JARMILA KRZYMIŃSKA, TADEUSZ NAMIOTKO

Quaternary Ostracoda of the southern Baltic Sea (Poland) – taxonomy, palaeoecology and stratigraphy

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CONTENTS

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[1] Polish Geological Institute – National Research Institute, Marine Geology Branch, Kościerska 5, PL-80-328 Gdańsk, Poland; e-mail: jarmila.krzyminska@pgi.gov.pl

[2] University of Gdańsk, Faculty of Biology, Department of Genetics, Laboratory of Limnozoology, Wita Stwosza 59, PL-80-308 Gdańsk, Poland; e-mail: tadeusz.namiotko@biol.ug.edu.pl

Abstract. To reconstruct environmental changes in water hydrology and salinity in the Late Glacial to Holocene of the Polish part of the southern Baltic Sea, the distribution of ostracod valves was studied in 85 sediment cores collected from both the open sea and the coastal zone. The studied sequences yielded 30 species, of which six appeared new to the Quaternary Baltic deposits of Poland. The most common species were non-marine *Candona neglecta* (present in 52 cores), *C. candida* (31 cores) and *Cytherissa lacustris* (30 cores) as well as holeuryhaline *Cyprideis torosa* (52 cores). Initial Late Glacial–early Holocene palaeoassemblages dominated by inhabitants of the profundal/sub-littoral zones of modern oligo-mesotrophic lakes (*C. lacustris*, *C. neglecta*, *C. candida*) or species typical of the lacustrine littoral (*Darwinula stevensoni*, *Limnocythere inopinata*, *Ilyocypris decipiens*) were replaced in middle and late Holocene by the assemblages dominated by brackishwater species (*Cyprideis torosa*, *Cytheromorpha fuscata*). The revealed successional transitions indicate the fundamental environmental change in the history of the Baltic, when marine waters entered the Baltic Basin and caused the major hydrological shift from the freshwater system into the brackish-marine Littorina Sea. The present results consolidate inferences based on previously published ostracod data on the environmental transformation in the southern Baltic Sea.

Key words: palaeoenvironmental reconstruction, stratigraphical distribution, lacustrine conditions, Atlantic marine transgression, brackish-water species.

Abstrakt. W celu odtworzenia zmian środowiskowych w późnym glacjale i w holocenie na terenie polskiej części południowego Bałtyku zbadano rozmieszczenie małżoraczków w osadach 85 rdzeni pochodzących zarówno z obszarów otwartego morza, jak również ze strefy przybrzeżnej. W badanych osadach znaleziono łącznie 30 gatunków, z których sześć okazało się nowymi dla czwartorzędu polskiej części Bałtyku. Najczęstszymi były gatunki słodkowodne: *Candona neglecta* (występująca aż w 52 rdzeniach), *C. candida* (w 31 rdzeniach) i *Cytherissa lacustris* (w 30 rdzeniach), a także gatunek holeuryhalinowy *Cyprideis torosa* (w 52 rdzeniach). Pierwotne zgrupowania późnego glacjału i wczesnego holocenu, zdominowane przez gatunki strefy profundalu/ sublitoralu jezior oligo-mezotroficznych (*C. lacustris*, *C. neglecta*, *C. candida*) lub gatunki charakterystyczne dla litoralu jezior (*Darwinula stevensoni*, *Limnocythere inopinata*, *Ilyocypris decipiens*), w środkowym i późnym holocenie zostały zastąpione zgrupowaniami zdominowanymi przez gatunki słonawowodne–morskie (*Cyprideis torosa*, *Cytheromorpha fuscata*). Odnotowane prawidłowości sukcesyjne fauny małżoraczków wskazują na fundamentalne zmiany środowiskowe Morza Bałtyckiego, kiedy to wody morskie wdarły się do basenu bałtyckiego, powodując przekształcenie zbiornika słodkowodnego w słonawowodne Morze Litorynowe. Uzyskane wyniki poszerzyły wnioski zawarte w opublikowanych danych dotyczących małżoraczków i przemian środowiskowych południowego Bałtyku.

Słowa kluczowe: rekonstrukcja paleośrodowiskowa, zasięgi stratygraficzne, środowisko wód słodkich, transgresja morska, gatunki słonawowodne.

INTRODUCTION

In addition to pollen and plant macroremains, which are a major source of our knowledge of climate change, particularly valuable information on various aspects of the evolution of natural systems provide increasingly meiobenthonic aquatic animals, especially ostracods (Ostracoda). Easy to fossilization, small size and often massive presence, as well as differences in the carapace associated with developmental stage and gender and also strict environmental relations make these cosmopolitan crustaceans, today present in all types of water, very convenient objects of widely understood paleoecological and evolutionary studies (eg., von Grafenstein *et al*., 1999; Holmes, Chivas, 2002; Boomer *et al*., 2003; Danielopol *et al*., 2008; Namiotko, Martins, 2008; Belmecheri *et al*., 2009).

However, due to species-specific ecological requirements, a prerequisite for the use of Ostracoda to reconstruct past environment is faultless identification of the remains of their carbonate shells, relatively well-preserved in different types of Quaternary sediments (silts, gyttjas, lake chalk). In Polish literature, unfortunately there are no modern and comprehensive synopses and checklists on subfossil Quaternary ostracods of the Polish part of the Baltic Sea. Currently, there are only two monographs which could allow identification of Quaternary ostracods: a) the key to the determination of modern freshwater Polish species (Sywula, 1974) and b) the atlas of key and characteristic Ostracoda species of the Polish Quaternary (Sywula, Pietrzeniuk, 1989). Both papers, however, primarily deal with the species representing recent or Quaternary inland habitats.

The purpose of this paper is to fill this gap by presenting an up-to-date monograph of the Quaternary Ostracoda fauna on the Polish part of the Baltic Sea and our coastal zone. The monograph includes 38 species (about 25% occurring in Poland today) found in both the authors' own material (basically unpublished data) and in the literature, the latter data were critically verified. Unpublished data came from dozens of vibrocores taken from the bottom of the southern Baltic Sea and the coastal zone. Each species was illustrated on the base of a set of images from a scanning electron microscope (SEM) and, for some, also images from the transmitted light microscope (TLM). Descriptions of species contain current information on environmental preferences and characteristics of spatial and temporal occurrence in the study area on the background of geographical and stratigraphic range in Poland and around the world. Additionally, an outline of the morphology of ostracod valves as well as a pictorial key to the Quaternary species of the Polish Baltic is provided. This comprehensive study will certainly facilitate wider use of Ostracoda by paleontologists and Quaternary geologists, both in Poland and in other countries around the Baltic Sea.

Given the small number of this type of comprehensive studies for the Baltic Ostracoda (see for exception an excellent compilation by Frenzel *et al*., 2010), the major meaning of the monograph is to facilitate the use of ostracod in reconstruction and indication of various environmental changes, also in biostratigraphy and in assessing (paleo-) biodiversity.

AREA COVERED AND GEOLOGICAL SETTING

This monograph covers the Polish part of the Baltic Sea (considered here as limited by the Polish Exclusive Economic Zone) as well as the coastal zone streaching landward out to less than 10 km from the seacoast (within the Szczecin, Koszalin and Gdańsk coastal physicogeographical macroregions). The sediment profiles from which material was obtained for the present study were recovered from three areas (western, central and eastern) delimited in Fig. 1.

Basic knowledge about the geology of the Quaternary Baltic Sea has been shaped mainly by Scandinavian, Russian and German researchers, especially by Ignatius *et al*. (1981), Gudelis, Emelyanov (1982), Grigelis (1991), Blazhchishin (1998), Gelumbauskaitë (2000, 2009), Harff *et al*. (2011). With regard to the southern Baltic Sea, it was complemented and extended by many Polish geologists, inter alia, by Rosa (1963), Kramarska (1991, 1998), Kramarska, Jurowska (1991), Uścinowicz (1991), Michałowska, Pikies (1992), Uścinowicz, Zachowicz (1992, 1994), Kramarska *et al.* (1995), Pikies (1995), Pikies, Jurowska (1995).

According to Kramarska *et al.* (1995) the thickness of Quaternary sediments in the southern Baltic Sea ranges from 1.3 m to at least 300 m, and the degree of recognition of sediment thickness is varied. The smallest thickness was observed in the areas of contemporary deep-water pools. These areas include the southern edge and the bottom of Słupsk Furrow and the southern periphery of Gotland Basin. Larger thickness is associated with shallow-water zone, and especially of the better known coastal zone in which Quaternary sediments locally appears over 300 m.

Pleistocene sediments are best studied within the deep basins of the southern Baltic Sea. On the southern slopes of Słupsk Furrow and southern edges of the Gotland Basin they are represented by a single layer of boulder clay with thickness less than 10 m. In the Bornholm Basin and Gdańsk Basin and the northern slopes of Słupsk Furrow there are two layers of boulder clay, covered with clay, and varve and microvarve Baltic Ice Lake deposits, building a roof of Pleistocene. In these areas, Pleistocene thickness ranges from 10 to 20 m, reaching up to 30 m in the center of Gdańsk Basin. Greater thickness of Pleistocene sediments (up to 60 m), occur in pools only locally, within the deep indentation in the ground of Quaternary (subglacial trough). Much more complicated is

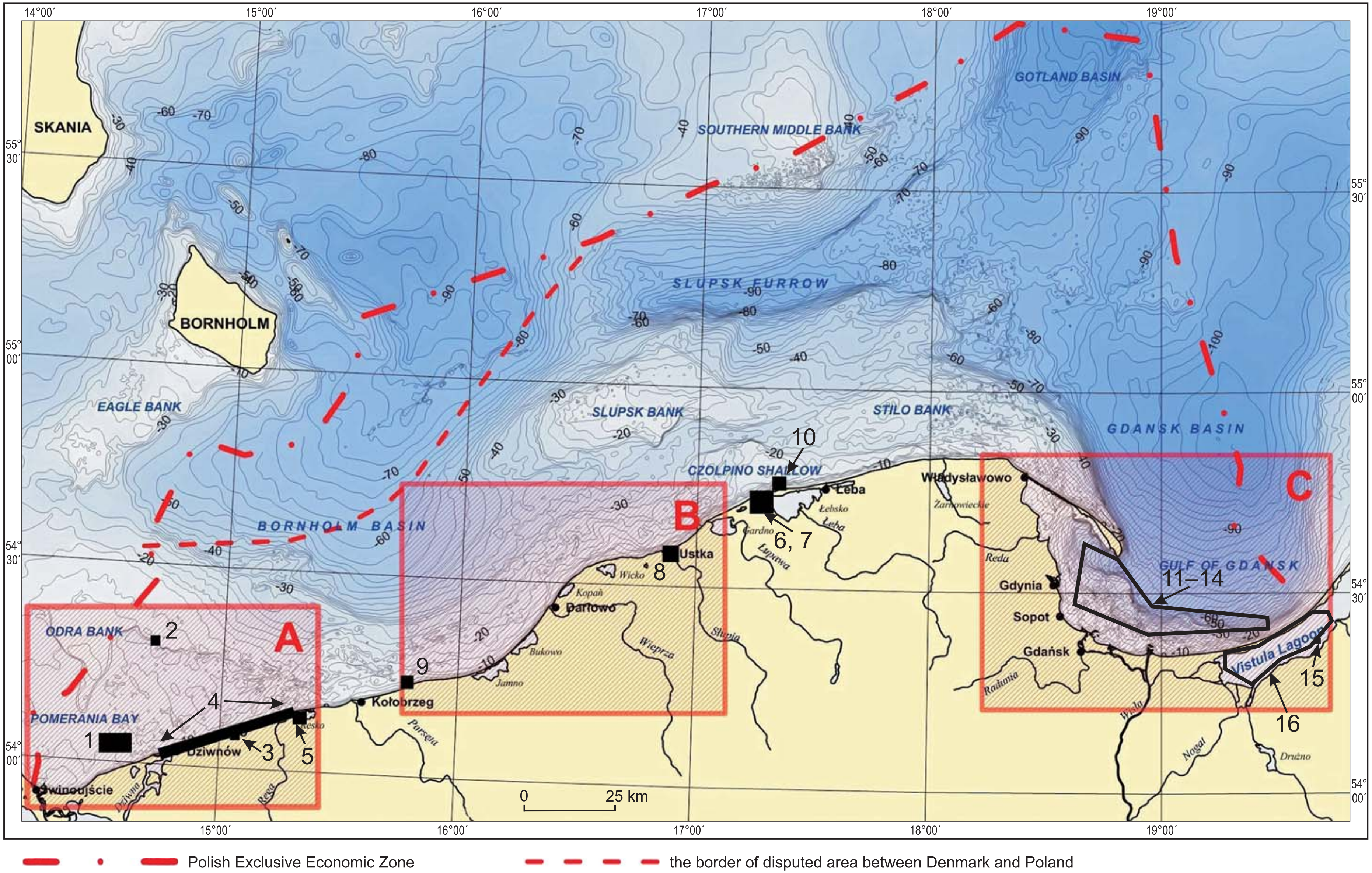


Fig. 1. Location of the three areas from which material was obtained for the present study (A – western, B – central and C – eastern) along with the sites/areas of the historical records on Quaternary (Late Glacial to Holocene) Ostracoda in the Polish part of the southern Baltic Sea and its coastal area

Numbers 1–16 after the references in Table 1; location of the coring sites of the re-examined own published material is detailed in Figs. 2 and 4 the construction of the Pleistocene deposits in shallow-water zone. Apart from a few layers of glacial till there are deposits of waterglacial and glacial-lacustrine accumulation and also interglacial sediments and lateglacial sandbar sediments of Baltic Ice Lake. The thickness of these formations in the area is very diverse, ranging from 5 m to the west of Jarosławiec to about 300 m in the region of Czołpino. The greatest thickness is in the subglacial gutters, slitting Quaternary bedding (Kramarska *et al*., 1995).

Holocene sediments of the southern Baltic Sea are bipartite. In the deepwater pools the bottom link is formed by silty-clayey sediments of the Yoldia Sea and Ancylus Lake, from the Preboreal and Boreal periods, and the upper link is built by muddy sediments of the Mastogloia, Littorina and Postlittorina seas representing the Atlantic, Subboreal and Subatlantic periods. The total thickness of the Holocene sedimentary cover is 7–8 m in the Bornholm Basin, 5–6 m on the northern slopes of Słupsk Furrow and only 3–4 m in the southern part of the Gotland Basin. The largest thickness of the Holocene deposits occurs in Gdańsk Basin (Kramarska *et al*., 1995).

In the shallow water zone, the lower link of the Holocene are lacustrine-marshy, delta and the lagoon sediments which belong to Preboreal, Boreal and Atlantic chronozones. They occur in the Pomeranian Bay, Gulf of Gdańsk, Słupsk Bank, and in some areas of the coastal zone of the southern Baltic Sea. These deposits were largely destroyed during the transgression, so that the slopes of pools and large areas of shallow water zone occurs only upper Holocene sea link. It is represented by sands and gravels of the Littorina and Postlittorina Seas, included in the Atlantic, Subboreal and Subatlantic periods. The greatest thickness of the Holocene deposits in the shallow water zone are found on the bottom of the Gulf of Gdańsk, whitin the area of the Vistula Lagoon and the Vistula Spit and the Pomeranian Bay and the Odra Bank. At the prevailing areas of shallow water zone thickness of marine sand and gravel is generally less than 2 m, and large areas does not reach up to 1 m thickness of Holocene marine sands locally exceed 3 m in the south-eastern part of the Southern Middle Bank, the southern part of Słupsk Bank Shallow and Czołpino Holocene sand thickness up to 6 m (Kramarska *et al.*, 1995). At the prevailing areas of shallow water zone, thickness of marine sand and gravel is generally less than 2 m, and over most areas does not reach up to 1 m. Holocene marine sand thickness only locally exceeds 3 m. In the south-eastern part of the Southern Middle Bank, the southern part of Slupsk Bank and within Czołpino Shallow, Holocene sand thickness reaches up to 6 m (Kramarska *et al*., 1995).

HISTORY OF RESEARCH ON OSTRACODA FROM QUATERNARY DEPOSITS OF THE POLISH PART OF THE BALTIC SEA

Distribution of fossil Quaternary Ostracoda in Polish part of the southern Baltic Sea based on historical records is presented in the Table 1, whereas locations of the sites are shown in Fig 1. Two existing, although outdated, catalogues of the Quaternary Ostracoda of Poland, one by Brodniewicz (1977) and the other one by Sywula and Pietrzeniuk (1989, and English version published in 1994), provided a starting point to attempt the compilation of a comprehensive list of the known hitherto Quaternary ostracods of the southern Baltic Sea. To produce the present checklist, mostly peer reviewed publications were examined, no effort was made to include all works of the "grey literature" which is characteristic of receiving little or no international dissemination (i.e. abstracts of local symposia and congresses, unpublished reports, dissertations, institute proceedings, etc.). Some species reported in the published works are excluded from the checklist because they have been named only in open nomenclature (as sp.). The generic assignments of some species are updated according to taxonomic progress elsewhere. The checklist is arranged alphabetically with no synonyms or previous combinations included which seems to be easier in use by non-specialists. Hierarchical taxonomic position of Quaternary Ostracoda of the southern Baltic Sea is provided in the subsequent chapter.

There has been little published relating to ostracods in Quaternary sediments of the Polish region of the southern Baltic Sea. To our knowledge until the end of the 20th century only six papers have reported in total 21 species from boring holes at modern coastal inland sites (Brodniewicz and Rosa, 1967; Brodniewicz, 1972, 1979; Kopczyńska-Lamparska *et al*., 1984) and from cores taken from the bottom of the Vistula Lagoon (Janiszewska-Pactwa, 1973; Zachowicz and Uścinowicz, 1997) (Table 1, Fig. 1).

The first record of Quaternary Ostracoda from Polish part of the southern Baltic Sea was taken by Brodniewicz and Rosa (1967) who mentioned 10 species (plus one in open nomenclature as *Loxoconcha* sp. excluded from the present checklist) collected from Holocene (the Littorina Sea) sediment layers of the drillhole made near the lighthouse in Czołpino, *ca*. 5 km W of lake Łebsko (Koszalin Coastal Zone). The drawings of the majority of the listed species show sufficient detail for identification. Later, from sediment samples of one profile taken at Brenkowo (Koszalin Coastal Zone), 4 km SE of the previously mentioned Czołpino site, Brodniewicz (1972) reported 15 species, documenting successive changes in salinity, depth and water temperature of a more or less isolated marine bay during the Holocene. Although there were no accompanying illustrations or taxonomic treatment of the recorded species, the list included a number of well-known and common species and their identifications may be regarded valid. Janiszewska-Pactwa (1973) analysed a succession of zoobenthic assemblages in sediments of Holocene cores taken from the Vistula Lagoon

Table 1

Distribution of Ostracoda in Late Glacial and Holocene sediments of the southern Baltic Sea based on historical records

Species \ Region	Pomeranian Bay and Odra Bank	Szczecin Coastal Zone	Koszalin Coastal Zone	Gdańsk Bay	Vistula Lagoon
Candona angulata	1	4, 5	6, 7, 10	11, 13	
Candona candida	1, 2	3, 4, 5	8, 10	11, 13, 14	16
Candona neglecta	1[a], 2[a]	4[a], 5	7,10	11[a],13,14	15, 16[a]
Candona weltneri		5		13, 14	
Cyclocypris laevis	1, 2	5	7, 8, 10	13, 14	
Cyclocypris ovum		4, 5	7, 8	14	
Cyclocypris serena		4			
Cypria ophtalmica			7		
Cyprideis torosa	1	4, 5	6, 7	13, 14	15, 16
Cypridopsis vidua		5	8, 10	11, 13, 14	
Cytherissa lacustris	1, 2	4, 5	9, 10	11, 12, 13, 14	
Cytheromorpha fuscata	1	5	6, 7	14	16
Cytherura gibba			6, 7		16
Darwinula stevensoni	2	4, 5	6, 7, 10	13, 14	15, 16
Fabaeformiscandona alexandri	2			11, 13, 14[b]	
Fabaeformiscandona levanderi				14	
Fabaeformiscandona protzi		5		11, 14	
Herpetocypris reptans	1	4, 5	10	11, 13, 14	
Heterocypris salina			7		
Ilyocypris decipiens		4, 5	10	11, 13, 14	
Ilyocypris gibba			6, 7		
Ilyocypris lacustris	1	4	10	13, 14[c]	
Limnocythere inopinata	1	4, 5	6, 7, 8, 9, 10	11, 13, 14	16
Limnocytherina sanctipatricii		5	10	13, 14	
Loxoconcha elliptica	1		6		
Metacypris cordata		4	10	13, 14	
Pseudocandona compressa		3, 5	7, 8	13, 14	16
Pseudocandona rostrata			7		
Sarscypridopsis aculeata			7		16
Scottia tumida				13, 14[d]	
Semicytherura nigrescens			6		
Xestoleberis aurantia			6		

References/Sites: 1 – Krzymińska, Przezdziecki (2001): 13 profiles of Late Glacial–middle Holocene sediments from the 10–11 m-deep sea bottom; 2 – Uścinowicz (2006): one profile of early Holocene from the Odra Bank, ostracods identified by J. Krzymińska; 3 – Kopczynska-Lamparska *et al*. (1984): one profile of Oldest Dryas–Pre-Boreal at Niechorze; 4 – Krzymińska *et al*. (2003): 11 profiles of Late Glacial–Holocene sediments from the coast and sea bottom between Międzywodzie and Dźwirzyno; 5 – Krzymińska, Cedro (2011, 2012): two Holocene profiles at Mrzeżyno; 6 – Brodniewicz, Rosa (1967): one Holocene (Littorina Sea) profile at Czołpino; 7 – Brodniewicz (1972): one Holocene profile at Brenkowo; 8 – Brodniewicz (1979): one Late Glacial (Alleröd) profile at Ustka; 9 – Krzymińska *et al.* (2003): one profile of Late Glacial–Holocene from the sea bottom off Ustronie Morskie; 10 – Zawadzka *et al*. (2005): one profile of Late Glacial–Holocene from the sea bottom off Łebsko; 11 – Krzymińska *et al.* (2005): three profiles of Late Glacial–Holocene from the 30–62 m-deep sea bottom off Gdynia; 12 – Uścinowicz (2006): one profile of Late Glacial–Holocene from the 53 m-deep sea bottom off Krynica Morska, ostracods identified by J. Krzymińska; 13 – Krzymińska, Przezdziecki (2010): four profiles of Late Glacial–Holocene from the 11–30 m-deep sea bottom off Gdynia, Sopot and Gdańsk; 14 – Krzymińska, Namiotko (2011, 2012): 20 profiles of Late Glacial–Holocene from the 11–68 m-deep sea bottom; 15 – Janiszewska-Pactwa (1973): two Holocene (Littorina Sea) profiles; 16 – Zachowicz, Uścinowicz (1997): 12 Late Glacial–Holocene profiles, ostracod identifications based on unpubl. report of J. Krzymińska

[a] – juveniles as *Candoniella subellipsoidea* Sharapova and/or *Candoniella suzini* Schneider, [b] – as *Fabaeformiscandona* cf. *alexandri*, [c] – as *Ilyocypris* cf. *lacustris*, [d] – as *Scottia* cf. *tumida*

north of Frombork, mentioning three ostracod species from two cores. Brodniewicz (1979) in her faunistic analysis of Late Glacial (Alleröd) freshwater deposits from the sea-cliff near Ustka (less than 30 km W of the two sites of her previous studies, Koszalin Coastal Zone) identified six ostracod species (and one in open nomenclature listed as *Candona* sp. juv., excluded from the present checklist), for which provided photographs together with brief descriptions. Kopczyńska-Lamparska *et al.* (1984) reported five species (three in open nomenclature as sp. excluded from the present checklist) from Late Glacial to early Holocene (Oldest Dryas–Pre-boreal) freshwater sediment samples of a profile exposed at Niechorze, 10 km NW of Trzebiatów (Szczecin Coastal Zone). Zachowicz and Uścinowicz (1997) in their study on Late Pleistocene and Holocene deposits of the Vistula Lagoon listed 11 ostracod species based on the identifications by J. Krzymińska, without accompanying illustrations. Since valves identified as *Candoniella subellipsoidea* appeared to represent juveniles of *Candona neglecta*, 10 species are included in the present checklist.

Quaternary ostracods of the southern Baltic Sea have been recently receiving significant attention from micropalaeontologists. Since 2000 eleven papers have been published which are included in the present checklist. In each of these papers, ostracod identifications were done by the first author of the present study, even if two of the papers were not co-authored by her (Table 1).

The first publication dealing with the subfossil ostracods of the Pomeranian Bay was by Krzymińska and Przezdziecki (2001). This contribution documents the transition from freshwater into marine conditions based on both seismoacustic data and the distribution of ostracods (and molluscs) in Late Glacial to middle Holocene (Atlantic) intervals of 16 core profiles recovered from the 10–11 m-deep bottom. Although the authors reported in total 11 ostracod species with accompanying SEM photographs (their *Candoniella subellipsoidea*, considered here as juvenile instars of *Candona neglecta*, is excluded from the present checklist), no detailed stratigraphical distribution of particular species in each of the cores was provided. Adding the data on six ostracod species (two other *Candoniella subellipsoidea* and *C. suzini* not included in the present checklist, see Table 1 for a conservative reappraisal) of one early Holocene profile P IX 2 from the 18 m-deep sea bottom of the Odra Bank provided by Uścinowicz (2006), the number of Quaternary ostracod species known hitherto from the Pomeranian Bay including the Odra Bank (the westernmost part of the Polish Baltic) totals 13 (10 freshwater and 3 brackishwater/marine) (Table 1).

Studies undertaken by Krzymińska *et al*. (2003) at both modern coastal inland sites and the open sea zone sites along the southern Baltic Sea shore listed 14 species (*Candoniella subellipsoidea* not included in the present checklist) in Late Glacial–Holocene sediments of 11 profiles along the Szczecin Coastal Zone between Międzywodzie and Dźwirzyno as well as two species in one Late Glacial–Holocene profile from the sea bottom off Ustronie Morskie (off Koszalin Coastal Zone). Neither illustrations nor stratigraphical ostracod distribution in the individual cores were provided. Later, Krzymińska and Cedro (2011; 2012) analysing succession of ostracod assemblages in two Holocene profiles at Mrzeżyno, ca. 10 km N of Trzebiatów, reported 17 species, bringing the total number of Quaternary ostracod species recorded along the Szczecin Coastal Zone (both at the inland and open sea sites) to 20 (18 freshwater and 2 brackishwater/marine) (Table 1).

As regards sites located along the Koszalin Coastal Zone, new data were given by Zawadzka *et al*. (2005). These authors described stratigraphical distribution of 13 species in freshwater sediments of one Holocene core recovered from the 10 m-deep sea bottom off lake Łebsko. Thus, the total number of ostracod species recorded along the Koszalin Coastal Zone (mainly from the inland sites) amounts to 26 (20 freshwater and 6 brackishwater/marine, see Table 1).

Finally, five papers have dealt with Quaternary ostracods of the Gdańsk Bay. Krzymińska *et al*. (2005), Uścinowicz (2006), Krzymińska and Przezdziecki (2010) and Krzymińska and Namiotko (2011, 2012) identified overall 22 species (20 freshwater and 2 brackishwater/marine, some in open nomenclature as cf.) in sediments of 20 Late Glacial to Holocene cores recovered from the 11–68 m-deep sea bottom of this area (Table 1, Fig. 1).

To conclude, in Quaternary (Late Glacial to Holocene) sediments of the Polish maritime and coastal zones of the Baltic Sea thus far a total of 33 ostracod species have been recorded, which constitutes 67% of the total number of ostracod species appearing in Polish coastal waters (Namiotko in press; Appendix) and 25% of the extant and Holocene ostracods known from the whole Baltic (Frenzel *et al*., 2010). Since some of the papers cited above in this section give an overall analysis and do not provide detailed lists of species for individual profiles, selected of the published profiles were re-examined before including in any compilations and the palaeoenvironmental analyses in the following sections.

MATERIAL AND METHODS

Material for this study came from 85 cores of Quaternary sediments (Pleistocene and Holocene) taken from the bottom of the Polish part of the Baltic Sea and its coastal zone with vibrocores. As a result of years of work carried out by the Branch of Marine Geology of Polish Geological Institute within the Polish Economic Zone, most of these sediment profiles were studied geologically (lithological characteristics, seismoacoustic, chronostratigrafic and biostratigraphic research), for geotechnical purposes and for exploration of natural aggregate deposits. The core sites were located in the three areas (western, central and eastern) delimited in Fig. 1. Out of 85 cores, 14 were recovered from the western area

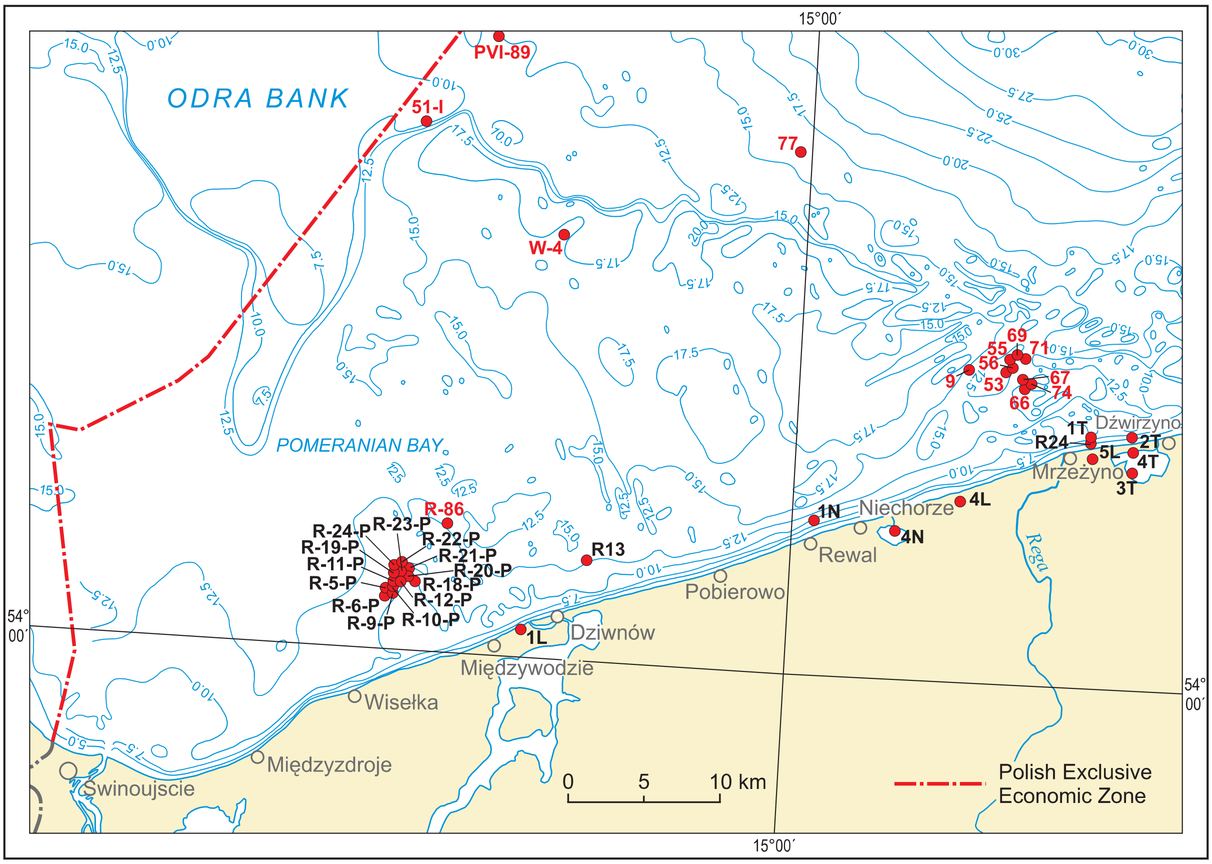


Fig. 2. Location of the coring sites within the western area of the Polish part of the southern Baltic Sea

Site codes in red indicate new records, whereas those in grey are sites of the re-examined material of the own published data (Krzymińska, Przezdziecki, 2001 and Krzymińska *et al*., 2003, see Table 1 for details)

(Fig. 2), 13 from the central area (Fig. 3), and 34 from the eastern area (Fig. 4). Besides new data on 61 cores, the material from 24 other cores from the western area (partly published by Krzymińska, Przezdziecki, 2001 and Krzymińska *et al*., 2003) was re-examined and included in the palaeoenvironmental analysis, as was the recently published by Krzymińska and Namiotko (2012) own material from 20 cores taken from the Gulf of Gdańsk (the eastern area).

Ostracods were examined following standard methods (Griffiths, Holmes, 2000) in selected sediment layers throughout the recovered profiles. Each sediment sample of a 200 cm^3 volume was disaggregated with H_2O_2, sieved at 100 µm with water and dried at room temperature. Ostracod valves were handpicked from the remaining sediment residue, counted and identified under a stereomicroscope at a magnification up to ×100. Taxonomic references were Sywula (1974), Sywula and Pietrzeniuk (1994), Griffiths and Holmes (2000), Meisch (2000) and Frenzel *et al*. (2010). Scanning electron micrographs (SEM) and/or transmitted light microscope pictures (TLM) were taken to illustrate the recovered ostracod valves. The study material is housed in the Marine Geology Branch of the Polish Geological Institute – National Research Institute in Gdańsk.

An important part of the description of the species was characteristic of its spatial and temporal occurrence in the study area on the background of geographical and stratigraphic range in Poland and in the world. In this part of the paper we used (a) the latest checklists of Recent and Quaternary Ostracoda species developed on the basis of the NODE (Non-marine Ostracoda Distribution in Europe) database in Europe (Griffiths, 1995; Meisch, 2000; Horne, 2004) and national (Sywula, Namiotko, 1997; Namiotko, 2008), and (b) all published works concerning the area taken into account in this monograph, and finally (c) unpublished database of the authors of this volume. Descriptions of species stratigraphical and geographical distribution were supplemented with recent data on their environmental preferences.

To estimate the total species richness of the area and time span covered by this study (i.e. to deduce, having own empirical data, how many more species we would expect to find if the sampling effort were increased), a sample (core)-based assessment protocol was used (samples were randomised 1000 times) with a number of non-parametric estimators: Chao's estimator using the presence-absence data (Chao 2), Second order Jacknife estimator (Jacknife 2), Bootstrap estimator

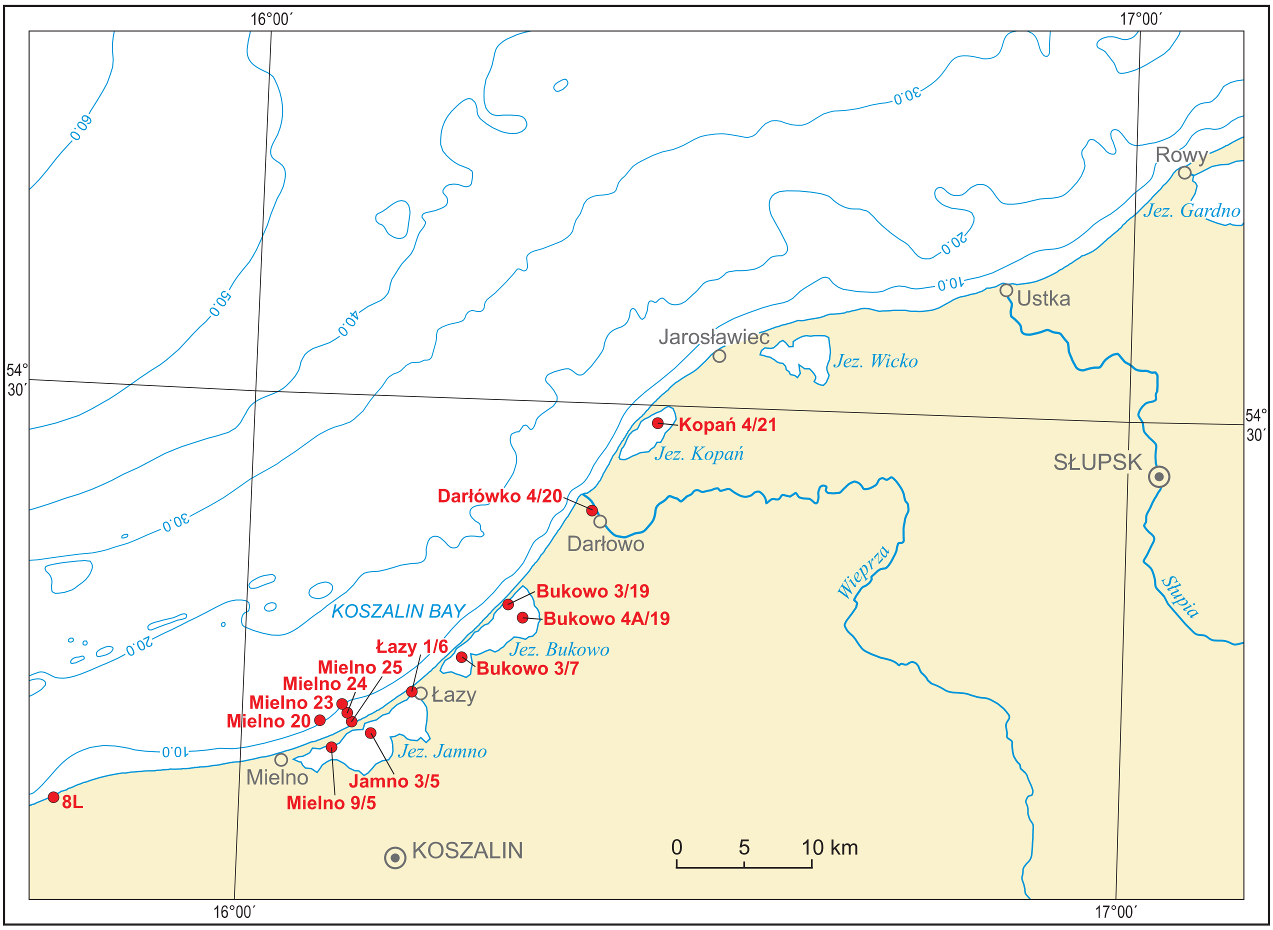


Fig. 3. Location of the coring sites within the central area of the Polish part of the southern Baltic Sea

(Bootstrap) and Michaelis-Menten curve fitted to the observed curve (MM), all implemented in the PRIMER ver. 6.1.10 software (Clarke, Gorley, 2006).

Species diversity of the ostracod site assemblages were estimated using the average taxonomic diversity (Delta+) index, which is a mean taxonomic distance between every pair of individuals in a sample (Clarke, Warwick, 1998). The average taxonomic diversity index is used to distinguish site assemblages with the same number of species but with different taxonomic affinity (for details of this method see Clarke, Warwick, 2001 and Clarke, Gorley, 2006).

RESULTS AND DISCUSSION

GENERAL OVERWIEW ON THE DISTRIBUTION AND DIVERSITY OF OSTRACODA IN THE LATE GLACIAL TO HOLOCENE SEDIMENTS OF THE STUDIED CORES

The studied 85 core sequences yielded in total valves of 30 ostracod species (Table 2) recovered from sediment layers corresponding to the period of the Late Glacial to the late Holocene. In all, 24 species were recorded in the 38 cores from the western area, 12 species in the 13 cores from the central area, and 26 species from the 34 cores from the eastern area (Table 2). Six of the collected species have not previously been recorded in Quaternary of the Polish part of the southern Baltic Sea (although they are known from the Quaternary of Poland: Sywula, Pietrzeniuk, 1989): *Fabaeformiscandona caudata*, *F. fabaeformis*, *F. tricicatricosa*, *Ilyocypris* cf. *bradyi*, *Potamocypris similis* and *Scottia browniana* (compare historical records in Table 1 with the original ones in Table 2), and three of these, i.e. *F. tricicatricosa*, *P. similis* and

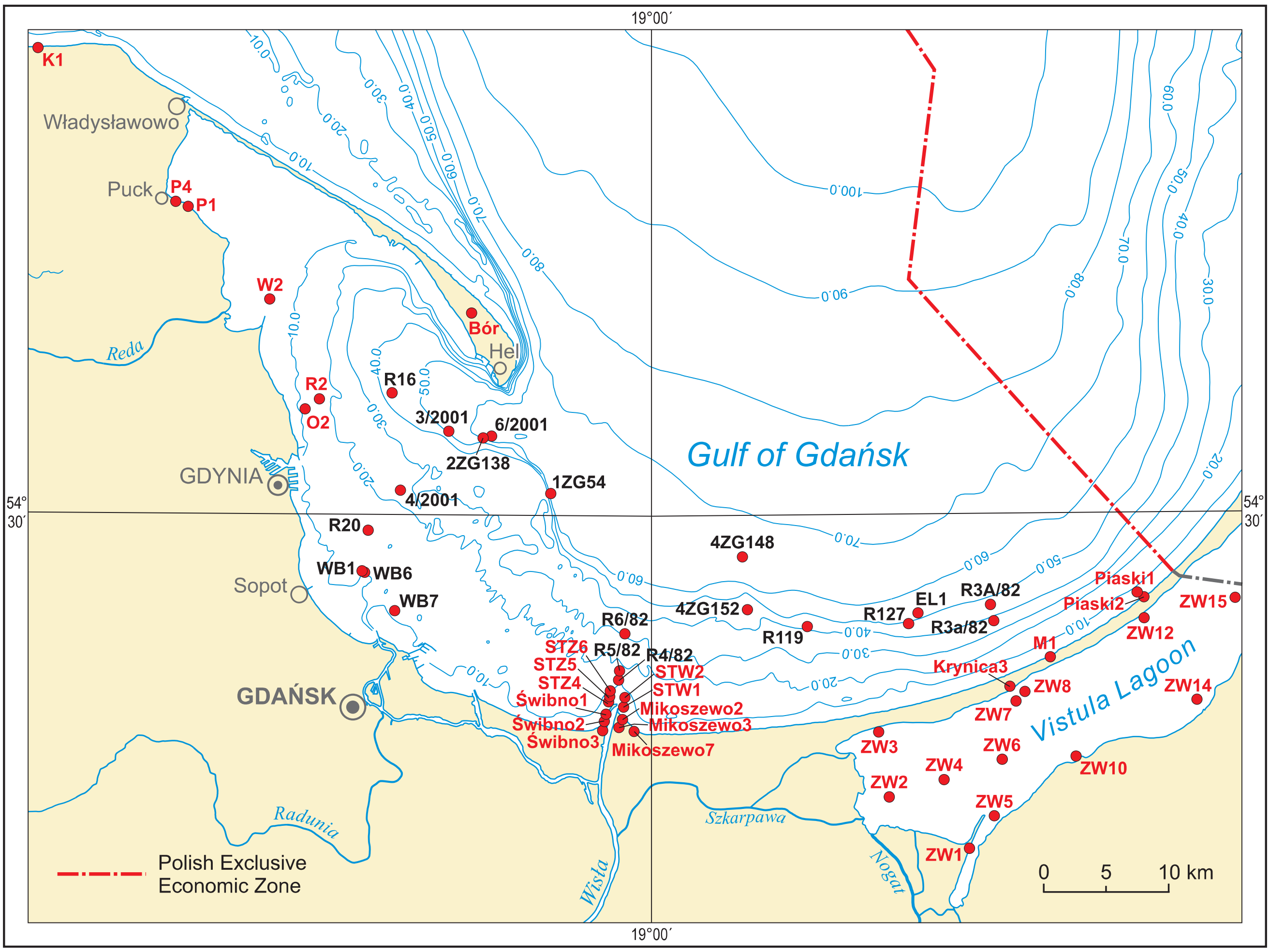


Fig. 4. Location of the coring sites within the eastern area of the Polish part of the southern Baltic Sea

Site codes in red indicate new records, whereas those in grey are sites of the recently published own data (Krzymińska, Namiotko, 2012)

S. browniana, appeared new also to the Postglacial to Recent ostracod fauna of the whole Baltic Sea (Frenzel *et al*., 2010). On the other hand, seven species previously recorded in the Quaternary of the Polish part of the southern Baltic Sea (*Candona angulata*, *Fabaeformiscandona alexandri*, *Heterocypris salina*, *Ilyocypris gibba*, *Pseudocandona rostrata*, *Scottia tumida* and *Xestoleberis aurantia*) were not found in the present collection. Two of these (*F. alexandri* and *S. tumida*) as well as *Ilyocypris* cf. *lacustris* (already known from the historical sites of the Polish Baltic Quaternary: Table 1) should also be considered new to the Postglacial to Recent ostracod fauna of the whole Baltic Sea (Frenzel *et al*., 2010). All of the six species new to the Late Glacial and Holocene Baltic (*F. alexandri*, *F. tricicatricosa*, *I. lacustris*, *P. similis*, *S. browniana* and *S. tumida*) have to be regarded as rare in the European freshwater Quaternary deposits of various kind (each species recorded at <7 sites: Grifiths, 1995), and (excepting both species of *Scottia* which are extinct) these species are uncommon in modern Europe (Meisch, 2000). To summarise, the present collection brings the total number the Quaternary ostracod species known from the Polish part of the southern Baltic Sea to 38 (see the following chapters for their taxonomic descriptions, a key to their identification, and their stratigraphical distribution in the studied areas), which constitutes 28% of the extant and Holocene ostracods known from the whole Baltic Sea (Frenzel *et al*., 2010).

The total number of recorded species (species richness) per individual profile varied between just one and 16 (mean ± standard deviation SD = 4.5 ±3.47), however, the species richness distribution across the cores was strongly right-skewed and leptokurtic with the median = 4.0. Although the number of the cores recovered in the three studied areas differed (see Figs. 2–4 and Table 2), the differences in the median value of the core species richness among the areas appeared no statistically significant (Kruskal-Wallis test: H = 3.873, P = 0.144). The most common species in the studied core sequences were *Candona neglecta* and *Cyprideis torosa* found in 52 cores (61% of the total 85 cores studied) as well as *Candona candida* (31 cores, 36%), *Cytherissa lacustris* (30 cores, 35%), *Darwinula stevensoni* and *Limnocythere*

Table 2A

Distribution of Ostracoda in Late Glacial to Holocene core sediments of the western area of the Polish part of the southern Baltic Sea based on the new unpublished records (N) and some own re-examined published data (* – Krzymińska *et al.*, 2003; ** – Krzymińska, Przezdziecki, 2001)

Species / Site	1L (*)	R-5-P (**)	R-6-P (**)	R-9-P (**)	R-10-P (**)	R-11-P (**)	R-12-P (**)	R-18-P (**)	R-19-P (**)	R-20-P (**)	R-21-P (**)	R-22-P (**)	R-23-P (**)	R-24-P (**)	R-86 (N)	R 13 (*)
Candona candida			X					X			X					
C. neglecta		X	X	X		X		X			X			X	X	X
C. weltneri																
Cyclocypris laevis																
C. ovum								X								
C. cf. *serena*																
Cyprideis torosa	X				X		X			X		X	X	X		
Cypridopsis vidua																
Cytherissa lacustris			X			X									X	X
Cytheromorpha fuscata										X				X		
Cytherura gibba																
Darwinula stevensoni																
Fabaeformiscandona caudata																
F. fabaeformis																
F. levanderi									X							
F. protzi																
F. tricicatricosa										X	X					
Herpetocypris reptans											X					
Ilyocypris cf. *bradyi*																
I. decipiens																
I. cf. *lacustris*		X	X	X												
Limnocythere inopinata			X							X	X			X		
Limnocytherina sanctipatricii																
Loxoconcha elliptica												X				
Metacypris cordata																
Potamocypris similis																
Pseudocandona compressa																
Sarscypridopsis aculeata																
Scottia browniana																
Semicytherura nigrescens																
Total number of species	1	2	5	2	1	2	1	3	1	4	5	2	1	4	2	2

Codes and location of the core sites as in Fig. 2

Table 2B

Distribution of Ostracoda in Late Glacial to Holocene core sediments of the western area of the Polish part of the southern Baltic Sea based on the new unpublished records (N) and some own re-examined published data (* – Krzymińska *et al.*, 2003)

Species \ Site	PVI-89 (N)	W-4 (N)	51-I (N)	77 (N)	1N (*)	4N (*)	4L (*)	5L (*)	1T (*)	2T (*)	3T (*)	4T (*)	R24 (*)	9 (N)	53 (N)	55 (*)	56 (N)	66 (N)	67 (N)	69 (N)	71 (N)	74 (N)
Candana candida		X	X	X	X	X	X	X	X		X		X							X		X
C. neglecta	X	X	X		X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	
C. weltneri																				X		
Cyclocypris laevis												X	X									
C. ovum					X																	
C. cf. *serena*									X									X	X			
Cyprideis torosa						X	X	X		X	X			X				X	X		X	X
Cypridopsis vidua		X														X	X	X	X	X	X	X
Cytherissa lacustris		X	X		X		X		X				X									X
Cytheromorpha fuscata		X																X	X			
Cytherura gibba																						
Darwinula stevensoni			X			X					X							X	X	X	X	X
Fabaeformiscandona caudata																		X		X		
F. fabaeformis																						
F. levanderi		X							X						X			X				
F. protzi		X																				
F. tricicatricosa																						
Herpetocypris reptans		X			X				X		X		X		X	X	X	X	X	X	X	X
Ilyocypris cf. *bradyi*			X		X																	
I. decipiens	X				X				X		X			X				X				
I. cf. *lacustris*		X	X				X						X									
Limnocythere inopinata		X	X	X			X				X		X						X	X		
Limnocytherina sanctipatricii		X																				
Loxoconcha elliptica																						
Metacypris cordata								X								X	X	X	X	X	X	X
Potamocypris similis																						
Pseudocandona compressa															X	X	X	X	X	X	X	X
Sarscypridopsis aculeata																						
Scottia browniana																						
Semicytherura nigrescens																						
Total number of species	2	11	7	2	7	4	6	4	7	1	7	1	7	3	4	5	5	12	10	10	7	8

Codes and location of the core sites as in Fig. 2

Table 2C

Distribution of Ostracoda in Late Glacial to Holocene core sediments of the central area of the Polish part of the southern Baltic Sea based on the new unpublished records

Species \ Site	8L	Mielno 9/5	Mielno 20	Mielno 23	Mielno 24	Mielno 25	Jamno 3/5	Łazy 1/6	Bukowo 3/7	Bukowo 3/19	Bukowo 4A/19	Darłówko 4/20	Kopań 4/21
Candana candida												X	X
C. neglecta									X	X	X	X	X
C. weltneri													
Cyclocypris laevis										X	X	X	
C. ovum													
C. cf. *serena*													
Cyprideis torosa		X	X	X	X	X	X	X	X	X	X		X
Cypridopsis vidua										X	X		
Cytherissa lacustris	X									X	X	X	X
Cytheromorpha fuscata													
Cytherura gibba													
Darwinula stevensoni													X
Fabaeformiscandona caudata													
F. fabaeformis													
F. levanderi												X	X
F. protzi													
F. tricicatricosa													
Herpetocypris reptans													
Ilyocypris cf. *bradyi*													
I. decipiens													
I. cf. *lacustris*									X				
Limnocythere inopinata	X											X	X
Limnocytherina sanctipatricii												X	X
Loxoconcha elliptica													
Metacypris cordata													
Potamocypris similis													
Pseudocandona compressa									X				
Sarscypridopsis aculeata													
Scottia browniana													
Semicytherura nigrescens													
Total number of species	2	1	1	1	1	1	1	1	4	5	5	7	8

Codes and location of the core sites as in Fig. 3

Table 2D

Distribution of Ostracoda in Late Glacial to Holocene core sediments of the eastern area of the Polish part of the southern Baltic Sea based on the new unpublished records

Species / Site	K1	BÓR	P1	P4	W2	R2	O2	Świbno 1	Świbno 2	Świbno 3	Mikoszewo 2	Mikoszewo 3	Mikoszewo 7	STZ 4	STZ 5	STZ 6	STW 1	STW 2
Candana candida	X				X		X					X						
C. neglecta	X			X	X		X	X		X	X	X		X				X
C. weltneri																		
Cyclocypris laevis								X										
C. ovum																		
C. cf. *serena*																		
Cyprideis torosa	X							X	X	X	X		X	X	X	X	X	X
Cypridopsis vidua	X									X		X						
Cytherissa lacustris	X	X					X	X	X		X							
Cytheromorpha fuscata								X	X		X		X				X	X
Cytherura gibba																		
Darwinula stevensoni	X							X	X		X							X
Fabaeformiscandona caudata																		
F. fabaeformis																		
F. levanderi	X									X							X	
F. protzi										X								
F. tricicatricosa																		
Herpetocypris reptans	X		X							X								
Ilyocypris cf. *bradyi*										X								
I. decipiens	X						X	X		X	X						X	
I. cf. *lacustris*	X							X		X								X
Limnocythere inopinata	X						X		X	X	X							
Limnocytherina sanctipatricii					X	X	X											
Loxoconcha elliptica																		
Metacypris cordata																		
Potamocypris similis																		
Pseudocandona compressa										X								
Sarscypridopsis aculeata																		
Scottia browniana																		
Semicytherura nigrescens																		
Total number of species	11	1	1	1	3	1	6	8	5	11	7	3	2	2	1	1	4	5

Codes and location of the core sites as in Fig. 4

T a b l e 2E

Distribution of Ostracoda in Late Glacial to Holocene core sediments of the eastern area of the Polish part of the southern Baltic Sea based on the new unpublished records

Species / Site	Krynica 3	M1	Piaski 1	Piaski 2	ZW1	ZW2	ZW3	ZW4	ZW5	ZW6	ZW7	ZW8	ZW10	ZW12	ZW14	ZW15	Total number of sites
Candana candida		X			X	X	X	X		X	X		X		X	X	31
C. neglecta		X			X	X	X	X		X	X		X		X	X	52
C. weltneri																	1
Cyclocypris laevis						X		X		X	X			X			11
C. ovum					X	X				X				X			6
C. cf. *serena*						X											4
Cyprideis torosa	X	X	X	X		X		X		X	X	X	X	X	X	X	52
Cypridopsis vidua																	13
Cytherissa lacustris		X			X	X	X			X			X	X	X		30
Cytheromorpha fuscata						X		X						X	X		15
Cytherura gibba														X			1
Darwinula stevensoni					X	X	X	X		X	X		X	X	X	X	24
Fabaeformiscandona caudata																	2
F. fabaeformis					X	X	X				X				X		5
F. levanderi																	10
F. protzi																	2
F. tricicatricosa																	2
Herpetocypris reptans																	17
Ilyocypris cf. *bradyi*					X	X											5
I. decipiens					X	X	X			X	X	X		X	X	X	21
I. cf. *lacustris*						X				X					X		15
Limnocythere inopinata					X	X	X								X		24
Limnocytherina sanctipatricii																	6
Loxoconcha elliptica																	1
Metacypris cordata		X															9
Potamocypris similis						X											1
Pseudocandona compressa								X	X	X	X	X	X	X	X	X	19
Sarscypridopsis aculeata						X											1
Scottia browniana										X							1
Semicytherura nigrescens										X							1
Total number of species	1	5	1	1	9	16	7	7	1	12	8	3	6	9	11	6	–

Codes and location of the core sites as in Fig. 4

inopinata (both latter recorded in 24 cores, 28%). The least common were seven species found only at one core site each (Table 2E).

Cumulative species estimation over samples shows (Fig. 5A) that the observed species-accumulation curve crossed the one generated by the MM estimator, thus it may be concluded that not too many species remain to be sampled (Magurran, 2004). Extrapolation from the data provided estimates of the total number of species between 33 (Bootstrap) and 41 (Jacknife 2) (see Fig. 5A).

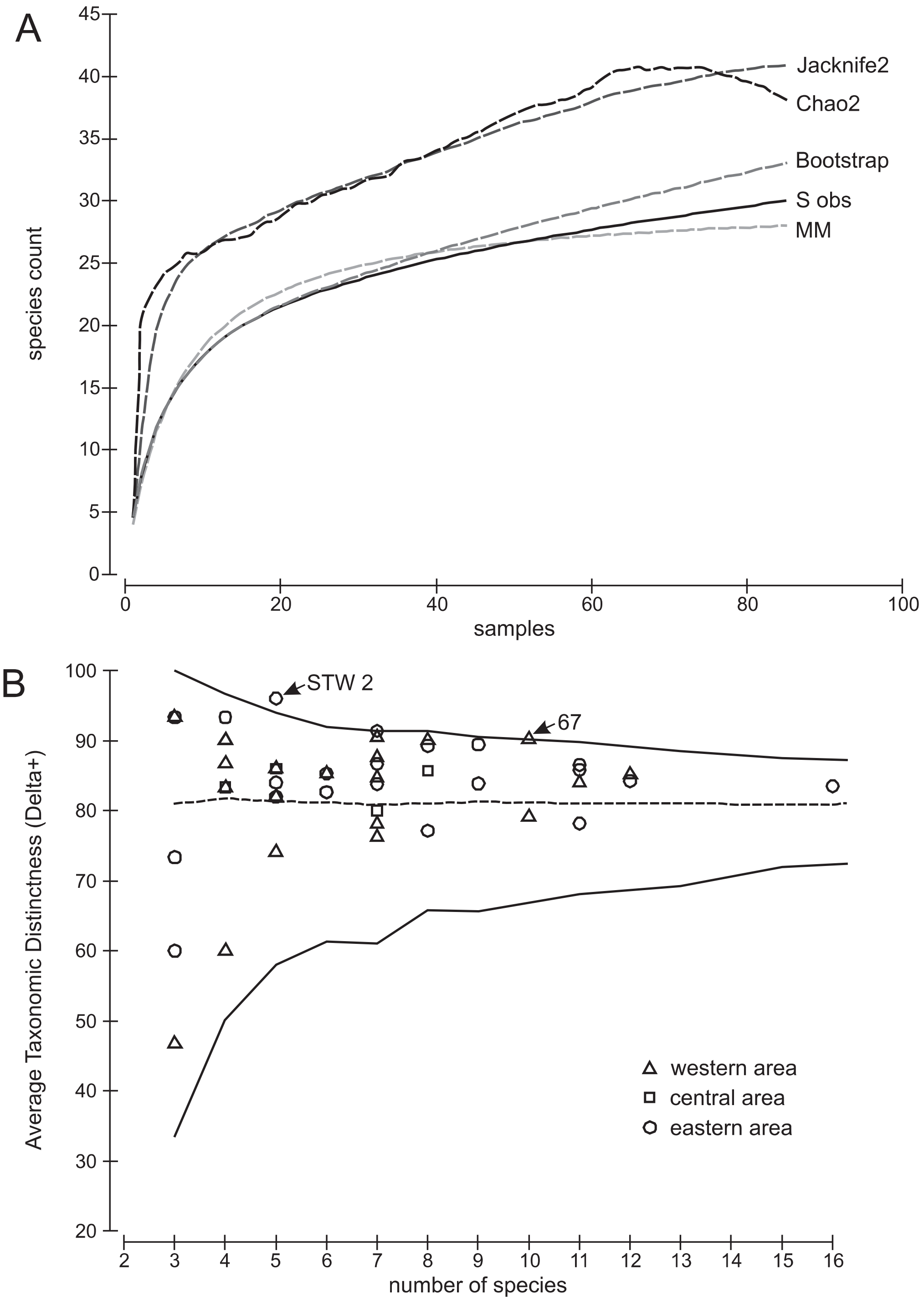


Fig. 5. A – cumulative species estimation curves (dashed lines) of four estimator models (Bootstrap, Chao 2, Jacknife 2 and MM – Michaelis-Menten) in relation to the observed species-accumulation (S obs) plot (solid line); B – funnel plot for simulated average taxonomic distinctness Delta+ (solid lines indicate limits within which 95% of the simulated values of the Delta+ index lie, central dashed line is the mean Delta+ value for the full inventory of the Quaternary ostracod species of the Polish part of the southern Baltic Sea, symbols represent the true values of the Delta+ index for the cores with species richness ≥3 within the three studied areas)

Biodiversity of the core palaeoassemblages was measured using the Delta+ index, a Clarke and Warwick's (2001) measure based on taxonomic relatedness of species. The Delta+ values of the studied core sequences (with the total species richness ≥3, N = 50) ranged from 47 to 96 (mean ± SD = 83 ±8.8) (Fig. 5B). The null hypothesis that the taxonomic diversity of the studied core palaeoassemblages of species richness ≥3 is not significantly different from that based on the inventory of 38 ostracod species known from the Quaternary sediments of the Polish part of the southern Baltic Sea was tested by Clarke and Warwick's (2001) approach and the results are presented in Fig. 5B as the funnel plot. Although the majority of all Delta+ values for the studied cores demonstrate generally increased average distinctness lying above the mean value drawn from the inventory of the south Baltic Quaternary ostracods, the Delta+ values of only two cores STW 2 (from the eastern area) and 67 (from the western area) lie outside the higher 95% of the mean Delta+ value (P = 0.042 and 0.034, respectively). This is because each of the five species recorded in the core STW 2 and of 10 species from the core 67 represents the separate genus, and in the case of STW 2 also the separate subfamily and family (consult Table 2B for the core 67 and Table 2D for STW 2). The differences in the average taxonomic distinctness among the three studied areas appeared not statistically significant (Kruskal-Wallis test: H = 0.048, P = 0.976).

AN OUTLINE OF STRUCTURE OF THE OSTRACOD CARAPACE AND VALVES

The most prominent feature of Ostracoda (mussel or seed shrimps) is their protective shell-like bivalved carapace enclosing the entire animal body. Although there are rare occurrence of ostracod "soft parts" (limbs, internal organs or giant spermatozoa) preservation in the Quaternary fossil record (e.g., Schmidt, Sellman, 1966; Horne *et al*., 1990, Matzke-Karasz *et al*., 2001; Iepure *et al*., 2012, Tanaka *et al*., 2012), extremely important in micropalaeontological work are "hard parts" (a carapace consisting of two valves). The two valves of the carapace are composed of chitin heavily impregnated in most species with low-magnesium calcite (Griffiths, Holmes, 2000), thus they fossilize easily and have an outstanding fossil record that dates back to the Early Ordovician (Martens *et al.*, 1998; Park, Rickets, 2003). The valves are hinged together dorsally, somewhat similar to a bivalved mollusc, but lack concentric growth rings, and deriving from the chitinous covering of the epidermis they are periodically moulted as the ostracod grows. The following outline of the ostracod "hard parts" morphology is restricted to the order Podocopida, to which all species known from the Polish Baltic belong, and follows mostly Van Morkhoven (1962) and Horne *et al*. (2002), to which references the reader is referred for more detailed description.

The two valves in Podocopida are typically unequal in size and shape, most often the left one is larger and overlaps the right valve. Adult valve size of the European fresh- and brackishwater podocopan ostracods rarely exceeds 3 mm, and usually the valve length ranges from *ca*. 0.5 mm to a bit over 1 mm.

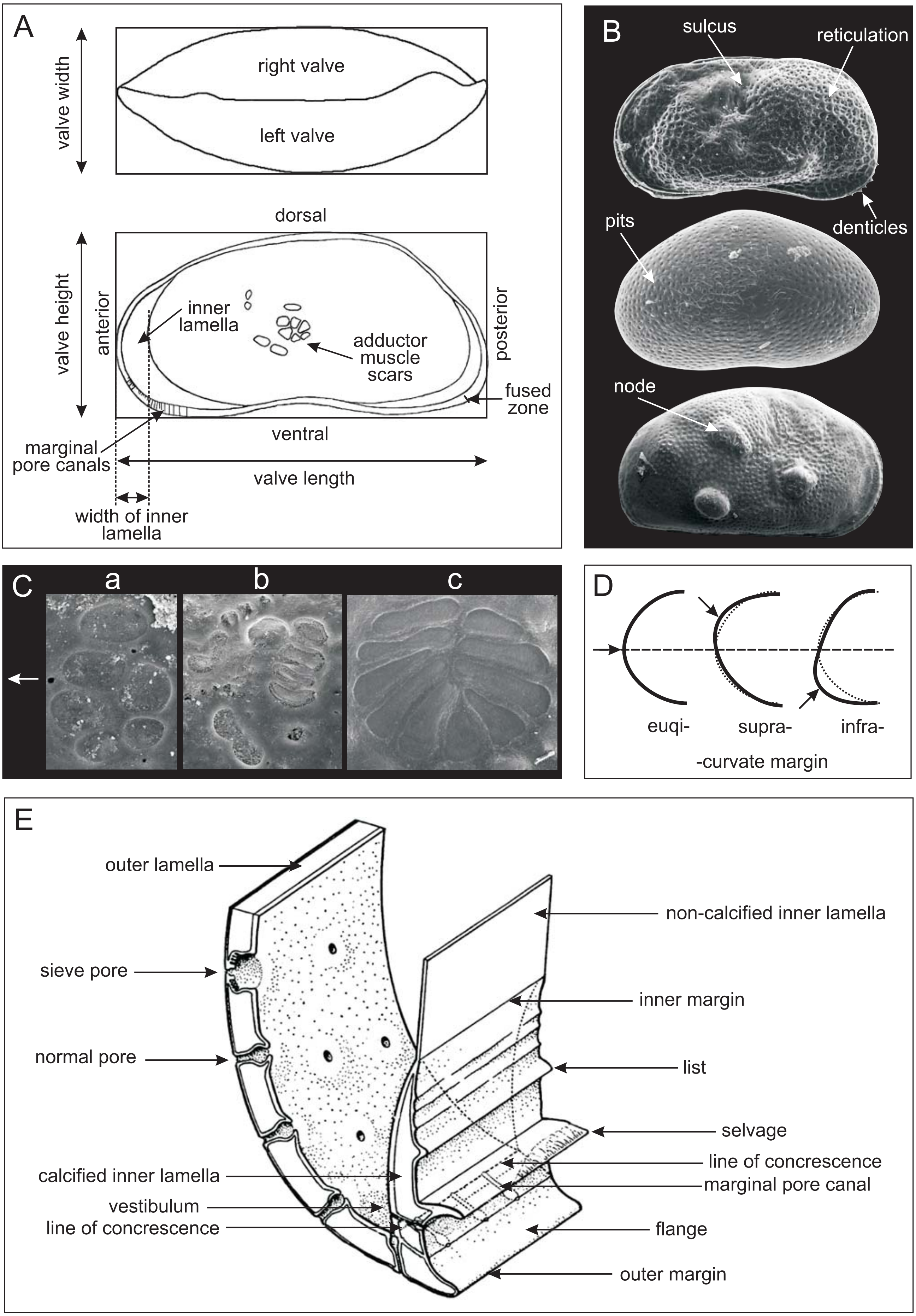
The ostracod carapace derives from two lateral epidermal folds (duplicatures), originating on each side of the body in the head region and extending to enclose the animal body. Each duplicature is made up of two layers termed the outer and inner lamella. The outer lamella is covered over its entire surface by a hard, calcareous layer, whereas the inner lamella is calcified only in the peripheral portion. In the living ostracod, calcareous layers of both lamellae are coated with a thin chitinous cuticle, which continues across the dorsal margin where it connects the valves to each other and is termed the ligament. In the fossil state usually only the hard calcified parts of the valves (of their outer and inner lamellae) are retained and they constitute the only material used by palaeontologists. As the present work deals with the fossil material, the terms: valve, outer lamella and inner lamella hereafter are used in the palaeontological usage (i.e., applied to the calcified parts only), and the term carapace refers to the left and right valves combined.

The inner lamella may be entirely or partly fused throughout its width with the inner surface of the outer lamella forming the fused zone, the innermost (proximal) boundary of which is termed the line of concrescence (Fig. 6). If the lamellae are not completely fused, the free (unfused) part of the inner lamella is separated from the outer lamella by a space designated as the vestibulum (Fig. 6), and the inner (free) edge

→

Fig. 6. Taxonomically important morphological characteristics of ostracod valves and carapaces

A – dorsal view of the carapace and internal view of the right valve of *Fabaeformiscandona tricicatricosa* showing indications for the valve/carapace length, height and width measurements as well as some valve features (modified after Diebel, Pietrzeniuk, 1969); **B** – two types of the valve surface ornamentation and other valve surface features useful in identification of the Baltic Sea ostracods (from top to bottom: SEM of *Limnocythere inopinata* female left valve, *Cypridopsis vidua* female right valve, *Cyprideis torosa* juvenile right valve, orig. not to scale); **C** – pattern of adductor muscle scars in the three superfamilies of the Baltic Sea ostracods: a – Cypridoidea (*Pseudocandona compressa*), b – Cytheroidea (*Cytheromorpha fuscata*), c – Darwinuloidea (*Darwinula stevensoni*) (orig., arrow points to the anterior); **D** – terminology of the anterior/posterior valve margin curvature (after Lüttig, 1962 and Sames, 2011); **E** – schematic cross section through the peripheral part of the valve (modified after Kesling, 1951)


A
valve width
right valve
left valve
dorsal
valve height
anterior
inner lamella
adductor muscle scars
posterior
fused zone
marginal pore canals
ventral
valve length
width of inner lamella
B
sulcus
reticulation
denticles
pits
node
C
a
b
c
D
euqi-
supra-
infra-
-curvate margin
E
outer lamella
non-calcified inner lamella
sieve pore
inner margin
normal pore
list
selvage
line of concrescence
marginal pore canal
calcified inner lamella
vestibulum
line of concrescence
flange
outer margin

of the inner lamella is called the inner margin of the valve. The outer margin of the valve is the real outer periphery of the valve. Marginal portion of the valve, where both lamellae meet, offers several taxonomically important traits, such as the number and shape of the marginal pore canals, presence of the inner lists or selvage, width and shape of the inner lamella, marginal denticulations, spines or caudal process (Fig. 6). However, it has to be stressed that several of these characteristics usually are completely developed only in the adult stage, and that the sexual dimorphism may be present.

The outer lamella is usually penetrated by various pores, the type of which can help in identification as do the pattern of all elevations and depressions at the outer valve surface, i.e. valve ornamentation. Valves may be smooth or pitted, reticulate, with ridges, protuberances, spines, etc. or with combinations thereof (Fig. 6). Also important in taxonomy are other thickenings (e.g., lateral extensions) or depressions (e.g., sulci) which are reflected on the inner surface of the valve, and as such are not included under the term ornamentation (Van Morkhoven, 1962). It is also worth mentioning that the differences in the pattern of either ornamentation or other valve surface folds or hollows are not unusual between juveniles and adults, between sexes or may be caused environmentally.

The two valves are joined by the hinge running along the dorsal edge of the valves. As its form can be varied and complex in detail in some groups, the hinge can play an important role in ostracod taxonomy in general, however in most freshwater ostracods the hinge is simple and as such not of high taxonomic importance. The valves close using adductor muscles that are attached to both valves. The muscles leave a pattern of scars on the valves that can be used in identification, especially at the superfamily level (Fig. 6).

Although it is difficult to express in words, in specific diagnoses the overall valve shape and outline (as viewed laterally and dorsally) as well as the valve/carapace size (length, height, width and ratios thereof) are extremely important (inspect Fig. 6 to see how to measure valves and carapaces). The valve shape and size change through the postembryonic development and at the adult stage sexual dimorphism is common. In general, the ostracod carapace, seen in lateral view, is elongate (Fig. 6), i.e. the length is normally greater than the height, however the maximum height may lie either in the mid-length or in the anterior or posterior half of the valve. The width of the carapace is as a rule less than the length and very often also less than the height, with its maximum situated usually in the posterior part of the carapace (Fig. 6). To describe the curvature of the anterior and posterior margins, terminology introduced by Lüttig (1962) as adopted and translated into English by Sames (2011) is recommended (see Fig. 6).

For the practical knowledge concerning methods of sampling, sample processing, initial laboratory treatments and further analysis of Quaternary ostracods the reader is referred to other publications in which such procedures are described in more detail: Van Morkhoven (1962), Griffiths and Holmes (2000), Holmes (2001), Danielopol *et al*. (2002) and Boomer *et al.* (2003).

PICTORIAL KEY TO LATE GLACIAL AND HOLOCENE OSTRACODA OF THE POLISH PART OF THE BALTIC SEA AND ITS COASTAL AREA

The key provided in Fig. 7A–C of the present section comprises most of all 38 ostracod species which have been recorded up till now from the Late Glacial to Holocene sediments of the Polish maritime and coastal zones of the Baltic Sea (Tables 1 and 2). These species are considered here the most common and often sufficient for (at least preliminary) palaeoenvironmental reconstruction. As identification of the species belonging to the genus *Ilyocypris* based solely on the valve morphology is generally thought to be uncertain, the present key allows the assignation of the valves to the genus only. Additionally, six other species (*Cyclocypris globosa* (Sars, 1863), *Fabaeformiscandona acuminata* (Fischer, 1851), *Fabaeformiscandona hyalina* (Brady et Robertson, 1870), *Plesiocypridopsis newtoni* (Brady et Robertson, 1870), *Pseudocandona marchica* (Hartwig, 1899) and *Scottia pseudobrowniana* Kempf, 1971) as well as one genus (*Leptocythere* Sars, 1925) were included in the key as they are either expected to be found in the area and the time span covered by this work or may be easily misidentified with some of the recorded species.

This identification guide allows taxonomical assignment of only adult ostracod valves and carapaces and is of a standard format of a (mostly) dichotomous pictorial key that is hoped to be accessible not only to ostracodologists but also to micropalaeontologists and other users (scientists and scholars concerned with the Quaternary environmental assessment) who wish to identify ostracods beyond their field of expertise. However, as for a number of reasons identification of taxa to the species level is not always possible, users of this guide are cautioned against attempting to force an identification of each unknown specimen if it does not key out readily. There are several taxonomically difficult species, the present knowledge of which often hardly permits their discrimination using valve characteristics alone (e.g., the above mentioned *Ilyocypris* species, several species of the genus *Pseudocandona* or representatives of the family Candonidae in general). In some instances, particularly for small samples, identification to a fine resolution is usually constrained by the preservation state or the immature nature of a valve specimen. It has to be also noted that several ostracod species have not yet been collected in Quaternary sediments of the southern Baltic Sea and await finding. Lastly, new (to science) species may be discovered as well, and as such not all specimens will always key out correctly.

Part 1 – Darwinuloidea and Cytheroidea

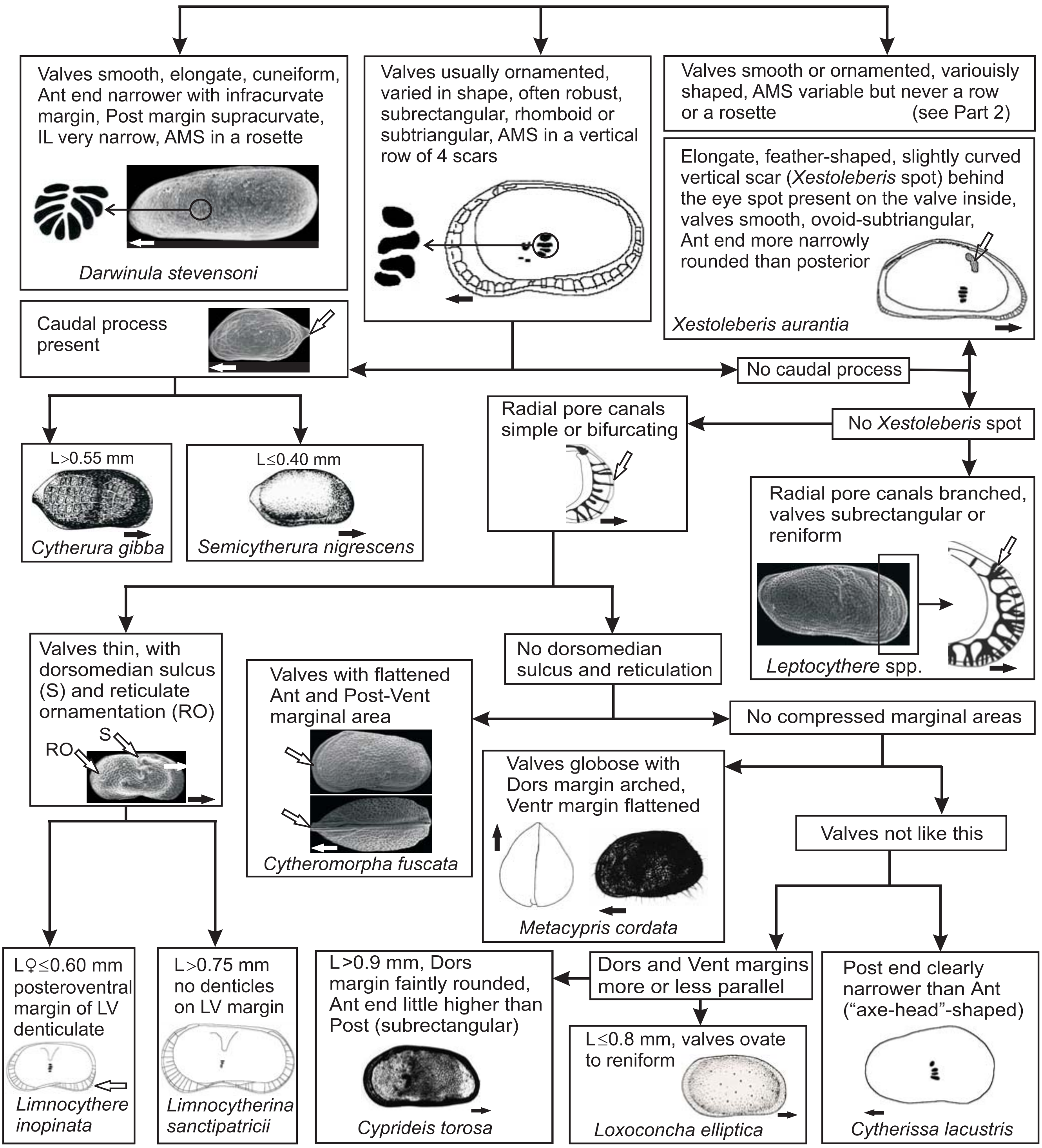


Fig. 7A. Pictorial key to valves and carapaces of Quaternary Ostracoda of the southern Baltic Sea

Abbreviations used in the key (Fig. 7A–C): AMS – adductor muscle scars, Ant – anterior, Dors – dorsal, H – height, IL – inner lamella, L – valve length, LV – left valve, Post – posterior, RV – right valve, Vent – ventral, W – width

Part 2 – Cyprididae, Ilyocyprididae, Cyclocypridinae

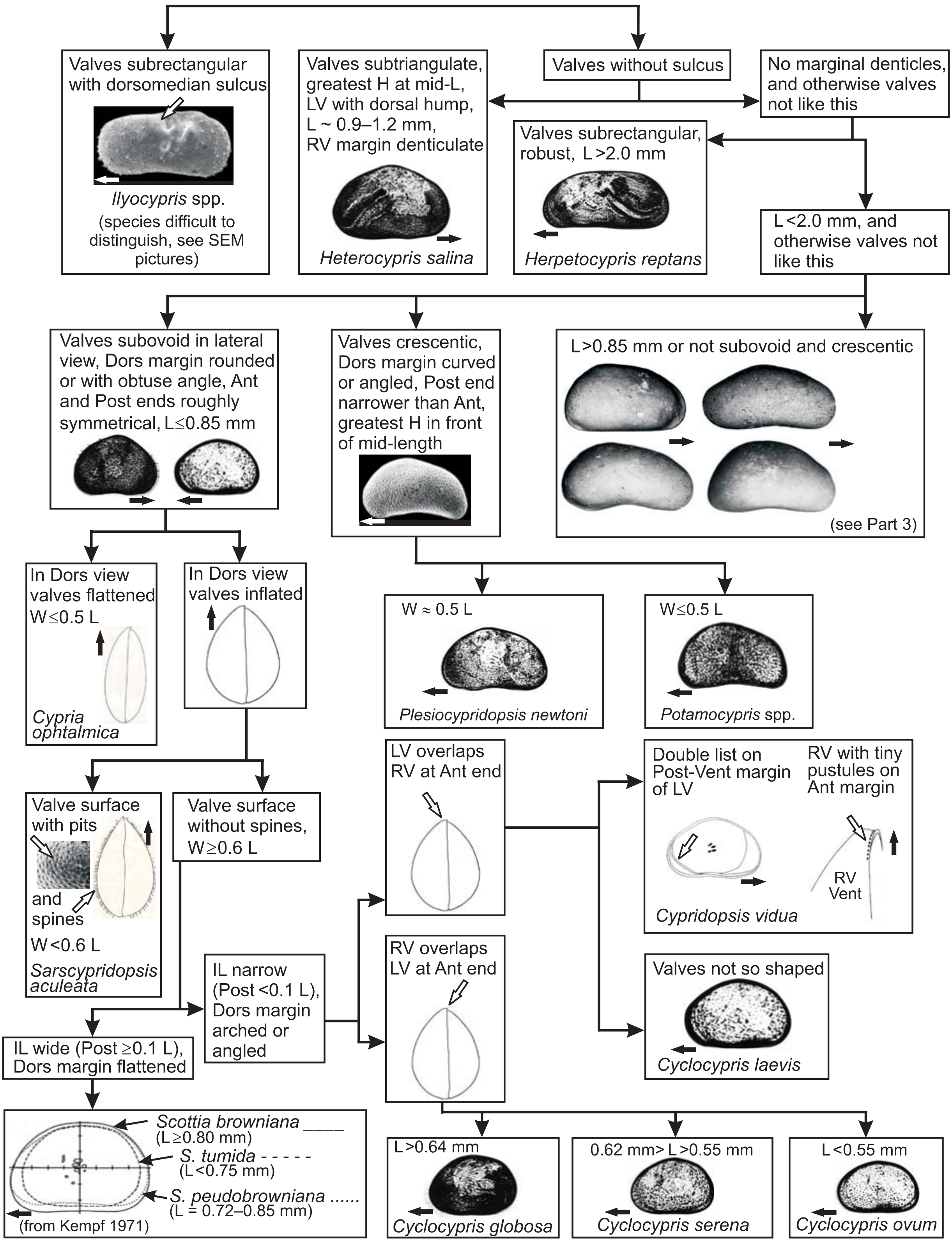


Fig. 7B. Pictorial key to valves and carapaces of Quaternary Ostracoda of the southern Baltic Sea

Part 3 – Candoninae

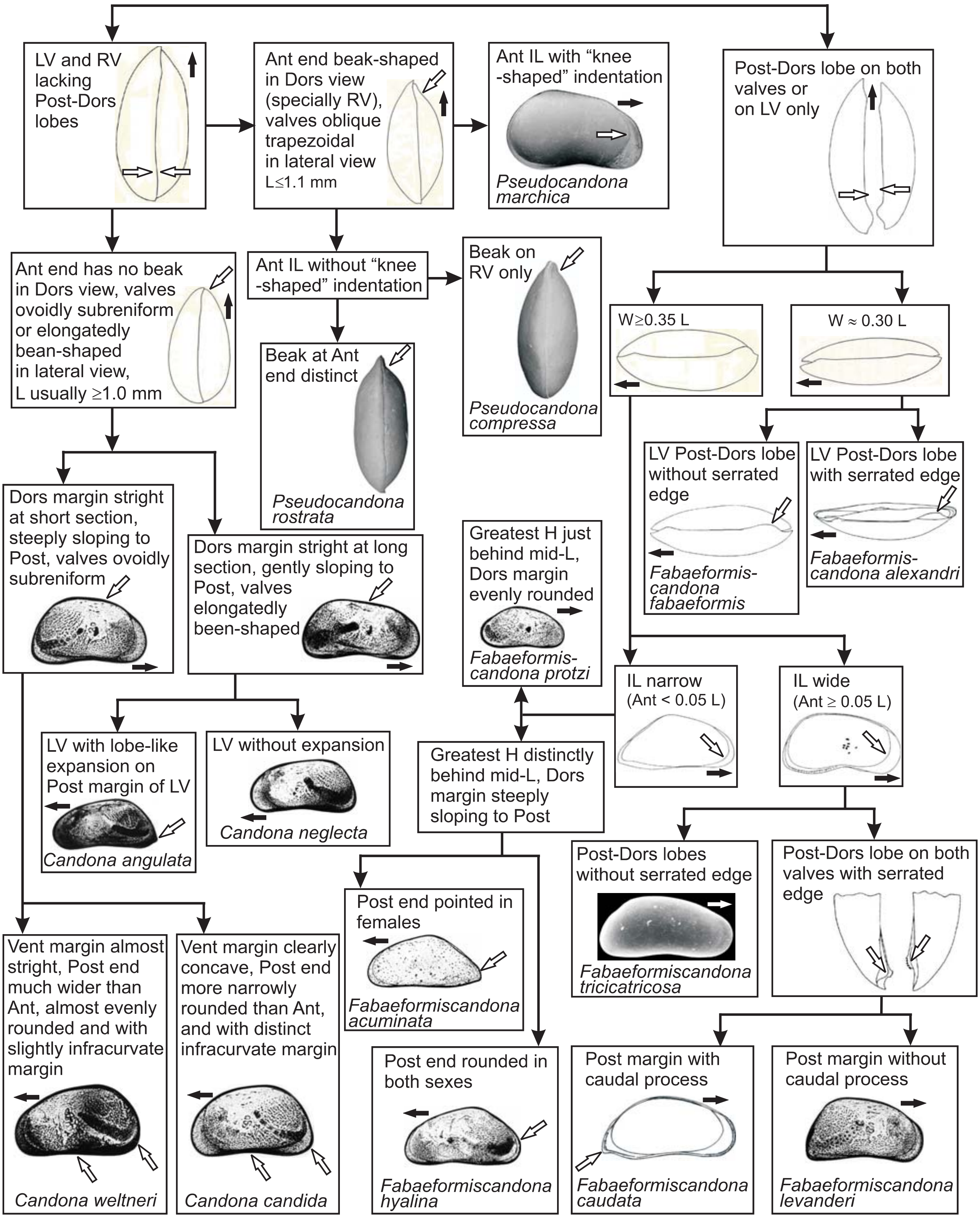


Fig. 7C. Pictorial key to valves and carapaces of Quaternary Ostracoda of the southern Baltic Sea

For those reasons, once having arrived at a species (genus) name in the key, the users are encouraged to look the SEM and TLM photographs up and read descriptions in the following chapter to confirm or reject the identification. Furthermore, it is always (not only in case of any uncertainty) advised to consult more detailed references, of which the most recommendable are the following: Sywula (1974: recent freshwater species of Poland), Athersuch *et al.* (1989: recent marine and brackishwater species of the UK), Sywula and Pietrzeniuk (1989, 1994: Quaternary fresh- and brackishwater species of Poland), Griffiths and Holmes (2000: Quaternary freshwater species of the UK), Meisch (2000: recent freshwater species of Central and Western Europe), and the most comprehensive and updated compilation on all recent and post-Pleistocene ostracods of the Baltic by Frenzel *et al*. (2010).

Finally, it is also recommended that, whenever possible, one should retain additional intact voucher specimens and/or deposit these in any recognisable collection for a verification of the identification by a professional ostracodologist or for a further use in other studies.

Ostracod valves and carapaces (preferably clean and intact) should be examined dry in cardboard or plastic cavity slides (micropalaeontological cells) under a high-power (magnification of up to ×100) stereoscopic binocular microscope. Prior to identification, it is advisable to orientate the valves using a damp fine paintbrush and examining the location of the adductor muscle scars, which typically are situated anterior to the mid-point of the valve. If the muscle scars or other details (as e.g., radial pore canals) are not clearly visible, gently brushing the valve with dilute food colouring may help (Griffiths *et al*., 1993) or the valve should be placed onto a microscope slide in a drop of water or glycerine and then observed in transmitted light. During the identification, besides the pattern of the adductor muscle scars, particular attention has to paid to the overall shape and structure of the valve/carapace viewed in both lateral (inner and outer) and dorsal/ventral sides, the valve size, the pattern of surface ornamentation, the shape and width of the inner lamella, the fused zone, and marginal denticulations (Fig. 6).

SYSTEMATIC RECORD AND DESCRIPTION OF SPECIES

In this chapter first the hierarchical taxonomic position of the genera of Quaternary Ostracoda of the southern Baltic Sea is provided following Martens and Savatenalinton (2011). Then descriptions of 38 species hitherto recorded in Quaternary sediments of the Polish part of the Baltic Sea (based on both the historical records and the new material summarised in Tables 1 and 2, respectively) listed alphabetically follow (all specimens are kept in the collection of the Marine Geology Branch in Gdańsk PGI-NRI – OGM PB I–III). Within these descriptions are provided:

– valid species and genus names, with author and year (mostly after Martens, Savatenalinton, 2011);

– SEM and/or TLM pictures of the valves;

– known size range of the adult valves in mm (abbreviations: H – height, L – length, W – width);

– ecological notes (mostly after Sywula, 1974; Sywula, Pietrzeniuk, 1989; Meisch, 2000 and Frenzel *et al*., 2010);

– general present occurrence in Poland, including both the Polish maritime zones of the Baltic Sea (following Namiotko, in press) and in inland waterbodies within the zoogeographical regions of Poland delimited and numbered as in Catalogus Faunae Poloniae (after Sywula, 1974, Sywula, Namiotko, 1997 and Namiotko, 2008);

– global recent distribution in zoogeographical regions (after Martens, Savatenalinton, 2011);

– stratigraphical range (mostly after Sywula, Pietrzeniuk, 1989, Griffiths, 1995 and Meisch, 2000);

– Quaternary records in Poland (stratigraphical subdivision of the Quaternary of Poland after Marks, 2011), excluding the sub-Recent (historical) records and those of the Polish part of the coastal zone and open sea sites of the Baltic Sea, which are listed in Table 1.

HIERARCHICAL TAXONOMIC POSITION OF GENERA OF QUATERNARY OSTRACODA OF THE SOUTHERN BALTIC SEA

Class OSTRACODA Latreille, 1806

Subclass Podocopa G.W. Müller, 1894

Order **Podocopida** Sars, 1866

Suborder Cypridocopina Baird, 1845

Superfamily Cypridoidea Baird, 1845

Family **Cyprididae** Baird, 1845

Subfamily Cypridopsinae Kaufmann, 1900

Genus *Cypridopsis* Brady, 1867

Genus *Potamocypris* Brady, 1870

Genus *Sarscypridopsis* McKenzie, 1977

Subfamily Cyprinotinae Bronshtein, 1947

Genus *Heterocypris* Claus, 1892

Subfamily Herpetocypridinae Kaufmann, 1900

Tribe Herpetocypridini Kaufmann, 1900

Genus *Herpetocypris* Brady et Norman, 1889

Subfamily Scottiinae Bronshtein, 1947

Genus *Scottia* Brady et Norman, 1889

Family **Candonidae** Kaufmann, 1900

Subfamily Candoninae Kaufmann, 1900

Tribe Candonini Kaufmann, 1900

Genus *Candona* Baird, 1845

Genus *Fabaeformiscandona* Krstić, 1972

Genus *Pseudocandona* Kaufmann, 1900

Subfamily Cyclocypridinae Kaufmann, 1900
Genus *Cyclocypris* Brady et Norman, 1889
Genus *Cypria* Zenker, 1854

Family **Ilyocyprididae** Kaufmann, 1900
Subfamily Ilyocypridinae Kaufmann, 1900
Genus *Ilyocypris* Brady et Norman, 1889

Superfamily Darwinuloidea Brady et Robertson, 1885
Family **Darwinulidae** Brady et Robertson, 1885
Genus *Darwinula* Brady et Robertson, 1885

Superfamily Cytheroidea Baird, 1850
Family **Cytherideidae** Sars, 1925
Subfamily Cytherideinae Sars, 1925
Tribe Cytherideidini Kollmann, 1960
Genus *Cyprideis* Jones, 1857
Genus *Cytherissa* Sars, 1925

Family **Cytheruridae** G.W. Müller, 1894
Genus *Cytherura* Sars, 1866
Genus *Semicytherura* Wagner, 1957

Family **Limnocytheridae** Klie, 1938
Subfamily Limnocytherinae Klie, 1938
Tribe Limnocytherini Klie, 1938
Genus *Limnocythere* Brady, 1868
Genus *Limnocytherina* Negadaev-Nikonov, 1967

Subfamily Timiriaseviinae Mandelstam, 1960
Genus *Metacypris* Brady et Robertson, 1870

Family **Loxoconchidae** Sars, 1925
Genus *Cytheromorpha* Hirschmann, 1909
Genus: *Loxoconcha* Sars, 1866

Family **Xestoleberididae** Sars, 1866
Genus *Xestoleberis* Sars, 1866

DESCRIPTION OF SPECIES

Candona angulata G.W. Müller, 1900

Pl. I, Figs. 1–3

Size. – L = 1.3–1.6 mm, H = 0.6–0.8 mm, W = 0.5–0.6 mm.

Ecological notes – At present the species lives of mouths of rivers flowing into sea and various coastal lakes with brackish water as well as the littoral in sheltered zones in the Baltic Sea, at muddy or sandy-muddy bottom. Both sexes always occur together.

General present occurrence in Poland. – (1) Baltic Sea and (5) Wielkopolska-Kujawy Lowland.

Global recent distribution. – Palaearctic Region.

Stratigraphical range. – Lower Pleistocene to Recent.

Quaternary inland records in Poland. – *Early Pleistocene* Augustovian Interglacial. – Szczebra (Skompski, Ber, 1999); *Middle Pleistocene* Mazovian Interglacial: Czarnucha and Sucha Wieś (Skompski, 2009); *Late Pleistocene* Eemian Interglacial: Nędzerzew (Sywula, Pietrzeniuk, 1989).

Candona candida (O.F. Müller, 1776)

Pl. I, Figs. 4–8

Size. – L = 0.9–1.2 mm, H = 0.5–0.7 mm, W = 0.4–0.6 mm.

Ecological notes. – Eurytopic species living in various types of water reservoirs: lakes, permanent and intermittent smaller reservoirs, water-covered areas related to springs, running and underground water, in water increased salinity. Males are rare.

General present occurrence in Poland. – (1) Baltic Sea, (2) Baltic Coast, (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland, (6) Mazovian Lowland, (8) Lower Silesia, (9) Upper Silesia, (11) Małopolska Upland, (13) Roztocze Upland, (15) Western Sudeten Mts, (16) Eastern Sudeten Mts, (17) Western Beskidy Mts, (17a) Nowotarska Dale, (19) Bieszczady Mts, (20) Pieniny Mts, (21) Tatra Mts.

Global recent distribution. – Palaearctic and Nearctic Regions.

Stratigraphical range. – Upper Pliocene and Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Mazovian Interglacial: Serniki (Diebel, 1961), Sucha Wieś (Skompski, 2009); Odranian Glacial: Horodło (Dolecki, Skompski, 1986); *Late Pleistocene* Eemian Interglacial: Cząstkowo (Krzymińska, Jurys, 2001 – orig. age: Mazovian Interglacial), Kruklanki (Kociszewska-Musiał, 1987; Namiotko *et al*., 2003), Krzyżówki (Szałamacha, Skompski, 1999), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Grochmalicki, 1931), Poznań-Winiary (Sywula, Pietrzeniuk, 1989), Ruszkówek (Kozydra, Skompski, 1995), Wieprzyce (Hucke, 1912); *Late Pleistocene* Late Glacial: Gorzechowo (Sywula, Pietrzeniuk, 1989); *Late Pleistocene–Holocene* Late Glacial–Holocene: Głębokie Lake (Kulesza, 2005), Hańcza Lake (Danielopol *et al*., 2008; Lauterbach *et al*., 2011), Orle (Bilan, 1988); Słone Lake (Kulesza *et al*., 2008, 2012); *Holocene*: Kuwasy (Żurek, Dzięczkowski, 1971), Raduńskie Lake (Sywula, Pietrzeniuk, 1989), Sąspówka (Bilan, 1992a, b), Trzebnica (Winnicki, Skompski, 1991).

Candona neglecta Sars, 1887

Pl. II, Figs. 1–8

Size. – L = 1.0–1.4 mm, H = 0.5–0.7 mm, W = 0.4–0.6 mm.

Ecological notes. – The species tends to live in lakes and various small water reservoirs, both permanent and intermittent, and muddy and muddy-sandy bottom in sheltered zones of the Baltic Sea. Both sexes always occur together.

General present occurrence in Poland. – (1) Baltic Sea, (2) Baltic Coast, (3) Pomeranian Lake District, (4) Masurian

Lake District, (5) Wielkopolska-Kujawy Lowland, (7a) Białowieża Forest, (8) Lower Silesia, (9) Upper Silesia, (15) Western Sudeten Mts, (17) Western Beskidy Mts, (18) Eastern Beskidy Mts, (20) Pieniny Mts.

Global recent distribution. – Palaearctic Region.

Stratigraphical range. – Pleistocene to Recent.

Quaternary inland records in Poland. – *Early Pleistocene* Augustovian Interglacial: Szczebra (Skompski, Ber, 1999); *Middle Pleistocene* Ferdynandowian Interglacial: Podgórze (Skompski, 2004); Mazovian Interglacial: Czarnucha (Skompski, 2009), Serniki (Diebel, 1961); Lublinian Interglacial: Hrud (Lindner *et al*., 1991); *Late Pleistocene* Eemian Interglacial: Cząstkowo (Krzymińska, Jurys, 2001 – orig. age: Mazovian Interglacial), Elbląg-Bażantarnia (Skompski, 1973), Kruklanki (Kociszewska-Musiał, 1987; Namiotko *et al*., 2003), Krzyżówki (Szałamacha, Skompski, 1999), Leszczyno (Krupiński *et al*., 2006), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Sywula, Pietrzeniuk, 1989), Poznań-Winiary (Sywula, Pietrzeniuk, 1989), Ruszkówek (Kozydra, Skompski, 1995); *Late Pleistocene–Holocene*: Late Glacial–Holocene: Hańcza Lake (Danielopol *et al*., 2008; Lauterbach *et al*., 2011), Orle (Bilan, 1988); Słone Lake (Kulesza *et al*., 2012); *Holocene*: Raduńskie Lake (Sywula, Pietrzeniuk, 1989), Sąspówka (Bilan, 1992a, b), Trzebnica (Winnicki, Skompski, 1991).

Candona weltneri Hartwig, 1899

Candona weltneri obtusa G.W. Müller, 1900

Pl. I, Figs. 9–12

Size. – L = 1.0–1.3 mm, H = 0.6–0.8 mm, W = 0.5–0.7 mm (*C. w. obtusa* L = 1.0–1.2 mm).

Ecological notes. – The species lives in lakes, oxbows and small permanent and intermittent water reservoirs. Both sexes always occur together.

General present occurrence in Poland. – (2) Baltic Coast, (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland, (19) Bieszczady Mts.

Global recent distribution. – Palaearctic and Nearctic Regions.

Stratigraphical range. – Middle Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Ferdynandowian Interglacial: Podgórze (Skompski, 2004); Mazovian Interglacial: Serniki (Diebel, 1961), Sucha Wieś (Skompski, 2009); Lublinian Interglacial: Hrud (Lindner *et al*., 1991); *Late Pleistocene* Eemian Interglacial: Krzyżówki (Szałamacha, Skompski, 1999), Leszczyno (Krupiński *et al*., 2006), Nędzerzew (Sywula, Pietrzeniuk, 1989), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Sywula, Pietrzeniuk, 1989); *Late Pleistocene–Holocene* Late Glacial–Holocene: Głębokie Lake (Kulesza, 2005), Słone Lake (Kulesza *et al*., 2012).

Cyclocypris laevis (O.F. Müller, 1776)

Pl. III, Figs. 1, 2

Size. – L = 0.5 mm, H = 0.4 mm, W = 0.4 mm.

Ecological notes. – Generalist species, known form various water reservoirs including those with water with slightly increased salinity. Both sexes always occur together.

General present occurrence in Poland. – (2) Baltic Coast, (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland, (6) Mazovian Lowland, (7) Podlasie Lowland, (7a) Białowieża Forest, (8) Lower Silesia, (9) Upper Silesia, (10) Kraków-Wieluń Upland, (11) Małopolska Upland, (14) Sandomierska Lowland, (15) Western Sudeten Mts, (17) Western Beskidy Mts, (19) Bieszczady Mts, (20) Pieniny Mts.

Global recent distribution. – Palaearctic and Nearctic Regions.

Stratigraphical range. – Early Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Mazovian Interglacial: Serniki (Diebel, 1961); *Middle Pleistocene* Lublinian Interglacial: Hrud (Lindner *et al*., 1991); *Late Pleistocene* Eemian Interglacial: Kruklanki (Kociszewska-Musiał, 1987; Namiotko *et al*., 2003), Kurzętnik (Brodniewicz, 1966), Nędzerzew (Sywula, Pietrzeniuk, 1989), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Grochmalicki, 1931), Poznań-Winiary (Sywula, Pietrzeniuk, 1989); *Late Pleistocene–Holocene* Late Glacial–Holocene: Głębokie Lake (Kulesza, 2005), Orle (Bilan, 1988); Słone Lake (Kulesza *et al*., 2008, 2012); *Holocene*: Kuwasy (Żurek, Dzięczkowski, 1971).

Cyclocypris ovum (Jurine, 1820)

Pl. III, Figs. 3–6

Size. – L = 0.4–0.5 mm, H = 0.3–0.4 mm, W = 0.3–0.4 mm.

Ecological notes. – Eurybiontic species living in inland water reservoirs varying in type and size. Both sexes always occur together.

General present occurrence in Poland. – (1) Baltic Sea, (2) Baltic Coast, (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland, (7a) Białowieża Forest, (8) Lower Silesia, (9) Upper Silesia, (11) Małopolska Upland, (15) Western Sudeten Mts, (17) Western Beskidy Mts, (18) Eastern Beskidy Mts, (19) Bieszczady Mts, (20) Pieniny Mts.

Global recent distribution. – Palaearctic and Nearctic Regions.

Stratigraphical range. – Miocene and Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Mazovian Interglacial: Czarnucha (Skompski, 2009), Serniki (Diebel, 1961); *Late Pleistocene* Eemian Interglacial: Kruklanki (Namiotko *et al*., 2003), Krzyżówki (Szałamacha, Skompski, 1999), Nędzerzew (Sywula, Pietrzeniuk, 1989), Poznań Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Sywula, Pietrzeniuk, 1989), Ruszkówek (Kozydra, Skompski, 1995); *Late Pleistocene–Holocene* Late Glacial–Holocene: Głębokie Lake (Kulesza, 2005), Orle (Bilan, 1988), Słone Lake (Kulesza *et al*., 2008, 2012); *Holocene*: Sąspówka (Bilan, 1992a, b).

Cyclocypris serena (Koch, 1838)

Pl. III, Figs. 7, 8

Size. – L = 0.5–0.6 mm, H = 0.3–0.4 mm, W = 0.3–0.4 mm.

Ecological notes. – The species lives in littoral of lakes and small reservoirs of various types, including those of the character of spring streams. Stenothermic, mesorheophilic species living in cold climate. Both sexes always occur together.

General present occurrence in Poland. – (3) Pomeranian Lake District, (4) Masurian Lake District, (17) Western Beskidy Mts, (18) Eastern Beskidy Mts, (19) Bieszczady Mts, (21) Tatra Mts.

Global recent distribution. – Palaearctic and Nearctic Regions.

Stratigraphical range. – Early Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Odranian Glacial: Horodło (Dolecki, Skompski, 1986); *Late Pleistocene* Eemian Interglacial: Kruklanki (Namiotko *et al*., 2003); Late Glacial: Gorzechowo (Sywula, Pietrzeniuk, 1989).

Cypria ophtalmica (Jurine, 1820)

Pl. III, Fig. 9

Size. – L = 0.5–0.7 mm, H = 0.3–0.5 mm, W = 0.2–0.3 mm.

Ecological notes. – Eurybionthic in freshwater reservoirs. Halophilic. Both sexes always occur together.

General present occurrence in Poland. – (1) Baltic Sea, (2) Baltic Coast, (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland, (6) Mazovian Lowland, (7a) Białowieża Forest, (8) Lower Silesia, (9) Upper Silesia, (10) Kraków-Wieluń Upland, (11) Małopolska Upland, (14) Sandomierska Lowland, (15) Western Sudeten Mts, (17) Western Beskidy Mts, (18) Eastern Beskidy Mts, (19) Bieszczady Mts, (21) Tatra Mts.

Global recent distribution. – Palaearctic and Nearctic Regions.

Stratigraphical range. – Miocene and Pleistocene to Recent.

Quaternary inland records in Poland. – There is no record so far.

Cyprideis torosa (Jones, 1850)

Pl. IV, Figs. 1–12

Size. – Female L = 0.9–1.1 mm, H = 0.5–0.6 mm, W = 0.4–0.5 mm; male L = 1.0–1.2 mm.

Ecological notes. – Holeuryhaline species living on muddy and muddy-sandy bottom down to about 15 m depth and in permanent coastal lakes. Both sexes always present.

General present occurrence in Poland. – (1) Baltic Sea, (2) Baltic Coast, (4) Masurian Lake District.

Global recent distribution. – Palaearctic, Nearctic, Afrotropical and Australasian Regions.

Stratigraphical range. – Miocene, Pliocene and Pleistocene to Recent.

Quaternary inland records in Poland. – *Late Pleistocene* Eemian Interglacial: Brachlewo (Brodniewicz, 1965), Elbląg-Bażantarnia (Skompski, 1973), Krzyżówki (Szałamacha, Skompski, 1999), Licze and Obrzynowo (Knudsen *et al*., 2012).

Cypridopsis vidua (O.F. Müller, 1776)

Pl. V, Figs. 1, 2

Size – L = 0.4–0.7 mm, H = 0.3–0.4 mm, W = 0.3–0.5 mm.

Ecological notes. – The species lives in small permanent reservoirs of standing and running water with abundant vegetation, and all the zones of lakes. It tolerates small increases in salinity. Males unknown.

General present occurrence in Poland. – (2) Baltic Coast, (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland, (6) Mazovian Lowland, (7a) Białowieża Forest, (8) Lower Silesia, (11) Małopolska Upland, (14) Sandomierska Lowland, (15) Western Sudeten Mts, (16) Eastern Sudeten Mts, (17) Western Beskidy Mts, (18) Eastern Beskidy Mts, (19) Bieszczady Mts, (21) Tatra Mts.

Global recent distribution. – Palaearctic, Nearctic, Afrotropical, Neotropical and Pacific (Oceanic Islands) Regions.

Stratigraphical range. – Lower Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Mazovian Interglacial: Serniki (Diebel, 1961); *Late Pleistocene* Eemian Interglacial: Kruklanki (Namiotko *et al*., 2003), Nędzerzew (Sywula, Pietrzeniuk, 1989), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Sywula, Pietrzeniuk, 1989), Poznań-Winiary (Sywula, Pietrzeniuk, 1989); Late Glacial: Gorzechowo (Sywula, Pietrzeniuk, 1989); *Late Pleistocene–Holocene* Late Glacial–Holocene: Głębokie Lake (Kulesza, 2005), Orle (Bilan, 1988); Słone Lake (Kulesza *et al*., 2008; 2012); *Holocene*: Raduńskie Lake (Sywula, Pietrzeniuk, 1989).

Cytherissa lacustris (Sars, 1863)

Pl. VI, Figs. 1–6

Size. – L = 0.9–1.0 mm, H =0.5 mm.

Ecological notes. – Lives in large and oligotrophic cold lakes, especially in their deep parts. Males known only from the Lake Baikal.

General present occurrence in Poland. – (1) Baltic Sea, (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland.

Global recent distribution. – Palaearctic and Nearctic Regions.

Stratigraphical range. – Pliocene and Pleistocene to Recent.

Quaternary inland records in Poland. – *Early Pleistocene* Augustovian Interglacial: Szczebra (Skompski, Ber, 1999); *Middle Pleistocene* Ferdynandowian Interglacial: Podgórze (Skompski, 2004); Mazovian Interglacial: Sucha Wieś (Skompski, 2009); Lublinian Interglacial: Hrud (Lindner *et al*., 1991); Odranian Glacial: Horodło (Dolecki, Skompski, 1986); *Late Pleistocene* Eemian Interglacial: Cząstkowo (Krzymińska, Jurys, 2001 – orig. age: Mazovian Interglacial), Elbląg-Bażantarnia (Skompski, 1973), Kruklanki (Kociszewska-Musiał, 1987; Namiotko *et al*., 2003), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Grochmalicki, 1931); *Late Pleistocene* Late Glacial: Gorzechowo (Sywula, Pietrzeniuk, 1989); *Late Pleistocene–Holocene* Late Glacial–Holocene: Hańcza Lake (Lauterbach *et al*., 2011), Orle (Bilan, 1988), Słone Lake (Kulesza *et al*., 2012); *Holocene*: Raduńskie Lake (Sywula, Pietrzeniuk, 1989).

Cytheromorpha fuscata (Brady, 1869)

Pl. V, Figs. 3–6

Size. – L = 0.6 mm, H = 0.3 mm, W = 0.3 mm; male L = 0.7–0.8 mm.

Ecological notes. – Brackish-marine species known from coastal waters of Europe and Caspian Sea. It usually tends to live on muddy-sandy seafloor at depths to about 20 m, but is also known from coastal lakes and, in a single case, inland salty water basins. Both sexes always present.

General present occurrence in Poland. – (1) Baltic Sea, (2) Baltic Coast.

Global recent distribution. – Palaearctic and Nearctic Regions.

Stratigraphical range. – Holocene to Recent.

Quaternary inland records in Poland. – There is no record so far.

Cytherura gibba (O.F. Müller, 1785)

Pl. XIV, Figs. 7, 8

Size. – L = 0.5–0.6 mm, H = 0.3 mm, W = 0.3 mm.

Ecological notes. – Species living in brackish-marine water, in the littoral at depths down to 20 m. Usually found on plants and detritus and only occasionally on other types of substrate. Both sexes always present.

General present occurrence in Poland. – (1) Baltic Sea, (2) Baltic Coast.

Global recent distribution. – Palaearctic Region.

Stratigraphical range. – Pleistocene to Recent.

Quaternary inland records in Poland. – *Late Pleistocene* Eemian Interglacial: Elbląg-Bażantarnia (Skompski, 1973).

Darwinula stevensoni (Brady et Robertson, 1870)

Pl. V, Figs. 7, 8

Size: L = 0.6–0.8 mm, H = 0.2–0.4 mm, W = 0.2–0.4 mm.

Ecological notes. – The species lives in lakes, rivers, small permanent reservoirs and wet habitat of moss of forest swamps, tolerating only minor increases in water salinity.

General present occurrence in Poland. – (1) Baltic Sea, (2) Baltic Coast, (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland, (15) Western Sudeten Mts, (19) Bieszczady Mts.

Global recent distribution. – Palaearctic, Nearctic, Afrotropical, Neotropical, Oriental and Australasian Regions.

Stratigraphical range. – Mid Oligocene to Recent.

Quaternary inland records in Poland. – *Early Pleistocene* Augustovian Interglacial: Szczebra (Skompski, Ber, 1999); *Middle Pleistocene* Mazovian Interglacial: Czarnucha and Sucha Wieś (Skompski, 2009), Serniki (Diebel, 1961); Lublinian Interglacial: Hrud (Lindner *et al*., 1991); *Late Pleistocene* Eemian Interglacial: Elbląg-Bażantarnia (Skompski, 1973), Kruklanki (Kociszewska-Musiał, 1987; Namiotko *et al*., 2003), Krzyżówki (Szałamacha, Skompski, 1999), Nędzerzew (Sywula, Pietrzeniuk, 1989), Poznań Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Grochmalicki, 1931), Ruszkówek (Kozydra, Skompski, 1995), Wieprzyce (Hucke, 1912); *Late Pleistocene–Holocene* Late Glacial–Holocene: Głębokie Lake (Kulesza, 2005), Orle (Bilan, 1988); Słone Lake (Kulesza *et al*., 2008, 2012).

Fabaeformiscandona alexandri (Sywula, 1981)

Fig. 7C

Size. – L = 1.0–1.2 mm, H = 0.5 mm.

Ecological notes. – Living in lakes. Both sexes always present.

General present occurrence in Poland. – (3) Pomeranian Lake District.

Global recent distribution. – Palaearctic Region (rare species occurring only at a few sites in Germany and Poland).

Stratigraphical range. – Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Lublinian Interglacial: Hrud (Lindner *et al*., 1991); *Late Pleistocene* Eemian Interglacial: Leszczyno (Krupiński *et al*., 2006), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Sywula, Pietrzeniuk, 1989).

Fabaeformiscandona caudata (Kaufmann, 1900)

Pl. VIII, Figs. 1, 2

Size. – L = 1.0–1.3 mm, H = 0.5–0.6 mm, W = 0.4–0.5 mm.

Ecological notes. – Species living in lakes, especially in their deeper parts, small permanent reservoirs of standing and running water, and larger, more eutrophic ones. Males unknown.

General present occurrence in Poland. – (15) Western Sudeten Mts.

Global recent distribution. – Palaearctic and Nearctic Regions.

Stratigraphical range. – Middle Pleistocene to Recent.

Quaternary inland records in Poland. – There is no record so far.

Fabaeformiscandona fabaeformis (Fischer, 1851)

Pl. IX, Figs. 1–4

Size. – Female L = 0.9–1.2 mm, H = 0.4–0.6 mm, W = 0.3–0.4 mm; male L = 1.0–1.3 mm, H = 0.5–0.7 mm.

Ecological notes. – Halophilic species living in permanent and intermittent small reservoirs of various types and shallow littoral in lakes. Both sexes always occur together.

General present occurrence in Poland. – (2) Baltic Coast, (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland, (7a) Białowieża Forest, (10) Kraków-Wieluń Upland, (14) Sandomierska Lowland.

Global recent distribution. – Palaearctic and Oriental Regions.

Stratigraphical range. – Miocene, Pliocene and Pleistocene to Recent.

Quaternary inland records in Poland. – *Late Pleistocene* Eemian Interglacial: Kruklanki (Namiotko *et al*., 2003), Poznań-Szeląg (Grochmalicki, 1931); *Late Pleistocene–Holocene* Late Glacial–Holocene: Słone Lake (Kulesza *et al*., 2008; 2012); *Holocene*: Kuwasy (Żurek, Dzięczkowski, 1971).

Fabaeformiscandona levanderi (Hirschmann, 1912)

Pl. VII, Figs. 1–8

Size. – Female L = 1.1–1.3 mm, H = 0.5–0.7 mm, W = 0.4–0.6 mm, L = 1.2–1.4 mm.

Ecological notes. – The species tends to live in lakes, especially their littoral and profundal, being also known from brackish water. Both sexes always occur together.

General present occurrence in Poland. – (3) Pomeranian Lake District, (5) Wielkopolska-Kujawy Lowland.

Global recent distribution. – Palaearctic Region.

Stratigraphical range. – Early Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Lublinian Interglacial: Hrud (Lindner *et al*., 1991), Odranian Glacial: Horodło (Dolecki, Skompski, 1986); *Late Pleistocene* Eemian Interglacial: Krzyżówki (Szałamacha, Skompski, 1999), Leszczyno (Krupinski *et al*., 2006), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Ruszkówek (Kozydra, Skompski, 1995); *Late Pleistocene–Holocene* Late Glacial–Holocene: Orle (Bilan, 1988); *Holocene*: Raduńskie Lake (Sywula, Pietrzeniuk, 1989).

Fabaeformiscandona protzi (Hartwig, 1898)

Pl. VIII, Figs. 3–9

Size. – L = 1.0–1.2 mm, H = 0.5–0.6 mm, W = 0.4 mm.

Ecological notes. – The species lives in all the zones of lakes and small permanent water reservoirs. Both sexes always occur together.

General present occurrence in Poland. – (2) Baltic Coast, (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland, (11) Małopolska Upland, (15) Western Sudeten Mts.

Global recent distribution. – Palaearctic region.

Stratigraphical range. – Early Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Mazovian Interglacial: Serniki (Diebel, 1961); Lublinian Interglacial: Hrud (Lindner *et al*., 1991); *Late Pleistocene* Eemian Interglacial: Cząstkowo (Krzymińska, Jurys, 2001 – orig. age: Mazovian Interglacial), Kruklanki (Kociszewska-Musiał, 1987; Namiotko *et al*., 2003), Krzyżówki (Szałamacha, Skompski, 1999), Leszczyno (Krupiński *et al*., 2006), Nędzerzew (Sywula, Pietrzeniuk, 1989), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Grochmalicki, 1931), Ruszkówek (Kozydra, Skompski, 1995); *Late Pleistocene–Holocene* Late Glacial–Holocene: Głębokie Lake (Kulesza, 2005), Hańcza Lake (Lauterbach *et al*., 2011), Orle (Bilan, 1988), Słone Lake (Kulesza *et al*., 2008, 2012); *Holocene*: Sąspówka (Bilan, 1992a, b).

Fabaeformiscandona tricicatricosa
(Diebel et Pietrzeniuk, 1969)

Pl. IX, Figs. 5–8

Syn.: *Fabaeformiscandona lozeki* (Absolon, 1973)

Size. – Female L = 1.2–1.3 mm, male L = 1.4 mm.

Ecological notes. – Lacustrine species, living in deeper zones of oligotrophic lakes. Most probably oxyphilic. Both sexes present.

General present occurrence in Poland. – (4) Masurian Lake District.

Global recent distribution. – Palaearctic Region (rare species, living individuals are known only from a few lakes in Germany and Poland).

Stratigraphical range. – Pleistocene to Recent.

Quaternary inland records in Poland. – *Late Pleistocene* Eemian Interglacial: Leszczyno (Krupiński *et al*., 2006), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Sywula, Pietrzeniuk, 1989).

Herpetocypris reptans (Baird, 1835)

Pl. X, Figs. 3–6

Size. – L = 1.8–2.6 mm, H = 0.8–1.2 mm, W = 0.7–1.0 mm.

Ecological notes. – The species lives in small permanent basins with abundant vegetation and littoral of lakes. It tolerates slightly increased salinity of water. Males unknown.

General present occurrence in Poland. – (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland, (9) Upper Silesia, (11) Małopolska Upland, (14) Sandomierska Lowland, (15) Western Sudeten Mts.

Global recent distribution. – Palaearctic, Nearctic and Neotropical Regions.

Stratigraphical range. – Early Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Mazovian Interglacial: Serniki (Diebel, 1961); Lublinian Interglacial: Hrud (Lindner *et al*., 1991); *Late Pleistocene* Eemian Interglacial: Kruklanki (Kociszewska-Musiał, 1987; Namiotko *et al*., 2003), Nędzerzew (Sywula, Pietrzeniuk, 1989), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Sywula, Pietrzeniuk, 1989), Wieprzyce (Hucke, 1912), Żmigród (Skompski, 1983); Late Glacial: Gorzechowo (Sywula, Pietrzeniuk, 1989); *Late Pleistocene–Holocene* Late Glacial–Holocene: Orle (Bilan, 1988), Słone Lake (Kulesza *et al*., 2008, 2012); *Holocene*: Raduńskie Lake (Sywula, Pietrzeniuk, 1989).

Heterocypris salina (Brady, 1868)

Pl. X, Figs. 1, 2

Size. – L = 0.8–1.3 mm, H = 0.5–0.8 mm, W = 0.4–06 mm.

Ecological notes. – Halobiont species occupying muddy bottom of the shallowest marine brackishwater littoral as well as inland permanent saline waterbodies. Males unknown.

General present occurrence in Poland. – (1) Baltic Sea, (2) Baltic Coast, (5) Wielkopolska-Kujawy Lowland, (9) Upper Silesia, (11) Małopolska Upland, (18) Eastern Beskidy Mts.

Global recent distribution. – Palaearctic, Nearctic and Neotropical Regions.

Stratigraphical range. – Upper Miocene and Pleistocene to Recent.

Quaternary inland records in Poland. – *Late Pleistocene* Eemian Interglacial: Krzyżówki (Szałamacha, Skompski, 1999); *Holocene*: Kuwasy (Żurek, Dzięczkowski, 1971).

Ilyocypris bradyi Sars, 1890

Pl. XI, Figs. 3–6

Size. – L = 0.8–1.1 mm, H = 0.4–0.6 mm, W = 0.4–0.5 mm.

Ecological notes. – Lives in freshwater reservoirs of various types, especially associated with springs. Males unknown.

General present occurrence in Poland. – (2) Baltic Coast, (3) Pomeranian Lake District, (5) Wielkopolska-Kujawy Lowland, (11) Małopolska Upland, (15) Western Sudeten Mts, (17) Western Beskidy Mts, (18) Eastern Beskidy Mts, (19) Bieszczady Mts, (20) Pieniny Mts.

Global recent distribution. – Palaearctic, Nearctic, Neotropical and Oriental Regions.

Stratigraphical range. – Miocene, Pliocene and Pleistocene to Recent.

Quaternary inland records in Poland. – *Early Pleistocene* Augustovian Interglacial: Szczebra (Skompski, Ber, 1999); *Middle Pleistocene* Ferdynandowian Interglacial: Podgórze (Skompski, 2004); Mazovian Interglacial: Czarnucha and Sucha Wieś (Skompski, 2009); Lublinian Interglacial: Hrud (Lindner *et al*., 1991); Odranian Glacial: Horodło (Dolecki, Skompski, 1986); *Late Pleistocene* Eemian Interglacial: Kruklanki (Kociszewska-Musiał, 1987; Namiotko *et al*., 2003), Poznań-Winiary (Sywula, Pietrzeniuk, 1989), Ruszkówek (Kozydra, Skompski, 1995), *Late Pleistocene–Holocene* Late Glacial– Holocene: Głębokie Lake (Kulesza, 2005), Słone Lake (Kulesza *et al*., 2012); *Holocene*: Sąspówka (Bilan, 1992a, b), Trzebnica (Winnicki, Skompski, 1991).

Ilyocypris decipiens Masi, 1905

Pl. XI, Figs. 7–11

Size. – L = 0.9–1.1 mm, H = 0.5–0.6 mm.

Ecological notes. – Occurrs in ponds and lake littoral, rarely also in rivers and temporary pools. Both sexes always present.

General present occurrence in Poland. – (1) Baltic Sea, (2) Baltic Coast, (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland.

Global recent distribution. – Palaearctic Region.

Stratigraphical range. – Pleistocene to Recent.

Quaternary inland records in Poland. – *Late Pleistocene* Eemian Interglacial: Kruklanki (Namiotko *et al*., 2003).

Ilyocypris gibba (Ramdohr, 1808)

Pl. XI, Figs. 1, 2

Size. – L = 0.8–1.2 mm, H = 0.4–0.6 mm.

Ecological notes. – Lives mainly in various permanent and intermittent standing water reservoirs and nearshore zones in lakes. Halophilic. Males occur sporadically.

General present occurrence in Poland. – (5) Wielkopolska-Kujawy Lowland, (9) Upper Silesia, (11) Małopolska Upland, (17) Western Beskidy Mts.

Global recent distribution. – Palaearctic, Nearctic and Neotropical Regions.

Stratigraphical range. – Miocene and Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Ferdynandowian Interglacial: Podgórze (Skompski, 2004); Mazovian Interglacial: Sucha Wieś (Skompski, 2009); *Late Pleistocene* Eemian Interglacial: Elbląg-Bażantarnia (Skompski, 1973), Kruklanki (Namiotko *et al*., 2003), Wieprzyce (Hucke, 1912), Żmigród (Sywula, Pietrzeniuk, 1989); *Late Pleistocene–Holocene* Late Glacial–Holocene: Głębokie Lake (Kulesza, 2005).

Ilyocypris lacustris Kaufmann, 1900

Pl. XI, Figs. 12–16

Size. – L = 0.8–0.9 mm, H = 0.45 mm, W = 0.4 mm.

Ecological notes. – Living in lakes. In the fossil record known from sections of interglacial lacustrine sediments and other representing cold periods.

General present occurrence in Poland. – There is no record so far.

Global recent distribution. – Palaearctic Region (few records in Europe and one doubtful from Mongolia, see Meisch, 2000).

Stratigraphical range. – Middle Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Mazovian Interglacial: Czarnucha (Skompski, 2009), Serniki (Sywula, Pietrzeniuk, 1989); *Late Pleistocene* Late Glacial: Gorzechowo (Sywula, Pietrzeniuk, 1989).

Limnocythere inopinata (Baird, 1843)

Pl. XII, Figs. 1–3

Size. – L = 0.5–0.7 mm, H = 0.3–0.4 mm, W = 0.2–0.3 mm.

Ecological notes. – The species lives in lakes and small but permanent reservoirs of stagnant and slowly flowing water, being also found on inland salines and in underground water.

General present occurrence in Poland. – (1) Baltic Sea, (2) Baltic Coast, (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland, (11) Małopolska Upland, (15) Western Sudeten Mts, (17) Western Beskidy Mts.

Global recent distribution. – Palaearctic, Nearctic and Afrotropical Regions.

Stratigraphical range. – Pleistocene to Recent.

Quaternary inland records in Poland. – *Early Pleistocene* Augustovian Interglacial: Szczebra (Skompski, Ber, 1999); *Middle Pleistocene* Mazovian Interglacial: Serniki (Diebel, 1961); Lublinian Interglacial: Hrud (Lindner *et al*., 1991); *Late Pleistocene* Eemian Interglacial: Kruklanki (Kociszewska-Musiał, 1987; Namiotko *et al*., 2003), Krzyżówki (Szałamacha, Skompski, 1999), Nędzerzew (Sywula, Pietrzeniuk, 1989), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Grochmalicki, 1931); Late Glacial: Gorzechowo (Sywula, Pietrzeniuk, 1989); *Late Pleistocene–Holocene* Late Glacial–Holocene: Głębokie Lake (Kulesza, 2005), Orle (Bilan, 1988); Słone Lake (Kulesza *et al*., 2008, 2012); *Holocene*: Raduńskie Lake (Sywula, Pietrzeniuk, 1989).

Limnocytherina sanctipatricii
(Brady et Robertson, 1869)

Pl. XII, Figs. 4–10

Size. – L = 0.8–0.9 mm, H = 0.4 mm.

Ecological notes. – Living in lakes, mainly in the sublittoral and profundal, being occasionally found in small permanent reservoirs. Does not occur in flowing water nor water with increased salinity. Both sexes always present.

General present occurrence in Poland. – (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland.

Global recent distribution. – Palaearctic and Nearctic Regions.

Stratigraphical range. – Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Mazovian Interglacial: Czarnucha (Skompski, 2009); Lublinian Interglacial: Hrud (Lindner *et al*., 1991); *Late Pleistocene* Eemian Interglacial: Kruklanki (Kociszewska-Musiał, 1987; Namiotko *et al*., 2003), Krzyżówki (Szałamacha, Skompski, 1999), Leszczyno (Krupiński *et. al*., 2006), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Grochmalicki, 1931), Ruszkówek (Kozydra, Skompski, 1995); *Late Pleistocene–Holocene* Late Glacial– Holocene: Głębokie Lake (Kulesza, 2005), Hańcza Lake (Lauterbach *et al*., 2011), Orle (Bilan, 1988), Słone Lake (Kulesza *et al*., 2012).

Loxoconcha elliptica Brady, 1868

Plate XIV, Fig. 12

Size. – L = 0.6–0.7 mm.

Ecological notes. – Living in the upper littoral at depths not greater than a few meters, on plants or bottom overgrown by plants. Marine-brackish water species. Both sexes always present.

General present occurrence in Poland. – (1) Baltic Sea.

Global recent distribution. – Palaearctic Region.

Stratigraphical range. – Holocene to Recent.

Quaternary inland records in Poland. – There is no record so far.

Metacypris cordata Brady et Robertson, 1870

Pl. XIII, Figs. 1–6

Size. – L = 0.5–0.6 mm.

Ecological notes. – The species lives in shallows of lakes and sometimes rivers and small permanent water reservoirs. Both sexes always present.

General present occurrence in Poland. – (2) Baltic Coast, (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland, (7a) Białowieża Forest.

Global recent distribution. – Palaearctic Region.

Stratigraphical range. – Upper Pliocene and Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Mazovian Interglacial: Serniki (Diebel, 1961); Lublinian Interglacial: Hrud (Lindner *et al*., 1991); *Late Pleistocene* Eemian Interglacial: Elbląg-Bażantarnia (Skompski, 1973), Krzyżówki (Szałamacha, Skompski, 1999), Leszczyno (Krupiński *et al*., 2006), Nędzerzew (Sywula, Pietrzeniuk, 1989), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Grochmalicki, 1931), Ruszkówek (Kozydra, Skompski, 1995), Wieprzyce (Hucke, 1912); *Late Pleistocene–Holocene* Late Glacial–Holocene: Głębokie Lake (Kulesza, 2005), Orle (Bilan, 1988), Słone Lake (Kulesza *et al*., 2008, 2012); *Holocene*: Kuwasy (Żurek, Dzięczkowski, 1971).

Potamocypris similis G.W. Müller, 1912

Pl. X, Figs. 7, 8

Size. – L = 0.5–0.6 mm, H = 0.3 mm, W = 0.2–0.3 mm.

Ecological notes. – The species lives in ponds and littoral of lakes. Males unknown.

General present occurrence in Poland. – (2) Baltic Coast.

Global recent distribution. – Palaearctic Region.

Stratigraphical range. – Pleistocene to Recent.

Quaternary inland records in Poland. – *Late Pleistocene* Eemian Interglacial: Elbląg-Bażantarnia (Skompski, 1973), Kruklanki (Kociszewska-Musiał, 1987; Namiotko *et al*., 2003), Nędzerzew (Sywula, Pietrzeniuk, 1989).

Pseudocandona compressa (Koch, 1838)

Pl. XIII, Figs. 7–9

Size. – L = 0.8–1.0 mm, H = 0.4–0.6 mm, W = 0.3–0.4 mm.

Ecological notes. – Lives in lake littoral and small permanent and temporary waters, halophilic species.

General present occurrence in Poland. – (1) Baltic Sea, (2) Baltic Coast, (3) Pomeranian Lake District, (4) Masurian Lake District, (5) Wielkopolska-Kujawy Lowland, (7a) Białowieża Forest, (10) Kraków-Wieluń Upland, (17) Western Beskidy Mts, (20) Pieniny Mts, (21) Tatra Mts.

Global recent distribution. – Palaearctic and Nearctic Regions.

Stratigraphical range. – Pliocene and Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Mazovian Interglacial: Serniki (Diebel, 1961); Lublinian Interglacial: Hrud (Lindner *et al*., 1991); Odranian Glacial: Horodło (Dolecki, Skompski, 1986); *Late Pleistocene* Eemian Interglacial: Kruklanki (Kociszewska-Musiał, 1987; Namiotko *et al*., 2003), Krzyżówki (Szałamacha, Skompski, 1999), Leszczyno (Krupiński *et al*., 2006), Nędzerzew (Sywula, Pietrzeniuk, 1989), Poznań-Główna (Sywula, Pietrzeniuk, 1989), Poznań-Szeląg (Sywula, Pietrzeniuk, 1989), Ruszkówek (Kozydra, Skompski, 1995); Late Glacial: Gorzechowo (Sywula, Pietrzeniuk, 1989); *Late Pleistocene–Holocene* Late Glacial–Holocene: Głębokie Lake (Kulesza, 2005), Orle (Bilan, 1988); Słone Lake (Kulesza *et al*., 2008, 2012); *Holocene*: Kuwasy (Żurek, Dzięczkowski, 1971), Trzebnica (Winnicki, Skompski, 1991).

Pseudocandona rostrata (Brady et Norman, 1889)

Fig. 7C

Size. – L = 0.9–1.2 mm, H = 0.5–0.7 mm, W = 0.4–0.5 mm.

Ecological notes. – Occurs mainly in permanent and temporary ponds as well as in the littoral and sub-littoral lakes.

General present occurrence in Poland. – (7a) Białowieża Forest, (21) Tatra Mts.

Global recent distribution. – Palaearctic and Nearctic Regions.

Stratigraphical range. – Pleistocene to Recent.

Quaternary inland records in Poland. – *Middle Pleistocene* Mazovian Interglacial: Serniki (Diebel, 1961); Lublinian Interglacial: Hrud (Lindner *et al*., 1991); *Late Pleistocene* Eemian Interglacial: Poznań-Szeląg (Grochmalicki, 1931).

Sarscypridopis aculeata (Costa, 1847)

Pl. XIII, Figs. 10–12

Size: L = 0.6–0.8 mm, H = 0.4–0.6 mm, W = 0.3–0.4 mm.

Ecological notes. – Halobiontic species living in the shallowest sea littoral, in sheltered zones of brackish waters, in coastal lakes and various small permanent inland saline waterbodies. Males unknown.

General present occurrence in Poland. – (1) Baltic Sea, (2) Baltic Coast, (5) Wielkopolska-Kujawy Lowland, (11) Małopolska Upland.

Global recent distribution. – Palaearctic, Nearctic, Afrotropical, Neotropical and Australasian Regions.

Stratigraphical range. – Pliocene and Pleistocene to Recent.

Quaternary inland records in Poland. – There is no record so far.

Scottia browniana (Jones, 1850)

Pl. XIV, Figs. 1–3

Size. – L = 0.8 mm, H = 0.5 mm, W = 0.5 mm.

Ecological notes. – It seems that it mainly lived in shrinking parts of large water reservoirs (lakes and oxbows).

General present occurrence in Poland. – Extinct species.

Global recent distribution. – Extinct species.

Stratigraphical range. – Upper Pliocene to Pleistocene.

Quaternary inland records in Poland. – *Early Pleistocene* Augustovian Interglacial: Szczebra (Skompski, Ber, 1999); *Middle Pleistocene* Ferdynandowian Interglacial: Podgórze (Skompski, 2004); *Middle Pleistocene* Mazovian Interglacial: Czarnucha and Sucha Wieś (Skompski, 2009); Krępa (Jesionkiewicz, 1982), Opole, Ruda, Sosnowica and Zwierzyniec (Skompski, 1987, 1991); *Middle Pleistocene* Lublinian Interglacial: Hrud (Lindner *et al*., 1991).

Scottia tumida (Jones, 1850)

Pl. XIV, Figs. 4–6

Size. – L = 0.7 mm, H = 0.5 mm.

Ecological notes. – The species lives in habitats including shrinking parts of lakes and major oxbows, similar to that of *S. browniana* (Jones).

General present occurrence in Poland. – Extinct species.

Global recent distribution. – Extinct species.

Stratigraphical range. – Upper Pliocene to Pleistocene.

Quaternary inland records in Poland. – *Early Pleistocene* Augustovian Interglacial: Szczebra (Skompski, Ber, 1999); *Middle Pleistocene* Ferdynandowian Interglacial: Podgórze (Skompski, 2004); Mazovian Interglacial: Czarnucha and Sucha Wieś (Skompski, 2009); Krępa (Jesionkiewicz, 1982), Ruda (Skompski, 1987, 1991), Serniki (Diebel, 1961), Sosnowica (Skompski, 1987, 1991); Lublinian Interglacial: Hrud (Lindner *et al*., 1991); *Late Pleistocene* Eemian Interglacial: Ruszkówek (Kozydra, Skompski, 1995).

Semicytherura nigrescens (Baird, 1838)

Pl. XIV, Fig. 9

Size. – L = 0.40–0.45 mm.

Ecological notes. – Brackish-marine species living on plants in the upper littoral at depths down to 20 m. Both sexes always present.

General present occurrence in Poland. – (1) Baltic Sea.

Global recent distribution. – Palaearctic Region.

Stratigraphical range. – Pleistocene to Recent.

Quaternary inland records in Poland. – *Late Pleistocene* Eemian Interglacial: Licze (Knudsen *et al*., 2012).

Xestoleberis aurantia (Baird, 1838)

Pl. XIV, Figs. 10, 11

Size. – Female L = 0.42–0.50 mm, male L = 0.36–0.42 mm.

Ecological notes. – Euryhaline marine species living in the upper littoral on plants. Both sexes always present.

General present occurrence in Poland. – (1) Baltic Sea, (2) Baltic Coast.

Global recent distribution. – Palaearctic Region.

Stratigraphical range. – Holocene to Recent.

Quaternary inland records in Poland. – There is no record so far.

STRATIGRAPHY, DISTRIBUTION AND PALAEOECOLOGY OF OSTRACODA FROM THE QUATERNARY OF THE SOUTHERN BALTIC SEA

The following geological history of the Baltic Sea is presented after Ignatius *et al.* (1981) and Gudelis, Emelyanov (1982). According to these authors (see Fig. 8), the Baltic Ice Lake gradually expanded into an extensive dam. Recession of the glacier face northwards from Billingen (the peak in Sweden) led to a strong inflow of Baltic Ice Lake waters. The water level of the reservoir equaled with the level of the ocean. Near Närke there was a wide strait through which the exchange waters with the ocean took place. The outflow of waters from the Baltic Ice Lake commenced development of the Baltic Sea. Marine waters penetrated and spread slowly. A reservoir came into existence and was called the Yoldia Sea after the name of the sea mussel *Yoldia arctica*. The strait of the Yoldia Sea in Närke under the influence of rising the earth's crust disappeared. In the absence of connection to the ocean, the Baltic reservoir began to gradually transform into the freshwater lake. This gave rise to the development of Ancylus Lake, called after the snail *Ancylus fluviatilis.* Following the eustatic world ocean level rise, 8,000 years ago, waters of the North Sea began to penetrate to the Baltic Sea using the Danish straits. The phase of the Littorina Sea began, which name was taken from snail *Littorina littorea*. Tectonic movements around the Danish straits reduced the inflow of saline water from the ocean, which caused some freshening of the sea. Changes in salinity and temperature led to changes in the animals and plants' world. After the Littorina stage the final formation of the modern Baltic Sea happened.

LATE GLACIAL AND EARLY HOLOCENE FAUNA

The studied sediment sequences of the Late Glacial and early Holocene in the southern Baltic Sea region including fauna, were represented by lacustrine-marsh sediments, peat, mud and sand, and also delta and lagoon sand.

On the Odra Bank area in the bottom of the profiles W4, 77, R86, 51-I and PVI-89 (Fig. 2), as well as at the base of the core PIX-2 (according to Uścinowicz, 2006, see Table 1 here), in the marsh-lacustrine sediments freshwater ostracods species such as: *Candona neglecta, Cytherissa lacustris* and *Candona candida* occured (Table 2A, 2B).

The age of the studied sediments was dated by ^{14}C and ranged from about 14,060 to 12,010 years BP (Kramarska, 1998). In the profiles of the area of Dziwnów (R-05-P, R-06-R, 09-R-P, R-P-11, R-18-P, R-P-21, R-24-P) (Fig. 2) also *Candona candida*, *Candona neglecta* and *Cytherissa lacustris* (Table 2A) abundantly and commonly occured. However, in the profiles from Mrzeżyno (9, 53, 55, 56, 66, 67, 69, 71) (Fig. 2) *Candona candida*, *Candona neglecta*, *Cypridopsis vidua*, *Cyclocypris ovum*, *Darwinula stevensoni*, *Herpetocypris reptans*, *Metacypris cordata*, *Ilyocypris decipiens* (Table 2A) appeared.

In lake mud and organic alluvia in the sea profiles (R13, 1N, 1T, 2T, and R24, 5L) and the cores taken from the sea lakes (4T, 3T and 4 N) (Fig. 2) freshwater ostracods occured numerously. They were: *Fabaeformiscandona levanderi*, *Candona candida*, *Candona neglecta*, *Cyclocypris ovum*, *Cytherissa lacustris*, *Herpetocypris reptans*, *Ilyocypris decipiens* (Table 2A, 2B). This type of assemblage may indicate that there were shallow reservoirs of stable deposition conditions, and the group of ostracods such as: *Candona candida*, *Candona neglecta*, *Cytherissa lacustris* indicates oligotrophic reservoir with cold water.

In the central area (Fig. 1), in the organic and clay alluvia of the borehole of Kopań Lake (4/21) (Fig. 3) ostracode assemblages: *Cytherissa lacustris*, *Fabaeformiscandona levanderi*, *Candona neglecta*, *Candona candida*, *Limnocythere inopinata* and *Limnocythere sanctipatricii* (Table 2C) which are typical for freshwater environment also occured.

In the bottom part of the borehole of Bukowo 4A/19 and 3/19 (Fig. 3), there were freshwater ostracods such as: *Candona neglecta*, *Cytherissa lacustris* and also *Cypridopsis vidua* and *Cyclocypris laevis*, while in the profile 8L – *Cytherissa lacustris* and *Limnocythere inopinata* (Table 2C).

In the eastern area (Fig. 1), the sediments in profiles K1, P1, P4, W2, R2, O2 and Bór (Fig. 4), which were palynologicaly dated (Uścinowicz, Zachowicz, 1994) for Preboreal and Boreal period, contained freshwater species: *Candona candida*, *C. neglecta*, *Cytherissa lacustris*, *Limnocytherina sanctipatricii* (Table 2D). Similar palaeoassemblages Krzymińska and Namiotko (2012) also described in the muddy sands and sandy silts dark-gray coloured with a large plant detritus from the core 1ZG54 from the western part, the deeper one, of the Gulf of Gdańsk (Fig. 4) and they were radiocarbon dated for 12,200 ±240 BP (Uścinowicz, Zachowicz, 1994), as well as in sediments coming from the cores 4ZG148, 2ZG138 and R16 (Fig. 4) from the middle part of the Gulf of Gdańsk (Krzymińska, Namiotko, 2012). Also in the eastern part of the Gulf of Gdańsk, the sediments of the core El 1, sandy silts and muddy sands brown-grey coloured, included freshwater ostracods. They were also dated (from the lower part of the core) by ^{14}C method for 10,650 ±160 years BP and (from the top of the core) for 9,000 ±260 years BP (Uścinowicz, Zachowicz, 1994). Ostracod group was represented by the following species: *Candona candida*, *C. neglecta*, *Cytherissa lacustris*, *Limnocytherina sanctipatricii*, *Ilyocypris decipiens*. Also the deposits (clayey silts and silty sands) of cores: R3/a82 and R3A/82 and R 127 and the M1 showed freshwater type of sedimentation. They were ostracod species such as: *Candona candida*, *C. neglecta*, *Cytherissa lacustris*, *Limnocytherina sanctipatricii*, *Cyclocypris ovum*, *Ilyocypris decipiens*. In the cores: R6/82, R5/82, R4/82, 4ZG152, R119 and 20, located in the foreland of the mouth of the Vistula the presence of ostracods was also found. They were: *Candona candida*, *Cytherissa lacustris*, *Limnocythere inopinata*.

In the area of the active part of the Vistula delta, in the area of Mikoszewo and Świbno, in profiles: Świbno 1, 2 and 3, Mikoszewo 2, 3 and 7 and also STW1 and STW2 (Fig. 4), a group of freshwater ostracods such as: *Candona candida*, *C. neglecta*, *Cypridopsis vidua*, *Cyclocypris laevis*, *Cytherissa lacustris*, *Darwinula stevensoni*, *Ilyocypris decipiens*, *Limnocythere inopinata* (Table 2D) marked its presence.

In shallow-water western part of the Gulf of Gdańsk, up to 30 m below sea level (cores WB1, WB6 and WB7), analysis of ostracod group suggest that the tested sediments (clays, silts, muddy sands) were deposited in lacustrine reservoirs during preboreal and boreal period. The sediments of the ostracod associations are typical of freshwater environment, and the presence of some taxa may indicate changing conditions during their deposition. This interpretation of palaeoenvironment is supported by ostracod species composition represented by such forms of freshwater ones as: *Cytherissa lacustris*, *Candona neglecta*, *Fabaeformiscandona levanderi*, *Limnocythere inopinata*, *Ilyocypris lacustris*, *Cyclocypris laevis*, *Herpetocypris reptans*.

In the sediments from the core ZW3 of the Vistula Lagoon, which were dated at 10,200 years BP, and also in the profiles ZW 6, 7 ZW, ZW 12 (Fig. 4), there were common ostracod assemblages typical for freshwater environment, such as: *Candona candida*, *C. neglecta*, *Cytherissa lacustris*, *Darwinula stevensoni*, *Ilyocypris decipiens, Limnocythere inopinata* (Table 2E).

In the light of these results can be considered that ostracode assemblages of the Late Glacial and early Holocene occuring in the sediments of the western, central and eastern parts of the southern Baltic Sea represent species typical for deeper or coastal zone of lakes and small reservoirs connected to rivers. The results of ostracod studies correlated with ^{14}C dating of ostracod sediments revealed that sediments characterized by the presence of ostracod species tolerating cold climate such as: *Candona candida*, *C. neglecta*, *Cytherissa lacustris*, *Darwinula stevensoni*, *Limnocythere inopinata*, *Limnocytherina sanctipatricii* formed during the Late Glacial. However, the occurrence of species with higher thermal requirements such as: *Cyclocypris laevis*, *Ilyocypris decipiens*, *Ilyocypris lacustris*, *Metacypris cordata* in the sediments indicates that the deposits probably formed in the early Holocene.

MIDDLE AND LATE HOLOCENE FAUNA

For almost the entire area of the southern Baltic Sea sediments representing the climatic optimum of the middle and late Holocene included marine fauna typical for reservoirs with low salinity. Assemblages of ostracods indicating such an environment were found in the cores taken in each of the three studied regions of the southern Baltic Sea. In some profiles already in the top of lacustrine sediments in addition to the freshwater fauna, the marine one appeared. Deposits of mixed fauna were directly above the organic layer dated to 7,240 years BP age (Kramarska, 1998). With the rise of sea level and transgression progress it begins to create a sandy cover composed mainly of fine-grained sand. Date of 5,190 years BP (Kramarska, 1998) documents transgression of the Littorina Sea in the area of the Odra Bank.

In the western part of the southern Baltic Sea (Fig. 2), in the sea sands of the profiles from the area of Dziwnów (R-10-P, R-12-P, R-20-P, R-22-P, R-23-P i R-24-P) and Mrzezyno (9, 66, 67, 71, 74) the presence of marine ostracods such as: *Cyprideis torosa*, *Cytheromorpha fuscata* and *Loxoconcha elliptica* (Table 2A, B) was on record. This may prove the existence of the lagoon, separated with the mainland from the sea reservoir and periodically powered by salty waters (Krzymińska, Przezdziecki, 2001).

In the borehole 4T (Fig. 2) in organic alluvia underlain with peat layer which floor was dated for 6,480 ±60 years BP, and ceiling for 6,210 ±60 years BP (Dobracki, Zachowicz 1997) and in the sea sand of the cores (1L, 4L, 2T, 1N) (Fig. 2), *Cyprideis torosa* (Table 2A, B) numerously occured.

In the central area, the profiles Jamno 3/5, Bukowo (3/7, 4A/19, 3/19) and Kopań 4/21 (Fig. 3), holeuryhaline *Cyprideis torosa* (Table 2C) also appeared.

Above the peat in sediments of the Mielno profiles (9/5, 20, 23, 24 and 25) (Fig. 3) *Cyprideis torosa* appeared as the only species of Ostracoda (Table 2C). In Mielno 23 and 25, the age of this layer of peat was radiocarbon dated for 7,370 ±50 years BP and 7,090 ±40 years BP.

Similarly, in profile Łazy 1/6, where *Cyprideis torosa* can document the fauna of the Atlantic period.

The disappearance of freshwater species and occurrence of marine brackish species in sediments of the middle and late Holocene has also been documented in the eastern area.

In the area of the Vistula Lagoon (Fig. 4) fauna appeared only in the bottom and the top part of each profile (ZW1, ZW2, ZW3, ZW4, ZW5, ZW6, ZW8, ZW10, ZW12, ZW13, ZW15). They were marine euryhaline species: *Cyprideis torosa*, *Cytheromorpha fuscata* and *Semicytherura nigrescens*. In the Holocene sediments of the Vistula Spit (core sites Piaski 1, 2 and Krynica 3) occurred only *Cyprideis torosa* (Table 2E).

Similar succession patterns were documented in the Gulf of Gdańsk by Krzymińska and Namiotko (2012). Atlantic period was marked here by the influence of the Littorina Sea about 8,750 years BP. Halophilous and euryhaline species occurred such as: *Cyprideis torosa* and *Cytheromorpha fuscata*. In the muddy sands of WB7 profile (Fig. 4) dated for 6,720 years BP (Krzymińska, Przezdziecki, 2010) and in the muddy sands of the Boreal period in the profiles R4/82 and R6/82 only *Cyprideis torosa* and *Cytheromorpha fuscata* occured.

To sum up, in the middle and late Holocene sediments of the southern Baltic Sea only five brackish-marinespecies in total were found: *Cyprideis torosa*, *Cytheromorpha fuscata*, *Cytherura gibba*, *Semicytherura nigrescens* and *Loxoconcha elliptica* but only the first one occured commonly and abundantly. *Cytheromorpha fuscata* was found in five western area profiles and 10 profiles of the eastern area, while the remaining three species appeared only at one site each (Table 2). All these five species occur in our Baltic also today (Sywula, Pietrzeniuk, 1989) and they are euryhaline species which have a high tolerance to salinity changes, typical of boreal climate zone (Frenzel *et al*., 2010).

CONCLUDING REMARKS (Fig. 8)

Studied sediment sequences of the Late Glacial and early Holocene in the southern Baltic Sea region, including fauna, were represented by lacustrine-marsh peats and muds and also by delta and lagoon sands. The first phase of existence of water reservoirs was characterized by the sediments with lacustrine fauna typical for the cold climate which corresponds to the phase of the Baltic Ice Lake.

The sediments dated for the period from 14,060 to 12,010 years BP in the western part of the southern Baltic Sea (Odra Bank area and the Pomeranian Bay), for 9,885 years BP in the central part (Central Coast) and from 12,200 to 9,220 years BP in the eastern part (Gulf of Gdańsk) characterized by the presence of species such as: *Fabaeformiscndona levanderi*, *Candona candida*, *C. neglecta*, *Cytherissa lacustris*, *Limnocythere inopinata*, *Limnocytherina sanctipatricii*, *Cyclocypris ovum*, *C. laevis*, *Herpetocypris reptans*, *Ilyocypris decipiens*. This group tolerating cold climate conditions, indicates lacustrine sedimentation. The literature describes groups of such environmental requirements, occurring in local inland reservoirs in Niechorze (Kopczyńska-Lamparska *et al*., 1984) and between Ustka and the mouth of the Orzechowski Stream (Brodniewicz, 1979).

The phase of the Littorina Sea in the western part of the southern Baltic Sea marked from 8,090 years BP to 5,190 years BP. In the central part, the Atlantic period was marked by overgrowing of coastal reservoirs, which began in the period 8,655–7,090 years BP (boreal and atlantic peat layers) and continued to 5,415 years BP (Dobracki, Zachowicz, 1997; Kramarska, 1998). These reservoirs had only a short-lived connection with the sea (infusions of saline waters) as evidenced by the presence of numerous *Cyprideis torosa*, *Cytheromorpha fuscata* or *Loxoconcha elliptica*.

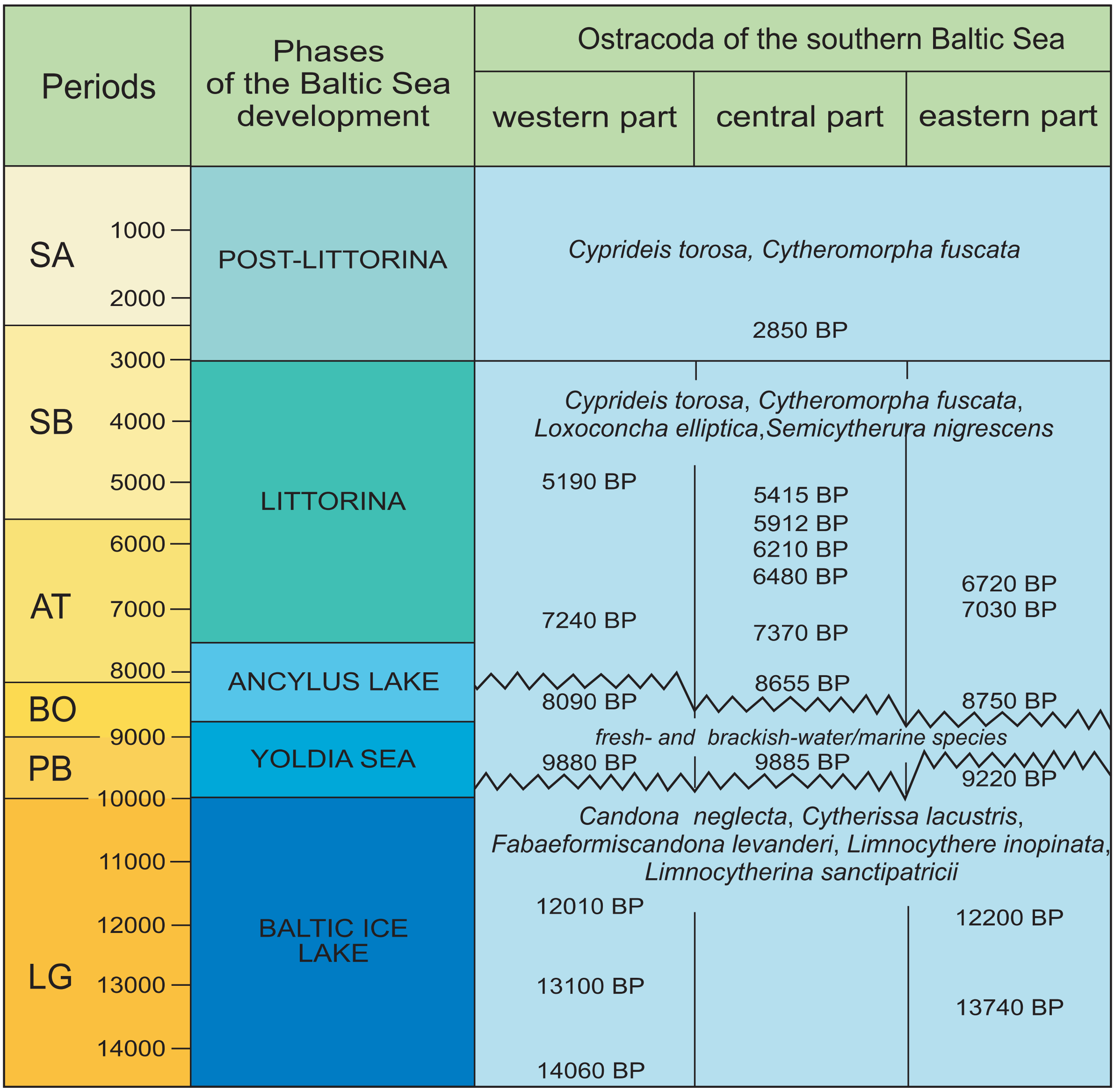


Fig. 8. Correlation between the succession of the ostracod palaeoassemblages and main Quaternary stratigraphic units (periods after Mangerud *et al*., 1974, developmental phases after Ignatius *et al*., 1981) of of the southern Baltic Sea

LG – Late Glacial, PB – Preboreal, BO – Boreal, AT – Atlantic, SB – Subboreal, SA – Subatlantic; radiocarbon dates according to the Marine Geology Branch of the Polish Geological Institute – National Research Institute

The transgression of the Littorina Sea, resulting in the formation of the modern Baltic Sea, especially heavily affected the southern coast of the basin. The individual lacustrine reservoirs were converted by the moving southwards in abrasive way shoreline into a shallow sea bays or reservoirs with periodic connections with the sea (2,850 years BP).

CONCLUSION

1. During the Late Glacial and Preboreal period, in the areas of the Pomeranian Bay, Central Coast and the Gulf of Gdańsk, freshwater fauna appeared (*Candona candida*, *C. neglecta*, *Cytherissa lacustris*, *Darwinula stevensoni*, *Limnocythere inopinata*, *Limnocytherina sanctipatricii*), which indicates the lacustrine conditions of sedimentation.

2. In the Boreal period, shallow-water part of the southern Baltic Sea was covered with lakes. Littorina transgression progressed gradually, slowly extending to the whole of the southern Baltic Sea. This is supported by the presence of marine fauna in the sediments (mainly *Cyprideis torosa*, *Cytheromorpha fuscata*).

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APPENDIX

SYSTEMATIC CHECKLISTS OF THE KNOWN OSTRACOD SPECIES LIVING IN POLISH COASTAL WATERS

In toal *ca.* 8000 of recent and 25,000 of fossil species belonging to the class Ostracoda have been described worldwide (Horne *et al*., 2002). 129 species have been found living in the Baltic Sea (Frenzel *et al*., 2010). In Poland thus far 154 species (both marine and non-marine) have been recorded (Namiotko, 2008), of which 49 species (14 marine and 35 fresh- and/or brackishwater species) known from the Polish part of the Balic Sea are included in the present checklist according to Namiotko (in press). The ostracods recorded from the Polish maritime zones belong to 16 families representing one subclass Podocopa, one order Podocopida and three suborders: Cytherocopina, Cypridocopina and Darwinulocopina. Higher-level taxonomy follows Martens and Savatenalinton (2011) and Frenzel *et al*. (2010).

Class OSTRACODA Latreille, 1806

Subclass Podocopa G.W. Müller, 1894

Order **Podocopida** Sars, 1866

Suborder Cypridocopina Baird, 1845

Superfamily Cypridoidea Baird, 1845

Family Cyprididae Baird, 1845

Subfamily Cypridopsinae Kaufmann, 1900

Genus *Plesiocypridopsis* Rome, 1965

***P. newtoni* (Brady et Robertson, 1870)**

Genus *Potamocypris* Brady, 1870

***P. arcuata* (Sars, 1903)**

Genus *Sarscypridopsis* McKenzie, 1977

***S. aculeata* (Costa, 1847)**

Subfamily Cyprinotinae Bronshtein, 1947

Genus *Heterocypris* Claus, 1892

***H. salina* (Brady, 1868)**

Family Candonidae Kaufmann, 1900

Subfamily Candoninae Kaufmann, 1900

Tribe Candonini Kaufmann, 1900

Genus *Candona* Baird, 1845

***C. angulata* G.W. Müller, 1900**

***C. candida* (O.F. Müller, 1776)**

***C. neglecta* Sars, 1887**

Genus *Pseudocandona* Kaufmann, 1900

***P. compressa* (Koch, 1838)**

Subfamily Cyclocypridinae Kaufmann, 1900

Genus *Cyclocypris* Brady et Norman, 1889

***C. ovum* (Jurine, 1820)**

Genus *Cypria* Zenker, 1854

***C. ophtalmica* (Jurine, 1820)**

Genus *Physocypria* Vavra, 1898

***Ph. kraepelini* G.W. Müller, 1900**

Family Ilyocyprididae Kaufmann, 1900

Subfamily Ilyocypridinae Kaufmann, 1900

Genus *Ilyocypris* Brady et Norman, 1889

***I. decipiens* Masi, 1905**

Superfamily Darwinuloidea Brady et Robertson, 1885

Family Darwinulidae Brady et Robertson, 1885

Genus *Darwinula* Brady et Robertson, 1885

***D. stevensoni* (Brady et Robertson, 1870)**

Superfamily Cytheroidea Baird, 1850

Family Bythocytheridae Sars, 1866

Genus *Jonesia* Brady, 1866

***J. acuminata* (Sars, 1866)**

[= *Jonesia simplex* (Norman, 1865)]

Family Cytheridae Baird, 1850

Genus *Palmenella* Hirschmann, 1916

***P. limicola* (Norman, 1865)**

Family Cytherideidae Sars, 1925

Subfamily Cytherideinae Sars, 1925

Genus *Cyprideis* Jones, 1857

***C. torosa* (Jones, 1850)**

Genus *Cytherissa* Sars, 1925

***C. lacustris* (Sars, 1863)**

Genus *Heterocyprideis* Elofson, 1941

***H. sorbyana* (Jones, 1857)**

Genus *Paracyprideis* Klie, 1929

***P. fennica* (Hirschmann, 1909)**

Genus *Sarsicytheridea* Athersuch, 1982

***S. bradii* (Norman, 1865)**

[= *Eucytheridea bairdii* (Sars, 1866)]

***S. punctillata* (Brady, 1865)**

[= *Eucytheridea punctillata* (Brady, 1865)]

Family Cytheruridae G.W. Müller, 1894

Subfamily Cytheropterinae Hanai, 1957

Genus *Cytheropteron* Sars, 1866

***C. latissimum* (Norman, 1865)**

Genus *Cytherura* Sars, 1866

***C. fulva* Brady et Robertson, 1874**

***C. gibba* (O.F. Müller, 1785)**

Genus *Microcytherura* G.W. Müller, 1894

***M. affinis* Klie, 1938**

Genus *Semicytherura* Wagner, 1957

***S. nigrescens* (Baird, 1838)**
***S. sella* (Sars, 1866)**

Family Eucytheridae Puri, 1954

Genus *Eucythere* Brady, 1868

***E. argus* (Sars, 1866)**
[= *Eucythere undulata* Klie, 1929]

Family Leptocytheridae Hanai, 1957

Genus *Leptocythere* Sars, 1825

***L. baltica* Klie, 1929**
***L. castanea* (Sars, 1866)**
***L. lacertosa* (Hirschmann, 1912)**
***L. pellucida* (Baird, 1850)**
***L. porcellanea* (Brady, 1869)**
***L. psammophila* Guillaume, 1976**
***L. tenera* (Brady, 1868)**

Family Limnocytheridae Klie, 1938

Subfamily Limnocytherinae Klie, 1938

Tribe Limnocytherini Klie, 1938

Genus *Limnocythere* Brady, 1868

***L. inopinata* (Baird, 1843)**

Family Loxoconchidae Sars, 1925

Genus *Cytheromorpha* Hirschmann, 1909

***C. fuscata* (Brady, 1869)**

Genus *Elofsonia* Wagner, 1957

***E. baltica* (Hirschmann, 1909)**
***E. pusilla* (Brady et Robertson, 1870)**

Genus *Hirschmannia* Elofson, 1941

***H. viridis* (O.F. Müller, 1785)**

Genus *Loxoconcha* Sars, 1866

***L. elliptica* Brady, 1868**
***L. impressa* (Baird, 1850)**
***L. tamarindus* (Jones, 1857)**

Family Neocytherideidae Puri, 1957

Genus *Neocytherideis* Puri, 1952

***N. crenulata* (Klie, 1929)**

Family Paradoxostomatidae Brady et Norman, 1889

Genus *Cytherois* G.W. Müller, 1884

***C. arenicola* Klie, 1929**
***C. fischeri* (Sars, 1866)**

Genus *Paradoxostoma* Fischer, 1855

***P. variabile* (Baird, 1835)**

Family Trachyleberididae Sylvester-Bradley, 1948

Genus *Robertsonites* Swain, 1963

***R. tuberculatus* (Sars, 1866)**

Family Xestoleberididae Sars, 1866

Genus *Xestoleberis* Sars, 1866

***X. aurantia* (Baird, 1838)**

PLATES

PLATE I

Fig. 1. *Candona angulata* G.W. Müller, female left valve outer view (TLM)

Fig. 2. *Candona angulata* G.W. Müller, female right valve outer view (TLM)

Fig. 3. *Candona angulata* G.W. Müller, male left valve outer view (TLM)

Fig. 4. *Candona candida* (O.F. Müller), female right valve outer view (TLM)

Fig. 5. *Candona candida* (O.F. Müller), female left valve outer view (SEM)

Fig. 6. *Candona candida* (O.F. Müller), female right valve outer view (SEM)

Fig. 7. *Candona candida* (O.F. Müller), juvenile (stage A-3) right valve outer view (SEM)

Fig. 8. *Candona candida* (O.F. Müller), juvenile (stage A-2) right valve outer view (SEM)

Fig. 9. *Candona weltneri* Hartwig, adult left valve outer view (SEM)

Fig. 10. *Candona weltneri* Hartwig, adult left valve inner view (SEM)

Fig. 11. *Candona weltneri obtusa* G.W. Müller, adult left valve outer view (SEM)

Fig. 12. *Candona weltneri obtusa* G.W. Müller, adult right valve inner view (SEM)

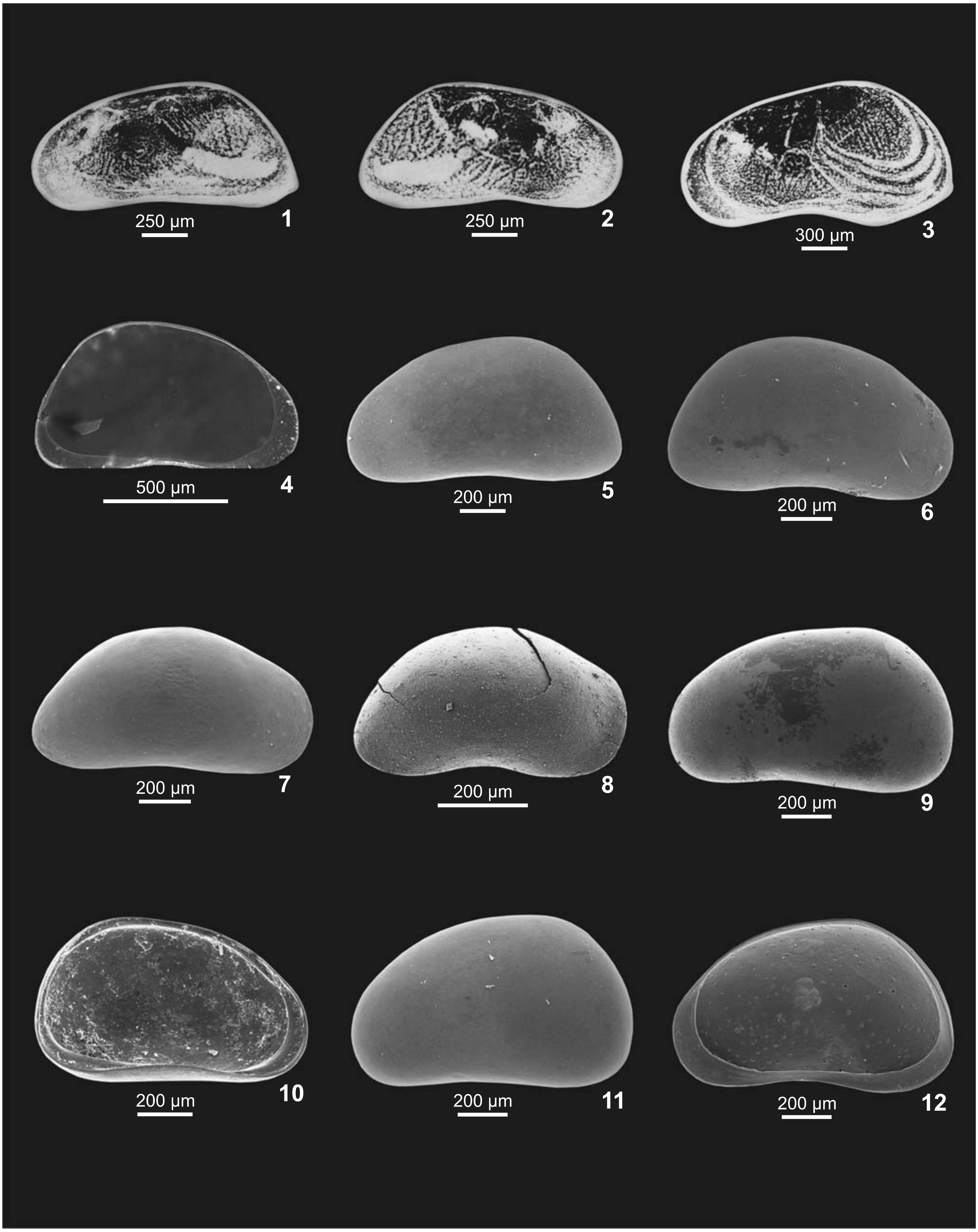
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PLATE II

Candona neglecta Sars

Fig. 1. Female right valve outer view (SEM)

Fig. 2. Male left valve inner view (SEM)

Fig. 3. Male left valve outer view (SEM)

Fig. 4. Male right valve outer view (SEM)

Fig. 5. Female left valve outer view (TLM)

Fig. 6. Female right valve outer view (TLM)

Fig. 7. Male left valve outer view (TLM)

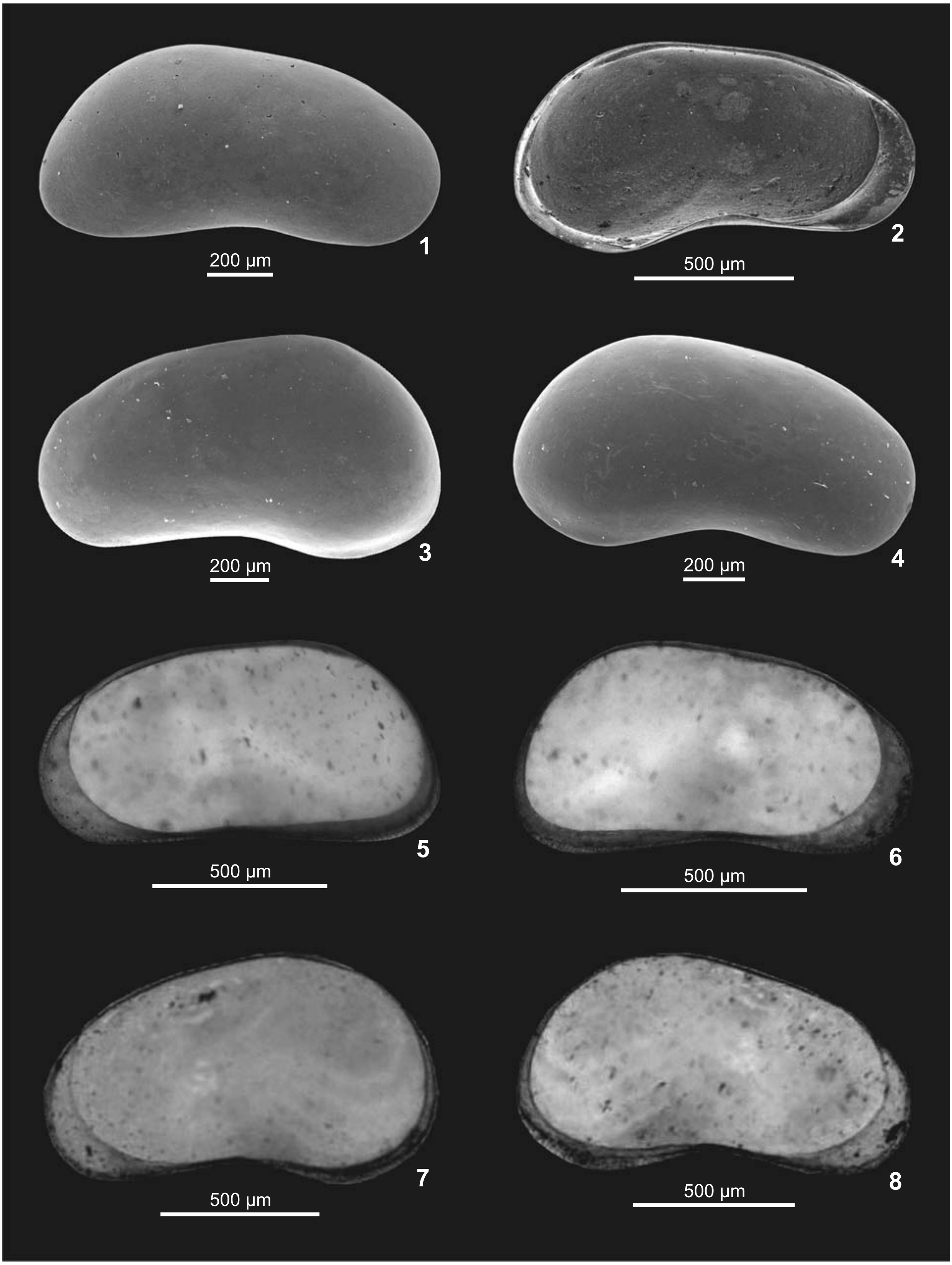
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PLATE III

Fig. 1. *Cyclocypris laevis* (O.F. Müller), adult left valve outer view (SEM)

Fig. 2. *Cyclocypris laevis* (O.F. Müller), adult carapace right side view (SEM)

Fig. 3. *Cyclocypris ovum* (Jurine), adult left valve outer view (SEM)

Fig. 4. *Cyclocypris ovum* (Jurine), adult right valve outer view (SEM)

Fig. 5. *Cyclocypris ovum* (Jurine), adult right valve inner view (SEM)

Fig. 6. *Cyclocypris ovum* (Jurine), adult left valve inner view (SEM)

Fig. 7. *Cyclocypris* cf. *serena* (Koch), adult right valve outer view (SEM)

Fig. 8. *Cyclocypris serena* (Koch), female left valve outer view (TLM)

Fig. 9. *Cypria ophtalmica* (Jurine), female left valve outer view (TLM)

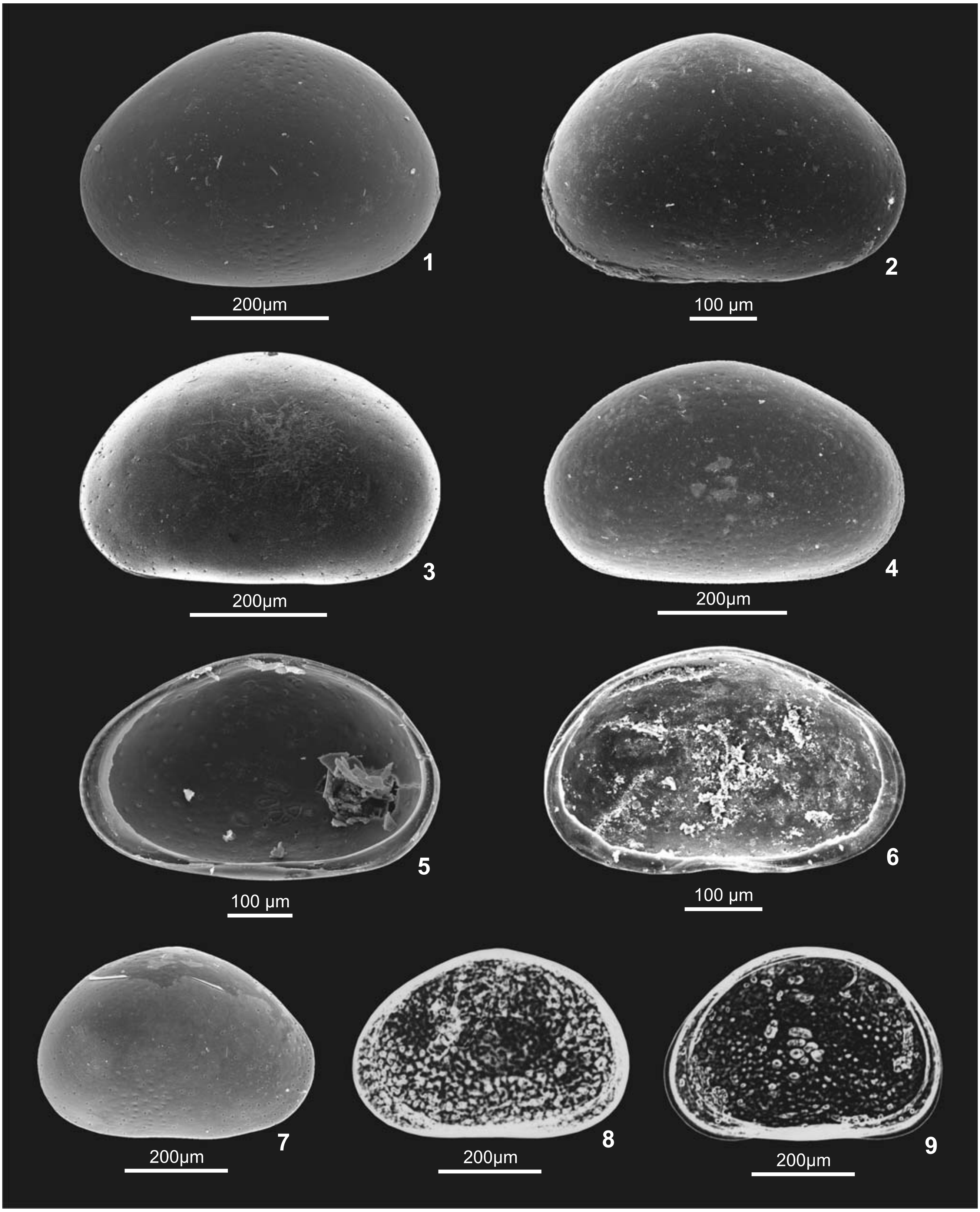
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PLATE IV

Cyprideis torosa (Jones)

Fig. 1. Female left valve outer view (SEM)

Fig. 2. Female right valve outer view (SEM)

Fig. 3. Female right valve inner view (SEM)

Fig. 4. Male left valve outer view (SEM)

Fig. 5. Male left valve inner view (SEM)

Fig. 6. Juvenile (stage A-1) carapace left side view (SEM)

Fig. 7. Female left valve outer view (TLM)

Fig. 8. Female right valve outer view (TLM)

Fig. 9. Male right valve outer view (TLM)

Fig. 10. Juvenile left valve outer view (TLM)

Fig. 11. Juvenile right valve outer view (TLM)

Fig. 12. Juvenile left valve outer view (TLM)

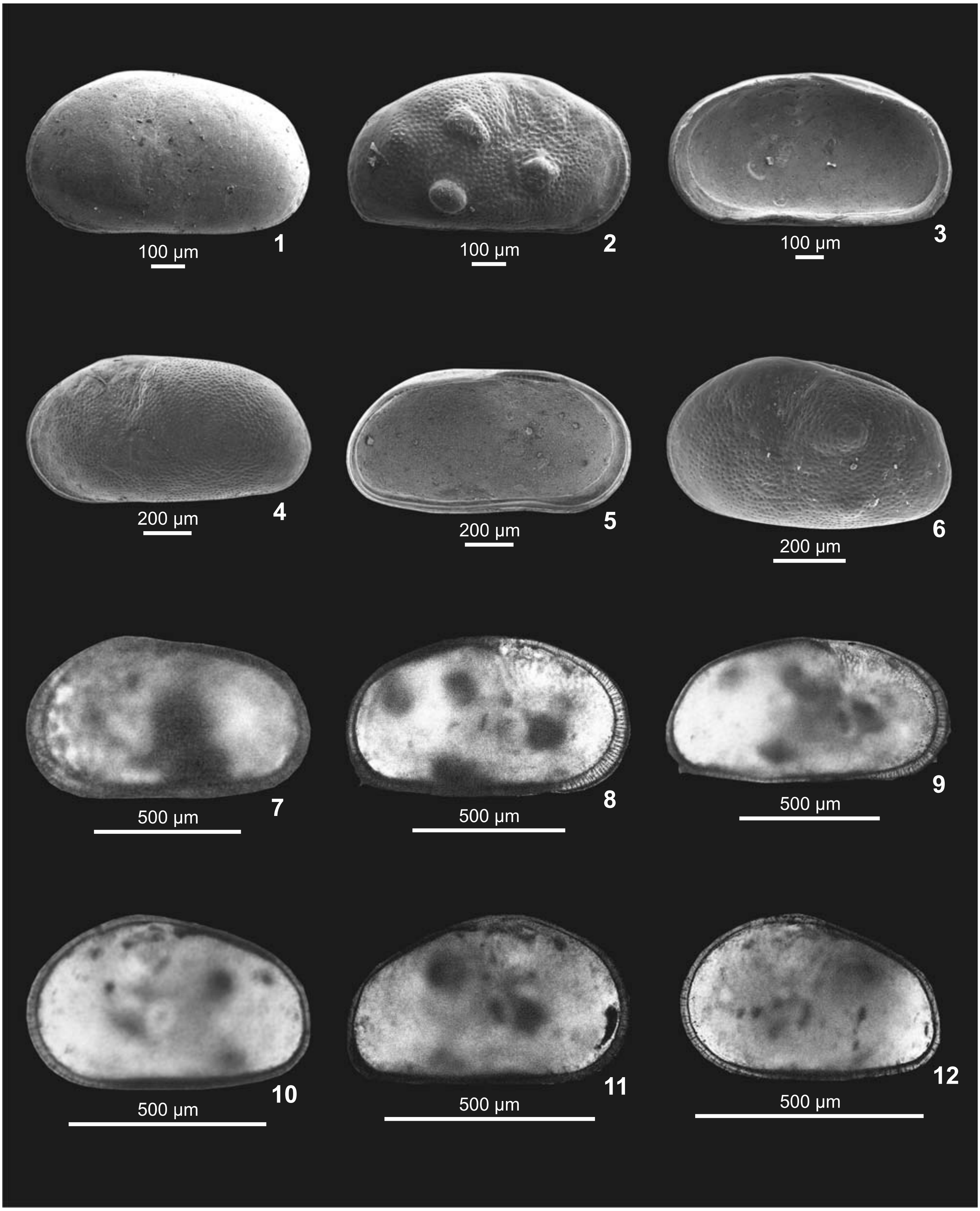
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PLATE V

Fig. 1. *Cypridopsis vidua* (O.F. Müller), female left valve outer view (TLM)

Fig. 2. *Cypridopsis vidua* (O.F. Müller), female right valve outer view (SEM)

Fig. 3. *Cytheromorpha fuscata* (Brady), female left valve inner view (SEM)

Fig. 4. *Cytheromorpha fuscata* (Brady), female right valve inner view (SEM)

Fig. 5 . *Cytheromorpha fuscata* (Brady), male left valve outer view (SEM)

Fig. 6. *Cytheromorpha fuscata* (Brady), male carapace right side view (SEM)

Fig. 7. *Darwinula stevensoni* (Brady et Robertson), female left valve outer view (SEM)

Fig. 8. *Darwinula stevensoni* (Brady et Robertson), female right valve outer view (SEM)

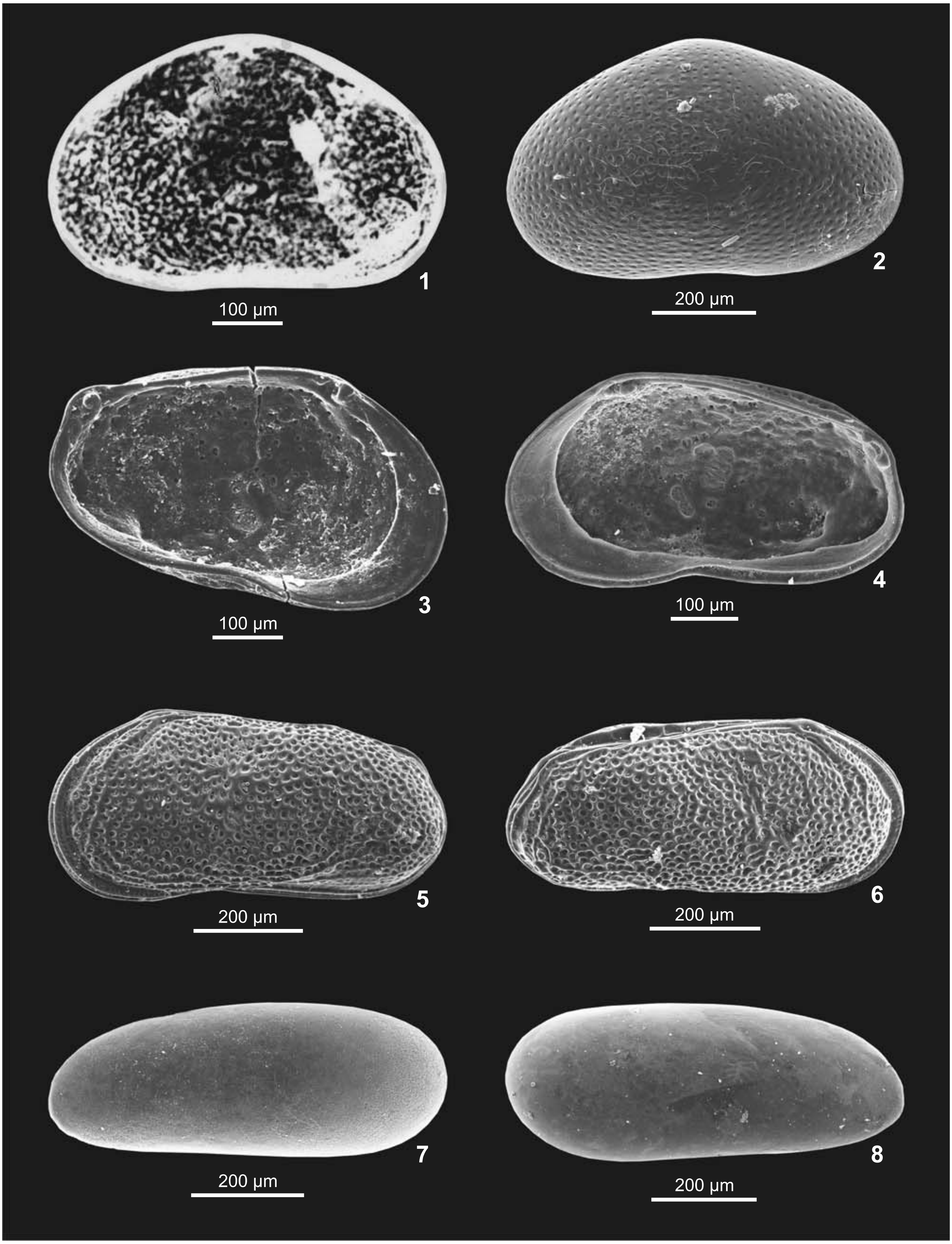
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PLATE VI

Cytherissa lacustris (Sars)

Fig. 1. Female left valve outer view, surface with indistinct reticulation and without medio-dorsal sulcus (SEM)

Fig. 2. Female left valve outer view, surface with prominent nodes (SEM)

Fig. 3. Female left valve outer view, surface with distinctly expressed reticulate ornamentation and prominent medio-dorsal sulcus (SEM)

Fig. 4. Female right valve outer view (SEM)

Fig. 5. Juvenile left valve outer view (SEM)

Fig. 6. Juvenile right valve outer view (SEM)

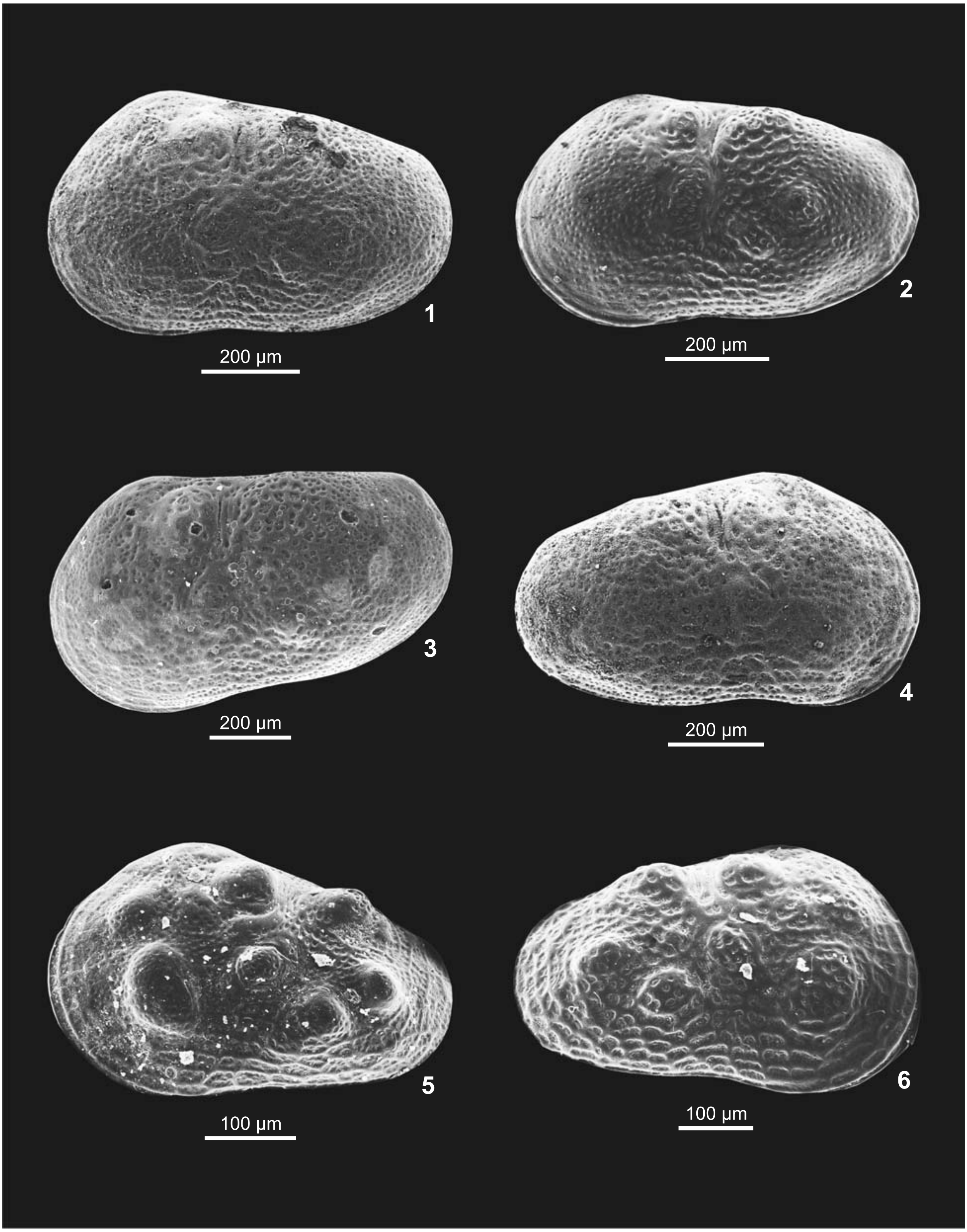
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PLATE VII

Fabaeformiscandona levanderi (Hirschmann)

Fig. 1. Female left valve outer view (SEM)

Fig. 2. Female right valve outer view (SEM)

Fig. 3. Male left valve outer view (SEM)

Fig. 4. Male right valve outer view (SEM)

Fig. 5. Female right valve inner view (SEM)

Fig. 6. Male left valve inner view (SEM)

Fig. 7. Female left valve outer view (TLM)

Fig. 8. Male right valve outer view (TLM)

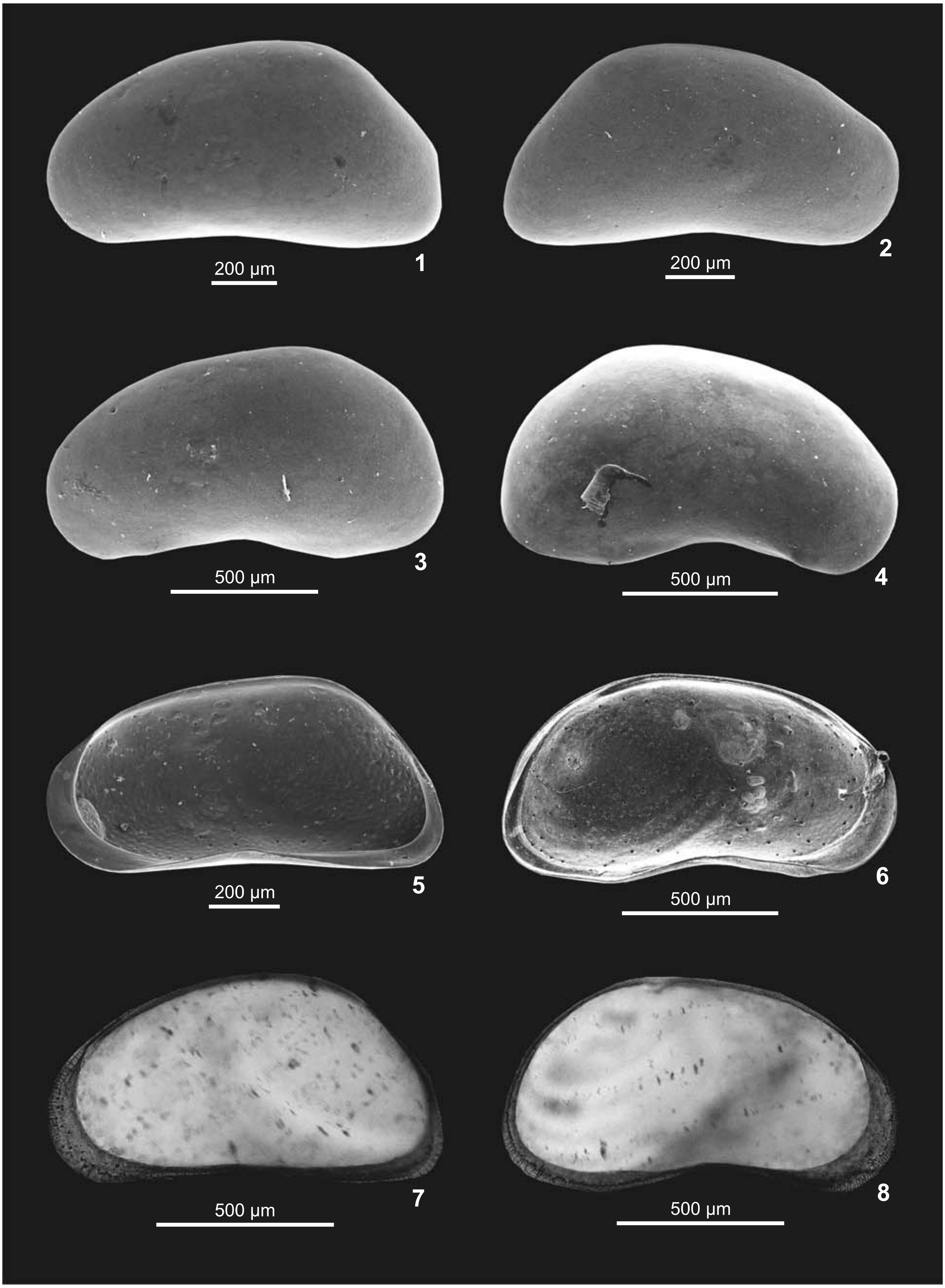
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PLATE VIII

Fig. 1. *Fabaeformiscandona caudata* (Kaufmann), female left valve outer view (SEM)

Fig. 2. *Fabaeformiscandona caudata* (Kaufmann), female right valve outer view (SEM)

Fig. 3. *Fabaeformiscandona protzi* (Hartwig), female carapace right side view (SEM)

Fig. 4. *Fabaeformiscandona protzi* (Hartwig), male left valve outer view (SEM)

Fig. 5. *Fabaeformiscandona protzi* (Hartwig), male left valve inner view (SEM)

Fig. 6. *Fabaeformiscandona protzi* (Hartwig), male right valve outer view (SEM)

Fig. 7. *Fabaeformiscandona protzi* (Hartwig), male right valve inner view (SEM)

Fig. 8. *Fabaeformiscandona protzi* (Hartwig), female right valve outer view (TLM)

Fig. 9. *Fabaeformiscandona protzi* (Hartwig), juvenile right valve outer view (TLM)

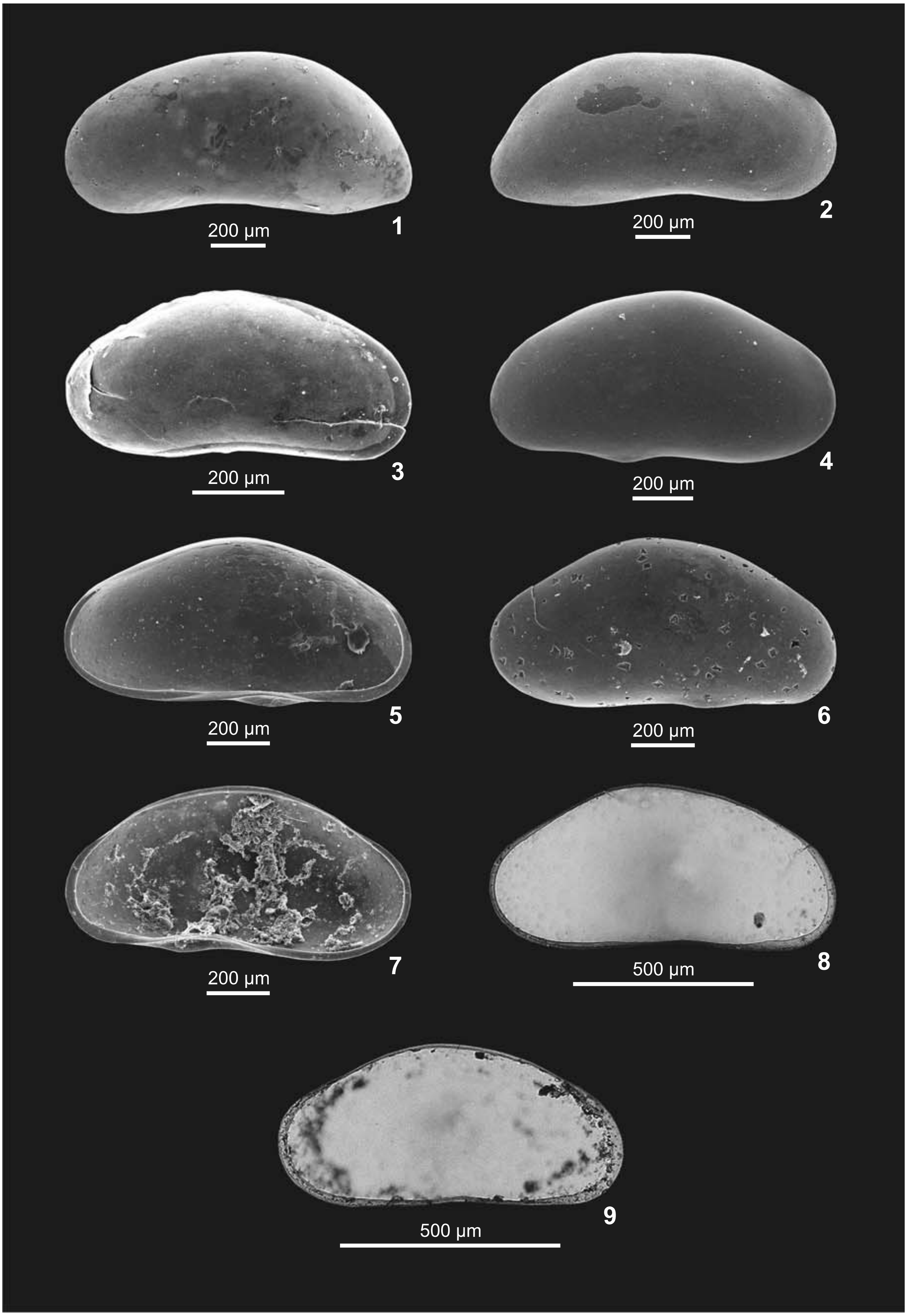
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PLATE IX

Fig. 1. *Fabaeformiscandona fabaeformis* (Fischer), female left valve outer view (SEM)

Fig. 2. *Fabaeformiscandona fabaeformis* (Fischer), female right valve outer view (SEM)

Fig. 3. *Fabaeformiscandona fabaeformis* (Fischer), female left valve outer view (TLM)

Fig. 4. *Fabaeformiscandona fabaeformis* (Fischer), male left valve outer view (TLM)

Fig. 5. *Fabaeformiscandona tricicatricosa* (Diebel et Pietrzeniuk), female left valve outer view (TLM)

Fig. 6. *Fabaeformiscandona tricicatricosa* (Diebel et Pietrzeniuk), female right valve outer view (SEM)

Fig. 7. *Fabaeformiscandona tricicatricosa* (Diebel et Pietrzeniuk), male left valve outer view (TLM)

Fig. 8. *Fabaeformiscandona tricicatricosa* (Diebel et Pietrzeniuk), male right valve outer view (TLM)

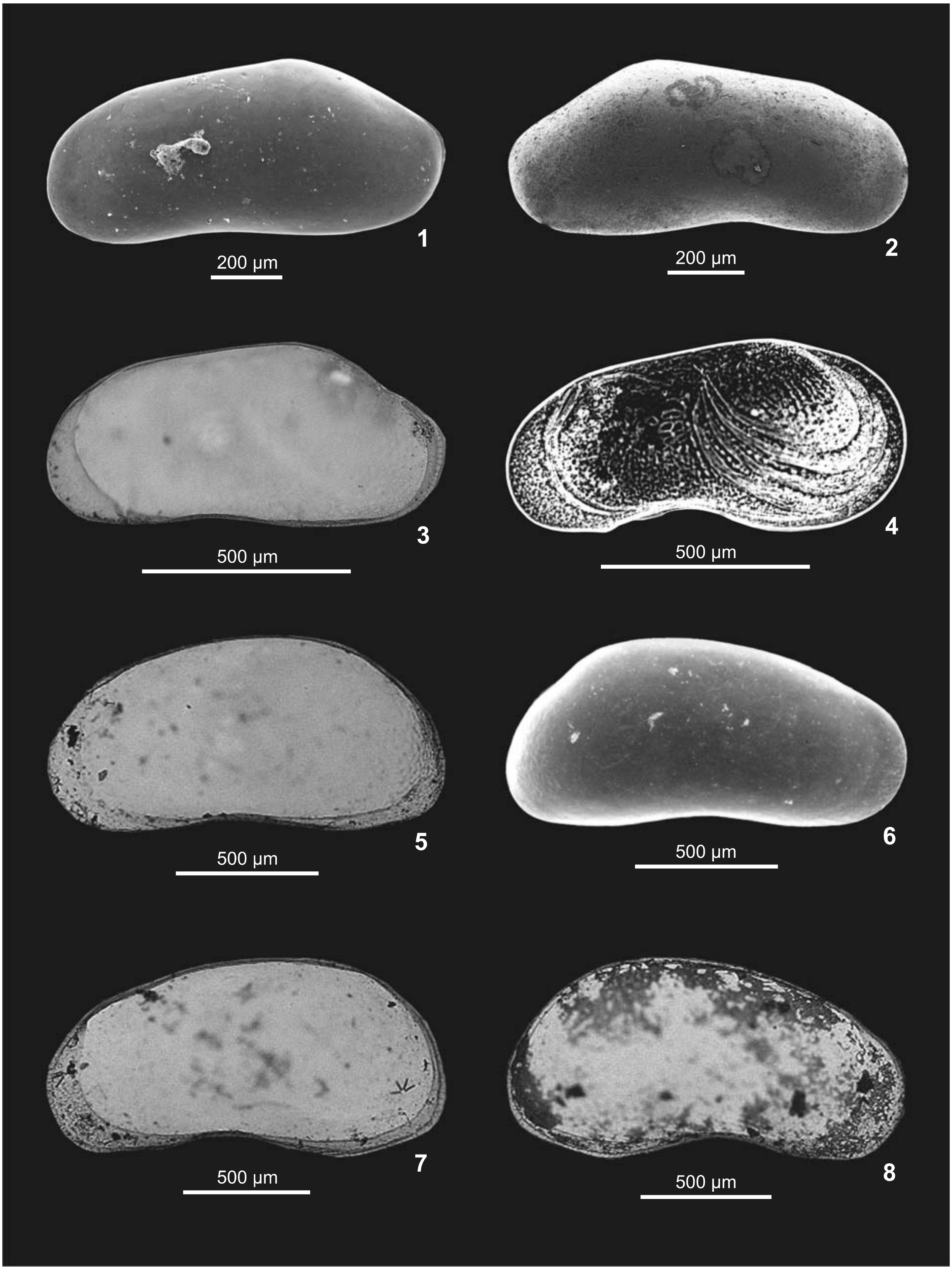
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PLATE X

Fig. 1. *Heterocypris salina* (Brady), female left valve outer view (TLM)

Fig. 2. *Heterocypris salina* (Brady), female right valve outer view (TLM)

Fig. 3. *Herpetocypris reptans* (Baird), female left valve outer view (SEM)

Fig. 4. *Herpetocypris reptans* (Baird), female right valve outer view (SEM)

Fig. 5. *Herpetocypris reptans* (Baird), female right valve inner view (SEM)

Fig. 6. *Herpetocypris reptans* (Baird), juvenile last stage right valve inner view (SEM)

Fig. 7. *Potamocypris similis* G.W. Müller, female carapace left side oblique view (SEM)

Fig. 8. *Potamocypris similis* G.W. Müller, female right valve outer view (TLM)

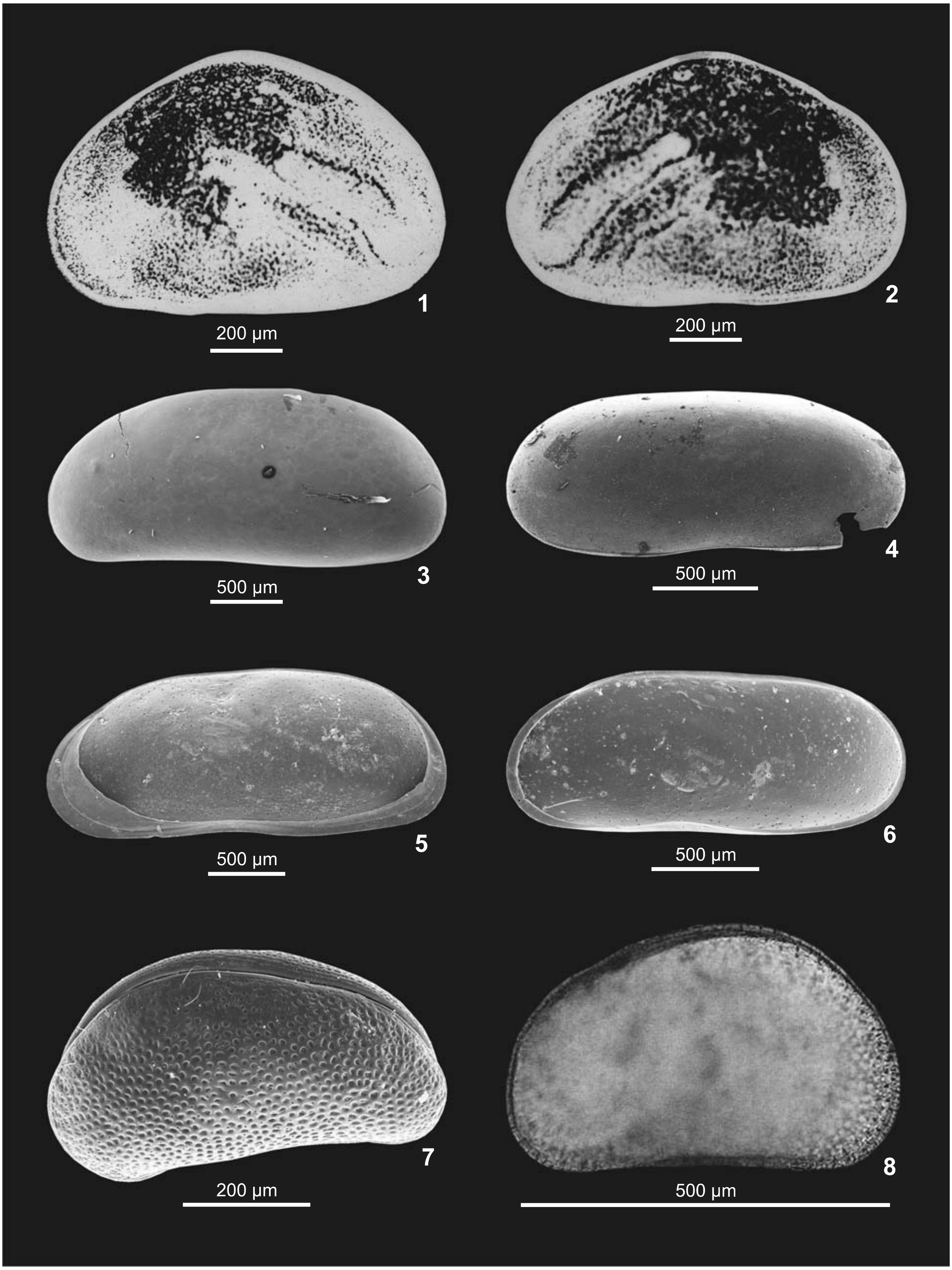
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PLATE XI

Fig. 1. *Ilyocypris gibba* (Ramdohr), female left valve outer view (TLM)

Fig. 2. *Ilyocypris gibba* (Ramdohr), female right valve outer view (TLM)

Fig. 3. *Ilyocypris bradyi* Sars, female left valve outer view (TLM)

Fig. 4. *Ilyocypris bradyi* Sars, female right valve outer view (TLM)

Fig. 5. *Ilyocypris* cf. *bradyi* Sars, adult left valve outer view (SEM)

Fig. 6. *Ilyocypris* cf. *bradyi* Sars, adult right valve outer view (SEM)

Fig. 7. *Ilyocypris decipiens* Masi, adult left valve outer view (SEM)

Fig. 8. *Ilyocypris decipiens* Masi, adult right valve outer view (SEM)

Fig. 9. *Ilyocypris decipiens* Masi, adult right valve inner view (SEM)

Fig. 10. *Ilyocypris decipiens* Masi, adult left valve inner view (SEM)

Fig. 11. *Ilyocypris decipiens* Masi, adult right valve outer oblique view (SEM)

Fig. 12. *Ilyocypris* cf. *lacustris* Kaufmann, adult left valve outer view (SEM)

Fig. 13. *Ilyocypris lacustris* Kaufmann, female left valve outer view (TLM)

Fig. 14. *Ilyocypris lacustris* Kaufmann, female right valve outer view (TLM)

Fig. 15. *Ilyocypris lacustris* Kaufmann, male left valve outer view (TLM)

Fig. 16. *Ilyocypris lacustris* Kaufmann, male right valve outer view (TLM)

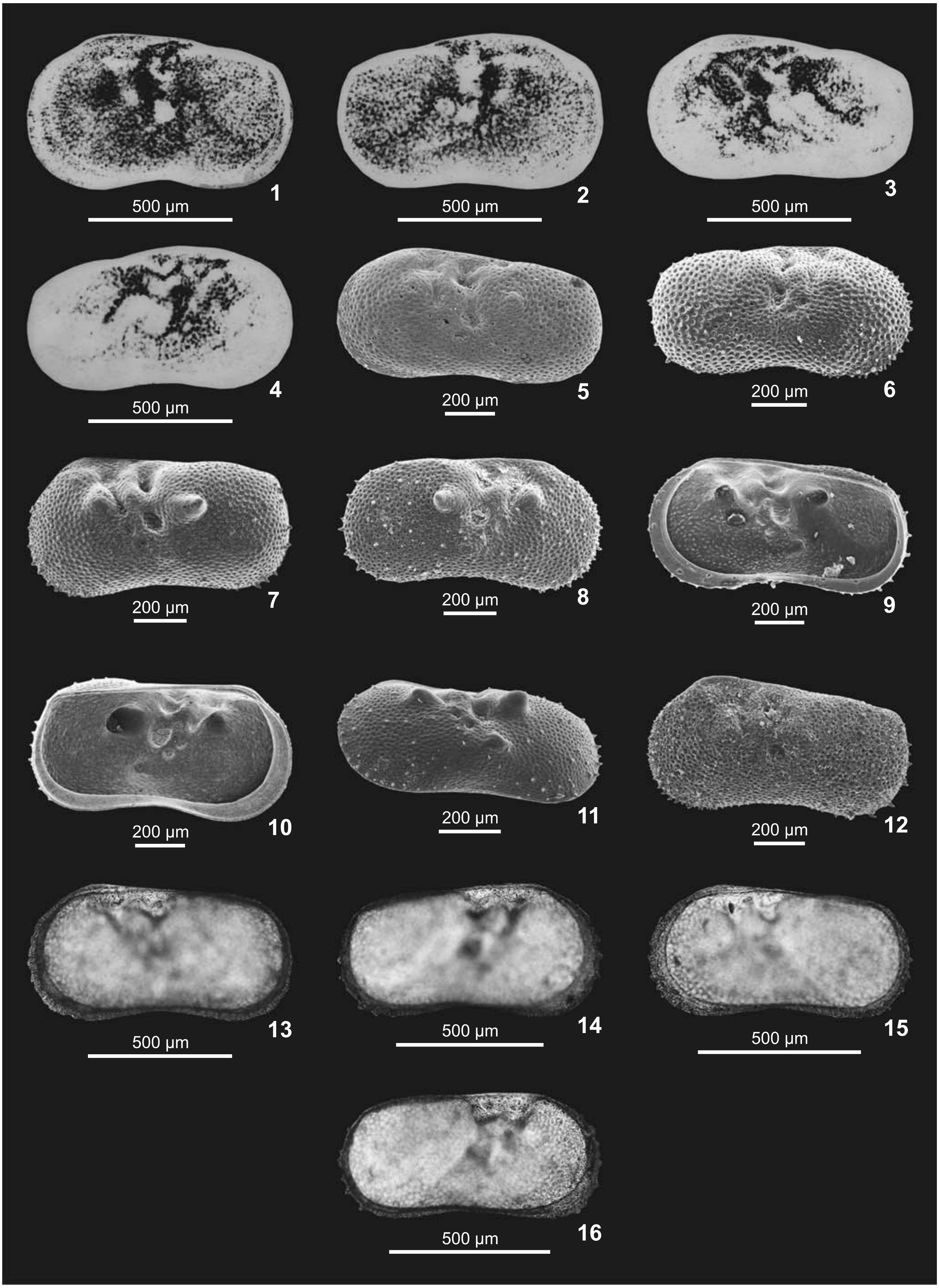
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PLATE XII

Fig. 1. *Limnocythere inopinata* (Baird), female carapace left side view (SEM)

Fig. 2. *Limnocythere inopinata* (Baird), female carapace right side view (SEM)

Fig. 3. *Limnocythere inopinata* (Baird), female right valve inner view (SEM)

Fig. 4. *Limnocytherina sanctipatricii* (Brady et Robertson), female left valve outer view (SEM)

Fig. 5. *Limnocytherina sanctipatricii* (Brady et Robertson), female right valve outer view (SEM)

Fig. 6. *Limnocytherina sanctipatricii* (Brady et Robertson), female right valve outer view (TLM)

Fig. 7. *Limnocytherina sanctipatricii* (Brady et Robertson), male left valve outer view (SEM)

Fig. 8. *Limnocytherina sanctipatricii* (Brady et Robertson), male right valve outer view (SEM)

Fig. 9. *Limnocytherina sanctipatricii* (Brady et Robertson), male right valve outer view (TLM)

Fig. 10. *Limnocytherina sanctipatricii* (Brady et Robertson), juvenile right valve outer view (TLM)

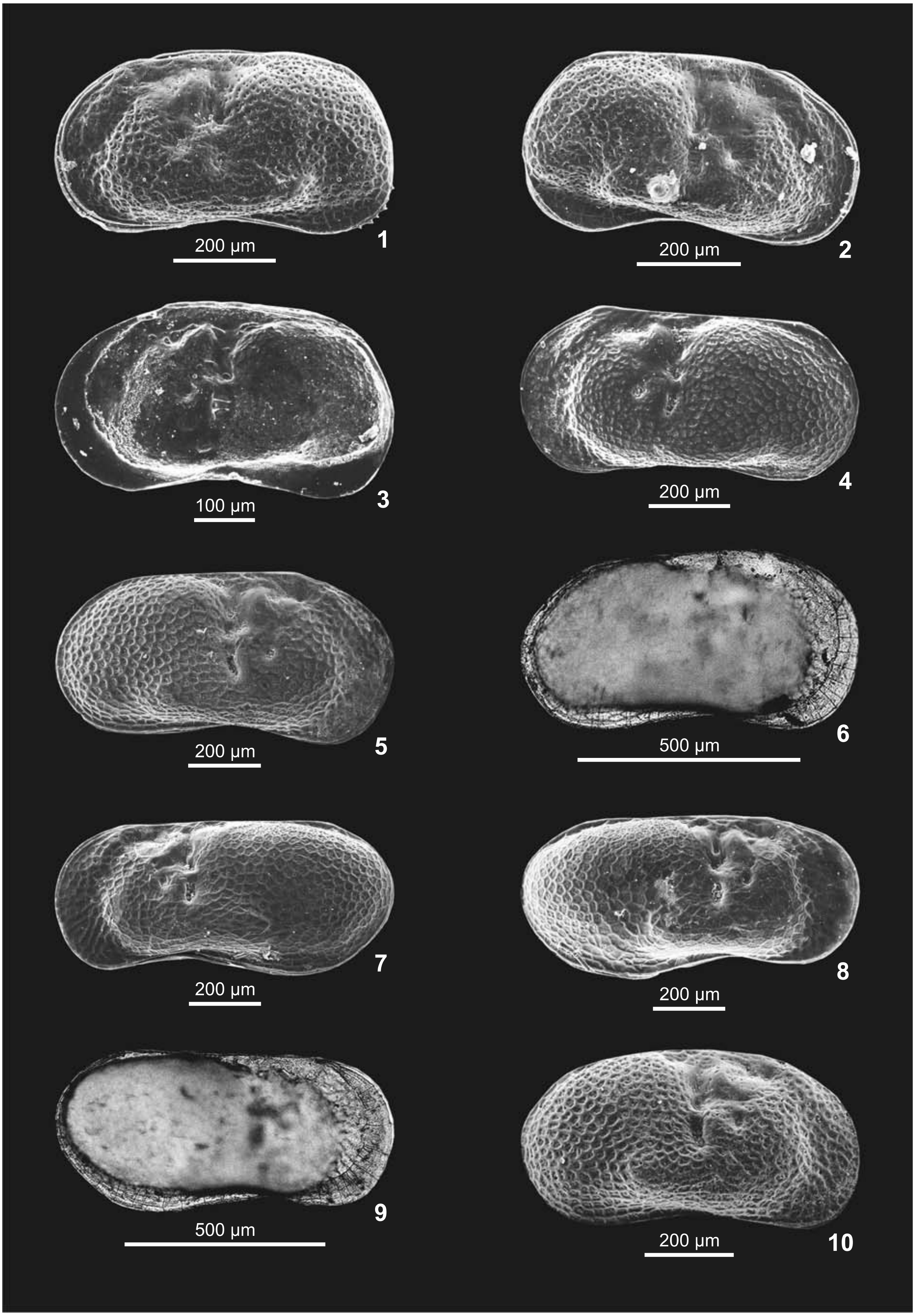
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PLATE XIII

Fig. 1. *Metacypris cordata* Brady et Robertson, male left valve outer view (TLM)

Fig. 2. *Metacypris cordata* Brady et Robertson, female left valve outer view (SEM)

Fig. 3. *Metacypris cordata* Brady et Robertson, female left valve outer view (SEM)

Fig. 4. *Metacypris cordata* Brady et Robertson, female left valve dorsal view (SEM)

Fig. 5. *Metacypris cordata* Brady et Robertson, female left valve inner view (SEM)

Fig. 6. *Metacypris cordata* Brady et Robertson, female left valve inner oblique view (SEM)

Fig. 7. *Pseudocandona compressa* (Koch), adult left valve outer view (SEM)

Fig. 8. *Pseudocandona compressa* (Koch), adult right valve outer view (SEM)

Fig. 9. *Pseudocandona compressa* (Koch), adult left valve inner view (SEM)

Fig. 10. *Sarscypridopsis aculeata* (Costa), female right valve inner view (SEM)

Fig. 11. *Sarscypridopsis* cf. *aculeata* (Costa), female right valve outer view (SEM)

Fig. 12. *Sarscypridopsis aculeata* (Costa), female left valve outer view (TLM)

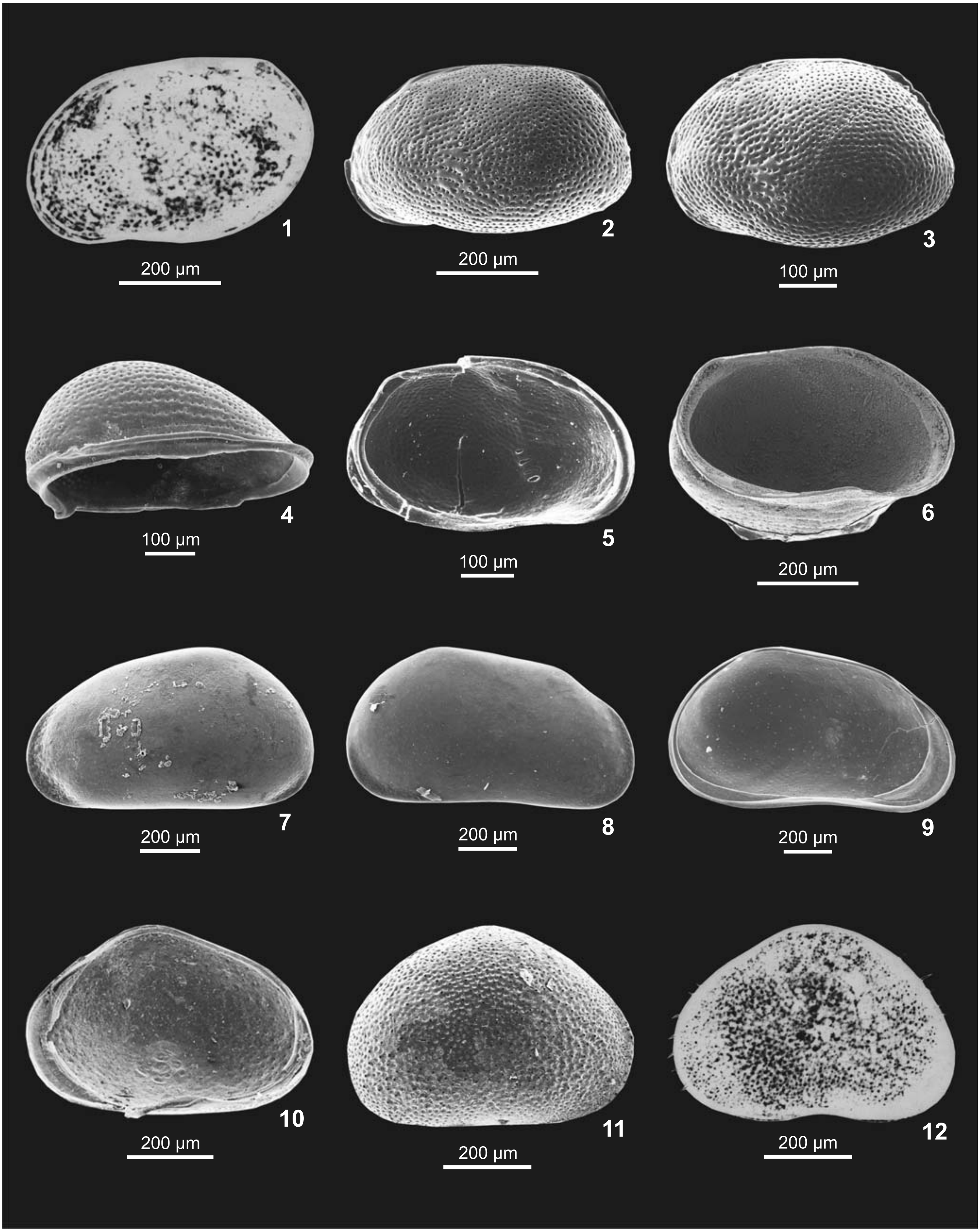
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PLATE XIV

Fig. 1. *Scottia browniana* (Jones), adult right valve inner view (SEM)

Fig. 2. *Scottia browniana* (Jones), adult right valve outer view (SEM)

Fig. 3. *Scottia browniana* (Jones), adult right valve inner view (SEM)

Fig. 4. *Scottia tumida* (Jones), adult left valve inner view (SEM)

Fig. 5. *Scottia tumida* (Jones), adult left valve outer view (SEM)

Fig. 6. *Scottia tumida* (Jones), adult carapace left side oblique view (SEM)

Fig. 7. *Cytherura gibba* (O.F. Müller), female left valve outer view (TLM)

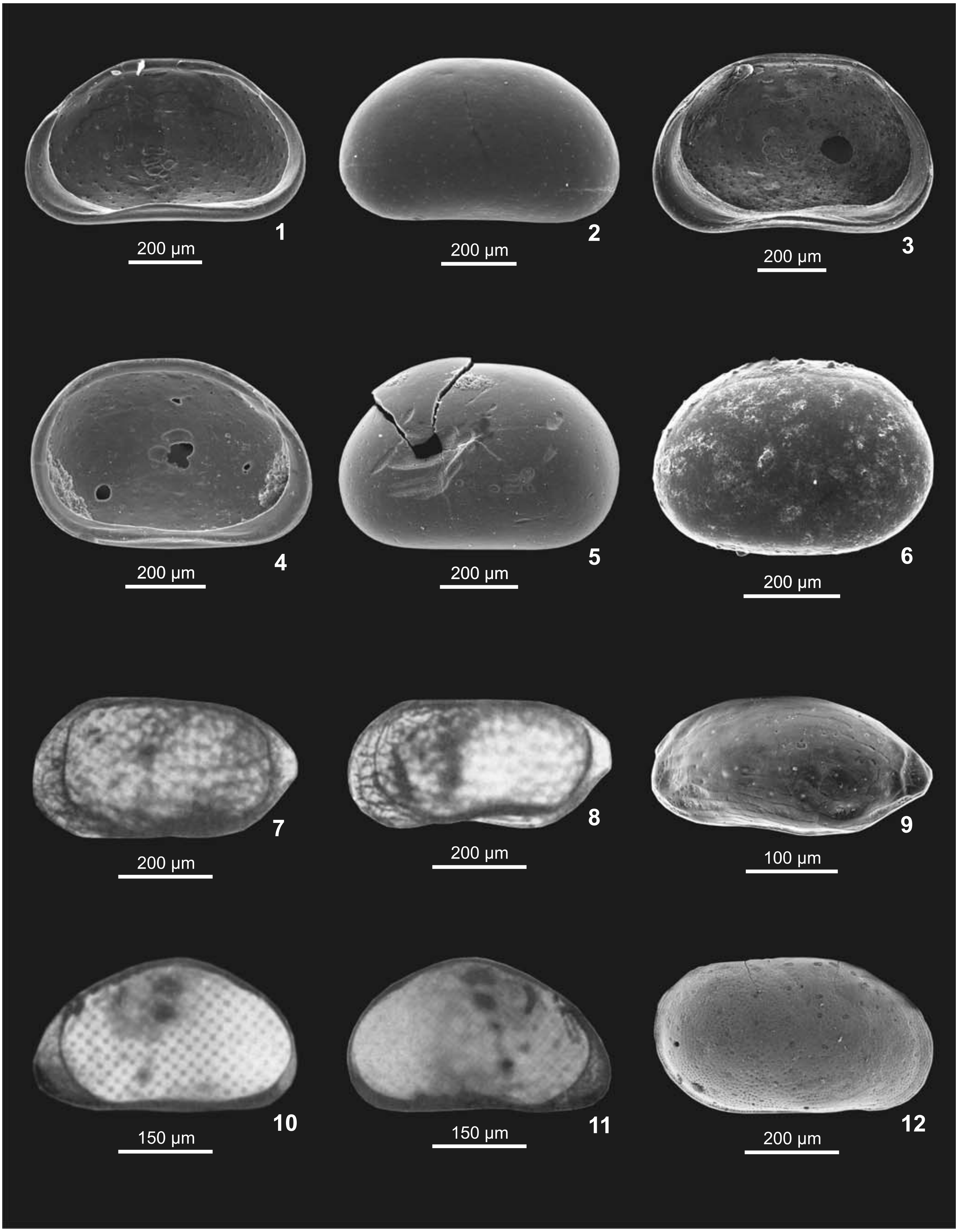
Fig. 8. *Cytherura gibba* (O.F. Müller), male left valve outer view (TLM)

Fig. 9. *Semicytherura nigrescens* (Baird), adult left valve outer view (SEM)

Fig. 10. *Xestoleberis aurantia* (Baird), female left valve outer view (TLM)

Fig. 11. *Xestoleberis aurantia* (Baird), female right valve outer view (TLM)

Fig. 12. *Loxoconcha elliptica* Brady, female right valve outer view (SEM)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