Late Early Devonian ostracodes from the Torkoz area (SW Morocco) and the Emsian/Eifelian boundary

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Abstract
A new rich and diversified ostracode fauna from the Torkoz area (section Hassi Mouf South, Moroccan Anti-Atlas) is described and the ostracode distribution near the Early/Middle Devonian boundary is discussed. This ostracode fauna of a single limestone bed yields 32 taxa and is compared with the less-diversified ostracode fauna from an adjacent parallel section Hassi Mouf South as well as with a published conodont-bearing sample from section Torkoz. All three ostracode faunas are closely related, and therefore, the same latest Emsian age is postulated. Palynomorphs (acritarchs and prasinophytes) from section Torkoz support this late Early Devonian age and the scarce brachiopod fauna of the equivalent level from section Hassi Mouf South suggests a stratigraphical position very close to the Emsian/Eifelian boundary, probably latest Emsian. Zygobeyrichia subcylindrica from a thin marly bed embedded in shales, slightly below the ostracode-rich sample from section Hassi Mouf South, and the conodonts of the patulus Zone from section Torkoz, favours the position of the Early/Middle Devonian boundary within the Yeraifia Formation and not in or on top of the Rich 4 Sandstone in the SW Dra Valley area as hitherto published. The latest Early Devonian ostracode faunas from the Torkoz area belong to the shallow-water Eifelian Ecotype of G. Becker. The new genus Karlingrella for Euglyphella? granulosa Blumenstengel, 1962 and the new species Quasillites (Beckjennites) gebeckeri are erected.

Keywords Ostracoda · Taxonomy · Biostratigraphy · Palaeobiogeography · Palaeoecology · SW Anti-Atlas

Introduction and geological setting (R. T. Becker, E. Schindler and H. Groos-Uffenorde)
The Devonian of the Anti-Atlas of southern Morocco is world-famous for its extensive outcrops incredibly rich in well-preserved faunas. Detailed investigations of Devonian stratigraphy in the Dra Valley (southwestern Anti-Atlas) began with Hollard and Jaquemont (1956), followed by a large number of specialised publications mainly by H. Hollard (see reference lists, e.g., in Bultynck and Hollard 1980; Bullyck and Walliser 2000; Jansen 2001).

More recent overviews of the Dra Valley stratigraphy, including many new palaeontological data, and with introduction of new lithological units, were given by R.T. Becker et al. (2004c) and Jansen et al. (2007). Sedimentological compilations and sequence stratigraphic aspects were published by Ouanaimi and Lazreq (2008) and Lubeseder et al. (2009). A first brief record of the succession at section Hassi Mouf South was published by Baird et al. (2009), with
additional details in DeSantis and Brett (2011) shown for comparison in Fig. 2, section Hassi Mouf gully.

Recently, many sections in the Dra Valley region were studied by research groups from the University of Münster and the Senckenberg Research Institute Frankfurt. Some of the conodont samples from sections Bou Tserfine, Rich Tamelougou, and Hassi Mouf South in the Dra Valley south of the village of Aouinet Torkoz yielded late Early Devonian to early Middle Devonian age ostracodes, which will be described in a forthcoming publication by Dojen et al. Only the latest Early Devonian ostracodes of the Torkoz area are described in the present paper. Figure 1 shows the studied localities in the Torkoz area north of the Dra valley in southwestern Morocco and Fig. 2 shows the different sections in this area as named by different authors.

The complete section Hassi Mouf South ranging from the late Emsian Rich 4 Sandstone Member to the early Givetian was discovered by students from Münster University mapping in the Hassi Mouf area ca 10 km SSE of Aouinet Torkoz (Fig. 1), whereas the Senckenberg group sampled together with, e.g., G. Baird during a bilateral US–German National Geographic project in 2007 only in Early/Middle Devonian boundary beds (Crinoid Marl Member of the lower Yeraifa Formation above the Rich 4 Sandstone of the upper Khebchia Formation). In Fig. 2, this section is cited as Torkoz 5 according to the figured section in an e-mail of G. Baird (State University of New York at Fredonia, NY) from 28 November 2014, but cited in the systematics as Hassi Mouf South according to Baird et al. (2009).

The ostracodes described in the systematic part have been found in a thin calcareous siltstone intercalation (sample FRA-TKZ 4 with many large Zygobeyrichia valves, first cited as shell lags with macrofauna and ‘large, distinctive ostracodes’ in Baird et al. 2009, but not marked in the section Hassi Mouf South of the Münster group in Fig. 2) some tens of metres above the top of the Rich 4 Sandstone Member and only a few decimetres below a distinct limestone bed. This limestone bed characterising the base of the onset of limestone intercalations of the section Torkoz 5 (e-mail by G. Baird 2014) resp. Hassi Mouf-South of Baird et al. (2009) contained the diversified ostracode fauna of sample FRA-TKZ 4c2 (see Fig. 2). The age of these ostracode faunas together with the conodont determination by K. Weddige (Frankfurt) is discussed below under the subsequent heading ‘Stratigraphy of the ostracodes of the Torkoz area’. Their correlation with sample Tor Eif/2d from the detailed section Hassi Mouf South of the Münster group and with the section Torkoz II sensu G. Becker et al. (2004)
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Towards the west is shown in Figs. 2 and 19. The ostracodes from the overlying Middle Devonian Pinacites Limestone, as well as from the underlying Early Devonian (e.g., Hollardops Limestone) will be included in a planned paper by Dojen et al. mentioned above.

**Sedimentology and facies (E. Schindler)**

Two samples are described concerning their sedimentology, facies, and faunal content (Fig. 3); sample FRA-TKZ 4c2 from the section Hassi Mouf South (sensu written communication G. Baird 2014) and sample Tor Eif/2d from the section Hassi Mouf South of R.T.B. (for detailed explanation, see previous section and Fig. 2). Sample FRA-TKZ 4 situated slightly below sample FRA-TKZ 4c2 is less calcareous and no thin sections were studied. This thin fossiliferous layer is hitherto not described from other sections.

**Sample FRA-TKZ 4c2, section Hassi Mouf South**

The (partly) sparitic appearance of the ostracode-rich bed is mainly due to the presence of large amounts of echinoderm fragments (mainly crinoid ossicles including longer stem fragments, but also other echinoderms). Some of the crinoid ossicles are oval and some are heavily corroded. The arrangement of most of the debris is chaotic with bedding indicated by the alignment of platy brachiopod shells.
and other elongate fossils (best seen in the polished slab on Fig. 3a). Also present are randomly distributed fine-grained extra-clasts of siliciclastic material (right part of Fig. 3a and subsequent close ups).

Besides the dominance of echinoderms, the fossil content yields a number of bryozoans, which are also visible on bedding planes of smaller pieces of the bed (Fig. 3f). Also present—but in smaller numbers—are trilobite fragments (e.g., arrows in Fig. 3d). Striking fossils are punctate shells of brachiopods (with very densely spaced puncta) which are most probably arranged according to bedding (frequently visible in Fig. 3a–e). Other brachiopods (mostly smaller fragments of ribbed forms) are present, but in restricted numbers (e.g., in Fig. 3a slightly above base of lower left; Fig. 3c right below punctate brachiopod shell). Cross-sections of unknown fossils are also visible (e.g., Fig. 3b right part; Fig. 3e right above big punctate brachiopod shell). Although the conodont sample residue yields a great variety of ostracode taxa, they are hardly visible in the polished slab or in the thin section. This may be due to sporadic occurrence with eventual accumulations in “pockets”.

The observations from a polished slab as well as from a thin section indicate agitated water. The ostracode-rich bed represents a relatively high-energy deposit and can be described as crinoid-debris limestone.

**Sample Tor Eif/2d, section Hassi Mouf South**

At first glance, the polished slab of sample Tor Eif/2d looks rather different from that of bed FRA-TKZ 4c2, but there are some similarities present (Fig. 3g–h). The bed also represents a debris limestone, deposited in shallow agitated water. The number of fossils is even higher. Crinoid ossicles (some still attached to each other forming longer stem fragments) are also frequent; some show selective corrosion (blue “c” in Fig. 3g, central part). Amongst the brachiopods, the same punctate shells are present comparable to those in sample FRA-TKZ 4c2. However, there are more of other brachiopods, in many cases with relatively large and smooth shells (blue “sb” in Fig. 3g, h). Also, similar are numerous bryozoan specimens (at least as many as in sample FRA-TKZ 4c2, but even more diverse) of which some are quite long (up to 2 cm). Trilobites are also present, in even higher numbers, and the specimens are mostly somewhat bigger (roughly twice the size).

Although we did not find so many ostracode specimens/taxa in this bed comparable to sample FRA-TKZ 4c2, the polished slab seems to show some questionable ostracode valves (o in Fig. 3h). The shells are perhaps better visible because of different shell material due to reduced ore even missing recrystallisation. Besides such small shells, there are higher numbers of other shells of unknown organisms. Some small circular fossils (cross-sections showing crystals inside) of unknown origin (? spines) are present (frequently visible in Fig. 3g, h).

The slightly different character and greater thickness of this bed compared to that of sample FRA-TKZ 4c2 (somewhat different distribution of the main fossil content, bedding not recognisable) may indicate a facies change, i.e., from a relatively thick limestone bed (Tor Eif/2d) to a more shaly/marly succession with thin intercalated limestone beds (FRA-TKZ 4c2).

**Systematic palaeontology of the ostracodes (H. Groos-Uffenorde)**

In the paper in hand, the spelling of the term ostracode (and not ostracod) is used in accordance with Moore (1961: p. Q2). The history and the use of the spelling including the linguistic arguments are summarised by Benson (1981). The slightly different character and greater thickness of this bed compared to that of sample FRA-TKZ 4c2 (somewhat different distribution of the main fossil content, bedding not recognisable) may indicate a facies change, i.e., from a relatively thick limestone bed (Tor Eif/2d) to a more shaly/marly succession with thin intercalated limestone beds (FRA-TKZ 4c2).

**Introduction to the material**

Thirty-two subgeneric taxa out of at least 24 genera of Ostracoda have been found in sample FRA-TKZ 4c2 (coll. E.S. 2007) overlying the latest Early Devonian (latest Emsian) bryichiacean-bearing calcareous shales (sample FRA-TKZ 4, coll. E.S. 2007) in the section Hassi Mouf South of Baird et al. 2009 (= section Torkoz 5 of Baird 2014 in Fig. 2). For an overview of the sections in the SW Anti-Atlas/Dra Valley about 10 km south of Aouinat Torkoz, see Introduction and Fig. 2.
More than 500 silicified ostracodes (the geochemical composition of the ostracode valves has not been analysed) of sample FRA-TKZ 4c2 were picked and described from a large conodont sample residue of a coarse-grained crinoidal limestone at the base of the fossiliferous limestones and calcareous shales of the Crinoid Marl Member. The rock sample was prepared by standard conodont preparation techniques and a lot of the residue is available for further studies.

The preservation of the ostracodes (mostly single valves and rare carapaces) varies greatly. Some ostracodes have excellent preservation because of fine-grained recrystallization, but others are poor and often damaged, because of coarse-grained recrystallisation. The latter specimens were, of course, less resistant during the conodont sample processing.

In contrast, the calcareous ostracode valves of the unprocessed sample FRA-TKZ 4 are preserved on slabs of a thin calcareous intercalation near the top of the argillaceous basal Yeraifa Formation. Besides very few small non-beyrichiacean ostracodes, e.g., *Bollia* and *Jenningsina*, the bedding planes are crowded with large *Zygobeyrichia* valves (see Fig. 4).

Some silicified ostracodes of sample Tor Eif/2d (residue of conodont sample of R.T.B. poor in ostracodes) from the same basal limestone bed in section Hassi Mouf South are cited for comparison. A detailed description will be included in the forthcoming paper of Dojen et al.

Remarks on the brachiopod fauna from this sample are given by U.J.

Silicified ostracodes of sample Torkoz Giv 1 sensu G. Becker et al. (2004) from the Torkoz section at Rich Tame-lougou in the north of the Dra Valley, south of Aouinet Torkoz (Fig. 1), are also discussed. In the following text, the material of G. Becker et al. (2004) from the Torkoz section is cited as sample Giv 1B and additional material picked from the remaining conodont sample residue of K. Weddige is cited as sample GIV 1 W. Remarks on palynomorphs from this sample are given by R. B.

The material is deposited in the collections of the Senckenberg Research Institute Frankfurt. The ostracodes are cited under the SMF Xe numbers, palynomorphs under the cited SMF PMP numbers, brachiopods, and sedimentology/facies samples under the cited SMF numbers.

**Remarks on the systematic nomenclature**

According to the glossary of the fourth edition of the ICZN 1999, the ending of the Palaeozoic ostracode ‘superfamilies has the suffix—OIDEA’, which is a change from the traditionally used ending—acea into—oidea. We think that there is no need to change the traditionally used names only to unify Palaeozoic and post-Palaeozoic nomenclature without any new interpretations or new results or knowledge. Instead, we want to avoid misunderstandings in using the important international literature of the former centuries. Therefore, we prefer, like many colleagues working in the Palaeozoic (e.g., G. Becker 2002, G. Becker 2003; G. Becker et al. 2004; Dojen 2005; Kornicker and Sohn 2000; Nazik and Groos-Uffenorde 2016; Perrier et al. 2011; Wang 2009), the traditional and undisputed name—e.g., *Beyrichiacea* instead of *Beyrichioidea*. We follow the unanimous decision after discussions during the ISO Meetings (International Symposia on Ostracoda, e.g., in Houston 1982) and not the unified ending of the superfamily names proposed by the International Commission on Zoological Nomenclature (ICZN effect from 1 January 2000).

**Abbreviations in the nomenclature**

cf.—Exact species determination not possible because of slightly differing features
aff.—Taxon differing from the cited species but related to it
sp.—Sparse material or poorly preserved
? in front of a genus name—Definition or classification questionable
? behind a genus name—Doubtful determination, often because of obscure definition
? behind a species name—Identification uncertain often because of poor preservation
gr. (group)—Taxa with great variation, no delimitation or exact determination possible
vel (latin, ‘or’)—No delimitation between two taxa possible
TKZ—Torkoz area, samples FRA-TKZ
GIV—Section Torkoz Giv sensu G. Becker et al. (2004)

**Abbreviations in the descriptions**

L—Length
H—Height
W—Width, thickness of carapace
lv—Left valve
rv—Right valve
DR—Dorsal border
VR—Ventral border
L1—Praesulcal/anterior lobe or node
L2—Postsulcal lobe or node
L—Ventral lobe (e.g., ventral connection L1_L4)
zygal ridge (e.g., in Bolliidae)—Ventral connection of L1
S—Sulcus
S2—Adductorial sulcus
Stk—Steinkern, internal mould
het.—Heteromorph, presumably female
tecn.—Tecnomorph, presumably male or juvenile (= juv.)

**Description of the ostracode species from section Hassi Mouf South**

Order *Palaeocopida* Henningsmoen, 1953
Suborder *Palaeocopina* Henningsmoen, 1953
Superfamily *Beyrichiacea* Matthew, 1886
Family Beyrichiidae Ulrich, 1894

Genus Zygobeyrichia Ulrich, 1916

*1916 Zygobeyrichia n. gen.—Ulrich: p. 290–291

v 1970 Zygobeyrichia Ulrich 1916—Groos and Jahnke: p. 41

v 1983 „Zygobeyrichia“—Groos-Uffenorde: p. 338

2012 Zygobeyrichia Ulrich 1916—G. Becker and Franke: p. 92

2016 Zygobeyrichia Ulrich 1916—Nazik and Groos-Uffenorde: p. 212 (with synonymy)

Type species. Zygobeyrichia apicalis Ulrich, 1916.

Important diagnostic features. Large trilobate beyrichiacean ostracodes, according to Ulrich (1916) characterised by a varying distinctness of a ventral connection of L1 and L2 (zygal ridge). In contrast to Gibba Fuchs, 1919, the tecnomorphs do not have an alate structure.

Remarks. Closely related is Arikloedenia Adamczak, 1968, which does not show a distinct adventral structure in adults. According to Přibyl (1986: p. 79), Arikloedenia zlíchovensis (Pribyl, 1955) seems to be related to ‘Zygobeyrichia (recte Arikloedenia) subcylindrica (R. Richt.)’. According to Berdan (1972: p. 24), the crumina of Lophoklodenia Swartz and Withmore, 1956 and Zygobeyrichia interrupts the velar ridge in contrast to Kloedeniopsis Berdan, 1972. According to Groos and Jahnke (1970: p. 41), there are close relations between Z. apicalis and Z. devonica, that is between a North American and a European species.

Occurrences. Late Silurian and Early Devonian of North America, Early Devonian of Germany (Rhenish Schiefergebirge, Harz, Thuringia), northern France, Spain, Barrandium, Turkey.

The oldest but very doubtful record is Zygobeyrichia ? sp. A in Wolfahrt (1970: p. 85, pl. 19, pl. 3, fig. 14) from middle Ordovician sediments near Malestan in Eastern Afghanistan.

Zygobeyrichia subcylindrica (Rh. Richter, 1863)

1863 Beyrichia Kloedeni M'Coy—Rh. Richter: p. 671, pl. 19, figs. 7, 8, 9, 10 and 11.

*1863 Beyrichia subcylindrica n. sp.—Rh. Richter: p. 671–672, pl. 19, figs. 12, 13, 14 and 15.

1968 Zygobeyrichia subcylindrica (Rh. Richter, 1853)—K. Zagora: p. 13–15, text-figs. 4, 5, pl. 1, figs. 1, 2 and 3 (with synonymy).

2012 Zygobeyrichia subcylindrica (Rh. Richter 1863) [sensu stricto]—G. Becker and Franke: p. 92–93, figs. 9 and 10.

v 2012 “Zygobeyrichia subcylindrica” (Rh. Richter 1863) sensu lato—Nazik and Groos-Uffenorde: p. 215, 217, fig. 12 (with synonymy).

Remarks. The species was revised by K. Zagora (1968) due to new material from the latest Emsian of Thuringia (moulds of tecnomorphs and heteromorphs as well as silicified mostly juvenile valves). The characteristic tubercle on L2 of the Thuringian material has never been found by G. Becker (Becker and Franke 2012: p. 93), but has been observed especially on external moulds in several samples from the Rhenish Schiefergebirge by H. G.-U.

A discussion on the Zygobeyrichia subcylindrica group was given by G. Becker and Franke (2012: p. 81–82, 92–93) and related forms summarised by G. Becker and Franke (2012: p. 93–99) under the name ‘Zygobeyrichia ssp., ex Gr. Z. subcylindrica (Rh. Richter 1963)’. Because of the great variation in the strength of the lobation and only rare specimens of external moulds showing the tubercle on L2, Z. subcylindrica sensu lato [including Zygobeyrichia devonica (Jones and Woodward, 1889)] was used by Nazik and Groos-Uffenorde (2016) in a broad sense.

Occurrence. Zygobeyrichia subcylindrica is often reported from the European late Early Emsian to latest Emsian. External and internal moulds are common and widespread in the Emsian shales and siltstones of Germany (see Groos-Uffenorde 1982: pl. 3 fig. 19 and discussion in G. Becker and Bolz 1991). Nazik and Groos-Uffenorde (2016) described Early Devonian records from NW Turkey.

Zygobeyrichia sp. TKZ aff. subcylindrica (Rh. Richter, 1863)

Figure 4a–k

Material. Many calcareous valves on bedding planes of 7 slabs from section Hassi Mouf South, sample FRA-TKZ 4 (SMF Xe 23497–Xe 234503 coll E. S.), first mentioned by Baird et al. (2009: p. 193) as ‘large, distinctive ostracodes’. The specimens are often incomplete, internal views of heteromorph and tecnomorph valves mostly covered with sediment.

Important diagnostic feature. Large beyrichiacean ostracodes with straight L1, relatively long and anteroventrally pointed and not connected with L2 or L3; L2 distinct, elongate and ventrally pointed (but without tubercle or carina like Gibba or Carinokloedenia Abushik 1971); L3 large but less distinct, ventrally connected with an indistinct ventral lobe, but ventrally not distinctly connected with L2 as in the
Fig. 4 Zygobeyrichia sp. TKZ aff. subcylindrica (Rh. Richter, 1863) on bedding planes with crinoids, sample FRA-TKZ 4, section Hassi Moug South. a SMF Xe 23497, part of the bedding plane of slab A; b SMF Xe 23500, bedding plane of slab D; c SMF Xe 23497a, detail of slab A, L = > 4.3 mm, interior view of tecnomorph rv of Zygobeyrichia, besides SMF Xe 23497b, L = 1.3 mm, exterior view of Bollia sp.; d SMF Xe 23500a, detail of slab D, L = 4.6 mm, interior view of a heteromorph rv; e–g SMF Xe 23501a, detail of slab E, L = > 3.5 mm, posteriorly slightly incomplete tecnomorph lv; e slightly tilted lateral view; f dorsal view and g anterior view; h SMF Xe 23498 = bedding plain of slab B; i SMF Xe 23501, bedding plane of slab E; j SMF Xe 23500, bedding plane of slab D; k SMF Xe 23,499, bedding plane of slab C
American genus type material. The anteroventral crumina of the heteromorphs is not clearly separated from the lateral surface. The row of marginal tubercles (‘kurze Randborsten’) described by Spriestersbach (1925: p. 400) is hard to be seen at calcareous valves in contrast to the better preservation on external moulds. The outline and lobation is comparable to Zygobeyrichia devonica of Spriestersbach (1925: fig. 2) from the late Early Devonian of Germany.

Remarks. In contrast to the European Zygobeyrichia subcylin- drica, the Moroccan material does not clearly show the characteristic tubercle on the L2. This tubercle is best seen on external moulds in the German material, but in general, the internal views of the shell or internal moulds do not show this tubercle. The L2 is bulbous and not elongate as in the Moroccan material.

There are close relations to Zygobeyrichia devonica (Jones and Woodward, 1889) sensu Spriestersbach 1925 (but not sensu Jones!) and Zygobeyrichia subcylin- drica (Rh. Richter, 1863), but it has still to be verified if both species are conspecific.

G. Becker and Franke (2012: p. 96, pl. 7, fig. 6) figured a ventral view of a tecnomorph Zygobeyrichia sp. W, ex gr. Z. subcylin- drica with distinctly pointed end of the L1 comparable to Turkish material (Nazik and Groos-Uffenorde 2016: p. 208, fig. 7.4 named Gibba ? sp., aff. kayseri) characterised by a subdivided L1 instead of the subdivided L3 in Gibba ? kayseri. Because of the long S2 the Luxemburg material clearly belongs to Zygobeyrichia. Tecnomorphs of G. ? kayseri are still unknown and an exact genus determination is not possible.

Occurrence. Known only from the Torkoz area, SW Morocco.

Superfamily Hollinacea Swartz, 1936
Family Ctenoloculinidae Jaanusson and Martinsson, 1956
Genus Ctenoloculina Bassler, 1941
Type species. Tetradella cicatricosa Warthin, 1934
Remarks. This quadrilobate genus is characterised by a pro- nounced locular dimorphism. The species are mainly separated by the difference in the shape of the lobation and velar structure.

Ctenoloculina disjuncta Zagora, 1968
Figure 5a–g

*1968 Ctenoloculina disjuncta n.sp.—K. Zagora: p. 22–24, pl. II, figs. 6 and 7, pl. III, figs. 1, 2, 3 and 5.
1977 Ctenoloculina disjuncta Zagora, 1968—G. Becker and Sanchez de Posada: p. 128, pl.1, figs. 1 and 2.

1986 Ctenoloculina disjuncta—K. and I. Zagora: photo 1.

Material. Ten heteromorph valves partly incomplete (rv SMF Xe22757, lv SMF Xe22760, lv SMF Xe22761 and 7 valves in SMF Xe 23512). Five tecnomorph valves (rv SMF Xe 22764 and SMF Xe 22765, lv SMF Xe22762 and 2 valves in SMF Xe 23511) from sample FRA-TKZ 4c2, section Hassi Mouf South.

Important diagnostic features. Most important are the ven- tral parts of the lobes: only the broader L3 of the hetero- morphs is isolated from the adventral structure (‘Velum’), but the L1 and L2 are connected with the adventral structure. The lobes do not overreach the dorsal margin. A row of tubercles is visible in the prolongation of the adventral structure. The heteromorph valves have 6 loculi. The sulci are narrow.

Remarks. Ctenoloculina similidisjuncta Becker n.sp. in G. Becker et al. (2004) is characterised by lobes overreaching the dorsal border, and L2 and L3 are not connected with the adventral structure. The heteromorph valves show only 5 instead of 6 loculi.

The lobation of C. latisulcata Adamczak, 1968 (Grzegorzowicz beds of the Holy Cross Mountains, Poland) is very similar, but the sulci are broader.

All lobes (L1, L2, and L3) are isolated and separated from the adventral structure in C. vulgaris Adamczak, 1968 from the Skaly beds, Eifelian of the Holy Cross Mountains, Poland.

Within C. skalyensis Adamczak, 1968, also from the Skaly beds, the L2 and L3 are only partly separated from the adventral structure.

Occurrences. Latest Early Devonian (Emsian) of Germany (Thuringian Tentaculitenschiefer III in Zagora 1968 and Heisdorf Formation in the Eifel Mountains in G. Becker and Groos-Uffenorde 1982) and Spain (lowermost Moniello Formation, Cantabrian Mountains in G. Becker and Sanchez de Posada 1977). G. Becker (2004) in Jansen et al. (2004: p. 80, tab. 1) listed Ctenoloculina cf. disjuncta Zagora, 1968 from the Torkoz IIa section (Early Devonian Assa Formation, Unit 17) but not from sample Torkoz GIV 1.

Ctenoloculina latisulcata Adamczak, 1968

*1968 Ctenoloculina latisulcata sp. n.—Adamczak: p. 65–66, pl. 22, figs. 2–4.
2004 Ctenoloculina latisulcata Adamczak 1968—G. Becker et al.: p. 19, pl. 6, figs. 7, 10–11.
2015 Ctenoloculina latisulcata Adamczak, 1968—Olemp- ska et al.: p. 301, fig. 4a, b
Remarks. The heteromorph valves have 6 loculi comparable to *Ctenoloculina disjuncta* Zagora, 1968 from sample FRA-TKZ 4c2: a SMF Xe 22760, L = 1.4 mm, lateral view of a heteromorph lv; b SMF Xe 22761, L = > 1.0 mm, interior view of an incomplete heteromorph lv; c SMF Xe 22657, L = 1.25 mm, lateral view of a heteromorph rv; d SMF Xe 22762, L = 1.35 mm, lateral view of a tecnomorph lv; e SMF Xe 22764, L = 1.4 mm, oblique ventral view of tecnomorph rv and f lateral view; g SMF Xe 22765, L = 1.4 mm, lateral view of tecnomorph rv; h *Ctenoloculina* sp. from sample Torkoz GIV 1 W. SMF Xe 23046, L = 1.4 mm, lateral view of tecnomorph lv; i *Parabolbina* sp. from sample Torkoz GIV 1 W. SMF Xe 23034, L = 0.82 mm, lateral view of a tecnomorph rv

*Ctenoloculina* sp.

*Material.* Only one tecnomorph lv from sample GIV 1 W (SMF Xe 23046), section Torkoz.

Remarks. Because of lack of heteromorph specimens, a precise determination is not possible. The narrow sulci of the specimen from GIV 1 W are comparable to those of *C. disjuncta* but the shape of the lobes resembles those of *C. cicatricosa* sensu Zagora, 1968 from the Late Emsian of Germany (Tentaculitenschiefer of Thuringia).

Genus *Parabolbina* Swartz, 1936

*Type species.* *Ctenoloculina granosa* Ulrich, 1900.
**Parabolbina kroemmelbeini** K. Zagora, 1968

*1968 Parabolbina kroemmelbeini* n. sp.—K. Zagora: p. 25–26, pl. 4, figs. 1 and 2.

2005 *Parabolbina kroemmelbeini* K. Zagora 1968—Dojen: p. 64–65, text-fig. 8.10 (with synonymy).

*Important diagnostic features.* Preplete outline, distinct oblique $S_2$, heteromorphs with four loculi and tecnomorphs with anteroventral velate spine. Surface granulated.

*Remarks.* According to K. Zagora (1968: p. 26), *P. kroemmelbeini* is related to several taxa in the Silurian and Devonian of North America, especially to *P. granosa* (Ulrich, 1900), *P. arvinoda* Swartz and Swain, 1941, *P. loculosa* Bassler, 1941, and *P. acinina* Kesling and Weiss, 1953. *Parabolbina kroemmelbeini* is distinguished from these through its prominent $L_1$ and its oblique $S_2$, Groos (1969: p. 26) compared *P. kroemmelbeini* with *P. octovesica* Adamczak, 1968, which differs in having a distinctly developed $L_1$. *Parabolbina tetrassphaerula* Blumenstengel, 1969 has a smooth surface. *Parabolbina aff. kroemmelbeini* sensu G. Becker et al., 2004 has a lateral spine.

*Occurrences.* Late Early Emsian, Aragón, Spain; Pragian, Armorican Massif, France; Late Emsian, Thuringia, Germany; Middle Devonian, Rhenish Schiefergebirge, Germany. G. Becker et al. (2004: p. 21) reported *P. aff. kroemmelbeini* from the late Emsian of the sections Torkoz IIa and IIb, but not from the section Torkoz Giv.

**Parabolbina** sp.

Figure 5i

*Material.* Two tecnomorph valves (rv, SMF Xe 23034) from sample Torkoz GIV 1 W and one incomplete rv (SMF Xe 23510) from sample FRA-TKZ 4c2, Torkoz area.

*Remarks.* The tecnomorph rv with granulose surface from sample Torkoz GIV 1 W may belong to *Parabolbina kroemmelbeini* Zagora, 1968, but parts of the adventral structure are incomplete. The lateral spine of the second tecnomorph rv from sample FRA-TKZ 4c2 is more distinct compared with the specimen from Torkoz GIV 1 W, but incomplete posteriorly and resembles *Parabolbina* sp. sensu Zagora, 1968.

Superfamily Drepanellacea Ulrich and Bassler, 1923
Family Bolliidae Boucek, 1936

Genus *Bollia* Jones and Holl, 1886

*Type species.* *Bollia uniflexa* Jones and Holl, 1886.

*Important diagnostic features.* (see, e.g., Dojen 2005: p. 69 and text-fig. 8.13). U-shaped lobation, and the preadductorial node $L_1$ and the $L_2$ are ventrally connected through a zygal ridge ($L_{1V}$-$L_{2}$) and a distinct adventral ridge (resp. velate ridge, pseudovelum) along the free margin. Outline preplete to subamplete, $L_1$ mostly larger than $L_2$.

**Bollia azagora** Becker, 2004

1967 *Bollia aff. ungula* JONES 1889—Weyant: p. 119–120, pl. 2, fig. 6; pl. 4, fig. 6.

1968 *Bollia* n. sp. A—K. Zagora: p. 16, pl. 1, fig. 6.

1976 *Bollia aff. ungula* Jones 1889—Weyant: p. 169, pl. 35, figs. 14, 15.

*2004 Bollia azagora* Becker n. sp.—G. Becker et al.: p. 26–27, pl. 3, figs. 15 and 16.

2005 *Bollia azagora* Becker 2004—Dojen: p. 71–73, text-figs. 8.16, 8.17, pl. 4, figs. 1–4 (with synonymy).

*Important diagnostic features.* Amplete to preplete outline; $S_2$ long and deep bending anteroventrally, surrounded by a slightly oblique U-shaped lobal structure (ventral lobe, zygal ridge); adventral ridge (pseudovelum) rather broad. Smooth valve surface.

*Occurrences.* Pragian to Emsian of Europe and North Africa and doubtfully Eifelian of Tarfaya, SW-Morococo (for details, see G. Becker et al. 2004), who cited about ten valves with question mark from Torkoz Giv 1 (= Giv 1B).

**Bollia bezagora** Becker in G. Becker et al. 2004

1968 *Bollia* n. sp. B—K. Zagora: p. 16, pl. 1, fig. 4.

1976 *Bollia cf. ungula* Jones ?—Weyant: p. 169, pl. 35, fig. 13.

*2004 Bollia bezagora* Becker n. sp.—G. Becker et al.: p. 27–28.

2005 *Bollia bezagora* Becker 2004—Dojen: p. 73–76, text-figs. 8.18–8.21, pl. 4, figs. 5 and 6 (with synonymy).

*Important diagnostic features.* Almost amplete outline; $S_2$ long and deep, surrounded by a U-shaped lobal structure (ventral lobe, zygal ridge); adventral structure (pseudovelum) distinct, valve surface smooth.

*Occurrences.* Pragian to Emsian of Europe and North Africa, but not cited from the Torkoz area. The doubtful occurrence in the Eifelian of Algeria is not mentioned in the revision of Maillet et al. (2013).

**Bollia azagora vel bezagora**

Figure 6g–i
Material. More than 25 valves (SMF Xe 22628, Xe 22629, Xe 22781, Xe 22786, Xe 22792–22794, Xe 23513, Xe 23952) from sample FRA-TKZ 4c2, section Hassi Mouf South and more than 20 valves (SMF Xe 23047, Xe 23504) from sample GIV 1 W, section Torkoz.

Two valves have been found in sample FRA-TKZ 4 (e.g., SMF Xe 23497b, slab A, see Fig. 4).
Remarks. Becker (G. Becker et al. 2004: p. 26–27) separated B. azagora and B. bezagora, which are age-equivalent and often co-occurring in the same samples, but their discrimination is insufficiently known. An exact discrimination of the new material from Morocco is unsatisfactory because of the great variation in outline, lobation, and ornamentation. Several specimens from the Torkoz area show a reticulated surface with smooth sulci. The separation of the two species in G. Becker et al. (2004a, b, c, d) is not followed because of the very small number of specimens in the material of K. Zagora (1968) and the questionable assignment of Becker (G. Becker et al. 2004: p. 26) of his own material from sample Torkoz Giv 1.

Bollia lavibadia Becker, 1996

*B1996 Bollia lavibadia n. sp.—G. Becker: p. 144, figs. 6, 7/3–4.

2005 Bollia lavibadia Becker 1996—Dojen: p. 69–70, text-fig. 8.14, pl. 3, fig. 1 (with synonymy).

Material. Nine incomplete valves from sample GIV 1 W, section Torkoz (7 valves SMF Xe 23505, 2 rv SMF Xe 23506).

Important diagnostic features (according to Dojen 2005: p. 70). Prominent knob-like prae-adductor node (\(L_1\)) is distinctly larger than \(L_2\), hemispherical inflated above the slightly angular zygal ridge (resp. ventral lobe).

Occurrences. Early Devonian, Pragian—early Emsian of Northern Spain and now latest Emsian of Morocco, but not mentioned from Morocco in G. Becker et al. (2004).

Bollia? sp. 2 sensu Weyant, 1976

?1963 Londinia? sp. 1—Le Fèvre: pl. 3, fig. 44, pl. 4, fig. 66. 1976 Bollia? sp. 2—Weyant: p. 169, pl. 35, fig. 16.

2005 Bollia? sp. 2 sensu Weyant 1976—Dojen: p. 76–78, text-figs. 8.22, 8.23, pl. 3, figs. 2, 3, 4, 5 and 6 (with synonymy).

Material. Four incomplete valves in sample FRA-TKZ 4c2 (SMF Xe 23960), section Hassi Mouf South with varying lobes are only provisionally assigned to this taxon.

Important diagnostic features. (according to Dojen 2005). Outline of valves semicircular in lateral view; dorso-median lobes large but slim, ventrally indistinctly connected; both lobes anteriorly slightly concave; pseudovelum ventrally indistinct.

Occurrences. Besides the new questionable specimens from the latest Early Devonian of the Torkoz area, Bollia? sp. 2 sensu Weyant, 1976 is known from the middle Lochkovian to early Pragian, Eastern Guadarrama, Spain; Pragian of Aragón, Spain and early Pragian of Armorica, France. Probably “Emsien médian” of Ougarta, Algeria.

Genus Ulrichia Jones, 1890

Type species. Ulrichia conradi Jones, 1890.

Important diagnostic features. Distinct dorso-median lobes (\(L_2\) and \(L_3\)), no connecting lobe, complete adventral structure (marginal ridge, pseudovelum), lateral surface reticulated, granulose or punctate.

Remarks. Two different subgenera have been created because of the different outline and the adventral structure: Ulrichia (Ulrichia) Jones, 1890 und Ulrichia (Subulrichia) Abushik, 1971. It has still to be verified if the often simultaneous occurrences of these two subgenera may be interpreted as sexual dimorphism. U. (Ulrichia) is much more common than U. (Subulrichia) in the material of G. Becker et al. (2004). Thus, U. (Ulrichia) could be considered as the heteromorph form with the possibility of parthenogenesis. On the other hand, the outline of U. (Subulrichia) matches closely the outline of a typical heteromorph. This problem remains unsolved.

Occurrences. Silurian of Canada and doubtful specimens from Gotland, Sweden; Early and Middle Devonian of Europe and North America.
Subgenus *Ulrichia* (*Ulrichia*) Jones, 1890

**Type species.** *Ulrichia conradi* Jones 1890.

**Remarks.** The nearly amplete outline and the adventral structure (= velate ridge or adventral ridge) parallel to the free margin differentiates the subgenus from *Ulrichia* (*Subulrichia*) Abushik, 1971. It is characterised by a preplete outline and an adventral structure which curves posteroventrally onto the lateral surface.

*Ulrichia* (*Ulrichia*) *spinifera* Coryell and Malkin, 1936

*1936* *Ulricha* *spinifera*, new species—Coryell and Malkin: p. 1–3, pl. 1, figs. 1 and 2.

**Remarks.** The differences between the North American and European specimens are discussed, e.g., in G. Becker et al. (2004: p. 28–29).

**Ulrichia* (*Ulrichia*) *spinifera* group

Figure 6m–o

2004 *Ulrichia* (*Ulrichia*) ex gr. *spinifera* Coryell and Malkin, 1933—G. Becker et al.: p. 28–29, pl. 3, figs. 1, 2, 6, 7, 8, 9, 10, 11, 12, 13 and 14 (with detailed synonymy).

2005 *Ulrichia* (*Ulrichia*) ex gr. *U. (U.)* *spinifera* Coryell and Malkin, 1933—Dojen: p. 81–82, text-fig. 8.27.

**Material.** The figured rv SMF Xe 22626 and 4 valves (SMF Xe 23520) from sample FRA-TKZ 4c2, section Hassi Mouf South and the figured rv (SMF Xe 23033) and 4 valves (SMF Xe23514) from sample GIV 1 W, section Torkoz.

**Important diagnostic features.** Outline nearly amplete, dorso-median nodes L2 and L3 varying in shape and size; reticulated lateral surface.

**Remarks.** We consider the European material as a highly varying group closely related to *U. spinifera* from North America.

**Occurrences.** Ostracodes very closely related to the American *U. (U.)* *spinifera* are known from the Early to Middle Devonian of Europe, North Africa, and North America, and were reported by G. Becker et al. (2004) from Torkoz GIV 1.

Subgenus *Ulrichia* (*Subulrichia*) Abushik, 1971

**Type species.** *Ulrichia obliqua* Abushik, 1968.

*Important diagnostic features.** Preplete outline and an adventral structure (marginal ridge) which curves posteroventrally onto the lateral surface.

*Ulrichia* (*Subulrichia*) *fragilis* Warthin, 1934

*1934* *Ulrichia* *fragilis*, sp. nov.—Warthin: p. 213–214, pl. 1, fig. 11.

1968 *Ulrichia* cf. *fragilis* Warthin, 1934—K. Zagora: p. 17, pl. 1, figs. 10, 11, 13.

2000 *Ulrichia* (*Subulrichia*) *fragilis* Warthin 1934—G. Becker: p. 81–82, pl. 1 fig. 1, text-fig. 5/5 (with detailed synonymy).

2015 *Ulrichia* (*Subulrichia*) *fragilis* Warthin, 1934—Olempska et al.: p. 303, fig. 5a–c

**Occurrences.** Widespread in Early and Middle Devonian strata of North America, Europe, and North Africa (Morocco).

*Ulrichia* (*Subulrichia*) *fragilis* group

Figure 6p

v. 2004 *Ulrichia* (*Subulrichia*) *fragilis* Warthin 1934 sensu Zagora 1968—G. Becker et al.: p. 30, pl. 3, figs. 3–5 (with synonymy)

2005 *Ulrichia* (*Subulrichia*) ex gr. *Ulrichia* *fragilis* Warthin 1934—Dojen: p. 83–86, text-figs. 8.29 to 8.32; pl. 5, figs. 1–9.

**Material.** Three valves from sample FRA-TKZ 4c2 (SMF Xe 22627 and SMF Xe 23521), section Hassi Mouf South.

**Important diagnostic features.** Outline preplete; dorso-median node L2 larger than L3 projecting above the dorsal margin. Velar ridge (admarginal rim) parallel to the anterior and ventral margins and curving behind mid-length of the ventral margin up to the posterior lateral surface, but indistinct in the dorsal region; reticulated lateral surface.

**Remarks.** As in *U. spinifera*, the Moroccan material shows great variation.

**Occurrences.** Widespread in Early and Middle Devonian strata of North America, Europe, and North Africa (Morocco) incl. the Early Devonian of section Torkoz II in G. Becker et al. (2004), but not reported from the latest Early Devonian of the Torkoz area.
Late Early Devonian ostracodes from the Torkoz area (SW Morocco) and the Emsian/Eifelian boundary

Family **Aechminidae** Bouček, 1936

Genus **Aechmina** Jones and Hall, 1869

*Type species.* *Aechmina cuspidata* Jones and Hall, 1869.

*Important diagnostic features.* Distinct dorso-median spine, commonly with marginal spines or papillae; no adductorial pit.

**Aechmina** sp. B G. Becker et al., 2004

Figure 6a

2004 *Aechmina* sp. B—G. Becker et al.: p. 32, pl. 7, figs. 7 and 8.

*Material.* Only two valves (SMF Xe 23040, Xe 23519) from sample GIV 1 W, section Torkoz.

*Important diagnostic features.* Distinct dorso-median short, blunt but pointed spine.

*Remarks.* The base of the spine seems to be less pronounced in *Aechmina* sp. B figured in G. Becker et al. (2004) from Torkoz Giv 1B. The spine is broader and shorter as within *Aechmina* aff. sp. A sensu Becker and Sanchez de Posada, 1977 in G. Becker et al. (2004: p. 32).

*Occurrences.* Two left valves from Torkoz Giv 1B (supposed early Eifelian of Morocco in G. Becker et al., 2004), a few valves from Torkoz Giv 16 (early Givetian of Morocco) and questionable specimens from the “Eifelian supérieur” of Ougarta, Algeria (LeFèvre, 1963: pl. 10, fig. 152). In the latest Early Devonian of the Torkoz area, only two specimens have been found in sample Torkoz GIV 1 W and no specimens in sample FRA-TKZ 4c2.

Family **Aechminellidae** Sohn, 1961

*Remarks.* This family was placed within the Drepanellacea by Sohn (1991). Because of the probably dimorphic lateral outline, the suborder and superfamily is unknown (Sohn 1975: G4).

Genus **Balantoides** Morey, 1935

*Type species.* *Balantoides quadrilobatus* Morey, 1935.

*Important diagnostic features.* Small trilobate or quadrilobate ostracodes often with lobes terminating in spines; no marginal rims or frills.

**Balantoides** sp. TKZ

Figure 6c–f

*Material.* Ten valves (SMF Xe 23517) besides the three figured valves (SMF Xe 22630, Xe 22755, and Xe 22756) from sample FRA-TKZ 4c2, section Hassi Mouf South.

*Important diagnostic features.* Small, unrimmed, amplete, trilobate species with elongate, distinct L2 overreaching the dorsal border. The less-pointed L1 and L3 slightly overreaching the DR are ventrally weakly connected. The S3 parallel to the posterior border is much longer than the short S2. The valve surface is reticulated.

*Occurrences.* The new Moroccan material is the first record in the latest Early Devonian. This genus was hitherto known from the Middle Devonian and has not previously been reported from the Devonian of Morocco.

Family **Richinidae** Scott, 1961

*Important diagnostic features.* Bilobate Drepanellacea without marginal rim resp. adventral structure.

*Remarks.* According, e.g., to G. Becker et al. (2004: p. 31)), *Richina* is basically a bolliid genus like *Ulrichia*, but without velum, and therefore no separate family necessary.

Genus **Richina** Coryell and Malkin, 1936

*Type species.* *Richina truncata* Coryell and Malkin, 1936.

*Important diagnostic features.* Bilobate Drepanellacea with distinct L1 and L2, separated by the adductorial sulcus (S2); subcentral protuberance possible, no adventral structures developed.

**Richina** sp. TKZ

Figure 6b

*Material.* Only two rv (SMF Xe 22651 and Xe 23509) with incomplete free margin were found in sample FRA-TKZ 4c2, section Hassi Mouf South.

*Important diagnostic features.* Distinctly lobate and reticulated *Richina*. The anterior lobe is globose with a small tubercle on the top directed anteriorly. The smaller posterior lobe is directed postero-dorsally. Both are separated by the deep S2 above the distinct median protuberance. The surface
of the valve Xe 22,651 is reticulated except on the lobes and sulcus; the second rv is less well preserved. 

Remarks. The lobation of Richina sp. A sensu G. Becker and Groos-Uffenorde, 1982 is comparable to R. kozlowski Krandievsky sensu Abushik, 1971, but the reticulated
Fig. 7 Kirkbyacea from sample FRA-TKZ 4c2, section Hassi Mouf South. a–r Kirkbyrhiza zagofevlazrorum Becker, 2003: a SMF Xe 22782, L = 1.55 mm, lateral view of rv, subtype a; b SMF Xe 22783, L = 1.4 mm, lateral view of lv, subtype a; c SMF Xe 22796, L = 1.15 mm, lateral view of lv, subtype a; d SMF Xe 22787, L = 1.7 mm, lateral view of rv, subtype a; e SMF Xe 22799, L = 1.6 mm, interior view of rv, subtype a; f SMF Xe 22779, L = 1.15 mm, lateral view of ? rv, intermediate of subtype a and b; g SMF Xe 22801, L = 1.3 mm, lateral view of rv, subtype a; h–i SMF Xe 22788, L = 1.5 mm; h tilted interior view and i ventral view of rv, subtype a; j–k SMF Xe 22802, L = 1.25 mm; j tilted interior view of rv, with juvenile valve on the left side and k tilted ventral view, small marginal ridge visible; l SMF Xe 22778, L = 1.2 mm, lateral view of lv, intermediate of subtype a and b; m SMF Xe 22791, L = 1.2 mm, slightly squeezed specimen, subtype b; p SMF Xe 22798, L = 0.65 mm, lateral view of juvenile lv, subtype a; q SMF Xe 23056, L = 0.45 mm, lateral view of juvenile rv, subtype a; r SMF Xe 22803, L = 0.75 mm, lateral view of juvenile rv, subtype b; s–t SMF Xe 22772, L = 0.75 mm, lateral view of rv

surface is lacking in the latter. The lobation is also similar in R. biconica Abushik, 1968 with a less distinct subcentral protuberance. The reticulated Richina sp. B sensu G. Becker and Groos-Uffenorde, 1982 from the latest Early Devonian Heisdorf Formation of the Eifel area, Germany is very similar, but the lobation is less distinct. The related Richina sp. C sensu G. Becker et al. (2004: p. 31) reported from sample Torkoz Giv 1 seems to have a finer reticulation. Richina sp. M41 sensu Dojen, 2005 (only one coarsely pitted silicified right valve from the Early Emsian of Aragón, Spain) is similar, but the lobes are smaller and S2 more narrow.

The number of specimens of the species with open nomenclature is too small for an exact delimitation of species including the evaluation of the variation.

Occurrences. All cited occurrences seem to be restricted to the late Early Devonian (Emsian).

Superfamily Kirkbyacea Ulrich and Bassler, 1926
Family Arcyzonidae Kesling, 1961
Genus Kirkbyrhiza Becker and Lundin, 1995

Type species. Amphissites primaevus Roth, 1929.

Remarks. This North American Middle Devonian genus lacks distinct frill, velar ridge, or carina, and is characterised by a smooth rounded adventral bend. The surface is reticulate.

Becker (see G. Becker et al. 1995 and discussion in G. Becker et al. 2004: p. 33–34) placed the genus Kirkbyrhiza in the Superfamily Kirkbyacea Ulrich and Bassler characterised by the distinct ‘kirkbyan’ subcentral muscle pit within the nonsulcated family Arcyzonidae Kesling.

Occurrences. Late Silurian-to-Early Devonian of the North American Midcontinent and late Early Devonian of Europe and North Africa and questionable occurrences in the Middle Devonian.

Kirkbyrhiza zagofevlazrorum Becker, 2003

Figures 7a–r

1968 Reticestus ? n.sp.—K. Zagora: p. 27–28, pl. 4, figs. 15, 16, 17, 18 and 19.
*2003 Kirkbyrhiza zagofevlazrorum n. sp.—G. Becker: p. 196–198, text-figs. 1/1–2, 2.

v 2004 Kirkbyrhiza zagofevlazrorum Becker 2003—G. Becker et al.: p. 35, pl. 7, figs. 10, 11, 12 and 13 (with synonymy).

Material. More than 40 specimens from sample FRA-TKZ 4c2 (SMF Xe 22778, Xe 22779, Xe 22782, Xe 22783, Xe 22787–22789, Xe 22791, Xe 22796–22803, Xe 23056, Xe 23944), section Hassi Mouf South and more than 30 valves (SMF Xe 23926) of varying size and outline from sample GIV 1 W, section Torkoz, the type locality. The species was defined by Becker (2003) on specimens from sample Torkoz Giv 1B.

Important diagnostic features. Coarsely reticulated surface around an elongate distinct muscle pit below an indistinct S2. The outline and the ornamentation clearly vary. The arrangement of the reticulae may be in rows (parallel to the anterior, ventral, and posterior margins), irregular or with intermediate ornamentation (= indistinct rows). The reticulation is coarser and the sulcation more distinct in juvenile specimens.

Remarks. The valve orientation differs in the literature; according to K. Zagora (1968: pl. 4, fig. 16a), the greatest height is anterior, whereas the right valve of the holotype (refigured in G. Becker et al. 2004: pl. 7, fig. 10) shows a central muscle pit and a higher posterior end. The specimen SMF Xe 22783 from sample FRA-TKZ 4c2 closely resembles the holotype from sample Torkoz Giv 1B.

The reticulation of the Thuringian late Early Devonian Reticestus? n. sp. Zagora, 1968 figured on his pl. 4, fig. 16 is very similar, but the outline is more rectangular. Reticestus sp. A sensu G. Becker (2001a: p. 44) from the late Early Devonian Santa Lucia Formation of northern Spain shows close relations to the Moroccan specimen SMF Xe 22789.
Reticestus acclivitatus Kesling and Weiss, 1953 shows a very similar outline and ornamentation, but differs in a smooth broad marginal bend.

**Occurrences.** Late Emsian (latest Early Devonian) of Thuringia (Germany) and Anti-Atlas (Morocco) and questionable Eifelian of the Massif de Mouthoumet (Southern France) and Ougarta (Algeria).

Family **Kirkbyellidae** Sohn, 1961

**Important diagnostic features.** This family includes small, subquadrate, reticulated, sulcate ostracodes with subventral horizontal lobe terminating in a posterior spine.

The problem of the systematic position of this family is still unsolved as stated, e.g., by G. Becker (1997: p. 37–38), G. Becker et al. (2004: p. 36), and Dojen (2005: p. 105).

**Occurrences.** Silurian to Carboniferous.

Genus **Kirkbyella** Coryell and Booth, 1933

**Type species.** Kirkbyella typa Coryell and Booth, 1933.

**Diagnosis.** (after Sohn 1971: p. 143): Kirkbyellid genus with distinct horizontal lobe, bordered by a distinct smooth unreticulated narrow rim.

**Remarks.** Based on small differences in the ornamentation, the genus *Kirkbyella* has been subdivided into different subgenera, i.e., *Kirkbyella* (Kirkbyella) Coryell and Booth, 1933, *Kirkbyella* (Berdanella) Sohn, 1961 and *Kirkbyella* (Refrahella) Becker, 1967, which nevertheless have later been considered as different genera. The poor new Moroccan material cannot solve the question of subgeneric delimitation.

Genus **Berdanella** Sohn, 1961

**Type species.** Kirkbyella perplexa Wilson, 1935.

**Diagnosis.** (after Sohn 1971: p. 145): Kirkbyellid with indistinct ventral lobe merging with the lateral surface except the posterior pointing spine.

Genus **Refrathella** Becker, 1967

**Type species.** Refrahella struwei Becker, 1967.

**Diagnosis.** Kirkbyellid genus with distinct, comparatively large ventral lobe, surrounded by a crest (cristal loop), in addition lateral and dorsal cristae possible, distinct adventral rim present.

**Berdanella** vel **Refrathella** sp.

**Figure 7s–t**

**Material.** Rare specimens from sample FRA-TKZ 4c2, section Hassi Mouf South (rv, SMF Xe 22772; rv, SMF Xe 22625; 3 lv SMF Xe 23518). The only lv from sample GIV 1 W, section Torkoz (SMF Xe 23935) shows an isolated short carina below the carinated ventral lobe.

**Important diagnostic features.** Subrectangular outline, anterior cardinal angle more rounded than the posterior one, short $S_2$, reticulated surface. The distinctness of the smooth carina on the ventral lobe varies; some specimens show an indistinct carina but with a distinct pointed posterior end on the shallow ventral lobe like *Berdanella* sp. A sensu G. Becker et al. (2004: p. 37) reported from the Moroccan sample Torkoz IIA and Giv 1B.

**Remarks.** The comparatively poor preservation of the ornamentation does not allow an exact determination. The figured specimen SMF Xe 22625 shows a very indistinct shallow cristal loop, which is more distinct in *Refrathella*.

**Occurrences.** Only a few specimens from the Early Devonian (latest Emsian) of the Torkoz area, SW Morocco.

Suborder **Eridostracina** sensu Jones and Olempska, 2013 (= Eridostraca Adamczak, 1961 and Order Eridocopida in Abushik, 1990)

**Remarks.** The multilamellar Eridostraca have been studied, e.g., by Adamczak (1961), K. Zagora (1966), Schallreuter (1968), and thoroughly revised by Olempska (2012) after a controversial discussion on their systematic position. Olempska suggested that the Eridostracina belong to the ostracodes, but are a polyphyletic group, probably comprising ancestors amongst the conchostracans, leperditellids, and beyrichid ostracodes (Olempska 2012: p. 161).

Family **Eridoconchidae** Henningsmoen, 1953

**Important diagnostic features.** Eridostracina with distinct admarginal structures like thickened ridges, rows of tubercles, or small spines at the ventral border of the lamellae.

Genus **Eridoconcha** Ulrich and Bassler, 1923

**Type species.** Eridoconcha rugosa Ulrich and Bassler, 1923.

**Important diagnostic features.** Eridoconchids with prominent umbo and up to 11 lamellae.
**Eridoconcha papillosa** Zagora, 1966

Figure 8a–k

*1966 Eridoconcha papillosa n.sp.—K. Zagora: p. 233–34, pl. 22, figs. 1–8.
1986 Eridoconcha papillosa—K. and I. Zagora: fig. 4 (photo 3).
?1998 Eridoconcha papillosa K. Zagora 1966—G. Becker in Becker and Jansen (1998): p. 205, pl. 1, fig. 21.

**Material.** Abundant in sample FRA-TKZ 4c2 (SMF Xe 22652–22656, Xe 22709, Xe 22711 and > 20 valves in SMF Xe 23528), section Hassi Mouf South and rare in sample GIV 1 W (6 specimens in SMF Xe 23925), section Torkoz

**Important diagnostic features.** Medium-sized suboval-to-nearly round valves with a maximum of 11 lamellae ornamented with an irregular row of tubercles and pustules.

**Remarks.** The size of the valves is larger, the outline is more variable, and the number of lamellae is higher with fewer regular rows of tubercles than in the related species *Eridoconcha spinosa* Zagora, 1966 from the same Thuringian locality as *E. papillosa*. *Eridoconcha cf. rugosa* Ulrich and Bassler sensu K. Zagora, 1966 shows nearly equal number of lamellae, but the spines are indistinct. This species is the only one cited in G. Becker et al. (2004) from the Torkoz area and is also known from Germany (Thuringia).

**Occurrences.** Early Devonian (Late Emsian) of Germany (Thuringia and Mosel area SW of Koblenz) and Torkoz area in SW Morocco, but not reported by G. Becker et al. (2004) from sample Torkoz Giv 1, resp. not mentioned above the Emsian in G. Becker et al. (2004).

Family **Rhabdostichidae** Rusconi, 1954 sensu Jones and Olempska, 2013

(= Cryptophyllidae Adamczak, 1961)

Genus **Cryptophyllus** Levinson, 1951

**Type species.** Eridoconcha oboloides Ulrich and Bassler, 1923.

**Remarks.** According to Schallreuter (2000: p. 834), *Cryptophyllus gibbosum* Harris, 1951 should be the type because of a misinterpretation of *Cryptophyllus oboloides* (Ulrich and Bassler, 1923) by Levinson (1951). See discussion in G. Becker et al. (2004: p. 90). According to Jones and Olempska (2013: p. 346), *Cryptophyllus* may be a junior synonym of *Rhabdostichus* Raymond, 1946. In contrast to *Eridoconcha*, the lamellae of *Cryptophyllus* are smooth. Many species with great variation in the number of lamellae were described from the Ordovician to Carboniferous from all over the world.

**Cryptophyllus** sp. TKZ

Figure 8i–o

**Material.** Rare in sample FRA-TKZ 4c2 (SMF Xe 22657, Xe 22658, Xe 22710 and > 5 valves in SMF Xe 23528), section Hassi Mouf South.

**Remarks.** The specimens from FRA-TKZ 4c2 are closely related to *Cryptophyllus* sp. A sensu G. Becker and Sanchez de Posada, 1977 but lack the short weak sulcus and the less symmetrical outline.

**Occurrences.** Latest Emsian, Torkoz area, SW Morocco.

Suborder **Platycopina** Sars, 1866

Superfamily **Kloedenellacea** Ulrich and Bassler, 1908

Family **Kloedenellidae** Ulrich and Bassler, 1908

**Platycopine** gen. indet. sp. TKZ

**Material.** Only one smooth heteromorph carapace (SMF Xe 22770) of a nonsulcate platycopine ostracode was found in sample FRA-TKZ 4c2, section Hassi Mouf South.

**Remarks.** Sample FRA-TKZ 4c2 and GIV 1 almost lack any platycopine ostracodes, in contrast to many Early Devonian (Emsian) areas with, e.g., *Sulcella* Coryell and Sample, 1932 and sulcate *Poloniella* Gürich, 1896 species.

Suborder, superfamily, and family **unknown**

Genus **Punctoprimitia** Stewart and Hendrix, 1945

**Type species.** Haploprimitia simplex Stewart, 1936.

**Important diagnostic features.** Slightly postplete outline, unisulcate (distinct S2), broad posterior border rising into prominent shoulder, surface punctate.

**Remarks.** The genus *Punctoprimitia* was taken as a primitive genus by Stewart, and Hendrix (1945: p. 90), but, e.g., Becker and Sanchez de Posada (1977: p. 146) and Adamczak (2003: p. 2) classified *Punctoprimitia* as a questionable kloedenellid genus. K. Zagora (1968: p. 33) included *Punctoprimitia* within the Leperditellacea Ulrich and Bassler, 1906 resp. Leperditellidae Ulrich and Bassler, 1906, because it lacks kloedenellid dimorphism. Weyant (1967: p. 130) placed the genus with reservations in the Kloedenellidae because of the dimorphism in the outline of *P. europaea* from the Early Devonian of North France.
We agree with Adamczak (2003: p. 6) that the higher taxonomy of the genus *Punctoprimitia* is still ambiguous, and further investigations are necessary.

*Punctoprimitia* sp. TKZ

Figure 9a–e

![Images of *Punctoprimitia* sp. TKZ](image)

Material. Abundant in sample FRA-TKZ 4c2 (SMF Xe 22644, Xe 22646–22648, Xe 22804, Xe 22805, Xe 23943)
and more than 30 valves SMF Xe 23507), section Hassi Mouf South and rare in sample GIV 1 W (SMF Xe 23524), section Torkoz.

Important diagnostic features. Relatively small unisulcate species with straight dorsal border, subrectangular outline and a distinct posterior shoulder in front of a carapace depression. A very faint reticulation is sometimes visible.

Remarks. The outline of the closely related late Early Devonian Punctoprimitia cf. simplex (Stewart, 1939) sensu K. Zagora, 1968 from Thuringia, Germany seems to be more suboval and the position of the shoulder nearer to the posterior border as in P. cf. simplex sensu G. Becker and Sanchez de Posada, 1977 from the latest Early Devonian of Asturias, Spain. The larger Punctoprimitia africana Becker, 1998 is characterised by a less pronounced posterior shoulder and less distinct sulcus. The much larger P. europaea Weyant, 1967 differs in the more semicircular outline, the coarse reticulation and smaller shoulder. Because a distinct reticulation is absent, we prefer open nomenclature. Only the valves SMF Xe 22645 and 22649 show a weak ornamentation, their indistinct posterior shoulder without a depression between the shoulder and the posterior border points to juveniles of Punctoprimitia ? aff. europaea.

Occurrences. Known from the Early Devonian (latest Emsian) of the Torkoz area in SW Morocco.

Punctoprimitia europaea Weyant, 1967

*1967 Punctoprimitia europaea n. sp.—Weyant: p. 129–131, pl. 2 figs. 8, 9, pl. 4, fig. 3.
2005 Punctoprimitia europaea Weyant 1967—Dojen: p. 116–118, text-fig. 8.64, pl. 8, figs. 7–10 (with synonymy).

Important diagnostic features. Outline semicircular with median, deep S2, lateral surface coarsely reticulated, depression between the distinct shoulder and the posterior border.

Occurrences. Early Devonian (middle Pragian-to-early Emsian) of northern France and Spain.

Punctoprimitia ? aff. europaea Weyant, 1967

Figure 9f–l

v 2004 Genus 1 sp. A—Becker et al.: 74, pl. 10, fig. 16.

Material. the late Eifelian sample Torkoz Giv 10 (Yeraifa Formation FRA-TKZ 4c2 (e.g., SMF Xe 22633, SMF Xe 22642, SMF Xe 22643, SMF Xe 22650, SMF Xe 22780, SMF Xe 22784, SMF Xe 23942), section Hassi Mouf South and sample GIV 1 W (SMF Xe 23048 and SMF Xe 23508), section Torkoz, and poorly preserved valves from sample Tor Eif/2d from section Hassi Mouf South.

Occurrences. Known only from the Early Devonian (latest Emsian) of the Torkoz area in SW Morocco.

Genus 2 sp. B Becker et al., 2004

Remarks. G. Becker et al. (2004: p. 74) reported one lv from the late Eifelian sample Torkoz Giv 10 (Yeraifa Formation, SW Anti-Atlas, Morocco) with paraparchitid appearance and coarse reticulation, but because of the distinct adductorial sulcus (S2), the placement within the paraparchitids cannot be followed herein.

Genus 2 sp. TKZ

Figure 9m

Material. The figured valve SMF Xe 23051 and one fragment (SMF Xe 23524) from sample GIV 1 W, section Torkoz.

Remarks. The relatively large valve with distinct and long S2 differs from Genus 1 sp A sensu G. Becker et al. 2004 (see remarks about Punctoprimitia aff. europaea in P. sp. TKZ) in the more elongate outline and the lack of the distinct reticulation, perhaps caused by recrystallisation.

It has to be verified if the single specimen of Genus 2 sp. B sensu G. Becker et al. (2004) from the Moroccan sample Torkoz Giv 10 with indistinct reticulation may belong to the same taxon.

We prefer open nomenclature because of the poor material and unknown dimorphism.

Order Podocopida Sars, 1866
Suborder Metacopina Sylvester-Bradley, 1961
Superfamily Healdiacea Harlton, 1933
Family Healdiidae Harlton, 1933

Remarks. The holosolenic (= contact groove connected with hinge groove) contact groove of the larger left valve is the most important feature. The outline is subtriangular-to-subovate. Posterior shoulder with spines and anterior ridge are possible. K. Zagora (1968: p. 39) reported for the first time calcified inner lamella and vestibulum in the late Early Devonian Healdia kirchbergensis K. Zagora, 1968 and Healdia sigmoidalis I. Zagora, 1968, but this could not be verified in the new Moroccan material.

Because, the poor preservation of the internal structures (e.g., the typical contact groove) of the specimens is not visible and an exact determination is impossible. Different
species of *Healdia* have been published from the late Early Devonian of Thuringia, but they differ in the outline and reticulation pattern.

Genus **Bythocyproidea** Stewart and Hendrix, 1945

Type species. **Bythocyproidea sanduskyensis** Stewart and Hendrix, 1945.

**Remarks.** A detailed description and delimitation of **Bythocyproidea** was discussed in G. Becker et al. (2004: p.42–43). This genus is known from Early and Middle Devonian strata of Europe and Middle Devonian of Morocco, but has not been reported from the Emsian of Thuringia.
Material. Rare specimen from sample FRA-TKZ 4c2 (rv SMF Xe 22631, rv Xe 23052 and corroded rv 23054) section Hassi Mouf South.

Important diagnostic features. One row of subrectangular distinct pits behind the curved anterior rim and shallow elongate pits in front of the nearly vertical posterior rim and the posterior part of the lateral surface.

Remarks. Described species of Bythocyproidea Stewart and Hendrix, 1945 are related, but they differ in the smaller and more elongate pits and less distinct ribs. Bythocyproidea polaris (Gürich, 1896) known from the Early and Middle Devonian of Europe and North Africa and recorded from the Middle Devonian of the Torkoz area was not reported from sample Torkoz Giv 1 in G. Becker et al. (2004).

Bythocyproidea ? sp. 2

Figure 10e–j

Material. Rare specimen from sample FRA-TKZ 4c2 (rv SMF Xe 22712 and lv SMF Xe 22767), section Hassi Mouf South.

Diagnostic important features. In contrast to Bythocyproidea ? sp. 1, the reticulation covers the surface between the anterior rim and distinct posterior shoulder and the broadly spaced reticulae are nearly round (less elongate) with distinct pore canals. The spacing of the pits in the row behind the anterior margin is not as close as in sp. 1.

Remarks. The ornamentation of Favulella Swartz and Swain, 1941 covers the complete lateral surface except the very distinct, more rounded extramarginal ridge and the large muscle spot.

Bythocyproidea ? sp. 3

Figure 10k–l

Remarks. The figured specimens from sample FRA-TKZ 4c2 (rv SMF Xe 22713 and lv Xe 22714) from section Hassi Mouf South show a more elongate outline (like quassilitids) and a row of pits behind the curved anterior rim (like Bythocyproidea ? sp. 1) besides a distinct short posteroventral spine. The less distinct posterior reticulation may be due to preservation.

Superfamily Thlipsuracea Ulrich, 1894
Family Thlipsuridae Ulrich, 1894
Genus Polyzygia Gürich, 1896

Type species. Polyzygia symmetrica Gürich, 1896.

Important diagnostic features. Bas-relief sculpture, which is characterised by the S-formula (mostly five vertical sulci and one horizontal sulcus) since Michel (1972) and used to discriminate species. The lateral outline varies from subrectangular to subtriangular and ovoid.

Remarks. In the following text, the terminology is used after Michel (1972) and Adamczak (1971) in Dojen (2005). The sulci are numbered (S₁–S₅ and Sᵥ), and used for the S-formula sensu Michel (1972) to discriminate species in the Moroccan Polyzygia specimens. The broad anterior and posterior marginal structures (ridges or flange-like) are often not preserved, and therefore, the complete outline is not exactly known. Well-preserved anterior marginal structures are visible, e.g., on the figured valves (rv SMF Xe 22677, lv SMF Xe 22681, rv SMF Xe 22684, rv SMF Xe 22691, and lv SMF Xe 22727). The exact species determinations of juvenile valves of Polyzygia is difficult (five specimens SMF Xe 23954 and two specimens SMF Xe 23951, all from sample FRA-TKZ 4c2). The surface morphology of juvenile valves is often not completely developed. The S₁ and S₃ are very distinct and the Sᵥ is indistinct or missing. The sulcation shows close relations to Thlipsurella species without the distinct lobes of Polyzygia (see SMF Xe 23055 juv. Polyzygia vel Thlipsurella ? sp.). Some juvenile valves from sample FRA-TKZ 4c2 are assigned to Polyzygia symmetrica – antecedens group (see Fig. 12v–w) because of the distinctly inclined Sᵥ.

Occurrences. Polyzygia species are widespread in the Early-to-Late Devonian of Europe and North Africa. Their stratigraphical importance was summarised by Groos-Uffenorde et al. (2000: p. 106), and the drawings of these species were later used by G. Becker (2001b: p. 454) and G. Becker et al. (2003: p. 46) in the figure of the “insculpta line” with biostratigraphically important taxa.

Some Polyzygia species are restricted to the Early Devonian like P. vinea, P. kroemmelbeini, P. insculpta beckeri, and P. nomannica sensu stricto, and these species are very useful for biostratigraphy and correlation. More detailed studies on the variation of Polyzygia symmetrica s.l. (P. symmetrica group including the late Early Devonian P. symmetrica triebeli) are necessary to verify a possible stratigraphical tool for defining the Early/Middle Devonian boundary.

Polyzygia symmetrica Gürich, 1896

Figure 11

* 1896 Polyzygia symmetrica sp. n. Gürich—Gürich: p. 387–388, pl. 14, figs. 8 and 9.
1972 Polyzygia symmetrica Gürich, 1896—Michel: p. 229–231, fig. 33a, pl. 12, fig. 3.
2004 Polyzygia symmetrica Gürich 1896—G. Becker et al.: p. 46–47 (with synonymy).
Important diagnostic features. Distinctly lobate species with subrectangular outline, \( L_1 \) and \( L_4 \) ventrally connected with a relatively straight ventral lobe \( L_5 \), well-developed knob-like \( L_2 \) and varying \( L_3 \). S-formula \( S_1, S_2, S_3, S_4, S_5 \). Remarks. *Polyzygia grekoffi* differs in the more bow-shaped admarginal rim and \( S_e \) and the narrow \( L_3 \) is not ventrally isolated.
In sample FRA-TKZ 4c2, there are a lot of *P. symmetrica* specimens with varying outline and varying lobation similar to those figured by Michel (1972: e.g., Figure 13) from the Santa Lucia Formation (latest Early Devonian of Spain).

**Polyzygia symmetrica** group

Because of the differences in the shape and development of the lobation—details and additional material will be described by Dojen et al. (in prep.)—the specimens from the new Moroccan collections are provisionally grouped into different morphotypes:

a. with nearly equal-sized L2 and L3 ventrally isolated and not connected with the Lv, see *P. symmetrica symmetrica* Gürich, 1896,

b. with narrow L3, ventrally connected with the Lv and not isolated, see *P. symmetrica triebeli* Becker 1994,

c. with carina on the narrow elongate L3, see *P. symmetrica* var. *carinata* var. nov.

**Occurrences.** Latest Emsian (Early Devonian)-to-Middle Devonian of Europe and North Africa. Besides specimens from Eifelian samples, G. Becker et al. (2004: p. 46) listed a few valves from sample Torkoz Giv 1, and later, some specimens have been found in sample FRA-TKZ 4c2, both from the Torkoz area.

**Polyzygia symmetrica symmetrica** Gürich, 1896

1995 *Polyzygia symmetrica symmetrica* Gürich 1896—G. Becker: p. 129.

**Material.** Relatively rare in sample FRA-TKZ 4c2 (SMF Xe 22674, Xe 22730, Xe 22733, Xe 22734, Xe 22740, Xe 22739, partly broken SMF Xe 22738) from section Hassi Mouf South.

**Important diagnostic features.** *Polyzygia symmetrica* with well-developed knob-like L2 and varying L3 both ventrally not connected with the ventral lobe. S-formular: $S_1-S_v-S_5-S_4$. $S_1-S_v-S_5-S_4-S_3$. $S_4$.

**Remarks.** The outline of the valves and the position and the shape of the lobes L3 and L5 vary (see, e.g., Adamczak 1956, 1971, and Michel 1972).

**Occurrences.** Late Early Devonian (latest Emsian) and Middle Devonian of Europe and North Africa.

**Polyzygia symmetrica triebeli** Becker, 1995

Figure 12e–g

1972 *Polyzygia symmetrica* Gürich, 1896—Michel: p. 229–231, fig. 33d, e, pl. 12, fig. 1.

1994 *Polyzygia symmetrica triebeli* Becker 1994—G. Becker: p. 420, figs. 4 and 5.

1995 *Polyzygia symmetrica triebeli* n. subsp.—G. Becker: p. 129, figs. 2 and 3.

2004 *P. s. triebeli* Becker 1994—G. Becker et al.: p. 47.

The holotype was first named and figured by Becker (1994), but the diagnosis followed in G. Becker (1995).

**Material.** Only three partly incomplete valves (SMF Xe 22689, Xe 22735, Xe 22736) from sample FRA-TKZ 4c2, section Hassi Mouf South.

**Important diagnostic features.** A subspecies of *Polyzygia symmetrica* with relatively large, knob-like L2, isolated dorsally and ventrally. L3 narrow and dorsally and ventrally not isolated resp. ventrally connected with the Lv. S-formula: $S_1-S_v-S_5-S_4$.

**Remarks.** *Polyzygia greekoffi* differs in L2 not ventrally isolated and a more bow-shaped Sv and Lv.

In *P. symmetrica symmetrica*, the L2 and L3 differ less in shape and both are isolated from the Lv.

**Occurrences.** Late Early Devonian of Northern Spain (Santa Lucia Formation) and North Africa (SW Morocco). G. Becker et al. (2003: p. 41) listed a closely related form from section Torkoz IIb (Late Early Devonian of SW Morocco), but not cited from sample Torkoz Giv 1.

**Polyzygia symmetrica** var. *carinata* var. nov.

Figure 12h–n

2004 *P. s.* var. *carinata* n. subsp.—G. Becker: p. 129, figs. 2 and 3.

The holotype was first named and figured by Becker (1994), but the diagnosis followed in G. Becker (1995).

**Material.** More than ten specimens (SMF Xe 22687, Xe 22688, Xe 22690, Xe 22725, Xe 22726, Xe 22728, Xe 22729, Xe 22732, Xe 22741 and questionable specimen Xe 22683) from sample FRA-TKZ 4c2, section Hassi Mouf South and only SMF Xe 23035 from sample Torkoz GIV 1 W, section Torkoz.

**Important diagnostic features.** *Polyzygia symmetrica* with a distinct and isolated, relatively large L2. The L3 is narrow with a nearly vertical rib, dorsally connected but (sometimes
Polyzygia normannica–antecedens group

Figure 12o–w

Material. Many specimens (SMF Xe 22677, Xe 22678, Xe 22680, Xe 22681, Xe 22691, Xe 22727, and >5 specimen from SMF Xe 23950) from sample FRA-TKZ 4c2, section Hassi Mouf South and 5 specimens (SMF Xe 23037, Xe 23044 and 3 valves in SMF Xe 23934) from sample GIV 1 W, section Torkoz.

Remarks. This variable group is characterised by reticulated lobes L1 and L4, a small L2 and a narrow L3. Because of the ongoing discussion on the independence of P. beckmanni antecedens and P. normannica, all reticulated Polyzygia specimens from the new Moroccan samples from the Torkoz area are cited as P. normannica–antecedens group.

The oldest representative of this group is Polyzygia normannica Weyant, 1967 in the Early Devonian. The relatively small L2 of this species is ventrally connected to the ventrally straight lobe, the S4 is very short, and the L4 is large and reticulated. The youngest representative of this group is Polyzygia beckmanni beckmanni Krömmlbein, 1954 common in the late Middle Devonian (latest Givetian) and early Late Devonian (earliest Frasnian). This less elongate species is characterised by distinctly edged ridges and a long and curved L5. There is no great difference in the size and shape of L2 and the reflected image of L4. Polyzygia beckmanni antecedens Zagora, 1968 was separated, because the round L2 is only slightly connected ventrally, and L3 is straight, narrow, and connected dorsally and ventrally. This taxon is reported from Early Emsian to Givetian strata of Europe. In contrast to G. Becker (1989: p. 143), Michel (1972: p. 225) did not accept the separation of the subspecies of K. Zagora (1968) because of the great variation within the type material of P. beckmanni.

Polyzygia sp. ex gr. P. antecedens of Dojen (2005) is characterised by distinctly bordered rather straight and narrow lobes and sculptured L2. The outline and ornamentation of the Early Devonian Polyzygia sp. 1 sensu Lethiers et al. (1985) is comparable to P. normannica and P. beckmanni antecedens, but in addition, the L1 and L4 are surrounded by a distinct, but narrow rib. The Early Devonian (Pragian-to-Early Emsian) Polyzygia vinea Michel, 1972 with reticulated lobes can be distinguished by its differing sulcation and reduced L5.

Occurences. The new material comes from the Early Devonian (latest Emsian) of the Torkoz area in SW Morocco.

Polyzygia grekoffi Weyant, 1980

Figure 12x

1966 Polyzygia sp. A—Weyant: p. 126—127, pl. 3, fig. 8, pl. 5, fig. 5.
1980 *Polyzygia grekoffi* n. sp.—Weyant: p. 281, pl. 37, figs. 1–3, 5, 6 and 8.
2005 *Polyzygia grekoffi* Weyant 1980—Dojen: p. 145–146, text-figs. 8.92–8.94, pl. 12, figs. 13–17 (with synonymy).

**Material.** Only three specimens from sample FRA-TKZ 4c2 (SMF Xe 22672, Xe 22675, questionable specimen Xe 22673), section Hassi Mouf South.

**Important diagnostic features.** Lobes relatively narrow and subvertical, S4 long, Sv bow-shaped. S-formula: S1–S5–S4, S2–S3.

**Remarks.** In contrast to *P. symmetrica*, the Sv is more bow-shaped. A few specimens from FRA-TKZ 4c2 are characterised by small elongate lobes L2 and L3, similar to fig. 8.92b in Dojen (2005).

**Occurrences.** Early Devonian of Europa and N-Africa. G. Becker et al. (2004: p. 46) cited *P. grekoffi* only from the Moroccan Late Emsian Khebchia Formation of the Torkoz IIa section. Due to the poor preservation, G. Becker (1989: p. 142–143) himself questioned the determination of his specimens from the Polentinos Formation and the Gustalapiedra Formation (Late Emsian-to-Early Eifelian) of Palencia (Spain). The lowermost Middle Devonian occurrences have to be verified (doubtful Hobräck Formation from Germany in Groos (1969) and ‘Eifélien supérieur’ from Ougarta), but *P. grekoffi* is not reported by Maillet et al. (2013) from the Ougarta Range in Algeria.

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1968 *Polyzygia insculpta beckeri* K. Zagora, 1968

**Figure 12y-bb**

1963 *Polyzygia kroemmelbeini*—LeFèvre: p. 149–151, pl. 2, fig. 28 [nom. nudum].

1967 *Polyzygia kroemmelbeini* n. sp. LeFèvre & Weyant—Weyant: p. 124–126, pl. 3, figs. 4–6, pl. 5, fig. 3.

2004 *Polyzygia kroemmelbeini* LeFèvre & Weyant 1966—G. Becker et al.: p. 45, pl. 4, figs. 1 and 2 (with synonymy).

2005 *Polyzygia kroemmelbeini* LeFèvre & Weyant 1967—Dojen: p. 143–145, text-figs. 8.89–8.91, pl. 12, figs. 6–12.

2010 *Polyzygia kroemmelbeini*—Dojen et al.: table 1.

**Material.** More than 40 valves (SMF Xe 22676, Xe 22679, Xe 22685, Xe 22686) from sample FRA-TKZ 4c2, section Hassi Mouf South and 3 valves from sample GIV 1W (SMF Xe 23039, Xe 23939), section Torkoz.

**Important diagnostic features.** One continuous sulcus beginning and ending separately in the anterior part of the valve, with S-formula sensu Michel (1972): S1–S5–S4–S3–S2.

**Occurrences.** Restricted to the Early Devonian (Pragian—late Emsian) of Europe and N-Africa. G. Becker et al. (2004: p. 45) cited the species only from section Torkoz II, but not from section Torkoz Giv. Material from Poland was originally dated as Middle Devonian (Grzegorzowice Formation sensu Adamczak 1968 and 1976), but later, the latest Emsian age was verified by conodonts (Malec and Turnau 1997), only the uppermost beds were dated as basal Eifelian.

**Genus Favulella** Swartz and Swain, 1941

**Type species.** *Bythocypris favulosa* Jones, 1889.

**Important diagnostic features.** (according to G. Becker 2001a: p. 63). Submarginal structure (carina, ridge) extending to the dorsal margin; posterior spine possible; lateral surface reticulated; adductorial area smooth.
Late Early Devonian ostracodes from the Torkoz area (SW Morocco) and the Emsian/Eifelian boundary

**Favulella frankenfeldi** Becker, 1989

Figure 13e–g

*1989 Favulella frankenfeldi* n.sp.—G. Becker: p. 155, pl. 5, figs. 1–2, pl. 7, fig. 8, pl.10, figs. 5–6.
2004 *Favulella frankenfeldi* Becker, 1989—G. Becker et al.: p. 51, pl. 4, fig. 16.
2005 *Favulella frankenfeldi* Becker, 1989—Dojen: p. 152.

**Material.** Rare in sample FRA-TKZ 4c2 (SMF Xe 22635, Xe 22641, Xe 22670), section Hassi Mouf South and 5 valves (SMF Xe 23629) in sample GIV 1 W, section Torkoz. The preservation of the ornamentation varies most probably caused by the recrystallisation.

**Important diagnostic features.** Outline subrectangular, distinct anterior and posterior extramarginal ridge, surface between the ridges reticulated except the smooth muscle area and the dorsal and ventral margins.

**Remarks.** The late Early Devonian *Favulella perrumpta* Becker, 2001 from Spain is closely related, but differs in the more egg-shaped outline and the very coarse reticulation. The smooth extramarginal ridge/rim parallel to the borders is less velum-like and the outline less *ropolonellid* compared with those of *Leptoprimitia* Kummerow, 1953.

**Occurrences.** Early Devonian (Emsian) and Middle Devonian (Eifelian) of Spain and Morocco. Hitherto only known from the early Emsian of the Torkoz area (Torkoz IIa of G. Becker et al. 2004), the new Moroccan material is of late Emsian age.

**Favulella ? sp.**

Figure 13h

**Remarks.** Some specimens in sample FRA-TKZ 4c2, section Hassi Mouf South, have a distinct anterior and posterior marginal rim (SMF Xe 22724) and often indistinct reticulation, perhaps due to preservation resp. recrystallisation.

Genus **Ponderodictya** Coryell and Malkin, 1936

**Type species.** *Leperditia punctulifera* Hall, 1860.

**Important diagnostic features** (after Dojen 2005: p. 156). Outline suboval; hinge line depressed; ridges and spines frequently developed, particularly in the smaller RV; lateral surface reticulate or punctate; larger left valve with internally a mid-ventrally interrupted contact groove and with small bow-shaped projection.

**Remarks.** The family assignment of *Ponderodictya* is still uncertain; see, e.g., G. Becker et al. (2004: p. 52).

**Ponderodictya** sp. GIV

Figure 13a

**Material.** Only the figured lv of SMF Xe 23050 from sample GIV 1 W from section Torkoz is well preserved. The specimen SMF Xe 22750 from sample FRA-TKZ 4c2 is less well preserved and, therefore, only provisionally included.

**Important diagnostic features.** Oval outline, reticulated surface, smooth adductor muscle scar, posterodorsal and posteroventral spine and indistinct ridge parallel to the anterior end.

**Remarks.** *Ponderodictya aggeriana* Groos, 1969 and *P. punctulifera* (Hall, 1860) seem to be related, but differ in a more elongate outline. Dojen (2005) figured on pl. 14 *Ponderodictya* sp., ex gr. *P. aggeriana* Groos, 1969 from the Early Devonian (Pragian) of Aragon with varying outline and sculpture comparable to the latest Early Devonian material of *Ponderodictya* from the Torkoz area.

G. Becker et al. (2004: p. 52) reported a few specimens of *Ponderodictya* sp. indet from sample Giv 1B and Giv 5, section Torkoz.

**Ponderodictya ? sp.**

Figure 13b

**Remarks.** Only one left valve (SMF Xe 23049) from sample Torkoz GIV 1 W was found without reticulation (perhaps due to preservation?).

**Ponderodictya ? sp. TKZ**

Figure 13c, d

**Material.** The figured lv of SMF Xe 22717 and SMF Xe 22766 from sample FRA-TKZ 4c2, section Hassi Mouf South.

**Remarks.** The relatively large smooth muscle area instead of a muscle spot resembles *Ponderodictya*, but the outline of *Ponderodictya* is more egg-shaped, the posterodorsal angle less distinct. The straight dorsal border and the posterodorsal and posteroventral short blunt spine resemble *Jenningsina* Coryell and Malkin, 1936, but the distinct ribbing pattern of the latter is missing. The outline and posterior spines resemble those of the Healdiidae, but these do not show a large muscle spot and are characterised by a more distinct posterior shoulder.

**Family Quasillitidae** Coryell and Malkin, 1936

Genus **Quasillites** Coryell and Malkin, 1936
This genus with posteroventral and/or posterodorsal spines was subdivided in G. Becker et al. (2004) into the following subgenera:

**Quasillites (Quasillites)** without any shoulder, including the nonlobate type species *Qu. obliquus* Coryell, and Malkin, 1936 with posteroventral spine.

**Qu. (Jennillites)** Becker, 1989, including the nonlobate type species *Qu. (Jennillites) umerus* Becker, 1989, posterior spines connected by a ridge-bearing shoulder.

**Qu. (Beckjennites)**, including the lobate type species *Qu. (Beckjennites) chimaera* Becker 2004 with two posterior spines.

**Qu. (Beckmannillites)** with a small subcentral node, including the lobate type species *Qu. (Beckmannillites) beckmanni* Becker, 1988 without spines.

**Quasillites (Beckmannillites)** Becker, 1988

Type species. *Quasillites (Beckmannillites) beckmanni* Becker, 1988.
Remarks. According to G. Becker et al. (2004: p. 52), this subgenus comprises only the Middle Devonian type species from the Cantabrian Mountains (Spain). G. Becker (1988: p. 414) discussed the relationship to the Lower Devonian Quasillites bohemicus Přibyl, 1967. His presumption, that "Quasillites " bohemicus Přibyl, 1967 in Groos-Uffenorde and Jahnke (1973: p. 92) is a phyletic precursor of Quasillites (Beckmannillites) is not accepted because of the different ornamentation and outline. In contrast, it belongs to a hitherto unnamed new genus as proposed by Groos-Uffenorde in Groos-Uffenorde and Jahnke (1973: p. 92).

**Quasillites (Beckjennites) Becker, 2004**

*Type species.* Quasillites (Beckjennites) chimaera Becker, 2004 in G. Becker et al. (2004: p. 53–54).

*Important diagnostic features.* Lobate quasillitid with reticulated surface and posteroventral and posterodorsal spines.

*Remarks.* The type species is characterised by distinct posterodorsal and posteroventral spines in front of the posterior ridge.

*Occurrences.* Only known from type locality Assa Giv 9, early Givetian Yeraifa Formation, SW Morocco.

**Quasillites (Beckjennites) gebeckeri** Groos-Uffenorde sp. nov. Figure 14a–m

*Derivation of name.* Named after Gerhard Becker, who listed this taxon for the first time from the Late Emsian of the Torkoz IIa section (SW Morocco) as Quasillites (aff. Beckmannillites) sp. 22 in Jansen et al. (2004: p. 80).

*Holotype.* Left valve, Fig. 14a, SMF Xe 22768, L = 0.8 mm, H = 0.48 mm.

*Paratypes.* SMF Xe 22659–Xe 22666, SMF Xe22769, SMF Xe 22773, SMF Xe 22776 from sample FRA-TKZ 4c2, section Hassi Mouf South.

*Type locality.* Crinoid Marl Member, Lower Yeraifa Formation, Hassi Mouf South, Torkoz area, Dra Valley, SW Anti-Atlas, Morocco.

*Material.* Silicified, often incomplete valves (SMF Xe 23526) relatively abundant in sample FRA-TKZ 4c2, section Hassi Mouf South and only three damaged valves (SMF Xe 23527) from sample GIV 1 W, section Torkoz.

**Diagnosis.** Lobate Quasillites with fine corrugate ornamentation, posteroventral and posterodorsal short spines.

*Description.* Subrectangular outline, anterior rim and posterior shoulder, distinct knob-like L₂, posterodorsal and posteroventral short and blunt spines at the end of the posterior shoulder. The corrugate ornamentation covers the lateral surface consisting of thin ribs and thin furrows nearly parallel to the anterior end and diverging posteriorly. Complete specimens show a distinct broad, smooth velate structure parallel to the anterior margin with tubercles at the border. The anterodorsal end of the anterior rim is more or less elevated, sometimes as a blunt spine.

*Remarks.* The distinctness of the ornamentation and lamination varies. The smooth muscle area is not always visible. The posterior shoulder and anterior rim are more distinct in the type species Qu. (Beckjennites) chimaera Becker, 2004, and its posterior spines are isolated in front of the posterior margin.

*Occurrences.* Known from the late Early Devonian of the Torkoz area, Anti-Atlas in SW Morocco.

**Genus Jenningsina Coryell and Malkin, 1936**

*Type species.* Graphiodactylus catenulatus van Pelt, 1933.

*Important diagnostic features.* Carapace outline kidney-shaped to subovate; posterior shoulder without spines; surface ornamentation of horizontal or vertical ribs.

*Remarks.* According to G. Becker (2001a: p. 64–65), Jenningsina is characterised within the family Quasillitidae by the distinct posterior shoulder, whereas Graphiadactylus Roth, 1929 [= Graphiadactyllis Roth, 1929] and Eriella Stewart and Hendrix, 1945 are not used uniformly (mostly for spine-less forms). Quasillitids with posteroventral and/or posterodorsal spines are classified as Quasillites Coryell and Malkin, 1936. Costatia Polenova, 1952 is considered as a younger synonym of Jenningsina (for further information, see G. Becker 2001a: p. 65). Svantovites Pokorny, 1950 was classified as Quasillitidae lacking a distinct shoulder and vertical ribs.

*Jenningsina* specimens from the Torkoz area are very often found as carapaces in contrast to most of the accompanying taxa.

**Jenningsina catenulata** (van Pelt, 1933) Figure 15a–d
*1933 Graphiodactylus catenulatus—van Pelt: p. 333–334, pl. 39, figs. 31, 32.
2004 Jenningsina catenulata (van Pelt 1933)—G. Becker et al.: p. 56, pl. 10, fig. 7 (with detailed synonymy).

Material. More than 14 valves in sample FRA-TKZ 4c2 (SMF Xe 22669, Xe 22671, Xe 23041, Xe 23042, and > 10 valves in Xe 23,959), section Hassi Mouf South, and 22 valves in sample Torkoz GIV 1 W (SMF Xe 23930, Xe 23965), section Torkoz.

Important diagnostic features. Subrectangular outline, surface with delicate, longitudinal ribbing pattern narrow spaced and diverging backwards (more in the upper part, than in the lower part of the valves), adductor muscle spot very small.

Remarks. Jenningsina levis Zagora, 1968 from the latest Emsian Tentaculitenschiefer of Thuringia was included in *J. catenulata* by Adamczak (1976: p. 364).
Occurrences. Widely distributed in the Givetian of North America and in the Middle Devonian of Europe and latest Early Devonian (Grzęgorzowice Formation) of Poland. One right valve was figured from Torkoz Giv 1 in Becker et al. (2004: pl. 10, fig. 7).

*Jenningsina* cf. *catenulata* (van Pelt, 1933) was cited in Maillet et al. (2013) at the Emsian/Eifelian boundary (sensu LeFèvre 1963, 1971) in Algeria.

*Jenningsina thuringica* Zagora, 1968

Figure 15e, f

1968 *Jenningsina thuringica* n.sp.—K. Zagora: 46–47, pl. 10, figs. 12, 13, 15–18.

1998 *Jenningsina thuringica* K. Zagora 1968—G. Becker: p. 36, pl. 4, figs. 1–5 (with synonymy list).

Material. Only the figured carapace from sample FRA-TKZ 4c2 (SMF Xe 22667), section Hassi Mouf South.

Remarks. This species differs from *J. catenulata* (van Pelt, 1933) in the more lens-like ribbing pattern. According to Adamczak (1968: p. 364), the Polish *J. catenulata* with noteworthy variability ‘is only indistinctly separable’ from the European (Thuringia and Eifel Mountains) and Algerian forms.

Occurrences. Late Emsian of Thuringia, Spain and Morocco, but not cited from the Torkoz area. According to Dojen et al. (2011: p. 54), *J. thuringica* disappears worldwide ‘at the Chotec Event, approx. Emsian/Eifelian boundary’.

*Jenningsina* cf. *thuringica* Zagora, 1968

Figure 15g–i

Material. Very rare in sample FRA-TKZ 4c2 (SMF Xe 22668), section Hassi ouf South and sample GIV 1 W (SMF 23940) from section Torkoz.

Remarks. The ribbing pattern is partly recrystallised and may be less lense-like as in *J. thuringica*.

Family *Ropolonellidae* Coryell and Malkin, 1936

Genus *Leptoprimitia* Kummerow, 1953

Type species. *Leptoprimitia compressa* Kummerow, 1953.

Important diagnostic feature. Subrectangular, ropolonellid outline, mostly dorsally interrupted extramarginal rim nearly parallel to the margins, valve surface tuberculate or granulose.

Remarks. On Kummerows type material in the collection of the former ZGI in Berlin, studied by H. G.-U. in 1971: The figure-captions of *Leptoprimitia* in Kummerow (1953: pl. 4) have to be changed because of a misprint in the publication. The label of the catalogue number X 406 was *L. compressa* n.sp., Orig., Kamieniarnia K3, that is the carapace of the holotype figured by Kummerow on pl. IV, Fig. 7 a–c (non 5, 6). The label of the catalogue number X 412 was *L. circumvallata* n.sp., Orig. Tartak, T5, that is the right valve of the holotype figured by Kummerow on pl. IV, Fig. 5 (non 7 a–c).

*Leptoprimitia plana* (Gürich, 1896) sensu Kummerow (1953) synonymised with *Leptoprimitia granosa* Zagora, 1968 by Adamczak (1971) does not belong to *Leptoprimitia*: it should be taken as *Evlanella* Egorov, 1950. The specimen ZGI X 420 of Kummerow (1953: pl. VII not VI, fig. 1) was ( provisionally ?) labelled as ‘*Jonesites planus* GÜR., Dombrowa’. The specimens housed in the Palaeontological collection of the Natural History Museum in Berlin labelled ‘*Primitia plana* n. sp., Dombrowa, Slg. Gürich, Poln. Mittelgebirge, Orig. zu Gürich (1896, pl. VIV, fig. 2)’ (one carapace and 5 valves on slabs) may belong to *Evlanella rhenana* (Kummerow, 1953) according to Feist and Groos-Uffenorde (1979: p. 144).

Occurrences. Early and Middle Devonian of Europe and North Africa.

*Leptoprimitia granosa* Zagora, 1968

1968 *Leptoprimitia granosa* n.sp.—K. Zagora: p. 54–55, pl. XII, figs. 10–14.

1976 *Leptoprimitia granosa* Zagora 1968—Adamczak: p. 386–387, text-fig. 51, pl. 28, figs. 175–178, pl. 29, figs. 184–187.

Important diagnostic features. Outline nearly amplete, extramarginal velum-like rim posterodorsally bent, valve surface granulose.

Remarks. We do not follow Adamczak (1971) who included *Leptoprimitia granosa* Zagora, 1968 in *Leptoprimitia plana* (Gürich, 1896) sensu Kummerow (1953), because we determine the latter as *Evlanella*. Further studies are necessary to elucidate the variation and delimitation of the similar species *L. granosa* Zagora, 1968, *L. polonica* (Přibyl, 1953), *L. dubia* Adamczak, 1976, and *L. circumvallata* Kummerow, 1953.
**Leptoprimitia symmetrica** Zagora, 1968

*1968 Leptoprimitia symmetrica* n. sp.—K. Zagora: 52–53, pl.XI, figs. 14–15.

**Important diagnostic features.** Outline subelliptical, extramarginal velum dorsally interrupted and not bent to the centre, valve surface delicately granulose.

**Occurrence.** Early Devonian: Late Emsian Tentaculites-schiefer of Thuringia (Germany), probably latest Emsian Grzegorzowice Formation, Holy Cross Mountains (Poland).

**Leptoprimitia granosa** vel symmetrica

Figure 16d–k

**Material.** Relatively abundant in sample FRA-TKZ 4c2 (SMF Xe 22634–Xe 22636, Xe 22638–22640, 4 lv in Xe 23042, L=0.85 mm, lateral view of lv, sample GIV 1 W; e–f Jenningsina thuringica Zagora, 1968 from sample FRA-TKZ 4c2. SMF Xe 22667, L=0.70 mm; e right lateral and f tilted dorsal view of a carapace; g–i Jenningsina cf. thuringica Zagora, 1968 from sample FRA-TKZ 4c2, SMF Xe 22668, L=0.70 mm; g right lateral, h tilted dorsal, and i dorsal view of a carapace

**Fig. 15** Jenningsina species from the Torkoz area. Sample FRA-TKZ 4c2 from section Hassi Mouf South and sample GIV 1 W from section Torkoz (sensu G. Becker et al. 2004). a–d Jenningsina catenulata (van Pelt, 1933): a SMF Xe 22669, L=0.70 mm, left lateral view of a carapace, sample FRA-TKZ 4c2; b SMF Xe 22671, L=0.80 mm, lateral view of rv, sample FRA-TKZ 4c2; c SMF Xe 23041, L=0.90 mm, lateral view of rv, sample GIV 1 W; d SMF Xe 23969 and > 30 valves in SMF Xe 23956), section Hassi Mouf South and more than 20 valves (SMF Xe 23928 and Xe 23966) in sample Torkoz GIV 1 W, section Torkoz.

**Important diagnostic features.** Subamplete to nearly preplete outline, extramarginal velum-like rim dorsally interrupted. The dorsal part of the extramarginal rim varies, that is, the bending of the posterodorsal part to the centre is indistinct (as within *L. granosa*), sometimes even missing (as within *L. symmetrica*). The surface of the valves is granulose resp. pustulose.

**Occurrence.** Only found in the latest Emsian of the Torkoz area, SW Morocco, but not mentioned in G. Becker et al. (2004).
1977 *Leptoprimitia ornata* K. Zagora, 1968—G. Becker and Sanchez de Posada: p. 154–155, pl. 7, fig. 1.
1986 *Leptoprimitia ornata*—K. and I. Zagora: photo 3.

**Material.** Only the figured rv from sample FRA-TKZ 4c2 (SMF Xe 22795) and two questionable valves from sample Torkoz GIV 1 W (SMF Xe 23043 and Xe 23523).

**Important. diagnostic features** Dorsally uninterrupted extramarginal rim parallel to the elongate suboval margin.

**Remarks.** *Leptoprimitia ornata* is characterised by an uninterrupted extramarginal rim comparable to the rim of the related *L. balbiniensis* Weyant, 1967 from the Early Devonian of northern France, but the latter has in addition two distinct bars dorsally in front and behind mid-length.

**Occurrences.** Known from the late Emsian of Thuringia (Germany) and Northern Spain, only very rare in the latest Emsian of the Torkoz area (Morocco), but not mentioned from Torkoz Giv 1.

*Leptoprimitia polonica* (Přibyl, 1953)

Figure 16a

*1953 Euglyphella (?) polonica nov. spec.—Přibyl: p. 334–335, pl. IV, figs. 6–9.*
*1976 Leptoprimitia polonica* (Přibyl 1953)—Adamczak: p. 387–389, pl. 28, fig. 179, pl. 29, figs. 188–191.
?1976 *Leptoprimitia dubia* n. sp.—Adamczak: p. 389–390, pl. 29, figs. 192–193.

**Material.** Only one rv from sample FRA-TKZ 4c2 (SMF Xe 23718), section Hassi Mouf South and one lv in sample GIV 1 W (SMF Xe 23927), section Torkoz.

**Remarks.** The slightly compressed figured valve SMF Xe 22637 from sample FRA-TKZ 4c2 with a ropolonellid outline is a dorsally slightly damaged rv with reticulated surface (typical for *Favulella*) instead of the tuberculated surface of *Leptoprimitia*, and the extramarginal rim is slightly rounded (similar to *Favulella*) and less elevated (distinctly elevated in *Leptoprimitia*).

**Genus Zeuschnerina** Adamczak, 1976

**Type species.** *Zeuschnerina retis* Adamczak, 1976.

**Zeuschnerina ? sp.**

**Material.** Two valves from sample FRA-TKZ 4c2 (SMF Xe 23516, Xe 23978), section Hassi Mouf South and two valves from sample GIV 1 W (SMF Xe 23964, Xe 23967), section Torkoz.

**Remarks.** The badly preserved resp. recrystallised valves with ropolonellid outline and weak marginal carina are provisionally placed in the genus *Zeuschnerina*.

**Occurrences.** The genus *Zeuschnerina* with several species was described from Early and Middle Devonian sections in Europe and from the Moroccan Torkoz area by G. Becker et al. (2004), but not from the latest Early Devonian sample Torkoz Giv 1.

**Family ? Ropolonellidae** Coryell and Malkin, 1936

**Genus Karlingrella** Groos-Uffenorde gen. nov.

**Type species.** *Euglyphella ? granulosa* Blumenstengel, 1962.

**Derivatio nominis.** Named after Karl and Ingrid Zagora in remembrance of their important ostracode research in the Devonian of Thuringia, Germany.

**Diagnosis.** Egg-shaped outline with straight dorsal border, anterior end higher than posterior end. Coarsely pustulose surface with anterior, anterodorsal and posterodorsal spines, some specimens with additional posteroventral spine. A very
small anterior marginal structure (narrow rim, not velate) developed.

Remarks. The dorsocentral shallow node characterising *Loquitzella* Zagora, 1968 and a broad anterior velate structure (= marginal flange sensu G. Becker et al. 2004) of *Zeuschnerina* could not be verified in the present material. According to K. Zagora (1968: p. 56), *Loquitzella granulosa* shows a close relationship to *Loquitzella mesodevonica*, but differs in the lack of the dorsocentral node and less elongate outline. The extramarginal smooth carina of *Zeuschnerina verrucosa* Becker, 2004 (in G. Becker et al. 2004) from the Givetian of Morocco is missing. The presumption of Becker and Sanchez de Posada (1977: p. 159) that *L. mesodevonica* and *L. granulosa* are only different ontogenetic stages and could be conspecific is not accepted, because of the missing ropolonellid outline, dorsocentral node, and velate anterior marginal structure in *L. granulosa* and the missing distinct spines in *L. mesodevonica*.

According to Blumenstengel (1962: p. 14), only an anterodorsal spine is developed in the left valve of the type species, but within the Moroccan material, the presence and strength of the spines may depend on the preservation.

The position within the Ropolonellidae is questionable because of the missing ropolonellid outline. The outline shows a relationship to the Scrobiculidae Posner, 1951.

Occurrences. Early Devonian of Europe and North Africa, but not cited in G. Becker et al. (2004).

*Karlingrella granulosa* (Blumenstengel, 1962)

Figure 17a–i

*1962 Eughlyphella ? granulosa n.sp.—Blumenstengel: p. 14, pl. 1, figs. 19–21, pl. 7, figs. 124–127
1967 Loquitzella granulosa (B1.)—I. Zagora: p. 322 (table 1).
Late Early Devonian ostracodes from the Torkoz area (SW Morocco) and the Emsian/Eifelian boundary

1968 *Loquitzella granulosa* (Blumenstengel, 1962)—K. Zagora: p. 55, 56.

1970 *Loquitzella granulosa* (Blum.)—Jordan (1970): p. 10 (table 1).

1977 *Loquitzella granulosa* (Blum.)—Blumenstengel 1977: p. 12 (list).

1977 *Loquitzella* sp. A—G. Becker and Sanchez de Posada: p. 160.

**Holotype.** Left valve 38/1 in the material of Blumenstengel, deposited in the collection of the University of Freiberg/Sachsen.

**Paratypes.** Material of Blumenstengel: 12 lv and 7 rv from the type locality in Germany.

**New Moroccan material.** Ten valves from sample FRA-TKZ 4c2 (SMF Xe 22716, Xe 22742–22749, Xe 23525), section Hassi Mouf South and two valves in sample GIV 1 W (SMF Xe 23032, Xe 22036), section Torkoz.

**Type locality.** Borehole Mötzelbach 3 at 572.2 m, late Early Devonian ‘Tentaculiten-Knollenkalk’, Thuringia, Germany.

**Diagnosis.** See genus description.

**Measurements.** The specimens reported by Blumenstengel (1962) from the Harz Mountains in Germany are larger in comparison to the new Moroccan specimens.

**Remarks.** The outline of the related *Loquitzella mesodevonica* Zagora, 1968 from the Tentaculitenschiefer of Thuringia is more elongate, the tubercles of the lateral surface are less distinct, and the spines are smaller. The Moroccan specimens *L. mesodevonica* in G. Becker et al. (2004) show a distinct ropolonellid outline and anterior marginal flange.

The figured specimen of Gen. et sp. indet. 1, aff. *Euglyphecilla abdita* Petersen, 1966? in Lethiers et al. (1985: pl. 7, fig. 3) from Saint Fiacre in northern France seems to be related, but the anterior spine is missing and the admarginal spines are longer.

*Zeuschnerina verrucu* Becker n. sp.? in G. Becker et al. (2004: pl. 9, fig. 7 and pl. 10, fig. 14) from sample Assa Giv 16 from the Givetian of Morocco may be conspecific, but has to be verified.

**Occurrences.** Late Early Devonian ‘Tentaculiten-Knollenkalk’ of the Harz Mountains, Germany and the latest Emsian Moniello Formation of Asturias, Spain. The new material comes from the latest Early Devonian of the Torkoz area of SW Morocco.

Suborder *Podocopina* Sars, 1866

Superfamily *Bairdiocypridae* Shaver, 1961

Family *Bairdiocypridae* Shaver, 1961

“*Cytherellina* inconstans” K. Zagora, 1967

Figure 18a–c

* 1967 *Cytherellina* inconstans n. sp.—K. Zagora: p. 705–706, pl. 3, figs. 22–28.

2004 “*Cytherellina* inconstans”—G. Becker et al.: p. 70, pl. 11, figs. 2–7 (with detailed synonymy).

2004 “*Cytherellina* inconstans”—Dojen et al.: p. 742–743, figs. 5–5, 5–6.

2010 “*Cytherellina* inconstans”—Dojen et al.: p. 40.

2013 “*Cytherellina* inconstans”—Maillet (2013): p. 100–101, pl. 13, fig. 6.

2013 *Unicornites* ?chotecensis* Príbyl & Snajdr, 1950—Maillet et al.: table1, pl. 1, fig. 26.

2015 “*Cytherellina* inconstans” Zagora, K., 1967—Olemska et al.: p. 8, fig. 6 n–o

**Material** Only very few incomplete valves (SMF Xe 22720–Xe 22722, Xe 23,058) from sample FRA-TKZ 4c2, section Hassi Mouf South and one specimen (SMF Xe 23931) in sample GIV 1 W, section Torkoz.

**Important diagnostic features.** Smooth ostracode with elongate suboval-to-subtriangular outline and maximum height at or slightly behind mid-length; small posterior spine especially on rv, but also possible on lv; calcified inner lamella present.

**Remarks.** Originally described and figured as having a posteroventral spine in each valve (K. Zagora 1967: p. 705), further material of this taxon, e.g., from Turkey, Cantabrian Mountains and Morocco, show mainly a posteroventral spine only in the right valves (cf. Dojen et al. 2004: p. 744).

The determination of the specimens from sample FRA-TKZ 4c2 is uncertain, because of the missing spine and the variation of the outline.

**Occurrences.** Late Early Devonian (Emsian)-to-Middle Devonian of Germany, Spain, Turkey and North Africa.

Suborder *Cytherocopina* Gründel, 1967

?Superfamily *Cytheracea* Baird, 1850

Family *Bythocytheridae* Sars, 1926
Remarks. The discrimination and systematic position of the Bythocytheridae Sars, 1926 and the Berounellidae Sohn and Berdan, 1960 is unsolved.

Genus *Kirkbyellina* Kummerow, 1939

*Type species.* *Kirkbyellina styliolina* Kummerow, 1939

*Remarks.* Blumenstengel (1965: p. 56) concluded after the study of the types, that *Kirkbyellina* Kummerow, 1939 is a synonym of *Berounella* Bouček, 1936, but, e.g., G. Becker et al. (1993: p. 46) and G. Becker et al. (2004: p. 72) followed Schornikov and Michailova (1990: p. 189) in accepting the independence of Kummerow’s genus.

The spinose and lobated genera *Kirkbyellina* resp. *Berounella* are characterised by a distinct posterodorsal rostrum. These taxa are common in Germany and northern Spain in the ‘Thuringian Ecotype’ or ‘mixed faunas’, but they are very rare in Moroccan faunas from the Eifelian Ecotype (see below: Palaeoecology, Fig. 23).

**Fig. 17** Lateral views of *Karlingrella granulosa* (Blumenstengel, 1962) (measured without spines) from sample FRA-TKZ 4c2, section Hassi Mouf South and sample GIV 1 W from section Torkoz (sensu G. Becker et al., 2004). a–g From sample FRA-TKZ 4c2. a SMF Xe 22716, L = 0.70 mm, lv; b SMF Xe 22745, L = 0.60 mm, lv; c SMF Xe 22746, L = 0.70 mm, lv; d SMF Xe 22742, L = 0.70 mm, lv; e SMF Xe 22744, L = 0.60 mm, rv; f SMF Xe 22747, L = 0.70 mm, rv; g SMF Xe 22749, L = 0.55 mm, rv; h–i from sample GIV 1 W. h SMF Xe 23032, L = 0.80 mm, lv; i SMF Xe 23036, L = 0.70 mm, slightly tilted rv

*Kirkbyellina sp.*

*Material.* One juvenile lv (SMF Xe 23515) with L = > 0.5 mm and H = 0.25 mm was found in sample FRA-TKZ 4c2, section Hassi Mouf South.

*Remarks.* The prominent lobation is similar to that of *Berounella spinosa* Blumenstengel, 1962 from the Emsian of Germany, France and Spain. The anterodorsal spine is missing, but a distinct and small round knob-like lobe and a spine below the dorsal border above the adductorial sulcus are developed. The open posterior end (rostrum) is broken.

*Occurrences.* One Moroccan encrusted valve was cited in G. Becker et al. (2004: p. 72) from the Middle Devonian sample Assa Giv 9, but not reported from section Torkoz.

Order, Suborder and Superfamily *unknown*
Family *Scrobiculidae* Posner, 1951

Remarks. The systematic position was discussed in G. Becker et al. (2004: p. 74).

Genus *Roundyella* Bradfield, 1935

Type species. *Amphissites simplicissima* Knight, 1928.

Occurrences. Middle Devonian-to-Permian according to G. Becker (2001a: 40), but first occurrences within the late Early Devonian of Europe and Morocco.

*Roundyella pokornyi* (Zagora, 1968)

Figure 18d–f

1968 *Amphissella pokornyi* n.sp.—K. Zagora: p. 28–29, pl. 6, figs. 16–20
2004 *Roundyella pokornyi* (Zagora 1968)—G. Becker et al.: p. 75, pl. 7, fig. 4 (with synonymy)
2015 *Roundyella pokornyi* (Zagora, 1968)—Olempska et al.: p. 6, fig. 7 s,t

Material. The figured valves (SMF Xe 22715, Xe 22752, Xe 22753) from sample FRA-TKZ 4c2, section Hassi Mouf South are slightly damaged and show only parts of the row of marginal tubercles.

Important diagnostic features. Subrectangular outline, reticulation on lateral surface medium-sized, marginal structure with row of tubercles.

Occurrences. Late Early Devonian and Middle Devonian of Europe. Very few valves were reported by G. Becker et al. (2004) from the early Givetian (sample Assa Giv 9) of the southwestern Anti-Atlas, Morocco.

*Roundyella* sp. A sensu G. Becker et al., 2004

One coarsely reticulated valve was found and figured in G. Becker et al. (2004: p. 75–76, pl. 7, fig. 3) from sample GIV 1, section Torkoz.

Smooth Ostracoda indet.

Smooth and mostly damaged or recrystallized ostracodes are not discussed in the present paper. They are less common compared to other late Early Devonian ostracode faunas (e.g., Adamczak 1968, 1976; Zagora 1968). Carapaces of smooth ostracodes are extremely rare (e.g., SMF Xe 22623).
Stratigraphy of the ostracodes of the Torkoz area (H. Groos-Uffenorde)

The present paper focuses on the rich ostracode faunas from the latest Early Devonian of the Crinoid Marl Member (see Figs. 2 and 19). The ostracode faunas from the underlying Early Devonian Hollardops Member to the Middle Devonian Pinacites Limestone Member will be published by Dojen et al.

The Emsian/Eifelian boundary

The type section of the Early/Middle Devonian (Emsian/Eifelian) boundary was defined in the ‘Wetteldorf Richtschnitt’ in the Eifel area of western Germany by the entry of the conodont Polygnathus costatus partitus Klapper, Ziegler, and Mashkova, 1978. The subspecies are taken as species by Vodrážková et al. (2011). The boundary is located in the uppermost Heisdorf Formation very close to the transition from the Heisdorf Formation to the Lauch Formation. The ostracode distribution of these formations was summarised by G. Becker and Groos-Uffenorde (1982). No ostracodes have been found directly above the boundary; therefore, the hitherto known change of the ostracode fauna occurs slightly higher.

The ostracode faunas from the Torkoz area (see Table 1) have only very few taxa in common with those of the type section because of the different facies. Only Ctenoloculina disjuncta, Polyzygia insculpta bekeri, and ‘Zygobeyrichia’ occur in both areas in the latest Emsian.

According to text-fig. 1 in Gooday and Becker (1979: p. 194), only the ostracode families Craspedobolinidae and Beyrichiidae do not cross the Early/Middle Devonian boundary, but they are important elements of the late Early Devonian worldwide benthic faunas.

In Europe, there is no complete Early/Middle Devonian boundary section available rich in ostracodes and well dated by conodonts. The isolated but diverse ostracode fauna of the Tentaculitenschiefer of Thuringia was well dated by brachiopods and tentaculites (Dalejian cancellata Zone) as latest Emsian (latest Early Devonian) and summarised by K. and I. Zagora (1986). This ostracode fauna has many taxa in common with the new Moroccan faunas (samples FRA-TKZ 4, FRA-TKZ 4c2, and Torkoz GIV 1; see Table 1).

The ostracodes of the crinoid marl member (lower yeraifa formation) near Torkoz

The Emsian/Eifelian (Early/Middle Devonian) boundary is recognised by R.T. Becker et al. (2004c: p. 6, 14) and Dojen et al. (2010: p. 39) within the Rich 4 Sandstone and the boundary Khebchia/Yeraifa formations are drawn within the earliest Eifelian Polygnathus partitus Zone. In R.T. Becker et al. (2004b: p. 93, 94), the Choteč Event is indicated directly above the Rich 4 Sandstone coinciding with the Emsian/Eifelian boundary resp. the boundary Khebchia/Yeraifa formations, the latter is comparable with the boundary in G. Becker et al. (2004: p. 7).

Sample FRA-TKZ 4c2 yielded only one Icriodus corniger rectirostratus, which could not be exactly dated, but could be compared with the Heisdorf and Lauch formations in the Eifel area (K. Weddige, oral comm. 2012). The ostracodes of sample FRA-TKZ 4c2 have many taxa in common with late Early Devonian faunas (e.g., late Emsian Tentaculitenschiefer of Thuringia), but very few and rare taxa show Middle Devonian aspects (e.g., the occurrence of Polyzygia symmetraca has its acme in the Middle Devonian).

Sample Tor Eif/2d from the first thick limestone bed of the Crinoid Marl Member of the Hassi Mouf section delivered only a very poor ostracode fauna (see Fig. 19) and no conodonts.

G. Becker et al. (2004) reported 13 ostracode taxa from sample Torkoz Giv 1 (= Giv 1B) from the Middle Devonian Yeraifa Formation. The sample residue of Karsten Weddige (sample GIV 1 W) was recently picked and studied by H. G.-U., and more than 20 ostracode taxa could be determined. The conodonts cited in G. Becker et al. (2004: p. 8) and additional specimens were restudied by Weddige, and dated as latest Emsian patulus Conodont Zone.

Most of the ostracodes from Torkoz Giv 1 are in common with those from FRA-TKZ 4c2 (see Table 2), and they show relationships to the very rich ostracode fauna of the latest Emsian Thuringian ‘Tentaculitenschiefer’ (cancellata Zone), and therefore the same age is assumed.

The underlying beyrichiacean sample FRA-TKZ 4 from shales shows similarities to nearshore faunas in areas with more terrigenous influx; therefore, the correlation of the ostracode fauna FRA-TKZ 4 and FRA-TKZ 4c2 together with those from Torkoz GIV 1 are treated separately.

The conodonts of sample GIV 1 W and Giv 1B (e-mail K. Weddige of February 5th 2013)

The conodonts of Torkoz Giv I B (the determination in G. Becker et al., 2004: 8 is cited in brackets) were restudied and compared with sample Torkoz GIV 1 W by Weddige (January 2013) and determined as

- Caudicriodus culicellus altus Weddige, 1985;
- Icriodus corniger rectirostratus Bulynck, 1970 (probably not Icriodus struvei Weddige, 1977);
- Icriodus werneri Weddige, 1977;
- 1 Polygnathus costatus partitus Klapper, 1971 (probably not Polygnathus costatus partitus Klapper, Ziegler, and Mashkova, 1978);
- 2 Polygnathus linguiformis bulyncki Weddige, 1977;
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1 Polygnathus linguiformis subsp. (not Polygnathus costatus costatus Klapper, 1971).

and dated as patulus Zone resp. Heisdorf Formation, latest Emsian and not ‘lowermost costatus costatus Zone’ sensu G. Becker et al. (2004: p. 8). The earliest Eifelian resp. Lauch Formation is excluded by K. Weddige, because the conodont Icriodus retrodepressus is missing.

The Crinoid Marl Member is overlain by the Pinacites Limestone Member of early Middle Devonian (Eifelian) age (see Fig. 19). The boundary is currently not exactly known.

Fig. 19 The supposed Emsian/Eifelian boundary in section Hassi Mouf South according to the ostracodes. Sample Tor Eif/2d (coll. R.T.B.) is correlated with sample FRA-TKZ 4c2 (coll. E.S.) and Torkoz GIV 1W (dated by K. Weddige as patulus Zone) above sample FRA-TKZ 4 (coll. E.S.). The complete section with Middle Devonian ostracodes will be published in a forthcoming paper by Dojen et al.

Correlation of the beyrichiacean fauna of sample FRA-TKZ 4

Layers full of beyrichiacean ostracodes are widespread in Early Devonian nearshore facies of Europe (summarised in Groos-Uffenorde 1983), especially in terrigenous sediments of Germany (Rhenish Schiefergebirge, Harz Mountains, Thuringia), in shales from southern and eastern Spain, northern France, and Turkey (summarised by Nazik and Groos-Uffenorde 2016), and in limestones of northern Spain and Podolia. The most common species in the latest Early Devonian is Zygobeyrichia subcylindrica (Rh. Richter, 1863) ultimately discussed in G. Becker and Franke (2012) and characterising neritic shallow-water areas.
Table 1  The occurrences of selected Moroccan ostracodes in the Early Devonian (Emsian) of the Torkoz area compared with German occurrences in Thuringia and in the boundary stratotype in the Eifel area

| Ostracode taxa (listed alphabetically) Torkoz Thur Latest Emsian Morocco | KF | TTh | TKZ | G1W | G1B | Eif 2d | Hei | Lau |
|--------------------------------------------------------------|----|-----|-----|-----|-----|-------|-----|-----|
| Aechmina sp. B sensu Becker et al., 2004 | – | – | – | 2 | 2 | – | – | – |
| Balantoides ? sp. TKZ | – | – | 3 | – | – | – | – | – |
| Berdanella vel Refratihella sp. | o | – | 5 | 1 | o | – | – | – |
| Bollia azagoni Becker et al., 2004 | – | × | – | – | ? | – | sp | – |
| Bollia azagoni vel bezagora | – | – | × | × | – | – | – | – |
| Bollia lavabadiana Becker, 1996 | – | – | – | × | – | – | – | – |
| Bythocypridea ? sp. 1 | – | – | 3 | – | – | – | – | – |
| Bythocypridea ? sp. 2 | – | – | 2 | – | – | – | – | – |
| Bythocypridea ? sp. 3 | – | – | ? | 2 | – | – | – | – |
| Cryptophyllus sp. A Becker and Sanchez de Posada, 1977 | × | – | o | – | – | – | – | – |
| Ctenolocalina disjuncta Zagora, 1968 | cf | × | × | – | – | – | – | – |
| Ctenolocalina sp. | – | – | – | 1 | o | – | – | – |
| “Cytherellina” inconstans Zagora, 1976 | × | × | × | 1 | – | × | – | – |
| Eridocoma papillosa Zagora, 1968 | – | × | × | × | – | – | – | – |
| Favuellens frankenfeldi Becker, 1989 | – | – | × | × | – | 1 | – | – |
| Genus 2 sp. TKZ | – | – | – | 2 | – | – | – | – |
| Jenningsina thuringica Zagora, 1968 | – | × | 1 | – | – | – | – | – |
| Jenningsina catenulata (van Pelt, 1933) | – | cf | × | × | 1 | – | – | × |
| Karlingella granulosa (Blumenstengel, 1962) | – | × | × | 2 | – | – | – | – |
| Kirkbyricha zagovelezazorum Becker, 2003 | – | × | × | × | × | o | – | – |
| Kirkbyellina sp. | – | – | 1 | – | – | – | – | – |
| Leptoprimita sp., ex g. L. polonica (Pribyl, 1953) | × | – | cf | – | × | – | – | o |
| Leptoprimita granosa vel symmetrica | – | cf | × | × | – | × | – | cf |
| Parabolbina kroemmelbeini Zagora, 1968 | o | × | 1 | cf | 1 | cf | – | – | o |
| Polyzygia grecoffi Weyant, 1980 | × | – | × | – | – | – | cf | cf |
| Polyzygia inopina beckeri Zagora, 1968 | 1 | × | × | × | – | – | – | – |
| Polyzygia kroemmelbeini LeFèvre and Weyant, 1966 | × | – | × | × | – | – | – | – |
| Polyzygia normannica—anteecedens group | – | × | × | × | – | 1 | – | – |
| Polyzygia symmetrica group | – | × | × | × | × | – | – | – |
| Ponderodictya punctilifera (Hall, 1889) | – | × | – | cf | sp | – | – | – |
| Punctoprimita sp. TKZ | – | ? | × | × | – | – | cf | ? |
| Punctoprimita ? aft. P. europaea Weyant, 1967 | – | – | × | × | 1 | × | – | – |
| Quasillites (Beckjennites) gebeckeri sp. nov. | – | – | × | 3 | – | – | – | – |
| Richina sp. A sensu Becker and Groos-Uffenorde, 1982 | × | – | – | – | – | – | – | × |
| Richina sp. B sensu Becker and Groos-Uffenorde, 1982 | – | – | 2 | cf | – | cf | – | × |
| Roundyella pokoroyi (Zagora, 1968) | – | × | × | – | 1 | cf | sp | – | – |
| Ulrichia (S.) fragilis Warthin, 1934 sensu Zagora, 1968 | × | × | o | – | – | – | cf | – |
| Ulrichia (U.) spinifera Coryell and Malkin, 1933 | cf | × | × | o | o | cf | – | – | – |
| Zygoberichia subcylindrica (Rh. Richter, 1863) | – | × | cf | – | – | – | × | – |
| KF = Khebchia Formation sensu G. Becker et al. (2004), sections Torkoz Ila and Iib (Late Emsian, Morocco) | TTh = “TentaculitenSchicht” of Thuringia sensu K. Zagora (1968) (cancellata Tentaculite Zone), Germany | TKZ = Crinoid Marl Member, sample FRA-TKZ 4c2 (with one conodont Icriodus rectirostratus Bultynck, 1970) and sample FRA-TKZ 4 | G1W = section Torkoz, unpublished conodont sample GIV 1 of Weddige (patitus Conodont Zone) | G1B = sample Torkoz Giv 1 sensu G. Becker et al. (2004) interpreted as lowermost costatus Conodont Zone | Eif 2d = section Hassi Mofk-South, sample Tor Eif/2d of R.T.B., details of the ostracodes will be published by Dojen et al. | Hei = latest Emsian Heisdorf Fm. in G. Becker and Groos-Uffenorde (1982) (patitus Conodont Zone), Eifel area, Germany | Lau = earliest Eifelian Lauch Fm. in G. Becker and Groos-Uffenorde (1982) (partitus Conodont Zone), Eifel area, Germany | Late Emsian E’Eif. |

Used abbreviations in the list of occurrences: rare occurrences are marked with number of specimens; o = comparable but not the same species; sp = same genus, species undeterminable; cf = related species, probably the same; ? = determination uncertain. For the used abbreviations in the open nomenclature, see “Introduction” to the systematics.
Late Early Devonian ostracodes from the Torkoz area (SW Morocco) and the Emsian/Eifelian boundary

| Torkoz Giv 1 W | = | Torkoz Giv 1 B | = | FRA-TKZ 4c2 | = | Tor Eif/2d |
|---------------|---|---------------|---|--------------|---|-----------|
| coll. Weddige 1996, det. Gr-Uff | = | G. Becker et al. 2004 | = | coll. Schindler 2007, det. Gr-Uff | = | coll. R.T. Becker, det. Dojen |
| Aechminia sp. B (2 specimens) | = | Aechminia sp. B (2 h) | = | Balantoides sp. TKZ | = | --- |
| ---- | --- | B. vazagora vel bezagora | = | B. vazagora | = | B. vazagora vel bezagora |
| ---- | --- | Bollia vagabunda | = | --- | = | --- |
| ---- | --- | Ctenoloculina (1 tecnomorph) | = | C. latisulcata (1 specimen) | = | --- |
| ---- | --- | Cytherellina inconstant | = | Cytherellina inconstant (rare) | = | Cytherellina inconstant |
| ---- | --- | Enicococha papillosa (rare) | = | --- | = | --- |
| ---- | --- | Favillea frankenfeldi | = | --- | = | --- |
| ---- | --- | Genus 2 sp. TKZ (2 specimens) | = | --- | = | --- |
| ---- | --- | J. catenulata | = | J. catenulata (1 specimen) | = | Jenningsina catenulata (rare) |
| ---- | --- | Karlingella granulosa (2 specimens) | = | --- | = | Jenningsina frutigina (1 specimen) |
| ---- | --- | Kirkbyriaza zagozflazlorum | = | K. zagozflazlorum | = | K. zagozflazlorum |
| ---- | --- | Leptopromita granosa vel symmetrica | = | --- | = | Leptopromita polonica |
| ---- | --- | Leptopromita ornata | = | --- | = | Leptopromita ornata (1 specimen) |
| ---- | --- | Parabolbina sp. (2 specimens) | = | --- | = | Parabolina sp. (1 specimen) |
| ---- | --- | Polyzygia kroemmelbeini (rare) | = | --- | = | P. kroemmelbeini (abundant) |
| ---- | --- | Polyzygia insculpta beckeri | = | --- | = | P. insculpta beckeri |
| ---- | --- | P. normannia vel antecedens | = | --- | = | P. normannica vel antecedens (abundant) |
| ---- | --- | Ponderodictya sp. GIV(1 specimen) | = | Ponderodictya sp. indet | = | Paderodictiya ? aff. P. europea |
| ---- | --- | Punctopromita ? aff. P. europea | = | --- | = | --- |
| ---- | --- | Qu. (Beckjennites) gebeckeri | = | --- | = | Punctopromita sp. TKZ (abundant) |
| ---- | --- | Roundyella sp. | = | --- | = | Roundyella pokorny (3 specimens) |
| ---- | --- | Ulrichia (U.) sp. | = | --- | = | U. (Ulrichia) spinifera group |
| ---- | --- | Zeuschnerrina ? sp. (2 specimens) | = | --- | = | Zeuschnerrina sp. (2 specimens) |
| ---- | --- | Ctenoloculina disjuncta | = | --- | = | --- |
| ---- | --- | Cytherellina inconstant | = | --- | = | --- |
| ---- | --- | Enicococha papillosa | = | --- | = | --- |
| ---- | --- | Favillea frankenfeldi | = | --- | = | --- |
| ---- | --- | Jenningsina catenulata (rare) | = | --- | = | --- |
| ---- | --- | Karlingella granulosa | = | --- | = | --- |
| ---- | --- | Kirkbyriaza zagozflazlorum | = | --- | = | --- |
| ---- | --- | Leptopromita granosa vel symmetrica | = | --- | = | --- |
| ---- | --- | Leptopromita ornata | = | --- | = | --- |
| ---- | --- | Parabolbina sp. (2 specimens) | = | --- | = | --- |
| ---- | --- | Polyzygia kroemmelbeini (rare) | = | --- | = | --- |
| ---- | --- | Polyzygia insculpta beckeri | = | --- | = | --- |
| ---- | --- | P. normannia vel antecedens | = | --- | = | --- |
| ---- | --- | Ponderodictya sp. GIV(1 specimen) | = | Ponderodictya sp. indet | = | --- |
| ---- | --- | Punctopromita ? aff. P. europea | = | --- | = | --- |
| ---- | --- | Qu. (Beckjennites) gebeckeri | = | --- | = | --- |
| ---- | --- | Roundyella sp. | = | --- | = | --- |
| ---- | --- | Ulrichia (U.) sp. | = | --- | = | --- |
| ---- | --- | Zeuschnerrina ? sp. (2 specimens) | = | --- | = | --- |

**Table 2** Ostracodes of samples GIV 1 W and Giv 1 B from section Torkoz compared with sample FRA-TKZ 4c2 and Tor Eif/2d from section Hassi Mouf South. The typical taxa hitherto known from the Emsian silicified ostracode fauna of K. Zagora (1968) contain any beyrichiacean ostracodes. The Thuringian ‘Tentaculitenschiefer’ is underlain by shales dominated by *Z. subcylintrica*.

Poorly preserved beyrichiacean faunas have been published from Morocco by Termier and Termier (1950). The ostracode faunas described by LeFèvre (1963, 1964) include very rare Early Devonian beyrichiacean ostracodes from Algerian Sahara sections. Groos-Uffenorde (1991: p. 341) published *Cornikloedenina* ‘meridiana’ from an Early Devonian sample of G.K.B. Alberti (Hamburg) from Central Morocco. A new Beyrichiaceae species *Gibba kandarenis* was described by Vannier (1994) from the Emsian of NW-Morocco. Baird et al. (2009) reported large, distinctive ostracodes from calcareous shales and silstones above sandstones of the Rich 4 Member (Hassi Mouf South section, 11 km S of Torkoz, named Torkoz 5 section in Fig. 3) and below the *Pinacites* Limestone. Sample FRA-TKZ 4 (with rare specimens of *Bollia* between many large valves of *Zygobeyrichia*) was collected in the same section a few decimeters below sample FRA-TKZ 4c2, the latter does not contain any beyrichiacean ostracodes. A late Early Devonian age of sample FRA-TKZ 4 is assumed, because no layers full of large beyrichiacean ostracodes from well-dated Middle Devonian sections have been described. However, the lack of large beyrichiacean ostracodes in early Middle Devonian strata may also be due to a widespread facies change because of a deepening of the sea after the Early Devonian. The planned paper by Dojen et al. will focus on the relationship between event stratigraphy and Devonian ostracodes.

**Correlation of non-beyrichiacean ostracode faunas of Europe and Morocco**

The international Early/Middle Devonian boundary was placed between the late Emsian Heisdorf Formation and the basal Eifelian Lauch Formation in the German Eifel stratotype area and defined by conodonts (boundary between *Polygnathus costatus patulus* and *P. c. partitus* Zones). Small ostracode faunas were described by G. Becker and Groos-Uffenorde (1982). Only some of the Moroccan ostracode species are in common (see Table 1: Hei, Lau). No
ostracodes were found directly above the boundary in the stratotype section; therefore, the change of the ostracode fauna is slightly higher. The ostracode faunas from the SW Dra Valley in Morocco have only very few taxa in common because of the different facies. The shallow-water taxa, very abundant and diverse in central Europe (e.g., Kozłowskiiella and Polonia) are completely missing in the Torkoz area.

From the Rhenish Schiefergebirge and Harz Mountains, only very few non-beyrichiacean ostracodes near the Emsian/Eifelian boundary are known, e.g., Grigo (1994a, b), Groos (1969), and Stoltidis (1971) besides the beyrichiacean ostracode faunas. Conodont data are very rare because of the mostly terrigenous nearshore facies. Only very few ostracodes are in common with the Moroccan faunas and typical components of the German sections are completely missing in Morocco.

The diverse silicified ostracode faunas of the ‘Tentacularischiefer, Horizont III’ from Thuringia (Germany) described by K. Zagora (1968) were first dated as Middle Devonian and later correlated by K. and I. Zagora (1986) with dacryocarnoids and brachiopods as late Early Devonian (late Emsian). These Thuringian ostracode faunas are very similar to those of the Moroccan samples FRA-TKZ 4c2 and GIV 1. Even the composition of these samples with mostly isolated valves of juveniles as well as adults, and only very few carapaces is comparable. In contrast, there are only very few genera are in common with the Moroccan latest Early Devonian faunas. Conodont species reported from the latest Early Devonian of Thuringia (Germany) are completely missing in Morocco.

The very well-preserved calcareous ostracode faunas of Poland described by Adamczak (1968, 1976) have been dated as Middle Devonian. The fossiliferous Grzegorzowice beds were interpreted as basal Middle Devonian overlying the Early Devonian terrigenous sediments, but according to the conodont faunas studied by Malec and Turnau (1997), the Grzegorzowice beds were dated as late Emsian; only the uppermost beds range into the partitus Conodont Zone (with Polygnathus costatus partitus) of the basal Eifelian. Many species described by Adamczak (1968, 1971, 1976) from Poland are very similar or even conspecific to those described by K. Zagora (1968) from Thuringia. The Moroccan samples FRA-TKZ 4c2 and GIV 1 have some sculptured taxa, e.g., Polyzygia, Ctenoloculina, Jenningsina, Quasilites, and Leptoprinitia in common, but relatively smooth taxa, such as Ochescapha and the diverse Primitiopisaceae and Bairdiaceae are missing in the latest Early Devonian of the Torkoz area.

The Early Devonian ostracode faunas with large beyrichiaceans described by Nehring-Lefeld (1985) from the Polish Syncyna Formation (Gedinnian–Siegenian) show relations to the Rhenish Schiefergebirge of Germany, Podolia and to the sample FRA-TKZ 4.

Many late Early Devonian and Middle Devonian calcareous ostracode faunas have been described from Bohemian limestones, e.g., by Přibyl (1953, 1955, 1987). Only very few genera are in common with the Moroccan latest Early Devonian faunas.

The silicified diverse ostracode fauna from Late Early Devonian to earliest Middle Devonian limestones from the Western Pontides, NW Turkey described by Olempska et al. 2015 have many taxa in common with Thuringia (Germany), Cantabrian Mountains (Spain), and Morocco.

The detailed study of the Devonian of the ‘Rade de Brest’ in Brittany (Northern France) by Morzadec (1983: p. 278) shows some similarities of facies, but only three ostracode taxa (including Polyzygia insculpta beckeri) have been reported from the Fiacre Formation at the base of the Middle Devonian. Silicified ostracodes from the so-called ‘Eifélien’ of Saint Fiacre (Finistère) figured by Lethiers et al. (1985), have not been published in detail, but they show many taxa in common with the sample FRA-TKZ 4c2 and may also be dated as latest Early Devonian.

The rich and diversified Early Devonian ostracode faunas published by Feist and Groos-Uffenorde (1979) from the Montagne Noire in southern France do not show close relations to the Moroccan sample FRA-TKZ 4c2 because of the younger age of the latter.

Many Devonian ostracodes have been described, e.g., by G. Becker and Sanchez de Posada (1977) and G. Becker (1989, 1998, 2001) from the Cantabrian Mountains in Northern Spain. The late Emsian faunas have species in common with those of sample FRA-TKZ 4c2.

Of special interest is the last occurrence of Polyzygia insculpta beckeri, cited, e.g., by G. Becker et al. (2004: p. 49) in the latest Early Devonian/latest Emsian of Northern Spain. We do not accept the determination of the figured P. insculpta ssp. indet. in G. Becker (1989: p. 42, Gustalapiedra Formation, late Eifelian, figured on pl. 5, fig. 3); therefore, hitherto no Middle Devonian occurrences are known.

Many Early Devonian ostracodes have been described from the Iberian Chains in Eastern Spain by Dojen (2005), but the Dalebian resp. Emsian/Eifelian boundary interval is not represented.

The Algerian Early Devonian ostracode faunas described by LeFèvre (1963, 1971) from Saharan sections show some similarities at the generic level with sample FRA-TKZ 4c2. Polyzygia kroenmelbeini is reported only from Emsian strata and P. symmetrica from the late Couvinian (in Maillet et al., 2013 cited above the partitus Zone). Maillet et al. (2013) listed some species from the boundary interval.
Many Early Devonian ostracodes have been described from North American limestones and marls, e.g., by Berdan and Copeland (1973), Lundin (1968) and Swartz (1936), but only very few taxa are in common with the Moroccan fauna. According to Berdan (1990: p. 229), ‘It seems most likely that barriers separating the provinces were either land or deep water’.

From South America, only latest Silurian-to-earliest Early Devonian (Lochkovian) ostracodes were described by Vanier et al. (1995), including beyrichiacean-dominated faunas. The slightly older ostracodes are different and do not show any relations to the Early Devonian Moroccan ostracode faunas.

The silicified ostracode faunas of the Emsian Receptaculites Limestone of New South Wales in Australia (Reynolds 1978) are dominated by smooth taxa indicating offshore environment. The Australian genera Acanthoscapha, Ampulloides, Tricornina, and new spinose taxa show relations to the Thuringian fauna described by I. Zagora (1967) from the Tentaculiten-Knollenkalk, but there is no relation to the slightly younger Moroccan ostracode fauna.

The Early Devonian ostracode fauna from Central Japan described by Kuwano (1987) delivered many spinose taxa and, therefore, belongs to the Thuringian Ecotype with less relations to the new Moroccan ostracode faunas. Only very few Early Devonian Moroccan ostracodes show relationships to Chinese or Russian faunas, mostly because of facies differences.

### The palynomorphs of sample GIV 1 W from the Torkoz section (R. Brocke)

#### Introduction

Palynological sample PMP 774 is originally derived from the non-magnetic fraction of the conodont preparation of sample GIV 1 W (=GIV 1A sampled by K. Weddige) from the Torkoz section (G. Becker et al. 2004). The residue was palynologically treated with hydrochloric acid (38%) and hydrofluoric acid (43%) to remove carbonates and silicates, to enrich the organic content (e.g., Traverse 2007). The remaining kerogen was sieved (10 μm mesh width) without any oxidation. Palynological slides were studied using a transmitted-light microscope (Nikon Eclipse 90i).

Palynological samples from the field studies in 2007 in the section Hassi Mouf South have been proven non-productive; the analysed rocks (24 samples in total) are uniformly depleted in organic matter most probably due to weathering processes.

The citation of stratigraphical occurrences in the following text are taken from the cited references. Because they have not been changed according to recent definitions of the stratigraphical nomenclature, they are shown in brackets.

#### Results

The sample analysed is generally poor in organic matter and the frequency of palynomorphs is low. Palynomorphs are without exception marine components (acritarchs, prasinophytes, and a single scelocodont specimen), no miospores or other terrestrial derived material like phytoclasts are present. However, it cannot be excluded that separation techniques of the conodont processing—e.g., magnetic and density fractionation—may have influenced the composition of the palynological assemblage. The assemblage is of low diversity and specimens are moderate-to-poorly preserved. Accordingly, palynofacies interpretation as well as taxonomic studies are limited. Nevertheless, due to the lack of organic markers of terrestrial origin, it can be concluded that the depositional environment was an open-marine shelf at some distance from the coast.

The sample yielded very few prasinophytes such as small leiospheres and specimens of the genus Cymatosphaera. Acritarchs are represented by rare taxa assigned to the genera Cymbosphaeridium, Multiplicisphaeridium, and Veryhachium (Fig. 20).

*Cymatosphaera carminae* (Cramer, 1964) (Fig. 20a) was first described and subsequently reported from the upper part of the La Vid Formation (NW Province of Léon, Spain); the species is rare but characteristic for the Emsian in Spain, e.g., Cramer (1964), Cramer and Diéz (1976) and Cramer (1967) probably misspelt as *C. carmencitae*. *Cymatosphaera carminae* has also been recorded from northern Africa (Algeria) in a systematic discussion with the genus *Crameria* (Jardiné et al. 1972) and the Anti-Atlas, Morocco (Snape 1993). Hence, it can be concluded that this species is restricted to northern Gondwana and peri-Gondwana, respectively.

*Cymbosphaeridium cariniosum* (Cramer) Listner 1970 (Fig. 20e) was first described by Cramer (1964) from the San Pedro Formation which is “Ludlovian” (Ludlow) in age. Ludlow is also given for the record in Shropshire/Britain (Listner 1970) and Morocco (Snape 1993). Most of the younger occurrences (“Ludlovian to Gedinnian” = Ludlow to Lochkovian) are reported from the Algerian Sahara (Jardiné et al. 1972), Lochkovian from Libya (Le Hérissé 2002) and Brittany (Deuff 1980), Silurian to Emsian from Morocco (Rahmani-Antari 1990), “Wenlockian to Ludlovian” in (Martin 1989) and “Siegenian” to Emsian” (Prajgian to Emsian) from Belgium (Vanguestaine 1979), and late “Gedinnian” to early Emsian from Germany (Moreau-Benoit and Kremer 1985; Steemans 1989). Further documentations include for example South America with a range from late
Landover to early Wenlock, or Přidolí, respectively (e.g., Rubinstein 1997).

The genus Multiplicisphaeridium is represented by quite a number of species and is very common in Palaeozoic sequences. The specimen reported herein belongs to Multiplicisphaeridium cf. raspum (Cramer) Eisenack et al., 1973 (Fig. 20g). A further specimen with comparatively longer processes is provisionally assigned to Multiplicisphaeridium cf. raspum (Fig. 20f). The species M. raspum was also established from the La Vid Formation in Spain with a given specific range for the “Siegenian” to Emsian (Cramer 1964, 1967; Eisenack et al. 1973, Cramer and Diéz 1976). The species—or morphotypes similar to this species—were also frequently reported from the Ordovician to the Devonian worldwide, but the overall data suggest a slight predominance for the Silurian-to-Early Devonian of Gondwana and peri-Gondwana (see Palynodata Inc. and White, 2008).

The genus Vehryachium is one of the most frequently reported acritarchs at all and very common in the Palaeozoic with a cosmopolitan distribution. The illustrated triangular form with scabrate-to-rugulate sculpture elements (Fig. 20b) is assigned to Vehryachium scabrum established by Cramer (1964) from the San Pedro Formation in NW-Spain. The stratigraphic range of this taxon is “Ludlovian to Emsian” (Cramer 1964; Jardiné et al. 1974). Moreover, the specimen reported herein belongs to Vehryachium scabratum (Drevermann, 1973) (cf. Vehryachium scabratum—were subsequently established from the La Vid Formation in Spain with a given specific range for the “Siegenian” to Emsian (Cramer 1964, 1967; Eisenack et al. 1973, Cramer and Diéz 1976). The species—or morphotypes similar to this species—were also frequently reported from the Ordovician to the Devonian worldwide, but the overall data suggest a slight predominance for the Silurian-to-Early Devonian of Gondwana and peri-Gondwana (see Palynodata Inc. and White, 2008).

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The tetragonal specimen (Fig. 20c) is attributed to the genus Vehryachium with a question mark because of the poor preservation; the four processes are incomplete; their length and termination are unknown. The specimen could be provisionally attributed to Vehryachium cf. V. inflatis-simum. This species was described by Cramer (1964) from the La Vid Shale with a stratigraphic range from “Middle Siegenian to Emsian” (e.g., Diez and Cramer 1974). Older occurrences are from Ludlow to Přidolí in Argentina (e.g., Rubinstein 1995), younger are from the “Givetian” of Libya (Moreau-Benoit 1984) and Algeria (Abdesselam-Rouighi 1986).

In conclusion, very few palynological data exist from the Devonian of Morocco (e.g., cutting material from the Doukkala and Essaouira basins reported by Rahmani-Antari 1990 and Rahmani-Antari and Lachkar 2001, respectively, and the Anti-Atlas by Snape 1993), but none from the Torkoz area so far. The palynostratigraphic zonation provided by Rahmani-Antari and Lachkar (2001) is mainly based on miospores. The herein reported prasinophyte and acritarch taxa from the Torkoz section (sample GIV 1 W) can best be compared with those described and established from the Lower Devonian of NW-Spain (e.g., Cramer 1964). They suggest a late Emsian age mainly based on the occurrence of Cymatosphaera carminae, which is predominant in the Emsian. However, due to the scarce occurrence of palynomorphs at all and in particular the lack of miospores and chitinozoans, more data from other fossil groups are needed to solve the biostatigraphic puzzle.

### Discussion

The brachiopod material is scarce, but allows some stratigraphic, palaeobiogeographic, and biofacial remarks:

1. A well-preserved dorsal valve (SMF 102111; Fig. 21a) and an articulated shell (SMF 102115; Fig. 21b) of a leptaenid strophomenide are questionably determined as Leptaena dicax nom. nud. García-Alcalde (sensu Racheboeuf, 1981). Rugation of the exterior and the elevated dorsal muscle platform are consistent with this assignment. As the internal characters of the ventral valve are unknown, a conclusive determination is not possible. The taxon L. dicax nom. nud. was reported from the upper (and uppermost) Emsian of the Armorican Massif (NW France) and the Spanish Cantabrian Mountains (Racheboeuf 1981), and from the Ougarta Chains in Algeria (Racheboeuf 1997). However, affinities to Leptaena analogaeformis (Biernat, 1966) are also possibly close. That species was first described from the upper Eifelian of the Holy Cross Mountains (Poland), but it is also common in the Eifelian of the Eifel area (Rhenish Massif, Germany) and the Maïder in the Moroccan Anti-Atlas (Halamski and Baliński 2013); in the Rhenish Massif, similar forms first occur in the latest Emsian (Jansen, work in progress).

2. Tyersella tetragona (Roemer, 1844) is essentially an Eifelian species (Walmsley and Boucot 1975), with the Ahrdorf Formation or lower Junkerberg Formation.
Late Early Devonian ostracodes from the Torkoz area (SW Morocco) and the Emsian/Eifelian boundary

Fig. 20 Palynomorphs from sample GIV 1 W, section Torkoz, collection number SMF PMP 775. E.F. = England Finder coordinates; a Cymatosphaera carminae Cramer, 1964; E.F. G41-1; b Veryhachium scabratum sensu Cramer, 1964; E.F. L51-3; c ?Veryhachium cf. V. inflatissium Cramer, 1964; E.F. S56-4; d Cymbosphaeridium cf. C. cariniosum. E.F. E40-1; e Cymbosphaeridium cariniosum (Cramer) Jardiné et al., 1971; E.F. K56-3; f Multiplicisphaeridium cf. M. raspum; E.F. P50-2; g Multiplicisphaeridium raspum (Cramer) Eisenack et al., 1973; E.F. U42-1
(middle Eifelian, Eifel area) as possible type stratum (Struve in Walmsley and Boucot 1975: p. 62), but it has also been described from the Mandeln Formation (latest Emsian) in the Rhenish Schiefergebirge (Dahmer 1915) and from the Marettes and Reun ar C’Hrank formations (late Emsian) in the Armorican Massif (Melou 1981a, b); moreover, it has been recorded from the ‘Couvinien’ (latest Emsian–Eifelian) of the Ardennes (Maillieux 1938). The specimens from Hassi Mouf, two articulated shells (SMF 102111, dorsal valve interior; b SMF 102115, ventral valve exterior; c Rhipidomella cf. subcordiformis (Kayser, 1871), SMF 102116, ventral valve interior; d Tyersella cf. tetragona (Roemer, 1844), SMF 102112, articulated shell in dorsal view; e Alatiformia cf. alatiformis (Drevemann, 1907), SMF 102122, dorsal valve exterior; f-h Tyersella cf. tetragona (Roemer, 1844); f SMF 102114.3, dorsal valve exterior; g SMF 102113, articulated shell in ventral view; h SMF 102,123, dorsal valve interior; i Schizophoria sp., SMF 102110, dorsal valve interior; j Trigonirhynchiidae ? indet. (juv.?), SMF 102120, ventral valve exterior; k Atrypa (Planatrypa) sp., SMF 102121, articulated shell in ventral view.

3. In its type region (Eifel area, Germany), the punctate orthide Rhipidomella subcordiformis (Kayser, 1871) first occurs in the lowermost Eifelian (lower Lauch Formation, Wolfenbach Member), but this may partly be due to the onset of a suitable, calcareous-marly facies there (‘allorhenotypic subfacies’ of Jansen 2016). A single ventral valve from the Hassi Mouf section (SMF 102116; Fig. 21c) is at least closely related to that species and accordingly determined as R. cf. subcordiformis. In the Cantabrian Mountains, the genus Rhipidomella has its onset at the Emsian–Eifelian boundary and has been reported to have evolved from the very similar genus Castrillonia (García-Alcalde, 2015). A single specimen is difficult to determine. However, most characters, such as the median ridge that is limited to a shallow median sulcus is present (SMF 102103.3; Fig. 21f). The Hassi Mouf specimens could belong to an undescribed species close to T. tetragona. The form seems to be closer to the late Emsian specimens from the Armorican Massif.

Fig. 21 Brachiopods from sample Tor Eif/2d, section Hassi Mouf South. a–b Leptaena dicax ? nom. nud. García-Alcalde (sensu Racheboeuf, 1981); a SMF 102111, dorsal valve interior; b SMF 102115, ventral valve exterior; c Rhipidomella cf. subcordiformis (Kayser, 1871), SMF 102116, ventral valve interior; d Tyersella cf. tetragona (Roemer, 1844), SMF 102112, articulated shell in dorsal view; e Alatiformia cf. alatiformis (Drevemann, 1907), SMF 102122, dorsal valve exterior; f–h Tyersella cf. tetragona (Roemer, 1844); f SMF 102114.3, dorsal valve exterior; g SMF 102113, articulated shell in ventral view; h SMF 102,123, dorsal valve interior; i Schizophoria sp., SMF 102110, dorsal valve interior; j Trigonirhynchiidae ? indet. (juv.?), SMF 102120, ventral valve exterior; k Atrypa (Planatrypa) sp., SMF 102121, articulated shell in ventral view.
the muscle field, the circular cross-section of marginal crenulations, and the development of teeth, rather suggest an affiliation with *Rhaphidomella*.

4. A single dorsal valve of *Schizophoria* sp. (SMF 102110; Fig. 21i) has a poorly preserved, but certainly irregular (parvicostellate?) ornamentation, a low cardinal process, very strong brachiophores, short fulcral plates, and shallow latero-apical cavities. It most resembles *S. interstrialis* Biernat, 1954 from the Grzegorzowice Formation (late Emsian) of the Holy Cross Mountains, Poland (Halamski 2012). García-Alcalde (2015: fig. 7) listed *S. aff. interstrialis* from the latest Emsian in the Cantabrian Mountains.

5. A coarsely ribbed, small ventral valve of a rynchonellide (SMF 102,120; Fig. 21j) questionably belongs to the family Trigonirhynchiidae. Due to the marked homeomorphy of several genera, a determination is not possible as long as no internal characters are known, and not much weight should be put on this specimen.

6. *Alatiformia alatifomis* (Drevermann, 1907) is a typical species of the Heisdorf–Lauch interval (latest Emsian–earliest Eifelian). It has previously been described from the Anti-Atlas by Drot (1964) the Ouargata Chains in Algeria (Gourvennec 2019) and the Cantabrian Mountains (García-Alcalde 2005)—always from beds dated as latest Emsian or earliest Eifelian. A single dorsal valve (SMF 102,122; Fig. 21e) and a fragmentary ventral valve (SMF 102,121.1) are determined as *Alatiformia cf. alatifomis*.

7. A number of atrypids (SMF 102121.1–14) are tentatively assigned to *Atrypa* (*Planatrypa*) sp. (specimen on Fig. 21k, SMF 102121.6). They suggest a relatively clear, shallow-water palaeoenvironment.

In summary, the brachiopods suggest a latest Emsian–earliest Eifelian age, with *Alatiformia cf. alatifomis* pointing to this interval and *Rhaphidomella cf. subcordiformis* rather indicating an earliest Eifelian age, whereas *Leptaena dicax*? nom. nud. and possibly also *Tyersella cf. tetragona* and *Schizophoria* sp. are more suggestive of a late Emsian age. Weighing up all the arguments, the stratigraphic position of this horizon is possibly very close to the Emsian–Eifelian boundary and more probably slightly older than the boundary—i.e., of Heisdorf age (latest Emsian). A few finds from the underlying Rich 4 Sandstone of the Khebchia Formation in the Torkoz IIa section (Jansen et al. 2007: p. 30), in particular *Iridistrophia* (*Flabellistrophia*) cf. *hipponyx* (Schmir, 1851) and *Sollisspirifer cf. steiningeri* (Solle, 1953), suggest a latest Emsian age also for this slightly lower level. In general, the specimens from section Hassi Mouf South show relationships to approximately coeval ones from the Eifel region, the Holy Cross Mountains, the Armorican Massif, and the Cantabrian Mountains. Litho- and biofacial traits, in particular the brachiopod taxa rather preferring clear water, are consistent with the allorhenotypic subfacies (Jansen 2016). Accordingly, the palaeoenvironment of the Hassi Mouf fauna was the open-marine shelf with relatively little and fine-grained siliciclastic input of terrestrial origin.

**Palaeogeographic distribution of Early Devonian ostracodes in the Torkoz area (H. Groos-Uffenorde)**

According to Scotese (2020), the Iapetus Ocean had closed by Mid-Palaeozoic times. This continental collision of Laurentia and Baltica resulted in the formation of the Caledonides in Scandinavia, northern Great Britain and Greenland, and the Northern Appalachian Mountain Range along eastern North America. The Rheic Ocean separated Gondwana from Laurussia and began to close in the Devonian, but the exact time within the Devonian differs in the literature and is still in Discussion.

The late Early Devonian (Emsian) Baltic-British ostracode province (Fig. 22b) sensu Berdan (1990: p. 228) is not known from the Emsian of North America, Great Britain, or the Baltic area (without the Pontides) because of differing facies. The North American Acadian Mountains may have served as a land barrier between the Baltic-British and Appohimchi Province, but in Emsian time, the provinces are less different and the Thuringian Ecotype ostracodes are also known from the Appohimchi Province. According to Berdan (1990: p. 229), it seems most likely that the barriers separating the provinces were either land or deep water. The Moroccan Emsian ostracode faunas belong to the Baltic-British province sensu Berdan (1990: p. 228) reported, e.g., from the Emsian of Germany, France, Spain, and North-Africa and no longer present in North America, but the ostracode genera *Bollia, Ulrichia, Ctenoloculina*, and *Favulella* are in common.

The palaeogeographical reconstruction of Paris and Robardet (1990: fig. 4) (Fig. 22c) shows a wide area of continental shelves and slopes in the northeast of Gondwana south of the Rheic Ocean. Many localities with large beyrichiacean ostracodes can be found in this area, but the position of important localities like those, e.g., in Podolia and Germany are separated from Perigondwana by the Rheic Ocean. Dojen (2009: p. 220) showed possible migration paths of beyrichiacean ostracodes also using the reconstruction of Cocks and Torsvik (2006), but she concluded that shallow-water connections existed between Laurussia, Gondwana, and Perigondwana, and questioned the presence of the Rheic Ocean in late Silurian-to-Early Devonian times. Olempska et al. (2014) described new silicified Early Devonian non-beyrichiacean ostracodes from the western Pontides/Istanbul Terrane, discussed the different
Early Devonian palaeogeography after PARIS & ROBARDET (1990: 204, Fig. 4)

- occurrences of large beyrichacean ostracodes

**Baltica:**
- BO = Boulonnais
- BR = Brabant Massif
- AR = Ardennes
- RS = Rheinisches Schiefergebirge + Harz

**Rheic Ocean**
- WA = Wales
- CO = Cornwall
- POD = Podolia

**North Gondwana:**
- MNA = Mid-North-Armorian domain
- CI = Central Iberian domain

**South Armoric Ocean until the Middle Devonian**
(later the „Ligerian Orogen“)
- CM = Cantabrian Mountains/Northern Spain
- AQ = Aquitaine
- MC = French Massif Central
- BOH = Bohemia
- AA = Anti-Atlas/Morocco
- OU = Ougarta Chains
- N.MA = northern Maghreb
- TUR = Pontides, Northern Turkey

Vertical ruling = oceanic areas
white = continental shelves and slopes
stippled = land areas
Kirkbyellina placed all known Early Devonian localities of the ostracode on the palaeogeographic map of Torsvik and Cox (2017) and deep ocean. In contrast, Tanaka et al. (2019: fig. 7) used for dispersal of benthic shallow-water ostracodes across this Euramerica and Gondwana does not show any possibility of Blakey (2016) with a broad Rheic Ocean between.

The palaeogeographic interpretation of Crasquin and Horne (2018) is more likely. The shallow-water area instead of a deep Rheic ocean between Laurussia and Gondwana in the palaeogeographic interpretation for the Late Devonian of Golonka (2020: fig. 6) would allow the distribution of benthic ostracodes with long-shore currents or, e.g., island-hopping on both sides of the Rheic, and could explain their distribution in Laurussia (Laurentia and Baltica) as well as in Perigondwana and Gondwana as required, e.g., by Nazik et al. (2018).

In contrast to our interpretation, Crasquin and Horne (2018: fig. 3, 7) preferred the reconstruction of Blakey (2016) with an open Rheic Ocean and deep water (Thuringian Ecotype) ostracod faunas on both sides of this ocean interpreted as palaeopsychrosphaeric fauna inhabiting bathyal to abyssal, cold, well-oxygenated waters.

**Palaeoecology of the ostracode faunas from the Torkoz area (H. Groos-Uffenorde and C. Dojen)**

The Devonian ostracode palaeoecology was summarised in Groos-Uffenorde et al. (2000: fig. 1) including the different interpretations focussing on sedimentology and facies. Publications on Early Devonian ostracodes were listed according to their regional distribution by Nazik and Groos-Uffenorde (2016: p. 22), but not including studies from North America, Bolivia, Uzbekistan, Salair, China, and Japan.

The palaeoecology of marine Devonian ostracode faunas was especially studied by G. Becker, e.g., Bandel and Becker (1975), G. Becker (1981), and G. Becker and Bless (1990), and mainly interpreted on the basis of carapace morphology, water movement (energy level), and water depth. The ostracode assemblages (Fig. 23a: ‘Eifeler Ökotyp’ with subtypes a-e, “mixed faunas” f, ‘Thüringer Ökotyp’ g and ‘Entomozaen Ökotyp’ h) introduced by G. Becker were recently adopted by Casier (2008, 2017) and, e.g., Maillet et al. (2016) as Mega-Assemblages 0–V (Fig. 23c: 0–III = Eifel Mega-Assemblage, IV = Thuringian Mega-Assemblage, and V = Myodocopida Mega-Assemblage in the oxygen minimum zone of the external platform).

The widespread ‘mixed faunas’ sensu G. Becker (e.g., 2000: p. 558, text-fig. 3) (Mischfaunen resp. Mixed Assemblages sensu G. Becker and Bless 1990) seem to be included by Casier (2008) and Crasquin and Horne (2018) without.
The first ostracodes above the Rich 4 Sandstone Member (topmost Khebchia Formation, late Emsian) in the Hassi Mouf South section (sample FRA-TKZ 4) have been found in marly shales, represented by a nearly monospecific layer with large beyrichialean ostracodes (many Zygobeyrichia specimens and very rare small non-beyrichiaceans). They may indicate a relatively restricted nearshore area with terrigenous influx (beyrichiid complex sensus Polenova 1971). The nektobenthic mode of life suggested for Zygobeyrichia by G. Becker and Franke (2012: p. 95) seems unlikely because of the anteroventral crumina in heteromorphs.

The new silicified ostracode faunas from the Crinoid Marl Member of the Torkoz area (samples FRA-TKZ 4c2, Torkoz GIV 1, and Tor Eif/2d) are interpreted as autochthonous ‘Eifelian Ecotype’ sensu G. Becker resp. ‘Eifel Mega-Assemblage, MA III’ (Mega-Assemblage de l’Eifel sensu Casier 2017). They contain diverse sculptured taxa (lobated, ribbed, and reticulated) of different size (juvenile and adult valves, rare carapaces), and extremely rare specimens of spinose taxa (e.g., Kirkbyellina resp. Berouella) characterising open-marine environments below wave base. The related, well-preserved silicified ostracode fauna described by K. Zagora (1968) from the Thuringian ‘Tentaculiten-schiefer’ (latest Emsian cancellata Dacryonarid Zone) was interpreted by K. and I. Zagora (1986) as shallow-water fauna of the Eifelian Ecotype transported by proximal turbidity currents into a deeper area before being embedded. This interpretation was not accepted by G. Becker et al. (2004: p. 82) and is now included in his ‘mixed faunas’. The preservation of the figured ostracodes in K. Zagora (1968) does not show any sign of transport or damage.

For many years, H. G.-U. tried to get access to this very important fauna, but the material of K. Zagora (1968) including the types is still not available in the collection of the Geological Institute of the University of Jena, Germany. Only the ostracodes described by I. Zagora (1967) have been found in the Geological magazine of the University of Jena.

In common with the new Moroccan, faunas are the heavily sculptured genera such as Bollia, Ctenoloulna, Eridococoncha, Jenningsinsa, Karlingrella, Kirkbyrhiza, Polyzygia, Punctoprimitia, Ulrichia, and Zygobeyrichia. However, in contrast to the new ostracode faunas in the latest Early Devonian of the Torkoz area, the Thuringian fauna of K. Zagora (1968) contains spinose genera such as Baschkirina, Bufina, Healdia, Praepilatina, and Tricornina. In G. Becker et al. (2004: p. 83), the ostracode assemblage from Zagora’s ‘type cancellata zone’ is therefore interpreted as clearly mixed faunas indicating an offshore position below wave base. They are comparable to the mixed faunas in G. Becker et al. (2004) from the Emsian (Oui-n-Mesdour and Khebchia formations), and in Dojen et al. (2010) from the late Emsian to early Eifelian from SW Morocco.

A detailed description of new Moroccan ostracodes of the ‘mixed fauna’ will follow in Dojen et al. Late Early Devonian ostracode faunas of the Thuringian Ecotype (= Mega-Assemblage MA IV) with many spinose podocopids and the Entomozaeacean/Myodocopiaceae Ecotype (= Mega-Assemblage MA V) from deeper water sediments have not yet been recorded from the Torkoz area, but they are known from younger sediments in Morocco.

Surprisingly, very nearshore sculptured genera like Kozlowskiiella and Poloniella (‘subtype a’ of the Eifelian Ecotype sensu G. Becker 2000b), amphitsititids, bufinids, and smooth ostracodes (like bairidiids, bairidiocypridids, pachydomellids) are completely missing in the new Moroccan ostracode faunas of the Crinoid Marl Member in the Torkoz area, but they are common in time-equivalent faunas of, e.g., Germany, Bohemia, and Poland. This may indicate less agitated and slightly deeper water for the Moroccan ostracodes in the latest Emsian.

**Conclusion**

A very rich and diversified ostracode fauna (22 genera resp. 32 species) from one conodont sample residue of the latest Early Devonian Yeraifia Formation of section Hassi Mouf South is described and 49 ostracode taxa from the Torkoz area in SW Morocco are discussed. The new silicified fauna of the ‘Eifelian Ecotype’ shows very close relationships to the silicified Thuringian ostracode fauna of the same age. It has to be verified why there are minor relations to the well-preserved, but calcareous ostracode fauna of the latest Early Devonian Grzegorzowice Beds in the Holy Cross Mountains of Poland (e.g., Adamczak 1968, 1971, 1976), likewise interpreted as Eifelian Ecotype but with lots of bairidiids, bairidiocypridids, pachydomellids, and bufinids. In common are only the taxa Ctenoloculina, Jenningsinsa, Lep- toprimitia, Polyzygia krommelbeini, P. symmetrica, and P. insculpta.

Associated brachiopods from the first limestone of the Crinoid Marl Member (Lower Yeraifia Formation) suggest an age close to the Emsian/Eifelian boundary for sample.
Tor Eif/2b (Hassi Mouf South section) and more likely a latest Emsian age. This brachiopod fauna is consistent with an open-marine shelf environment with relatively little terrestrial input, corresponding to the sedimentological interpretation. It shows relationships to coeval brachiopod faunas from the Cantabrian Mountains, the Armorican Massif, the Eifel region, and the Holy Cross Mountains.

The composition of the palynological assemblage is somewhat deficient, but the reported marine acritarchs, prasinophytes, and the scolecodont from the Torkoz section (sample GIV 1 W) suggest an open shelf environment. Palaeogeographically, the identified taxa show a prevailing Gondwanan affinity and can be best compared with those recorded from northern Spain. The studied prasinophyte and acritarch taxa support as well the stratigraphic assignment of the ostracode and brachiopod faunas as late Emsian age close to the Early/Middle Devonian boundary.

In summary, the described arguments favour a late Emsian (latest Early Devonian) age for all studied samples (FRA-TKZ 4, FRA-TKZ 4c2 and Tor Eif/2b from section Hassi Mouf South, Torkoz Giv 1B and GIV 1 W from section Torkoz). This implies the position of the Emsian/Eifelian boundary within the Crinoid Marl Member and not at the top or within the underlying Rich 4 Sandstone Member as published from the southwestern Dra Valley area in SW Morocco by e.g., R.T. Becker et al. (2004a, 2004c) and Dojen et al. (2010).

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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