



First Records of Late Devonian Entomozoacean Ostracods in North-western Turkey

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Abstract: Entomozoacean ostracods (pelagic so-called fingerprint-ostracods) have recently been observed for the first time in Upper Devonian sediments of the Darlık B Section from the İstanbul region, north-western Turkey. These new assemblages consist of *Entomoprimitia nitida*, *Entomoprimitia sartenari*, *Entomoprimitia concentrica*, *Franklinella calcarata*, *Waldeckella erecta?*, *Rabienella* n. sp. c, aff. *reichi* sensu Rabien & Rabitz 1958, *Rabienella reichi*, *Richterina (Volkina) zimmermanni* and *Nehdentomis pseudorichterina* and can be dated as Late Frasnian *Entomoprimitia sartenari* Zone (= *variostrata* Zone sensu Rabien 1954).

These entomozoacean ostracods indicate a faunal relationship with Germany (Rhenish Schiefergebirge, Harz Mountains, Thuringia), Poland (Holy Cross Mountains), N France-Belgium (Ardennes), Volgo-Ural Region and South China in the Late Devonian.

Key Words: Ostracods, Entomozoacea, Late Devonian, Frasnian, Turkey

Kuzeybatı Türkiye’de Frasnien Yaşlı Entomozoacean Ostrakodlarının İlk Bulguları

Özet: Entomozoacean ostrakodlar (parmakizi ostrakodları), bu çalışma ile Kuzeybatı Türkiye’de İstanbul civarında Geç Frasnien’de ilk olarak bulunmuştur. Bu çalışmadaki entomozoacean ostrakod topluluğunu, *Entomoprimitia nitida*, *Entomoprimitia sartenari*, *Entomoprimitia concentrica*, *Franklinella calcarata*, *Waldeckella erecta?*, *Rabienella* n.sp. c, aff. *reichi* sensu Rabien & Rabitz 1958, *Rabienella reichi*, *Richterina (Volkina) zimmermanni*, *Nehdentomis pseudorichterina* türleri oluşturmaktadır ve *Entomoprimitia sartenari* Zonu (= *variostrata* Zone sensu Rabien 1954) türlerin topluluk yayılımına göre oluşturulmuştur.

Bu entomozoacean ostrakod türlerinin Geç Devonien döneminde, Polonya (Holy Cross Dağları), Almanya (Rhenish Schiefergebirge, Harz Dağları, Thuringia), Kuzey Fransa-Belçika (Ardenler), Volgo-Ural Bölgesi ve Güney Çin ile faunal bir ilişkisinin olduğunu göstermektedir.

Anahtar Sözcükler: Ostrakod, Entomozoacea, Geç Devonien, Frasnien, Türkiye

Introduction

Devonian sequences of north-western Anatolia (İstanbul area) are characterized by shallow to deep marine deposits. The Devonian units have been studied by many authors for many years (Paeckelmann 1938; Haas 1968; Kaya 1973; Önalın 1988; Göncüoğlu 1997; Göncüoğlu & Kozur 1998, 1999; Gedik & Önalın 2001; Gedik *et al.* 2005) and their fauna, including bivalvia, brachiopods,

trilobites, goniatites, corals, conodonts and ostracods have been described by e.g. Paeckelmann & Sieverts (1932); Paeckelmann (1938); Abdüsselamoğlu (1963); Kaya (1973); Çapkınoğlu (1997, 2000); Dojen *et al.* (2004). No entomozoceans have yet been reported within the ostracod faunas.

We report here that during recent studies in the İstanbul region, north-western Turkey, supported by IGCP-499 of UNESCO and by TÜBİTAK/Turkey

and bmb+f/Germany (DEVEC-TR) projects, the first entomozoacean ostracods were observed in the Büyükada Formation (Yörükali Member). The studied section is located at Darlık Reservoir, İstanbul region (NW Turkey) (Figure 1).

The paper aims to analyse the Late Frasnian entomozoacean ostracod record from the İstanbul region, north-western Turkey and to correlate it with European, African, American and Chinese entomozoacean assemblages and zonation.

Stratigraphy

The Palaeozoic successions of the İstanbul region and surrounding areas of the Pontides show different tectonic and stratigraphic characteristics (Şengör *et al.* 1984; Göncüoğlu & Kozur 1998; Yanev *et al.* 2006). The studied unit belongs to the Büyükada Formation. This unit was previously included in the 'Nierenkalk-Kieselschiefer-Serie' by Paeckelmann (1938), 'Yelken Tepe-Schichten' by Haas (1968) and 'Yörükali Member' within the 'Tuzla Formation' by Önalın

(1982, 1988). The Büyükada Formation is subdivided into three members, namely the Bostancı, Yörükali and Ayineburnu members by Kaya (1973) and its type locality is south of Yörükali Bay at Büyükada, by the Sea of Marmara.

The ostracods were collected from the Yörükali Member in the middle part of the Büyükada Formation, which typically consists of laminated, silicified shales, radiolarites and chert beds. The Yörükali Member overlays the Bostancı Member and gradually passes up into the nodular limestones of the Ayineburnu Member. A Givetian to Frasnian age was only suggested by dating the underlying and overlying units, and by several radiolarian genera (Kaya 1973; Gedik *et al.* 2005).

Material and Methods

The samples were collected from laminated silicified shales between 70–80 metres in the Darlık B section in the Yörükali Member of the Büyükada Formation (Figure 2). The entomozoacean ostracods are

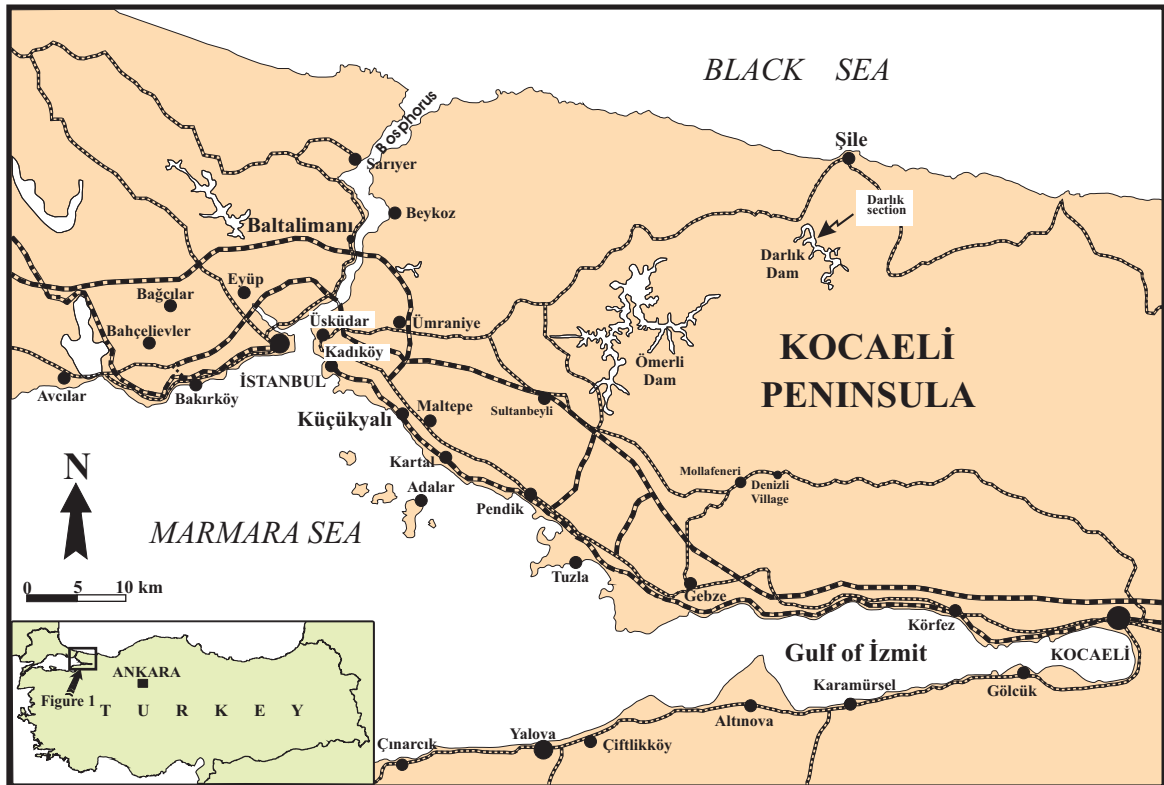


Figure 1. Location map of the Darlık B Section (from Noble *et al.* 2008).

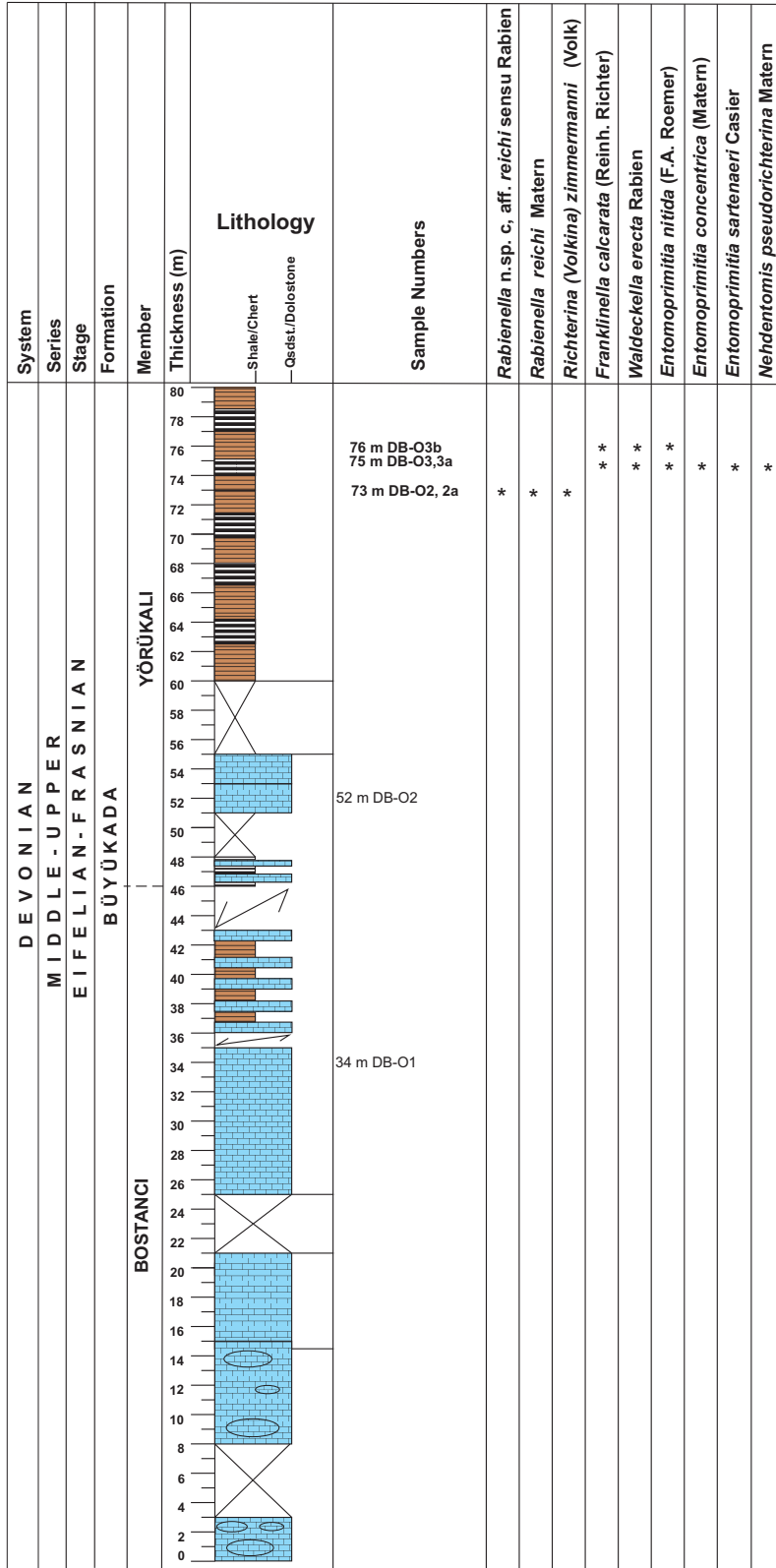


Figure 2. Darlık B measured stratigraphic section and distribution of entomozocean ostracods.

preserved as external and internal moulds of single valves and only rarely as closed carapaces. They are very abundant in the samples. No benthic ostracods have been found coexisting with entomozoacean ostracods in the studied area. A stereomicroscope and a digital camera were used for the photographs of uncoated ostracods (Plate 1). The figured specimens are stored in the Devonian Project (DEVEC TR) Collections for references in Plate 1 at the Geology Museum of İstanbul University, Avcılar Campus in Turkey. Additional material will be stored in Department of Geological Engineering, University of Çukurova, Adana in Turkey.

Entomozocean Assemblages and Systematic

The entomozocean ostracods are important Palaeozoic ostracods but their exact systematic position is still uncertain. They originated in the Late Silurian (Siveter & Vannier 1990) and have their acme in diversity and abundance in the Late Devonian and Early Carboniferous. They are characterised by varied fingerprint sculpture, an adductor muscle field or pit and occasionally by an adductor sulcus.

Six genera and nine species of entomozocean ostracods were observed in the Darlık B Section: *Entomoprimitia nitida*, *Entomoprimitia sartenaeri*, *Entomoprimitia concentrica*, *Franklinella calcarata*, *Waldeckella erecta?*, *Rabienella* n.sp. c, aff. *reichi* sensu Rabien & Rabitz 1958, *Rabienella reichii*, *Richterina (Volkina) zimmemmanni*, *Nehdentomis pseudorichterina* (Plate 1).

The following synonymy lists are abbreviated; they only show the publication dates of the species and publications of detailed descriptions, revisions and new figures.

Taxonomic Remarks

Superfamily Entomozoacea Přibyl 1950

The systematic position of the 'Entomozoacea' (or Entomozooidea) is still debated but they were mostly taken as Myodocop(id)a resp. Myodocopamorphes (different opinions summarised in Groos-Uffenorde 1991). Despite the fact that the type species of the so-called 'fingerprint-ostracods' *Entomozoe (Entomozoe) tuberosa* (Jones 1861) is a smooth ostracod belonging to the Bolbozoacea, the name Entomozoacea is still

in use (Olempska 2002a; Groos-Uffenorde 2004; Gooday 2009).

The outline of specimens, the ribbing pattern and the presence of spines, adductor sulcus and muscle pit are important in identifying entomozocean ostracods. A distinct rostrum or rostral incisure is missing but some species show an anteroventral indentation of the outline and of the sculpture. The original shell structure and morphology in entomozoceans from the late Devonian of the Holy Cross Mountains were identified by Olempska (1992).

Family Entomozoidae Přibyl 1950

The subdivision of this family into the subfamilies Entomozoinae Přibyl 1950, Entomoprimitiinae Gründel 1962 and the very rare Bouciinae Přibyl 1950 is not used here.

Genus *Entomoprimitia* Kummerow 1939

The subgenera *Entomoprimitia (Entomoprimitia)* Kummerow 1939 and *Entomoprimitia (Reptiprimitia)* of Gründel 1962 are not used in this paper. The detailed study of well preserved Russian material (thesis by A.N. Orlov, St. Petersburg 1993) is still unpublished.

Entomoprimitia concentrica (Matern 1929)

Plate 1, Figure 1

- 1929 *Haploprimitia concentrica concentrica* n.sp. and
Haploprimitia concentrica inflata n.sp. – Matern: 15–17, plate 1, figure 15, plate 2, figure 16.
- 1954 *Entomoprimitia concentrica* (Matern 1929). – Rabien: 80–83, plate 2, figure 9.
- 1984 *Entomoprimitia concentrica* (Matern 1929). – Groos-Uffenorde: plate 2, figures 12–15 (= photos of Matern's types).

Diagnosis: Narrowly concentric ribbed valves with small muscle pit in the centre of the ribbing pattern, indistinct adductor sulcus, anterodorsal bulb (sometimes with spine) only visible in well preserved specimens.

Remarks: The subdivision into 2 subspecies is not justified according to Rabien (1954).

Stratigraphical Distribution and Occurrence: Middle to late Frasnian of Europe (Germany, Belgium), Africa (Algeria), South China (Guangxi Province), North-western Turkey (Darlık B Section, İstanbul region).

Entomoprimitia nitida (F.A. Roemer 1850)

Plate 1, Figures 2–3

1850 *Cypridina nitida* n. sp. – F.A. Roemer: 28, plate 4, figure 20a, b.

1954 *Entomoprimitia nitida* (F.A. Roemer 1850). – Rabien: 65–70, plate 1, figure 6; plate 3, figure 24.

Diagnosis: Relatively straight and distinct adductorial sulcus (S_2) ending above the large and deep muscle pit, many fine concentric ribs with varying distinctness.

Remarks: Specimens with less distinct ribbing pattern to nearly smooth valves were included in this species by Rabien (1954), but separated by Müller-Steffen (1964) as *Entomoprimitia inconstans* n. sp.

Stratigraphical Distribution and Occurrence: Middle and Late Frasnian of Europe (Poland, Germany, Belgium), South China (Guangxi Province), North-western Turkey (Darlık B Section, İstanbul region).

Entomoprimitia sartenaeri Casier 1975

Plate 1, Figures 4, 5

1884 *Entomis variostriata* Clarke. – Clarke: 184, plate IV, figure 3.

1975 *Entomoprimitia (Entomoprimitia) sartenaeri* n. sp. – Casier: 9–11, plate I, figures 6a–c; plate II, figures 1, 3.

1984 *Entomoprimitia variostriata* (Clarke 1884) sensu Rabien (1954). – Groos-Uffenorde: plate 2, figures 1–3.

1998 *Entomoprimitia (Entomoprimitia) sartenaeri* Casier (1987). – Casier & Lethiers: 74, figure 3c.

Diagnosis: Concentric ribbing pattern comparable to *E. kayseri* but with distinct muscle pit. In contrast to *E. kayseri* the elliptic ribs of *E. sartenaeri* are truncated anteriorly.

Stratigraphical Distribution and Occurrence: Middle to Late Frasnian of Europe (Germany, Belgium, Poland), North America, South China (Guangxi Province), North-western Turkey (Darlık B Section, İstanbul region).

Genus *Nehdentomis* Matern 1929

Nehdentomis was formerly considered as a subgenus of *Entomozoe* Přibyl 1950. But because of the missing characteristic ‘fingerprint’ sculpture and the presence of a rostral incisure the type-species *Entomozoe tuberosa* Jones 1861 was placed within the Bolbozoacea by Siveter & Vannier 1990 and therefore the subgenera *Richteria* Jones 1874 and *Nehdentomis* Matern 1929 are now taken as genera.

Nehdentomis pseudorichteria (Matern 1929)

Plate 1, Figure 10

1929 *Entomis (Nehdentomis) pseudorichteria* n. sp. – Matern: 59–60, plate 4, figures 46a–c.

1954 *Entomozoe (Nehdentomis) pseudorichteria* (Matern 1929). – Rabien: 102–104, plate 1, figure 7; plate 2, figure 52.

1994 *Entomozoe (Nehdentomis) pseudorichteria* (Matern 1929). – Gozalo: 128–130, plate 21, figures 6, 7a, b; plate 22, figures 1, 2.

Diagnosis: Outline and ornamentation like *Richteria* Jones 1874 but with an additional adductorial pit.

Stratigraphical Distribution and Occurrence: Middle and late Frasnian until earliest Famennian (abundant in the Middle and Late doI = ‘Adorf’ stage and rarely in the early doII/‘Nehden’ stage of Germany) of Europe (Germany, Belgium, Poland, Spain, Great Britain), Africa (Algeria), Russia, South China, North-western Turkey (Darlık B Section, İstanbul region).

Genus *Rabienella* Gründel 1962

This genus is distinguished from *Entomoprimitia* Kummerow 1939, especially by the lack of a muscle pit. *Rabienella* has been considered as a subgenus of *Waldeckella* Rabien 1954 resp. *Bertillonella* Stewart & Hendrix 1945 by Gründel (1962), but we follow Groos-Uffenorde & Wang 1989.

Rabienella reichi (Matern 1929)

Plate 1, Figure 8

- 1929 *Primitiella reichi* n.sp. – Matern: 21–22, 78, plate 1, figure 9a–c.
 1954 *Waldeckella reichi* (Matern 1929). – Rabien: 159–160.
 1989 *Rabienella reichi* (Matern 1929). – Groos-Uffenorde & Wang: 69, plate 4, figures 25–27, 29.

Diagnosis: Outline subcircular to ovoid with a vertically arranged coarse rectangular ribbing pattern.

Stratigraphical Distribution and Occurrence: Late Frasnian of Europe (Germany, Belgium, Poland, Spain) South China, Russia, North-western Turkey (Darlık B Section, İstanbul region).

Rabienella n. sp. c, aff. *reichi* sensu

Rabien & Rabitz 1958

Plate 1, Figures 6, 7

- 1958 *Waldeckella* n. sp. c, aff. *reichi* (Matern 1929). – Rabien & Rabitz: 174.

Diagnosis: Outline subcircular to ovoid with a coarse subquadrangular ribbing pattern.

Stratigraphical Distribution and Occurrence: Late Frasnian of Germany and North-western Turkey (Darlık B Section, İstanbul region).

Remark: *Rabienella* aff. *reichi* (Matern 1929) is also recorded from Germany and South China.

Genus *Richterina* Gürich 1896

This genus was revised by Rabien (1954) and subdivided into the subgenera *R. (Richterina)*, *R. (Volkina)* and *R. (Fossirichterina)*. The oval outline, the longitudinal ribbing pattern and the lack of an adductor sulcus are the most typical features of the genus.

Subgenus *Richterina (Volkina)* Rabien 1954*Richterina (Volkina) zimmermanni* (Volk 1939)

Plate 1, Figure 9

- 1939 *Entomis (Nehdentomis) zimmermanni* n. sp. – Volk: 250, plate 1, figure 10.
 1954 *Richterina (Volkina) zimmermanni* (Volk 1939). – Rabien, 110–113, plate 2, figure 14; plate 4, figures 33, 34.

Diagnosis: Elliptic outline; the dense longitudinal ribbing pattern has a lenslike centre.

Stratigraphical Distribution and Occurrence: Common in the middle and late Frasnian – questionable in the Famennian of Europe (Germany, Belgium, Poland, Spain), Africa (Algeria), South China (Guangxi Province), North America (Ohio), North-western Turkey (Darlık B Section, İstanbul region).

Genus *Waldeckella* Rabien 1954

Gründel (1962) separated to two subgenera: *Waldeckella (Waldeckella)* and *Waldeckella (Rabienella)* and renamed them as *Bertillonella (Bertillonella)* and *Bertillonella (Rabienella)*.

According to Casier (1982) these types of *Bertillonella* are juvenile stages of *Entomoprimitia concentrica* and therefore the name *Waldeckella* is valid (Groos-Uffenorde & Wang 1989).

Late Givetian to earliest Frasnian species of *Bertillonella* are only known from South China, whereas Frasnian and earliest Carboniferous species are especially known from Europe.

Waldeckella erecta Rabien 1954?

Plate 1, Figure 12

- 1954 *Waldeckella erecta* n. sp. – Rabien: 152–154, plate 1, figure 10; plate 5, figure 44.

Diagnosis: Lateral outline broadly oval, dorsal border straight but relatively short. Fine concentric ribs are arranged elliptically with long axes vertical in contrast to the horizontal elliptical arrangement in *Entomoprimitia concentrica*.

Stratigraphical Distribution and Occurrence: Middle 'Adorfian' stage (Frasnian) of Germany, Great Britain and South China in the *Waldeckella cicatricosa* Zone and not reported together with the coarsely ribbed *Rabienella* species of the Late Frasnian.

The identification of the specimens from the Darlık B Section (İstanbul region) north-western Turkey is doubtful because the valve margins are not preserved and the ribbing pattern is not very fine.

Family Rhomboentomozoidea Gründel 1962

Genus *Franklinella* Stewart & Hendrix 1945

There is no homonymy with the Pleurotomariid *Franklinella* Nelson 1937, but synonymy with *Ungerella* Livalent 1948. The Lower Devonian Brachiopod new genus *Franklinella* Lenz 1973 is a younger homonym of the entomozocean ostracod genus.

Franklinella calcarata (Reinh. Richter 1856)

Plate 1, Figure 11

- 1856 *Cypridina calcarata* Richter. – Reinh. Richter: 123, plate 2, figures 36–38.
- 1954 *Franklinella calcarata* (Reinh. Richter 1856). – Rabien: 48–51, plate 1, figure 1
- 1998 *Franklinella (Franklinella) calcarata* (Reinh. Richter). – Gozalo & Sanchez de Posada: 237–238, plate 1, figures 1–5.

Diagnosis: Small species with 6–12 longitudinal thin ribs joining in the antero-ventral and postero-dorsal corner (resp. in the long spines), 1(–2) concentric ribs parallel to the borders, distinct and long adductorial sulcus (S_2) developed.

Stratigraphical Distribution and Occurrence: Frasnian and lowermost Famennian of Europe (Germany, Belgium, Spain), North America, South China,

North-western Turkey (Darlık B Section, İstanbul region).

Entomozocean Zonation

A detailed Late Devonian entomozocean zonation was established by Rabien (1954) in the Rhenish Schiefergebirge of Germany. Recently, this zonation was summarised by Groos-Uffenorde *et al.* (2000).

This Late Devonian ostracod zonation is only partly based on total ranges of species (range zone). The beginning of a zone resp. subzone in the late Frasnian (early Late Devonian) is defined by the first occurrence of a new index species and not by the extinction of a species or subspecies (Concurrent range zone). The evolution of the ribbing pattern of *Rabienella* (from elongate triangular and triangular becoming more horizontally rectangular and quadrangular to vertically rectangular) was used for the first time by Rabien & Rabitz (1958) for a subdivision of late Frasnian shales. This detailed biozonation was verified in German sections and used for correlation with South China by Groos-Uffenorde & Wang (1989).

The entomozocean faunas in the studied area in north-western Turkey with short ranging species of *Rabienella* can be dated as Late Frasnian *Entomoprimitia sartenaeri* (= *variostrata* sensu Rabien) Zone, and correlated with the fauna described by Casier (1975) from the Matagne Formation at Boussu-en-Fagne, in the type region of the Frasnian Stage. This fauna is characteristic of the middle part of the Upper Frasnian as recently defined by the Subcommission on Devonian Stratigraphy. Thus, the age of Yörükali Member can be established as Late Frasnian, whereas it was previously assumed to be Givetian to Frasnian in age, based on its relationship with the underlying Bostancı Member and overlying Ayineburnu Member.

Lifestyle of the Entomozocean Ostracodes

The detailed study by Rabien (1954) of Late Devonian sequences in Germany proves the pelagic mode of life of the thin-shelled entomozocean ostracods which are widespread worldwide and

of high biostratigraphical value. Gooday (1983, 2009) stated that the carapace morphology of entomozoaceans provides no clear evidence for either planktonic or benthic existence and both modes may have been represented. Bless (1983) concluded that Entomozoacea were pelagic inhabitants of marine basins and only occasionally would they have been swept into shelf areas. Casier (1987, 2004) believed in the nektobenthic mode of life in an environment very poor in oxygen and even in shallow water. According to Perrier (2007) the entomozocean ostracods are benthic in Cambrian to early Ordovician time, nektobenthic in the late Ordovician and early Silurian, hyperbenthic in the late Silurian and pelagic in Devonian time. Perrier *et al.* (2007) regarded the late Silurian 'entomozoaceans' as pioneer pelagic myodocopes. The first discovery of Frasnian entomozoaceans in the İstanbul area (that is in addition to the hitherto known occurrences in Europe and South China) support the interpretation of their pelagic mode of life.

Regional Distribution of Entomozocean Ostracodes

The entomozocean ostracod assemblages of this study especially indicate a relationship with the Early Late Devonian of the Rhenish Schiefergebirge, Harz Mountains and Thuringia in Germany, the Holy Cross Mountains in Poland, Belgium, Timan-Petchora of Russia, and South China (Rabien 1954; Olempska 1979, 2002b; Casier 1982, 1985, 1987; Wang 1983, 1989; Groos-Uffendorde 1984; Groos-Uffendorde & Wang 1989; Lethiers *et al.* 1998; Groos-Uffendorde *et al.* 2000). The widespread occurrence of

entomozoaceans is not restricted to Avalonia or the Rheic Ocean.

Conclusion

In previous research, the Yörükali Member was assumed to be of Givetian to Frasnian age based on its relationship with the underlying Bostancı Member and overlying Ayineburnu Member. The new results, based on entomozocean ostracods, prove a late Frasnian age for the upper part of the Yörükali Member, which was deposited in a slope environment (Önalın 1982, 1988). The associated faunas of entomozocean ostracods and homoctenids (Tentaculitoidea) are typically associated with outer-shelf depositional environments.

Additional studies of Upper Devonian sequences in the İstanbul area are needed to find more entomozocean ostracods to obtain a detailed zonation of the Late Devonian sequences.

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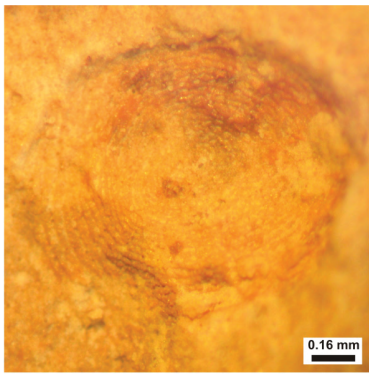
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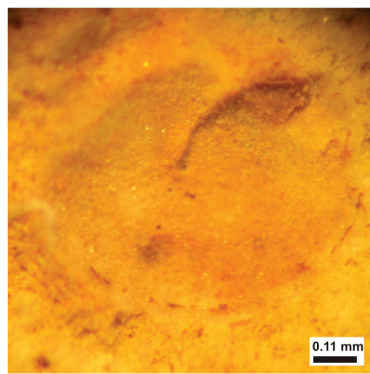
PLATE 1

- Figure 1.** *Entomoprimitia concentrica* (Matern 1929), DEVEC TR/DB-O3, 75m of the Darlık B Section.
- Figures 2, 3.** *Entomoprimitia nitida* (F.A. Roemer 1850), DEVEC TR/DB-O3b, 76m of the Darlık B Section.
- Figures 4, 5.** *Entomoprimitia sartenaeri* Casier 1975, DEVEC TR/DB-C9, between 73-80m of the Darlık B Section.
- Figures 6, 7.** *Rabienella* n. sp. c, aff. *reichi* sensu Rabien & Rabitz 1958, DEVEC TR/DB-O2a, 73m of the Darlık B Section.
- Figure 8.** *Rabienella reichi* (Matern 1929), DEVEC TR/DB-O2a.
- Figure 9.** *Richterina (Volkina) zimmermanni* (Volk 1939), DEVEC TR/DB-O2a, 73m of the Darlık B Section.
- Figure 10.** *Nehdentomis pseudorichterina* (Matern 1929), DEVEC TR/DB-C9, between 73-80m of the Darlık B Section.
- Figure 11.** *Franklinella calcarata* (Reinh. Richter 1856), DEVEC TR/DB-C9, between 73-80 m of the Darlık B Section.
- Figure 12.** *Waldeckella erecta* Rabien 1954?, DEVEC TR/DB-O3b, 76m of the Darlık B Section.

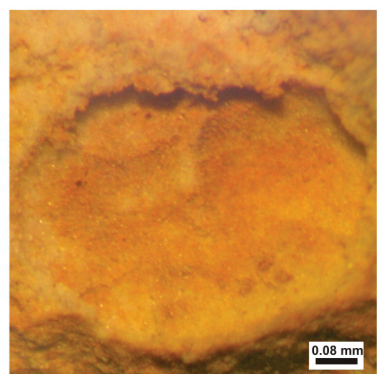
LATE DEVONIAN ENTOMOZOACEAN OSTRACODS, NW TURKEY



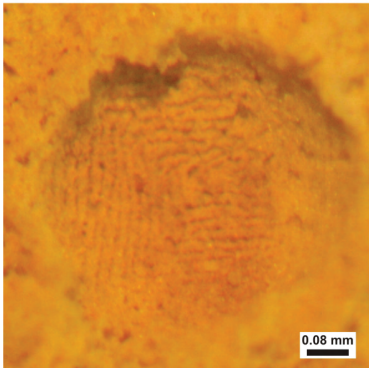
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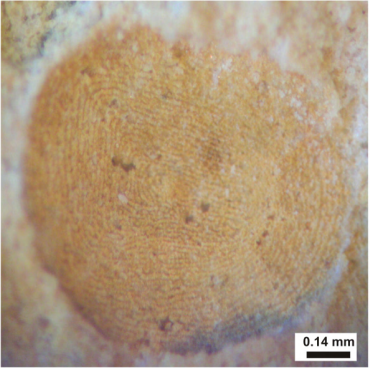
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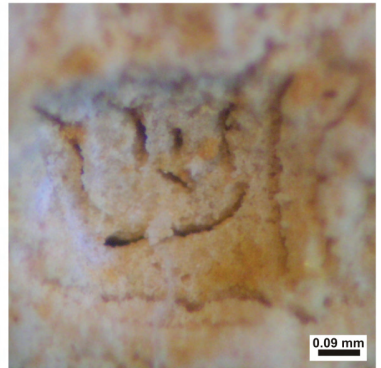
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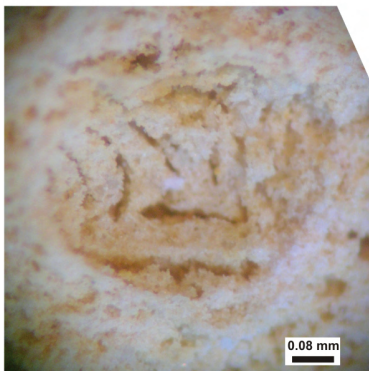
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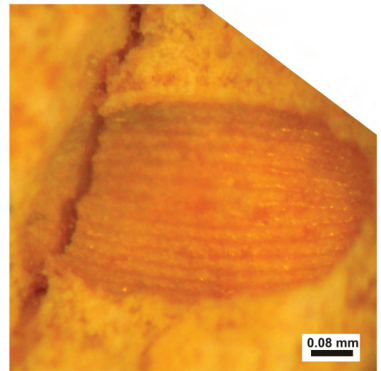
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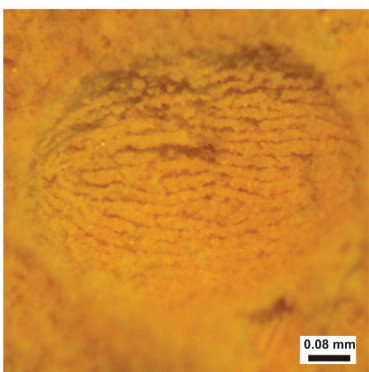
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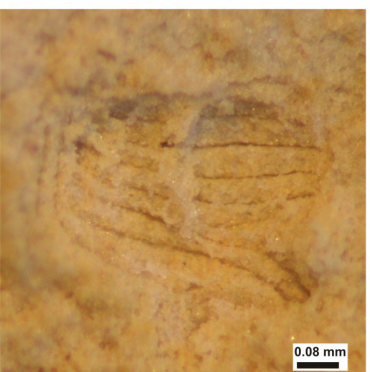
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