

Supplementary online material

The Middle Miocene freshwater mollusk fauna of Lake Gacko (SE Bosnia and Herzegovina): taxonomic revision and paleoenvironmental analysis

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Systematic paleontology

Type material of Neumayr (1869, 1880) and Brusina (1870, 1872, 1874, 1876, 1882, 1884, 1897, 1902, 1904) stored in the Natural History Museum Zagreb (NHMZ), the Natural History Museum Sarajevo (NHMS) and the Geological Survey Vienna (GBA), and material from the collection of the Natural History Museum Vienna (NHMW) have been studied. Material from the present study is stored in the NHMW under the prefix 2011/0138. For further synonyms see Brusina (1907), Wenz (1923–1930) and Milan et al. (1974).

Class **Gastropoda** Cuvier, 1797

Subclass **Caenogastropoda** Cox, 1959

Order **Cerithiimorpha** Golikov & Starobogatov, 1975

Superfamily **Cerithioidea** Fleming, 1822

Family **Melanopsidae** H. & A. Adams, 1854

Melanopsis Férussac, 1807

Type species. *Buccinum praemorsum* Linnaeus, 1758, Recent, Spain.

Diagnosis. Ovate to conical shell, highly variable in outline. Protoconch smooth, comprising a little more than one whorl, not demarcated from the teleoconch. Acute oval aperture with siphonal canal and usually with prominent callus pad. Axial or spiral sculpture might be present. No umbilicus developed (modified after Bandel 2000).

***Melanopsis lyrata* Neumayr, 1869**

Figures 5A–G

1869 *Melanopsis (Canthidomus) lyrata* Neumayr, p. 358, pl. 11, fig. 8.

2011 *Melanopsis lyrata*. – Mandic et al., figs 5.1–4.

2011 *Melanopsis lyrata*. – Neubauer et al., p. 207, pl. 1, figs 1–9, 22 [cum syn.].

Holotype. GBA 1869/01/6.

Type locality. Ribarić N Maljkovo, Sinj Basin, SE Croatia; Middle Miocene.

Material. 98 specimens from samples 0804/039, 0804/039 coal, 0804/039b, 0804/039 debris, 0907/Moll4 and 0907/Moll4A; mostly fragmented.

Description. Slender to rather bulky conical shell with smooth protoconch, measuring around 1 whorl. Usually up to 15 mm in height and 6 mm in width; occasionally forms occur with height > 20 mm. Shape highly variable, ranging from broad and rather sturdy forms with inflated last whorl and coeloconoid outline up to highly slender ones with straight outline. Shell with 8–9 whorls that are moderately convex to straight-sided. Last whorl attaining somewhat more than half of shell height. Aperture rather narrow, exposing short siphonal canal. In broad morphotypes weak callus pad and/or columellar swelling may be developed. Coloring preserved in some individuals in the form of yellow/brownish-white chess or zigzag pattern.

Morphotypes also differing in sculpture. Early teleoconch always entirely smooth. On last 1–2 whorls sculpture may occur in the form of weak to distinct axial ribs and/or two rows of nodes below upper suture. In most specimens from Vrbica lower row stronger expressed (Fig. 5G). Nodes forming well-rounded knobs or sometimes produce rather distinct spikes. Expression of ribs and nodes may vary even on same individual. Thus, a classification into discrete morphotypes is difficult. Five forms can be roughly distinguished: smooth (morphotype A; not illustrated); intentions of ribs on last whorl (morphotype B; Figs 5A–B); weak ribs on last two whorls (morphotype C; Figs C–D); more distinct ribs with two rows of weak nodules (morphotype D; Fig. 5E); ribs with strong nodes, occasionally ribs reduced (morphotype E; Figs 5F–G).

Remarks. The variability of *Melanopsis lyrata* was shown by Olujić (1999), Mandić et al. (2011), and Neubauer et al. (2011). The specimens found in Vrbica with distinct ribs and nodes (morphotype E) correspond to the Lake Sinj *costata*-morphotype in Olujić (1999) and morph C in Neubauer et al. (2011), respectively. However, the prominence of the nodes in the lower row is uncommon in Lake Sinj morphotypes. Those recorded from Gračanica mine (Fig. 5A–E; Mandić et al. 2011) are usually weaker sculptured with blunt riblets and/or regularly rounded small knobs.

The slender *Melanopsis visianiana* Brusina, 1874 can be distinguished by the distinct angle between flank of the last whorl and the concave base. *Melanopsis sostarici* Brusina, 1897 from Dugo Selo (Glina subdepression, southern Pannonian Basin) has fewer and relatively higher whorls, has no callus pad and develops two fascioles on the neck. The bulky forms are reminiscent of *M. camptogramma* Brusina, 1876 and *M. lanzaeana* Brusina, 1874, which usually develop a more bulky body whorl. The overall similar shape might indicate a close relationship.

Occurrence. Gacko Basin (Vrbica, Gračanica). Sinj Basin (Lučane W Sinj, Ribarić N Maljkovo), Drniš Basin (Miočić) (Neumayr 1869; Brusina 1874).

Order **Littorinimorpha** Golikov & Starobogatov, 1975

Superfamily **Rissooidea** Gray, 1847

Family **Bithyniidae** Gray, 1857

Bithynia Leach in Abel, 1818

Type species. *Helix tentaculata* Linnaeus, 1758, Recent, Europe.

Diagnosis. Conical to ovoid shell with highly convex to stepped whorls. Calcified operculum with concentric growth lines (modified after Glöer 2002).

***Bithynia jurinaci* Brusina, 1884**

Figures 6G–H

1869 *Bythinia* [sic] *tentaculata*. – Neumayr, p. 363, pl. 12, fig. 8 [non *Helix tentaculata* Linnaeus, 1758].

1884 *Bythinia* [sic] *Jurinaci* Brusina, p. 53.

non 2004 *Bithynia jurinaci*. – Harzhauser & Binder, p. 7, pl. 2, figs 8–11.

Neotype. NHMZ 3853-1493 (syntypes lost).

Type locality. Miočić, Drniš Basin, SE Croatia; Middle Miocene.

Material. 1 complete specimen and 1 operculum from 0804/039 debris, 17 opercula from 0708/GA14.

Description. Broad conical shell, measuring 8 mm in height and 5 mm in width, consisting of 5 convex whorls. Protoconch insufficiently preserved. Last whorl particularly broad, sometimes even developing weak shoulder, attaining 65–75% of shell height. In late ontogeny last whorl displaying weakly allometric growth, reflected by stronger anteriorly-oriented growth. Base straight to slightly convex. Aperture only rudimentarily preserved but known to be roughly ovoid, exposing typical notch at posterior part of inner lip, resulting in posterior tip. Umbilicus narrow, slit-like. In lateral view, aperture inclined to the axis with c. 10°; lips parallel. Directly behind peristome thin, shallow furrow for operculum occurring inside shell. Calcified operculum showing fine concentric growth lines.

Remarks. This species is the only documented *Bithynia* from the DLS. It is morphologically closely related to the extant *B. tentaculata* (Linnaeus, 1758). Harzhauser & Binder (2004) identified specimens from the Late Miocene of the Vienna Basin as *B. jurinaci*. Despite the similar morphology the large stratigraphic gap of more than 5 Ma raises doubts on that identification and the Pannonian species might need a reevaluation.

Occurrence. Gacko Basin (Vrbica, Gračanica). Sinj Basin (Ruduša [= Goručica] and Župića potok in Sinj, Trnovača, Turiake), Drniš Basin (Miočić) (Brusina 1884).

Family **Emmericiidae** Brusina, 1870

Fossarulus Neumayr, 1869

Type species. *Fossarulus stachei* Neumayr, 1869, Miocene, Dalmatia/SE Croatia.

Diagnosis. Shell bulky to slender conical, often with spiral sculpture. Protoconch smooth, large and immersed. Umbilicus narrow. Aperture broad and ovoid. Lips

continuous and thickened, outer lip sinusoidal in lateral view (modified after Neumayr 1869).

***Fossarulus moniliferus* Brusina, 1876**

Figures 6A–F, I

1876 *Fossarulus moniliferus* Brusina, p. 111.

1882 *Fossarulus fuchsi* Brusina, p. 38 [nomen nudum].

1897 *Fossarulus Bulići* Brusina, p. 22, pl. 8, figs 19–20.

1897 *Fossarulus Buzolići* Brusina, p. 22, pl. 8, figs 14, 17–18.

1897 *Fossarulus Buzolići complanatus* Brusina, p. 22, pl. 8, figs 15–16.

1897 *Fossarulus fuchsi*. – Brusina, p. 21, pl. 7, figs 27–28.

1897 *Fossarulus moniliferus*. – Brusina, p. 21, pl. 8, figs 3–6.

1902 *Fossarulus Bulići*. – Brusina, pl. 11, figs 40–43.

2009 *Fossarulus tricarinatus*. – Krstić et al., p. 42, pl. 1, figs 1–2 [non *Fossarulus tricarinatus* Brusina, 1870].

2011 *Fossarulus bulici*. – Mandić et al., fig. 5.6.

2011 *Fossarulus buzolici*. – Mandić et al., fig. 5.7.

2011 *Fossarulus fuchsi*. – Mandić et al., fig. 5.8.

2011 *Fossarulus fuchsi*. – Neubauer et al., p. 212, pl. 5, figs 3–4, 9, 13.

Holotype. NHMZ 3024-670.

Type locality. Ribarić N Maljkovo, Sinj Basin, SE Croatia; Middle Miocene.

Material. 228 specimens from samples 0804/039, 0804/039 coal, 0804/039b, 0804/039 debris, 0907/Moll1, 0907/Moll2, 0907/Moll3, 0907/Moll4, 0907/Moll4A, 090713/1, 090713/2, 0708/GA1, 0703/024, Gacko 1; mostly fragmented.

Description. Conical shell with 4–4.5 moderately to strongly convex whorls and maximum height of 9.5 mm. Protoconch smooth, strongly immersed, with less than 1 whorl, grading continuously into teleoconch; measures 650–700 µm. Depending on highly variable sculpture three morphotypes can be distinguished: smooth (morphotype A); keeled (B); another form with nodes on the keels (C). Especially between morphs A and B transitions are observed in the form of faint keels (Fig. 6B). If present, 3 keels are usually expressed; on convex base additional weak subjacent keels may emerge. Short sutural ramp developed above upper keel. Aperture ovoid with typical posterior notch on inner lip. Sometimes posterior canal developed. Outer lip thickened and occasionally everted; in profile exposing posterior and wide anterior emarginations.

Remarks. Within the DLS a great number of *Fossarulus* species and subspecies were introduced. The conspicuous morphological overlap of several of these taxa suggests that several of the taxa are superfluous.

All forms mentioned in the synonymy list correspond largely regarding shape, size and whorl convexity but display some variability concerning sculpture. These are mere morphotypes rather than distinct species: *Fossarulus buzolici complanatus* represents the smooth morphotype A; *F. buzolici* displays a transitional form with faint keels (morphotype A/B); *F. moniliferus* and *F. bulici* comprise finely keeled specimens

(morphotype B); *F. fuchsi* is the strongly sculptured with distinct nodes on the keels (morphotype C) exclusively found in Vrbica.

Maybe also the more bulky *F. stachei* Neumayr, 1869, *F. armillatus* Brusina, 1876, *F. auritus* Brusina, 1897, and *F. hoernesii* Brusina, 1897 are only extreme morphs of a single polymorphic species. More detailed studies of type material will have to be performed to elucidate these relations. *Fossarulus tricarinatus* Brusina, 1870 and *F. eginiae* Brusina, 1897 are more slender, have less convex whorls and a relatively broad last whorl. Specimens from drill cores determined as *F. tricarinatus* by Krstić et al. (2009) fully correspond to the present description.

Occurrence. Gacko Basin (Vrbica, Gračanica). Sinj Basin (Potravlje, Ribarić N Maljkovo), Drniš Basin (Miočić) (Brusina 1876, 1882, 1897).

Family **Hydrobiidae** Stimpson, 1865

Subfamily **Pyrgulinae** Brusina, 1881

Prososthenia Neumayr, 1869

Type species. *Prososthenia schwartzi* Neumayr, 1869, Miocene, Dalmatia/SE Croatia.

Diagnosis. Small shell, conical to ovoid. Protoconch weakly granular. Last whorl often narrow and allometric. Aperture oblique and ovoid. Lips continuous and thickened, with outer lip protruding centrally in lateral view (modified after Neumayr 1869).

***Prososthenia neutra* Brusina, 1897**

Figures 7A–H

1897 *Prososthenia? neutra* Brusina, p. 19, pl. 9, figs 3–4, 7–8.

2011 *Prososthenia neutra*. – Mandić et al., figs 5.9–10.

2011 *Prososthenia neutra*. – Neubauer et al., p. 209, pl. 4, figs 3–4, 6, 12.

Holotype. NHMZ 3041-687.

Type locality. Miočić, Drniš Basin, SE Croatia; Middle Miocene.

Material. 160 specimens from samples 0804/039, 0804/039 coal, 0804/039b, 0804/039 debris, 0907/Moll1, 0907/Moll4, 0907/Moll4A, 090713/1 and 090713/2.

Description. Drop-shaped, smooth shell with up to 6 moderately convex whorls. Protoconch granular, consisting of about 1 whorl; continuous transition to teleoconch. This taxon comprises individuals with a variety of shapes, ranging from fairly broad to extremely slender. Whorls moderately convex. Last whorl making up c. 60% of shell height, grading into slightly convex base. Aperture including posterior tip poorly thickened and not detached; ranging from ovoid to semilunar in slender elongated specimens. Sometimes thin umbilicus developed. Laterally, quite weak posterior indentation occurring at outer lip. Apart from fine prosocline growth lines faint spiral lines covering whorls. In some specimens traces of weak subsutural band may be developed.

Remarks. Its apertural characteristics classify it as true *Prososthenia*. It is broader and has rounder whorls than *P. eburnea* Brusina, 1884.

Occurrence. Gacko Basin (Vrbica, Gračanica). Sinj Basin (Lučane W Sinj), Drniš Basin (Miočić) (Brusina 1897; Neubauer et al. 2011).

Subfamily unknown

Bania Brusina, 1896

Type species. *Bania prototypica* Brusina, 1872, Middle Miocene, Dalmatia/SE Croatia; by monotypy (ICZN 2001).

Diagnosis. Small and sturdy to broad ovoid shell. Protoconch reticulate. Whorls convex to step-like. Aperture ovoid, simple or thickened, occasionally with opercular ridge (compiled after Brusina 1874, 1897; Neubauer et al. 2012).

***Bania valvatoides* (Brusina, 1874)**

Figures 8A–I

1872 *Stalioa valvatoides* Brusina, p. 144 [nomen nudum].

1874 *Stalioa valvatoides*. – Brusina, p. 61, pl. 4, figs 9–10.

1897 *Pseudoamnicola? Stošićiana crassa* Brusina, p. 22, pl. 12, figs 17–18.

1896 *Bania valvatoides*. – Brusina, p. 130.

2009 *Pseudoamnicola (Staja) šoštaričiana* [sic]. – Krstić et al., pl. 1, fig. 5.

2011 *Bania prototypica*. – Mandić et al., fig. 5.14 [non *Stalioa prototypica* Brusina, 1874].

Neotype. NHMZ 3925-1565/1-3 (holotype lost).

Type locality. Miočić, Drniš Basin, SE Croatia (Holotype from Goručica in Sinj, Sinj Basin, SE Croatia); Middle Miocene.

Material. 139 specimens from samples 0804/039, 0907/Moll1, 0907/Moll2, 0907/Moll4, 0907/Moll4A, 090713/1, 090713/2, 0708/GA1 and 0703/024. Further occurrences (< 1 mm) are recorded from 0804/039 coal, 0804/039b and 0708/GA14.

Description. Small, shiny and bulky shell with up to 4 whorls. Protoconch consisting of 1.1 whorls; initially covered with mesh of densely arranged wrinkles, fading out towards transition to teleoconch and forming pattern of irregular spiral threads. Spire shape variable, ranging from broad and bulky to more slender and drop-shaped in some cases. Whorls strongly convex with moderately incised sutures, usually exposing a bluntly step-like profile. Last whorl attaining up to 80% of total height. Aperture elliptical to ovoid, only touching base of preceding whorl in its posterior part, forming fairly wide umbilicus. In lateral view, outer lip slightly protruding below umbilicus, forming broad basal emargination. Peristome sharply edged in earlier ontogeny; becomes distinctly everted and sometimes slightly thickened in latest stages. Opercular ridge developed in fully-grown specimens, ranging from weak riblet to strong varix-like structure (as in type material). Distinct prosocline growth lines and faint spiral grooves covering whorl surface.

Remarks. The morphological variability of this species is enormous. Shell shape ranges from low valvate, as is the case for the (lost) holotype and the syntypes, to higher coiled, drop-shaped forms, including all kind of intermediates. Likewise, the expression of the opercular ridge and the thickening of the peristome vary greatly, partly depending on ontogenetic stage.

Concerning shell shape, this species is similar to '*Lithoglyphus tripaloi* Brusina, 1884 (*Bania tripaloi* after Neubauer et al. 2012). This form has less convex whorls and no stepped spire, lacks the apertural thickening, the opercular ridge and the basal emargination. Some specimens from units A and D, erroneously determined as *Bania prototypica* (Brusina, 1874) by Mandić et al. (2011: fig. 5.14), fully correspond to the present description of *B. valvatooides*. *B. prototypica*, as well as '*Amnicola torbariana* (Brusina, 1874) and '*Amnicola stosiciana* (Brusina, 1874), differ from *B. valvatooides* in the higher spire and the more distinctly stepped whorl outline with highly incised sutures. All forms share the characteristic protoconch sculpture and are therefore assigned to the genus *Bania* (Neubauer et al. 2012). The subspecies *B. stosiciana crassa* Brusina, 1897, originally described from Gacko, fully corresponds to the slender specimens studied here and is thus considered synonymous.

Krstić et al. (2009) identified specimens from drill cores as "*Pseudoamnicola (Staja) šoštarićiana* Brusina, 1874". With regard to the denoted authority, this attribution obviously is a wrong spelling of *Pseudamnicola* [= *Bania*] *stosiciana* (Brusina, 1874). The specimens fully match with the present description.

Detailed discussions of this genus and attended nomenclatorial problems as well as its phylogenetic relations are provided by Kadolsky (1993, 1998) and Neubauer et al. (2012).

Occurrence. Gacko Basin (Vrbica, Gračanica). Sinj Basin (Ruduša in Sinj), Drniš Basin (Miočić) (Brusina 1884).

Clade **Panpulmonata** Jörger et al., 2010

Order **Hygrophila** Férussac, 1822

Suborder **Branchiopulmonata** Morton, 1955

Family **Lymnaeidae** Rafinesque, 1815

Galba Schrank, 1803

Type species. *Buccinum truncatulum* Müller, 1774, Recent, Europe.

Diagnosis. Small, slender, elongated ovoid shell. Protoconch conical and smooth. Whorls well rounded to stepped, slowly increasing in dimensions; separated by deep sutures. Last whorl large, but not inflated. Aperture narrow, egg-shaped, with posterior angulation. Columella fairly straight and everted over the slit-like umbilicus (compiled from Zilch 1959–1960; Neubert 1998).

***Galba* sp.**

Figure 9C

Material. 3 spire fragments from sample 0907/Moll3.

Description. Extremely slender lymnaeid. Most complete specimen comprising 4 whorls, exposing highly convex whorl outline producing stepped spire. Protoconch smooth, passing into teleoconch without distinct rim. Aperture unknown. Strong growth lines covering shell.

Remarks. The distinctly stepped whorl outline and the slender shape suggest a classification as *Galba*. The slim habitus reminds of *Omphiscola* Rafinesque, 1819, which has convex but not stepped whorls. No comparable taxon is recorded from the DLS, but the insufficient material and preservation, do not allow establishing a new species.

***Radix* Montfort, 1810**

Type species. *Helix auricularia* Linnaeus, 1758, Recent, Europe.

Diagnosis. Globular ovoid, thin-walled shell with short spire and acute apex. Whorls increase fast in dimensions. Last whorl large, bulgy, and inflated. Aperture round, wide, often slightly everted, and sharply terminated. Columella slightly twisted, with broad margin (compiled from Montfort 1810; Zilch 1959–1960).

***Radix korlevici* (Brusina, 1884)**

Figures 9A–B, D

1884 *Limnaea* [sic] *Korleviči* Brusina, p. 56.

1897 *Limnaea* [sic] *Korleviči*. – Brusina, p. 3, pl. 2, figs 6–7.

1902 *Lymnaea hyaloleuca* Brusina, pl. 1, figs 36–39.

2009 *Lymnaea* (*Omphiscola*) aff. *servica*. – Krstić et al., pl. 1, fig. 3.

2009 *Succinea* sp. ex gr. *S. drnišana* juv. – Krstić et al., pl. 1, fig. 4.

2011 *Radix hyaloleuca*. – Mandić et al., fig. 5.5.

Holotype. NHMZ 2945-591.

Type locality. Miočić, Drniš Basin, SE Croatia; Middle Miocene.

Material. 76 largely fragmented specimens from samples 0804/039, 0804/039 coal, 0804/039b, 0907/Moll1, 0907/Moll2, 0907/Moll4, 0907/Moll4A, 090713/1, 090713/2, 0703/024 and Gacko 3; some remains < 1mm are found in samples Gacko 1 and Gacko 2.

Description. Glossy, smooth, thin-walled and slender shell with blunt apex and 4 whorls. Precise measurements cannot be performed as the largest specimens were fragmented; estimated height: 15–20 mm. Protoconch smooth with indistinct transition to teleoconch. Whorls moderately convex. Last whorl (including aperture) attaining c. 85% of total shell height. Aperture ovoid, slightly everted and posteriorly elongated. Inner lip thin and attached to base of preceding whorl, leaving no umbilicus; columella rarely with weak fold. Weak prosocline growth lines covering surface.

Remarks. The generic affiliation is based on the wide and elongated aperture.

'*Lymnaea*' *hyaloleuca* Brusina, 1902 is represented by two syntypes, which slightly deviate in the relative size of the last whorl. While the first one is slightly broader and exposes an angle next to the umbilicus, the second one (Brusina 1902: pl. 1, figs 38–39)

fully corresponds to the holotype of *Radix korlevici*. In respect to intraspecific variability both forms are regarded as synonyms of *Radix korlevici* (Brusina, 1884). *Lymnaea klaici* Brusina, 1884 from Miočić is much larger and more slender. Krstić et al. (2009) misidentified this species and even attributed some fragmented apices to the terrestrial gastropod *Succinea*.

Occurrence. Gacko Basin (Vrbica, Gračanica). Drniš Basin (Miočić) (Brusina 1884, 1902).

Family **Planorbidae** Rafinesque, 1815

Subfamily **Planorbinae** Rafinesque, 1815

Gyraulus Charpentier, 1837

Type species. *Planorbis albus* Müller, 1774, Recent, Europe; by subsequent designation (Dall 1870).

Diagnosis. Small discoidal planorbid taxon. Protoconch with distinct spiral striae. Umbilical side almost flat or immersed. Few rounded, angular or carinate whorls, increasing rapidly in diameter. Aperture wide with expanded basal margin (modified after Zilch 1959–1960; Brown 1994).

***Gyraulus pulici* (Brusina, 1897)**

Figures 10A–C, E–F

1897 *Planorbis Pulici* Brusina, p. 6, pl. 2, figs 8–10.

1902 *Planorbis Pulici*. – Brusina, pl. 3, figs 22–24.

2009 *Segmentina* sp. – Krstić et al., pl. 1, fig. 6.

2009 *Planorbis pulici*. – Krstić et al., pl. 1, figs 7–8.

2011 *Gyraulus pulici*. – Mandić et al., figs 5.11, 5.15.

Holotype. NHMZ 2946-592.

Type locality. Gacko-Avtovac, Gacko Basin, SE Bosnia and Herzegovina; Middle Miocene.

Material. 254 largely fragmented shells from samples 0804/039, 0804/039 coal, 0804/039b, 0907/Moll1, 0907/Moll2, 0907/Moll3, 0907/Moll4, 0907/Moll4A, 090713/1, 090713/2, 0708/GA1, 0708/GA14, Gacko 1 and Gacko 3; some fragments < 1 mm are found in Gacko 2.

Description. Broad planorbid shell with up to 3 whorls. Protoconch consisting of c. 0.7 whorls bearing 7 spiral striae that fade out after about half a whorl. Transition to teleoconch marked by initiation of growth lines, which are quite prominent in some specimens. Whorls overgrowing up to 50% of preceding ones and attaining up to more than double height. Last whorl making up c. 40% of shell diameter. No point of maximum convexity in early ontogeny; in later stages sometimes stronger convexity emerging in lower half resulting in roughly trapezoid outline. Peristome sharply edged and with c. 30° inclined to the axis.

Remarks. *Gyraulus geminus* (Brusina, 1897) and *G. dalmaticus* (Brusina, 1884) from Sinj and Drniš basins both are flatter with a more distinct angulation in lateral view. The smaller *Gyraulus nedici* (Brusina, 1902) from Dugo Selo (Glina subdepression, southern Pannonian Basin) has more convex whorls with a fairly equilateral profile. The likewise small *Gyraulus oncostomus* (Brusina, 1902) from Dugo Selo has a more distinctly angled profile with a deltoid shaped aperture and is relatively broader. Some fragments of earliest whorls were erroneously identified as *Segmentina* sp. by Krstić et al. (2009).

Occurrence. Endemic to the Gacko Basin (Vrbica, Gračanica) (Brusina 1897).

***Orygoceras* Brusina, 1882**

Type species. *Orygoceras dentaliforme* Brusina, 1882, Miocene, Dalmatia/SE Croatia.

Diagnosis. Shell small, dentaliform, asymmetrical and more or less curved. Protoconch planispiral bearing faint spiral striae. Teleoconch surface with faint growth lines, occasionally with ring-like sculpture or spiral lines. Aperture oblique and elliptical to semilunar (modified after Brusina 1882, 1902).

***Orygoceras dentaliforme* Brusina, 1882**

Figure 10D

1882 *Orygoceras dentaliforme* Brusina, p. 42, pl. 11, figs 9–15.

2011 *Orygoceras dentaliforme*. – Mandić et al., fig. 5.17.

2013 *Orygoceras dentaliforme*. – Neubauer et al., p. 146, figs 6D–E [cum syn.].

Syntypes. NHMZ 3574-1214/1a, NHMZ 3576-1216/1a.

Type locality. Ribarić N Maljkovo, Sinj Basin, SE Croatia; Middle Miocene.

Material. 4 fragments from samples 0804/039, 0804/039 coal and 0804/039b.

Description. Shell uncoiled and dentaliform. Protoconch consisting of about half a whorl bearing faint striae. Teleoconch mainly smooth apart from fine growth lines. In some specimens distinct rings may occur in various ontogenetic stages. Shell elliptical to semilunar in cross-section. Aperture not preserved in any specimen.

Remarks. The development of sculpture is assumed to range within intraspecific variability as no clear separation of distinct morphotype-groups can be performed. Discussion on the validity of the many species introduced by Brusina (1882, 1902) is provided by Neubauer et al. (2012).

Occurrence. Gacko Basin (Vrbica, Gračanica). Sinj Basin (Ribarić N Maljkovo, Lučane W Sinj, Župića potok in Sinj, Trnovača), Drniš Basin (Miočić, Parčić), Kupres Basin (Fatelj), Džepi Basin, southern Pannonian Basin (Dugo Selo / Lasinja) (Brusina 1882; Neubauer et al. 2012).

***Planorbarius* Duméril, 1806**

Type species. *Helix cornea* Linnaeus, 1758, Recent, Europe; by subsequent designation (Froriep 1806).

Diagnosis. Shell moderately to very large, thick-shelled, disciform. Shell on both sides immersed, more on apical side. Whorls high, evenly rounded, increasing regularly in diameter, covered with growth lines and spiral striae. Aperture round or elliptical, basal margin protruding (compiled from Zilch 1959–1960; Brown 1994).

***Planorbarius* sp.**

Figures 11A–F

2011 *Planorbarius* sp. – Mandić et al., fig. 5.12.

Material. 5 spire fragments from samples 0804/039b, 0907/Moll4 and 0703/024; additional fragments < 1 mm found in 0804/039 coal.

Description. Spire completely immersed with highly convex initial whorls and strongly incised sutures. Protoconch consisting of c. 1 whorl and measuring 550 µm. Initial cap making up c. 50 µm; covered with short and faint irregular threads. Termination indicated by onset of spiral rows of distinct circular pits (c. 5 µm). Between them fragile irregular ridges may be formed in axial direction. Onset of teleoconch indicated by formation of growth lines. Whorls exposing distinct shoulder to moderately curved flank. Strong irregularly shaped, spiral grooves covering whole teleoconch surface. They are confined to bundles of 4–5 grooves each, separated by slightly raised smooth bands (Fig. 11F). Where they cross more pronounced growth lines a weakly undulated pattern is formed. Aperture only marginally preserved; seemingly not conspicuously thickened or everted.

Remarks. The identification of the fragments is based on the characteristic protoconch features and the spiral teleoconch sculpture, which are typical elements for *Planorbarius*. A determination on species level is not possible from the available material.

Subfamily **Ancylinae** Rafinesque, 1815

***Ferrissia* Walker, 1903**

Type species. *Ancylus rivularis* Say, 1817, Recent, Eastern North America.

Diagnosis. Shell thin-walled, low ancyliform, with acute apex pointing to the right. Protoconch with radial striae and small pit in its center. Surface smooth or covered with radial striae (modified after Walker 1903).

***Ferrissia illyrica* (Neumayr, 1880)**

Figures 11G–K

1880 *Ancylus Illyricus* Neumayr, p. 486, pl. 7, fig. 16.

1902 *Ancylus illyricus*. – Brusina, pl. 1, figs 20–21.

2009 *Ancylus* cf. *illyricus*. – Krstić et al., p. 42, pl. 1, figs 10–11.

2011 *Ferrissia illyrica*. – Mandić et al., fig. 5.16.

2011 *Ferrissia illyrica*. – Neubauer et al., p. 214, pl. 6, figs 8–9, 13.

Holotype. Type specimen is lost; no neotype defined yet.

Type locality. Gacko-Avtovac, Gacko Basin, SE Bosnia and Herzegovina; Middle Miocene.

Material. 25 specimens and several spire fragments from samples 0804/039, 0804/039 coal, 0804/039b, 0907/Moll3, 0708/GA14 and Gacko 3.

Description. Small and narrow ancylid shell with broadest diameter anterior. Largest specimen found attaining 6 mm in length, 3.5 mm in width and 2 mm in height. Apex round and blunt, slightly inclined to the right, measuring c. 400 µm. Initial part attaining about half of total protoconch diameter, smooth with small, circular and shallow pit in its center. It is surrounded by a collar-like array of thin radial threads, which are terminated distally by a distinct rim. Growth lines already starting during this interval and forming more or less strong concentric rings. Inner surface covered with highly granular pattern in early ontogeny that gradually fades out towards shell margins. In some specimens radial threads may occur in late ontogeny, but only on the inner surface.

Remarks. The lack of radial ribs on the outer teleoconch surface separates this species from *Ferrissia wittmanni* (Schlickum, 1964) from the Early Miocene of the Western Paratethys (Kowalke & Reichenbacher 2005). *Ferrissia crenellata* Harzhauser & Neubauer in Harzhauser et al., 2012 from the Aflenz Basin (Austria) has a smaller protoconch and a typical pinnacle-like sculpture on the radial threads, which reach almost to the central pit.

Occurrence. Gacko Basin (Vrbica, Gračanica). Sinj Basin (Lučane W Sinj), Drniš Basin (Miočić, Parčić) (Neumayr 1880; Neubauer et al. 2011).

Suborder **Eupulmonata** Haszprunar & Huber, 1990

Infraorder **Acteophila** Dall, 1885

Superfamily **Ellobioidea** Pfeiffer, 1854

Family **Carychiidae** Jeffreys, 1830

Carychium Müller, 1773

Type species. *Carychium minimum* Müller, 1774, Recent, Europe.

Diagnosis. Small egg-shaped to almost cylindrical shells with 4–7 whorls and obtuse apex. Aperture 30–40% of total height, thickened and everted, usually bearing 1 parietal, 1–2 palatal and 1 columellar tooth. Parietal and columellar tooth continue as

lamellae on the columella. Umbilicus slit-like (compiled from Zilch 1959–1960; Strauch 1977).

***Carychium* sp.**

Figures 12A–B, D

Material. 1 complete specimen and few fragments from samples 0804/039 and 0804/039 coal.

Description. Small elliptical shell with up to 4 whorls. Protoconch fine-punctate, dome-shaped, measuring 300 µm. Whorls roughly cylindrical in profile with maximum convexity in adapical half. This results in a slightly stepped outline. Last whorl attaining about two thirds of total shell height, forming moderately convex base. Narrow umbilicus developed. Aperture displaying typical angle between columellar and parietal region, widely convex basal margin and roughly straight palatal lip. Margin broad, thickened and everted and throughout covered with numerous small granules (Fig. 12D). Columellar and palatal lamellae forming small rounded triangular tubercles; parietal lamella quite strong. Distinct prosocline growth lines covering shell, occasionally forming regular riblets.

Remarks. Only few terrestrial mollusks have been described so far from the Dinaride Lake System. Prysazhnyuk (2008) recorded several taxa from DLS deposits in south-western Serbia. Because of their poor preservation as molds a reliable identification is difficult.

Infraorder **Stylommatophora** Schmidt, 1855

Superfamily **Pupilloidea** Turton, 1831

Family **Vertiginidae** Fitzinger, 1833

Vertigo Müller, 1773

Type species. *Vertigo pusilla* Müller, 1774, Recent, Europe.

Diagnosis. Shell usually dextrally coiled, bulgy to elongate ovoid, with obtuse apex. Whorls well-rounded, separated by deep sutures. Aperture subcircular, usually bearing 2 parietal, 1 columellar, 1 basal, and 2 palatal lamellae; occasionally strongly reduced; accessory teeth may occur. Peristome slightly everted. Palatal margin often indented. Surface covered with faint growth lines (compiled from Zilch 1959–1960).

***Vertigo* sp.**

Figures 12C, E

Material. A single fragment bearing the aperture from sample 0804/039b.

Description. Only last whorl with aperture preserved. Parietalis strong, accompanied by weaker, thin and slightly inclined angularis; columellaris broad but rather weak; very weak basalis formed below; palatalis inferioris inclined, displaying most prominent

tooth; palatalis superioris thin and similarly inclined but weaker expressed. Narrow umbilicus developed.

Remarks. The generic identification is based on the arrangement of the teeth and the indented palatal margin. The dentition with the strong parietalis and infrapalatalis is reminiscent of *Vertigo callosa* (Reuss, 1849) from Czech Republic (Early Miocene) and the Steinheim (Middle Miocene) and Vienna basins (Late Miocene). However, due to insufficient preservation a definite determination on species level is not possible.

Class **Bivalvia** Linnaeus, 1758

Superorder **Heterodonta** Neumayr, 1883

Order **Venerida** Gray, 1854

Family **Dreissenidae** Gray in Turton, 1840

Mytilopsis Conrad, 1857

Type species. *Mytilus leucophaeatus* Conrad, 1831, Recent, Eastern USA.

Diagnosis. Shell mytiliform to modioliform, umbo terminal, or nearly so, dorsal margin straight. Hinge with septum, beneath which on the cardinal side is a triangular cup-shaped process (apophysis). Ligament pit rather deep, pallial sinus absent or weak, byssal gap usually marked (compiled from Conrad 1857; Nuttall 1990).

***Mytilopsis friči* (Brusina, 1904)**

Figures 13A–D

1904 *Congeria Friči* Brusina, p. 497, pl. 1, fig. 7a, pl. 2, figs 7b–f, pl. 3, figs 7g–m.

1966 *Congeria drvarensis*. – Stojčić in Milojević, p. 357, figs 1–2 [non *Congeria drvarensis* Toulou, 1913].

1966 *Congeria friči*. – Stojčić in Milojević, p. 357, figs 3–4.

1978 *Congeria friči*. – Kochansky-Devidé & Slišković, p. 60, 94, pl. 11, figs 1–7, textfig. 8.

2011 *Mytilopsis friči*. – Mandić et al., figs 3.4–3.5

Lectotype. Single left valve embedded by interior side into sediment (NHMS MB1683/7), originally illustrated by Brusina (1904: pl. 3, fig. 7m) and designated as lectotype by Kochansky-Devidé & Slišković (1978: pl. 11, fig. 1). 12 paralectotypes are additionally available from the same locality.

Type locality. Field at the hill-slope east of Šipovo, Bosnia and Herzegovina; Middle Miocene.

Material. 1 specimen from the historical collection of the NHMW of Gacko and about 20 originally articulated but largely fragmented individuals from 4 rock samples collected in the *Mytilopsis* shell-bed unit of the open-cast mine Gračanica (Mandić et al. 2011).

Description. Shell fragile, thin-walled, less inflated, equivalve, inequilateral with pointed, prosogyre beak in anterior-most position. Long as high, usually about 40 mm in

length, with maximal length of 52 mm in available material. Circular to sub-triangular in outline, with wing-like, upwards pointed dorsal margin and rounded posterior and ventral margins. Hinge plate straightened, meeting ventral margin at about 110°. Byssal notch broad and shallow concave. Posterior sinus occasionally present; up to three fine transversal threads can arise posteriorly striking in its direction. Anteriorly, sharp transversal ridge present within the first 15 to 20 mm of growth. Additionally to fine growth lines, broad, concentric rugae might be present. Exceptionally well preserved specimens show a nacreous, shiny interior surface with slightly thickened but smooth shell margin.

Remarks. The species is closely related to *M. aletici* and *M. drvarensis* due to its size, circular, dorsally flabellate outline, fragile shell and fine transversal ridge at the proximal shell exterior surface. However, it clearly differs from *M. aletici* by the straightened anterodorsal margin missing the anterior beak-like prolongation of the hinge line (Neubauer et al. 2012). *M. drvarensis* is distinctly stronger inflated, has a longer transversal ridge, an acute umbonal angle and is not exceeding 40 mm in length. Based on this features we regard shells erroneously identified as *M. drvarensis* by Stojčić in Milojević (1966) as belonging to *M. frici*.

Occurrence. Gacko Basin (Gračanica, Gacko). Šipovo Basin, Drvar Basin (Vidovo Selo, Kochansky-Devidé & Slišković 1978: pl. 11, fig. 4), Bugojno Basin (Gračanica, top of the lacustrine series; Muftić & Behlilović 1966, not illustrated). The presence from the Hodovo Basin reported by Stojčić in Raić & Papeš (1977) has not been confirmed by Kochansky-Devidé & Slišković (1981), who found there only the similar *M. aletici*.

***Mytilopsis jadrovi* (Brusina, 1892)**

Figures 14A–C

1892 *Congeria Jadrovi* Brusina, p. 195.

1897 *Congeria Jadrovi*. – Brusina, p. 30, pl. 17, figs 12–14.

1902 *Congeria Jadrovi*. – Brusina, pl. 21, figs 2–5.

1978 *Congeria jadrovi*. – Kochansky-Devidé & Slišković, p. 37, 87, pl. 1, figs 26–39.

2011 *Mytilopsis jadrovi*. – Neubauer et al., p. 215, pl. 7, figs 1–2, 9.

Holotype. NHMZ 3150-796/1.

Type locality. Trnovača, Sinj Basin, SE Croatia; Middle Miocene.

Material. 8 shells from samples 0907/Moll4 and 0907/Moll4A.

Description. Shell elongated triangular with weak and wide anterior byssal notch and rounded ventral end. Prodissoconch smooth, cap-like, regularly circular, measuring 250 µm. A distinct rim and beginning growth lines signal its termination. Broad and slightly curved keel developed, reaching from umbo to ventral margin and forming convex crest in dorsoventral view. Hinge plate small and curved bearing posterior apophysis. Thin interior ligamental band present, originating posteriorly from umbo.

Remarks. The similarly shaped *Mytilopsis neumayri* (Andrusov, 1897) from the Middle to Late Miocene of the Pannonian Basin System is larger and has a lower keel; its anterior external surface field is strongly reduced.

Occurrence. Gacko Basin (Gračanica). Sinj Basin (Lučane W Sinj, Župića potok in Sinj, Trnovača, Sveta Kata NW Sinj, Bila glavica near Trilj), Drniš Basin (Miočić, Biočić, Kadina glavica E Drniš), Livno-Tomislavgrad Basin (Eminovo Selo N Tomislavgrad), Zenica-Sarajevo Basin (Čajdraš W Zenica, Blažuj near Sarajevo), Konjic Basin (Čelebići W Konjic), southern Pannonian Basin domain (Požega Basin: Rogoljica; Karlovac Basin: Utinja; Prijedor Basin: Marini, Mala/Velika Žuljevica) (Kochansky-Devidé & Slišković 1978).

***Mytilopsis* sp.**

Figures 14D–F

Material. 3 hinge fragments from samples 0804/039 coal (2 LV) and 0804/039b (1 RV).

Description. Shell modioliform, inflated, with smooth exterior surface except for fine growth lines. Umbo prosogyral but not terminal. Prodissoconch smooth, circular, measuring around 275 µm. Anterior margin rounded; dorsal and ventral margins straightened, meeting anteriorly at rectangular to acute angle. Septum narrow, posteriorly elongated, bearing transversally oriented apophysis; anteriorly bends 45° downwards, grading there into a narrow ledge, oriented subparallel to anterior margin; anteriorly shallow, crescent depression present.

Remarks. The presence of an anterior shell portion in the dreissenids of the DLS was reported by Kochansky-Devidé & Slišković (1978, 1981) from a few species only, including *M. aletici* and *M. scaphula*. Each of these species is characterized by the presence of a transversal dorsal ridge at the proximal exterior shell surface, which is, however, not developed in this species. With exception of the relatively larger and posteriorly shifted apophysis, the available fragments are reminiscent of specimens from the Lower Miocene Freshwater Molasse (Kirchberg-Formation, S Germany), attributed to *M. amygdaloides* (Dunker, 1848) by Nuttall (1990) and Kowalke & Reichenbacher (2005). However, these specimens differ notably from the type material of *M. amygdaloides* (Dunker 1848: pl. 21, figs 8–9) from the Freshwater Molasse near Ulm (S Germany). The holotype (single right valve) shows a terminal beak position and thus a consequently different shell outline. Therefore, the identification of the Kirchberg-Fm. specimens as *M. amygdaloides* seems questionable.

Family **Sphaeriidae** Deshayes, 1854 (1820)

***Pisidium* Pfeiffer, 1821**

Type species. *Tellina amnica* Müller, 1774, Recent, Palearctic and North America.

Diagnosis. Elongate, inequilateral shell. Umbo pointing posteriorly, often protruding, sometimes with terminating growth rim. Ligament immersed. Right valve with one cardinal tooth and two anterior and two posterior teeth. Left valve with two cardinal teeth and one anterior and one posterior tooth (modified after Pfeiffer 1821; Zeissler 1971).

***Pisidium bellardii* Brusina, 1884**

Figures 14J–L

1884 *Pisidium Bellardii* Brusina, p. 48.

1897 *Pisidium Bellardii*. – Brusina, p. 36, pl. 21, figs 43–45.

Holotype. Single right valve illustrated in Brusina (1897) (by monotypy; NHMZ 3203-849).

Type locality. Trnovača, Sinj Basin, SE Croatia; Middle Miocene.

Material. 16 single valves from samples 090713/1 (1 LV, 1 RV), 090713/2 (2 LV, 3 RV), 0804/039 (2 LV, 2 RV), 0804/039b (1 LV), 0907/Moll4 (1 LV, 2 RV) and 0907/Moll4A (1 LV, 1 RV).

Description. Elliptical, inequilateral, anteriorly elongated shell. Umbo narrow, elongated and suppressed; no pronounced beak. In lateral view, shell highly curved, nearly semilunar. Fine and regular growth lines covering surface. Hinge plate short and narrow with weak emarginations formed by lateral teeth. On right valve outer lateral teeth broad and low; inner ones pointy and more distinct. Cardinal tooth (C 3; dental nomenclature after Herrington 1962) forming sharp and simple crest with proximal thickening; it is inclined and slightly curved. Ligament pit short, narrow, lanceolate and well demarcated. On left valve lateral teeth both small but quite distinct, in lateral view forming pointy, triangular cusps. C 4 short and sharp, inclined and slightly angled, distally touching margin of hinge plate; in lateral view exposing M-like profile with two acute tips, one on each side. Lower cardinal tooth (C 2) straight and parallel to hinge plate; in lateral view forming rectangular, sharp crest; roughly same length as C 4.

Remarks. This taxon has not been described so far properly. Clessin in Brusina (1884) only provided a comparison with the extant *P. fossarinum* Clessin in Westerlund, 1873 (= *P. casertanum* Poli, 1791). Despite similar shell shape this form differs in its strongly angled C 2 and C 3.

Occurrence. Gacko Basin (Vrbica, Gračanica). Sinj Basin (Ruduša in Sinj, Trnovača), Driš Basin (Miočić) (Brusina 1884, 1897).

***Pisidium vukovici* n. sp.**

Figures 14G–I

Etymology. After Dr.sc. Boško Vuković, mine geologist of RiTE "Gacko", for his assistance and help with the geological studies in the Gacko Basin.

Holotype. Right valve illustrated in Figures 14G–I, NHMW 2011/0138/0173, sample 090713/2; H=2.8 mm, L=3.0 mm, C=1.2 mm.

Paratype 1. Right valve, NHMW 2011/0138/0178, sample 090713/1.

Paratype 2. Left valve, NHMW 2011/0138/0179, sample 090713/2.

Paratype 3. Left valve, NHMW 2011/0138/0180, sample 090713/2.

Material. 6 single valves from samples 090713/1 (1 LV, 2 RV) and 090713/2 (2 LV, 1 RV) of the type horizon.

Type locality. Open-cast coal-mine "Gračanica" near Gacko, Minepit B.

Type horizon. Unit A of the Section Gračanica in Mandić et al. (2011), footwall coal II lithostratigraphic unit of the Gacko Basin, Langhian, Middle Miocene (~15.83 Ma).

Diagnosis. Shell subtrigonal. Hinge plate massive; prominent lateral teeth.

Description. Subtriangular shell with regularly semicircular dorsal margin. Umbo low and broad, measuring 750 µm. In lateral view, shell roughly semilunar. Outer surface covered with faint, regular growth lines. Hinge plate prominent and broad. Ligament pit short and lanceolate. Cardinals subcentral, oblique, dipping anteriorly; C 2 broadened, blunt; C 3 prominent, crescent, convex-up, sharp, surrounded by two shallow cavities; C 4 sharp and straightened. Laterals prominent and long with bulbous, sharp cusps. On right valve anterior teeth massive, forming distinct emargination; posterior teeth somewhat weaker. In both cases inner teeth stronger than outer ones.

Remarks. This taxon can be clearly distinguished from *Pisidium bellardii* Brusina, 1884 by its subtrigonal shell shape and very prominent hinge plate. *P. hybonatum* Brusina, 1897 is somewhat broader in outline and has a less prominent hinge plate. This species, originally described from Pliocene deposits of the southern Pannonian Basin, was additionally reported by Jovanović (1935) from the close-by Bihać Basin. Shells from the possibly coeval Austrian Aflenz Basin, determined as *Pisidium* cf. *casertanum* Poli, 1791 by Harzhauser et al. (2012), are broader and expose a narrower, delicate hinge plate. Likewise, *P. amnicum* (Müller, 1774) (= *P. priscum* Hörnes, 1862; non Eichwald, 1830) from the Middle to Late Miocene of the Central and Eastern Paratethys and the Upper Freshwater Molasse is broader and has narrower and less distinct lateral teeth (cf. Schneider & Prieto 2011). The about coeval *P. bakonyensis* Kóckay, 2006 from Hungary is quite similar in shape but exposes an elevated umbo and smaller lateral teeth. In shape and hinge characteristics it is similar to the Recent *P. supinum* Schmidt, 1851, but does not develop such a high umbo with the typical fold. Extant *P. tenuilineatum* Stelfox, 1918 has stronger posterior teeth and a transversally oriented C 3.

Superorder **Palaeoheterodonta** Newell, 1965

Order **Unionida** Stoliczka, 1871

Family **Unionidae** Rafinesque, 1820

Unio Philipsson, 1788

Type species. *Mya pictorum* Linnaeus, 1758, Recent, Europe.

Diagnosis. Shell inequilateral, oval to elongated, rounded in front and pointed or biangulate behind, with a more or less developed posterior ridge, often becoming slightly arcuate when old. Beaks only moderately inflated, generally sculptured with coarse ridges, which run parallel with the growth lines, or are somewhat doubly looped, sometimes broken and showing fine radiating lines behind. Surface smooth, slightly concentrically ridged or pustulous. Hinge plate narrow; two pseudocardinals and two laterals in the left valve and one pseudocardinal and one lateral in the right, with rarely a vestige of a second lateral. Cavity of the beaks not deep or compressed (compiled from Simpson 1900).

***Unio rackianus* Brusina, 1874**

Figures 15A–G

1874 *Unio Račkianus* Brusina, p. 115, pl. 5, figs 9–10.

1987 *Unio rackianus rackianus*. – Žagar-Sakač, p. 72, pl. 1, figs 1–2, pl. 2, figs 1–2, pl. 3, figs 1–2, pl. 9, fig. C.

1987 *Unio rackianus simplex* Žagar-Sakač, p. 76, pl. 4, figs 1–3, pl. 9, fig. A.

1987 *Unio rackianus intermedius* Žagar-Sakač, p. 77, pl. 5, figs 1–3, pl. 9, fig. B.

2011 *Unio rackianus*. – Neubauer et al., p. 216, pl. 7, figs 3–7.

Syntypes. Single left and right, posteriorly fragmented valves (NHMZ 3232-878/1-2) illustrated by Brusina (1874) and Žagar-Sakač (1987).

Type locality. Miočić, Drniš Basin, SE Croatia; Middle Miocene.

Material. Moderately to poorly preserved; fragmented single valves from samples 090713/1 (6 LV) and 090713/2 (6 LV, 2 RV).

Description. Shell moderate in size with (reconstructed) maximal length of 50 mm and height attaining about 60 % of length; postero-anteriorly elongated, elliptical in outline, inequilateral, with strongly prosogyral oriented umbo and posterior shell part 3 times longer than anterior part; highly inflated with (single valve) convexity reaching about 45 % of shell height. Shell wall nacreous, lamellate and massive (~8 mm thick in largest specimen). Proximal shell exterior bearing concentric, projecting lamellae for up to 4 mm of growth. Anteriorly regularly zigzag-like undulated; posteriorly, prominently banded, forming a backwards oriented, sharp, trigonal protrusion. Left valve: posteriorly elongated and thickened ventral lateral tooth (dorsal one not preserved in available material); massive, trigonal posterior pseudocardinal; elongated anterior pseudocardinal. Right valve: thickened, elongated pseudocardinal; sharp, elongated posterior lateral tooth. Anterior adductor scar deep and rugose, portioned by transversal ledges.

Remarks. The always co-occurring *U. rackianus simplex* Žagar-Sakač, 1987 and *U. r. intermedius* Žagar-Sakač, 1987 certainly represent only morphs of *U. rackianus* Brusina 1874 and are consequently reunited herein (see also Neubauer et al. 2011). In contrast, *Unio katzeri* Brusina, 1904 is morphologically well differentiated from *U. rackianus* by its trigonal outline and the presence of 2 to 4 prominent posterior ribs (Žagar-Sakač 1987). The latter species was originally described from the Šipovo Basin from deposits likely bearing *Mytilopsis frici*. *Unio cubranovici* Brusina, 1902 from about the same stratigraphic horizon of the Glina Basin (~16 Ma according to Mandić et al. 2012) can be hardly distinguished from *U. rackianus* except for being smaller in size and having more fragile shells. However, detailed taxonomic analyses by Žagar-Sakač (1990) supported their independent status.

Occurrence. Gacko Basin (Gračanica). Sinj Basin (Lučane W Sinj, Muša SW Otok, Panj N Hrvace, Goručica and Novi Bunar in Sinj, Koljane and Ribarić N Maljkovo), Drniš Basin (Miočić) (Žagar-Sakač 1987; Neubauer et al. 2011).

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