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Middle Miocene "Badenian" (Langhian) decapod crustaceans from the Retznei quarry, Styrian Basin, Austria

Joe S. H. Collins

The Natural History Museum, Cromwell Road, London SW7 5BD and 8, Shaws Cottages, Perry Rise, London, SE23 2QN, England

Abstract

Thirty-four species (of which two are represented in the present collection by plaster casts) of anomuran and brachyuran decapods have been found in the Middle Miocene Langhian "Badenian" in the Retznei quarry, Stryrian Basin, Austria. Of these, twenty-nine are determined, some tentatively, to species level. Six new species are described: *Pisidia*? *subnodosa* sp. nov., *Pagurus retznensis* sp. nov., *Dromia evae* sp. nov., *Portunus muelleri* sp. nov., *Glabropilumnus nitidus* sp. nov. and *Eomaldivia friebei* sp. nov. Previously described species are *Callianassa"* sp. aff. "*Callianassa" sismondae* A. Milne-Edwards, "*Callianassa" almerai* Müller, *Galathea weinfuerteri* Bachmeyer, *Petrolisthes haydni* Müller, *Pisidia viai* Müller, *Dardanus hungaricus* Lőrenthey *in* Lőrenthey and Beurlen, '*Anapagurus' miocenicus* Müller, *Calappa praelata* Lőrenthey *in* Lőrenthey and Beurlen (plaster cast), *Kerepesia viai* Müller, *Kromtitis koberi* (Bachmayer and Tollman), *Charybdis fragilis* (Müller), *Charybdis mathiasi* Müller, *Lobocarcinus* sp. aff. *sismondai* (von Meyer), *Carpilius antiquus* Glaessner, *Daira speciosa* (Reuss), *Hyastenus* sp., *Liocarcinus* sp. aff. *rakosensis* Lőrenthey *in* Lőrenthey and Beurlen (plaster cast), *Pilumnus* sp. aff. *mediterraneus* (Lőrenthey), *Pilumnus* sp., *Panopeus wroni* Müller, *Chlorodiella juglans* Müller, *Chlorodiella loczyi* Müller, *Chlorodiella mediterranea* (Lőrenthey *in* Lőrenthey and Beurlen), *Chlorodiella tetenyensis* Müller, *Xantho moldavicus* (Yanakevich), *Pilodius vulgaris* (Glaessner), *Haydnella steiningeri* Müller and Majidae gen. et sp. indet.

Relationships with species of similar age and those with extended range affecting other localities are discussed. The specimens were collected from two stratigraphic units which could be correlated with substages in the Hungarian Badenian, but others, including type specimens, are from unknown units.

Introduction

Müller's first contribution to the Badenian crabs from Hungary in 1974 was followed by his major work, *Decapod Crustacea of the Badenian* (1984b), in which he not only summarized the known Hungarian species, but included those from Poland and Austria. However, despite being known since Hilber (1871), no crabs from Retznei were included in the (1984b) publication. Anxious to redress this omission and continue researches on the Badenian of Central Europe, Müller, together with Dr. J. G. Friebe, Dornbirn, Austria, collected from exposures in the extensive quarry at Retznei, Styrian Basin, Austria. By the late 1990s, preparation and initial identification was well advanced, when a series of unforeseen events forced Müller to postpone the project. Subsequent progressive ill health impeded resumption of the work and the present author was invited to adopt the project. In so doing, relevant parts of the stratigraphic account prepared by Dr. Friebe were made available and, adapted, are included herein.

As far as can be ascertained, the earliest Badenian decapods to be recorded from Retznei were by Hilber (1871); these were *Neptunus granulatus* Milne-Edwards, 1860, and *Daira speciosa* Reuss, 1871. Although the former species was subsequently included in the synonomy of *Neptunus* [*Portunus*] *monspeliensis* Milne-Edwards, 1860, neither that, nor *D. speciosa*, were included in the localities listed by Müller (1984 b, table 1, p. 37). In 1986, Flügel recorded *P. montspeliensis*, and both "*Callianassa" pseudorakosensis* Lőrenthey *in* Lőrenthey and Beurlen 1929 and "*Callianassa" almerai* Müller, 1993 were added by Hyžný (2011), the former was transferred to *Eucalliax* Manning and Felder, 1991, by Hyžný and Hudáćková (2012).

Because of the hard, splintery nature of the rock, much of the material is fragmentary, with small species or juveniles predominating. Also, there was an abundance of pre-fossil breakages. These aspects of collecting were brought home to the author while reducing several kilos of 'hope-blocks' brought back and placed in store, with the result adding little to the available specimens.

Müller (1884b, p. 100) regarded the Badenian decapod fauna

as "modern in its character", and considered only twelve of its 72 established genera could be considered extinct. One of the genera, *Thalamita*, has since been synonymised with *Charybdis* (Karasawa *et al*., 2008) of this, original, total, only 25 genera, are presently known from Retznei.

Identification of much of the material in the present study is dependent almost entirely on Müller's expertise and experience. Of the 34 Lower Badenian decapod species in 26 genera recorded from Retznei herein, six, *Pisidia*? *subnodosa*, *Pagurus retzensis*, *Dromia evae*, *Glabroplumnus nitidus, Portunus muelleri* and *Eomaldivia*? *friebei,* are new. A dactylus associated with '*Anapagurus' miocenicus* is described for the first time. Twenty-two species (see Table 1) are directly comparable with previously described Hungarian taxa and four are tentatively associated. A further three are recorded only to generic level; one of these, *Hyastenus,* is a fossil/extant genus known elsewhere from the Oligocene of Italy, and Miocene of Japan and Sabah (Karasawa, 1991; Collins *in* Collins *et al*., 2003; De Angeli and Beschin, 2008).

In correspondence with Friebe, Müller remarked upon the presence of 'good carapaces' of *Calappa praelata* and a portunid, both non-reefal inhabiting species, from Retznei, in an acquaintance's collection. These are undoubtedly represented in the present collection by plaster casts, both clearly marked 'Retznei' on the reverse and are described herein from an unknown unit, but are not included in the distribution of coral-inhabiting forms summarised below.

Bachmeyer and Tollman (1953) brought together the most Austrian Badenian crabs previously known from any one locality, which was Gross Hoflein. These totalled eight species, including three tentatively identified. Of these, Müller (1985a) recognised five, omitting the tentative recordings, and an additional seven species. All but one, *Necronectes schafferi* Glaessner, 1928, are present in the Retznei collection. Concerning the palaeogeographic distribution of the Langhian decapod fauna of Olédola (Catalonia), Müller (1993, p. 5) cited that out of 22 determined species, nine (*rectae* ten) were "certainly reported from the rich Paratethyan fauna". Representing a comparatively high proportion, ten firmly and/or tentatively indentified members of the presently known Retznei taxa are common to the Olédola collection. A small number of Middle Badenian species common to the Austrian fauna has been recorded from the Maksymivka quarry, near Termopil, Ukraine, by Ossó and Stallenny (2012) (see Table 1). With so many species recorded from an unknown unit, content comparison ratios among the Retznei assemblage are of no value. The distribution and ecology of Badenian, Messinian and Langhian reef-dwelling crabs of Europe and the Mediterranean, together with their generic affinities to Indo-West Pacific forms has been discussed in detail by Müller (1979 b, 1984a, b, 1993, 1996, 1998, 2004, 2006), Saint-Martin and Müller (1988), Müller and Galil (1998), Giorgiades-Dikeoulia and Müller (1984), Moissett and Müller (1990), Hyžný and Hudáćková (2012).

Retznei quarry: Stratigraphy

The Retznei quarry of the Lafarge-Perlmooser Zementwerke offers an excellent opportunity to study the internal structure of a Leithakalk build-up. Biogenic sedimentation was controlled by an inherited relief and by relative sea-level. In the build-up and its silicilastic surroundings, seven distinct lithographic units can be distinguished (Friebe, *in* Pillar *et al.,* 1991).

An erosional event following tectonic uplift and tilting of the Karpatian Steirischer Schlier (= Kreutzkrumpl Formation; Schell, 1994), created a pronounced relief (Friebe, 1991a). The south-dipping slope is covered by gravelly marlstone representing reworked basement. Small channels are characterised by lag deposits of metamorphic pebbles originating from coarse-grained layers within the Kreutzkrumpl Formation. Lag deposits are also found on top of this reworkedhorizon indicating emersion and erosion at the Karpatian/Badenian boundary.

With the Badenian transgression, Leithakalk sedimentation started (Rögl and Steininger, 1983; Friebe, 1993). The base of the build-up shows a distinct facies zonation (see also Buxton and Pedley, 1989). In the deeper part of the slope the emersion horizon is overlain by a coral patch reef (unit 3). The coarse-grained lag deposits acted as a stable substrate for coral colonisation. In the centre of the shoal, poorly to moderately sorted, bioturbated sand was deposited (unit 2). Stabilisation by seagrasses prevented winnowing of the sediment. Rare rhodoliths show branching growth forms. They indicate a reduction of wave energy by the seagrass (Almasi *et al*., 1987; Bosence, 1983). The blades have been encrusted by serpulids. Additionally, bones of sirenia (sea cows) were found in this facies. The low energy conditions permitted the preservation of crustacean debris.

Patch-reefs and seagrass meadows were separated by a rhodolith/corallith belt. In the rhodoliths columnar, speroidal to ellipsoidal growth forms prevailed. The coraliths (*sensu* Scoffin *et al*., 1985) show a complex intergrowth of coralline algae, serpulids and *Porites* sp. Commonly a small rhodolith was encrusted by the coral which was, in turn, overgrown by coralline algae and serpulids. Relatively large amounts of sediment were incorporated into these nodules. Due to their motion by waves and predatory fishes, the preservation potential for decapods was low.

During continuing transgression, the patch reefs spread over the whole shoal (unit 3). *Montastraea oligophylla* (Reuss), *Tarbellastraea reussiana* (Edwards and Haime) and *Porites* sp. are the main reef builders. Other corals (*e.g. Sidastraea* sp., *Flabellum* sp.) are scarce. Coral heads are intensively bored by *Lithophaga* spp. and recrystallised. Siltation was relatively

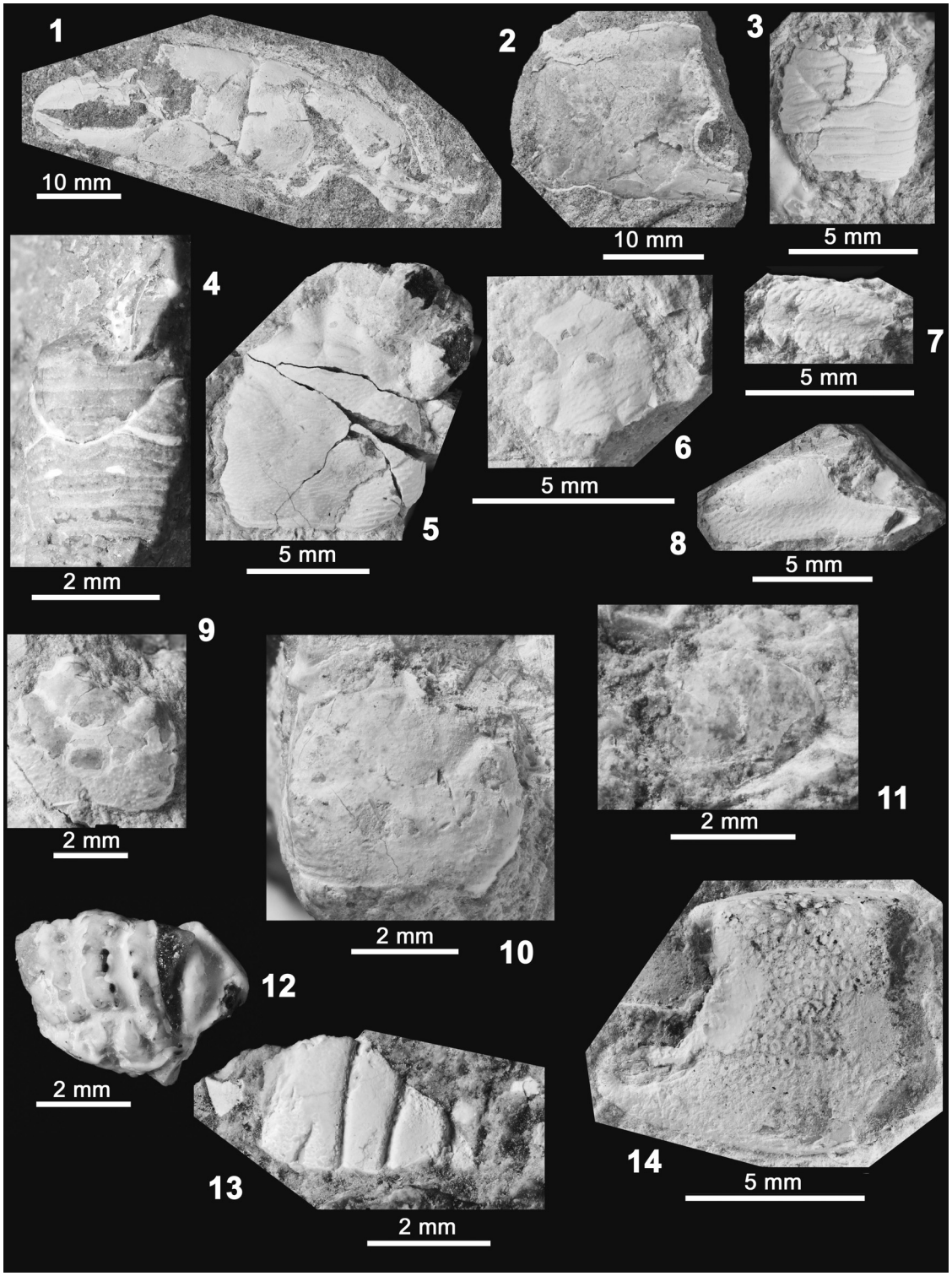

Plate 1

Fig. 1. "*Callianassa*" aff. "*Callianassa*" *sismondae* A. Milne-Edwards. NHM IC 636. Unit unknown. Left propodus and carpus. Fig. 2. "*Callianassa*" *almerai* Müller. NHM IC 637, Unit 6. Internal cast of right propodus. Figs. 3, 4. *Galathea weinfuerteri* Backmeyer. 3. NHM IC 638, Unit 3. 4. NHM IC 639. Unit 6. Figs. 5–8. *Petrolisthes haydni* Müller. 5. NHM IC 640. Unit 6. 6. NHM IC 641. Unit 3. 7. NHM IC 642. Unit unknown. Fragmentary merus. 8. NHM IC 643. Unit 6. Right propodus, Unit 3. Figs. 9, 10. *Pisidia viai* Müller. NHM IC 644. Unit 3. 10. IC 693. Unit unknown. Fig. 11. *Pisidia*? *subnodosa* sp. nov. Holotype, NHM IC 645. Unit unknown. Fig. 12, 13. *Dardarnus hungaricus* Lőrenthey, *in* Lőenthey and Beurlen. 12. NHM IC 646. Unit unknown. Left carpus. 13. NHM IC 647. Unit unknown. Framentary left propodus. Fig. 14. *Anapagurus miocenicus* Müller. NHM IC 648. Unit unknown. Left propodus.

strong and coral growth was frequently interrupted by silt layers. Decapod remains are preserved in sheltered caves between the coral heads. The patch reef show no distinct internal zonal facies. However, rhodoliths are present only in the uppermost parts of the reefs. The top of the reefs reflects a (tectonical induced) fall in relative sea level. Its surface is cut by grooves.

Unit 4 consists of an algal debris limestone (grainstone and rudstone; foramniferal algae and rhodolite debris facies). Above the reef crest a small mound consisting of rodolithiths and small, massive colonies of *Porites* sp., developed. It shed coarse-grained debris down the slope to the south. To the north a lagoon was filled by fine-grained algal debris rarely exceeding 1 mm in grain-size. In that area macrofossils are scarce. The only decapod found in unit 4 is *Daira speciosa* (Reuss) which is abundant in the vicinity of *Porites* colonies and large rhodoliths.

The following development of the build-up is characterised by a distinct facies zonation. In the centre of the shoal, sedimentation was strongly reduced. Corals are rare. Marly layers with columnar rhodoliths and abundant algal debris alternate with crutose pavement and boxwork rhodoliths (compare with Bosence and Pedley, 1982). Towards the top glauconite occurs. Molluscs (mainly bivalve moulds) become more abundant. Traces of irregular sea urchins (*e.g. Brissopsis* sp.) are common. Units 5 and 6 cannot be distinguished in that part of the build-up. At the same time, a wedge of marly Leithakalk developed at the southern flank of the build-up (units 5, 6). Unit 5 shows a distinct fining and deepening upward trend starting with a marly rhodolith pavement. This pavement differs from the pavement facies of Dullo (1983) by its relatively large amounts of marly matrix, whereas, in Dullo's pavement, cement dominates over primary matrix. Rhodoliths with branching to colunmnar growth forms reach diameters up to 10 cm. Corals are absent. Other biota include oysters, pectinids, bryozoa and clypeastriod sea urchins. The rhodolith pavement is soon replaced by boxwork rhodoliths and a crutose pavement. Scarse corals occur. The upper part of this unit consists mainly of marly limestone enriched in algal debris (bioclastic algal debris facies). Marly intercalations are enhanced by pressure solution. Some distinct marl beds can be attributed to volcanic ash falls.

Unit 6 can be subdivided into three fining and deepening upward subunits. Unit 6a starts with a well cemented pavement of columnar rhodoliths, followed by alternations of pavement facies and more marly layers. It grades upwards into marly limestone with branching and boxwark rhodoliths (bioclastic rhodolite facies). Again, marlstone layers are enhanced by pressure solution. The top of this subunit consists of marly algal debris limestone, with only occasional rhodoliths.

A distinct bed of bioclastic algal to rhodolith limestone constitutes the base of subunit 6b. Within this bed the rhodoliths show a prominent coarsening upward trend. It is succeeded by a coral carpet dominated by *Porites* sp. and occasionally ?*Mussismilia* sp., followed by two beds in pavement facies which are separarated by marlstones. This succession is overlain by a coral carpet to small patch reef dominated by *Porites* sp. and *Montastraea oligophylla* (Reuss) up to 1 m in diameter. Rhodoliths and marly intercalations are common. The uppermost 5 m consists of a rhodolith pavement with abundant *Porites* sp. Marly intercalations are concentrated at the top of this subunit.

Subunit 6c again starts with a well-cemented pavement of columnar rodoliths and oysters. It is succeeded by a small patch reef built up by *Porites* sp., *Montastraea oligophylla* and ?*Mussismilia* sp. in its lower partm and, above a distinct marly intercalation, by *Porites* sp. with only minor contribution from other corals. A rich decapod fauna originates from sheltered caves within the coral framework. The reef is overlain by a coral pavement. The top of this unit was not exposed properly. It probably consists of a more marly rhodolith to algal debris limestone showing a fining upward tend.

The Leithakalk build-up was in part suffocated by fine-grained siliciclastics (unit 7) and drowned during maximum sea-level rise. A drowning event can also be observed in the build ups of the Gamlitz area farther south (Friebe, 1993). As an alternative model chemical pollution of the environment by intensive ash falls may be discussed. A tuff layer (formally interpreted as distal apophyses of an andersitic intrusion; Hauser, 1951) is found only a few cm above the build up. However, the tuff is always separated from the limestone by fine-grained siliciclastics. A rich foraminiferal fauna with *Cibicidoiides ungarianus* (d'Orbigny), *Dentalina* spp., *Gyroiddinoides soldanii* (d'Orbigny), *Lenticulina* spp., M*elonis pompiliodes* (Fifhel and Moll), *Nodosaria* sp., *Pullenia bulloides* (d'Orbgny), *Sphaerodina bulliodes* d'Orbigny, *Spiroplectammina carinata* (d'Orbigny), *Stilostomella* spp., *Uvigerina* spp., abundant planktic foraminifera and others indicates a water depth of approximately 100 m for most of the shales.

The stratigraphic content of the Retznei succession in relation to other Badenian/Langian exposures in the Styrian Basin was given by Hohenegger *et al.* (2009).

Systematic Descriptions

Remarks: All figured specimens are contained in 'Material'; because of the fragmentary nature of much of the remaining material, all other specimens are listed in 'Additional material', either as carapaces or limbs irrespective of condition. All specimens prefixed 'IC' are deposited in the Department of Earth Sciences. The Natural History Museum, London.

Order Decapoda Latreille, 1802
Infraorder Axiidea de Saint Laurent, 1976
Family Callianassidae Dana, 1852

Subfamily Callianassinae Dana, 1852

Genus *Callianassa* Leach, 1814

Type species: *Cancer* (*Astacus*) *subterraneus* Montague, 1808, by original designation.

"*Callianassa*" sp. aff. "*Callianassa*" *sismondae* A. Milne-Edwards, 1860

(Pl. 1, fig. 1)

1928. *Callianassa sismondai* A. Milne-Edwards; Glaessner, p. 90. (see also for synonymy).

1984b. *'Callianassa' sismondae* A. Milne-Edwards; Müller, p. 5.

1998. "*Callianassa*" aff. *sismondae* A. Milne-Edwards, 1860; Müller, p. 273, pl. 1, figs. 1, 2.

Material: IC 636, a left cheliped; unit unknown; IC 710, An internal cst of a right propodus; unit unknown.

Remarks: Albeit largely decorticated, the left cheliped is better preserved than that figured by Müller (1998, pl. 1, fig. 1), which is associated with elements of the carapace

Description: Propodus. A little higher than long, the upper and lower margins are weakly curved, the lower leading straight into the fixed finger, which is longer than the manus; the carpal margin is almost straight and the interdigital margin, excavated to the dactyl articulation, becomes almost straight above. The fixed finger is sharply pointed, upturned and weakly inclined inwards. The occludent margin appears to be finely granulate, with a row of setae pores along the outer margin. Only the internal cast of the dactylus remains; from the down-curved, sharply pointed apex overlapping the fixed finger, a straight cutting edge set at one third the height and length, curves up to a (possibly) weakly curved posterior portion. As preserved, the surface has a median ridge and another bounding the cutting edge, suggesting corresponding grooves on the actual surface.

Carpus. Shorter than the manus, it tapers slightly posteriorly with the lower margin curving boldly towards the indented meral articulation. Traces of the shell on the outer surface are lined with fine undulating ridges. The upper margin of the propodus and carpus is smooth.

Merus. Is as long as the propodus and half its height, with weakly curved upper and lower margins; a subcentral rectangular incision along its length is lined with a row of granules above a thin ridge, with a scattering of fine granules above.

Traces of the 1st pereiopod laying above the manus of IC 636, indicate the dactylus to have been as long as the manus.

Right propodus. Proportions of the manus are much the same as the left manus; the proximal height of the left is shorter and there is a sparse scattering of granules about the middle of the interedigital margin.

Discussion: Müller (1993, p. 6), when comparing "*Callianassa*" *sismondae* with "*Callianassa*" *almerai* Müller, 1993, from the Langhian of Olédola, Spain, drew attention to tubercles common to both sides of the manus. These are absent (possibly through preservation) on the left specimen (IC 636). The presence of spines characteristic of the genus along the upper margin of the propodus, and lower margins of the carpus and merus, readily distinguishes the superficially similar *Glypturus munieri* (Brocchi, 1883) (*vide* Hyžný and Müller, 2012, p. 979, fig. 8). Furthermore, the propodal margin of the carpus is bounded by a groove in *G. munieri* and the meral margin is not so boldly rounded; also, there is no rectangular incision on the merus.

The nominal form of *C. sismundae* is known from the Karpatian, Lower Miocene, of Korneuburger, Austria (Müller, 1998, p. 273).

"*Callianassa*" *almerai* Müller, 1993

(Pl. 1, fig. 2)

1984a. *'Callianassa' desmerestiana* Milne-Edwards; Müller, p. 27.

1993. *Callianassa almerai* Müller; Müller, p. 6, figs. 2C–F.

2012. "*Callianassa*" *almerai* Müller; Hyžný and Hudáćková, p. 21.

Material: IC 637a, b, right inner surface of a propodus and counterpart from Unit 6.

Remarks: As preserved, the oblique fracture of the upper distal portion and articulation with the dactylus presents a distorted image of the length/width proportions when compared with published figures in (Müller, 1993; Hyžný, 2011). This could suggest placement with *Eucalliax pseudorakosensis* (Lőrenthey *in* Lőrenthey and Beurlen, 1929), but the cluster of granules, as reported by Müller (1993, p. 6), above the base of the fixed finger on the present specimen, is not developed in *E. pseudorakosensis*. Examples of both species preserved within their burrows have been described by Hyžný (2011) from Retznei and elsewhere. "*Callianassa*" *almerai* is also known from the Langhian of Olédola, Spain.

Infraorder Anomura MacLeay, 1838

Superfamily Galatheidea Samouelle, 1819

Family Galatheidae Samouelle, 1819

Genus *Galathea* Fabricius, 1793

Type species: *Cancer strigosa* Linnaeus, 1761, by subsequent designation of Latrielle (1810).

Galathea weinfurteri Bachmeyer, 1950

(Pl. 1, figs. 3, 4)

1950. *Galathea weinfurteri* Bachmeyer, p. 135–137, pl. 1, figs. 2–4.

1984b. *Galathea weinfurteri* Bachmeyer; Müller, p. 60, pl. 21. figs. 4, 5, pl. 22, figs. 1–5 (see also for intermediate synonomy).

2008. *Galathea weinfurteri* Bachmeyer; De Angeli and Beschin, p. 17, pl. 1, fig. 2.

Material: IC 638, a carapace from Unit 3: IC 639, a carapace from Unit 6.

Additional material: IC 711, carapace from Unit 3, and a fragment from an unknown unit.

Remarks: This fairly common, widespread species, previously

known from Hungary, Deutsch-Altenburg, Niederöstereich, Austria, southern Poland (Müller, 1984b, p. 47; 1996, p. 8) and near Ternopil, Ukraine (Ossó and Stallenny, 2012), was tentatively recorded from the Lower Oligocene of Vincenza, Italy (De Angeli and Beschin, 2008, p. 17). Discussing this species, De Angeli and Garassino (2002, p. 10), drew attention to "the cardiac region not distinctly defined by grooves breaking the cardiac region"—a character shared by the Retznei specimens. Also, there is a definite tendency towards fine, intercalated striae, as seen in Müller (1993, fig. E).

Fragmentary carapaces and a limb fragment from the Langhian of Olédola, Spain, were recorded by Müller (1993, p. 8) as *Galathea* cf. *squamifera* Leach, 1814, an extant species, on the similarity of a rostrum to that of extant forms; a rider suggests the possibility of the presence of more than one species. The Retznei carapaces differ primarily in having divided transverse striae.

Family Porcellanidae Haworth, 1825

Genus *Petrolisthes* Stimpson, 1858

Type species: *Porcellana violacea* Guérin Méneville *in* Duperrey, 1831, by monotypy.

Petrolisthes haydni Müller, 1984b

(Pl. 1, figs. 5, 6, 7, 8)

1984b. *Petrolisthes haydni* Müller, p. 6l, pl. 26, figs. 1–5.

Material: IC 640, a fragmentary carapace from Unit 6; IC 641, a carapace fragment, from Unit 3; IC 642, a fragmentary attributed merus; and IC 643, an attributed right propodus. Both from an unknown unit.

Additional material: Two specimens from Unit 3, IC 712, 693; four from Unit 6, IC 714, 715 and five from an unknown unit IC 716–720.

Remarks: As preserved all specimens compare favourably with the type series from the Badenian of Gross-Höflein. Austria. One carapace, IC 640, is almost three times larger than the type, thereby almost equalling the size of the contemporary *Petrolithes magnus* Müller, 1984b from Rákos, Budapest.

Genus *Pisidia* Leach, 1820

Type species: *Cancer longicornis* Linneaus, 1767.

Pisidia? *subnodosa* sp. nov.

(Pl. 1, fig. 11)

Diagnosis: Carapace subquadrate, short anterolateral margins; deep cervical furrow narrowly curved across midline, hepatic furrow short; branchiocardiac furrows deep laterally, bounded by ridge, become almost obsolete; epibranchial lobe indented by deep striae, dorsal surface granulate.

Material: Holotype IC 645, a fragmentary internal cast of a carapace from an unknown unit.

Description: The carapace is subquadrate posterior to the missing front, and flattened in both transverse and longitudinal sections. Short anterolateral margins are convex to a deep cervical notch. The straight posterolateral margins converge slightly to broadly rounded posterior angles. A ridge bounds the weakly concave posterior margin. A deep cervical furrow curves narrowly across the midline, unites with a short hepatic furrow, then turns abruptly out to the margin. Small, triangular hepatic lobes are depressed. The branchiocardiac furrows are deep laterally and bounded by a ridge running round weakly tumid epibranchial lobes, then, becoming almost obsolete, run straight towards the cardiac region. A smooth area outlines a broad, elliptic cardiac region. Scattered granules almost obscure weak transverse striae. Three epibranchial striae curve deeply round the lateral margin presenting a semi-nodose appearance.

Discussion: Although superficially similar to *Pisidia kokayi* Müller, 1974a, and *Pisidia viai*, both found in Badenian, Langhian and Messinian deposits, *P.*? *subnodosa* differs from both in that the cervical furrow runs in a more acute angle towards the front, in having apparent nodes on the epibranchial margin and an overall more densely granulate surface ornament. *Pisidia*? *subnodsa* differs further from *P. viae* in having posteriorly directed branchiocardiac furrows, similar to *P. kokayi*. Further differences must await better preserved specimens of *P. subnodosa.*

Pisidia viai Müller 1984a

(Pl. 1, figs. 9, 10)

1984a. *Pisidia viai* Müller p. 28, pl. 1, figs. 4, 6.

1984b. As *Pisidia kokayi* Müller; Müller, p. 61, pl. 27, fig. 6, pl. 28, figs. 1–3.

1993. *Pisidia viai* Müller; Müller, p. 8, figs. 4A–C.

Material: IC 644, a carapace; from Unit 3; IC 693, a carapace, unit unknown.

Additional material: IC 721, a carapace from Unit 3 and three carapaces from an unknown unit IC 721–723.

Remarks: Minute granules on the hepatic and epibranchial lobes readily distinguish *P. viai* from *Pisidia kokayi* Müller, 1974a, from the Hungarian Badenian. When recording the species from the Middle Miocene (Langhian) of Olédola, Müller (1993, p. 8) revised the identification of specimens from Törökmező, Hungary, and transferred specimens placed with *Pisidia kokayi*; he noted that, "this widespread species was described from the Messinian [of Greece (Müller, 1974, 1984 a)], but is frequent in the Paratethyan as well." Thus, the presence of the species from Austria was to be expected. The Retznei specimens reach a slightly larger size (width. *c*. 4.0 mm) than those from Olédola (width. *c*. 3.3 mm).

Superfamily Paguroidea Latreille, 1802

Family Diogenidae Ortmann, 1892

Genus *Dardanus* Paul'son, 1875

Type species: *Dardanus hellerii* Paul'son, 1875, by original designation, on official list, ICZN.

'*Dardanus' hungaricus* Lőrenthey *in* Lőrenthey and Beurlen, 1929

(Pl. 1, figs. 12, 13)

1929. *Dardanus' hungaricus* Lőrenthey *in* Lőrenthey and Beurlen, p. 34, 72, pl. 3, fig. 4.

1984b. '*Dardanus' hungaricus* Lőrenthey *in* Lőrenthey and Beurlen; Müller, p. 58, pl. 18, figs. 1–5.

1993. '*Dardanus' hungaricus* Lőrenthey *in* Lőrenthey and Beurlen; Müller, p. 7, figs. 3F, G.

Material: IC 646, IC 647, a fragmentary left propodus and a carpus. Both from an unknown unit. Addition material, IC 724, a carpus, unit unknown.

Remarks: Not previously recorded from Austria. The absence of denticles lining the distal edges of the ridges on the propodus immediately distinguishes this species from *Dardanus substriatiformis* Lőrenthey *in* Lőrenthey and Beurlen, 1929, and the specimens, albeit poorly preserved, are fully identical with those figured by Müller (1984b, pl. 28, figs. 1–5; 1993, fig. 3, F, G). The species was tentatively recorded from the Langhian of Olédola, Spain.

Family Paguridae Latreille, 1802

Genus *Anapagurus* Henderson, 1886

Type species: *Pagurus laevis* Bell, 1845.

'Anapagurus' miocenicus Müller, 1979

(Pl. 1, fig. 14; Pl. 2, figs. 1, 2)

1979. *Anapagurus miocenicus* Müller, p. 274, 277–278, 286, pl. 6.

1984b. *'Anapagurus' miocenicus* Müller; Müller p. 55, pl.11, figs. 4–9.

Material: IC 648, a left propodus; IC 649a, b, a right propodus and internal mould preserving associated dactylus. Both from an unknown unit.

Remarks: The propodus agrees in all respects with the type material. The dactylus, preserved as a part internal cast attached to the propodus and an internal mould, is weakly constricted at the articulation; the convex upper margin is flattened with sides inclined to a more or less straight outer surface and rounded inner surface. The occludent margin is weakly concave. Fine granules are coarser on the inner surface.

Genus *Pagurus* Fabricius, 1775

Type species: *Cancer pagurus* Linneaus, 1758 (on official list ICZN) by subsequent designation of Latreille (1810).

Pagurus retznensis sp. nov.

(Pl. 2, figs. 3–5)

Diagnosis: Length a little more than distal height; manus quadrate, a median ridge on outer surface; upper margin weakly convex, ridged; basal margin in line with narrow fixed finger, which is as long as manus.

Material: Holotype, IC 650, a left propodus (outer surface) from Unit 3; paratypes, IC 651 inner surface of left propodus from unit 3; IC 652, a left propodus from an unknown unit.

Derivation of name: A corruption of Retznei + *ensis.*

Description: Left propodus; manus, length a little more than distal height, the weakly ridged upper margin tapers in a gentle curve proximally; a ridged basal margin is almost straight from a rounded carpal angle and in line with the fixed finger; the outer surface of the manus is weakly depressed above a median ridge and rounded below. About three fourths the length of the manus, the fixed finger is weakly concave bounding a ridged occludent margin; the interdigital margin recedes in a gentle curve from above the median ridge and curves into the fixed finger. Numerous granules, finer above the ridge, crowd the outer surface.

Right propodus inner surface; the basal margin is rather more curved than the left; a depression on the lower half of the manus extends into the fixed finger; more even-sized granules tends to form oblique rows proximally.

Discussion: The basic outline of the right propodus approximates that of *Pagurus concavus* Müller, 1979, from the Badenian of Hungary, but the median ridge on *P. concavus* is stronger and the basal half is weakly concave; the carpal margin is vertical and the occludent margin of the fixed finger is cuspate and forms an angle with the interdigital margin.

Figured as *Pagurus* aff. *rakosensis* Müller, 1979 (Müller, 1996, pl. 1, fig. 3) from the Badenian of Poland, the left propodus more closely approximates that of *P. retznensis*, the occludent and basal margins are more or less parallel, but the 'step' before the interdigital margin is concave rather than abrupt. No median ridge on the manus is developed on the figured left propodus of *Pagurus rakosensis* Müller, 1979 (Müller, l984a. pl. 10, fig. 5).

Infraorder Brachyura Linnaeus, 1758

Superfamily Dromioidea De Haan, 1833

Family Dromiidae De Haan, 1833

Genus *Dromia* Weber, 1795

Type species: *Cancer pesonatus* Linnaeus, 1758 by subsequent designation ICZN, 1964 (ICZN Opinion 688).

Dromia evae sp. nov.

(Pl. 2, fig. 6)

Diagnosis: Carapace circular in outline, globose; cervical furrow deep, obtusely V-shaped and interrupted at midline, not produced laterally; branchiocardiac furrows transverse; mesogastric lobe not defined; cardiac region triangular with three obscure tubercles.

Material: Holotype, IC 653, a carapace from Unit 3.

Derivation of name: For Éva Müller for her devoted assistance

to her husband, Pál, over the years and her guidance to JSHC in the present circumstances.

Description: Carapace almost circular in outline, strongly vaulted in both longitudinal and transverse sections. There are two or three minute nodes on the short anterolateral margins and two before short, indented, transverse branchiocardiac furrows, bounded by a vague ridge to the urogastric lobe. Fairly sharp posterior angles lead to a gently concave posterior margin which is about as wide as the orbital margin and bounded by a shallow groove. The poorly preserved oblique orbitofrontal region takes up rather more than two thirds (70 %) of the carapace width; the front is narrow and weakly bilobed. The cervical furrow is deep and obtusely V-shaped across the midline; where it is interrupted, lateral parts are not developed. Corners of the rounded, tumid triangular cardiac region are thickened and there are three low granules set in an inverted triangle. Prefossil damage to the carapace gives a false impression of an elongated 'branchiocardiac furrow'.

Discussion: Although apparently similar to the considerably larger *Dromilites neogenica* Müller, 1979 (*vide* Müller, 1984b, pl. 39, fig. 1), significant differences are apparent; *D. neogenenica* has a tripartite front, only one spine between the cervical and branchiocardiac furrows and weak, straight lateral grooves separate the intestinal lobe from the cardiac region. The contemporary *Dromia eotvoesi* Müller, 1976 (*vide* Müller, 1984b, pl. 30, fig. 1), has a distinctly ovate carapace, the cervical and branchiocardiac furrows are well developed, and the regions are lobate. In both cases, conditions considered sufficiently distinct to cast doubt on the possibility of ontogenetic development.

Genus *Kerepesia* Müller, 1976

Type species: *Kerepesia viai* Müller, 1976, by monotypy.

Kerepesia viai Müller, 1976

(Pl. 4, fig. 15)

1976c. *Kerepesia* n. gen. *viai* n. sp. Müller, p. 150, 151, 155, pl. 3, figs. 1, 2, ?3, 4.

1979. *Kerepesia via* Müller; Müller, p. 274.

1984b. *Kerepesia viai* Müller; Müller, p. 64, pl. 31, figs. 5–7, pl. 32, fig. 4.

2012. *Kerepesia viai* Müller; Schweitzer, Feldmann and Karasawa, p. 30, pl. 20, fig. 2.

Material: IC 690, posterior part of a juvenile carapace, from Unit 3.

Remarks: A part cast/part decorticated carapace, about one fifth the size of the holotype, is obliquely fractured towards the left hand side, reaching the margin just above the second anterolateral 'spine'; the appearance on the figure of a more transverse fracture is illusory. The distance between the second and third 'spines' is proportional to those figured by Müller (1984a, pl. 31, fig. 5). Confined to the median section, the cervical furrow crosses the midline at an angle of 150 degrees, coincident with that of the holotype.

Hitherto, the species has been confined to the Badenian of Hungary where it has been found in, "layers formed in infralitoral environments not very close to surface. The bottom was sandy with abundant shells." (Müller, 1984a, p. 65).

Family Dynomenidae Ortmann, 1892

Subfamily Paradynomeninae Guinot, 2008

Genus *Kromtitis* Müller, 1984b

Type species: *Dromiltes koberi* Bachmayer and Tollman, 1954, by monotypy.

Kromtitis koberi (Bachmayer and Tollman, 1954)

(Pl. 2, figs. 7, 8)

1954. *Dromiltes koberi* Bachmayer and Tollman, p. 312, 313, pl. 1, figs. 2, 2a.

1984b. *Kromtitis koberi* (Bachmayer and Tollman, 1954); Müller, p. 64, pl. 31, figs. 1–4.

2012. *Kromtitis koberi* (Bachmayer and Tollman, 1954); Schweitzer, Feldmann and Karasawa, p. 33, fig. 21.4a.

Material: IC 654, IC 655 from Unit 6.

Addional materal: IC 723 carapaces from Unit three;

Remarks: The type locality is Gross-Höflein, Austria; this readily identifiable species is also known from Visegrád, Hungary, and Southern Poland (Müller, 1984b). *Kromtitis* spp. range from the Eocene to the Miocene and are coral associates (Beschin *et al*., 2007, p. 27), as are extant species of the Paradynomeninae which, according to Guinot, (2008, p. 21), "clearly are modified relics."

Superfamily Calappoidea de Haan, 1833

Family Calappidae de Haan, 1833

Subfamily Calappinae de Haan, 1833

Genus *Calappa* Weber, 1795

Type species: *Calappa granulatus* Linnaeus, 1758, by subsequent designation of Latreille (1810).

Calappa praelata Lőrenthey *in* Lőrenthey and Beurlen, 1929

(Pl. 2, fig. 9)

1929. *Calappa praelata* Lőrenthey *in* Lőrenthey and Beurlen, p. 132–133, pl. 6, fig. 3.

1984b. *Calappa praelata* Lőrenthey *in* Lőrenthey and Beurlen; Müller, p. 66, pl. 35, figs. 1, 2, 7, ?figs. 3–6, ?pl. 36 (see also for intermediate synonymy).

Material: IC 656, a plaster cast of a carapace; unit unknown.

Remarks: The carapace agrees well with that figured by Müller (1984b, pl. 35, fig. 2) with which it is of much the same size. Müller (1984b, p. 67) drew attention to the similarity of this species to *Calappa granulata* Linnaeus [*sic* = *Calappa*

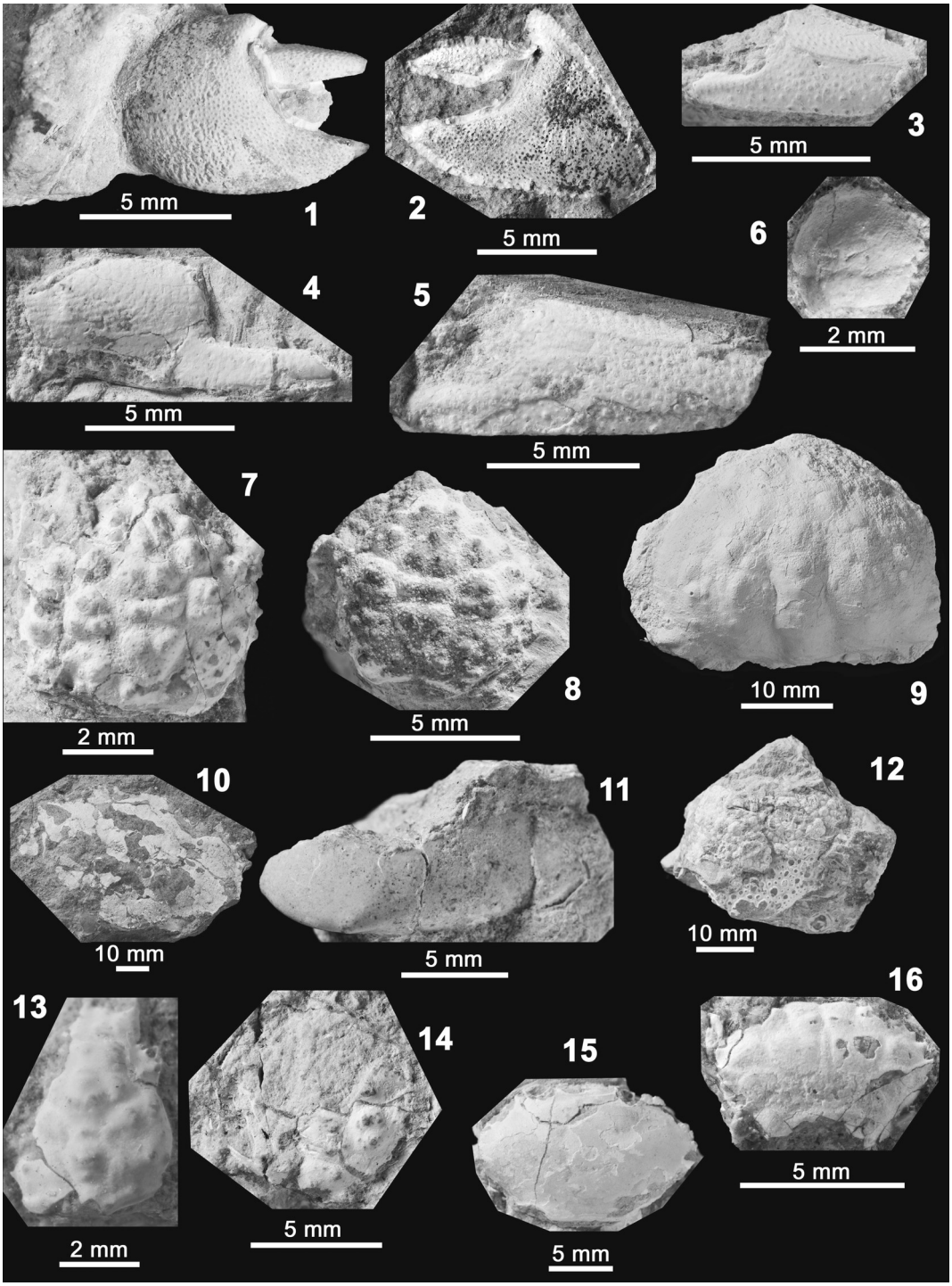

Plate 2

Figs. 1, 2. *Anapagurus miocenicus* Müller. NHM IC 649a and b. Unit unknown. 1. Internal cast of right propodus and, 2. counterpart preserving internal mould of cuticle. Figs. 3–5. *Pagurus retznensis* sp. nov. 3. Holotype NHM IC 650. Unit 3. Outer surface of left propodus. 4. Paratype. NHM IC 651. Unit 3. Interna surface of propodus. 5. NHM IC 652. Paratype. Unit unknown. Left propodus. Fig. 6. *Dromia evae* sp. nov. Holotype, NHM IC 653. Unit 3. Figs. 7, 8. *Kromtitis koberi* (Bachmayer and Tollman). 7. NHM IC 654. Unit 6. 8. NHM IC 655. Unit 6. A part cast/part decorticated carapace. Fig. 9. *Calappa praelata* Lőrenthey *in* Lőrenthey and Beurlen. NHM IC 656.Unit unknown. A plaster cast. Fig. 10. *Lobocarcinus* sp. aff. *Lobocarcinus sismondai* (von Meyer). Friebe Coll. Unit 3. Fig. 11. *Carpilius antiquus* Glaessner. NHM IC 658. Unit 3. Carapace orientated anterior to left. Fig. 12. *Daira speciosa* (Reuss). NHM IC 660. Unit 6. A fragmentary carapace. Fig. 13. *Hyastenus* sp. NHM IC 661. Unit 6. Fig. 14. Majidae gen. et sp. indet. NHM IC 662. Unit 6. Fig. 15. *Glabropilumnus nitidus* sp. nov. Holotype, NHM IC 663. Unit 3. Fig. 16. *Pilumnus* sp. aff. *Pilumnus mediterraneus* (Lőrenthey). NHM IC 644. Unit unknown.

granulata Fabricius, 1793] from which it differs in having "six big [marginal] lobes instead of four". The contempory *Calappa heberti* Brocchi differs primarily in having more numerous, regular sized surface tubercles. The species is known elsewhere from Hungary and Koryknika, Poland.

Superfamily Cancroidea Latreille, 1803
Family Cancridae Latreille, 1803
Subfamily Lobocarcininae Beulen, 1930
Genus *Lobocarcinus* Reuss, 1857

Type species: *Lobocarcinus paulinowurtembergensis* von Meyer, 1847, by monotypy.

Lobocarcinus sp. aff. *Lobocarcinus sismondai* (von Meyer, 1843)

(Pl. 2, fig. 10)

Material: Friebe Coll. A poorly preserved carapace and counterpart from an unknown unit.

Remarks: The comparatively featureless dorsal surface both resembles and falls within the growth range of *Lobocarcinus sismondai* (von Meyer, 1843) as figured by Moisette and Müller (1990, pl. 1, fig. 1, pl. 2, figs. 1, 2), from the Messinian of Oran. Readily recognisable characters of the species are the tripartite marginal spines usually separated by grooves leading a short way onto the dorsal surface, both characters being effected by preservation. A few marginal spines and basal scars on the right anterolateral margin of the Retznei specimen suggest the development of similar tripartite spines. Müller's figure (1984b, pl. 58, fig. 3) of *Cancer illyiacus* Bittner, 1883 (since synonymised with *L. sismondai)* appears to have been transversely compressed and, therefore, medially tumid; it retains a few basal scars of more or less similar appearance to those of *Lobocarcinus* sp. on the left side .

The extensive survey by Bonfglio and Donadeo (1982) of *L. sismondai*, based on carapaces from the Pliocene of Puglia, Italy, was illustrated primarily by line figures; these show a range of marginal spines varying from somewhat spike-like (fig. 7 therein), to generally moderate-sized spines, frequently multi-spinulous. The low transverse carapace profiles of *L. sismondai* figured (*op cit*. fig. 13) are also in keeping with IC 657. Müller (1984b, p. 76) drew attention to the rarity in the Paratethys of this, "wide-spread and frequent Mediterranean species known from the Miocene and Pliocene layers." C*ancer styriacus* (Bittner, 1884) from the Badenian of Austria and Hungary, also has tripartite lateral spines, but they are separated by more conspicuous grooves and the dorsal surface is rather more lobate.

Superfamily Carpilioidea Ortmann, 1893
Family Carpiliiae Ortmann, 1893
Genus *Carpilius* Leach in Desmarest, 1823

Type species: *Cancer maculatus* Linnaeus, 1758, by monotypy.

Carpilius antiquus Glaessner, 1928

(Pl. 2, fig. 11)

1928. *Carpilius antiquus* Glaessner, p. 191–193, text figs. 5, 6, pl. 3, fig. 13.

1984b. *Carpilius antiquus* Glaessner; Müller, p. 87, pl. 75, figs. 1–5. (See also for intermediate synonymy).

Material: IC 658, a carapace fragment.

Addional material: IC 725 limb fragment from Unit 3; IC 726, a limb fragment from Unit 6.

Remarks: The small carapace fragment is recognisable from the characteristic spine at the lateral angle. First known from Austria, the species was reported from several Badenian localities in Hungary and southern Poland, as well as the Langhian of Olédola, Spain (Müller, 1894b, 1993, 1996).

Superfamily Dairoidea Serène, 1965
Family Dairidae, Serène, 1965
Genus *Daira* De Haan, 1833

Type species: *Cancer perlatus* Herbst, 1790, by subsequent desination of ICZN. (ICZN Opinion 73, Direction 78).

Daira speciosa (Reuss, 1871)

(Pl. 2, fig. 12)

1871. *Phymatocarcinus speciosus* Reuss, 1871, p. 326, figs. 1–4.

1984b. *Daira speciosa* (Reuss, 1871); Müller, p. 90, pl. 79, figs. 1–6, pl. 80, figs. 1, 2. (See also for intermediate synonymy).

Material: IC 660, a carapace fragment from Unit 3.

Addional material, IC 727–731, five fragments from Unit 3; IC 732–735, three carapace fragments, unit unknown.

Remarks: The coarse granular ornament of this relatively common species is unmistakable; the large size of the species being a contributary factor to the fragmentary preservation. A widespread species, it is also known from the Badenian of Hungary, Poland and near Ternopil, Ukraine, the Langhian of Olédola, Spain and it is also common in the Badenian of Russia and Messinian of Oran (Müller, 1984b, p. 90).

Superfamily Majoidea Samouelle, 1819
Family Epialtidae MacLeay, 1838
Subfamily Pisinae Dana, 1851
Genus *Hyastenus* White, 1847

Type species: *Cancer sebae* White, 1847, by monotypy.

Hyastenus sp.

(Pl. 2, fig. 13)

Material: IC 661, a carapace lacking rostral horns from Unit 6.

Description: The carapace is subtriangular in outline, a little longer than wide, moderately curved transversely, longitudinally highest about the mesogastric lobe. Details of the front not preserved. There is a low tubercle between straight, rounded ridges extending from the base of the (absent)

rostral horns. Lateral to these, a curved frontal margin, terminating in a sharp spine forming the eave of the first orbital spine, terminates in a notch. The upper orbital margin has two minute anterior spines and another at the posteror angle. Medially parallel lateral margins are excavated before rounded posterolateral margins. The posterior margin is medially produced and bounded by a groove.

The broad, deep cervical furrow is straight across the midline, where there is a pair of gastric pits against the anterior edge, it then runs straight towards the orbital margin. Tumid median lobes are well defined. A tubercle on the anteromesogastric process is followed by a small one, immediately before a larger one on the ovate mesogastric lobe between vaguely hatchured ridges. There is a single tubercle on the depressed urogastric lobe, three in an inverted triangle on the cardiac lobe and one on the produced intestinal lobe. Each protogastric lobe has a small cluster of tubercles and a quadrate pattern of low tubercles is formed by one, marginal on each epibranchial and mesobranchial lobes and one, in line on the metabranchial lobes.

Discussion: In basic outline and general distribution of the tubercles the present specimen shares much in common with *Hyastenus* sp. of Karasawa (1991) from the Akeyo Formation of the early Middle Miocene of Japan and with *Hyastenus* sp. of Collins *in* Collins *et al.* (2003) from the Sandakan Formation, Middle to Upper Miocene of Sandakan, Sabah, which differs little more than the cervical furrow being angled across the midline rather than straight—a difference seen as being within the bounds of intraspecific variation, seen in the allied genus *Microphrys* Milne Edwards 1851 (*vide* Rathbun, 1925, pls. 174–177). The rostral horns are preserved with *Hyastenus corallinus* De Angeli and Beschin, 2008, from the Oligocene of Vizenza, Italy, which otherwise differs in having a greater number of secondary tubercles.

Majidae gen. et sp. indet.

(Pl. 2, fig. 14)

Material: IC 662, a fragmentary carapace from Unit 6.

Remarks: The carapace fragment comprises the right branchial region including the course of the cervical furrow converging to the midline. The boldly rounded posterolateral margin, becoming indented before a narrow rounded posterior margin, has much in common with that of *Schizophrys visagradensis* Müller, 1993, from the Langhian of Olédola, which has a similar cluster of tubercles on the cardiac rergion. However, as preserved, there appears to be additional median tubercles anterior to the cervical furrow. The constricted posterior margin distinguishes it from *Hyastenus* sp.

Superfamily Pilumnoidea Samouelle, 1819

Family Pilumnidae Samouelle, 1819

Subfamily Pilumninae Samouelle, 1819

Genus *Glabropilumnus* Balss, 1933

Type species: *Xantho dispar* Dana, 1852 by original designation.

Glabropilumnus nitidus sp. nov.

(Pl. 2, fig. 15)

Diagnosis: Carapace subhexagonal, wider than long; orbitofrontal margin about three fourths carapace width; anterolateral margins with five or six nodes; weakly rounded posterolateral angles leading to shallow coxigeal incisions almost in line with posterior margin; cardiac region weakly tumid.

Derivation of name: Referring to the glossy aspect of the dorsal surface.

Material: Holotype. IC 663, a carapace lacking front, from Unit 3.

Description: The carapace is subhexagonal in outline, the length being about 70% of the width; transversely and longitudinaly moderately convex, rather more steeply down-turned in the anterior third. Taking up about 78% of the width the damaged orbitofrontal margin is thin and weakly raised. The anterolateral margins are a little shorter than the posterolateral margins, basal scars indicate five or six evenly spaced nodes increasing in size to the largest at the lateral angle; lateral angles are broadly rounded. Comparatively wide coaxigeal incisions are almost in line with the weakly convex posterior margin which is and bounded by a fine rime and groove. Shallow hachuring defines the distal margin of a weakly tumid, pentagonal cardiac region on an otherwise smooth dorsal surface.

Remarks: *Glabropilumnus nitidus* agrees by and large with *Glabropilumnus sogensis* De Angeli and Beschin, 2008, from the Oligocene of Vicenza, Italy, which differs primarily in having a granular dorsal surface. The carapace outline of *Glabropilumnus fossatus* Müller, 1996, Middle Badenian, of Grobie, Poland, to which '*Glabropilumnus*' Müller (1984b, p. 91, figs. 1–3) from the lower Badenian of Törökmező, Hungary, was synonymised, has a rather more rounded carapace outline with vague epigastric lobes and an outlined anteromesogastric process.

Genus *Pilumnus* Leach, 1815

Type species: *Cancer hirtellus* Linnaeus, 1758, by monotypy.

Pilumnus sp. aff. *Pilumnus mediterraneus* (Lőrenthey, 1897)

(Pl. 2, fig. 16; Pl. 4, fig. 11)

1897. *Pilodius mediterraneus* Lőrenthey, p. 160, 167, 169.

1976. *Pilumnus mediterraneus* (Lőrenthey); Müller, p. 150.

1984b. *Pilumnus mediterraneus* (Lőrenthey); Müller, p. 98, pl. 87, figs. 2–5. (See also for intermediate synonymy.)

Material: IC 664, IC 692, two carapaces from Unit 3.

Additional material: IC 736, 737. Two carapaces from Unit

3; IC 739–741, three carapaces, unit unknown.

Remarks: All the fragments are of juveniles ranging in carapace width from *c*. 0.4 mm – *c*. 10 mm; they conform to the smaller specimens figured by Müller (1984b). Even within this range there is a tendency for the lobes to become less distinct as growth advances. The larger carapace from Unit 3 (W *c*. 7.0 mm) agrees closely with specimens of similar size from Diosd, Hungary, differing little more than having a denser, more regular surface granulation. Only a little larger (W *c*. 8.0 mm), *Pilumnus olivellai* Müller, 1993, from the Langhian of Olédola, Spain, has less developed lobes and a smooth dorsal surface.

Müller (1984b) considered this species to be, "probably the most common crab in the Badenian ...", seemingly "in all types of biotypes studied.", yet recorded it only from Hungarian exposures. In 1996 Müller extended the range to southern Poland and it has since been tentatively recorded (De Angeli, *et al.,* 2011) from the early Messinian of Aquabona, Toscana, Italy.

Referring to Zaraquiey Alvarez (1968) and Müller, (1984b, 94), considered *P. mediterraneus* to be extremely close to the Recent Mediterranean *P. hirtellus* and *Pilumnus spinifer* H. Milne Edwards, 1834.

Superfamily Portunoidea Rafinesque, 1815
Family Portunidae Rafinesque, 1815
Subfamily Portuninae Rafinesque, 1815
Genus *Portunus* Weber, 1795

Type species: *Cancer pelagicus* Linnaeus, 1758, by subsequent designation of Rathbun (1926).

Portunus muelleri sp. nov.

(Pl. 3, figs. 1, 2)

Diagnosis: Carapace longer than wide; seven anterolateral spines arranged wide and narrow, with a stronger one at the lateral angle; orbital margin about two thirds total carapace width; cervical furrow obtusely V-shaped across the midline, turns sharply forward and, bounded by an epi/mesobranchial ridge curves to the margin; protogastric and median lobes tumid.

Derivation of name: In recognition of Pál Müller, Budapest, for his outstanding contribution to our knowledge of Miocene coral/reefal crabs.

Material: Holotype IC 665, a carapace and paratype, IC 666, unit unknown.

Description: The carapace is subhexagonal in outline, about one third longer than wide; almost flat longitudinally, the median lobes are tumid in transverse section. The produced front takes up about half the straight, poorly preserved orbitofrontal margin which occupies about two thirds of the total carapace width. Thin, raised upper orbital margins have two, obscure, infilled notches and terminate in a sharp spine before seven equally sharp spines, alternating wide and narrow, on the anterolateral margins, there is a sharp spine behind the cervical furrow. Straight posterolateral margins converge to sharp posterolateral angles and a shallow embayment for the 5th limbs descends to a weakly rimmed, convex posterior margin, about as wide as the front. Broadly V-shaped behind the mesogastric lobe and a little more than half distant from the front, the cervical furrow turns sharply forward at the mesogastric angles before curving out towards the margin; the outer course bounded by narrow, tumid confluent epi- and mesobranchial lobes. A narrow depressed area extends behind the front; tumid protogastric lobes are subtriangular and the hepatic lobes are depressed. There is an inconspicuous node at the base of the anteromesogastric lobe. A narrow subrectangular lobe is depressed between a subtriangular mesogastric lobe and the rounded-triangular cardiac region, is as wide as the mesogastric lobe. The metabranchial lobes are weakly tumid basi-medially. The dorsal surface is smooth.

Discussion: This species closely resembles several Recent species formerly contained in the now synonymised genus *Achelous*, and with the arrangement of the anterolateral spines, particularly to *Portunus angustus* Rathbun, 1898, There can be no confusion with this species with *Portunus montpeliensis*, the only other species known from the Badenian, Austria, or *Portunus neogenicus* Müller, 1979a, from Budapest, Hungary. Any ontological relationship can be ruled out.

Subfamily Polybiinae Ortmann, 1893
Genus *Liocarcinus* Stimpson, 1871

Type species: *Portunus holsatus* Fabricius, 1798, by original designation.

Liocarcinus sp. aff. *Liocarcinus rakosensis* Lőrenthey *in* Lőrenthey and Beurlen, 1929

(Pl. 3, figs. 3, 5)

1929. *Liocarcinus rakosensis* Lőrenthey *in* Lőrenthey and Beurlen, p. 172–173, pl. 12, fig. 1.

1984a. *Liocarcinus rakosensis* Lőrenthey *in* Lőrenthey and Beurlen; Müller, p. 83, pl. 69, figs. 2–6, pl. 70, figs. 1–8. [See also for intermediate synonymy].

Material: IC 691, a plaster cast of a carapace, unit unknown; IC 667, an attributed right propodus, Unit 3.

Remarks: While closely resembling the figured specimens (Müller, 1984a, pl. 69, figs. 2–6) the cast has a more pronounced protogastric ridge and a much reduced urogastric lobe. Further specimens are needed before finite conclusions can be drawn.

A juvenile right propodus, in the present collection (Pl. 3, fig. 3), although only about one third the size, agrees well with the specimen figured by Müller (1984b, pl. 70, fig. 1) and may safely be attributed to the cast-carapace form.

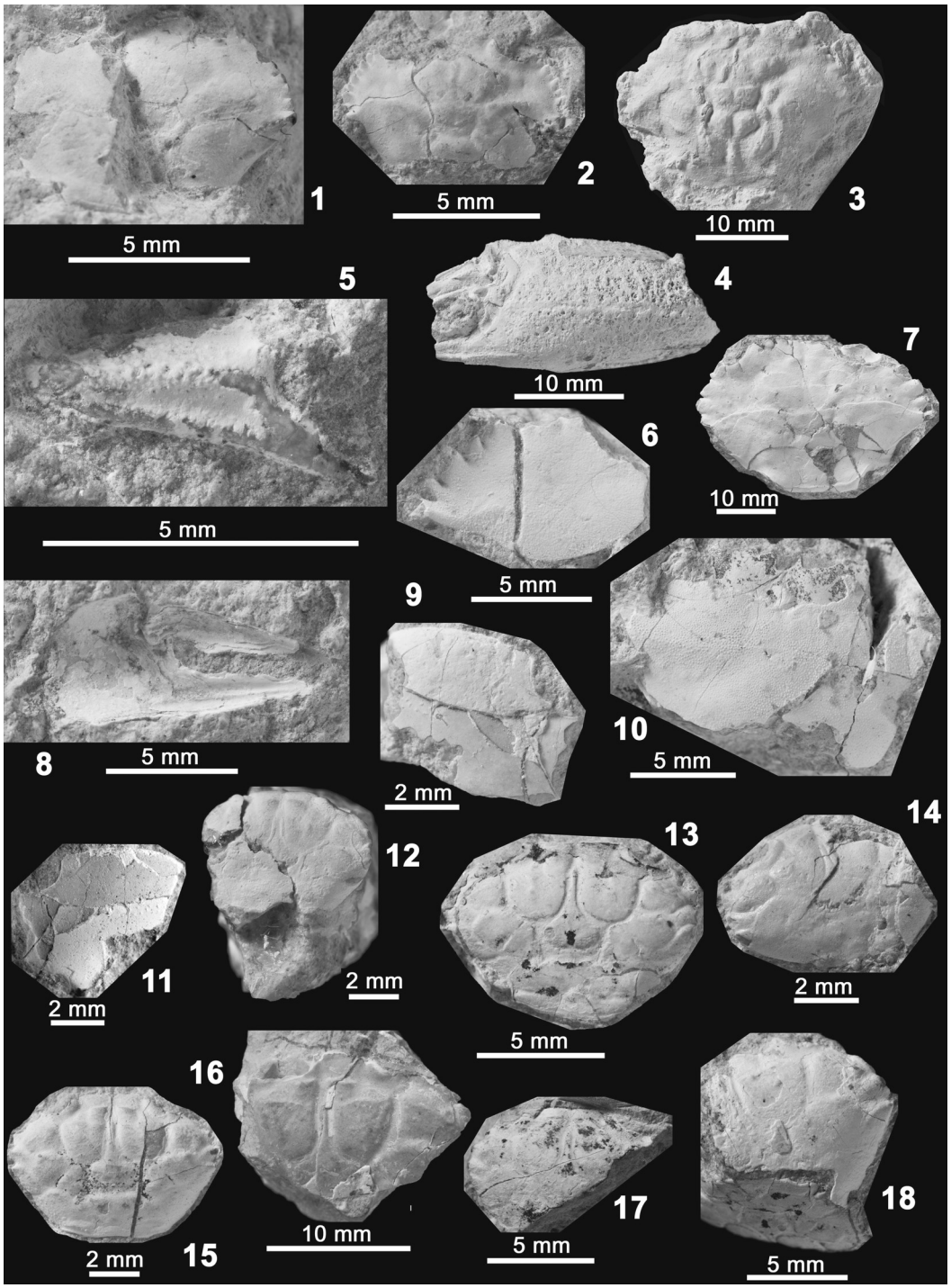

Plate 3

Figs. 1, 2. *Portunus muelleri* sp. nov. Paratype NHM IC 656. Unit unknown . 2. Holotype NHM IC 655. Unit unknown. Figs. 3, 5. *Liocarcinus* sp. aff. *Liocarcinus rakosensis* Lőrenthey *in* Lőrenthey and Beurlen. 3. NHM IC 657. Unit unknown. A juvenile right propodus. 5. NHM IC 691. Unit unknown. A plaster cast. Figs. 4, 6, 7, 8, 10. *Charybdis fragilis* (Müller). 4. Friebe Coll. Zone unknown. Internal cast of left propodus. 6. NHM IC 668. Unit 6. A fragmentrary carapace. 7. Freibe Coll. Carapace. Unit unknown. 8. NHM IC 669, Unit unknown. Internal mould of left propodus. 10. NHM IC 659. Unit 6. fragment of ?right branchiostegite. Figs. 9, 11. *Eomaldivia*? *friebei* sp. nov. 9. Paratype NHM IC 670. Unit 3. frontal fragment of a carapace. Holotype NHM IC 671. Unit unit unknown. Frontal fragment of a carapace. Figs. 12, 13, 15, 16. *Panopeus wroni* Müller. 12, 13, NHM IC 673, IC 672. Unit 6. 15, 16. NHM IC 674, IC 675. Unit unknown. Fig. 14. *Chlorodiella juglans* Müller. NHM IC 676. Unit unknown. Figs. 17, 18. *Chlorodiella loczyi* Müller. 17. NHM IC 678. Unit 6. 18. NHM IC 677a from Unit 6, .Carapace in two parts, association not immediately recognized; fig. 18 is left side of Pl. 4, fig. 1 and overlays Portunus wroni, Pl. 3, fig. 13.

Subfamily Thalamitinae Paul'son, 1875

Genus *Charybdis* De Haan, 1833

Type species: *Cancer sexdentatus* Herbst, 1783, by subsequent designation of Glaessner (1929). [ICZN Opinion 121].

Charybdis fragilis (Müller, 1979)

(Pl. 3, figs. 4, 6, 7, 8, 10)

1979a. *Thalamita fragilis* Müller, p. 274, 281, 289, pl. 17, figs. 1–3.

1984b. *Thalamita fragilis* Müller, Müller, p. 81, pl. 65, figs. 1, 2, 4, 5, ?pl. 65, fig. 3, pl. 66, figs. 1–7. [See also for intermediate synonomy.]

2008. *Charybdis fragilis* (Müller); Karasawa *et al*., p. 109.

Material: A carapace and left chela, unit unknown, Friebe Coll.: IC 668, a carapace fragment, Unit 6: IC 669, internal mould of left propodus from Unit 6; carapace fragment from Unit 6: IC 659, fragment of ?right branchiostegite.

Remarks: The carapace agrees in all respects with specimens figured by Müller (1984b, pl. 65, figs. 1–5). As preserved, the lateral spines of the present material show no indication of the bifurcated, or intercalcated spines seen in the essentially similar *Charybdis mathiasi* Müller 1879 (*vide* 1984b, pl. 63, figs. 1–4). No left chela was figured by Müller (1984b), That figured herein (Pl. 3, fig. 10), an internal cast, agrees with that of *C. mathiasi* Müller (1984b, pl. 64, figs. 1–5), whereas a proportionally lighter left chela (Pl. 3, fig. 8), preserved as a mould, corresponding with Müller's figure (*op cit*., pl. 66, figs. 1, 2) of a right chela of *C. fragilis,* may indicate sexual dimorphism. IC 653 (Pl. 3, fig. 10) is a presumed left branchiostegite with, apically, a trace of the grooved and rimmed pleural suture.

Superfamily Trapezioidea Miers, 1886

Family Trapeziidae Miers, 1886

Subfamily Trapeziine Miers, 1886

Genus *Eomaldivia* Müller and Collins, 1991

Type species: *Eomaldivia pannonica* Müller and Collins, 1991, by original designation.

Eomaldivia? friebei sp. nov.

(Pl. 3, figs. 9, 11)

Diagnosis: Carapace with smoothly rounded front bounded by a thin groove extending round orbits; inner orbital spine sharp.

Derivation of name: The species is named for Dr. J. G. Friebe, Dornbirn, Austria, Müller's companion in the field and erstwhile co-author, who also contributed largely to the stratigraphic part of this work.

Material: Holotype IC 670, a frontal fragment from Unit 3; paratype IC 671, a frontal fragment of carapace, unit unknown.

Description: A smoothly rounded front is bounded by a thin ridge continuing round the orbital margin, more obvious on IC 670, and sharp inner orbital angles almost vertically inclined into weakly oblique, ovate orbital margins.

Remarks: The front of *Trapezia glaessneri* Müller, 1976 (*vide* Müller 1984a, pl. 85, figs. 1–4) from the Hungarian Badenian, differs in being "undulate [with] three blunt nodes on each side" (Müller, 1984a, p. 92)—the same number as on *Trapezia* sp. in Karasawa (1993, p. 66), from the Middle Miocene, Megami Limestone, Japan. The smoothly rounded front appears to have a greater affinity to that of *Eomaldivia* Müller and Collins, 1991, founded on two species from the Priabonian, Szépvölgy Limestone of Hungary. Of these, *Eomaldivia trispinosa* Müller and Collins, 1991, has almost coincident inner orbital angles and orbital margins. Both species of *Eomaldivia* are distinguished by spinose anterolateral margins. Lack of evidence of these in the present material precludes full specific status. Both the stratigraphic and geographic range of the genus is tentatively extended.

Müller (2006, p. 44), described a new species of grapsoid, *Metopograpsus badensis*, from the Badenian of Örz Vezér tere, Budapest, illustrated by two figures (*op. cit*., pl. 2, figs, 5, ?6); of these, the tentatively assigned fig. ?6, a left anterior quadrant of a carapace agrees in all respects with *Trapezia glaessneri*. Therefore, the specimen figured as ?6, is here transferred to *Trapezia glaessneri.*

Superfamily Xanthoidea MacLeay, 1838

Family Panopeidae Ortmann, 1893

Subfamily Panopiinae Ortmann, 1893

Genus *Panopeus* H. Milne Edwards, 1834

Type species: Panopeus herbstii H. Milne Edwards, 1834, by subsequent designation of ICZN [Opinion 1282].

Panopeus wroni Müller, 1984b

(Pl. 3, figs. 12, 13, 15, 16)

1984b. *Panopeus wroni* Müller, p. 91, pl. 81, figs. 5, 6, pl. 82, figs. 1–4, pl. 84, figs. 1–4.

Material: IC 672, IC 673 two carapaces from Unit 6; IC 674, IC 675, two carapaces, unit unknown.

Additional material: IC 742–746, five carapace fragments from Unit 3.

Remarks: The specimens fall readily into the degree of variation of those figured by Müller, 1984b, from Gross-Höflein, the type locality. There appears to be a degree of acceptable surface variation amongst the figured species, which range between approximately 0.8 mm and 28.0 mm in carapace width, no doubt accounted for by ontogeny and preservation. The species is also known from several localities in Hungary, southern Poland and near Ternopil, Ukraine.

Family Xanthidae MacLeay, 1838

Subfamily Chlorodiellinae Ng and Holtuis, 2007

Genus *Chlorodiella* Rathbun, 1897

Type species: *Chlorodius niger* (Forskål, 1775) by subsequent designation of ICZN (pending).

Chlorodiella juglans Müller, 1984b

(Pl. 3. fig. 14)

1984b. *Chlorodiella juglans* Müller, p. 89, pl. 78, figs. 1–4.

Material: IC 676, a carapace, unit unknown.

Remarks: The suboctagonal carapace with four blunt spines on the anterolateal margins, large orbits and wide orbitofrontal margin, together with high, rounded epigastic, protogastric and hepatic ridges, distinguishes *C. juglans* from other Badenian chlorodiellids. The species has also been recorded from near Ternopil, Ukraine (Ossó and Stallenny, 2012).

Chlorodiella loczyi Müller, 1984b

(Pl. 3, fig. 18; Pl. 4, figs. 1, 2)

1984b. *Chlorodiella loczyi* Müller, p. 89, pl. 78, figs. 1–4.

Material: IC 677a, b, a carapace; IC 678 both from Unit 6.

Additional material: IC 747–750, four carapace fragments from Unit 6.

Remarks: The carapaces are rather more ovoid than the previous species, further differentiated by lines of pits across the frontal region. More sharply preserved than the figured type specimens, the internal cast of the dorsal surface of the smaller Retznei specimens is finely granulate. This is the first record outside the type locality, Rákos, Budapest, for this species.

NB. Carapace fragments in Pl. 3, fig. 18 and Pl. 4, fig. 1, belong to the same individual; the former fragment overlays *Panopeus wroni*, Pl. 3, fig. 13.

Chlorodiella mediterranea (Lőrenthey *in* Lőrenthey and Beurlen, 1929)

(Pl. 4, figs. 3, 4)

1929. *Zozymus mediterraneus* Lőrenthey, *in* Lőrenthey and Beurlen, p. 34, 251, 216, pl. 11, fig. 9.

1984b. *Chlorodiella mediterranea* (Lőrenthey, *in* Lőrenthey and Beurlen); Müller, 88, pl. 76, figs. 1–6, pl. 77, figs. 1–4. (see also for intermediate synonymy).

1996. *Chlorodiella mediterranea* (Lőrenthey, *in* Lőrenthey and Beurlen; Müller, p. 6.

Material: IC 679–680, two fragmentary carapaces from Unit 6.

Additional material: IC 751–753, three carapaces, unit unknown.

Remarks: The elliptical carapace outline and generally weakly defined regions serve to distinguish this common species from other Badenian members of the genus. It has previously been recorded from Hungary, Gross Höflein, Austria, the Holy Cross Mountains, Poland, and Olédola, Spain (Müller, 1996).

Chlorodiella tetenyensis Müller, 1984b

(Pl. 4, figs. 5, 6)

1984b. *Chlorodiella mediterranea tetenyensis* Müller, p. 88, pl. 77, figs. 5–7.

1993. *Chorodiella* cf. *mediterranea tetenyensis* Müller; Müller, p. 19.

Material: IC 681, 682, two fragmentary carapaces from Unit 3.

Additional material: IC 754–756, three fragmentary carapaces from an unknown unit.

Remarks: Müller's notes clearly indicated that this species be raised to specific status. A stronger ornament, derived largely from stronger ridges on the epigastric, hepatic and epibranchial lobes, distinguishes this species from *C. mediterranea* Müller (1984b, p. 88) stated that while the two species are found together, transitional forms are rare and clearly separable. Originally described from Rákos, Budapest, the (sub)species was recorded, as *Chlorodiella* cf. *mediterranea* (Lőrenthey) *tetenyensis*, from the Langhian of Olédola, Spain (Müller, 1993).

Genus *Pilodius* Dana, 1852

Type species: *Chlorodius pilumnoides* White, 1847, by subsequet designation of Forest and Guinot (1961).

Pilodius vulgaris (Glaessner, 1928)

(Pl. 4, figs. 7, 8)

1984b. *Pilodius vulgaris* (Glaessner, 1928); Müller, p. 91, pl. 83, figs. 5, 6, pl. 84, figs, 1–4.

1993 *Pilodius vulgaris* (Glaessner, 1928); Müller, p. 20, fig. 10E. (see also for previous taxonomy).

Material: IC 683, a juvenile carapace from Unit 3, IC 684, a carapace from Unit 6.

Additional material: IC 757–759, three carapace from Unit 6.

Remarks: The involved taxononmic listing of this species is explained by Müller (1974). The present carapaces agree with those figured by Müller (1984b) from Hungary and from the Langhian of Olédola, Spain. The hepatic lobes of the smallest carapace (width 0.3 mm, IC XXX) are only vaguely divided. The prominent nodes on the cardiac region are a particularly noticeable character, already well advanced in a juvenile (W *c.* 1.7 mm) and readily distinguish the species from *Actaea turcocampetris* Müller (1984b).

Subfamily Xanthinae MacLeay, 1838

Genus *Xantho* Leach, 1814

Type species: *Cancer incisus* Leach, 1814, by monotypy. (ICZNOpinion 423).

Xantho moldavicus (Yanakevich, 1977)

(Pl. 4, figs. 9, 10, 12)

1976. *Xantho moldavicus* Yanakevich, p. 80, 81.

1984b. *Xantho moldavicus* Yanakevich; Müller, p. 92, pl.85, figs. 5–8, pl. 86, figs. 1–5, pl. 87, fig. 1.

1991. *Xanrhotho moldavicus* Yanakevich; Müller, p. 20, fig. 10A, B.

1996. *Xantho moldavicus* Yanakevich; Müller, p. 11, pl. 2, fig. 9.

2011. *Xantho moldavicus* Yanakevich; De Angeli *et al.,* p. 115, fig. 7.

Material: IC 685, carapace from Unit 3; IC 686, a carapace

from Unit 6; IC 687, a carapace, unit unknown.

Additional material: IC 760–763, four carapaces from an unknown unit.

Remarks: In his remarks on previously recorded specimens, Müller (1984b, p. 93) was of the opinion that the species was subject to variants resulting from intermediate forms. Later, (1993, p. 20), he stated that some differences may be individual, but "may be of some taxonomic significance as well", and (in 1996, p. 11), he observed that among the rich assemblage from Poland "there was a continuous transition between the almost smooth and the decorticated carapaces. This dcortication consists of step-like ridges crowded near the frontal and the anterolateral margins, but may be quite obsolete in some specimens." Although largely fragmentary, it is evident that similar forms occur in the present material. The species has been recorded from the Badenian of Ukraine, and tentatively recorded from the Langhian of Olédola (Müller, 1996) and the early Messinian of Toscana, Italy (De Angeli, *et al*. 2011).

Subfamily unplaced

Genus *Haydnella* Müller, 1984b

Type species: *Haydnella steiningeri* Müller, 1984b, by monotypy.

Haydnella steiningeri Müller, 1984b

(Pl. 4, figs. 13, 14)

Material: IC 688, a carapace from unit 6, IC 689, a carapace, unit unkown.

Additional material: IC 764–767, four carapaces from Unit 6.

Remarks: Already well known from Hungarian and other Austrian exposures, the distribution elsewhere includes Grobie, southern Poland. The only well preserved Retznei specimen comes from an unknown unit; although less profusely granulated it agrees well with figured carapaces in Müller (1984 b); the comparatively wide cardiac region is a useful diagnostic character. Apart from marginally extending the geographic range of the species, the new material does little to extend the ecological conclusions reached by Müller (1984b). It has recently been tentatively recorded from the Messinian of Aquabona, Toscana, Italy (De Angeli *et al*., 2011).

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Table 1.

Crabs from the Badenian of Retznei, Austria, with distribution of firm and/or tentative recordings, and occurrences elsewhere.	**Retznei**			**Hungary**	**Poland**	**Austria – other localities**	**Other localities**
	Units						
	3	**6**	**?**				
"*Callianassa*" aff. "*Callianassa*" *sismondae* A. Milne-Edwards, 1860			+		+		
"*Callianassa*"*almerai* Müller, 1993		+		+	+	+	
Galathea. weinfuerteri Backmeyer, 1950	+	+	+	+	+	+	I U
Petrolisthes haydni Müller, 1984b	+	+	+	+	+	+	
Pisidia viai Müller, 1984	+		+	+	+		O G P
Pisidia? *subnodosa* sp. nov.			+				
Dardarnus hungaricus Lőrenthey, 1929			+	+			O
Anapagurus miocenicus Müller, 1977			+	+			
Pagurus retznensis sp nov.	+		+				
Dromia evae sp. nov.	+						
Kerepesia viai Müller, 1976	+						
Kromtitis koberi (Bachmayer &Tollman, 1954)	+	+	+	+	+	+	
Calappa praelata Lőrenthey 1929			+				
Lobocarcinus sp. aff. *L. sismondai* (von Meyer, 1843)	+						
Carpilius antiquus Glaessner, 1928	+	+		+	+	+	O
Daira speciosa (Reuss, 1871)	+	+	+	+	+		NROU
Hyastenus sp.		+					
Majidae gen. et sp. indet.		+					
Glabropilumnus nitidus sp. nov.	+						
Pilumnus aff *mediterraneus* (Lőrenthey, 1877)	+		+	+		+	A O
Portunus muelleri sp. nov.			+				
Liocarcinus aff *rakosensis* Lőrenthey, 1929	+						
Charybdis fragilis (Müller, 1984b)							
Eomaldivia friebei sp. nov.	+		+				
Panopeus wroni Müller, 1984b		+	+	+	+	+	U
Chlorodiella juglans Müller 1984b			+	+			U
Chlorodiella loczyi Müller, 1984b	+	+	+	+			
Chlorodiella mediterranea (Lőrenthey, 1929)			+	+			
Chlorodiella tetenyensis Müller, 1984b	+		+	+			O
Pilodius vulgaris (Glaessner, 1928)	+	+	+	+			O
Xantho moldavicus (Yanakevich, 1977)	+	+	+	+	+		A O U
Haydnella steiningeri Müller, 1984b		+	+	+	+		A O
Xantho moldavicus (Yanakevich, 1977)							A O U

A Messinian, Italy; **G** Messinian Greece; **N** Messinian, Oran; **O** Langhian, Spain;
P Messinian, Spain; **R** Badenian, Russia; **I** Oligocene, Italy; **U** Badenian, Ukraine

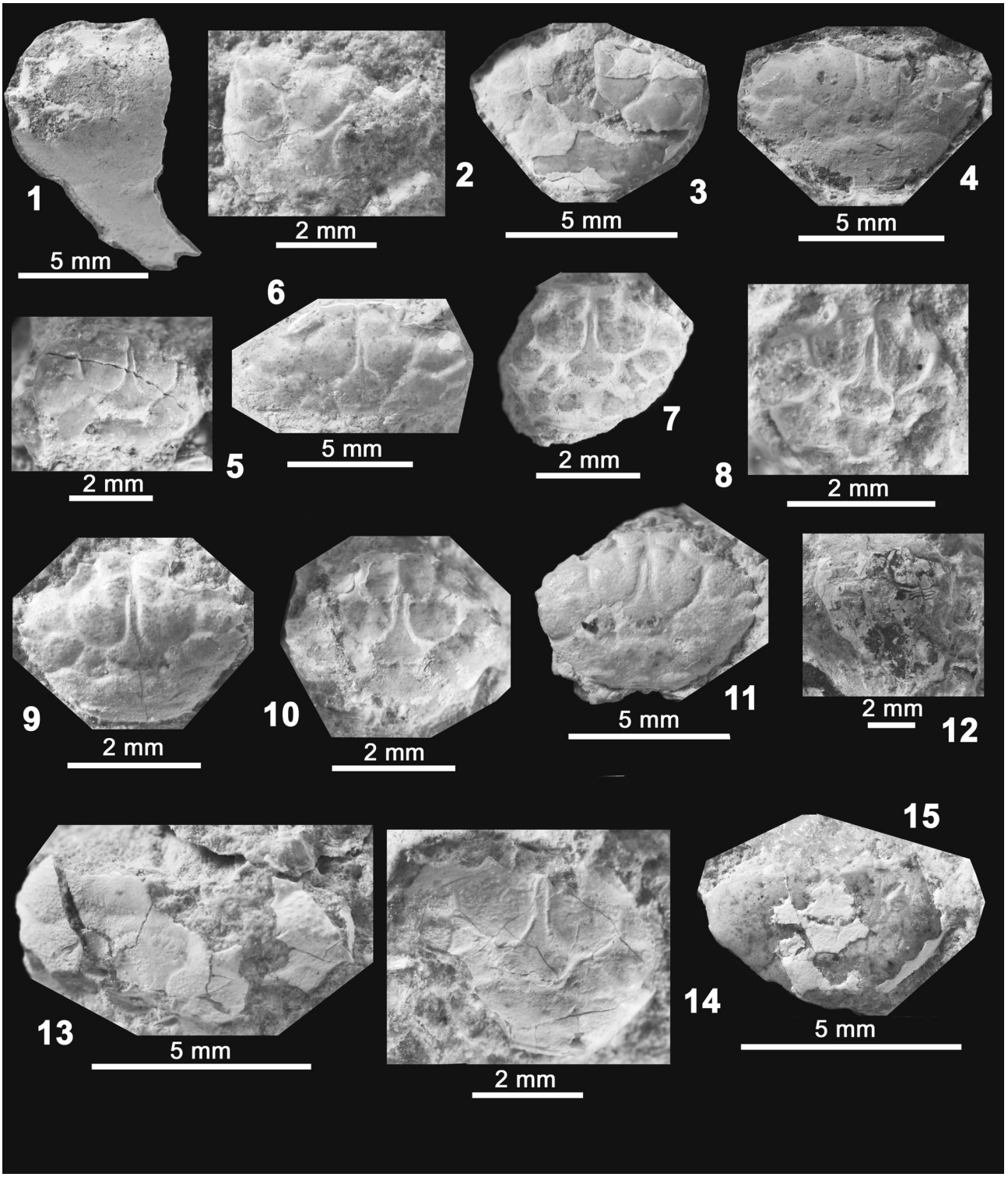

Plate 4

Figs. 1, 2. *Chlorodiella loczyi* Müller. 1. NHM IC 677b. Unit 6. 2. NHM IC 6780 Unit 6. Figs. 3, 4. *Chlorodiella mediterranea* (Lőrenthey *in* Lőrenthey and Beurlen). NHM IC 679, 680. Unit 6. Figs. 5, 6. *Chlorodiella tetenyensis* Müller. NHM IC 681, 682. Unit 3. Figs. 7, 8. *Pilodius vulgaris* (Glaessner). 7. NHM IC 683. Unit 3. 8. NHM IC 684. Unit 6. Figs. 9. 10, 12. *Xantho moldavicus* (Yanakevich). 9. NHM IC 686. Unit 6. 10. NHM IC 685. Unit 3. NHM IC 687. Unit unknown. Fig. 11. *Pilumnus mediterraeneus* Lőenthey, 1897. HMN IC 692. Unit 3. Figs. 13, 14. *Hydnella steiningeri* Müller. 13. NHM IC 688. Unit unknown. 14. NHM IC 689. Unit 6. Fig. 15. *Kerepesia viai* Müller. NHM IC 690. Unit 3.

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