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New Data on the Dasycladales from the Lower Eocene of Seyitgazi Region, Eskişehir, Central Turkey

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Abstract: An association of Dasycladalean algae is identified from the Lower Eocene (Ilerdian–Cuisian) of the Seyitgazi area, Western Anatolia. The association consists mostly of the genus *Belzungia* Morellet and *Anatolia* n. gen. This is the first discovery of such a rich and diversified dasycladalean flora with *Belzungia* in the Eocene of Central Tethys.

The genus *Belzungia* is represented by four species: *Belzungia terquemi* Morellet, *B. silvestrii* (Pfender), *B. bella* (Ju Ying) Radoičić and *B. pfenderae* n. sp. *Belzungia* articles consist of whorls characterized by an assemblage of laterals, in the transversal section of which, the primary laterals are distally enlarged (sub-triangular in shape), whereas in the vertical section, they are flat. Cylindrical laterals of younger order are somewhat irregular or, in some species, they may be of more or less anarchic arrangement. The laterals of some orders, even in the same assemblage, often vary in size. Laterals of the sixth order are commonly interlaced, but are seldom preserved.

Two new species (*Anatolia kıslae* n. sp. and *A. kozyakae* n. sp.) of a new genus *Anatolia* have been described. The *Anatolia* new genus combines the structural elements of *Belzungia* and *Thyrsoporella*: the primary laterals are divided into divergent secondaries: in *Trinocladus* four (phloiopforous) tertiaries, thin at the base, are gradually enlarged, ending at the skeleton surface as a minor swelling.

Besides some undetermined *Belzungia* and *Anatolia*, the dasycladalean flora of the studied area includes: *Furcoporella diplopora* Pia, *Dissocladell*a aff. *gracilis* Radoičić, *Acicularia* aff. *tavnae* Radoičić, *Uteria* aff. *merienda* (Elliott), *Uteria* sp., *Neomeris* sp., *Salpingoporella*? sp., *Clypeina*? sp. and some undetermined forms.

Key Words: Dasycladales (green algae), *Belzungia*, lower Eocene, Anatolia, Turkey

Seyitgazi Yöresinin (Eskişehir, Türkiye) Alt Eosen Yaşlı Dasyclad Alglerinde Yeni Bulgular

Özet: Seyitgazi yöresinin Alt Eosen (İlerdiyen–Küiziyen) çökellerinde Dascycladae alglerine ait bir topluluk tanımlanmıştır. Bu toplulukta, *Belzungia* Morellet ve *Anatolia* n. gen. baskın cinslerdir. Bu, merkezi Tetis Eosen'indeki çok zengin ve çeşitli *Belzungia*' lı dascyladean topluluğunun ilk bulgusudur.

Belzungia cinsi; *Belzungia terquemi* Morellet, *B. silvestrii* (Pfender), *B. bella* (Ju Ying) Radoičić ve *B. pfenderae* n. sp. türleri ile temsil olur. *Belzungia* iskeletleri; transversal kesitlerde birincil laterallerin uzaklaştıkça büyüdüğü (üçgen şekilli), düşey kesitlerde de basık olduğu, lateral topluluklar tarafından karakterize edilen turlar içerir. Daha genç sıralardaki silindirik lateraller oldukça düzensizdir ya da bazı türlerde az ya da çok karışık bir düzene sahip olabilirler. Aynı toplulukta bile, bazı sıralardaki lateraller sıklıkla farklı boyutlardadır. Altıncı sıradaki lateraller, genellikle iç içe geçmiştir, fakat bunlar nadiren korunmuştur.

*Anatoli*a yeni cinsine ait iki yeni tür (*Anatolia kıslae* n. sp. ve *A. kozyakae* n. sp.) tanımlanmıştır. Yeni cins, *Belzungia*, *Thyrsoporella* ve *Trinocladus* cinslerinin yapısal elemanlarını birleştirir. İlk iki cinste, birincil lateraller farklı ikincillere bölünürken, *Trinocladus*' da; tabanda ince, dereceli olarak genişleyen ve hafif bir şişme ile iskelet yüzeyinde bitmekte olan dört (phloiopforous) üçüncüllere bölünmektedir.

Çalışma alanının dascyladean topluluğu; *Belzungia* ve *Anatoli*a cinslerine ait tanımlanamamış türler ile birlikte, *Furcoporella diplopora* Pia, *Dissocladell*a aff. *gracilis* Radoičić, *Acicularia* aff. *tavnae* Radoičić, *Uteria* aff. *merienda* (Elliott), *Uteria* sp., *Neomeris* sp., *Salpingoporella*? sp., *Clypeina*? sp. ve bazı tanımlanamamış formları kapsar.

Anahtar Sözcükler: Dasycladales (yeşil alg), *Belzungia*, alt Eosen, Anadolu, Türkiye

Introduction

Palaeogene shallow-water deposits, largely exposed SW of Seyitgazi town, contain generally clayey-sandy limestones and limestones with rich porcellaneous benthic foraminifera. The first palaeontological information on these deposits was documented by Dizer (1964). Later, Özgen-Erdem *et al*. (2007) studied the systematic and biostratigraphic features of alveolinids and dated these sediments as early Ilerdian–middle Cuisian. That Halimedaceae and Dasycladalean algal assemblages found together with porcellaneous foraminifera within the unit is noteworthy. Palaeogene calcareous algae had not been investigated in the study area. Detailed investigations were first carried out on lower Eocene unit by Özgen-Erdem & Radoičić (2009) and a new genus, which belongs to Halimedaceae algae, was described.

The main objective of this study is to describe the new genus and species, which belongs to the Dasycladalean algae from the lower Eocene (Ilerdian–Cuisian) sediments in the Seyitgazi area, to document the occurrence of the *Belzungia* species in the lower Eocene sediments in Turkey and to report the calcareous algae inventory in the study area for the first time.

Larger foraminifera are present in all levels of the lower Eocene unit and are represented by alveolinids, including *Glomalveolina*, *Alveolina* and by soritids and *Orbitolites*, *Opertorbitolites* and *Cyclopertorbitolites* and by a few *Nummulites*, such as *Assilina*. Dasycladalean and Halimedaceae algae are secondary components within the fossil assemblage of these sediments. Species of the genera *Belzungia* (four species) and *Anatolia* n. gen. (two species) are predominant in the Dasycladalean association. Accessory components comprise small benthic foraminifera (miliolids, textularids and rotaliids), bivalves, corals, echinoderms and fragment of bryozoans.

Material

Samples with Dasycladalean algae were collected from the three well-exposed stratigraphic sections (Kışlatepe-NEK, Sarıbayır-NESAS and Kozyaka-NES) and from small outcrops (Kireçocağı-NEE, İskankuyu-NEI and Yanıklık-NEA sections) in the Seyitgazi region (Figure 1). Of the numerous Palaeogene thin sections from N. Özgen-Erdem's collection prepared for the study of foraminiferal fauna, 88 samples were selected, based on their algal content. Some 258 thin sections were prepared from these samples for detailed studies.

Descriptions, lithological features and the distribution of larger benthic foraminifera from the Kışlatepe, Sarıbayır and Kozyaka sections were given in Özgen-Erdem *et al*. (2007) and Özgen-Erdem & Radoičić (2009), respectively. Therefore, only the algal content of these sections is presented in this study (Figure 2).

Geological Setting

The Seyitgazi (Eskişehir) region is situated in the Tavşanlı Zone (Okay & Tüysüz 1999) south of the İzmir-Ankara Suture Zone. Triassic–Cretaceous basement rocks in the study area consist of cherty, dolomitic limestones. Upper Cretaceous–Lower Palaeocene ophiolitic rocks rest tectonically on the basement rocks (Özcan *et al*. 1989). The lower Ilerdian–Middle Cuisian unit unconformably overlies the basement rocks and ophiolites and comprises shallow water limestones, sandy-clayey limestones and marl (Özgen-Erdem *et al*. 2007). Based on these stratigraphic data, Okay (2011) stated that the area east of the Tavşanlı Zone had been covered with a shallow sea at the beginning of the Early Eocene. This unit is unconformably overlain by upper Miocene tuffite and lacustrine limestones.

Biostratigraphy and Environments

The stratigraphic distribution of the studied Dasycladalean algae is shown in Figure 2. The age of these successions is essentially based on larger benthic foraminifera (Özgen-Erdem *et al*. 2007; Özgen-Erdem & Radoičić 2009; Özgen-Erdem 2010).

In the study area, lower Ilerdian strata yield the following assemblages; porcellaneous benthic foraminifera and dasycladalean algae: *Glomalveolina lepidula* (Schwager), *G. karsica* Sirel, *Alveolina ellipsoidalis* Schwager, *A. vredenburgi* Davies & Pinfold, *A. avellana* Hottinger, *Opertorbitolites gracilis*

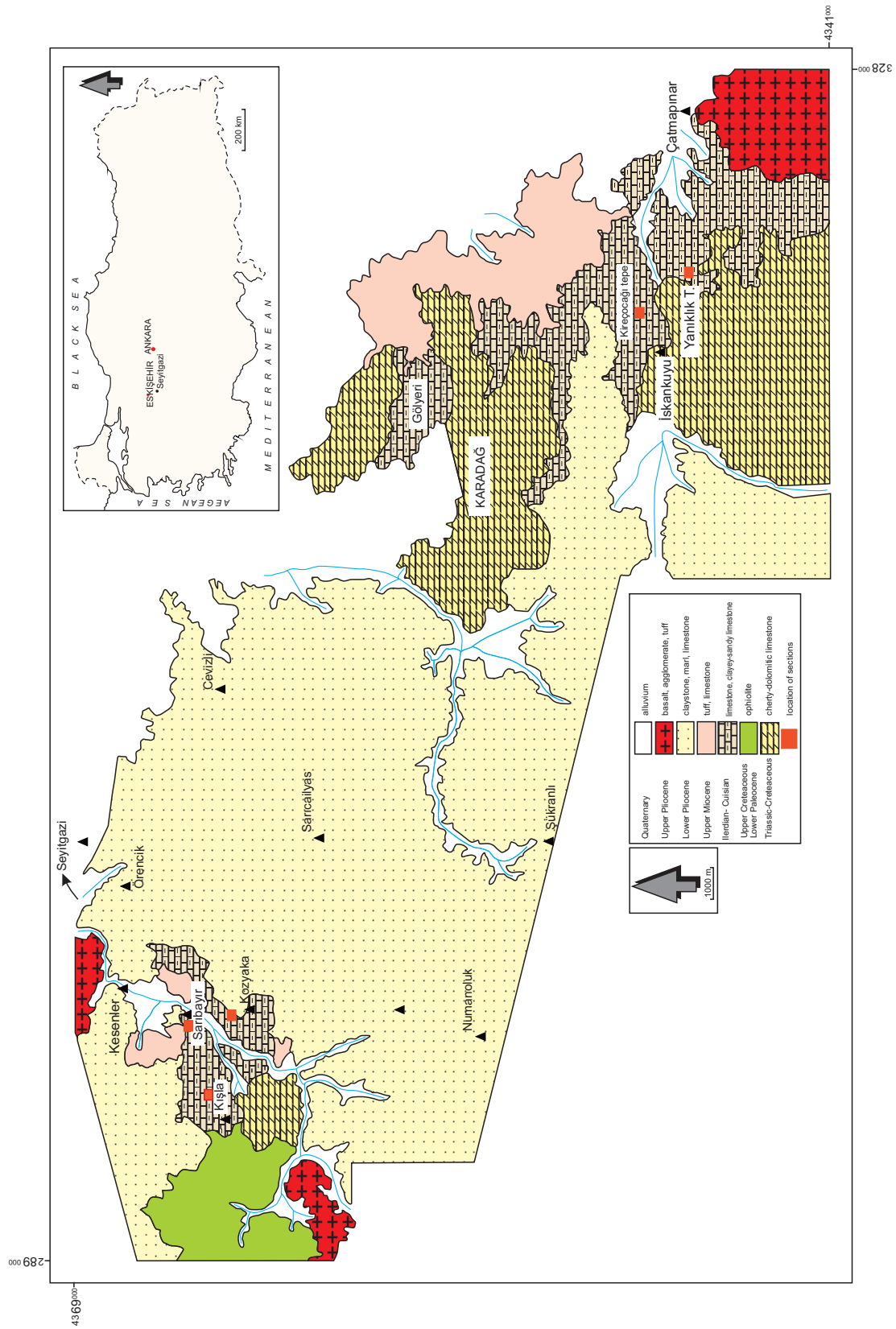

Figure 1. Geological map of the investigated area and location of stratigraphic sections (Geological map modified from Özcan *et al.* 1989).

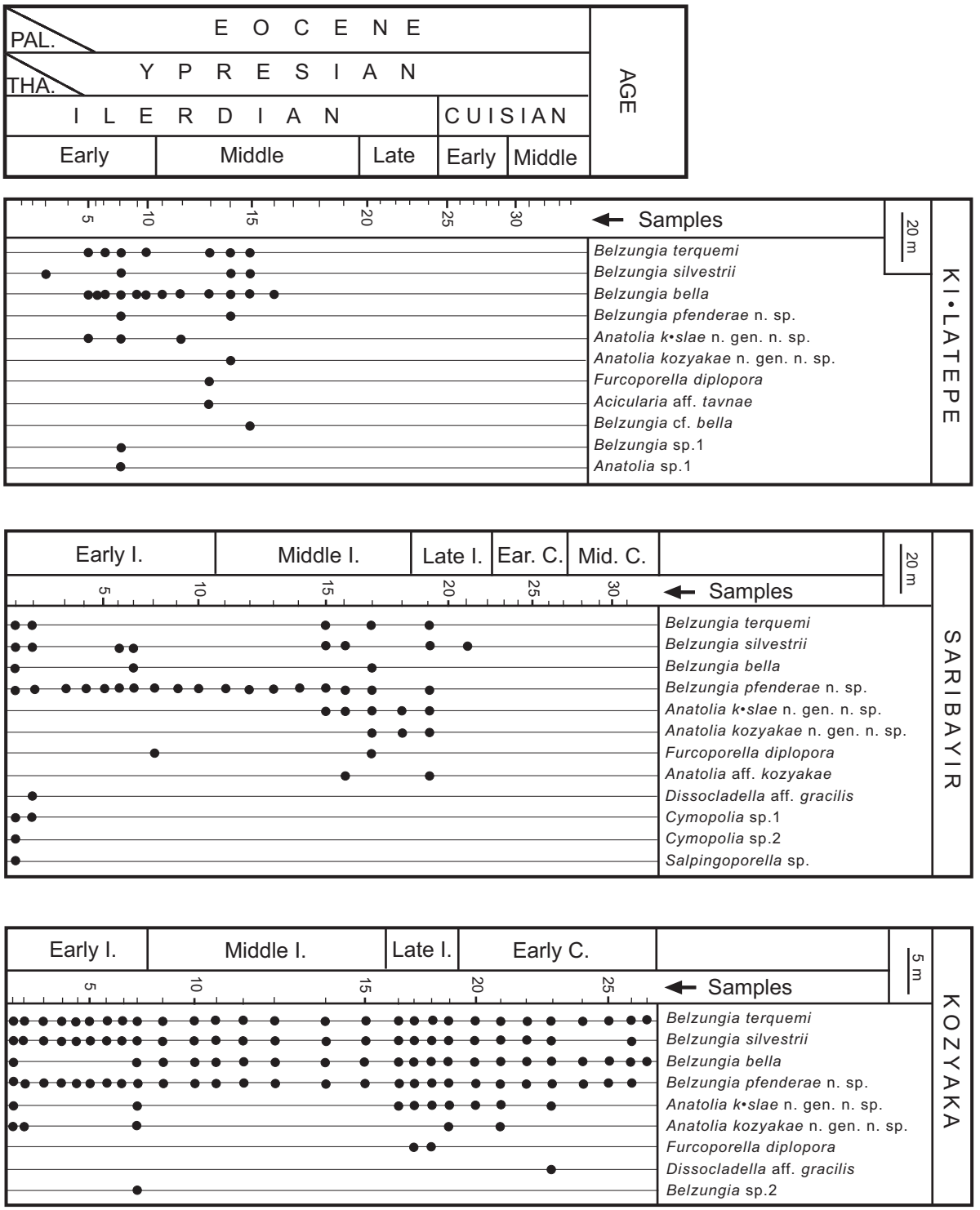

Figure 2. Stratigraphic distributions of dascycladalean algae in the Kışlatepe, Sarıbayır and Kozyaka sections.

(Lehmann), *Orbitolites* aff. *complanatus* Lamarck and *Belzungia terquemi* Morellet, *B. silvestrii* (Pfender), *B. bella* (Ju Ying) Radoičić, *B. pfenderae* n. sp., *Anatolia kıslae* n. sp., *A. kozyakae* n. sp., *Furcoporella diplopora* Pia, *Dissocladell*a aff. *gracilis* Radoičić.

The middle Ilerdian benthic foraminiferal association includes *Glomalveolina lepidula*, *G.* aff. *minutula*, *Alveolina ellipsoidalis*, *A. moussoulensis* Hottinger, *A. aragonensis* Hottinger, *A. ilerdensis* Hottinger, *A. laxa* Hottinger, *A. varians* Hottinger, *A. avellana*, *A.* aff. *minervensis* Hottinger, *A. subpyrenaica* Leymerie, *Orbitolites* aff. *complanatus*, *Opertorbitolites lehmanni* (Montanari), *Cyclopertorbitolites tokerae* Özgen-Erdem, *Nummulites praecursor* de la Harpe, *N. atacicus* Leymerie. Algae such as *Belzungia terquemi*, *B. silvestrii, B. bella*, *B. pfenderae* n. sp., *Anatolia kıslae* n. sp., *A. kozyakae* n. sp., *Furcoporella diplopora* and *Acicularia* aff. *tavnae* were identified in these strata.

Porcellaneous foraminifera such as *Glomalveolina lepidula*, *G.* aff. *minutula*, *Alveolina trempina* Hottinger, *A. aragonensis*, *A. citrea* Drobne, *Orbitolites* aff. *complanatus*, *Opertorbitolites lehmanni* and *Cyclopertorbitolites tokerae* are described in the upper Ilerdian beds. The dasycladalean algal assemblage of this age is dominated by species of *Belzungia* and *Anatolia*: *Belzungia terquemi*, *B. silvestrii, B. bella*, *B. pfenderae* n. sp., *Anatolia kıslae* n. sp., *A. kozyakae* n. sp. and *Furcoporella diplopora*.

The early Cuisian is characterized by *Glomalveolina minutula* (Reichel), *Alveolina canavarii* Checchia-Rispoli, *A. oblonga* d'Orbigny, *A. haymanensis* Sirel, *A. schwageri* Checchia-Rispoli, *A. ruetimeyeri* Hottinger, *Orbitolites* aff. *complanatus*, *Opertorbitolites lehmanni*, *Cyclopertorbitolites tokerae*, *Assilina placentula* (Deshayes) and *Belzungia terquemi*, *B. silvestrii, B. bella*, *B. pfenderae* n. sp., *Anatolia kıslae* n. sp., *A. kozyakae* n. sp. and *Dissocladell*a aff. *gracilis*.

Several studies have suggested that porcellaneous foraminifera such as alveolinids and soritids indicate an inner ramp environment (Ghose 1977; Hottinger 1983, 1997; Rasser *et al.* 2005; Zamagni *et al.* 2008; Brandano *et al.* 2009). Dasycladales probably lived in inner ramp infralittoral environments. The lower Eocene (Ilerdian–lower Cuisian) sediments of the study area contain abundant alveolinid and soritid foraminifera. Dasycladalean algae were also observed in many levels of these sediments. In some beds, very rare planktonic foraminifera (*Acarinina*) were found. The studied limestones are represented by packstone and packstone-wackestone. Based on fossil content and textural features, we concluded that the unit was deposited in an inner-middle ramp environment.

Systematic Palaeontology

Family TRIPLOPORACEAE Pia 1920

Tribus TYRSOPORELLEAE (Pia 1927)

Elliott 1977

Thyrsoporella to *Belzungia* Relationship

The genera *Thyrsoporella* Gümbel (1872) and *Belzungia* Morellet (1908), both characterized by a complex system of laterals, were for a long time regarded as practically identical (Deloffre & Génot 1982). Massieux (1966), while re-examining the collection studied by Pfender from the Egyptian nummulitic rocks, compared it with the corresponding Munier-Chalmas collection. The author established that the two genera essentially differ in the process of formation of the laterals, producing a conspicuous difference in the calcification pattern of *Belzungia* and *Thyrsoporella*.

Up to six orders of laterals are present in *Belzungia*. From the third order, the laterals are somewhat irregular or more or less arranged in an anarchic manner; they are commonly slender. *Thyrsoporella* differs from *Belzungia* in tetradichotomy, starting from the third order, reaching 4–5 orders of the laterals compounded onto the plates on the surface. Génot (1978) thought that the two genera may be separated, based on morphology of their laterals: the laterals of *Thyrsoporella* are thicker (stocky), while those of *Belzungia* are slender. Massieux (ibid.) also emphasized conspicuous differences in the type of the calcification in *Belzungia* and *Thyrsoporella*: 'Chez *Thyrsoporella,* la calcification est faible, et semble constituée de calcifications élémentaire grupées en plaquetes, alors que *Belzungia* présente une paroi calcaire continue, épasse e compact' (p. 138). When only the proximal part of the skeleton is preserved

(with two orders of laterals), the attribution to genus *Thyrsoporella* or *Belzungia* is conjectural.

Genus *Belzungia* Morellet 1908

The type species of the genus is *Belzungia borneti* Morellet, known only from isolated specimens from the Thanetian of the Paris Basin. It has rather short and somewhat swollen articles. *B. bella* (Yu Jing) Radoičić has cylindrical articles, while in *B. terquemi* Morellet, *B. silvestrii* (Pfender) and *B. pfenderae* n. sp. the articles are elongated and cylindrical. At a genus level, the skeleton consists of calcareous cylindrical articles 'united in life into a jointed branching thallus' (Deloffre & Génot 1982). A characteristic feature of the genus is the successive dichotomy of the laterals up to sixth order and their regular disposition in the vertical files. Starting from the second or third, or in some species from fourth or fifth order, they show more or less irregular or anarchic arrangements. The primaries usually are partly preserved. Laterals of the first and second order, or in some species also of forth order, are clearly stronger, while the higher order laterals are slender or very fine. Those of the sixth or even fifth order are interlaced and only partly calcified. Assemblages of laterals are downward inclined in the basal part of articles, in one or two basal whorls.

The genus *Belzungia* is characterized by particular branching – an 'assemblage of laterals' (Génot's term; see below). The primary laterals are not cylindrical in shape. In the transverse sections through the skeleton they are distally enlarged, sub-triangular, best seen in those species having robust primaries. In vertical sections they are flattened; therefore in longitudinal section through the skeleton they show up as cylindrical pores and, in the sections through the pores of the first and second or sometimes also third order they show up as single pores (noted by Massieux in *B. silvestrii*) (i.e. *B. pfenderae* n. sp.). A characteristic of *Belzungia* is the variable dimension of laterals of the same order in one whorl, even in the same assemblage of laterals. Assemblages of laterals in one whorl may also differ.

Belzungia is the most common algal association in the Ilerdian–Cuisian limestone of the Seyitgazi area. Besides the species described in this paper, thin sections showed few new sections of *Belzungia*.

Observation of *Thyrsoporella silvestrii* Pfender in Pfender & Massieux 1966 and *Belzungia silvestrii* (Pfender) Massieux 1992 (in Deloffre & Granier)

Specimens of the new Eocene species *Thyrsoporella silvestrii*, illustrated in Pfender's pl.1, come from two areas:

- 'Gebel Drunka, West Assiut, Libyan desert', Cuvillier collection, thin sections no. 109 and 109 bis, figures 1, 2; and from
- 'Beni Hassan, Upper Egypt', Cuvillier collection, thin section 202 and 202 bis, figures 3–7.

Although not mentioned in the text, it is implicit that Assiut is the type locality, because the new species was introduced on the specimens from Assiut (see: Pfender, p. 113 in Pfender & Massieux 1966 and Massieux 1966: the foot-note on p. 142). Comparing biometrical data of *Thyrsoporella silvestrii* from Assiut with *Belzungia terquemi* Morellet, Massieux (1966, p. 138) concludes that 'la grand similitude des nombres nous permettant de raprocher la forme d'Egypt de celle du Bassin de Paris'. Both specimens also are presented by Génot (1987, p. 263–264) in a synonym list of *Belzungia terquemi*.

According to Massieux, thin sections of no. 202 from Beni Hassan, studied by Pfender, contain rare sections sufficient to recognize *Belzungia*, but not to define the species adequately (p. 142, foot-note). Also thin sections from sample no. 406 (Cuvillier collection) studied by Massieux had been collected from the Beni Hassan area, but this material was neither mentioned nor illustrated by Pfender, and probably not sampled at the same time. It contains numerous well-preserved *Belzungia* sections. Because this species demonstrates characters sufficiently different from *Belzungia terquemi*, Massieux retains 'le nom d'espèce *silvestrii* qui lui donna Pfender en 1940'.

The species was typified by Massieux, in Deloffre & Granier 1992: '*Belzungia silvestrii* (Pfender) Massieux'. However this species cannot be valid because it is not based on the original material studied by Pfender. Excluding two specimens from Assiut (syntypes of *B. terquemi*) other sections illustrated by Pfender, figures 3–5, also originate from Beni Hassan. According to the International Code of Botanical Nomenclature, we designated,

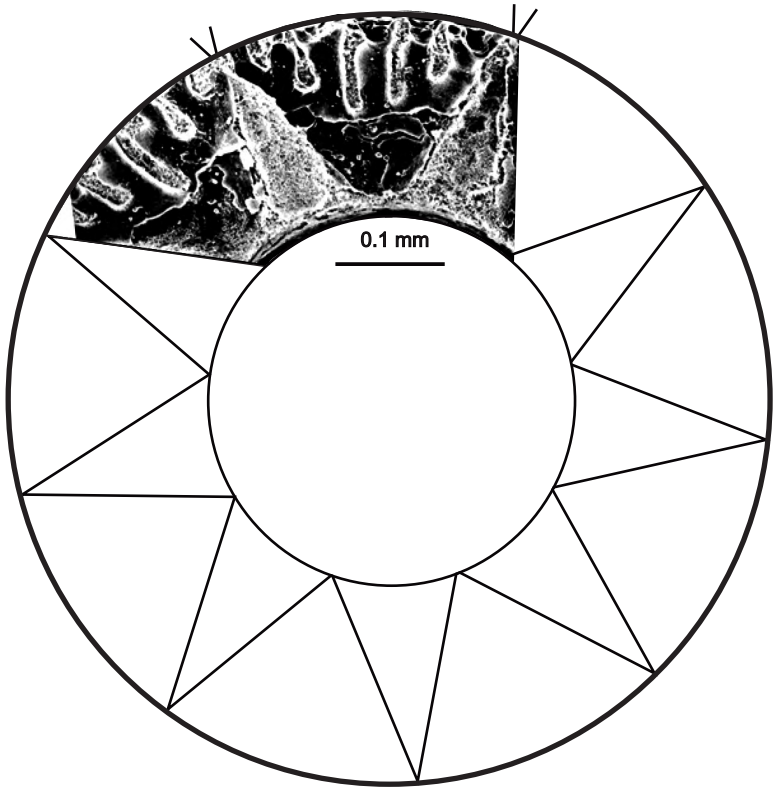

Figure 3. *Belzungia terquemi*, perfectly preserved pores in transverse section, from Génot (1987, plate 42, figure 5).

from among specimens illustrated in the prologue (Pfender 1966), the section on plate I, figure 4 left, as the nomenclature type of *Belzungia silvestrii*.

***Belzungia terquemi* Morellet & Morellet 1917**

Figures 4a–h & 10a, b, i

1917 *Belzungia terquemi* n. sp. Morellet & Morellet, p. 370–371, plate XIV, figures 13–17.

1966 *Thyrsoporella silvestrii* Pfender, Pfender in Massieux, plate 1, figures 1, 2, 8, p.113.

1966 *Belzungia terquemi* Morellet & Morellet, Munier-Chalmas, Massieux, p.138: *T. silvestrii* Pfender is younger synonym of *B. terquemi*.

1966 *Belzungia terquemi* Morellet & Morellet, Munier-Chalmas, Massieux, plate 1, figures 7–16, p. 237–138.

1987 *Belzungia terquemi* Morellet & Morellet, Génot, plate 42, figures 1–11, p. 263–269.

Belzungia terquemi is characterized by elongated cylindrical articles of a thick calcified skeleton. The wall includes five or six orders of laterals arranged in vertical rows. Massive horizontal laterals of the first two orders cover about half of the wall thickness; those from the third order thin gradually and are somewhat anarchical arranged. Laterals of the sixth order are rarely preserved.

The calcareous skeleton is compact, its outer surface plain or more or less abraded (sometimes down to the tertiaries). In better-preserved specimens, the inner skeleton surface is very smooth (Figure 4a, b, e, f). This limit line of the calcification represents the surface of a thin mucilage layer around the axis, which covered the proximal part of the primaries. *Belzungia terquemi* of Anatolia is characterized by variable skeleton dimensions. They are smaller than the material in the Munier-Chalmas collection (Massieux 1966). They mostly correspond to the specimens from Assiut, which have a remarkably

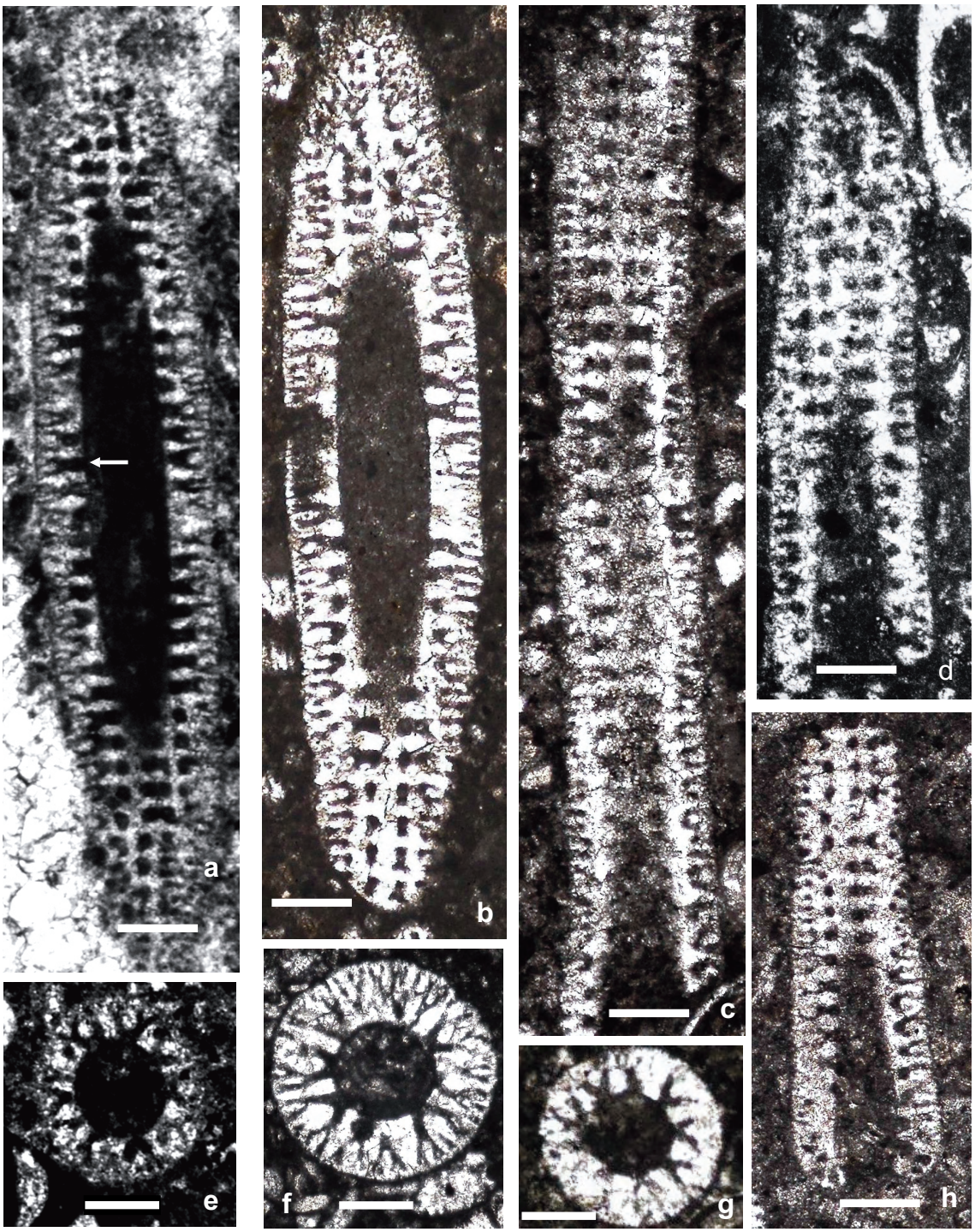

Figure 4. **(a–h)** *Belzungia terquemi* Morellet. **(a)** Longitudinal-oblique section of the largest specimen (arrow: measured assembly of laterals), NEA7a. **(b)** Longitudinal-oblique section, NESAS.19d. **(c)** Tangential oblique section, NESAS.17e. **(d)** Tangential oblique section, NEK.19d. **(e–g)** Transverse sections, **(e)** NEK.8-RR4300, **(f)** NESAS.1a, **(g)** NES.19b. **(h)** Tangential oblique section through the lower part of the article with poorly preserved lowermost downwards inclined assembly of laterals, NES.e. Scale bars 0.20 mm except (a) (0.35 mm).

large axial cavity. Two types of axial cavity should be differentiated (not only in *Belzungia*): (a) an axial cavity due to a secondarily enlarged inner skeleton surface, (abrasion, dissolution, microbial activity) and (b) an axial cavity with a smooth inner skeleton surface, representing the limit line of primary calcification (Figure 4a, b, e, f). In the latter case, in *Belzungia*, the diameter of this cavity is often nearly equal to the diameter of the main axis.

Dimensions

The external diameter of the Anatolian specimens is 0.400–0.750 mm; the inner diameter (nearly the main axis diameter) is 0.200–0.320 mm; spacing of the whorls is 0.075–0.090 mm; the number of the laterals per whorl, in our present state of knowledge, is always nine (or, possibly, is the most frequent case). Biometrical data obtained on the longitudinal-oblique section depicted in Figure 4a are the following: external diameter 0.750 mm, inner diameter 0.320 mm. The primaries (partly primary and secondary laterals) are 0.100–0.120 mm in length, with a thickness about 0.070 mm; tertiaries are up to 0.080 mm long, fourth order 0.045–0.050 mm and those of fifth order are very short. Because of their triangular shape (flat in the vertical section), the diameter of the primary laterals could be measured only in the basal part (near inception) which was not calcified. The width of the enlarged distal portion of primaries, below division, as measured in the tangential part of the oblique section in Figure 4a, is about 0.120 mm. The diameters of the secondaries are 0.060 mm, the tertiaries 0.025–0.030 mm and of the fourth order up to 0.015 mm.

Evidently, in some assemblages, the tertiary laterals have different lengths. In the measured assemblages (Figure 4a, arrow) the shorter one (right) is 0.045 mm long, while the longer (left) is 0.070 mm. In these assemblages, the shorter tertiaries usually bear longer fourth order (0.030 mm), and vice versa.

The angle of enlargement of the assemblages of laterals mainly depends on the diameter of the main axis. In small specimens, the angle is usually low. The angle in the transverse section illustrated by Massieux on plate 1, figure 8 with 9 primaries is 60–70° and the inner diameter 0.375 mm. Note that in a single whorl the assemblages of laterals may be different, and this is often partly visible from the dichotomy of laterals in different direction.

Discussion

Fossils of this species from the Paris basin best illustrate the characteristic branching of the genus *Belzungia* 'assemblages of laterals' (Génot's term 1987). The particularity of this branching is in the mode of their division, which is substantially different from those, for example, in the genus *Trinocladus*. In *Trinocladus*, tufts of higher order laterals arise from the top of distally enlarged (phloiophorous) laterals belonging to the previous order. In *Belzungia,* all the distally enlarged tops of laterals divide into two laterals in consecutive order.

In specimens of *Belzungia terquemi* from Génot's collection (1987, plate 42) the calcareous skeletons show remarkably preserved pores, which were observed under electronic microscope. The interpretation given by Massieux (1966) of the dichotomous system of laterals in *Belzungia*, was confirmed by Génot. The fragment of the transverse section in his plate 42, figure 5 is unique – in this section, the pore shapes in two assemblages are perfectly preserved as if during life (Figure 3). The horizontal primaries rapidly expand with an angle of 85–90°, dividing into two horizontal secondaries. The laterals of the further division more or less leave the horizontal plane and are of unequal sizes. In longitudinal sections, the primaries are flat (plate 42, figure 2). Génot mentions a characteristic isosceles triangular skeleton shape between two adjoining assemblages, with a narrow base at the main axis (1987, p. 269, plate 42, figure 5 = Figure 3).

***Belzungia silvestrii* (Pfender in Pfender & Massieux 1966) Emend**

Figures 5f–i, 6a–i, 7a, b (left), d–g, i–l & 10d, g, h

1966 *Thyrsoporella silvestrii* Pfender, in Pfender & Massieux 1966, plate 1, figure 4 (left).

non 1979 *Belzungia silvestrii* var. *debilis* Segonzac-Segonzac, plate 1, figure 3.

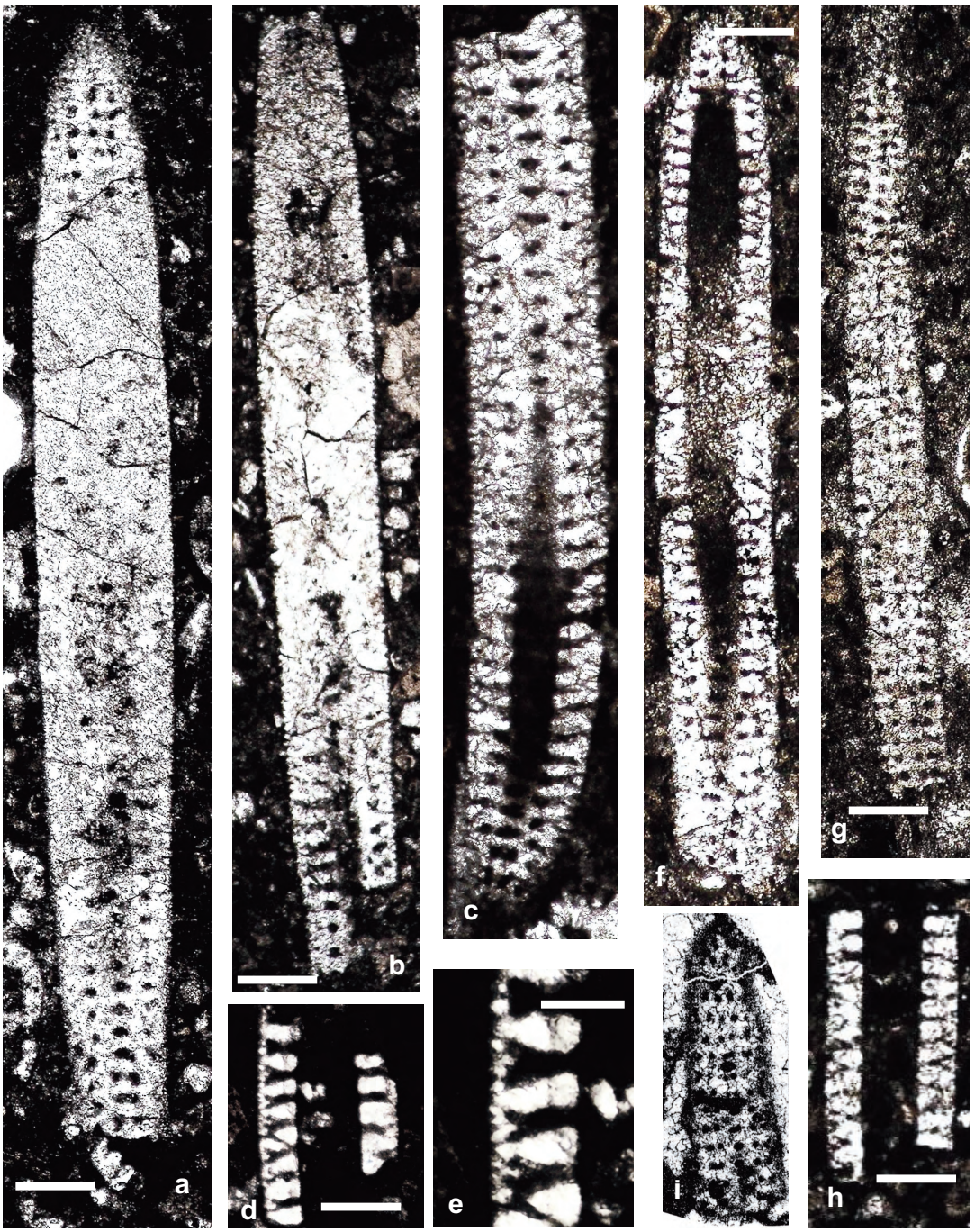

Figure 5. **(a–e)** *Belzungia pfenderae* n. sp. **(a)** Tangential oblique section, fairly recrystallized skeleton, note: minute fifth order pores at the top of skeleton, NES.c. **(b)** Tangential oblique section of fairly recrystallized skeleton, note on the surface: minute indentations of fifth order laterals, NESAS.19c. **(c)** Longitudinal-oblique tangential section, NEK.14f. **(d, e)** Holotype, the fragment of the sub-axial section in which is clearly differentiated internal area with strong laterals and thin subsurface area of fine laterals equal in size, **(e)** detailed view, NEK.8-RR4302. **(f–i)** *Belzungia silvestrii* (Pfender) emend. **(f)** Slightly oblique longitudinal section, in the upper part well visible tertiaries, NES.18a. **(g)** Tangential section, NES.a. **(h)** The fragment of the longitudinal section, NESAS.7a. **(i)** Lectotype, tangential section, Beni Hassan, Cuvillier collection (202-1), X35. Scale bar for a–c, f–g: 0.23 mm, d, h: 0.20 mm, e: 0.07 mm.

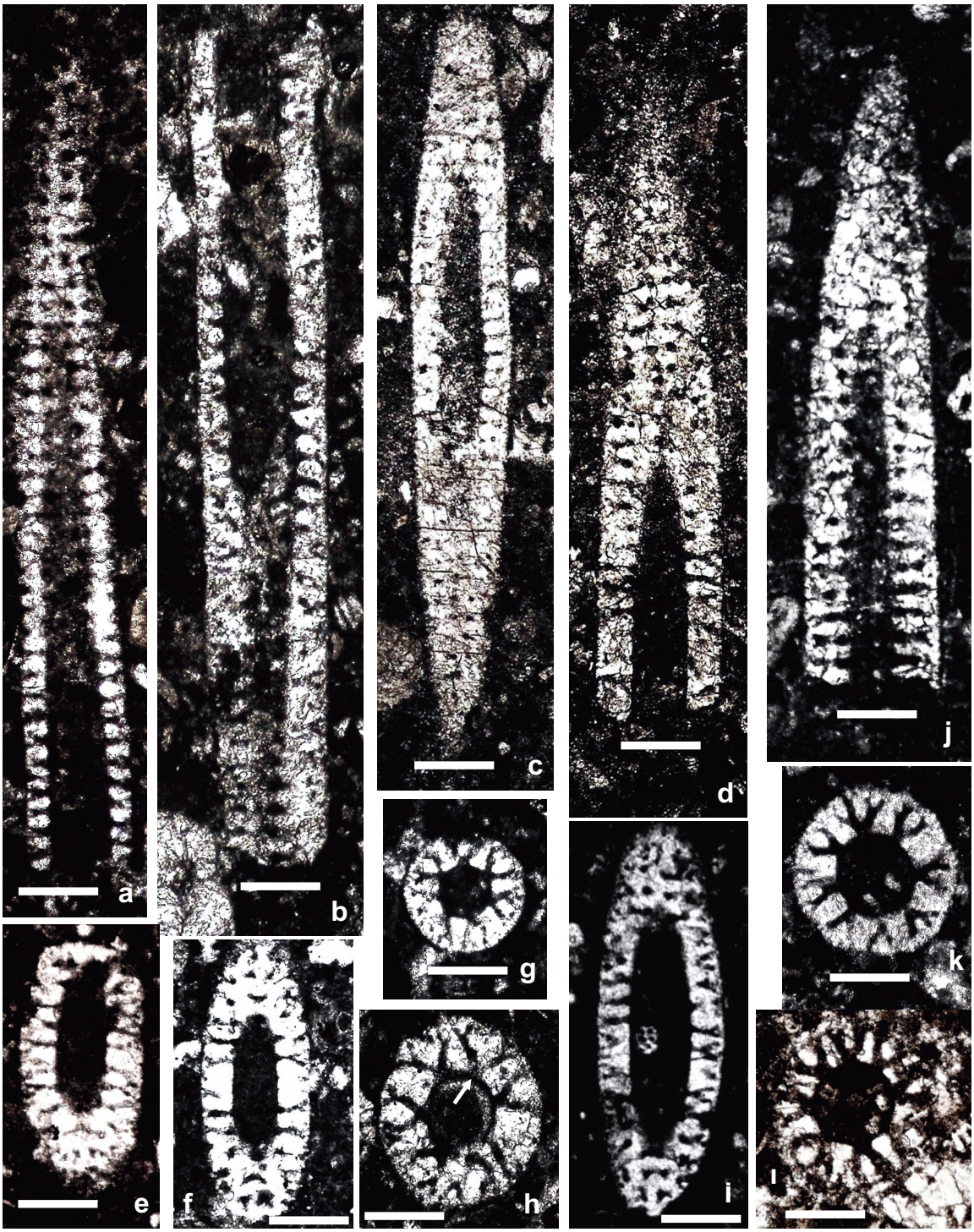

Figure 6. **(a–i)** *Belzungia silvestrii* (Pfender) emend. **(a, b)** Longitudinal-oblique sections, **(a)** NESAS.16d, **(b)** NESAS.15.a. **(c)** Elongated oblique section, recrystallized skeleton, NES.b. **(d)** Oblique section, NES.a. **(e–f)** Oblique sections, (e) NEK.8-RR4302, (f) NESAS.2c. **(g–h)** Transverse sections, (g) NESAS.15a, (h) the specimen possessing the skeleton with the best preserved axial area, NESAS.1a. **(i)** Oblique section, NEK.8-RR4302. **(j–l)** *Belzungia pfenderae* n. sp. **(j)** Oblique section, NES.23c. **(k–l)** Transverse sections, **(k)** NES.k, **(l)** NESAS.15a. All scale bars: 0.20 mm.

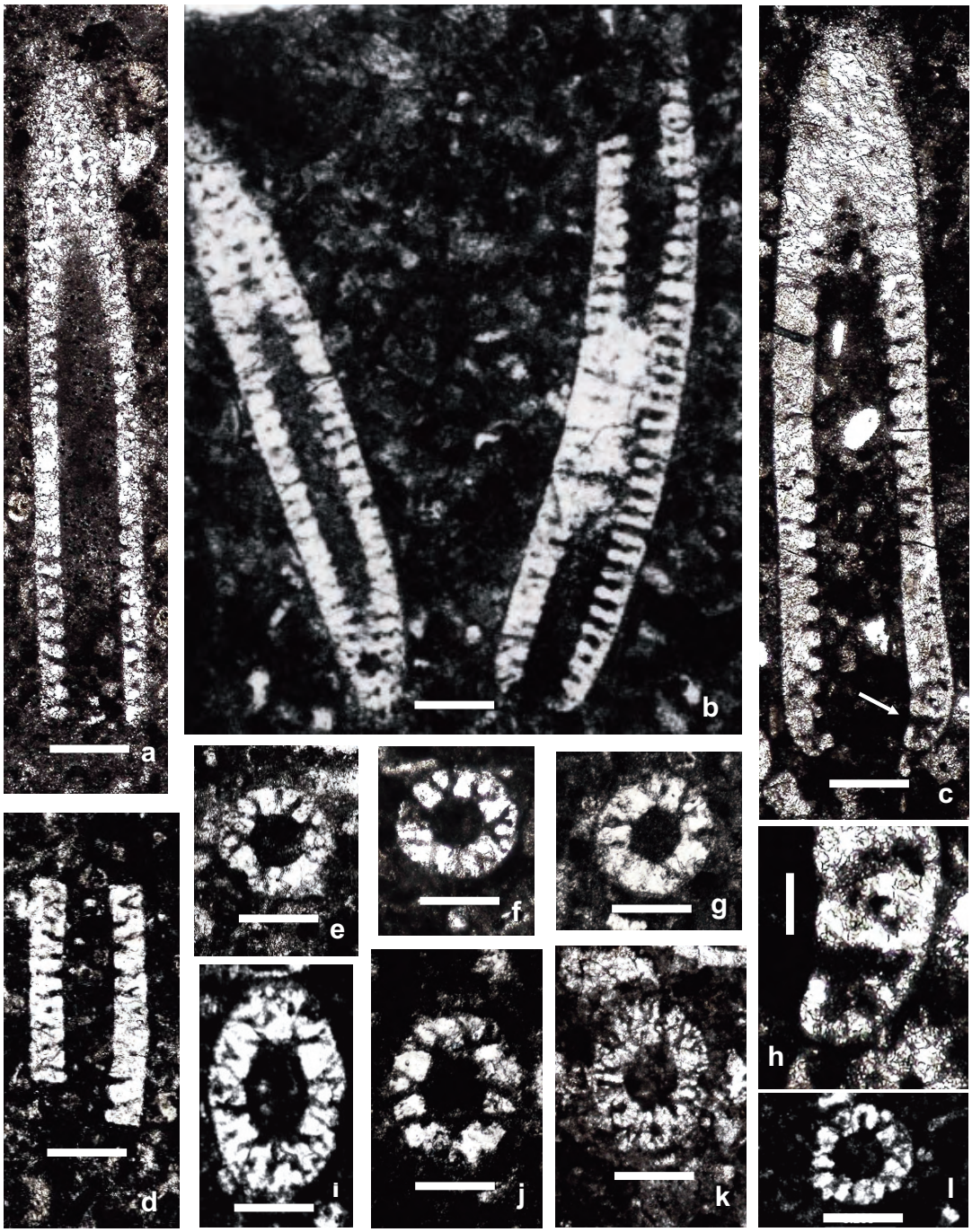

Figure 7. **(a, b, d–g, i–l)** *Belzungia silvestrii* (Pfender) emend. **(a)** Longitudinal slightly oblique section of poorly preserved, abraded skeleton, NEK.14i. **(b-left)** Longitudinal oblique section (thin slide is broken, the photography is used because the difference between this two species is evident). **(d)** The fragment of the longitudinal section, NES.23a. **(e–g)** Transversal sections, **(e)** NESAS.1a, **(f)** NES.17a, **(g)** RR4307. **(i–k)** Oblique sections, **(i)** NEK.8-RR4302, **(j)** NESAS.21a-RR4302, **(k)** NES.26a. (Many specimens in the analyzed thin slides have deformed assemblages of laterals as those in the Figure 7k). **(l)** The skeleton of the smallest diameter, NEK.8-RR4302. (**b–c, h**) *Belzungia pfenderae* n. sp. **(b-right)** Slightly deformed longitudinal section of skeleton with the basal part of the article feebly visible. **(c, h)** Slightly oblique longitudinal section of the article, in which are clearly recognizable downward inclined assemblages of laterals in the basal whorl, **(h)** detailed view, NES.c. Scale bars are 0.20 mm except h (0.05 mm).

non 1989 *Belzungia silvestrii* (Pfender in Pfender & Massieux 1966), Kuss & Leppig, figure 9a, b.

1993 *Belzungia silvestrii* (Pfender in Pfender & Massieux 1966), Kuss & Herbig, plate 2, figure 3; non plate 2, figures1, 2.

Lectotype

Tangential section shown by Pfender in Pfender & Massieux 1966, in plate 1, figure 4 (left), thin section p.m. 202 (1), Beni Hassan: Cuvillier collection.

Emended Diagnosis

Simple slender cylindrical calcareous skeleton forming articles, characterized by whorls of five (maximum six) successive dichotomous orders of laterals, perpendicular to the central axis, regularly disposed in vertical file. The primary and secondary laterals are simple, cylindrical and rather slender. The primaries are short, while the secondaries are the longest. In longitudinal section, pores of first and second order are perpendicular to the central axis, usually appearing as single pore. Distal laterals taper.

Dimensions

The longest observed article skeleton is 2.50 mm long. The external diameter is 0.320–0.410 mm (specimens of 0.320 mm in diameter are the more abundant). The axis in cavity 0.120–0.150 mm; those of lower value are nearer to the main axis diameter. The distance between whorls is 0.030–0.040 mm; the diameter of secondary pores measured at the top of Figure 5g is 0.020–0.030 mm. The largest (D= 0.410 mm, d= 0.140 mm) transverse slightly oblique section shown in Figure 6h, is a unique specimen with a preserved inner amorphous calcite (mucilage) layer coating the main axis. Calcification of the main axis membrane is discerned only as a trace of calcification. For other dimensions, the assemblage of laterals marked by the arrow was only measured. The primary laterals are 0.040 mm long and 0.050 mm wide below the dichotomy. Secondaries are of different length: the left is longer at 0.070 mm and the right is 0.040 mm long. In contrast, along the lateral of the left line, the left tertiary is shorter, at about 0.015 mm, whereas the right one is not preserved. Other assemblages of the section vary slightly in size; notably their angle of enlargement is different.

Description

The outer surface of the calcareous skeleton is abraded and mainly flat, as this inner surface. In the studied material the calcareous skeleton of this species is not well preserved, being partially recrystallized. Generally, only four orders of laterals can be seen. Often, only the skeletons with pores of first two orders are preserved.

Relationships

Belzungia silvestrii is well distinguishable from all other species of the genus owing to its narrower two first orders of laterals, narrower cylindrical articles and thinner walls.

***Belzungia bella* (Yu Jing 1976) Radoičić 2006**

Figures 8a–i, 9a–k & 10e

1976 *Trinocladus bellus* n. sp. Yu Jing, plate VIII, figures 10, 11, non 9 and 12.

Diagnosis

Cylindrical calcareous articles perforated by a system of pores corresponding to dichotomously arranged whorls of laterals. The laterals belonging to the first three orders are comparatively larger; as from the second order they are somewhat randomly oriented (Figures 8a, d, h & 9b, c, f, g, i), while the higher order of laterals are thin and anarchically arranged (dichotomies in different directions). The diameter of the external skeleton is 0.343–0.740 mm, that of the central cavity 0.129–0.250 mm, and the laterals number 6–7.

The calcareous skeleton is relatively thick, with some articles slightly swollen. Large articles probably belong to the basal part of the thallus. In articles with large diameters, the laterals are irregular, especially the interlacing in the distal area. Some better-preserved specimens have an inner skeleton diameter nearly equal to the main axis, about one third of the external diameter. The central cavity often obliterates

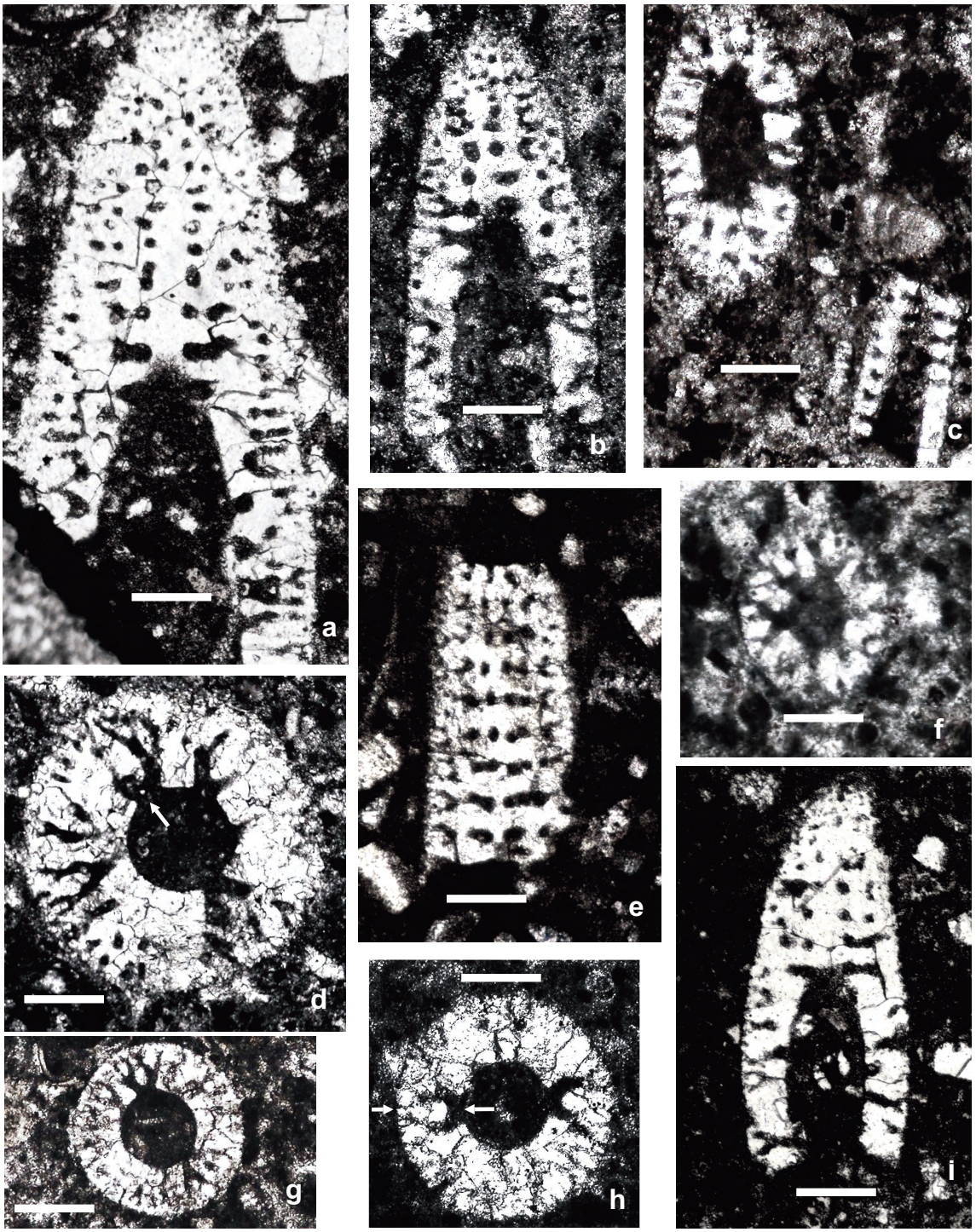

Figure 8. **(a–i)** *Belzungia bella* (Ju Ying) Radoičić. **(a, b)** Oblique section of large skeleton fragments, **(a)** NEK.8-RR4303, **(b)** NES.8a. **(c)** Oblique section of the small skeleton and lower part of *Belzungia silvestrii* at right, NES.8a. **(d)** Transverse section of the large skeleton (arrow: measured assemblage), NEK.5g. **(e)** Tangential section, NESAS.1-RR4306. **(f)** Transversal slightly oblique section, NESAS.17a. **(g)** Transverse section of the poorly preserved whorl structure, NESAS.1b. **(h)** Transverse section (arrow: measured assemblage), NEK.14b. **(i)** Oblique section, NEK.8-RR4303. Scale bars : 0.20 mm.

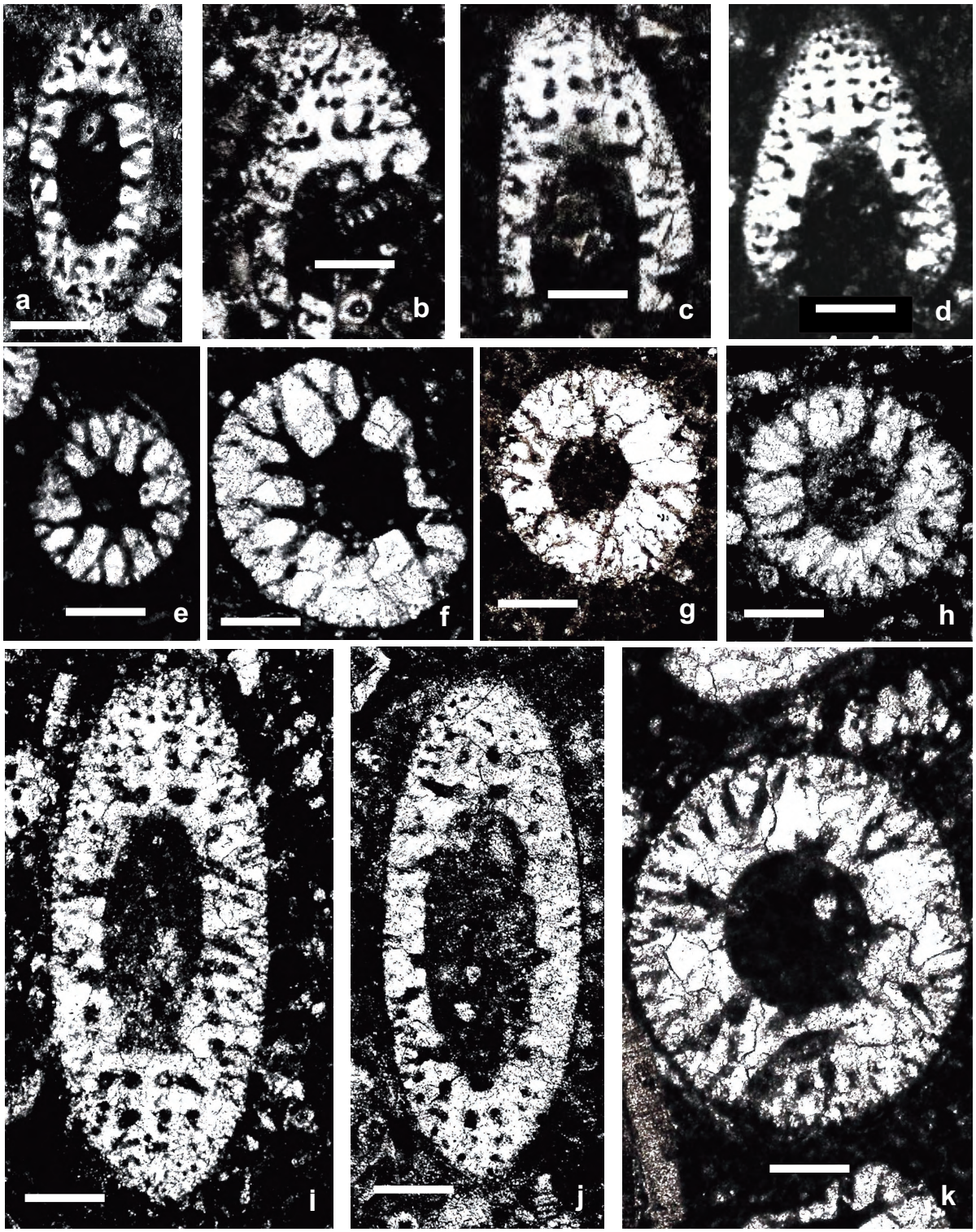

Figure 9. **(a–k)** *Belzungia bella* (Ju Ying) Radoičić. **(a)** Oblique section of the small skeleton, NES.17a. **(b, c)** Fragments from oblique sections, **(b)** NES.27a, **(c)** NES.17a. **(d)** Oblique section through lower part of article, NEK.8-RR4302. **(e–h, k)** Transverse sections (different preserved and different skeleton size), **(e)** NEK.14f, **(f)** NEK.14h, **(g)** NEK.15b, **(h)** NEK.14g & **(k)** NEK.14h. **(I, j)** Oblique sections, **(i)** NESAS.7d, **(j)** NES.8c. Scale bars : 0.20 mm.

the proximal part of the whorls, corresponding mostly to primary or a part of primary laterals. Consequently, the inner surface of such calcareous skeleton is interrupted by large pores corresponding to secondary laterals. In such transverse sections, starting from the secondaries, there are two laterals per whorl (12, in Yu Jing 1976).

The length of the laterals was measured in one assemblage of each specimen in the transverse sections of Figure 8d, h (arrow: measured assemblage). In the randomly arranged specimens in Figure 8d, the values are as follows: D= 0.740 mm, d= 0.260 mm, the primary lateral is 0.035 mm long and distally enlarged to a width of 0.095 mm (below the dichotomy). The right secondaries are 0.060 mm long, the tertiaries are approximately the same length, to 0.060 mm, the fourth order laterals about 0.040 mm, and the fifth order 0.020 mm. The specimen in Figure 8h: D= 0.530 mm, d= 0.200 mm, the primary lateral is 0.040 mm long and 0.090 mm wide at distally. The secondaries vary slightly in size, up to 0.050 mm long, the tertiaries are 0.040 mm long, those of the fourth order and fifth order are respectively 0.020 mm and 0.010 mm long.

Relationships

The skeleton of *B. bella* is much smaller than *Belzungia borneti*, its organization of laterals especially the higher order is more anarchical. Compared to *B. terquemi* and *B. silvestrii*, the calcareous articles of *B. bella* are shorter and the laterals more anarchically arranged.

***Belzungia pfenderae* n. sp.**

Figures 5a–e, 6j–l, 7b (right), c, h, 10f, j & 11a–c

1966 *Belzungia silvestrii* (Pfender), Massieux, plate 2, figures 1–3, 5, non figure 4, plate 3, figure 1, 2

Origin of Name

The species is dedicated to Juliette Pfender, for her contribution to study of algal flora from 'Nummulitique Egyptien'.

Holotype

Fragment of subaxial section (Figure 5d) with a clearly differentiated internal area with strong laterals and a thin subsurface area of equidimensional fine laterals; Kışlatepe section (sample NEK.8 - RR4302).

Isotypes

Different sections illustrated in Figures 5c & 10f, c. = Figures 5c, 10f & 11c.

Type Locality and Type Level

The Kışlatepe section, 2 km west of Kışla, SW of Seyitgazi town (UTM coordinates: 4362650°, 292500°, Figure 1). The type bed K.8 is represented by foraminiferal bioclastic limestones (packstone, wackestone) of early Ilerdian age and contains *Glomalveolina lepidula*, *G. karsica, Alveolina ellipsoidalis*, small *Nummulites*, *Orbitolites* sp., *Opertorbitolites* sp., rotalidae, miliolids, dasycladalean algae with *Belzungia terquemi*, *B. silvestrii, B. bella, Belzungia* sp. and halimedacean algae (Özgen-Erdem & Radoičić 2009).

Depository

The thin sections of the Nazire Özgen-Erdem collection are housed in the Department of Geological Engineering, Cumhuriyet University in Sivas. The thin section RR4303, collection R. Radoičić, is housed in the Geological Institute in Belgrade.

Diagnosis

Elongated cylindrical calcareous articles with whorls consisting of six orders of laterals. Laterals of each order are almost equidimensional, especially those of the fourth and fifth orders. In the first two orders laterals are robust. They give rise to large horizontal pores on the inner surface of calcareous skeleton. Tertiaries are also relatively robust and short, while pores of fourth and fifth orders are comparably thinner and shorter.

Dimensions

The longest observed specimen is 3.250 mm long; the outer diameter of the skeleton is between 0.200

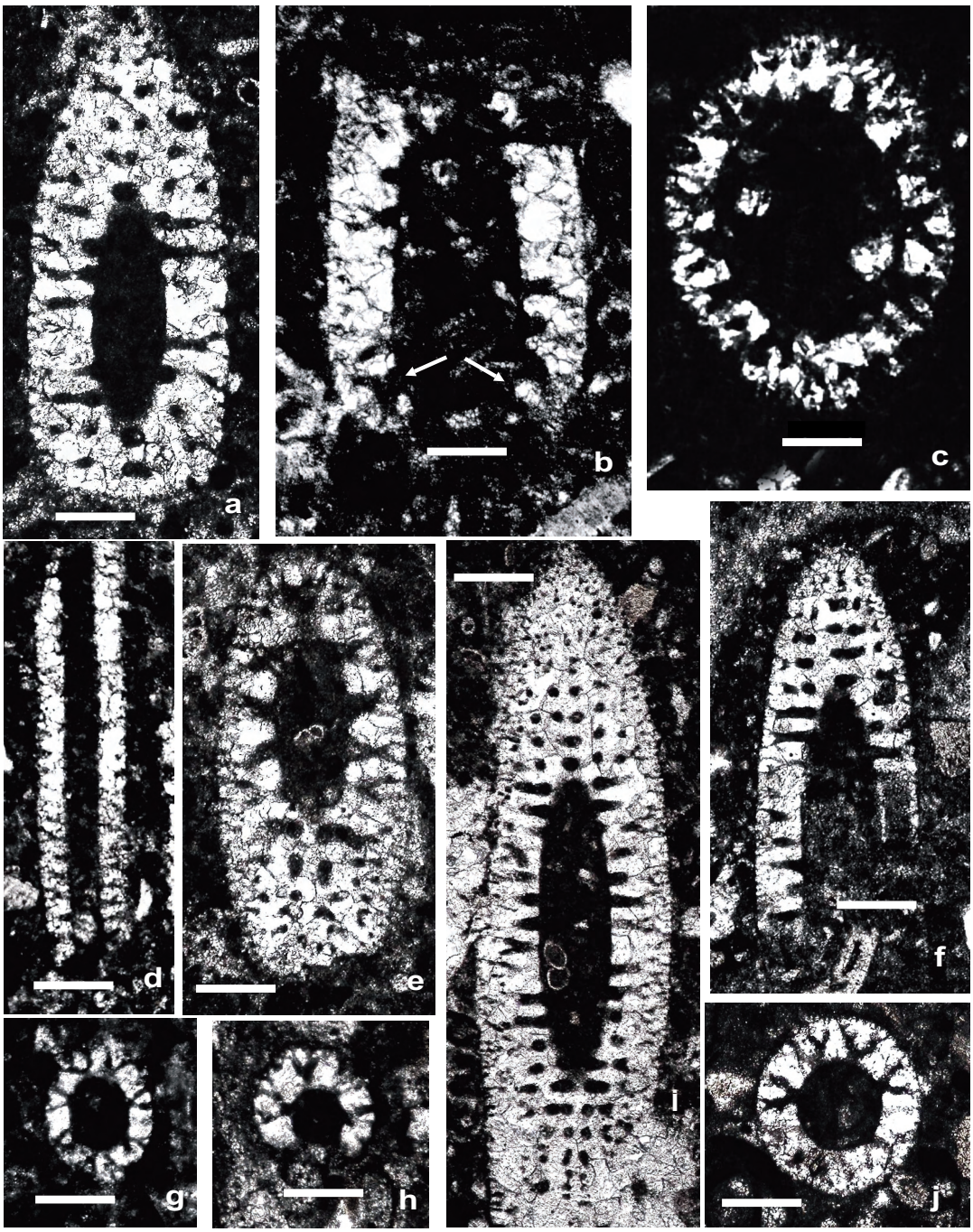

Figure 10. **(a, b, i)** *Belzungia terquemi* Morellet. **(a, i)** Oblique sections, **(a)** NES.4d, **(i)** NEK.14o. **(b)** Notice that in the basal whorl of the article assemblages of laterals are inclined downward, NESAS.1-RR4305. **(c)** *Belzungia* sp.l.: oblique section with very large central cavity and very strong proximal laterals (pores); large pores on the inner surface in fact are pores of secondaries, NEK.8-RR4302. **(d, g, h)** *Belzungia silvestrii* (Pfender) emend. **(d)** Poorly preserved longitudinal section, NEK.3b. **(g, h)** Oblique and slightly oblique sections, **(g)** NES.18b, **(h)** NES.18a. **(e)** *Belzungia bella* (Yu Jing) Radoičić; oblique section trough upper part of article, NEK.14g. **(f, j)** *Belzungia pfenderae* n. sp. **(f)** Large fragment of relatively well preserved skeleton showing thin tertiaries and minute fourth order laterals discernable on the subsurface of the skeleton, NES.8a. **(j)** Transverse section showing minute indentations on the surface, NESAS.17f. Scale bars are 0.20 mm except i (0.35 mm).

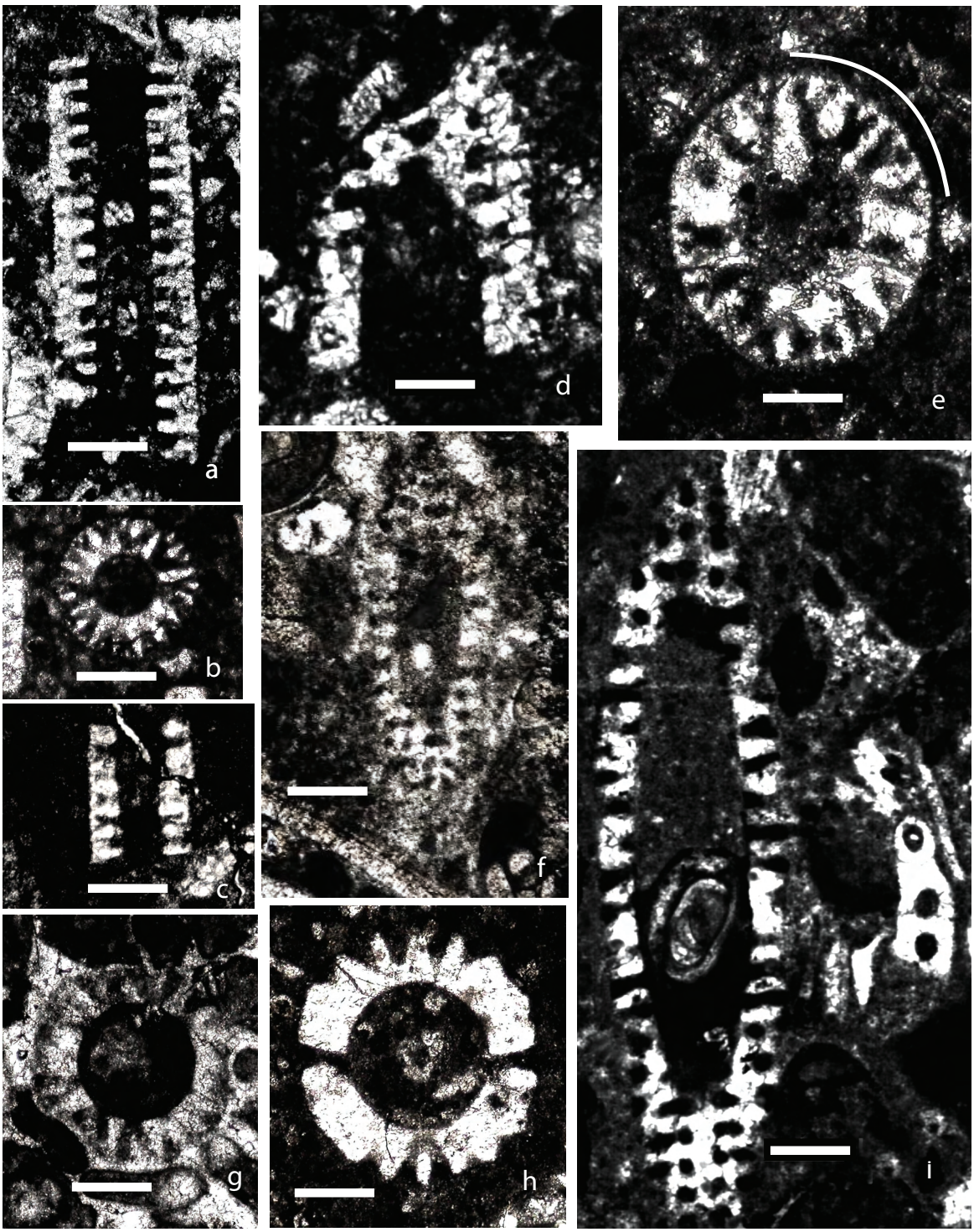

Figure 11. **(a–c)** *Belzungia pfenderae* n. sp. **(a)** Axial section, NESAS.16c. **(b)** Transverse section, NESAS.19d. **(c)** Subaxial section, NEK.8-RR4300. **(d)** *Anatolia* sp. **(d)** Oblique section, the fragment of relatively large specimen, NEK.8-RR4300. **(e)** *Belzungia* sp. 2. **(e)** Transverse slightly oblique section of the skeleton with 4 laterals in whorl (*B.* aff. *bella*), NES.8a. **(f–i)** *Furcoporella diplopora* Pia. **(f)** Oblique section, NEE.10b. **(g, h)** Transverse sections, **(g)** NEA.1a, **(h)** NES.17a. **(i)** Elongated oblique section of large specimen, at right tangential section of *Clypeina* or *Uteria*, NEK.13a-RR4314. Scale bars are 0.20 mm except e (0.10 mm).

mm and 0.480 mm; its inner diameter is 0.150–0.240 mm. In longitudinal section, large horizontal pores of primaries and secondaries range up to 0.060 mm long; pores of tertiaries are shorter and also strong – about 0.015–0.020 mm long and they are clearly distinguishable from fine pores of the fourth order in the relatively thin distal area of the skeleton (Figure 5d, e). Pores of the first three orders cover to 70–75% of the wall thickness, or more in specimens of the abraded surface. The number of assemblages of laterals per whorl is 7–8 (usually 8). The relation between dimensions of proximal whorl part, with three orders of strong laterals, and thin peripheral area with fine distal laterals is best visible in holotype (Figure 5d, e). Measurements made in the assemblage (transverse section) in Figure 6k are: D– 0.420 mm, d– 0.180 mm, primary lateral 0.030 mm long, distally enlarged to 0.050 mm. Secondaries and tertiaries range between 0.020 mm and 0.040 mm while the length of the fourth order is about 0.020 mm.

Minute pores of the fifth order are visible in the topmost portion of the recrystallized specimen in Figure 5a. Also, pores of the fifth order are discernible as minute peripheral indentations in Figure 5b.

Relationships

Regarding the regularity of the proximal area (especially in sections such as Figure 11a, b), *Belzungia pfenderae* resembles *B. terquemi,* which has a more massive skeleton and greater number (9) of laterals per whorl. Some recrystallized and poorly preserved skeletons of *B. pfenderae* are similar to *Belzungia silvestrii*, which has a relatively thinner skeleton and thinner laterals. Differences between the two species are compared in Figures 5–7.

Distribution

Belzungia pfenderae n. sp. was determined in the Kışlatepe section. The species is also found in the Kozyaka and Sarıbayır sections. It occurs at the base of the Kozyaka section (sample S), in beds at the thirteenth (S.8) and fifty seventh metres (samples S.23). In the Sarıbayır section, the species occurs in the 130–165 metre interval, in samples between Sas.15 and Sas.19 (Figure 2).

***Anatolia* n. gen.**

Type Species- Anatolia kıslae n. sp.

Origin of Name- Geographic term, studied area is part of Anatolia.

Diagnosis

The thallus consists of cylindrical articles with rather spaced whorls. The whorl consists of three orders of horizontal to sub-horizontal laterals arranged in vertical rows. The primary laterals divide into two divergent, strong and stocky secondaries. Each secondary lateral gives rise to 4–5 slender tertiaries, distally enlarged. Reproductive organs are unknown.

The calcareous skeleton is compact. Around the cylindrical main stem, the calcification is usually missing, so the inner smooth surface occurs perforated by large pores corresponding to the middle or distal part of the primaries or even to the proximal part of the secondaries. The outer surface is characterized by open pores (corresponding to the distal swelling of tertiary laterals).

Relationships

With respect to the tribe *Thyrsoporellae,* the new genus resembles both *Belzungia* and *Thyrsoporella* in the morphology of the proximal whorl structure, and the primary and divergent secondary laterals, both strong and stocky. In the shape of the tertiary laterals, they resemble the secondaries and tertiaries of *Trinocladus* (phloiophorous type). The genus *Anatolia* is classified into the tribus *Thyrsoporelleae*.

***Anatolia kıslae* n. sp.**

Figures 12a–l, 13a–n & 15e, f

Origin of Name- Geographic term, according to the type locality.

Holotype

The specimen in Figure 12a is an oblique section showing the structure of the whorls and the shape and number of the tertiaries, Kışlatepe section (sample NEK.8-RR4003).

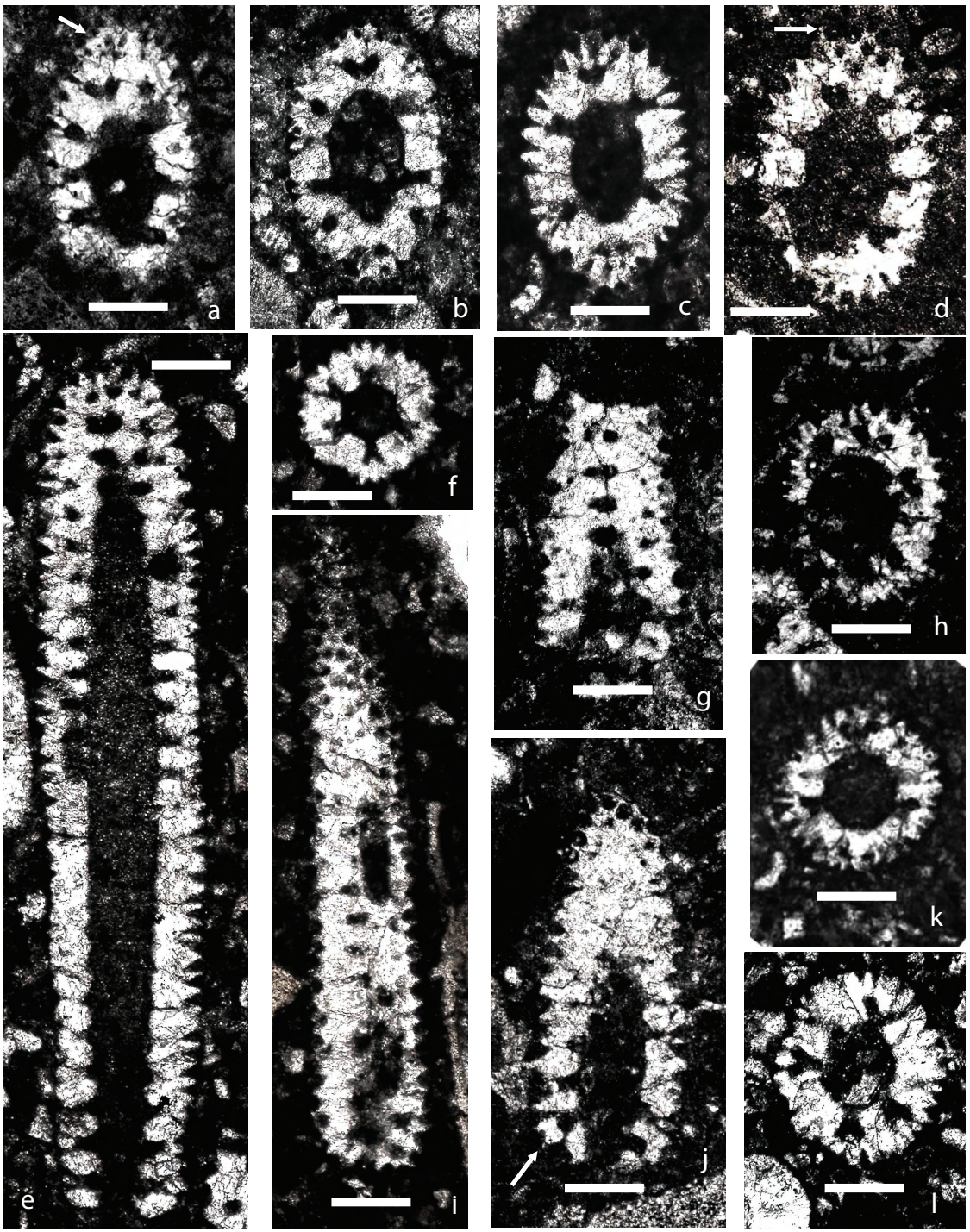

Figure 12. **(a–l)** *Anatolia kıslae* n. sp. **(a)** Holotype, oblique section, arrow: transverse section through 4 tertiaries, NEK.8-RR4301. **(b–d)** Oblique sections, **(b)** NES.d, **(c)** NES.h, **(d)** arrow: swollen part of tertiaries NES.17b. **(e)** Longitudinal section, NES.21d. **(f)** Transverse section, NESAS.16d. **(g)** Tangential section, NES.8a. **(h)** Poorly preserved oblique section, NESAS.18-RR4313. **(i)** Tangential section, in the lower part of article discerns downward inclined laterals of the basal whorl, NES.h. **(j)** Oblique section with clearly visible basal part of articles with vertically inclined single tertiary lateral with large swollen portion (arrow), NES.21b. **(k, l)** Transverse and transverse-oblique section, **(k)** NESAS.19a, **(l)** NESAS.19d. All scale bars: 0.20 mm.

Isotypes- Different sections illustrated in Figures 12h & 13a–j.

Type Locality and Type Level- This species has the same type locality and level as *B. pfenderae* n. sp.

Depository

The thin sections of the Nazire Özgen-Erdem collection are housed at the Department of Geological Engineering, Cumhuriyet University in Sivas, while the thin sections RR4300-4303, collection R. Radoičić, are housed at the Geological Institute in Belgrade.

Diagnosis

A cylindrical calcareous skeleton, 0.240–0.470 mm in diameter; diameter of axial cavity 0.100–0.200 mm; regularly spaced whorls, 0.070 mm apart and 4–7 laterals per whorl. A major characteristic of the species is the structure of the whorls: the proximal area, with strong and stout primary and secondary laterals, the latter being two in number and diverging, is clearly different from the distal whorl area with slender phloiophorous tertiaries. The largest part of the primaries, below the division, is 0.050–0.060 mm wide; the diameter of the secondaries is 0.30 mm, and the length ranges up to 0.050 mm. The tertiaries are 0.040–0.060 mm long; proximally thin, then gradually enlarged, ending at the surface with a swelling about 0.030–0.035 mm in diameter. The number of laterals is 4–6.

Description and Comments

Preservation of the calcareous skeleton in the studied material is poor to relatively very good. The basal portion of the primaries is not calcified. The smooth inner surface shows large, 0.050 mm wide pores which sometimes are more or less secondarily enlarged and, if the central cavity is large, these pores may correspond to the base of the secondaries (Figure 15f). Thin parts of the tertiaries are often obliterated by recrystallization, while their distal part is preserved as open pores, usually slightly abraded. The diameter of the pores (= swelling of tertiaries) is clearly visible at the top of the oblique section (arrows in Figure 12d) of the tangentially cut part of the skeleton surface.

The subaxial section (Figure 15e) in one of the better preserved specimens, shows, in the upper article area, the stronger and irregularly ramified proximal portions of the laterals. The whorls, in this specimen consist of four primaries, like the specimen in Figure 15f. The section in Figure 12j shows the articulated thallus of the genus *Anatolia*. This oblique section cuts the lower part of the article; the two lowermost whorls are tilted and the basal whorl shows one tertiary lateral with the largest swelling bent downward. The tangential-oblique section of the specimen in Figure 12i also cuts the lower part of an article in which only downward inclined laterals are discernable.

Distribution

Anatolia kıslae n. sp. was found in the Kışlatepe succession. The species is also found in the Kozyaka and Sarıbayır successions. It occurs at the base of the Kozyaka section (sample S), in beds at the 13th (S.8) and between 40th and 57th metres (samples S.16 and S.23). The species appears in the 130–165 metre interval (samples between Sas.15 and Sas.19) in the Sarıbayır succession.

***Anatolia kozyakae* n. sp.**

Figures 14a–f, i, j

1989 *Belzungia silvestrii* (Pfender) Massieux 1966, Kuss & Leppig, figure 9a.

Origin of Name- Geographic term, according to the type locality.

Holotype

The oblique section (Figure 14a) in which the proximal *Belzungia-Thyrsoporella* type and distal *Trinocladus* type whorl areas are clearly seen, Kozyaka section (sample NES.21f).

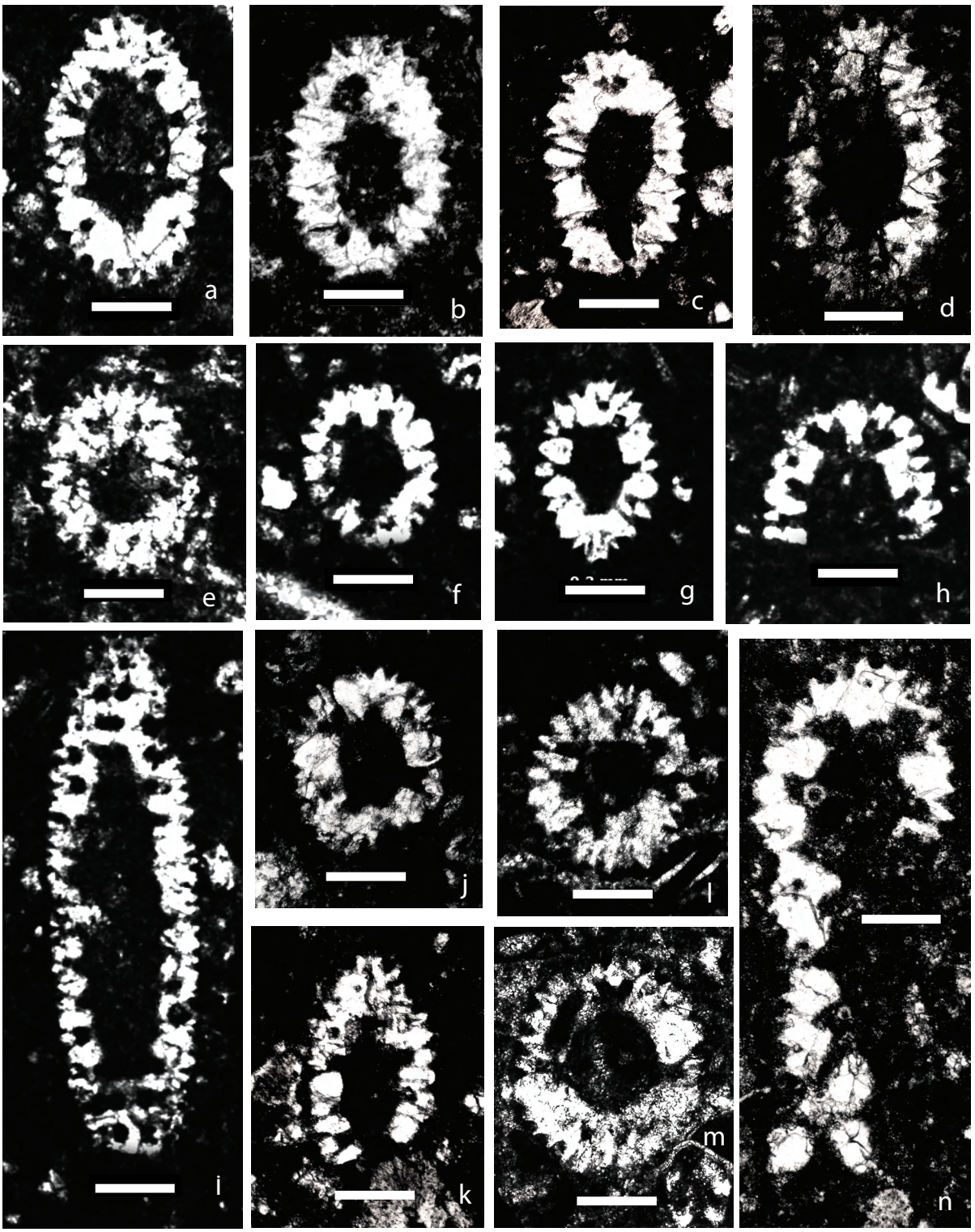

Figure 13. **(a–n)** *Anatolia kıslae* n. sp. **(a–k)** Different oblique sections, **(a–j)** NEK.8-RR4300-4302, **(k)** NESAS.15-RR4307. **(l, m)** Slightly oblique transverse sections, **(l)** NESAS.18a-RR4313), **(m)** NES.16d. **(n)** Deformed oblique section, NEK.8-RR4303. All scale bars: 0.20 mm.

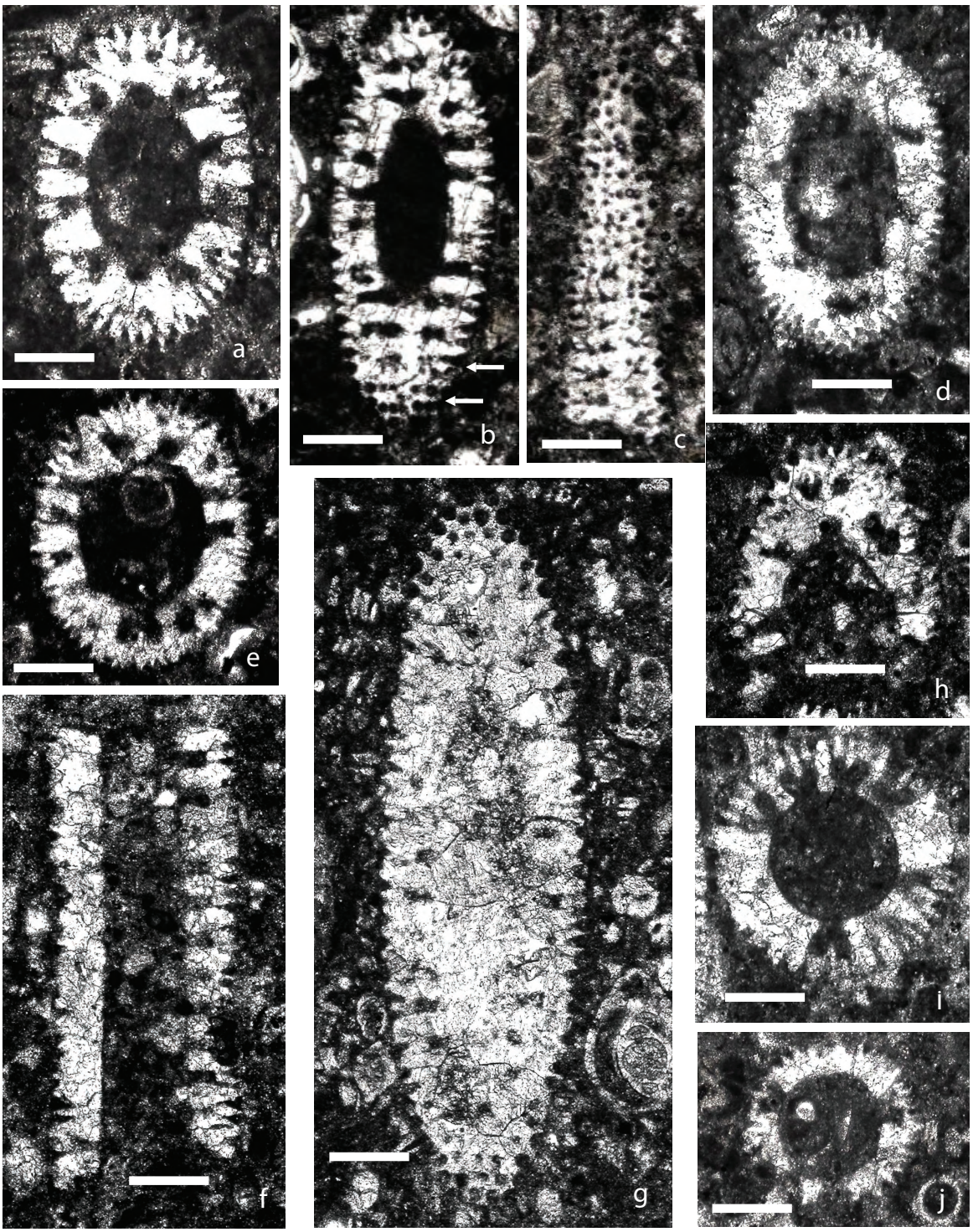

Figure 14. **(a–f, i, j)** *Anatolia kozyakae* n. sp. **(a)** Holotype, oblique section with clearly visible thin tertiaries with their distal swollen parts, NES.21f. **(b)** Oblique section, arrows: transverse section through tertiaries, upper arrow marks the section through its proximal part, the lower through swellings, NES.8a. **(c)** Tangential section, NES.8a. **(d)** Poorly preserved oblique section, NES.19a. **(e)** Oblique section, NES.h. **(f)** Longitudinal sub-axial section, NES.21f. **(i, j)** Transverse sections, specimens with 10 and 9 laterals, **(i)** NEK.14g, **(j)** NESAS.17e. **(g, h)** *Anatolia* aff. *kozyakae*. **(g, h)** Oblique sections, **(g)** NESAS.19e, **(h)** NESAS.16a. All scale bars: 0.20 mm.

Isotypes- Specimens shown in Figures 14b–f.

Type Locality and Type Level

The Kozyaka section is 1 km west of Kozyaka village (UTM coordinates: 4360900°, 294200°, Figure 1). A foraminiferal bioclastic packstone from the upper part (21st sample) of the studied section yielded *Belzungia terquemi, B. silvestrii*, *B. bella, B. pfenderae* n. sp., *Anatolia kıslae* n. sp. and halimedacean algae and foraminifera with *Glomalveolina minutula*, *Alveolina canavarii, A. ruetimeyeri, Orbitolites* aff. *complanatus*, *Cyclopertorbitolites tokerae*, *Nummulites* sp.and miliolids, indicating an early Cuisian age (Figure 2).

Depository

Thin sections of the Nazire Özgen-Erdem collection are housed at the Department of Geological Engineering, Cumhuriyet University in Sivas.

Diagnosis

An elongated cylindrical central stem with rather spaced out (0.050–0.070 mm) horizontal whorls, and 6–10 laterals per whorl. In the first two orders the laterals are thick and stout: the short primaries diverge into two secondaries. Each secondary lateral gives rise to 4 (–5?) phloiophorous tertiaries. The tertiaries, proximally very slender, gradually enlarge in the distal area and on the skeleton surface, ending in a moderate swelling.

The calcareous skeleton is compact, 0.220–0.600 mm in diameter, with the axial cavity 0.120–0.300 mm in diameter, primary pores (primary laterals p.p.) about 0.050 mm long and about 0.100 mm wide below the divergence. Secondary pores are 0.040–0.060 mm long, 0.04 mm wide; tertiaries are 0.050 mm long. The primaries are not calcified at the base, hence showing that the pores correspond to the middle or distal part of the primaries emerging from the skeleton inner face. In the better-preserved specimens, the outer skeleton surface shows a thin indentation corresponding to relatively small open pores (= swelling of the tertiaries).

Relationships

Anatolia kozyakae n. sp. differs from *A. kıslae* n. sp. in having a somewhat larger and more compact skeleton, a larger number of laterals, slightly smaller swollen portions of the tertiaries and, consequently, a thinner indentation of the skeleton surface.

The largest specimen (with 10 primary laterals) ascribed to this new species, illustrated in Figure 14i, was found in the Kışlatepe succession. This partly recrystallized and partly very well-preserved skeleton shows a very regular whorl structure, with two solid proximal orders of laterals and fine tertiaries. The smaller section in Figure 14j is similar. At present it is unknown whether these two specimens are varieties of *Anatolia kozyakae*?

Distribution

Anatolia kozyakae n. sp. also occurs in the Kışlatepe and Sarıbayır sections. It occurs only at the 90th metre of Kışlatepe section. In the Sarıbayır section, *A. kozyakae* n. sp. is present approximately in the 150–180 metre interval (samples Sas.17 and Sas.19) (Figure 2).

Tribus SALPINGOPORELLACEAE

Bassoullet *et al*. 1979

Genus *Furcoporella* Pia 1918

***Furcoporella diplopora* Pia (in Trauth) 1918**

Figures 11f–i

1918 *Furcoporella diplopora* Pia, plate 1, figures 1, 2.

1956 *Furcoporella diplopora* Pia, Elliott, plate 2, figures 5, 6.

1966 *Furcoporella diplopora* Pia, Pfender & Massieux, figure 4; plate 4, figures 8, 9.

1968 *Furcoporella diplopora* Pia, Elliott, plate 2, figures 7–9.

1976 *Furcoporella diplopora* Pia, Yu Jing, plate 9, figures 7, 8.

1989 *Furcoporella diplopora* Pia, Kuss & Leppig, figure 9g, h & 10a.

Specimens assigned to this species show a simple cylindrical thallus with two spaced horizontally set

orders of laterals. Very short primary laterals divide into two secondaries radially divergent at an angle (according to Elliott 1968) varying from 45° to 70°. Elliott's presumption on the further branching 'into spray of uncalcified tertiary branchelets' is not confirmed by Bassoullet *et al*. (1979).

The external diameter of the skeleton varies from 0.400 to 0.620 mm, its internal diameter from 0.175 to 0.350 mm, with whorls spacing at 0.09 mm; the length of the primaries is 0.04–0.05 mm, that of the secondaries is 0.07–0.09 mm, and the number of primary laterals is 10–12.

The species from the Middle East (Elliott 1968) and Anatolia are much larger than those from Austria (type material) and Egypt, Libya (Pfender & Massieux 1966) and China (Yu Jing 1976).

Rare specimens of *Furcoporella diplopora* were found in the Kozyaka, Sarıbayır, Yanıklık and Kireçocağı sections.

Tribus DISSOCLADELLEAE Elliott 1977

Genus Dissocladella Pia 1936

Dissoclacella aff. gracilis Radoičić 1991a

Figure 15a

A longitudinal section of elongated cylindrical skeleton with 0.150 mm spaced whorls, external diameter 0.470 mm and axial diameter 0.175 mm. Thin primary laterals distally globular (0.025 mm) bear, at tip, 4–5 similar secondaries clearly visible in part of the skeleton indicated by an arrow. The specimen, found only in the Sarıbayır section, is larger than type material *D. gracilis* from the Palaeocene of Bosnia.

Tribus UTERINEAE (Morellet & Morellet 1922) Bassoullet *et al.* 1979

Genus Uteria Michelin 1845

Uteria aff. merienda (Elliott 1955)

Figure 15g

The genus *Uteria* is characterized by alternating simple sterile and fertile whorls. The latter are incompletely calcified (short proximal part and thin distal area); consequently sterile whorls only are sometimes preserved. Where they are, single or two or more linked whorls may be dispersed. Some species resemble *Clypeina*. According to Dieni *et al*. (1985), *Clypeina merienda* Elliott "seems more properly referable to the genus *Uteria*".

In the studied material, few sections of sterile *Uteria* whorls have been recognized in the Kışlatepe, İskankuyu and Kireçocağı sections.

Family DASYCLADACEAE (Kützing 1843) Berger & Kaever 1992

Tribus DASYCLADEAE Pia 1920

Genus Cymopolia Lamouroux 1816

Figure 16a–d

In the lowest sampled bed of the Sarıbayır succession some specimens of *Cymopolia* sp.1 (Figure 16a–c) and *Cymopolia* sp. 2 (Figure 16d) were found.

Family ACETABULARIACEAE (Endlicher) Hauck 1885

Tribus ACETABULARIEAE Decaisne 1842

Genus Acicularia D'Archiac 1843

Acicularia aff. tavnae Radoičić 1991b

Figure 15b

Rare fragments of the elongated ampulla with large spherical cysts (to 0.120 mm in diameter), resembling *A. tavnae* described from the Palaeocene of Bosnia, are also present in the Palaeocene of Sardinia (unpublished, Radoičić) and the Western Carpathians (Samuel *et al*. 1972, plate 122, figure 2: 'incertae sedis').

In the Kışlatepe section, the species is found in the limestones bearing numerous *Alveolina ellipsoidalis*, *A. laxa*, *Cyclopertorbitolites tokerae*, *Glomalveolina* aff. *lepidula*, *Orbitolites* sp. and other foraminifera, such as *Furcoporella diplopora* and rare dasycladalean fragments *(Belzungia, Neomeris, Uteria, Clypeina*?).

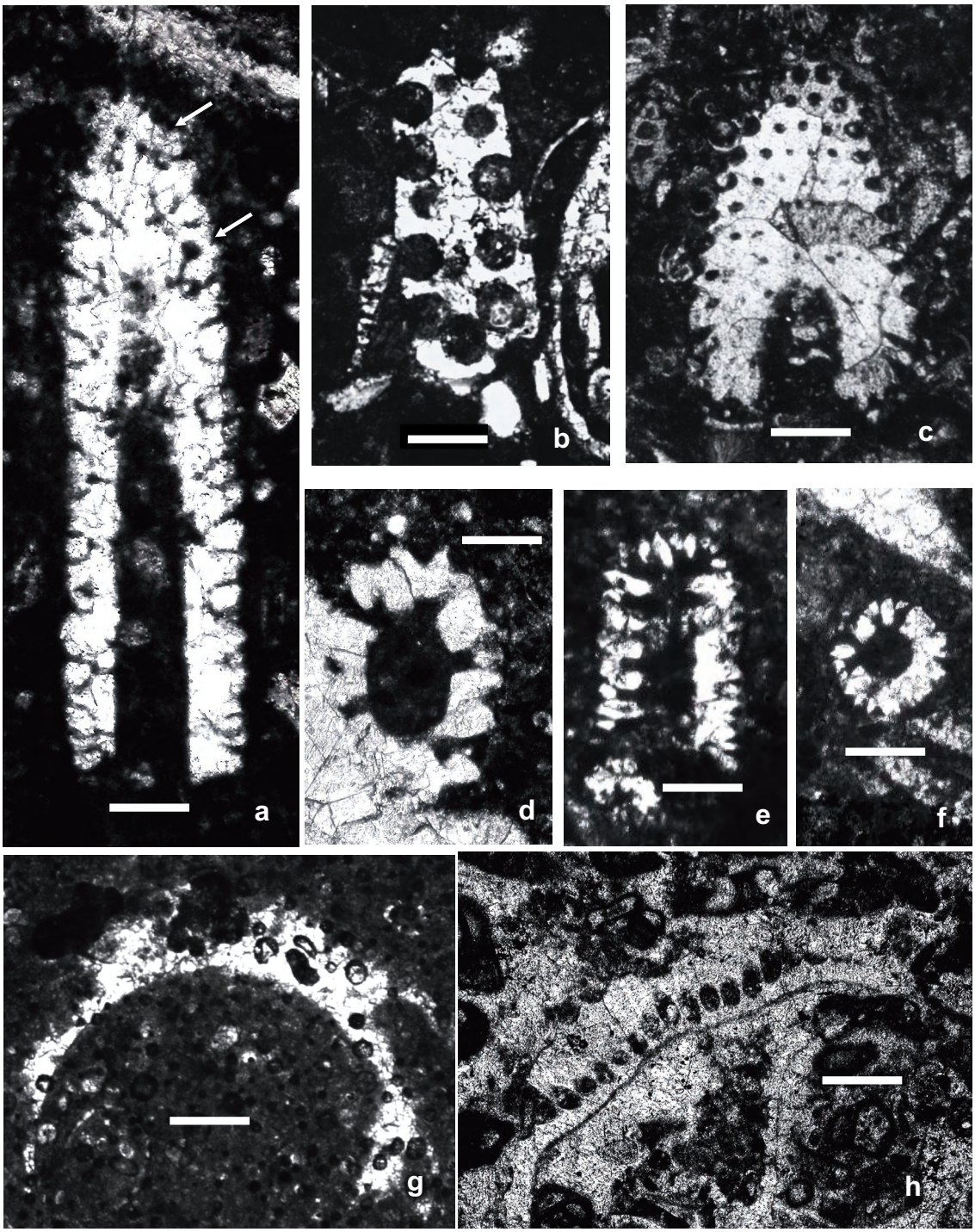

Figure 15. **(a)** *Dissocladella* aff. *gracilis* Radoičić, oblique section, arrows: the swelling of secondaries, NESAS.2a. **(b)** *Acicularia* aff. *tavnae* Radoičić, Oblique section, the fragment of the ampulla, NEK.13d. **(c)** Dasycladales aff. *Salpingoporella*, NESAS.1-RR4306. **(d)** *Anatolia*?, NES.17e. **(e, f)** *Anatolia kıslae* n. sp. **(e)** Sub-axial section, upper part of article with very robust first order laterals of the top thallus area (the specimen with 4 laterals), NEK.5a. **(f)** Transverse section of the whorl with 4 laterals, note: inner pores (upward) correspond to secondaries, NES.23a. **(g)** *Uteria* aff. *merienda* (Elliott). **(g)** Poorly preserved sterile whorl (only few sterile laterals are visible), NEISK.38a. **(h)** *Uteria* sp. **(h)** Transversal-oblique section of the sterile whorl, NEI.15a. Scale bars are 0.20 mm except g & h (0.30 mm).

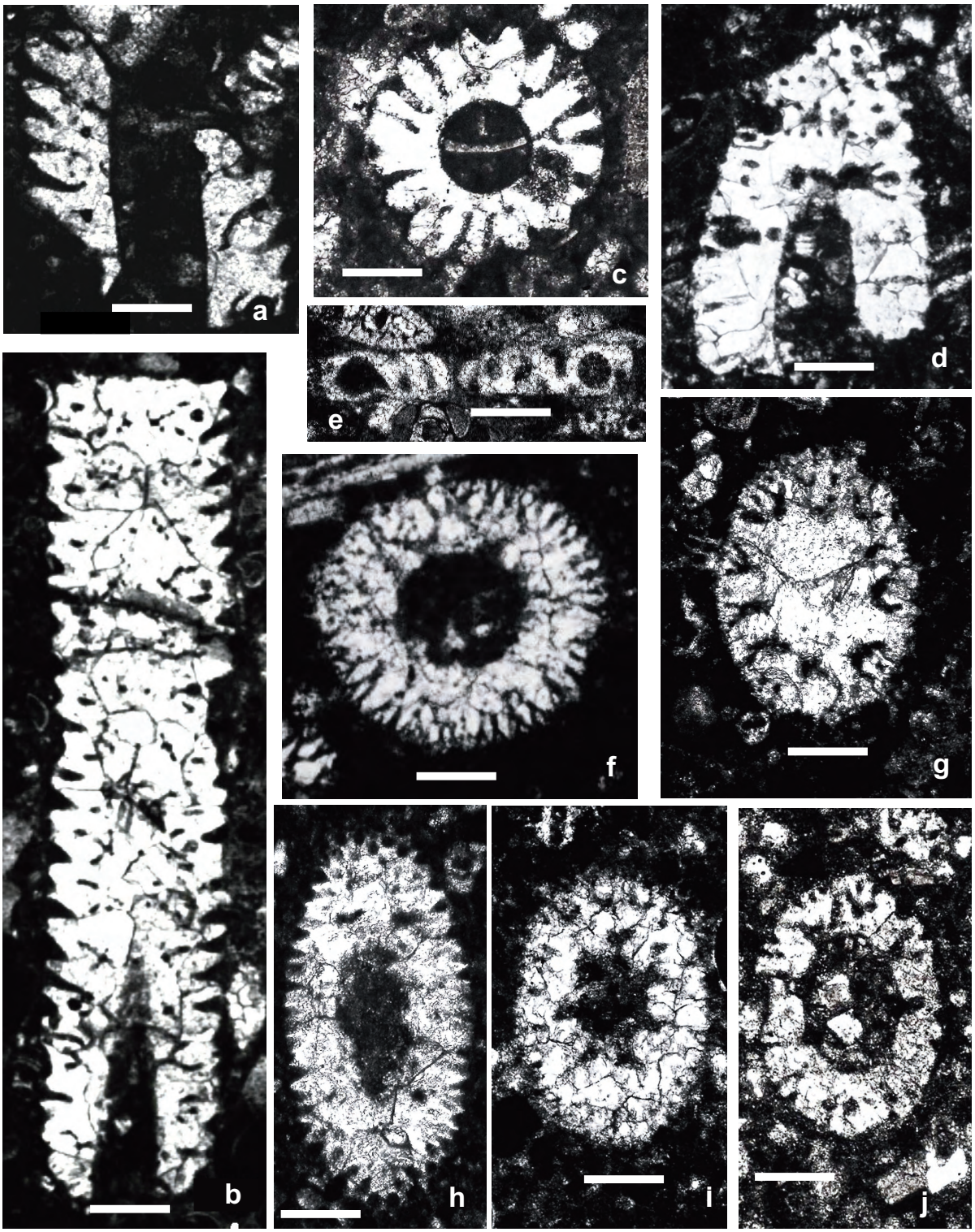

Figure 16. **(a–c)** *Cymopolia* sp.1, **(a)** NESAS.1-RR4306, **(b)** RR4304, **(c)** NESAS.2c. **(d)** *Cymopolia* sp.2, NESAS.1-RR4305. **(e)** *Neomeris* sp., NEE.10a. **(f)** *Belzungia* cf. *bella* (Ju Ying), transverse section of the large whorl of the lower thallus article, NEK.15. **(g–j)** *Anatolia* sp., different poorly preserved sections, **(g)** NESAS.16e, **(h)** NESAS.19d, **(i)** NEK.15b), **(j)** NES.a. Scale bars; a, c, f–j: 0.20 mm, b, d, e: 0.30 mm.

Discussion and Conclusion

Palaeogene dasycladalean algae are abundant in shallow water deposits of the Tethyan realm and significant in biostratigraphy. But no detailed previous work had been carried out on the Palaeogene calcareous algae of Turkey. Köylüoğlu (1986) documented the presence of some calcareous algae (*Neomeris*, *Cymopolia*, *Halimeda*) in the Palaeocene units from southeastern Turkey. Barattolo (1998) reported some dascyladacean genus (*Halimeda*, *Ovulites*, *Neomeris*, *Terquemella*, *Cymopolia*) in the Danian–Thanetian levels from Haymana-Polatlı (Ankara). Lower Eocene deposits of the Seyitgazi (Eskişehir) region are especially composed of clayey-sandy limestones and limestones with porcellanous larger benthic foraminifera and calcareous algae. This calcareous algae assemblage consists of very rich dasycladaleans and halimedacean algae. The first detailed study of these halimedacean algae was been carried out by Özgen-Erdem & Radoičić (2009), who found out that the early Ilerdian–early Cuisian dasycladalean assemblages are rich and diversified.

A new genus and its two new species (*Anatolia kıslae* n. sp. and *A. kozyakae* n. sp.) and a new *Belzungia* species (*B. pfenderae* n. sp.) were described in this study. *B. silvestrii* (Pfender) is emended. The other species recorded within the studied area for the first time are: *Belzungia terquemi* Morellet, *B. bella* (Ju Ying) Radoičić, *Furcoporella diplopora* Pia, *Dissocladell*a aff. *gracilis* Radoičić, *Uteria* aff. *merienda* (Elliott), *Acicularia* aff. *tavnae* Radoičić, *Uteria* sp., *Neomeris* sp., *Salpingoporella*? sp. and *Clypeina*? sp.

Species of *Belzungia* were especially dominant and more diversified among the genera identified within this unit. This genus was previously only documented in a few localities. *Belzungia silvestrii* was first defined by Pfender (1940) from the early Eocene in the Nile valley. *Belzungia silvestrii* and *Belzungia terquemi* were found in Thanetian rocks from France (Segonzac 1976, 1979). The former species was reported in upper Palaeocene–lower Eocene strata from the western Gulf of Suez, Egypt (Kuss & Leppig 1989). *B. terquemi* was also found in the upper Lutetian from the Campbon region (western France) by Génot (2009). This study also documents the presence of *Belzungia* species from the Seyitgazi region, central Turkey, for the first time. The genus was previously known from two regions (France and Egypt), but not from the central Tethys Eocene. Thus, the Seyitgazi region record markedly extends the geographical range of this genus.

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