GEOLOGIJA *60/1*, 77–85, Ljubljana 2017
https://doi.org/10.5474/geologija.2017.006

Early Miocene decapod *Retropluma slovenica* Gašparič & Hyžný, 2014 from Govce beds of Tunjice Hills (Central Slovenia)

Spodnjemiocenska rakovica *Retropluma slovenica* Gašparič & Hyžný, 2014 iz govških plasti Tunjiškega gričevja

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Prejeto / Received 5. 10. 2016; Sprejeto / Accepted 1. 3. 2017; Objavljeno na spletu / Published online 9.6.2017

Key words: Decapoda, Miocene, Govce beds, Central Paratethys, Slovenia
Ključne besede: deseteronožci, miocen, govške plasti, Centralna Paratetida, Slovenija

Abstract

Increasing reports of genus *Retropluma* Gill, 1894 from the siliciclastic sediments of South-East Europe demonstrate the abundance and preferred habitat of this genus in Miocene seas of Central Paratethys. In the present paper we report new specimens of decapod *Retropluma slovenica* Gašparič & Hyžný, 2014, which extend the known palaeogeographic and stratigraphic distribution of the species to the western borders of Slovenian Basin of the Central Paratethys. The described specimens originate from the Early Miocene locality of Rovček in the Tunjice Hills in Slovenia and exhibit associated preservation, characteristic for endobenthic infaunal mode of living.

Izvleček

Vse več najdb rakovice rodu *Retropluma* Gill, 1894 v klastičnih kamninah jugovzhodne Evrope kaže na to, da so bile v miocenskem morju Paratetide pogostejše kot smo doslej predvidevali. V članku predstavljamo nove najdbe rakovice *Retropluma slovenica* Gašparič & Hyžný, 2014, ki dopolnjujejo naše poznavanje paleogeografske in stratigrafske razširjenosti vrste do najbolj zahodnih delov Slovenskega bazena v miocenskem morju Centralne Paratetide. Opisani so primerki iz spodnjemiocenskih govških plasti iz nahajališča Rovček v Tunjiškem gričevju. Primerki so ohranjeni s povezanimi okončinami, kar je značilno za rakovice, ki so se vkopavale v podlago.

Introduction

The he rich palaeontological diversity of Tunjice Hills is known already from the early 19th century. Most fossiliferous strata in the region are Early and Middle Miocene beds, which were investigated by Austro-Hungarian geologists and amateur naturalists of the era (Fuchs, 1875; Hilber, 1888). One of most important researchers of the region was a local priest Simon Robič who collected fossils in his daily walks through the woods and creeks of Tunjice Hills (Žalohar & Hitij, 2014). His collection, stored in Natural History Museum of Slovenia consists of about 135 fossil specimens, among others also fossil crabs *Tasadia carniolica* (Bittner 1884) from *locus typicus* within Laško Formation beds in Košiše, which are common fossils in the region. Despite frequented finds of *T. carniolica* in Middle Miocene layers of Tunjice Hills, other occurrences of fossil decapods are unusually rare. The oldest are the remains of crabs from Early Miocene beds south of Tunjice village in Rovček creek. Rare specimens of *Chaceon sp.* and *Homarus sp.* (Križnar & Preisinger, 2008; Gašparič & Brajkovič, 2016) occur in concretions in Early Miocene claystones. The age of fauna, containing also *Teredo*-bored wood remains, is questionable and concretions could have been reworked from older (Oligocene) strata (Gašparič & Brajkovič, 2016).

Herein we present new findings of *Retropluma slovenica* Gašparič & Hyžný, 2015 from Early Miocene clastic sequence of Rovček creek in Tunjice Hills. The family Retroplumidae Gill, 1894 consists of nine genera of brachyuran crabs, seven of which have exclusively fossil representatives (De Grave et al., 2009; Khodaverdi et al., 2016). The two extant genera, *Retropluma* and *Bathypluma* de Saint Laurent, 1989, occur in the Indo-Pacific and have been reported from muddy or sandy bottoms in the depths ranging from 70 to 600 m (McLay, 2006).

Geology and stratigraphy of the localities

Tunjice Hills belong to the westernmost part of the Tunjice Syncline of the Sava Folds (Placer, 1999, 2008).

Cenozoic sequence of Tunjice Hills starts with few meters of Oligocene conglomerates alternating with beds of sandstones. These are followed by grey clays and a basal conglomerate horizon of fluvial origin. Oligocene layers end with a thick horizon of grey marine clay sequence, which at its top alternates with individual lenses of fine grained clastic rocks, particularly loose sands, and conglomerates (Žalohar & Zevnik, 2006; Gašparič & Brajković, 2016).

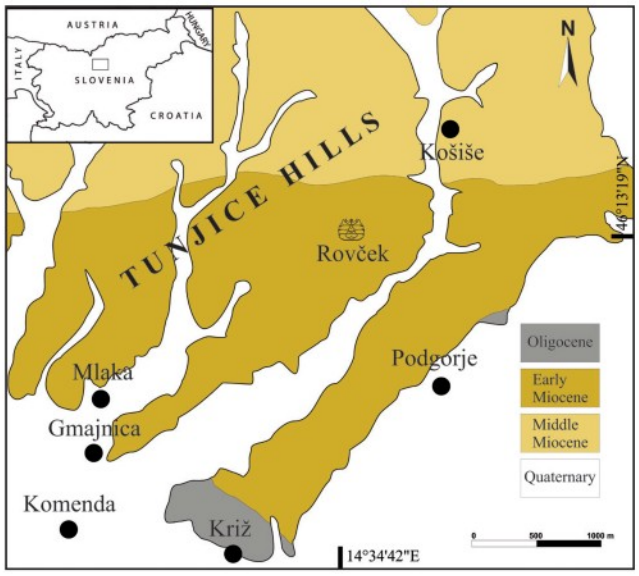


Fig. 1. Simplified geological map of the Tunjice Hills (modified after: Žalohar & Zevnik, 2006). Locality of Retropluma slovenica specimens, Rovček creek, is marked on the map.

Oligocene strata are discordantly overlain with Early Miocene Govce Formation. Lithologies of Govce Formation sequence starts with deposition of clays with lenses of sand and sandstones but it mostly consist of interchanging of conglomerates, sandstones, and fine-grained marls and clays. Succession of retrogradational and progradational sequences implies alternation of deepening and shallowing cycles (Vrabec, 2000). According to Žalohar & Zevnik (2006) Govce Formation layers consist of three separate members: the Lower Govce Member, the Middle Govce Member and the Upper Govce Member. The Lower Govce Member is represented by the succession of alternating beds of clay, siltstones, sandstone, and conglomerate. Middle Govce Member consists mainly of greenish (Glauconite rich) and brownish sandstones and marls. The Upper Govce Member begins with conglomerate, sandstones, sandy siltstones and ends with loose sands. The Rovček section, where the described specimens originate from is part of the Upper Govce Member. Total thickness of Govce beds is between 350 to 450 m (Premru, 1983).

The Early Miocene sediments in Tunjice Hills are followed, after an unconformity, by Laško Formation of Middle Miocene (Badenian). The Middle Miocene strata consist of sandstones, marls, and marly limestones, which are rich in marine macrofossil remains. In the upper part of Laško beds we recognize increasing terrestrial influence and a transition to the Sarmatian Dol Formation beds (Vrabec et al., 2014). The layers of Dol Formation are the youngest lithostratigraphic unit of Tunjice Hills. Characteristic horizons are cerithiid sandstone and Coprolitic horizon. Fossil fauna indicates marine environment still connected with Central Paratethys (Horvat, 2003). Upper most parts Dol Formation show renewed shallowing of the environment, fresh water influx and periodic tectonic isolation of the Tunjice basin (Žalohar & Hitij, 2014).

Material and methods

The studied material consists of 5 specimens of *Retropluma slovenica*. Original cuticle of specimens is lacking, so structures are preserved as impressions in fine grained brownish sandy siltstones. Following specimens were studied: an almost complete articulated specimen (Inv. No. RGA/SMNH 1500, part and RGA/SMNH 1501, counterpart), a partial articulated specimen (Inv. No. RGA/SMNH 1502, part and RGA/SMNH 1503, counterpart), a complete articulated specimen (Inv. No. RGA/SMNH 1504, part and RGA/SMNH 1505, counterpart), an isolated carapace (Inv. No. RGA/SMNH 1506), and an isolated cheliped (Inv. No. RGA/SMNH 1507). All specimens were photographed, measured and studied using computer programmes (CoreDRAW

X5, Adobe Photoshop CC and Statistica). Photographs were taken with digital camera Nikon D810 under low angle light source conditions.

Abbreviations

RGA/SMNH - Slovenian Museum of Natural History, Ljubljana, Slovenia (R. Gašparič Collection)

Systematic description

The higher systematics used herein follows De Grave et al. (2009).

Superfamily **Retroplumoidea** Gill, 1894

Family **Retroplumidae** Gill, 1894

Genus ***Retropluma*** Gill, 1894

Type species. *Archaeoplax notopus* Alcock & Anderson, 1894, by monotypy.

Retropluma slovenica Gašparič & Hyžný, 2014 (Plate 1. A–H)

2014 *Retropluma slovenica* Gašparič & Hyžný; p. 141–166, Figs. 18–21

2015 *Retropluma slovenica* Gašparič & Hyžný – Hyžný et al.; pp. 147, Fig. 5, A–F

Description

The studied specimens exhibit subrectangular carapace, about 1.20 times wider than long, maximum width at the level of median carina.

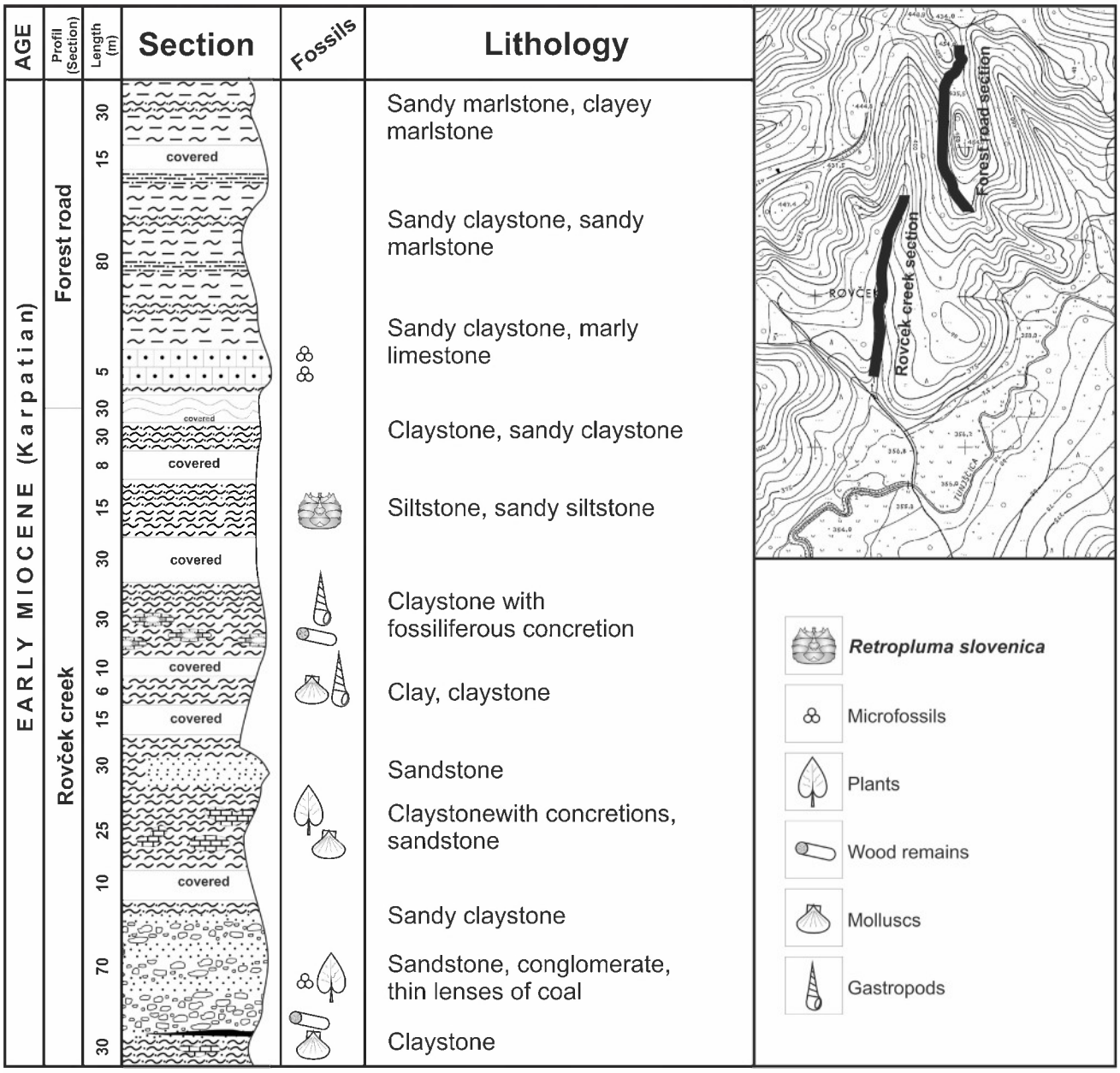


Fig. 2. A detailed lithostratigraphic section of Rovček creek locality with Early Miocene marine layers from where the described specimens were recovered.

Carapace partially deformed and flattened, but appears transversely slightly convex and longitudinally nearly flat (Pl. 1F). Rostrum long, with concave sides and wider distally (Pl. 1A). Orbital margin sinuous with well-developed anterolateral tooth, pointing by some degrees outward; the supraorbital tooth is present, but poorly preserved (Pl. 1E). Long anterolateral margin, concave till anterior carina. Lateral and posterior margins convex, with well-developed concave re-entrant for reduced fifth pereiopod at the posterolateral part.

Dorsal carapace is adorned with three transverse carinae, forming blunt projections at intersection with lateral carapace margin (Pl. 1A, C). Anterior carina almost straight, slightly downwards curved in last third toward lateral margin. Median carina strongly developed at flanks only, interrupted by urogastric region. Posterior carina sinuous and well formed. Dorsal carapace surface is pitted and finely granulose.

The mesogastric region pointedly pentagonal continuing over anterior carina in a long anterior process, ending behind the rostrum. All sides of mesogastric region are concave and posterior border is divided into two lobes. Protogastric regions are not clearly delimited from hepatic region, forming a sub-rectangular shape, which is intersected by the anterior carina (Pl. 1D). The urogastric region is well defined and recognized as a crescent shape; its posterior border is defined by the cervical groove. The cardiac region is large and well formed; its posterior margin is long and concave and the whole cardiac region is divided by the posterior carina. The intestinal region is wide and narrow, with concave anterior margin and straight lateral margin (Pl. 1G). The branchial regions are less defined, elongated and sub rectangular in outline (Pl. 1C). Male sternal plate round in outline sternites 7–5 long, overlapping, with squarer termination. Sternite 8 reduced and covered by pleon.

Male pleon narrow; somite 2 wide and narrow; somites 3–5 fused; male pleon narrows significantly after somite 3, lateral margins of fused 3–5 segment concave, narrowest between somites 4 and 5, slightly widening distally. Somite 6 almost as wide as long with rounded anterior corners and pronounced transverse crest. Telson narrow and longest, with rounded termination (Pl. 1A, B).

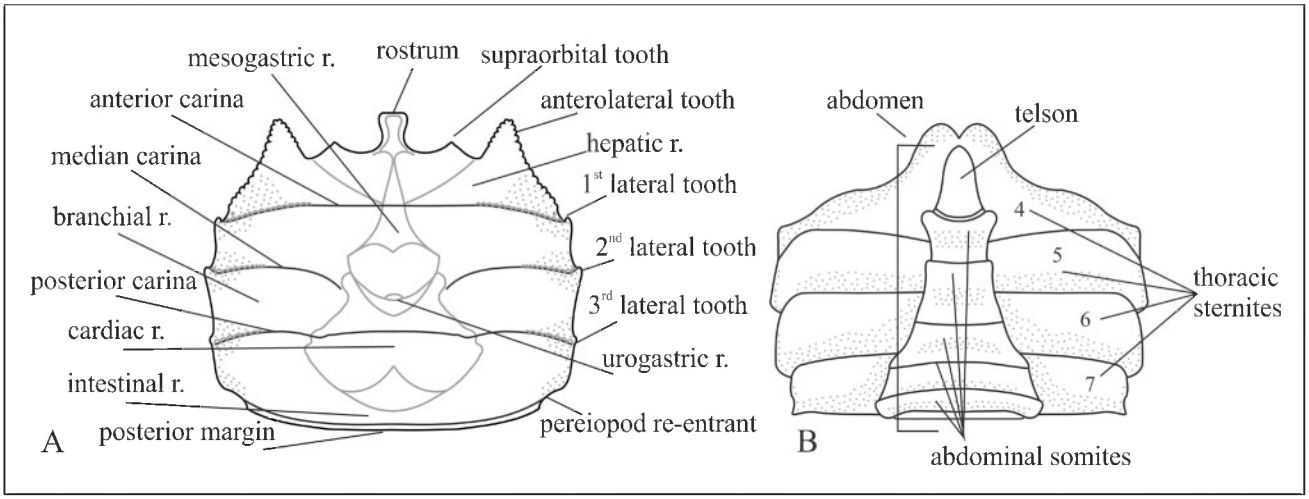
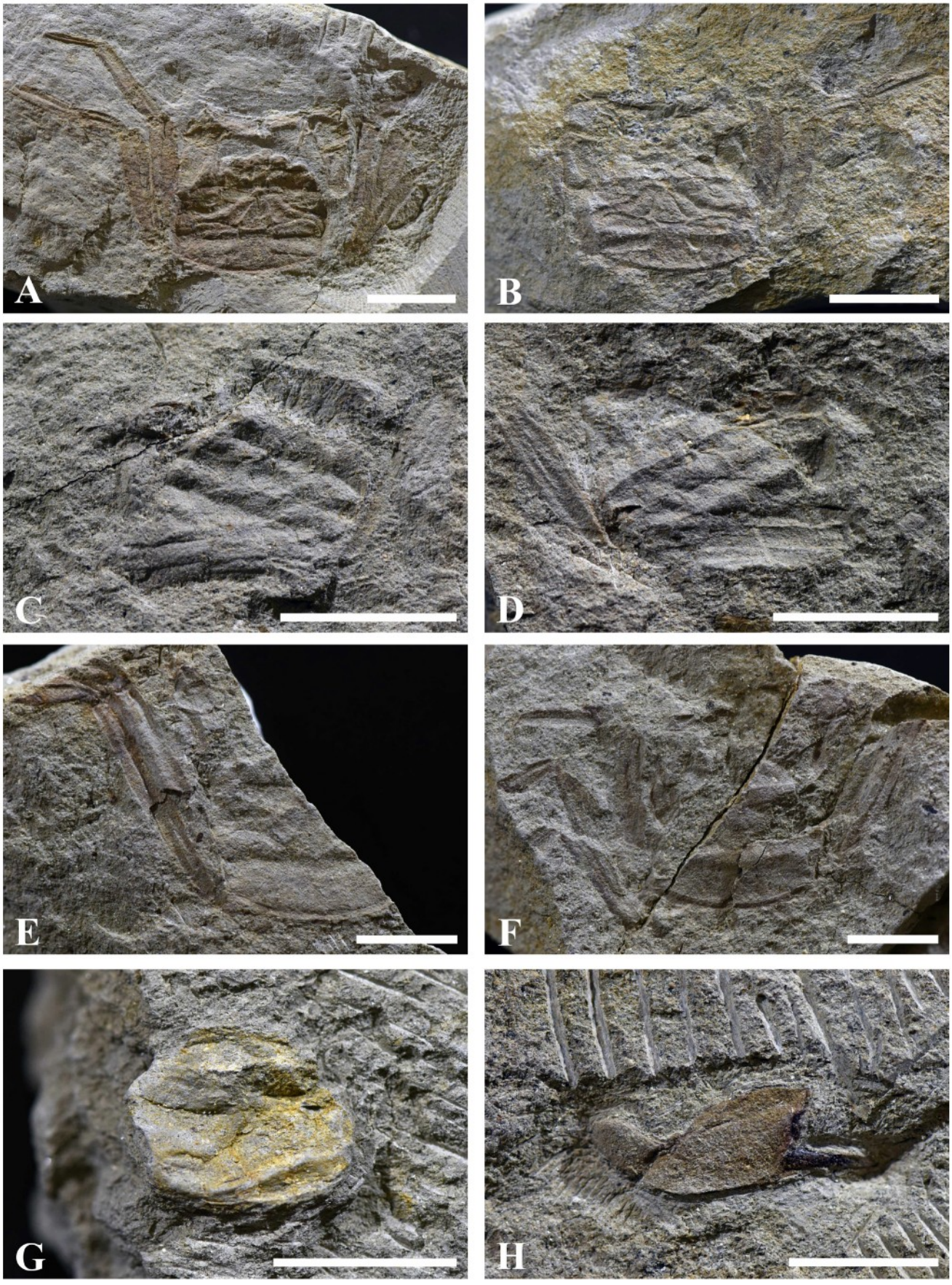


Fig. 3. Descriptive terminology used in the text showing dorsal (A) and ventral morphology (B) of retroplumid crab (modified after: Gašparič & Hyžný, 2014).

PLATE 1

Retropluma slovenica Gašparič & Hyžný, 2014. A – RGA/SMNH 1500, complete associated ventral carapace with chelipeds, male; B – RGA/SMNH 1501, complete associated ventral carapace with chelipeds, male; C – RGA/SMNH 1502, complete dislocated carapace showing abdomen and dorsal carapace, male; D – RGA/SMNH 1503, complete dislocated carapace showing abdomen and dorsal carapace, male; E – RGA/SMNH 1504, partial associated dorsal carapace; F – RGA/SMNH 1505, partial associated dorsal carapace; G – RGA/SMNH 1506, partial imprint of dorsal carapace; H – RGA/SMNH 1507, left cheliped without dactylus. Scale bars A – G are 10 mm, scale bar in H is 5 mm.

PLATE 1



Chelipeds long and appear equally big (Pl 1A); propodus and dactylus curved, narrowing distally and with smooth surface (Pl. 1H). Pereiopods 2–4 long and slender; surface finely granulose and flattened, ending in blade-like dactyli; third pereiopod longest. Fifth pereiopod strongly reduced (Pl. 1A, E), thin and fragile.

Palaeoecology and environment

Despite the study of extant representatives, several ecological and behaviouristic aspects of crabs from genus *Retropluma* are still undefined, mostly due to the deep sea environments which they preferentially inhabit. De Saint Laurent (1989) and McLay (2006) report the occurrences of extant specimens from deep-water muddy bottom waters of up to 470 m. Similarly it can be inferred that fossil representatives have been adapted to the soft muddy or sandy bottoms on inner to outer continental shelves (Gašparič & Hyžný, 2015). As Paleogene species are known also from shallower water settings (Beschin et al., 1996; Hyžný & Müller, 2010; Khodaverdi et al., 2016), it can be concluded that the deeper water habitation preference, with depth interval of 100–450 m, was developed by the Neogene representatives of genus *Retropluma*.

Extant retroplumids spend most of the time buried in soft substrate (Ahyong, 2008), exposing only the most posterior part of the carapace with reduced setose fifth pereiopods, which possibly have a sensory function (McLay, 2006). Known fossil retroplumid material has so far been found exclusively in fine grained clastic rocks, which exhibit relatively fast sedimentation rates (Fraaije et al., 2005; Hyžný, 2011). This supports the hypothesis, that most of the fossil remains represent an endobenthic infaunal community that spent most of the time already buried in the sediment, which enhanced the preservation potential of otherwise fragile retroplumid cuticle.

Palaeobiogeography

The Eocene has been considered as a time of high evolution within the decapoda (Schweitzer & Feldmann, 2001). This can be also concluded for the retroplumids, which show high diversity in Eocene Tethys Ocean, with six different genera and two species of *Retropluma* Gill, 1894 known from Eocene strata of Europe (Vía Boada, 1959; Beschin et al., 1996; Artal et al., 2006, 2013; van Bakel, et al. 2010; Hyžný & Müller, 2010; Gašparič & Hyžný, 2015). It was also observed that many taxa which evolved during this period were endemic to their regions of origin (Feldmann et al., 2010).

Retropluma is considered of Tethyan origin, as the oldest species *Retropluma gallica* Artal, van Bakel & Castillo, 2006 appeared in strata from Early Eocene of France (Artal et al., 2006). Genus survived in the Mediterranean until the Pliocene and Pleistocene with *R. craverii* known from Italy (Crema, 1895; Baldanza et al., 2013). The Miocene occurrences comprise of *Retropluma slovenica* from Early Miocene of Slovenia (Gašparič & Hyžný, 2015) and Middle Miocene of Slovakia (Hyžný et al., 2015), *Retropluma borealis* from Late Miocene of Denmark (Fraaije et al., 2005), and *Retropluma laurentae* from Late Miocene of Sabakh, Borneo (Collins et al., 2003). The genus is represented today by seven species of Indo-Pacific and North-Western Pacific distribution (McLay, 2006).

Conclusions

New findings of *Retropluma slovenica* Gašparič & Hyžný, 2014 from Early Miocene siliciclastic sequence of Rovček creek in Tunjice Hills represents an important report, which further enhances our knowledge of Early Miocene decapod communities in Paratethys of Slovenia. The species was previously known from a single Early Miocene locality on northern slopes of Pohorje mountain range, so the new locality expands the geographical distribution of the species to the western part of Slovenian Basin of Paratethys which was in Early Miocene very close to the Mediterranean and most likely connected to it through the Slovenian corridor. As genus *Retropluma* is missing from the Miocene of Mediterranean, but occurs in its Pliocene and Pleistocene strata, it is likely the genus was reintroduced in the Mediterranean from Paratethys before the marine connection between both realms closed in Late Miocene.

Further we conclude that all fossil representatives of genus *Retropluma* shared the extant species preference for inhabiting a wide range of siliciclastic environments of outer continental shelves. As part of infaunal community they have a good preservation potential and are therefore likely to exhibit a robust fossil record.

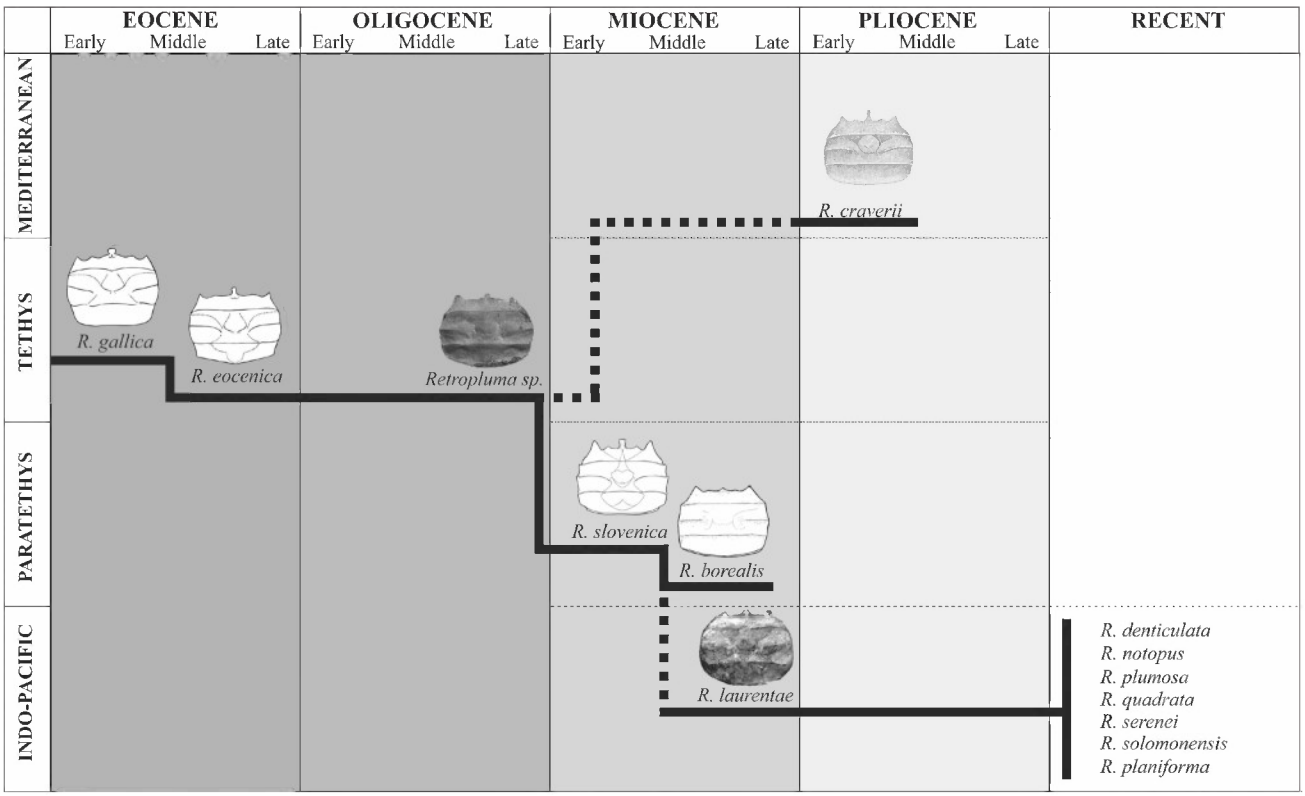


Fig. 4. Temporal and spatial distribution of fossil and extant species of *Retropluma* Gill, 1894.

Acknowledgements

We wish to thank Mojca Potočnik for access to the relevant fossil material, Rok Brajković for providing additional information on stratigraphy and Andreja Žibrat Gašparič for thoroughly proofreading our manuscript.

References

Ahyong, S. T. 2008: Deepwater crabs from seamounts and chemosynthetic habitats off eastern New Zealand (Crustacea: Decapoda: Brachyura). Zootaxa, 1708: 1–72.

Alcock, A. & Anderson, A. R. 1894: Natural History notes from H. M. Indian Marine Survey Steamer "Investigator", Commander C.F. Oldham, R.N., commanding. Series II, No. 14. An account of a recent collection of deep-sea Crustacea from the Bay of Bengal and Laccadive Sea. Journal of the Asiatic Society of Bengal, 63: 141–185.

Artal, P., Bakel, B. W. M. Van & Castillo, J. 2006: *Retropluma* Gill, 1894 (Crustacea, Decapoda) from the Eocene of the eastern Pyrenees (Spain, France). Cainozoic Research, 5: 65–71.

Bakel, B. W. M. Van, Artal, P., Fraaije, R. H. B. & Jagt, J. W. M. 2010: *Loerenthopluma danielae*, A new crab (Decapoda, Brachyura, Retroplumidae) from the Lower Eocene of Northwest Belgium. In: Castro, P. et al. (eds.): Brachyura: A Homage to Danièle Guinot. Studies on Brachyura, 41–49.

Baldanza, A., Bizzarri, R., Famiani, F., Garassino, A., Hyžný, M. & Pasini, G. 2013: The bathyal decapod crustacean community from the Poggio i Sodi quarries (Siena Basin, Tuscany, Italy). Boletín de la Sociedad Geológica Mexicana, 65/2: 335–353.

Beschin, C., Busulini, A., De Angeli, A. & Tessier, G. 1996: Retroplumoidea (Crustacea, Brachyura) nel Terziario del Vicentino (Italia settentrionale). Lavori – Società Veneziana di Scienze Naturali, 21: 83–102.

Bittner, A. 1884: Beiträge zur Kenntniss Tertiärer Brachyuren Faunen. Denkschriften der Akademie der Wissenschaften, Mathematik und Naturwissenschaften. Cl., 48/2: 3–18 (15-30).

Collins, J. S. H., Lee, C. & Noad, L. 2003: Miocene and Pleistocene crabs (Crustacea, Decapoda) from Sabah and Sarawak. Journal of Systematic Palaeontology, 1/3: 187–226.

Crema, C. 1895: Sopra alcuni decapodi terziario del Piemonte. Atti della Reale Accademia di Scienze di Torino, 30: 664–681.

De Grave, S., Pentcheff, N. D., Ahyong, S. T., Chan, T. Y., Crandall, K. A., Dworschak, P. C.,

Felder, D. L., Feldmann, R. M., Fransen, C. H. J. M., Goulding, L. Y. D., Lemaitre, R., Low, M. E. Y., Martin, J. W., Ng, P. K. L., Schweitzer, C. E., Tan, S. H., Tshudy, D. & Wetzer, R. 2009: A classification of living and fossil genera of decapod crustaceans. The Raffles Bulletin of Zoology, Supplement, 21: 1–109.

De Saint Laurent, M. 1989: La nouvelle superfamille des Retroplumoidea Gill, 1894 (Decapoda, Brachyura): systématique, affinités et évolution. In: Résultats des Campagnes Musorstom, 5 Mémoire du Muséum national d'Histoire naturelle, 144: 103–179.

Feldmann, R. M., Schweitzer, C. E. & Encinas, A. 2010: Neogene Decapod Crustacea from southern Chile. Annals of Carnegie Museum, 78/4: 337–366.

Fuchs, T. 1875: Die Tertiarbildungen von Stein in Krain. Verh. der k. k. Geol., 48–49.

Fraaije, R. H. B., Hansen, J. & Hansen, T. 2005: Late Miocene decapod fauna from Gram, Denmark. Palaeontos, 7: 51–61.

Gašparič, R. & Brajkovič, R. 2016: New Miocene decapod crustaceans from Tunjice Hills (Central Slovenia). 6th Symposium on Mesozoic and Cenozoic Decapod Crustaceans, Villers sur Mer, 30–34.

Gašparič, R. & Hyžný, M. 2014: An early Miocene deep-water Decapod Crustacean Faunule from the slovenian part of the Styrian Basin and its palaeoenvironmental and palaeobiogeographical significance. Papers in Palaeontology, 1/2: 141–166, doi:10.1002/spp2.1006.

Gill, T. 1894: A new bassalian type of crabs. American Naturalist, 28: 1034–1045.

Hilber, V. 1881: Ueber das Miocän, insbesondere das Auftreten sarmatischer Schichten bei Stein in Krain. Jb. Geol. R. A., 31: 473-478.

Horvat, A. 2003: Upper Badenian diatom paleoecology of the western part of Central Paratethys. Geologija, 46/2: 251–262, doi:10.5474/geologija.2003.022.

Hyžný, M. 2011: Synopsis of fossil decapod crustaceans from Slovakia (Western Carpathians). Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 260: 165–171.

Hyžný, M. & Müller, P. M. 2010: Loerenthopluma Beschin, Busulini, De Angeli & Tessier, 1996 (Decapoda: Brachyura: Retroplumidae) from the Oligocene of Hungary. Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano, 151/2: 129–140.

Hyžný, M., Hudáčková, N. & Szalma, Š. 2015: Taphonomy and diversity of Middle Miocene decapod crustaceans from the Novohrad-Nógrad Basin, Slovakia, with remarks on palaeobiography. Acta Geologica Slovaca, 7/2: 139–154.

Khodaverdi Hassan-vand, M., Bahrami, A., Yazdi, M., Ossó, À., Safari, A., Martínez, J. L. & Vegad, F. J. 2016: Occurrence of Retrocypoda almelai Via Boada, 1959 (Decapoda: Retroplumidae) in the Eocene of Central Iran. Paleontología Mexicana, 5/1: 21–31.

Križnar, M. & Preisinger, D. 2008: Rak *Coeloma* iz govške formacije Tunjiškega gričevja. Kamniški zbornik, 19: 335–338.

Mclay, C. L. 2006: Retroplumidae (Crustacea, Decapoda) from the Indo-Malayan archipelago (Indonesia, Philippine) and the Melanesian arc islands (Solomon Islands, Fiji and New Caledonia), and paleogeographical comments. In: Richer de Forges B. & Justine J. L. (eds.): Tropical Deep-Sea Benthos, 24. Mémoires du Muséum national d'Histoire naturelle 193: 375–391.

Placer, L. 1999: Strukturni pomen Posavskih gub = Structural meaning of the Sava folds. Geologija, 41: 191–221, doi:10.5474/geologija.1998.012.

Placer, L. 2008: Principles of the tectonic subdivision of Slovenia = Osnove tektonske razčlenitve Slovenije. Geologija, 51/2: 205–217, doi:10.5474/geologija.2008.021.

Premru, U. 1983: Osnovna geološka karta SFRJ 1:100.000. Tolmač za list Ljubljana. Zvezni geološki zavod Beograd, Beograd: 69 p.

Schweitzer, C. E. & Feldmann R. M. 2001: Differentiation of the fossil Hexapodidae Miers, 1886 (Decapoda: Brachyura) from similar forms. Journal of Paleontology, 75: 330–345.

Vía Boada, L. 1959: Décapodos fósiles del Eoceno español (Resumen - avance de la tesis doctoral). Boletin del Istituto Geológico y Minero de España, 70: 313–402.

Vrabec, M. 2000: Govški peščenjak v profilu Doblič (govška formacija - govške plasti): Diplomsko delo. UL NTF, Oddelek za geologijo, Ljubljana: 142 p.

Vrabec, M., Brajković, R. & Skaberne, D. 2014: Sedimentološke značilnosti terciarnih kamnin Tunjiškega gričevja. In: Rožič, B., Verbovšek, T., Vrabec, M. (eds.): Povzetki in ekskurzije, 4. slovenski geološki kongres, Ankaran 8.-10. oktober 2014. Naravoslovnotehniška fakulteta, Ljubljana: 75-76.

Žalohar, J. & Hitij, T. 2014: Fossil seahorses and other biota from the Tunjice Konservat-Lagerstätte, Slovenia. Faculty of Life Sciences, University of Machester, Manchester: 176 p.

Žalohar, J. & Zevnik, J. 2006: Miocenske plasti v Tunjiškem gričevju. Kamniški zbornik, 18: 289–301.