3.4.

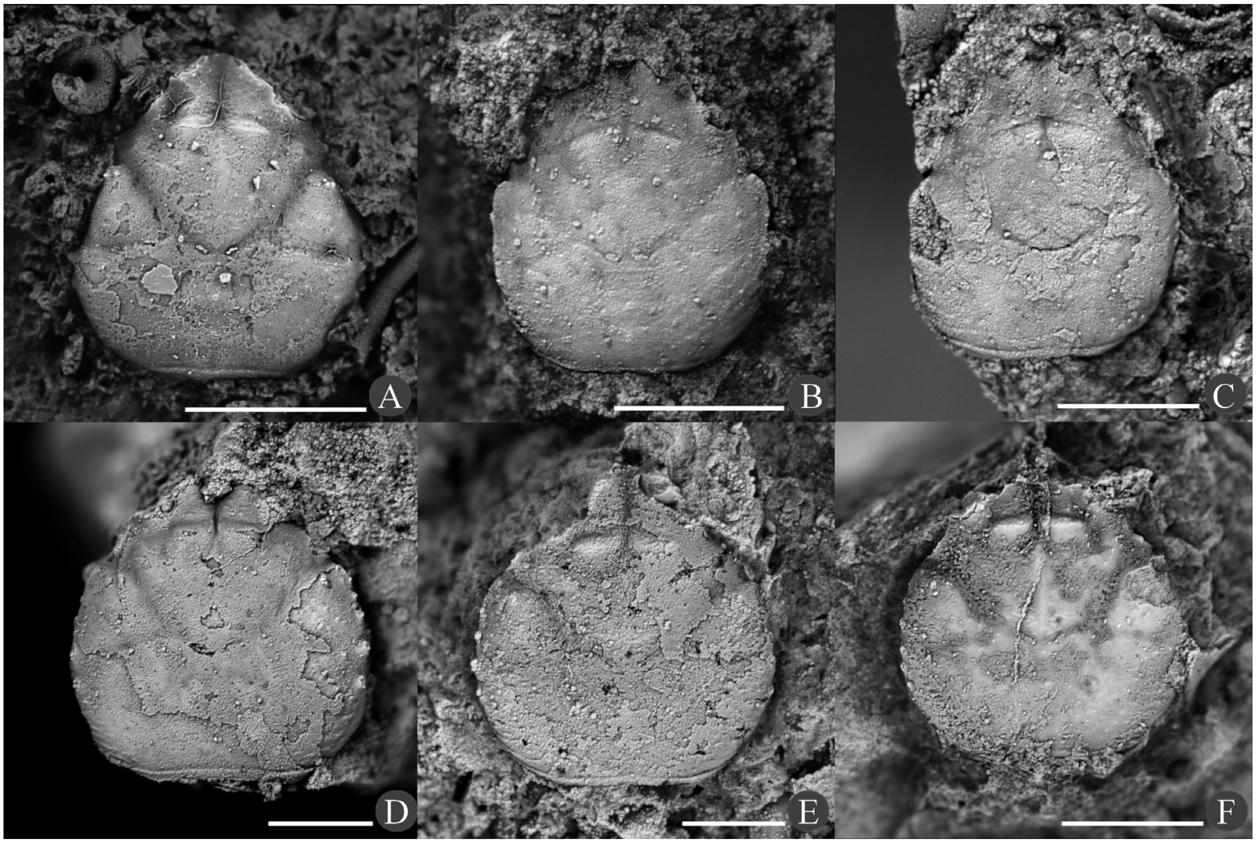

FIGURE 8. A: Carapace of *Petrolisthes haydni* (MAB11857). B: Carapace of *Petrolisthes haydni* (MAB10907) showing three anterolateral teeth. C: *Petrolisthes haydni* showing five anterolateral teeth on the right (one of them broken) (MAB13994). D: *Petrolisthes haydni* showing five anterolateral teeth (MAB10926). E: *Petrolisthes haydni* showing four anterolateral teeth (MAB10927). F: *Petrolisthes haydni* showing five anterolateral teeth (MAB10912). Scale bars are 2 mm on D & F, Scale bars are 1 mm on A, B, C & E.

2021 *Petrolisthes haydni* Müller – Hyžný and Dulai, page 131, figure 45.8-10.

Material. Three carapaces (MAB11856–11858) from Tochni; 80 carapaces (MAB10907, 10910-10912, 10916–10930.1, 10931.1, 10934.1, 11854, 11855, 11865.1, 13508.1, 13534.2, 13563, 13564.2, 13565.1, 13566-13568.1, 13569-13571.1, 13572-13574.2, 13575-13586.1, 13587.2, 13822.2, 13993.3 13994, 13995) from Mitsero.

Locality and stratigraphy. Tochni and Mitsero, Koronia Member (Pakhna Formation, late Serravallian-early Messinian).

Remarks. In the original description by Müller (1984a), the holotype was stated to have three teeth on the lateral margin as a diagnostic feature; the species is also much smaller than *P. magnus*. In comparison with *P. magnus*, the grooves on the dorsal carapace surface are also deeper. The size difference between *P. haydni* and *P. magnus* mentioned by Müller (1984a) is not suitable as a diagnostic feature, although the largest specimens do, in fact, belong to *P. magnus*. The number of posterolateral teeth in *P. haydni* is not restricted to three; occasionally four or five teeth are present in a row (as seen in figure 8C-F). This has likely not been noted by Müller (1984a), on account of the incomplete preservation of the holotype. This is possibly just intraspecific variation in which some individuals had more than three posterolateral teeth.

This species has also been recorded from the Middle Miocene ('Badenian') of Ukraine (Górka, 2018), Hungary (Müller, 1984a) and Poland (Müller, 1996).

Petrolisthes magnus Müller, 1984a
Figure 9A, B

1984a *Petrolisthes magnus* Müller, page 60, plate 23, figures 1-4, plate 24, figures 1-4, plate 25, figures, 4-5.

2006 *Petrolisthes magnus* Müller – Radwański et al., page 96, plate 2, figure 2.

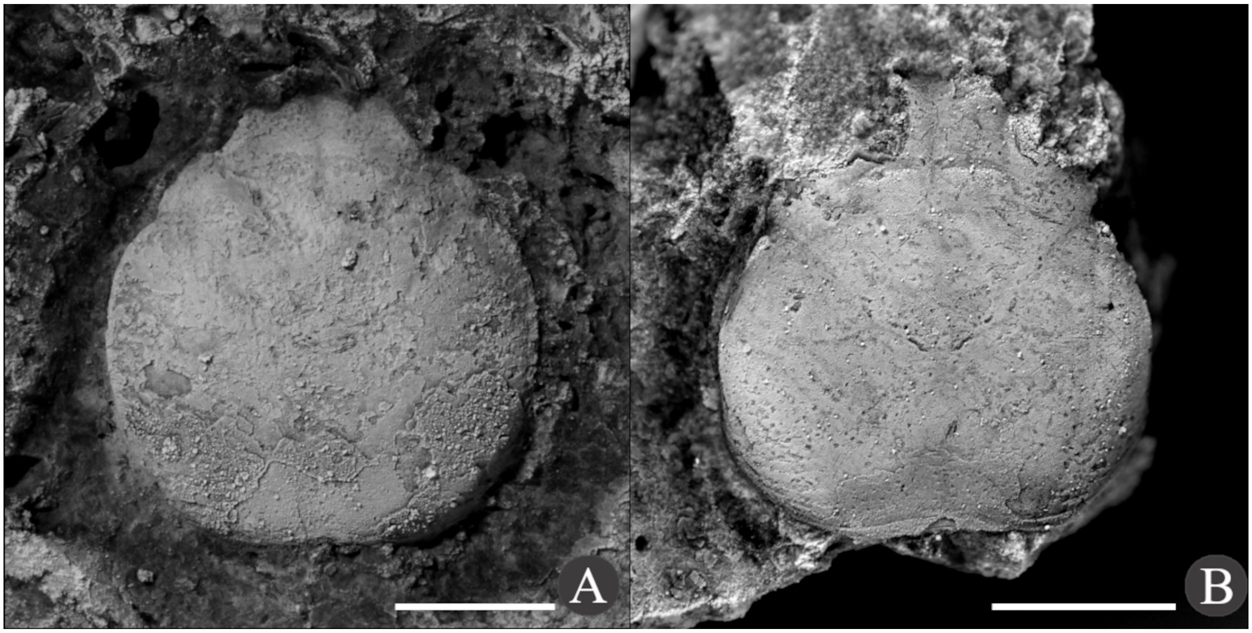

FIGURE 9. A: *Petrolisthes magnus* (MAB13530). B: *Petrolisthes magnus* (MAB10343). Scale bars are 2 mm.

2010 *Petrolisthes* cf. *magnus* Müller – Gatt and De Angeli, page 1327, plate 2, figure 5.

2011 *Petrolisthes magnus* Müller – Ossó and Stalennuy, figure 3.6 (figure 3.4, 3.5 = *Petrolisthes* sp. A sensu Górka 2018).

2012 *Petrolisthes magnus* Müller – Górka et al., page 171.

2018 *Petrolisthes magnus* Müller – Górka, page 516, text-figures 3.5-3.7.

2021 *Petrolisthes magnus* Müller – Hyžný and Dulai, page 128-129, figure 45.1-7.

Material. A single carapace (MAB10343) from Cap Greco; 37 carapaces (MAB879, 10905.1, 10906, 10908, 10909.1, 10913, 10914, 10915.1, 10934.2, 13530.3, 13530.4, 13532-13534.1, 13535.1, 13536.1, 13537.1, 13538-13540.1, 13541, 13542.1, 13543-13548, 13549.2, 13550.1, 13551-13554, 13587.1, 13823.1) from Mitsero.

Locality and stratigraphy. Cap Greco; Terra Limestone Member (Pakhna Formation, Aquitanian-Burdigalian); Mitsero, Koronia Limestone Member (Pakhna Formation, late Serravallian-early Messinian).

Remarks. The rostrum is rhombic with an elevated orbital ridge. The carapace is decorated with two posterior pointing V-shaped grooves, of which the anterior one is the deepest.

The complete surface is covered with fine transverse striations and the posterior margin is subcircular.

This species has also been recorded from the Middle Miocene ('Badenian') of Hungary (Müller, 1984) and Ukraine (Radwański et al., 2006; Ossó and Stalennuy, 2011; Górka, 2018) and possibly from the Messinian of Malta (Gatt and De Angeli, 2010). The presence of this species in the Aquitanian-Burdigalian of Cap Greco makes it the oldest occurrence.

Petrolisthes mitseroensis sp. nov.
Figure 10A, B

zoobank.org/15C31071-C213-4333-8529-7BD98F4CE225

Material. 2 carapaces from Mitsero (MAB13996, holotype and MAB13531, paratype)

Locality and stratigraphy. Mitsero; Koronia Member (Pakhna Formation, late Serravallian-early Messinian).

Etymology. The species is named after Mitsero, the locality where the holotype and paratype were found.

Description. The shape of the carapace of *P. mitseroensis* sp. nov. is subcircular, of which the anterior part is circular in outline, the posterior is square, with rounded corners. There are no teeth on the keeled anterolateral margins, a short, downturned rostrum, a bilobed frontal with small orbital ridges on the onset of the rostrum. The epibranchial region is faintly bulbous and well defined. The cervical groove is well defined, the branchial groove is less defined and disappears laterally. The gastric region is well defined and shows a deep dent posteriorly of the mesogastric region.

FIGURE 10. A: *Petrolisthes mitseroensis* sp. nov., paratype (MAB13531). B: *Petrolisthes mitseroensis* sp. nov., holotype (MAB13996). Scale bars are 2 mm.

The surface is smooth, with exception of the branchial region near the posterolateral margin, which is striated.

Remarks. This species can be distinguished from its congeners in having a subcircular carapace, striations on the metabranchial region, a short, downturned rostrum, a faintly bulbous epibranchial region and in lacking anterolateral teeth.

DISCUSSION

The highest anomuran diversity on Cyprus is found in the upper Serravallian-lower Messinian Koronia Member, comprising eight species, five of which are endemic (*Paguristes joecollinsi*, *Palmunidopsis muelleri*, *Dardanus cyprioticus* sp. nov., *Dardanus plevrotos* sp. nov. and *Petrolisthes mitseroensis* sp. nov.), compared to only two species in the Aquitanian-Burdigalian Terra Member. Two species have been collected from both members; *Galathea weinfurteri* and *Petrolisthes magnus*. This does not come as a surprise as far as the former taxon is concerned because this is a common and widespread species with an extensive stratigraphical range (Oligocene to Messinian) (Müller 1984a, b, 1993, 1996; Radwański et al., 2006; De Angeli et al., 2010; Gatt and De Angeli, 2010; Ossó and Stalennuy, 2011; Hyžný and Dulai, 2021; Ossó et al., 2022). *Petrolisthes magnus* is known exclusively from the Middle Miocene of Hungary and Ukraine (Müller, 1984; Radwański et al., 2006; Ossó and Stalennuy 2011; Górka, 2018; Hyžný and Dulai, 2021) and possibly from the Messinian of Malta (Gatt and De Angeli, 2010).

We are unaware of any Middle Miocene occurrences in Cyprus of *Petrolisthes magnus*; however, this species is known from localities further north and thus may have migrated back once reef formation in Cyprus resumed during the late Serravallian. Although more data are needed to gain a better understanding of anomuran migratory patterns in the Mediterranean during the Miocene. The absence of decapod crustacean-bearing Middle Miocene deposits hampers any interpretations of whether or not decapod crustaceans disappeared completely or survived in refugia somewhere in Cyprus.

It is of note that anomuran diversity increases towards the end of the Miocene, while coral diversity decreases. This may be a collection artefact, in view of the considerably greater number of decapod crustaceans recovered from the Koronia Member in comparison to the Terra Member, but more research is needed to shed light on this matter.

CONCLUSIONS

To date, only eight species of anomurans are known from the Miocene of Cyprus, which reflects the relative paucity of studies on this subject matter. The two anomuran species found in lower Miocene reefs in Cyprus are also present in the upper

Miocene; this level yields the greatest anomuran diversity. The demise of reefs during the Middle Miocene triggered the disappearance of all anomuran taxa, but these all returned when reef formation resumed during the Late Miocene. The associated brachyuran assemblages will be described in forthcoming research (Part 2).

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