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The distribution of *Triebelina raripila* and *Carinocythereis carinata* (Ostracoda) from the Middle Miocene of the Central Paratethys and their palaeogeographic implications

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Abstract – Late Middle Miocene (Upper Badenian) strata of the Fore-Carpathian Depression of Poland yield a shallow-water ostracod fauna which contains the species *Triebelina raripila* (G. W. Müller, 1894) and *Carinocythereis carinata* (Roemer, 1838). The palaeobiogeographic distribution of the two main species suggests, that in the late Middle Miocene, Central Paratethys was still connected to the Mediterranean, although still separated from the Eastern Paratethys and from southeastern Eurasia. The continuous occurrence of *Triebelina raripila* and *Carinocythereis carinata* in the Mediterranean basins, from the Early Miocene to Recent, indicates that marine conditions existed throughout, thereby allowing them to survive the Late Miocene salinity crisis. *J. Micropalaeontol.* **17**(2): 125–130, December 1998.

INTRODUCTION

Triebelina van den Bold, 1946 is an ornate bairdiid genus regarded by some authors (e.g. van Morkhoven 1963; Keij 1974, 1976; Teeter 1975; Tabuki & Nohara 1990) as being confined to tropical and subtropical, shallow marine environments, principally associated with coral reefs. Its Recent representative which lives in the Mediterranean, *Triebelina raripila* (G. W. Müller, 1894) is regarded as an endemic form. A previously unknown occurrence of this species in the Middle Miocene of the Fore-Carpathian Depression in southern Poland, once part of the Central Paratethys, provides an opportunity to verify its ecological requirements. The coexistence of *Carinocythereis carinata* (Roemer, 1838) with *Triebelina raripila* in the Middle Miocene of the Fore-Carpathian Depression, provides new data for the reconstruction of the Neogene palaeogeography of this area.

The material described here is housed at the Institute of Paleobiology of the Polish Academy of Sciences in Warszawa (abbreviated ZPAL).

MATERIAL

In the Fore-Carpathian Depression of southern Poland, which represents the northern margin of the Central Paratethys, *Triebelina raripila* (G. W. Müller, 1894) occurs throughout the Middle Miocene. A single specimen was found in Lower Badenian (corresponding to the Langhian) silty sediments of the Korytnica Bay, in an outcrop situated on the southern slope of the Holy Cross Mountains (Baluk & Radwański, 1977) (Fig. 1). The Korytnica Bay Middle Miocene section consists of a variety of lithologies (e.g. sands, silts, limestones), which contain ostracods, although in variable abundance (Szczechura & Pisera, 1986). The presence of *Globigerinoides*, praeorbulinids and large foraminifers, present in the deposits of the Korytnica Bay, indicates an Early Badenian age for these deposits (Papp *et al.*, 1978; Rögl & Brandstatter, 1993).

Triebelina raripila is more common in the Upper Badenian (corresponding to the Serravallian) sediments outcropping in Roztocze, i.e. at the southern boundary of the Lublin Upland (Fig. 1). In the Roztocze region, the Miocene marine sediments

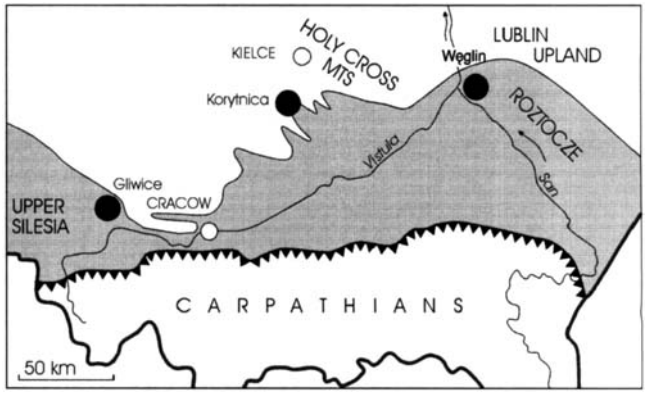
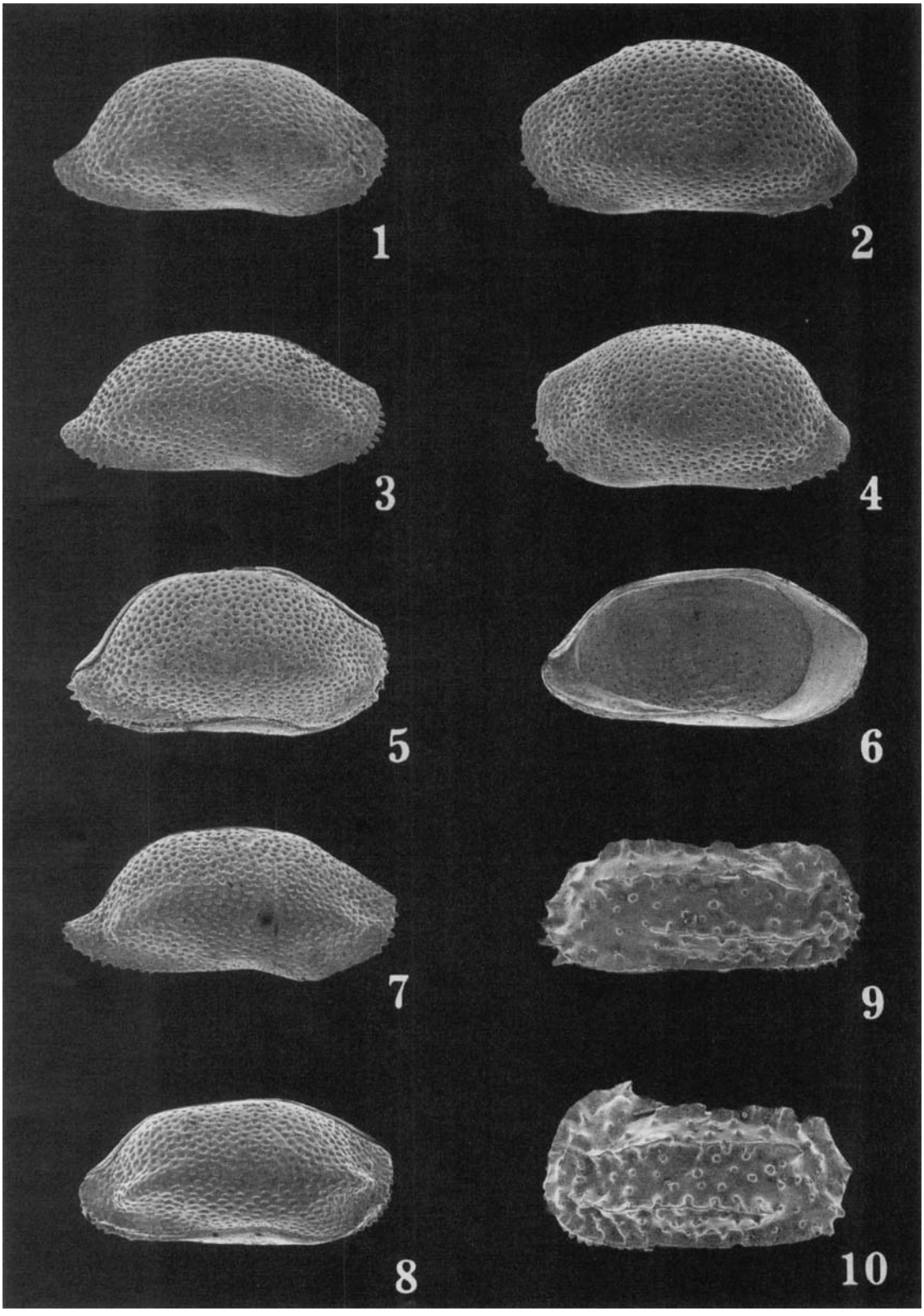


Fig. 1. Extent of the Middle Miocene (Badenian) sea in the Fore-Carpathian Depression (stippled) showing the location (black dots)of Gliwice, Korytnica and Weglin.

are also variable, consisting of silts, sands, clays, marls as well as lithothamnion-rich limestones. For example, marls with *Triebelina raripila* crop out at Weglin (Szczechura, 1982; Szczechura & Pisera, 1986, fig. 2). The age of the Weglin deposits is confirmed by the presence of *Velapertina* sp., a planktonic foraminifer characteristic of the Upper Badenian of the Central Paratethys (Papp *et al.*, 1978; Olszewska *et al.*, 1996). In this same section *Carinocythereis carinata* (Roemer, 1838) also commonly occurs. Other genera within this assemblage are *Aurila*, '*Bairdia*', *Cletocythereis, Xestoleberis, Loxoconcha, Callistocythere, Pterygocythereis, Cnestocythere, Cytheridea, Pseudocytherura, Phlyctenophora, Cyamocytheridea, Cytheretta, Propontocypris, Semicytherura, Neocytherideis, Tenedocythere, Nonurocythereis, Hemicytherura* and *Occultocythereis*. All indicate a shallow, upper neritic, coastal environment, probably associated with a regressing sea. This interpretation is reinforced by the occurrence of foraminifers, predominantly *Elphidium, Reussella, Rosalina, Cibicides* (*C. lobatulus*) and *Nonion*, as well as numerous miliolids. Within the same Weglin sample, remnants of calcareous algae (Chlorophyta) are found. These are related to those described by Malecki (1970) from the Sarmatian of the



Explanation of Plate 1

figs 1–8. *Triebelina raripila* (G. W. Müller, 1894). **figs 1, 3, 7.** External view of right valve, ZPAL O. XL/1, 3, 7 (×73, ×68, ×69, respectively). **figs 5, 8.** Carapace viewed from right side, ZPAL O. XL/5, 8 (×69, ×71, respectively). **figs 2, 4.** External view of left valve, ZPAL O. XL/2, 4 (×69, ×68, respectively). **fig. 6.** Internal view of left valve, ZPAL. O. XL/6, ×69. **figs 9, 10.** *Carinocythereis carinata* (Roemer, 1838). **fig. 9.** External view of male, right valve, ZPAL O. XL/9, ×53. **fig. 10.** External view of female, left valve, ZPAL O. XL/10, ×5. Specimens 1–7, 9, 10 are from the late Middle Miocene (Upper Badenian) of the Weglin exposure (Roztocze region, SE Poland) Specimen 8 from the beach sand near Rovinj (Adriatic Sea).

Central Paratethys and referred by him to *Acicularia* d'Archiac, 1843.

Only juvenile representatives of *Carinocythereis carinata* were found in the Upper Badenian (above gypsum layer), silty sediments of the Gliwice-21 borehole (depth 19.2–19.4 m, 31 m and 51 m), in Upper Silesia, soutwestern Poland (Fig. 1). In the Gliwice-21 borehole, however, *Carinocythereis carinata* appears to be an allochtonous shallow-water (shelf) contaminant since it is associated with deeper-water ostracodes such as *Henryhowella asperrima* (Reuss, 1850), *Pseudocythere caudata* Sars, 1866, *Pterygocytheres jonesi* (Baird, 1850), *Kangarina abyssicola* G. W. Müller, 1894, *Cluthia miocenica* Szczechura, 1986, *Xylocythere carpathica* Szczechura, 1995, *Cytheropteron* sp., *Parakrithe* sp., *Krithe* sp., *Sagmatocythere* sp. and *Argilloecia* sp.

The foraminifers associated with this assemblage include representatives of *Globigerina* sp., *Uvigerina* spp. (including the *Uvigerina peregrina* Cushman group), *Pullenia* sp., *Cassidulina* sp., *Melonis pompilioides* Fichtel & Moll, *Heterolepa dutemplei* (d'Orbigny), *Hoeglundina elegans* (d'Orbigny), *Cibicides ungerianus* d'Orbigny, *Hanzawaia boueana* d'Orbigny, *Bulimina* sp., *Bolivina* sp., *Sphaeroidina bulloides* d'Orbigny, *Gyroidina* sp., *Epistominella* sp. and *Gavelinopsis* cf. *praegeri* (Heron-Allen & Earland). All these foraminifers indicate a deeper-water, temperate/cold-water, open marine environment. The suggested environment is further supported by other coexisting microfossils, especially frequent bolboforms (predominantly *Bolboforma badenensis* Szczechura), radiolarians, pteropods and diatoms. *Bolboforma badenensis* is an index form for the Upper Badenian (=the calcareous nannoplankton Zone NN6) of the Central Paratethys (Szczechura, 1982; Spiegler & Rögl, 1992).

The Lower Badenian microfauna of the Central Paratethys apparently represents a tropical (or subtropical) environment, whereas the Upper Badenian portion in this area (especially its northern part) is interpreted as a temperate one. Szczechura (1982, 1986, 1994, 1996) identified these microfaunas as belonging to the *Globigerinoides* and *Globigerina* ecozones, respectively.

RELATIONSHIP BETWEEN *TRIEBELINA RARIPILA* (MÜLLER, 1894) AND *TRIEBELINA BOLDI* KEIJ, 1955

Triebelina boldi Keij, 1955, originally described from the Lower Miocene of the Aquitanian Basin, differs from *Triebelina raripila* (G. W. Müller, 1894) (originally referred to as *Bairdia raripila*) from the Tyrrhenian Sea, mainly on outline and in the ornamentation of the left valve (Keij, 1976). The left valve of *Triebelina boldi* is a little higher and less elongated than in *Triebelina raripila*; the length/height ratio is 1.8–1.9 for *Triebelina boldi* while 2.0 for *Triebelina raripila*. Moreover, the 'carina' of the right valve of *Triebelina boldi* is less prominent than in *Triebelina raripila*. Keij (1976) also states that *Triebelina boldi* is the ancestor of *Triebelina raripila* and that both species belong to the same lineage, probably stemming from the Late Oligocene *Paranesidea* Maddocks, 1969. A similar view was adopted by Malz and Lord (1988).

A comparison of specimens from the Middle Miocene of the Fore-Carpathian Depression, referred here to *Triebelina raripila* (Pl. 1, figs 1–7), as well as those Upper Miocene specimens belonging to that species from Turkey (Doruk, 1974) and its Recent representatives from the Aegean and the Adriatic Seas (see Barbeito-Gonzàlez, 1971; Uffenorde, 1972; Bonaduce *et al.*, 1975) and from my own collections (Pl. 1, fig. 8) provides evidence that length/height ratio does vary and even may overlap with those of *Triebelina boldi*. Even within Recent specimens from a single population the length/height ratio ranges between 1.6 and 2.3; at the same time, the 'carina' in the right valve is quite variable. Similar size variations may also be seen among specimens of the same sample from the Upper Badenian of Poland (Pl. 1, figs 1, 3, 5 & 7). For these reasons I agree with Nascimento (1988) and Ducasse and Cahuzac (1997) and regard *Triebelina boldi* Keij, 1955, as a junior synonym of *Triebelina raripila* (G. W. Müller, 1894). Malz and Lord (1988), on the other hand, regarded them as separate species.

Listed below is a complete synonymy of *Triebelina raripila* (G. W. Müller).

1894 *Bairdia raripila* G. W. Müller: 272, pl. 13, fig. 37; pl. 15, figs 5–7, 28.
1955 *Triebelina boldi* Keij: 107, pl. 14, figs 7, 8.
1965 *Triebelina boldi* Key; Moyes: 18, pl. 1, fig. 19.
1968 *Bairdia raripila* G. W. Müller; Masoli: 10, pl. 1, fig. 5; pl. 4, figs 44–46
1971 *Bairdia raripila* G. W. Müller; Barbeito-Gonzàles: 264, pl. 3, figs 1b, 2b, 3b; pl. 45, figs 24–26.
1971 *Triebelina boldi* Key; Olteanu: 127, pl. 1, fig. 6.
1972 *Bairdia raripila* G. W. Müller; Uffenorde: 52, pl. 5, fig. 7.
1974 *Triebelina raripila* (G. W. Müller); Doruk: pl. 2:12:66; pl. 2:12:68 (Stereo-Atlas of Ostracod Shells).
1975 *Triebelina raripila* (G. W. Müller); Bonaduce, Ciampo & Masoli: 23, pl. 6, figs 11, 12.
1979a *Bairdia raripila* G. W. Müller; Yassini: 374, pl. 1, fig. 6.
1979b *Bairdia raripila* G. W. Müller; Yassini: 374, pl. 1, fig. 6.
1984 *Triebelina raripila* (G. W. Müller); Malz & Jellinek: 124, pl. 2, fig. 12.
1988 *Triebelina raripila* (G. W. Müller); Nascimento: 65, pl. 2, fig. 9.
1988 *Triebelina raripila* (G. W. Müller); Malz & Lord: 70, pl. 1, fig. 12.
1988 *Triebelina raripila* (G. W. Müller); Bonaduce, Masoli & Pugliese: pl. 1, fig. 1.
1989 *Triebelina raripila* (G. W. Müller); Lachenal: 146, pl. 1, fig. 11.
1990 *Triebelina raripila* (G. W. Müller); Römmelt-Doll, pl. 2, fig. 19.
1996 *Triebelina raripila* (G. W. Müller); Szczechura: pl. 1, figs 1–3.

SPATIAL AND TEMPORAL DISTRIBUTION OF *TRIEBELINA RARIPILA* (G. W. MÜLLER, 1894)

The distribution of fossil representatives of *Triebelina raripila* is restricted to Europe, including the Mediterranean region (Fig. 2). Its earliest record is in the Lower Miocene of France (Aquitanian Basin) (Keij, 1955; Moyes, 1965); in 1997, Ducasse and Cahuzac described it from the Middle Miocene of the same area. It is also known from the Lower Miocene of Portugal (Nascimento, 1988). In the Middle Miocene (Badenian), this species appeared in the Central Paratethys (Olteanu, 1971; Szczechura, 1996). In the Upper Miocene of Turkey, *Triebelina raripila* is found (Doruk, 1974) as well as, in the Pliocene, being reported from the coast of Algeria (Yassini, 1979*a*). It is also

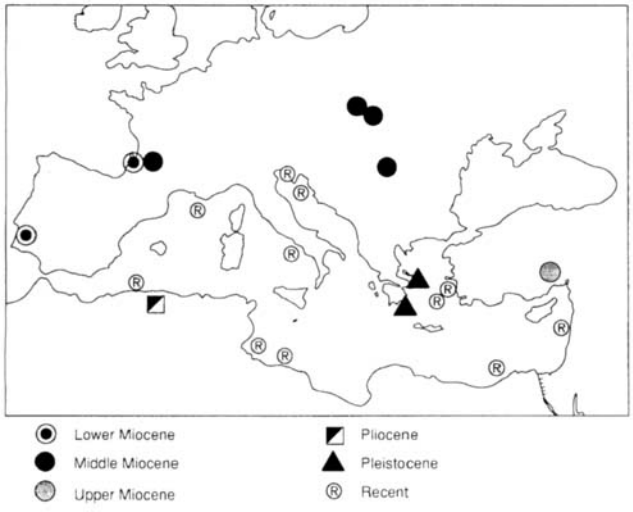


Fig. 2. Distribution of Recent and fossil representatives of *Triebelina raripila* (G. W. Müller, 1894).

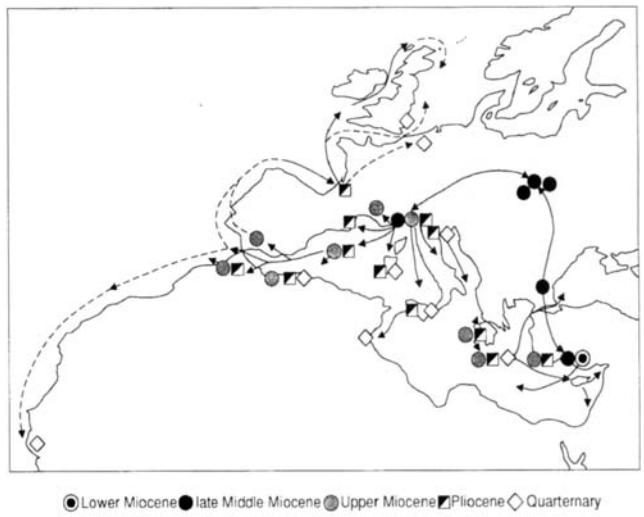


Fig. 3. Distribution of fossil representatives of *Carinocythereis carinata* (Roemer, 1838); taken from Carbonel (1977), and supplemented by my own data. Arrows indicate probable directions of species migrations.

recorded from Pleistocene sediments from Greece (Peloponnese Peninsula) (Malz & Jellinek, 1984; Römmelt-Doll, 1990).

The distribution of living *Triebelina raripila* is restricted to the Mediterranean, where it is widely dispersed and extends along its northern coast as well as its southern coast. It is known from southern France (Reys, 1964), southwestern Italy (G.W. Müller, 1894; Puri *et al.*, 1964), the Adriatic Sea (Masoli, 1968; Uffenorde, 1972; Bonaduce *et al.*, 1975), coasts of Greece (Barbeito-Gonzàlez, 1971), western Turkey (Doruk, 1974) and Lebanon (Bonaduce *et al.*, 1970) as well as the northern coasts of Africa: Egypt (Malz & Lord, 1988), Libya (Bonaduce & Pugliese, 1975), Tunisia (Lachenal, 1989) and Algeria (Yassini, 1979*b*) (cf. Fig. 2). This restricted distribution along the Mediterranean indicates a dependance on a somewhat temperate climate. According to Puri *et al.* (1964), Bonaduce *et al.* (1988), and Lachenal (1989), *T. raripila* prefers very shallow water and a sandy substrate covered with *Posidonia* and algal detritus.

SPATIAL AND TEMPORAL DISTRIBUTION OF *CARINOCYTHEREIS CARINATA* (ROEMER, 1838)

Carinocytherereis carinata (Pl. 1, figs 9, 10), was described by Roemer (1838) as *Cytherina carinata* from the Pliocene of northern Italy. According to Carbonel (1977), this species appeared first in the late Middle Miocene of northern Italy, and in Liguria and Piedmont of the Western Alps. During the Late Miocene, its range was extended to the Mediterranean, where it still lives today (Fig. 3). *Carinocythereis carinata* entered the Atlantic coasts of Europe during the Pliocene. In addition to the distribution mentioned by Carbonel (1977), *Carinocythereis carinata* is now known to occur in the Early Miocene and the late Middle Miocene of Turkey (Gökçen, 1984; Safak & Nazik, 1994) as well as in the late Middle Miocene (Upper Badenian) of the Central Paratethys (Steininger, 1977; Sokač, 1979; Jiřiček & Řiha, 1991; Szczechura 1996). From the late Middle Miocene of the Central Paratethys, it occurs in the Transcarpathian Basin of the Czech Republic (Brestenskà & Jiřiček, 1978; Jiřiček, 1983), in northeastern Bulgaria (Tzankov *et al.*, 1965) and southern Poland (Fore-Carpathian Depression) (Szczechura, 1996).

It favours a very shallow marine (littoral), sandy bottom habitat and is often associated with *Posidonia* and/or calcareous algae (Puri *et al.*, 1964; Uffenorde, 1972; Carbonel, 1977).

DISCUSSION

Triebelina van den Bold, 1946 is represented by more than a dozen species, ranging from the Eocene to the Recent. The Recent forms are known mostly from shallow, tropical to subtropical waters in the Indo-Pacific and Atlantic Oceans, principally from coral–algal reefs. The distribution and the environmental preferences of *Triebelina raripila*, however, are different. This species prefers (today as well as in past occurrences) a rather temperate climate and a sandy marine environment with algae and/or *Posidonia*. Maddocks (1969) grouped this species, together with *Triebelina reticulopunctata* Benson, 1959 which is described from the eastern Pacific Ocean (coasts of California), as the representatives of the genus *Triebelina* known from temperate latitudes. Of interest is that Valentine (1976) found *Triebelina reticulopunctata* (a taxon very similar to *Triebelina raripila*) within the Pliocene ostracod biofacies of the southwestern part of North America, which he attributed to a warm–temperate marine climate. Hartmann (1988) mentions *Triebelina reticulopunctata* Benson, 1959 within ostracod species which have an East Pacific–Indo–West Pacific distribution; according to Hartmann (1988) this species is also known from the Eocene of France.

Of interest is that the tropical species *Triebelina sertata* Triebel, 1948 invaded the eastern areas of the Mediterranean from the Indian Ocean (McKenzie, 1986; Malz & Lord, 1988), (probably) via the Suez Canal, while *Triebelina raripila* is still restricted to the Mediterranean. This implies particular preferences of *Triebelina raripila* for its environment and explains its palaeodistribution, especially its restriction to Europe.

Provincialism of Neogene faunas in Europe has been observed by a various authors. Tzankov *et al.'s* (1965) examination of the Neogene microfossils (including foraminifers and ostracods) of Bulgaria allowed them to distinguish two Middle Miocene

biogeographic provinces; *viz.* the north-western and north-central province, which he named 'viennois', and north-eastern province, named 'criméen-caucasien'.

Yassini's (1986) study of Neogene palaeobiogeography of the Eastern Paratethys identified different biogeographic provinces. According to this author (Yassini, 1986, fig. 1), there were two provinces (i.e. western and eastern) within the Paratethys, with a boundary placed at the western margin of the Black Sea. The eastern province included the Eastern Paratethys, while the western province contained the Western Paratethys as well as the Central Paratethys. Yassini (1986), however, also suggested separating these provinces from the Mediterranean.

Khalaf (1986) identified provincialism for the Middle Miocene shallow-water ostracod faunas by recognizing different biofacies in the Mediterranean and in southern Eurasia.

All these observations should help us to better understand Neogene palaeogeography, and the distribution of ostracods in the Middle Miocene in particular. As such, the differences between the southwestern European and central European forms from those of the eastern parts of Europe and south-eastern Eurasia are confirmed.

CONCLUSIONS

The palaeobiogeographic distribution of *Triebelina raripila* (G. W. Müller) indicates that in the Neogene (including the late Middle Miocene) this species was broadly distributed in Europe, encompassing the Central Paratethys. It was restricted (as it is now) to this broad area (now forming Europe) and is thus regarded a relict rather than an endemic form in the Mediterranean Sea.

The spatial and temporal distribution of *Carinocythereis carinata* (Roemer) supports the above conclusions concerning the extent of the late Middle Miocene marine basins, including the Central Paratethys as well as southern Europe, thus suggesting exchange of microfauna between these areas. In addition, there is a synchronous appearance of *Carinocythereis carinata* in the upper part of the Middle Miocene in the Central Paratethys and in the western Alps (northern Italy), while the first appearance of both species (*i.e.* shallow-water ones), occurs in the Early Miocene of the Mediterranean basins.

The above conclusions, concerning the extent of the Middle Miocene marine basins in Europe, which are based on the distribution of common, shallow-water ostracod species, are in agreement with those arrived at using deep-water ostracods as recognized in the Middle Miocene of the Central Paratethys (Szczechura, 1994, 1995).

The separation of the Neogene, and especially of the Middle Miocene, Paratethyan basins (including both the Central Paratethys and Eastern Paratethys) from the Mediterranean, as suggested by Benson (1976), Rögl & Steininger (1984), Briggs (1995) and others, is questioned by the present study. While these authors' suggestions may be valid for Sarmatian palaeogeography, additional confirmation is required through further studies.

The continuous occurrence, from the Early Miocene to the Recent, of *Triebelina raripila* and *Carinocythereis carinata* in the Mediterranean basins, indicates that marine basins persisted thereby allowing these species to 'survive' the Late Miocene salinity crisis.

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