

## OSTRACODA FROM THE LOWER BADENIAN (MIDDLE MIOCENE) GRUND FORMATION (MOLASSE BASIN, LOWER AUSTRIA)

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**Abstract:** In the present study the ostracods from the Lower Badenian (Middle Miocene) Grund Formation of the Molasse Basin in Lower Austria are investigated. Most of the material comes from the type area of Grund. A total of 61 species could be differentiated within the Grund Formation. The following taxa dominate the faunal spectrum: Hemicytheridae (*Aurila*, *Graptocythere*, *Grinioneis*, *Nonurocythereis*, *Pokornyyella*, *Senesia*, *Tenedocythere*, *Urocythereis*), *Cyamocytheridea derii* (Zalányi, 1913), *Cytheridea acuminata* Bosquet, 1852 and *Cytheridea paracuminata* Kollmann, 1960. The ostracod assemblage reflects a shallow warm water environment with a water depth probably not exceeding 100 m. A part of the material is assumed to be re-deposited. Deep water elements are only represented by single specimens of *Kriithe*, *Henryhowella* and *Pseudocytherura*. The stratigraphic classification of an Early Badenian age for the Grund Formation by means of Foraminifera can be supported mainly by the occurrence of *Acanthocythereis hystrix* (Reuss, 1850). Many species are also known either from Karpatian or from younger Badenian sequences in Austria. Furthermore a comparison between the ostracod contents of the formations of the former so-called Grund Beds is given (Karpatian: Laa and Korneuburg Formations; Lower Badenian: Grund and Gaiendorf Formations). The occurrence of *Loxococoncha vaisonna* Carbonnel, 1969, *Aurila laryeensis* Moyes, 1965, *Callistocythere karpatiensis* Zorn, 1998 and *Neocyprideis* aff. *corbleuensis* Ducasse, 1995 in the Karpatian formations is most useful to separate them from the Badenian formations with the occurrence of *Acanthocythereis hystrix* (Reuss, 1850) and several species of Hemicytheridae.

**Key words:** Miocene, Badenian, Lower Austria, Molasse Basin, Grund Formation, biostratigraphy, paleoecology, Ostracoda.

### Introduction

Few publications deal with ostracods from the former so-called “Grunder Schichten” or Grund Beds and especially from the Grund Formation, which together with the coeval Gaiendorf Formation comprises the upper part of the “Grunder Schichten”. These two formations stratigraphically belong to the Lower Badenian (Roetzel et al. 1999; Rögl & Spezzaferri 2003; Spezzaferri 2004).

In his revision of the Miocene Hemicytheridae from Austria, Cernajsek (1971) described the following species from an old wine cellar at Grund: *Aurila angulata angulata* (Reuss, 1850), *A. cinctella* (Reuss, 1850), *A. galeata* (Reuss, 1850), *A. punctata* (Münster, 1830), *A. similis* (Reuss, 1850), *A. trigonella* (Reuss, 1850), *Urocythereis* sp., *Procythereis deformis* (Reuss, 1850) and *P. sulcatopunctatus* (Reuss, 1850). From black-brown clay marls at Braunsdorf he mentioned *Aurila galeata* (Reuss, 1850) and *A. haueri* (Reuss, 1850).

Preliminary results of the author's own studies (Zorn 1999) on material from the area of Grund, Guntersdorf and Galgenberg provided species of *Acanthocythereis*, *Cnestocythere*, *Cytheridea*, *Cyamocytheridea* and Hemicytheridae.

The present study on ostracods is part of a joint investigation of the fauna from the type area of the Grund Formation at Grund north of Hollabrunn in the Molasse Basin of Lower Austria (Fig. 1). The excavations of nine sections were done from 1998 to 1999 by the Institute of Paleontology of the University of Vienna. The studied sections are described in

Roetzel & Pervesler (2004). Sections G and F have been analysed for ostracods. Additionally, samples from a wine cellar at Windmühlberg 2 km NW of Grund and 900 m W of sections F–H (leg. F. Rögl, Museum of Natural History, Vienna) are included in the research. The geographical situation of the localities and sections is shown in Fig. 1. The stratigraphy and correlation of the Grund Formation are summarized in Ćorić et al. (2004).

A re-investigation of the material of Cernajsek (1971) from Grund (sample CER 154) has also been carried out. The ostracod specimens of the present study are deposited in the collections of the Geological Survey of Austria in Vienna under the collection number 2002/26 (with subnumbers).

### *The ostracod fauna of the Grund Formation and its paleoecological and biostratigraphic interpretation*

#### *Faunal spectrum*

The sections F and G at Grund with 13 samples each and 4 samples from Windmühlberg were taken into consideration concerning the ostracod studies. Several samples of sections F and G (F-12, G-7, G-8, G-10) lack ostracods, 2 samples (F-3, F-6) yield only indeterminable fragments or larvae. The ostracod content of the other samples varies from 1 to 17 species. In section F 22 species and in section G 32 species can be distinguished. Section G is not only more diverse in species but richer in specimens as well. Also the preservation of the fos-

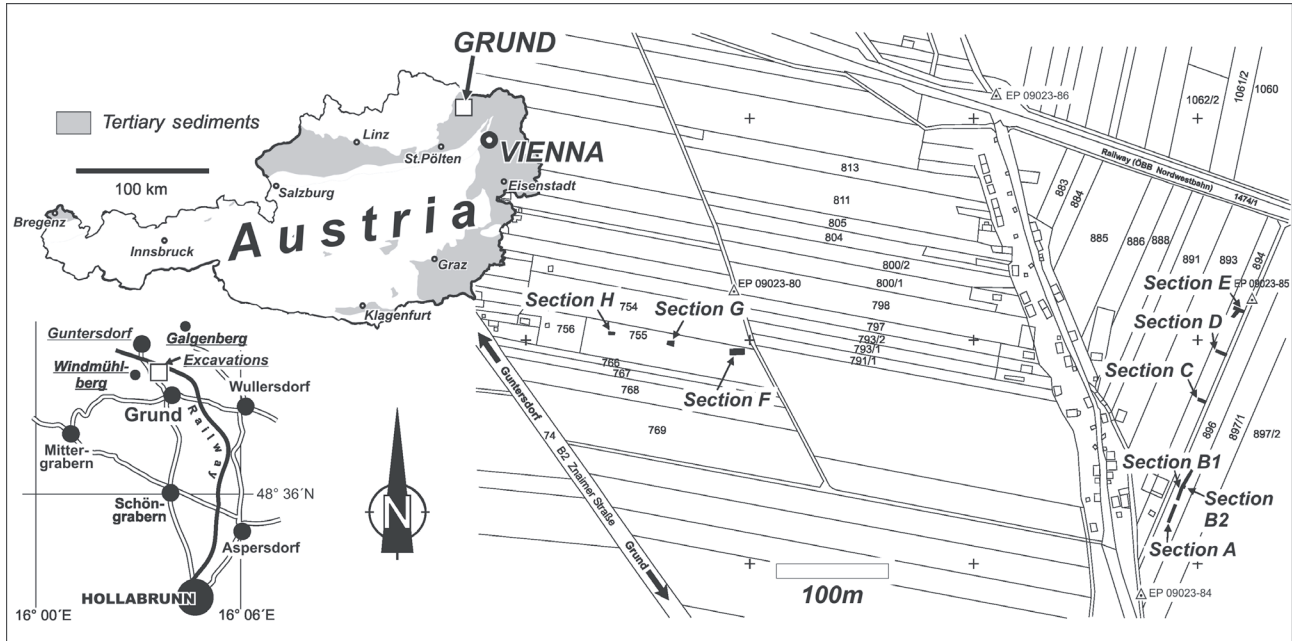


Fig. 1. Location map: Excavations at the type locality Grund and Windmühlberg wine cellars (inserted map).

sils is better in section G. A re-deposition of the bulk of specimens in both sections cannot be excluded because of the generally bad preservation. *Aurila angulata* (Reuss, 1850), *A. similis* (Reuss, 1850), *Cyamocytheridea derii* (Zalányi, 1913), *Cytheridea acuminata* Bosquet, 1852 and *Cytheridea paracuminata* Kollmann, 1960 are most common in both sections. In section G *Callistocythere daedalea* (Reuss, 1850), *Loxocorniculum hastatum* (Reuss, 1850) and *Senesia* ex gr. *vadaszi* (Zalányi, 1913) have to be mentioned.

Two samples from Windmühlberg are much more diverse (W-1: 35 species, W-3: 20 species) than the samples from the Grund sections and the preservation is better. Several species occur that have not been found at Grund: *Aurila trigonella* (Reuss, 1850), *Costa* aff. *edwardsi* (Roemer, 1838), *Costa tricolorata* (Reuss, 1850), *Cytheridea* sp., *Graptocythere polyp-tycha* (Reuss, 1850), *Hemicytherura gracilicosta* Ruggieri, 1953, *Loxoconcha* sp., *Pseudocytherura* sp., *Pterygocythereis calcarata* (Bosquet, 1852), *Semicytherura galea* Stancheva, 1962, *Semicytherura* sp. 1, *Tenedocythere sulcatopunctata* (Reuss, 1850) and *Xestoleberis* sp. 1 and 2 sensu Zorn 1998. The distribution of the ostracod species within the samples of the Grund sections G and F and from Windmühlberg can be seen in Table 1.

Cernajsek (1971) studied the Hemicytheridae from an old wine cellar at Grund. During the revision of this material (sample CER 154) it turned out that the sample yields 26 species, 5 of which are neither represented in sections F and G nor at Windmühlberg. These are: *Bairdia* sp., *Cytherella* sp., "*Phlyctenophora arcuata*" sensu Reuss, 1850, *Pontocythere* aff. *cribrosa* (Egger, 1858) and *Verrucocythereis verrucosa* (Reuss, 1850). Concerning the Hemicytheridae which are already mentioned in the introduction, *Urocythereis* sp. turned out to be *U. kostelensis* (Reuss, 1850). *Senesia cincitella* (Reuss, 1850) could not be re-identified.

Recently several old samples (leg. R. Weinhandl and R. Sieber, Geol. Survey Austria) from the Grund Formation (area Grund–Guntersdorf–Galgenberg) were studied in the scope of the mapping program of the Geological Survey of Austria (summary in Zorn 1999). Additional species which have not been found in any of the samples mentioned above are *Aurila haueri* (Reuss, 1850), *Flexus reussianus* Ruggieri, 1992, *Ghardagliaia pectinata* (Héjjas, 1894), *Heliocythere vejhonen-sis* (Procházka, 1893), *Henryhowella asperima* (Reuss, 1850) and *Konarocythere inflata* (Schneider, 1949). Summarizing the different investigations 61 species can be documented for the Grund Formation. They are listed in Table 2.

#### Paleoecology

The ostracod faunas of sections F and G reflect a shallow water environment. This corresponds well with the results on the molluscan assemblages in Zuschin et al. (2001, 2004) who estimate a shelf environment with a water depth less than 100 m by the shell beds geometry of the tempestites. Only one molluscan species was found in situ. Spezzaferri (2004) supposes a deposition on the outer shelf for section G based on foraminifers. A re-deposition is responsible for the Badenian shallow water species. The stated warm paleoclimate for section G on the basis of the foraminiferal research is supported by the occurrence of the warm water ostracod taxa *Acanthocythereis hystrix* (Reuss, 1850) and *Cytheretta*.

In the rich fauna of Windmühlberg elements of the deeper water occur. *Krithe* is an infraneritic to bathyal species and *Pseudocytherura* and *Pterygocythereis* are stated to be infraneritic (Morkhoven 1963). The latter genus is also present in sample 154 of Cernajsek (1971) from Grund. In an old sample from Galgenberg one specimen of the infraneritic species *Henryhowella asperima* (Reuss, 1850) could be identified.



**Table 2:** Distribution of the ostracod species within the formations of the former “Grunder Schichten”.

Ostracod species	Formations				Ostracod species	Formations			
	Laa Formation	Korneuburg Formation	Grund Formation	Gaiddorf Formation		Laa Formation	Korneuburg Formation	Grund Formation	Gaiddorf Formation
<i>Acanthocythereis hystrix</i> (Reuss, 1850)			x	x	<i>Krithe</i> cf. <i>papillosa</i> (Bosquet, 1852)				x
<i>Aurila angulata</i> (Reuss, 1850)			x		<i>Krithe</i> sp. 1	x			
<i>Aurila cicatricosa</i> (Reuss, 1850)			x	x	<i>Leguminocythereis martonfi</i> (Héjjas, 1894)				x
<i>Aurila galeata</i> (Reuss, 1850)			x	x	<i>Leptocythere</i> sp. 1 sensu Zorn, 1998		x		
<i>Aurila haueri</i> (Reuss, 1850)				x	<i>Loxococoncha punctatella</i> (Reuss, 1850)		x	x	x
<i>Aurila larieyensis</i> Moyes, 1965	x	x			<i>Loxococoncha vaisonna</i> Carbonnel, 1969	x	x		
<i>Aurila opaca</i> (Reuss, 1850)			x		<i>Loxococoncha</i> sp. 1 sensu Zorn, 1998		x	x	x
<i>Aurila</i> aff. <i>opaca</i> (Reuss, 1850)		x			<i>Loxococoncha</i> sp. 2 sensu Zorn, 1998		x		
<i>Aurila punctata</i> (Reuss, 1850)			x	x	<i>Loxococoncha</i> sp. 3 sensu Zorn, 1998		x		
<i>Aurila similis</i> (Reuss, 1850)			x	x	<i>Loxococoncha</i> sp.				x
Bairdiidae		x	x		<i>Loxocorniculum hastatum</i> (Reuss, 1850)		x	x	x
<i>Callistocythere canaliculata</i> (Reuss, 1850)			x	x	<i>Neocyprideis (Miocyprideis)</i> sp. indet.				x
<i>Callistocythere daedalea</i> (Reuss, 1850)	x	x	x		<i>Neocyprideis (M.)</i> aff. <i>corbleuensis</i> Ducasse, 1995	x	x		
<i>Callistocythere karpatisensis</i> Zorn, 1998	x	x			<i>Neocytherideis linearis</i> (Römer, 1838)	x	x		
Candonidae gen. et sp. indet.			x		<i>Neomonoceratina</i> ex gr. <i>helvetica</i> Oertli, 1958		x		x
<i>Carinivalva</i> aff. <i>neuhofenensis</i> (Witt, 1967)		x			<i>Nonurocythereis seminulum</i> (Seguenza, 1880)		x	x	
<i>Cnestocythere lamellicosta</i> Triebel, 1950			x	x	<i>Olimfalunia plicatula</i> (Reuss, 1850)	x	x	x	x
<i>Cnestocythere truncata</i> (Reuss, 1850)			x	x	<i>Olimfalunia spinulosa</i> (Reuss, 1850)		x	x	x
<i>Costa</i> cf. <i>batei</i> (Brady, 1866)			x		<i>Paracytheridea triquetra</i> (Reuss, 1850)		x	x	x
<i>Costa</i> aff. <i>edwardsi</i> (Römer, 1838)	x	x	x		<i>Parakrithe</i> sp.				x
<i>Costa tricostata</i> (Reuss, 1850)			x		“ <i>Phlyctenophora arcuata</i> ” sensu Reuss, 1850				x
<i>Cyamocytheridea derii</i> (Zalányi, 1913)	x	x	x	x	<i>Pokornyella deformis</i> (Reuss, 1850)				x
<i>Cyamocytheridea gracilis</i> Zorn, 1998		x			<i>Pontocythere</i> aff. <i>cribrosa</i> (Egger, 1858)		x	x	
<i>Cytherella</i> sp. 1 sensu Zorn, 1998			x		<i>Pontocythere</i> aff. <i>curvata</i> (Bosquet, 1852)				x
<i>Cytherella</i> sp.			x		<i>Pontocythere lithodomoides</i> (Bosquet, 1852)	x	x		
<i>Cytherelloidea jonesiana</i> (Bosquet, 1852)	x				<i>Pontocythere longa</i> (Reuss, 1850)				x
<i>Cytheretta ornata</i> (Héjjas, 1894)		x	x	x	<i>Pontocythere</i> sp. 1 sensu Zorn, 1998		x		
<i>Cytheridea acuminata</i> Bosquet, 1852			x	x	<i>Pseudocytherura</i> sp.				x
<i>Cytheridea paracuminata</i> Kollmann, 1960			x	x	<i>Pterygocythereis fimbriata</i> (Münster, 1830)	x			x
<i>Cytheridea</i> sp.				x	<i>Pterygocythereis calcarata</i> (Bosquet, 1852)		x	x	
<i>Cytheridea</i> sp. juv.	x				<i>Renicytherura (N.) textilis cornuta</i> (Brest., 1978)				x
<i>Cytherois</i> sp. 1 sensu Zorn, 1998	x	x			<i>Semicytherura galea</i> Stancheva, 1962				x
<i>Cytheropteron</i> sp.				x	<i>Semicytherura</i> aff. <i>inversa</i> (Seguenza, 1880)		x		
<i>Cytherura teiritzbergensis</i> Zorn, 1998			x		<i>Semicytherura</i> sp. 1 (this paper)				x
<i>Dorukella</i> sp. 1 sensu Zorn, 1998			x		<i>Semicytherura</i> sp. 2 (this paper)				x
<i>Flexus reussianus</i> Ruggieri, 1992				x	<i>Semicytherura</i> sp. 1 sensu Zorn, 1998		x		
<i>Ghardagliaia pectinata</i> (Héjjas, 1894)	x	x	x		<i>Semicytherura</i> sp. indet.	x			x
<i>Graptocythere polyptycha</i> (Reuss, 1850)			x	x	<i>Senesia trigonella</i> (Reuss, 1850)				x
<i>Graptocythere ungeri</i> (Reuss, 1850)			x	x	<i>Senesia</i> ex gr. <i>vadaszi</i> (Zalányi, 1913)	x	x	x	x
<i>Grinoneis haidingeri</i> (Reuss, 1850)			x		<i>Tenedocythere sulcatopunctata</i> (Reuss, 1850)				x
<i>Heliocythere leobendorfensis</i> Zorn, 1998			x		<i>Urocythereis kostelensis</i> (Reuss, 1850)				x
<i>Heliocythere vejhonensis</i> (Procházka, 1893)				x	<i>Verrucocythereis verrucosa</i> (Reuss, 1850)				x
<i>Hemicyprideis dacica</i> (Héjjas, 1894)				x	<i>Xestoleberis tumida</i> (Reuss, 1850)	x	x	x	x
<i>Hemicytherura</i> aff. <i>videns</i> (G.W. Müller, 1894)			x		<i>Xestoleberis</i> sp.				x
<i>Hemicytherura gracilicosta</i> Ruggieri, 1953				x	<i>Xestoleberis</i> sp. 1 sensu Zorn, 1998		x	x	
<i>Henryhowella asperrima</i> (Reuss, 1850)				x	<i>Xestoleberis</i> sp. 2 sensu Zorn, 1998		x	x	x
<i>Heterocythereis</i> aff. <i>albomaculata</i> (Baird, 1838)			x		<i>Xestoleberis</i> sp. 3 sensu Zorn, 1998		x		
<i>Konarocythere inflata</i> (Schneider, 1949)			x	x	x				

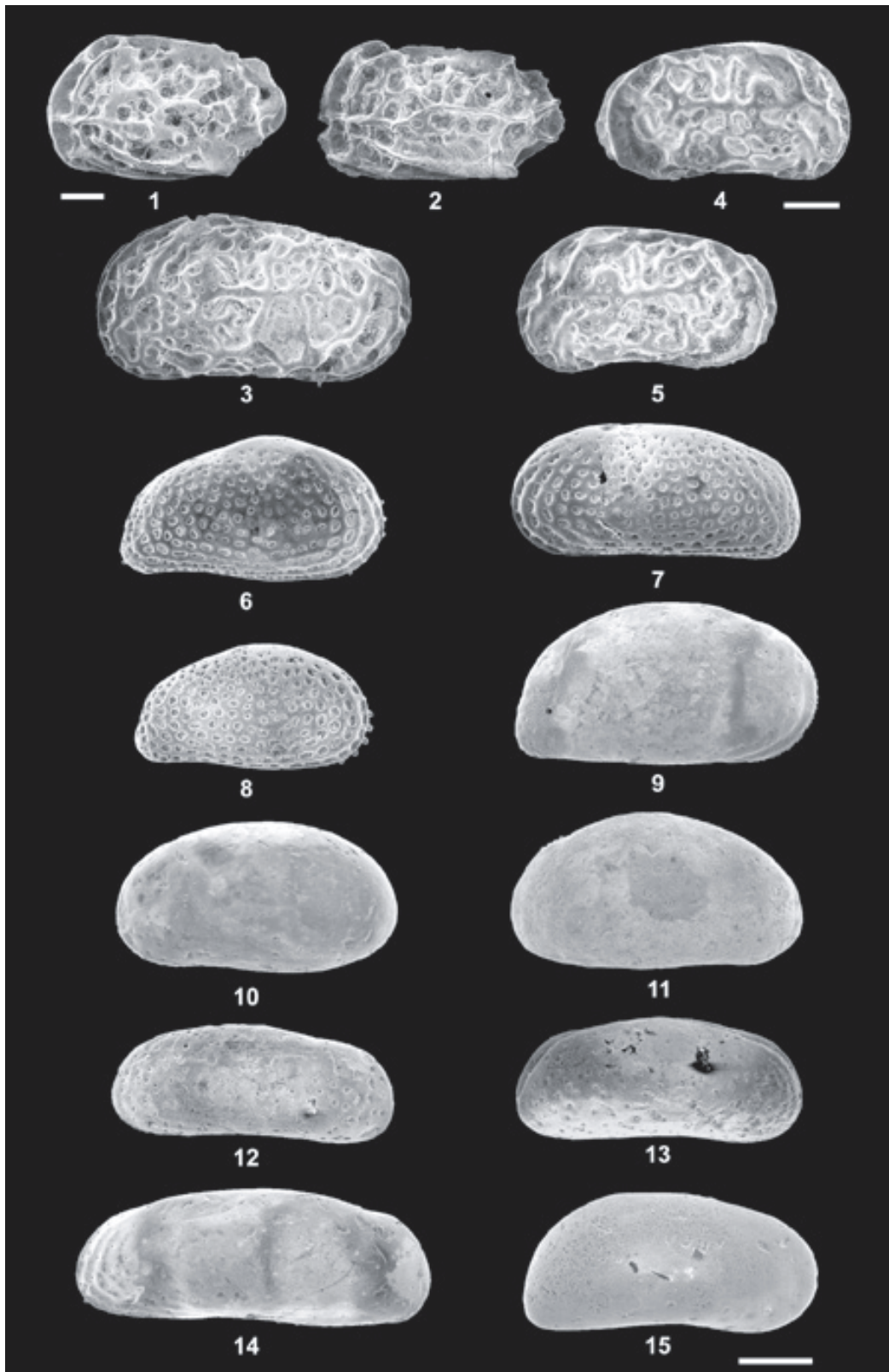
waters. A discussion of the biostratigraphical value of this species in Austria can be found in Zorn (2003). *Aurila similis* (Reuss, 1850) and *Renicytherura textilis cornuta* (Brestenská, 1978) are scarcely known in the Central Paratethys, but also seem to be restricted to the Lower Badenian.

The presence of the foraminifers *Praeorbulina glomerata circularis* (Samples F-6, G-6, G-9) and *Uvigerina macrocarinata* (Samples G-10) as well as *Bolboforma reticulata* in the Grund Formation allow a correlation with the Lower La-

genidae Zone of the Lower Badenian (Rögl et al. 2002; Spezzaferrri 2004).

#### Comparison between the ostracod faunas of the former “Grunder Schichten”

The former so-called Miocene “Grunder Schichten” or Grund Beds of the Molasse and Korneuburg Basin in Lower Austria are nowadays subdivided into four formations, two of which



**Fig. 2.** 1 — *Cnestocythere truncata* (Reuss, 1850), sample W-1. 2 — *Cnestocythere lamellicosta* Triebel 1950, sample W-1. 3 — *Callistocythere canaliculata* (Reuss, 1850), sample G-9. 4–5 — *Callistocythere daedalea* (Reuss, 1850), sample G-11. 6 — *Cytheridea paracuminata* Kollmann, 1960, sample G-4. 7 — *Cytheridea* sp., sample W-1. 8 — *Cytheridea acuminata* Bosquet, 1852, sample W-1. 9 — *Hemicyprideis dacica* (Héjjas, 1894), sample G-9. 10–11 — *Cyamocytheridea derii* (Zalányi, 1913), sample W-1. 12–13 — *Pontocythere* aff. *curvata* (Bosquet, 1852), sample W-1. 14 — *Pontocythere longa* (Reuss, 1850), sample G-3. 15 — *Krithe* cf. *papillosa* (Bosquet, 1852), sample W-1. Scale bars: figures 1–2 = 0.1 mm; figures 3–5 = 0.1 mm; figures 6–15 = 0.2 mm.

stratigraphically belong to the Karpatian (Laa and Korneuburg Formations), while the other two belong to the Lower Badenian (Grund and Gaiendorf Formations). The reader will find a summary on the history of research of the "Grunder Schichten" in Ćorić et al. (2004). Almost 100 ostracod species are distributed within the different formations. They are listed in Table 2. Few species have been found in all formations: *Cyamocytheridea derii* (Zalányi, 1913), *Olimfalunia plicatula* (Reuss, 1850), *Senesia* ex gr. *vadaszi* (Zalányi, 1913) and *Xestoleberis tumida* (Reuss, 1850).

#### *Laa and Korneuburg Formation (Karpatian)*

Ostracods from the Laa Formation in the Molasse Basin are documented from the type locality Laa an der Thaya. On the basis of foraminifers and nannoplankton Spezzaferri & Ćorić (2001) classified the sediments of Laa an der Thaya as being deposited in a water depth not exceeding 200 m with cool water conditions. In Rögl et al. (1997) 20 ostracod species are mentioned. Most of these species are also represented in the more diverse ostracod fauna of the coeval Korneuburg Formation in the Korneuburg Basin. Zorn (1998) described 48 species, which reflect a shallow water environment with temporary brackish water influence. The infraneritic facies of the Laa Formation is only indicated by the occurrence of *Pterygocythereis* and *Krithe*. The latter and *Cytherelloidea jonesiana* (Bosquet, 1852) only occur in the Laa Formation. Ostracods from the Laa Formation will be figured in a forthcoming paper in the scope of the re-edition of the Karpatian stratotype.

Several species are only known from the Korneuburg Formation, e.g. *Aurila* aff. *opaca* (Reuss, 1850), *Carinivalva* aff. *neuhofenensis* (Witt, 1967), *Costa* cf. *batei* (Brady, 1866), *Cyamocytheridea gracilis* Zorn, 1998, *Cytherura teiritzbergensis* Zorn, 1998, *Heliocythere leobendorfensis* Zorn, 1998, *Heterocythereis* aff. *albomaculata* (Baird, 1838). Species which are distributed in both Karpatian formations, but not in the Grund and Gaiendorf Formations are: *Aurila larieyensis* Moyes, 1965, *Callistocythere karpatiensis* Zorn, 1998, *Cytherois* sp. 1, *Loxoconcha vaisonna* Carbonnel, 1969, *Neocyprideis* (*Miocyprideis*) aff. *corbleuensis* Ducasse, 1995, *Neocytherideis linearis* (Römer, 1838) and *Pontocythere lithodomoides* (Bosquet, 1852).

The author agrees with the opinion of Gross (2002) that *Callistocythere* aff. *canaliculata* (Reuss, 1850) from the Korneuburg Formation belongs to *C. daedalea* (Reuss, 1850), which is also present in the Laa and Grund Formations. The smooth specimens of *Olimfalunia* from the Korneuburg Basin, which in Zorn (1998) were provisionally placed in the sculptured species *O. plicatula* (Reuss, 1850), because of the presence of intermediate specimens with the smooth species *O. spinulosa* (Reuss, 1850), are placed in *O. spinulosa* in this study for better faunal comparison. A detailed systematic investigation and comparison of more material of the two species could help to clear up the problem.

*Pterygocythereis* sp. from the Korneuburg Basin (Zorn 1998) herein is assumed to belong to *P. calcarata* (Bosquet, 1852). This species is also present in the Grund Formation. The specimens of *Pterygocythereis* from the Laa Formation and especially from the Mühlbach Formation show more

spines on the shell surface for which they were assigned to *P. fimbriata* (Münster, 1830). As it is demonstrated in Gross (2002) the separation of the two mentioned species and the recent species *Pterygocythereis jonesi* (Baird, 1850) is still not clear because more studies on their intraspecific variability are necessary. *Xestoleberis* aff. *pilosella* (Reuss, 1850) from the Korneuburg Formation turned out to be a male specimen of *Xestoleberis tumida* (Reuss, 1850) (see Gross 2002).

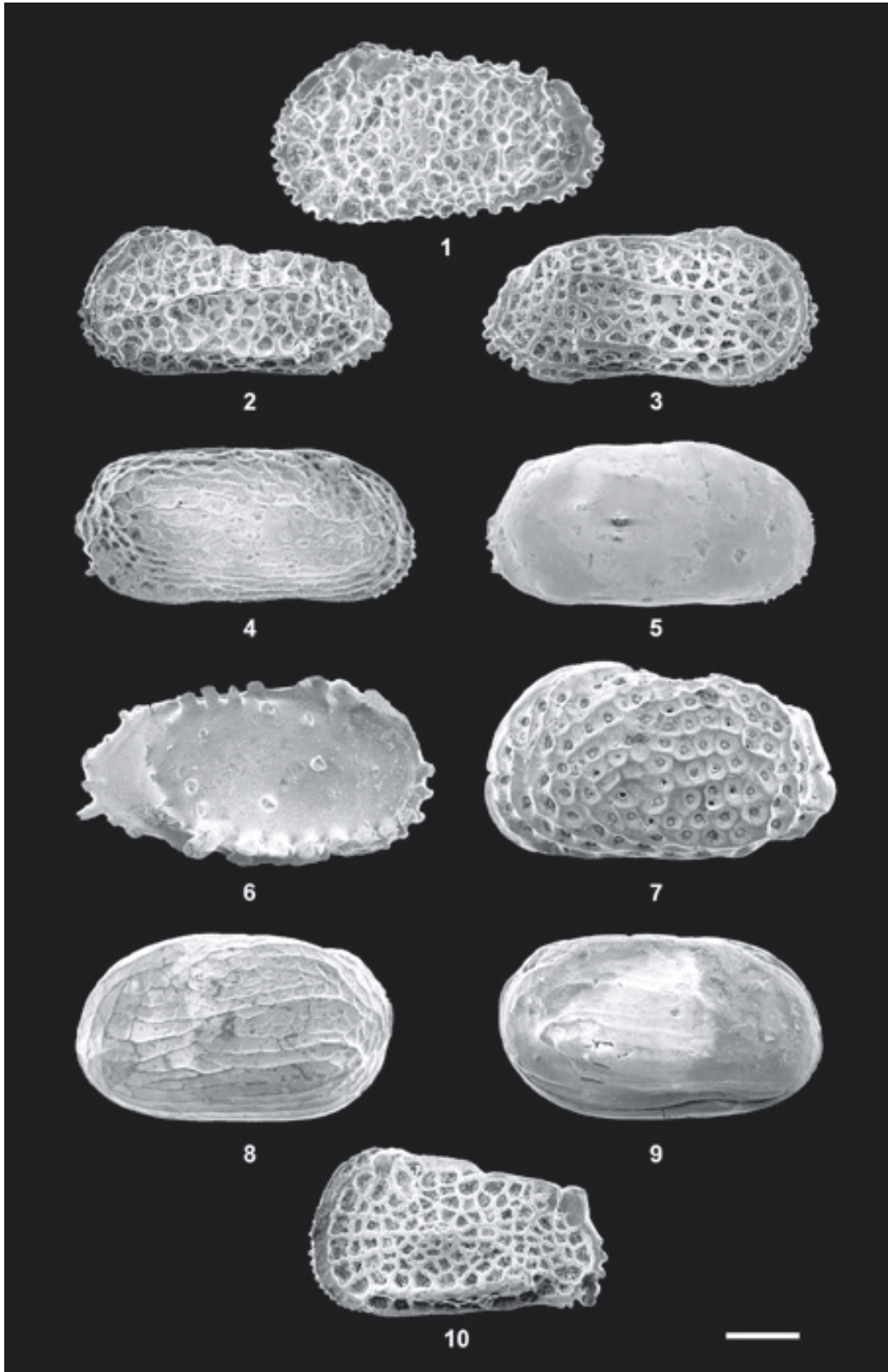
The Karpatian formations of the former "Grunder Schichten" can be separated from the Badenian formations mainly by the occurrence of *Loxoconcha vaisonna* Carbonnel, 1969, *Aurila larieyensis* Moyes, 1965, *Callistocythere karpatiensis* Zorn, 1998 and *Neocyprideis* aff. *corbleuensis* Ducasse, 1995. Furthermore *Cyamocytheridea gracilis* Zorn, 1998, *Heliocythere leobendorfensis* Zorn, 1998 and *Cytherura teiritzbergensis* Zorn, 1998 only occur in the Korneuburg Formation. The species *Cytheridea paracuminata* Kollmann, 1960, *Cyamocytheridea derii* (Zalányi, 1913) and *Senesia* ex gr. *vadaszi* (Zalányi, 1913) have their first occurrence in the Karpatian but the first two have a stratigraphic range up to the Badenian and the last to the Sarmatian.

#### *Grund and Gaiendorf Formations (Lower Badenian)*

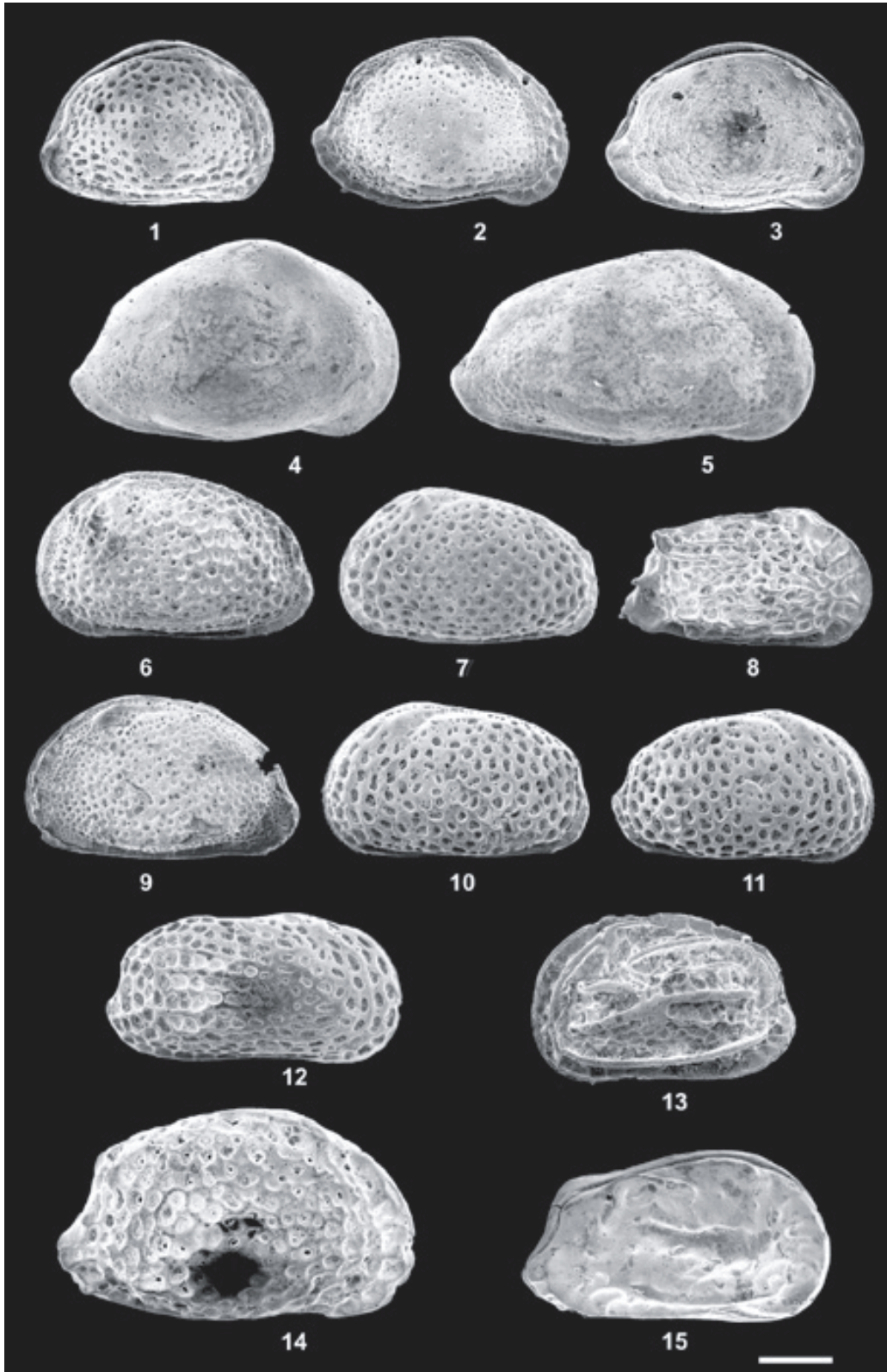
The ostracod assemblages of the Badenian Grund and Gaiendorf Formations (Molasse Basin) show evident differences compared to the Laa and Korneuburg Formations. The ostracods from the Gaiendorf Formation were recently investigated by Zorn (1999, 2003). Thirty species, which represent elements of the lower infralittoral to the circalittoral, can be distinguished. The ostracod fauna of the coeval Grund Formation consists of 61 species including most of the species of the Mühlbach Formation. *Cytheropteron* sp., *Neomonoceratina* ex gr. *helvetica* Oertli, 1958, *Parakrithe* sp., *Pterygocythereis fimbriata* (Münster, 1830), *Semicytherura* sp. indet. and *Xestoleberis* sp. occur in the Mühlbach, but not in the Grund Formation. *Cytheropteron*, *Parakrithe* and *Xestoleberis* sp. are also not known from the Karpatian formations.

On the basis of the comparison of the material from the Gaiendorf Formation with the material from the Korneuburg Basin and the Grund Formation, the following species must be added to the fauna reported in Zorn (2003): Mühlbach: *Aurila galeata* (Reuss, 1850), NNW Gaiendorf: *Costa* aff. *edwardsi* (Römer, 1838), *Loxoconcha* sp. 1 sensu Zorn, 1998, *Loxocorniculum hastatum* (Reuss, 1850), *Pseudocytherura* sp., *Semicytherura* sp. indet.; type locality SE Gaiendorf: *Xestoleberis* sp. 2 sensu Zorn, 1998 and *Xestoleberis* sp. In Zorn (2003) *Aurila albicans* (Ruggieri, 1958) is stated to occur in the Gaiendorf Formation. Within the material of Cernajsek (1971) the rare species *Aurila similis* (Reuss, 1850) could be studied. It is very similar to the first species and it is stated to occur in Grund. The material from the Gaiendorf and Grund Formations herein is assigned to *A. similis* (Reuss, 1850) until the differences between the two species and *Aurila galeata* (Reuss, 1850) are cleared.

The Hemicytheridae are much more diverse in the Grund Formation than in the other formations. Their occurrence is typical for shallow water environments. Deep water elements are especially *Krithe* cf. *papillosa* (Bosquet, 1852) and *Henry-*

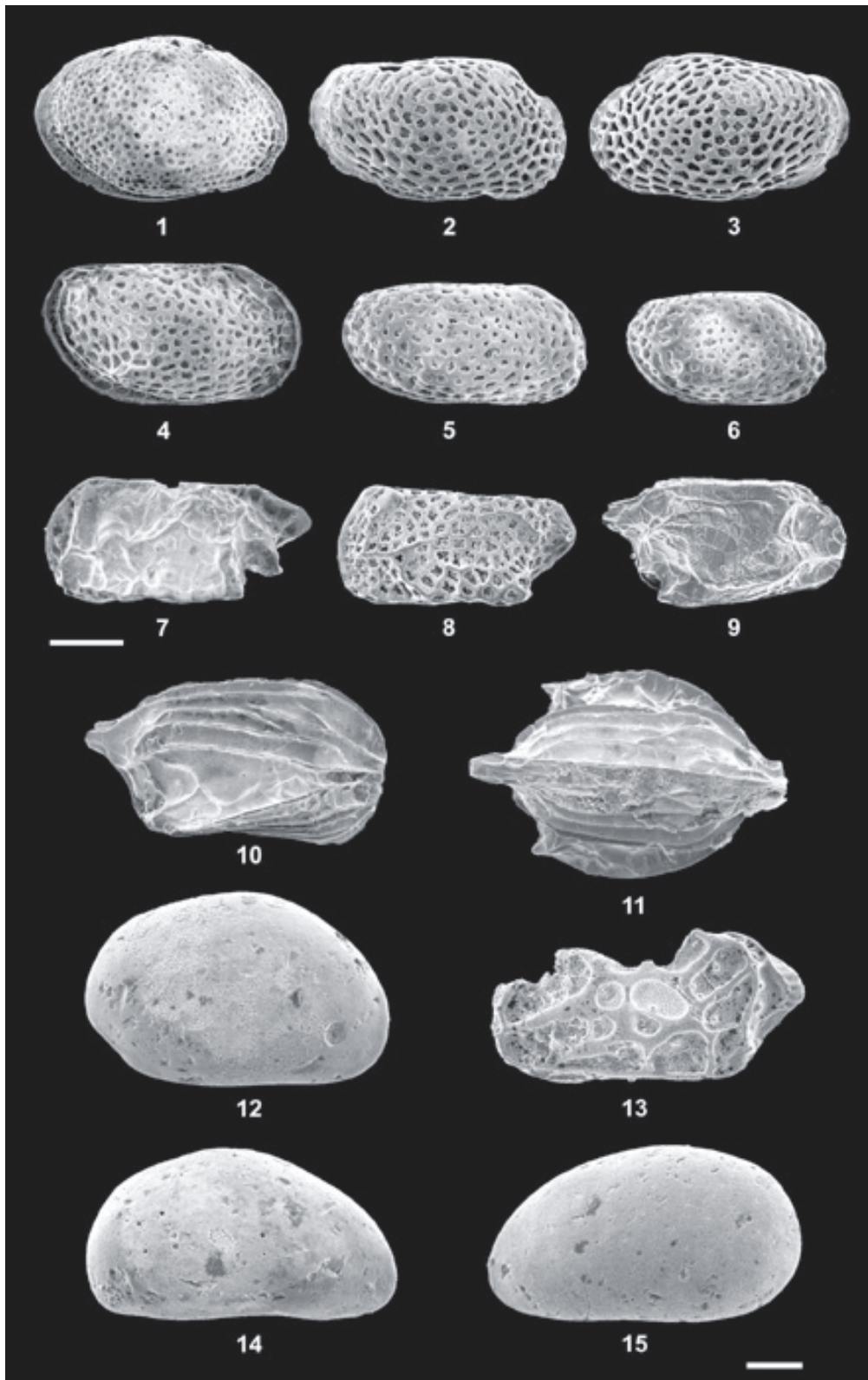


**Fig. 3.** 1 — *Acanthocythereis hystrix* (Reuss, 1850), sample G-3. 2 — *Costa* aff. *edwardsi* (Römer, 1838), sample W-1. 3 — *Costa tricostata* (Reuss, 1850), sample W-1. 4 — *Olimfalunia plicatula* (Reuss, 1850), sample W-1. 5 — *Olimfalunia spinulosa* (Reuss, 1850), sample G-3. 6 — *Pterygocythereis calcarata* (Bosquet, 1852), sample W-1. 7 — *Leguminocythereis martonfii* (Héjjas, 1894), sample F-8. 8–9 — *Cytheretta ornata* (Héjjas, 1894), 8: sample G-11, 9: sample G-4. 10 — *Grinioneis haidingeri* (Reuss, 1850), sample W-1. Scale bar = 0.2 mm.



**Fig. 4.** 1 — *Aurila punctata* (Münster 1830), sample G-4. 2 — *Aurila cicatricosa* (Reuss 1850), sample W-1. 3 — *Aurila opaca* (Reuss, 1850), sample G-4. 4 — *Aurila similis* (Reuss, 1850), sample G-11. 5 — *Aurila galeata* (Reuss, 1850), sample CER 154. 6 — *Aurila angulata* (Reuss, 1850), sample W-1. 7 — *Senesia vadaszi* (Zalányi, 1913), sample G-5. 8 — *Tenedocythere sulcatopunctata* (Reuss, 1850), larval stage, sample W-1. 9 — *Senesia trigonella* (Reuss, 1850), sample W-3. 10–11 — *Urocythereis kostelensis* (Reuss, 1850), sample G-4. 12 — *Nonurocythereis seminulum* Seguenza, 1880, sample G-9. 13 — *Graptocythere polyptycha* (Reuss, 1850), sample W-1. 14 — *Pokornyella deformis* (Reuss, 1850), sample F-8. 15 — *Graptocythere ungeri* (Reuss, 1850), sample G-4. Scale bar = 0.2 mm.





**Fig. 5.** 1 — *Loxoconcha punctatella* (Reuss, 1850), sample W-1. 2-3 — *Loxoconcha* sp., sample W-1. 4 — *Loxocorniculum hastatum* (Reuss, 1850), sample W-1. 5-6 — *Loxoconcha* sp. 1 sensu Zorn, 1998, 5: sample W-1, 6: sample G-9. 7 — *Paracytheridea triquetra* (Reuss, 1850), sample W-1. 8 — *Renciytherura textilis cornuta* (Brestenská, 1978), sample G-4. 9 — *Semicytherura* sp. 1, sample W-3. 10-11 — *Semicytherura galea* Stancheva 1962, 10: right valve, 11: carapaxe from dorsal, sample W-1. 12 — *Xestoleberis tumida* (Reuss, 1850), sample W-3. 13 — *Hemicytherura gracilicosta* Ruggieri, 1953, sample W-4. 14 — *Xestoleberis* sp. 1 sensu Zorn, 1998, sample W-1. 15 — *Xestoleberis* sp. 2 sensu Zorn, 1998, sample W-1. Scale bars: figures 1-7 = 0.2 mm; figures 8-15 = 0.1 mm.

*howella asperrima* (Reuss, 1850). These two and the following species are restricted to the Grund Formation: *Aurila angulata* (Reuss, 1850), *A. haueri* (Reuss, 1850), *A. opaca* (Reuss, 1850), *Cytherella* sp., *Cytheridea* sp., *Flexus reussianus* Ruggieri, 1992, *Grinioneis haidingeri* (Reuss, 1850), *Helio-cythere vejhonensis* (Procházka, 1893), *Hemicyprideis dacica* (Héjjas, 1894), *Hemicytherura gracilicosta* Ruggieri, 1953, *Leguminocythereis martonfii* (Héjjas, 1894), *Loxoconcha* sp., “*Phlyctenophora arcuata*” sensu Reuss, 1850, *Pokornyella deformis* (Reuss, 1850), *Pontocythere* aff. *curvata* (Bosquet, 1852), *P. longa* (Reuss, 1850), *Renicytherura textilis cornuta* (Brestenská, 1978), *Semicytherura galea* Stancheva, 1962, *Semicytherura* sp. 1-2, *Senesia trigonella* (Reuss, 1850), *Tenedocythere sulcatopunctata* (Reuss, 1850), *Urocythereis kostelensis* (Reuss, 1850) and *Verrucocythereis verrucosa* (Reuss, 1850).

A high diversity of ostracods and especially of the Hemicytheridae generally is characteristic of the Badenian in the Central Paratethys. The first occurrence of many Hemicytheridae species is valuable for the identification of the Badenian, but very probably it is not applicable for subdividing the Badenian (see Brestenská & Jiříček 1978; Gross 2002). The presence of the following species, which have been found in the Grund and Gaiendorf Formations, is restricted to the Badenian in the Central Paratethys: *Acanthocythereis hystrix* (Reuss, 1850), *Aurila similis* (Reuss, 1850), *A. galeata* (Reuss, 1850), *A. punctata* (Münster, 1830), *Cytheridea acuminata* Bosquet, 1852, *Cnestocythere lamellicosta* Triebel, 1950 and *Olimfalunia spinulosa* (Reuss, 1850). The same is also true for *Aurila angulata* (Reuss, 1850), *A. haueri* (Reuss, 1850), *A. opaca* (Reuss, 1850), *Renicytherura textilis cornuta* (Brestenská, 1978), *Senesia trigonella* (Reuss, 1850), *Semicytherura galea* Stancheva, 1962, *Tenedocythere sulcatopunctata* (Reuss, 1850) and *Urocythereis kostelensis* (Reuss, 1850), which have been found in the Grund Formation. *Acanthocythereis hystrix* (Reuss, 1850) is the index fossil for the Lower Badenian (Jiříček 1983). *Aurila similis* (Reuss, 1850) and *Renicytherura textilis cornuta* (Brestenská, 1978) are scarcely known in the Central Paratethys but also seem to be restricted to the Lower Badenian.

### Conclusion

The Grund Formation yields 61 ostracod species. Hemicytheridae (*Aurila*, *Graptocythere*, *Grinioneis*, *Nonurocythereis*, *Pokornyella*, *Senesia*, *Tenedocythere*, *Urocythereis*), *Callistocythere daedalea* (Reuss, 1850), *Cyamocytheridea derii* (Zalányi, 1913), *Cytheridea acuminata* Bosquet, 1852, *Cytheridea paracuminata* Kollmann, 1960, *Loxocorniculum hastatum* (Reuss, 1850) and *Senesia* ex gr. *vadaszi* (Zalányi, 1913) are most common.

The ostracod assemblage reflects a shallow warm water environment with a water depth probably not exceeding 100 m. Deep water elements are only represented by single specimens of *Krithe* cf. *papillosa* (Bosquet, 1852), *Henryhowella asperrima* (Reuss, 1850) and *Pseudocytherura* sp.

Very probably parts of the ostracod material especially at the Grund excavations have been re-deposited as the bad state of preservation reflects.

The stratigraphic classification of an Early Badenian age for the Grund Formation can be supported mainly by the occurrence of *Acanthocythereis hystrix* (Reuss, 1850). Many species are also known either from Karpatian or from younger Badenian sequences in Austria. *Aurila similis* (Reuss, 1850) and *Renicytherura textilis cornuta* (Brestenská, 1978) are scarcely known in the Central Paratethys, but also seem to be restricted to the Lower Badenian.

The occurrence of *Loxoconcha vaisonna* Carbonnel, 1969, *Aurila larieyensis* Moyes, 1965, *Callistocythere karpatiensis* Zorn, 1998 and *Miocyprideis* aff. *corbleuensis* Ducasse, 1995 in the Karpatian formations of the former “Grunder Schichten” is most useful to separate them from the Badenian formations with the occurrence of *Acanthocythereis hystrix* (Reuss, 1850) and several species of Hemicytheridae.

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