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Определитель родов раковинных амеб

Монография

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A Guide to Testate Amoebae with the Keys to Genera

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Приводится современный обзор систематики раковин-ных амеб до уровня рода с определительными ключами и кратким описанием 107 родов. Представлены иллюстрации наиболее типичных представителей каждого рода. Издание предназначено для сотрудников научно-исследовательских организаций и студентов высших учебных заведений.

The book provides the modern synthesis on testate amoebae taxonomy at the genus level with identification keys and short description of 107 genera. Illustrations of the most typical taxa for each genus are included. The book is intended for professional researches and students.

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Introduction

Testate amoebae (also referred to as testaceans) are free-living amoeboid protists in which the cytoplasm is enclosed within discrete shell or test and which produce pseudopodia for movement and feeding. Testate amoebae have worldwide distribution and form diverse and abundant communities in freshwater (Beyens, Meisterfeld, 2002; Mazei, Tsyganov, 2006) and terrestrial habitats, including soils, mosses, standing waters and sewage treatment works (Schönborn, 1962a, 1962b, 1966b, 1983, 1989; Coûteaux, 1976; Geltzer et al., 1985; Foissner, 1987; Charman et al., 2000; Finlay et al., 2000). They are generally considered rare in marine systems, but new taxa, predominantly interstitial, are continued to be described (Golemansky, 1978, 1990, 1994, 2000; Golemansky, Todorov, 1999; Scott et al., 2001; Nicholls, 2009a). Testate amoebae prey on a wide range of organisms including bacteria, fungi, algae, other protozoa, micrometazoa and may probably consume dead organic matter (Heal, 1963; Gilbert et al., 2000; Wilkinson, Mitchell, 2010). Some species of testate amoebae contain endosymbiotic algae and are probably mixotrophic; the genus *Paulinella* includes phototrophic species (Gomaa et al., 2014). The total number of testate amoebae species can be estimated as 2000 (Meisterfeld, 2000a, 2000b).

Studies on testate amoebae started in the beginning of the 19th century, when the first species were described (Leclerc, 1816; Ehrenberg, 1838; Dujardin, 1841). By the end of the 19th and beginning of the 20th century a considerable amount of material was published on the morphology and systematics of testate amoebae from different parts of the world (Wallich, 1864; Leidy, 1879; Penard, 1890, 1899, 1902, 1903; Cash, Hopkinson, 1905, 1909, Awerintzew, 1906; Wailes, 1912; Cash et al., 1915, 1919). Later fossil testate amoebae were discovered in lake sediments (Lagerheim, 1902) and peat deposits (Harnisch, 1924, 1925, 1927; Steinecke, 1927) that lay down the ground for further use of testate amoebae in palaeoecological studies. At the same time, accumulation of data on testate amoebae allowed to build a detailed systematic description of some genera based on morphology (Deflandre, 1928a, 1929, 1936), and to developing a macro taxonomy of testate amoebae (Saedeleer, 1934; Hoogenraad, de Groot 1940a; Jung, 1942; Deflandre, 1953). In the middle of the 20th century several monographs and identification guides covering all aspects of the biology and ecology of testate amoebae were published (Bartoš, 1954; Grospietsch, 1958; Harnisch, 1958; Schönborn, 1966c; Chardez, 1967a). By the 1990s, most of the genera of testate amoebae were revised basing on shell morphology: *Arcella* (Deflandre, 1928; Décloître, 1976), *Centropyxis* (Deflandre, 1929; Décloître 1978, 1979), *Cryptodifflugia* (Grospietsch, 1964; Schönborn, 1965a; Page, 1966), *Cucurbitella* (Gauthier-Lièvre, Thomas, 1960), *Cyclopyxis* (Deflandre, 1929; Décloître, 1977a), *Cyphoderia* (Chardez, 1991), *Difflugia* (Štěpánek, 1952; Gauthier-Lièvre, Thomas, 1958; Chardez, 1961, 1967c; Ogden, 1979, 1980a, 1980b, 1983, 1984; Ogden, Hedley, 1980; Ogden, Meisterfeld, 1989; Ogden, Fairman, 1979; Ogden, Živković, 1983), *Euglypha* (Décloître, 1962b), *Hyalosphenia* (Grospietsch, 1965), *Lesquereusia* (Thomas, Gauthier-Lièvre, 1959b), *Nebela* (Deflandre, 1936; Gauthier-Lièvre, 1953; Jung, 1942; Décloître, 1977b), *Plagiopyxis* (Thomas, 1958a), *Quadrulella* (Chardez, 1967b), *Paraquadrula* (Décloître, 1962a; Schönborn, 1965b), *Trinema* (Chardez, 1960a). Numerous studies investigated distribution of testate amoebae around the globe, with greater attention to the temperate regions of Europe and North America though, and their role in various types of ecosystems (Heal, 1961; Schönborn, 1992).

Research on testate amoebae has increased substantially since 1990s due to their increasing use as bioindicators for paleoecological studies (Mitchell et al., 2008). Multivariate classifications of testate amoeba assemblages (Tolonen et al., 1992, 1994; Mitchell et al., 1999) and quantitative relationships between community structure and specific environmental variables have been explored using univariate and multivariate statistics (Bobrov et al., 1999; Booth, 2001; Lamentowicz, Mitchell, 2005; Charman et al., 2007), which resulted in development of quantitative reconstructions of peatland surface moisture basing on fossil testate amoebae assemblages. Also, it has been shown that testate amoebae play important roles in the cycling of elements in terrestrial ecosystems (Aoki et al., 2007; Schröter et al., 2003). They are also increasingly used in ecotoxicology, forensic sciences, biomonitoring and in many other applied aspects (Nguyen-Viet et al., 2007; Payne, 2011, 2013; Fournier et al., 2012; Szelecz et al., 2014). Testate amoebae are a good model for taxonomical, evolutionary and ecological evolutionary studies because of their diversity, ubiquity, the presence of a shell which is taxonomically diagnostic, and their long (but discontinuous and still very poorly studied) fossil record (Porter, Knoll, 2000; Schmidt et al., 2004; 2006).

Molecular phylogenetic studies have considerable advanced our understanding of the relationships among testate amoebae and established their phylogenetic position in the tree of eukaryotes (Wylezich et al., 2002; Nikolaev et al., 2005; Gomaa et al., 2012; 2017; Kosakyan et al., 2012, 2013, 2016, 2016a). However, most of the especially useful taxonomical monographs for identification of testate amoebae followed morphology-based approach mostly (Ogden, Hedley, 1980; Ellison, Ogden, 1987; Corbet, 1973; Charman et al., 2000; Mazei, Tsyganov, 2006; Mazei, Warren, 2012, 2014, 2015). The most recent synthesis on testate amoebae taxonomy is a genus-level work released shortly before any molecular data on testate amoebae were available (Meisterfeld, 2002a, 2002b).

The main purpose of this guide was to combine all modern data on genus level systematics of testate amoebae and to provide identification keys to genera with illustrations of the most typical taxa. In this Guide, we compiled descriptions for 104 genera of testate amoebae. This covers most of the existing genera of testate amoebae with new taxonomic alterations since the last revision done by R. Meisterfeld (2002a, 2002b). The Guide does not cover most of marine species and filose testate amoebae with flexible shells (Thecofilosea).

High taxonomic levels and phylogeny accepted in this work are based on revisions provided by Adl et al. (2012) and Ruggiero et al. (2015). Low taxonomic levels (i.e. genera) accepted in this work are based on the revision of Kosakyan et al. (2016). Families within orders and genera within families are listed alphabetically. Pictures and species names are taken from Mazei, Tsyganov (2006).

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Chapter 1
Systematics, biology and ecology of testate amoebae

Systematics. The traditional morphology-based classification grouped testate amoebae together with other amoeboid protists in a macrotaxon named Sarcodina (Levine et al., 1980). However, recent molecular research has demonstrated that testate amoebae are polyphyletic and belong in three evolutionary distinct major groups not directly related to each other (table).

Table

Systematics of the higher taxonomy of testate amoebae based on hierarchical classification from superkingdom to order proposed by Ruggiero et al. (2015)

Superkingdom **Eukaryota**
Kingdom **Protozoa** Owen, 1858, emend. Cavalier-Smith, 1998
Subkingdom **Sarcomastigota** Cavalier-Smith, 1983, emend. Cavalier-Smith, 2013
Phylum **Amoebozoa** Lühe, 1913, emend. Cavalier-Smith, 1998
Subphylum **Lobosa** Carpenter, 1861, emend. Cavalier-Smith, 2009
Class **Tubulinea** Smirnov et al., 2005 [= **Lobosea** Carpenter, 1861]
Order **Arcellinida** Kent, 1880 [= **Testacealobosia** de Saedeleer, 1934]

Kingdom **Chromista** Cavalier-Smith, 2010
Subkingdom **Harosa** Cavalier-Smith, 2010 [= **"Supergroup SAR"**]
Infrakingdom **Halvaria** Cavalier-Smith, 2010
Superphylum **Heterokonta** Cavalier-Smith, 1981 [**= "Supergroup Stramenopiles"**]
Phylum **Bigyra** Cavalier-Smith et Chao, 2006
Class **Labyrinthulea/Labyrinthulomycetes** Dick, 2001
Order **Amphitremida** Poche, 1913, emend. Gomaa, Mitchell et Lara, 2013

Infrakingdom **Rhizaria** Cavalier-Smith, 2002
Phylum **Cercozoa** Cavalier-Smith, 1998, emend. Adl et al., 2005
Subphylum **Monadofilosa** Cavalier-Smith, 2003
Class **Imbricatea** Cavalier-Smith, 2011, emend. Cavalier-Smith, 2003
Subclass **Placonuda** Cavalier-Smith et Chao, 2012
Order **Eulyphida** Copeland, 1956, emend. Cavalier-Smith, 1997
Class **Thecofilosea** Cavalier-Smith, 2003, emend. Cavalier-Smith, 2011
Subclass **Eothecia** Cavalier-Smith et Chao, 2012
Order **Cryomonadida** Cavalier-Smith, 1993
Subclass **Tectosia** Cavalier-Smith et Chao, 2012
Order **Tectofilosida** Cavalier-Smith, 2003

The largest group of testate amoebae named Arcellinida comprises testaceans with lobose pseudopodia and belongs in protozoan phylum Amoebozoa (Nikolaev et al., 2005). Most of the remaining testate amoebae with filose pseudopodia are now placed in the phylum Cercozoa (Wylezich et al., 2002) which belongs in the "SAR" clade (Burki et al., 2007), now formally subkingdom Harosa of the kingdom Chromista (Cavalier-Smith, 2010). Some of testate amoebae with anastamosing networks of reticulopodia and two symmetrical apertures (i.e. genera *Amphitrema* and *Archerella*) are now classified in the phylum Bigyra of the subkingdom Harosa (Gomaa et al., 2013). Despite being a polyphyletic group, testate amoebae form a reasonably uniform morphological and ecological group (Wilkinson, Mitchell, 2010) which can be studied using common methods. Treating testate amoebae as a single group in ecological studies can be compared to the studies on vegetation ecology, which often include lichens.

Cell. In its simplest division, the main elements of the living amoeba are the cell itself and the shell in which it lives. The cytoplasm usually fills the chamber in smaller testate amoebae such as *Euglypha* and *Trinema*, whereas in larger species it only partially fills the chamber and thin cytoplasmatic strands (epipodia) attach it the shell wall. The most important cell structures for identification of testate amoebae are nucleus and pseudopodium type. According to the classification of Raikov (1982) two principal types of nuclei are found in testate amoebae: 1) vesicular nuclei with one, often central nucleolus, sometimes with a few additional, very small nucleoli; 2) ovular nuclei with several or many small nucleoli.

Testate amoebae can have three types of pseudopodia: lobopodia, filopodia or reticulopodia. Lobopodia are projections more or less broad, with cytoplasmic streaming; they may have a clear hyaline region at the front; additional fine projections may extend from this hyaline region. This type of pseudopodia is typical for the order Arcellinida. Filopodia are fine, pointed hyaline projections, containing no granuloplasm or microtubules, sometimes branching, but never anastomosing. This type of pseudopodia is typical for the order Euglyphida. Reticulopodia represent a network or of fine anastomosing pseudopodia without granules.

Testate amoebae mostly reproduce by asexual binary fission. The role of sexual reproduction in the life cycle of testate amoebae remains basically unknown, however the available data point at the wide distribution and an important role of sexual reproduction (Lahr et al., 2011). Under unfavourable environmental conditions testate amoebae produce cysts (Thomas, 1962).

Shell. Testate amoeba shells normally consist of one chamber with a single aperture. However, some taxa are characterised by two-chamber shells or by the presence of two apertures. Shells are composed of organic material which is often encrusted with exogenous mineral particles or covered by self-secreted silica plates. The principal function of the shell is the protection of amoebae from negative environmental influence, mainly from predation and desiccation. The aperture connects amoebae with the external environment so that pseudopodia can extend through the aperture for locomotion and feeding. The aperture determines the maximal size of food particles that can be ingested by the cell, participates in holding and positioning of shells during cell division and protects the cell from desiccation and predator invasions.

Shells of testate amoebae can be radially symmetrical or bilaterally symmetrical. Radially symmetrical shells can in turn be round in cross section (with several, i.e. more than two, cutting plains parallel to the axis of symmetry) or compressed in cross section (only two cutting plains parallel to the axis of symmetry). The axis of symmetry extends from the center of the oral pole which contains the aperture (mouth) to the centre of the opposite, or aboral, end (i.e. radial heteropolar symmetry). Such shells do not have left or right sides. Testate amoebae with two apertures (*Amphitrema, Archerella*) have radial homopolar symmetry. Apertures are normally located perpendicular (at the right angle) to the axis of symmetry.

When the length of the axis of symmetry is relatively short as compared to the diameter of the shell, shell is hemispheric or disk-like. In this case, the apertural side can sometimes be referred to as a ventral side, whereas the aboral region is referred to as dorsal side. These shells can be normally seen in preparations in the frontal view, which corresponds to a frontal plain (plains perpendicular to the axis of symmetry and dividing the shell into dorsal and ventral portions). Most of the radially symmetrical shells with a shortened axis of symmetry are circle in cross section, whereas elliptical cross section is typical only for *Ellipsopyxella* and *Ellipsopyxis*. The aperture can be just a simple circular opening on the ventral side (*Phryganella*) or be located at the end of the invaginated (rarely turned out) tube (*Acella, Antracella, Pyxidicula, Cyclopyxis*). Sometimes, aperture can be lobate, denticulate or reinforced by apertural apparatus such as thick teeth (Lamtopyxidae) or a perforated diaphragm (Distomatopyxidae).

In cases, when the length of the axis of the symmetry is comparable to the shell diameter or longer, shells can be spherical (close to or perfectly circular), ovoid (oval-shaped with convex sides), elongate (length more than 1.5 times greater than the breadth), pyriform (pear-shaped, wider posterior end than the anterior) or bottle-shaped with a well defined neck. Neck is an extension from a shell which terminates by an aperture. Aperture is generally situated at right angles to the axis of symmetry of the shell (terminal aperture). The aboral region is referred to as fundus. The shells are normally seen in preparations lying of their side (lateral view). In compressed shells, broad and narrow lateral views can be distinguished. Aperture is generally circle, but it can also be denticulate or lobed. Sometimes, aperture can be located in a small chamber (Cucurbitellidae, *Lagenodifflugia, Zivkovicia, Pontigulasia* etc.)

In bilaterally symmetrical (also called plane symmetry) shells, only one cutting plane (called the sagittal plane) divides a shell into roughly mirror image halves (with respect to external appearance only). There is no axis of symmetry. Often the two halves can meaningfully be referred to as the right and left halves. Bilaterally symmetrical shells are characterized by ventral and dorsal sides. The aperture can be located at an oblique angle to the axis of the symmetry (subterminal), at the end of a curved neck (*Lesqueresia, Cyphoderia*) or on ventral side of the shell (Plagiopyxidae). The aperture can be a simple circle opening or be located at the end of an invaginated tube, but sometimes it evolves to a slit-like structure (cryptostome) often covered by the anterior (dorsal) lip (*Plagiopyxis*) or a visor (*Planhoogenraadia*). This type of symmetry is generally characteristics for organisms which live on the surface.

Depending on the composition of the shell four shell types can be distinguished: proteinaceous, agglutinated, siliceous and calcareous.

Proteinaceous shells are completely organic and bear no or very scarce covering materials. There are two main types of proteinaceous shells: areolate and non-areolate. Areolate shells are constructed of regularly arranged hollow building units to from an areolate surface. These shells can be rigid (*Arcella* and *Pyxidicula*) or flexible to semi-rigid (Microchlamyiidae). Non-areolate shells are mostly composed of rigid sheet of fibrous material (*Hyalosphenia, Archerella* etc.). In rare case the shell is more or less flexible and represents a membrane that encloses the cytoplasm (Microcoryciidae).

Agglutinated shells consist of a cement matrix of often perforated building units or sheet-like cement in which foreign material (xenosomes) is incorporated. As xenosomes testate amoebae can use quartz grains, whole diatoms or pieces of diatoms and chrysomonad cysts from the environment (*Difflugia, Centropyxis, Lagenodifflugia, Awerintzewia* etc.) or siliceous scales their prey testate amoebae, usually members of the order Euglyphida (*Nebela*). Normally, xenosomes are randomly arranged on the shell surface; however they can have specific pattern of organization usually around the aperture (*Cyclopyxis*).

Siliceous shells are built of a cement matrix which is coved by endogenously synthesized siliceous scales or plates (idiosomes). Normally, the plates are regularly arranged on the surface of the shell. The plates differ in shape, size and arrangement and are genus- and species-specific. Normally, there are no more than four types of plates or spines can be produced by one species. Most of the species with siliceous shells are found among filose amoeba (Euglyphidae, Sphenoderiidae, Trinematidae, Cyphoderiidae etc.). Among lobose amoebae, this type of shells is typical for *Lesquereusia* and *Quadrulella*. Some testate amoebae can use both idiosomes and xenosomes for shell construction, e.g. *Heleopera*.

Calcareous shells are characterized by the presence of calcareous elements, either plates or shell layers. These shells are characteristic for the genus *Cryptodiffludia* and the family Paraquadrulidae. The former has a thick layer of calcium phosphate deposited within an organic template, whereas the later has rectangular calcite plates bound by an internal sheet of cement.

Ecology. A great number of studies have demonstrated the important role of substrate moisture in regulation of abundance, species diversity and assemblage composition of testate amoebae in soils (Geltzer et al., 1985; Foissner, 1987) and in *Sphagnum* mosses (Tolonen et al., 1992, 1994; Bobrov et al., 1999; Charman et al., 2000; Booth, 2002; Lamentowicz, Mitchell, 2005). The importance of substrate moisture in regulation of testate amoeba assemblages is related to the fact that water basically provides the environment for testate amoeba activity. That is why thicker water film can physically accommodate a greater number of testate amoebae. Low substrate moisture demands special adaptation from species to survive so that dry biotopes are normally inhabited by smaller number of predominantly xerophilous species. Testate amoebae adapted to water deficit by reduced shell size to reach smaller pores and inhabit thinner water films or by invagination of the pseudostome to protect cells from desiccation (Bonnet, 1975).

Testate amoebae have been shown to be sensitive to a number of other environmental parameters which affect testate amoebae either directly or indirectly: pH (Heal, 1961; Booth, 2002; Lamentowicz, Mitchell, 2005); nutrient availability (Aescht, Foissner, 1992; Mitchell, 2004; Krashevska et al., 2010); concentrations of metal ions (Mitchell et al., 2004; Carlson et al., 2010); vegetation (Carlson et al., 2010; Sullivan, Booth, 2011); food source type (Krashevska et al., 2008); concentration, composition of mineral of building particles for shells and light (Heal, 1962).

Chapter 2
Order Arcellinida Kent, 1880
[= Testacealobosia de Saedeleer, 1934]

Testate, inside an organic or mineral extracellular shell of either self-secreted elements (calcareous, siliceous, or chitinoid) or recycled mineral particles bound together, with a single main opening.

Key to the families of the order and genera *incertae sedis*

1. Shell is flexible or semi-rigid..2
1'. Shell is rigid...3
2. Shell is finely areolate........................ **Family Microchlamyidae**
2'. Shell is not areolate .... **Family Microcoryciidae**
3. Shell is radially symmetrical; cross section is circular or compressed...4
3'. Shell is bilaterally symmetrical or with a bent neck 42
4. Ventral face is flat, aperture is located in the center of ventral surface, invaginated or not 5
4'. Aperture is terminal..13
5. Shell is completely organic..6
5'. Shell is covered by mineral particles 8
6. Shell is areolate...7
6'. Shell is not areolate .... **Genus Cryptodifflugia (Family Cryptodifflugiidae)**
7. Aperture is smaller than half of the shell diameter .... **Family Arcellidae**
7'. Aperture is almost as large as the shell diameter........................ ....**Genus *Pyxidicula***
8. Shell is circular in cross section...10
8'. Shell is elliptic in cross-section 9
9. Aperture is circular ....**Genus *Ellipsopyxella***
9'. Aperture is elliptical .... **Genus *Ellipsopyxis***
10. Aperture is circular, ovular, triangular, polygonal, lobed or crescent-shaped 11

10’. Apertural apparatus with an internal opening at the end of an invaginated tubus and an external aperture with either teeth-like structures or two crescent shape openings 12

11. Aperture normally is less than a half of the shell diameter ....**Family Trigonopyxidae**

11’. Aperture normally is more than a half of the shell diameter...... ....**Family Phryganellidae**

12. External aperture with two crescent-shaped openings ....**Family Distomatopyxidae**

12’. External aperture bordered by large teeth ....**Family Lamtopyxidae**

13. Shell is compressed or polygonal in cross section (aperture is surrounded by a thin organic lip)..14

13’. Shell is circular or slightly compressed in cross section........18

14. Shell is compressed in cross section 15

14’. Shell is polygonal in cross section 17

15. Aperture is surrounded by a thin organic lip (rim, collar or fringle) 16

15’. Aperture is without organic lip ....**Genus *Difflugia***

16. Aperture is slit-like with acute notches at edges ....**Genus *Heleopera***

16’. Aperture is circular or oval, without acute notches at edges...... ....**Family Hyalospheniidae**

17. Shell is hexagonal in cross section, completely organic ....**Genus *Sexangularia***

17’. Shell is pentagonal, covered by mineral particles...................... ....**Genus *Pentagonia***

18. Shell is completely organic ....**Genus *Leptochlamys***

18’. Shell is covered by mineral particles, idiosomes of prey species or square plates 19

19. Aperture is surrounded by a distinct lobed or denticulate collar or by a complex, consisting of a central pore and irregularly elongate oval pores radiating around the central pore 20

19’. Aperture is circular, oval, lobed or denticulate, sometimes with an organic lip, no collar, no distinctions between internal and external opening 26

20. Aperture complex with central opening and numerous elongate oval pores radiating around central pore ....**Genus *Suiadifflugia***

20’. Aperture is surrounded by a collar..21

21. Collar is lobed 22
21'. Collar is relatively smooth or denticulate 24
22. Collar forms a cavity (frontal camera) which has an inner aperture (circular or lobed) on the level with the main body wall............. .... **Family Cucurbitellidae**
22'. Collar does not form a cavity, no inner aperture 23
23. Collar is lobed, with a thick organic rim or a necklace made of small idiosomes.. **Family Netzeliidae**
23'. Collar is formed by 3–5 separate lobes .... **Genus *Pseudocucurbitella***
24. Collar is straight, chitionoid or made of quartz grains............ 25
24'. Collar is recurved posteriorly, covered with siliceous exogenous plates .... **Genus *Physochilla***
25. Collar is chitionoid.................................. **Genus *Geamphorella***
25'. Collar is short, made of quartz grains................ **Genus *Jungia***
26. Shell composed mainly of mineral grains or diatoms, often opaque grayish 27
26'. Shell completely organic or composed of circular, oval, nail-shaped or rectangular plates, collected or endogenously formed, sometimes with admixture of mineral grains or diatoms.. 36
27. Shell is with 3-4 lateral bulges near aperture .... **Genus *Maghrebia***
27'. No lateral bulges 28
28. Aperture is denticulate 29
28'. Aperture is not denticulate.. 30
29. The peristome is surrounded by distinctive diaphragm .... **Genus *Mediolus***
29'. No diaphragm around the peristome.. .... **Genus *Protocucurbitella***
30. Shell partitioned in two parts by a diaphragm between neck an main body, often visible as constriction.................................... 31
30'. No such diaphragm... 33
31. Internal diaphragm with one opening .... **Genus *Lagenodifflugia***
31'. Internal diaphragm with two openings 32
32. Diaphragm composed of small mineral grains, two circular openings .... **Genus *Zivkovicia***

32’. The openings formed by a mainly organic bridge with few attached mineral particles which connects both broad sides .... **Genus *Pontigulasia***

33. Shell mainly composed of angular mineral particles of diatoms; aperture is relatively large, circular, oval or lobed ....**Genus *Difflugia***

33’. Aperture is relatively small, shell deep violet or brownish with smooth surface..34

34. Aperture at the broader end of the brownish shell with smooth chitionoid surface............. **Genus *Pseudawerintzewia***

34’. Aperture at the narrow end of the shell..................................35

35. Aperture is oval, shell deep violet............**Genus *Awerintzewi*a**

35’. Aperture is circular, relatively small .... aperture...**Genus *Schwabia***

36. Shell is completely organic or covered with rare particles of foreign material .... **Genus Cryptodifflugia (Family Cryptodifflugiidae)**

36’. Shell is completely agglutinated..37

37. Aperture with an organic lip 38

37’. Aperture without any organic lip 39

38. Organic lip is smooth ....**Genus *Longinebela*, Genus *Padaungiella* (Family Hyalospheniidae)**

38’. Aperture with organic, denticulate lip, appears lobed................ .... **Genus *Pseudonebela***

39. Shell is covered by square plates...40

39’. Shape of the plates covering shell is different 41

40. Aperture is slit-like.. .... **Genus *Paraquadrula* (Family Paraquadrulidae)**

40’. Aperture is slightly truncated...............**Genus *Microquadrula***

41. Shell is composed of collected idiosomes of small euglyphids ....**Genus *Schoenbornia***

41’. Aperture is surrounded by siliceous plates, giving it a rough outline .... **Genus *Argynnia***

42. Aperture is circular, elongated or irregular 43

42’. Aperture is slit-like ....**Family Plagiopyxidae**

43. Shell is covered by mineral particles.......................................44

43’. Shell is completely organic.. ....**Genus *Wailesella* (Family Cryptodifflugiidae)**

44. Aperture is located on a ventral side 45

44’. Aperture is located at the end of a bent neck 46

45. Aperture is relatively large, circle; ventral side is flat .... **Family Centropyxidae**

45’. Aperture is relatively small, irregular, ventral side is convex .... **Genus *Oopyxis***

46. Shell is covered by rod-like siliceous scales sometimes with admixture of mineral particles .... **Genus *Lesquereusia***

46’. Shell is covered by square scales 47

47. Marine species, scales are presumably siliceous........................ .... **Genus *Pomoriella***

47’. Tropical soil species, scales are presumably calcite .... **Genus *Lamtoquadrula* (Family Paraquadrulidae)**

Suborder Sphaerothecina Kosakyan et al., 2016

Shell is circular in lateral view, with radial symmetry; spherical or slightly flattened in cross section, aperture is circular or with lobes. Type family: Netzeliidae Kosakyan et al., 2016.

Family Arcellidae Ehrenberg, 1843

Shell is rigid, radially symmetrical, round, polygonal or dentate in the front view; spherical, hemispherical, flattened or disk-like in lateral view. Shell is completely organic, composed of box-like building units arranged in a single layer and cemented together, resulting in an areolar surface. Shell is transparent, colorless, yellow or brownish. Aperture is located on the ventral side, invaginated (rarely evaginated), circular, polygonal or lobed, often surrounded by small organic rim or a circle of pores.

Key to the genera of the family

1. Cytoplasm contains two or more vesicular nuclei .... **Genus *Arcella***

1’. Cytoplasm contains one ovular nucleus .... **Genus *Antarcella***

Genus *Arcella* Ehrenberg, 1832

Shell as the family description. Most species are binucleate, but several species have more nuclei, e.g. *A. megastoma* may have up to 200. These nuclei are always vesicular. Ecology: freshwater, mosses and soils. Type species: *Arcella vulgaris* Ehrenberg, 1832 (fig. 1–7).

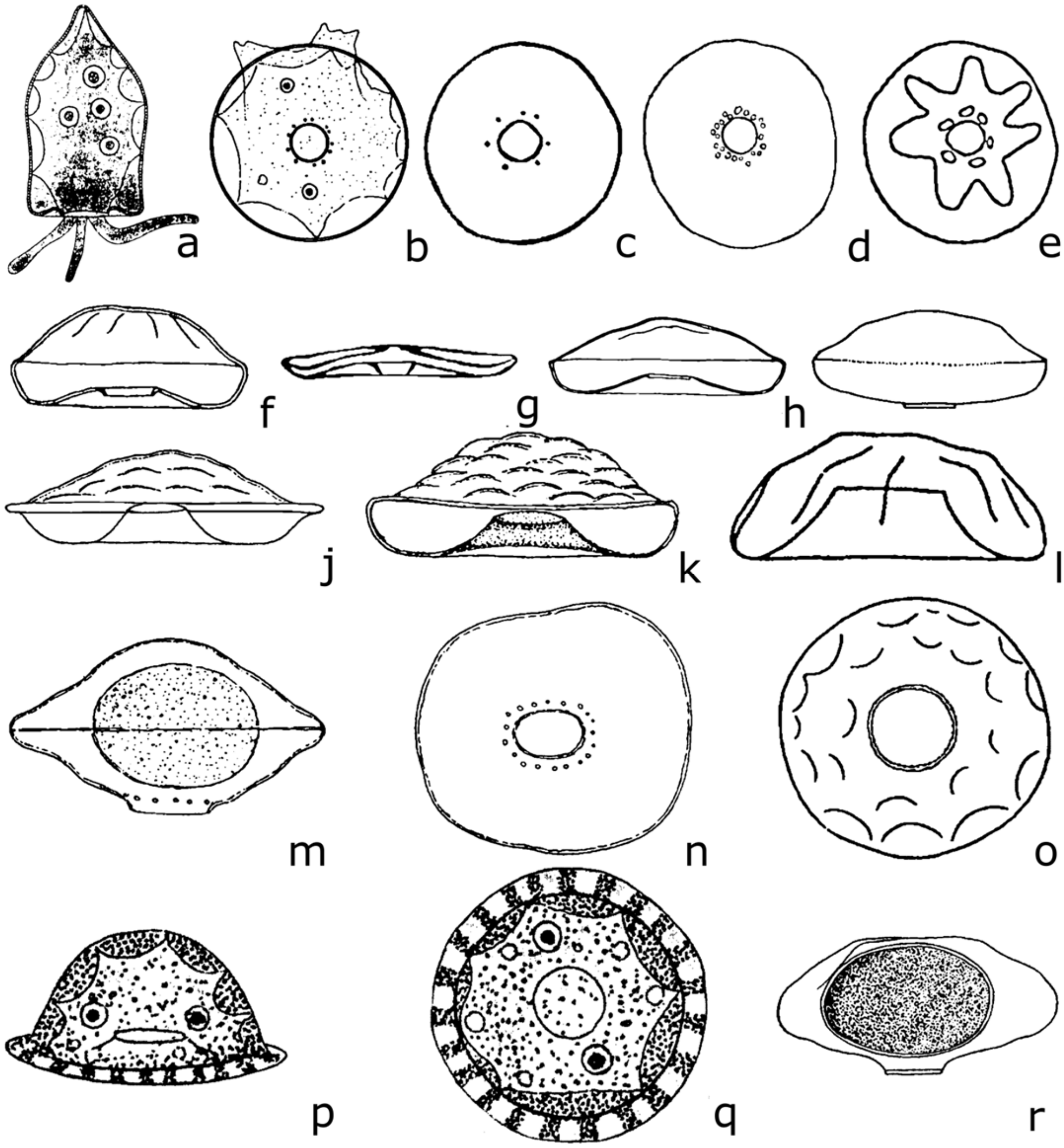

Fig. 1. Genus *Arcella*:
a – *A. apicata* lateral view (after Schaudinn, 1898); b, f – *A. arenaria* lateral (f) and aperture (b) view (after Deflandre, 1928a); c, g – *A. arenaria compressa* lateral (g) and aperture (c) view (after Décloître, 1976); d – *A. arenaria irregularis* aperture view (after Décloître, 1972); h, i – *A. arenaria sphagnicola* lateral (h) view and cysts (i) (after Deflandre, 1928a); e – *A. arenaria sphagnicola undulata* (after Décloître, 1976); j – *Arcella artocrea* (after Leidy, 1879); k, n, m – *A. artocrea pseudocatinus* lateral (k), aperture (n) view and cyts (m) (after Leidy, 1879); l, o – *A. bathystoma* lateral (l) and aperture (o) view (after Deflandre, 1928a); p, q – *A. brasiliensis* lateral (p) and aperture (q) view (after Cunha, 1913); r – *A. catinus* cyst (after Deflandre, 1928a)

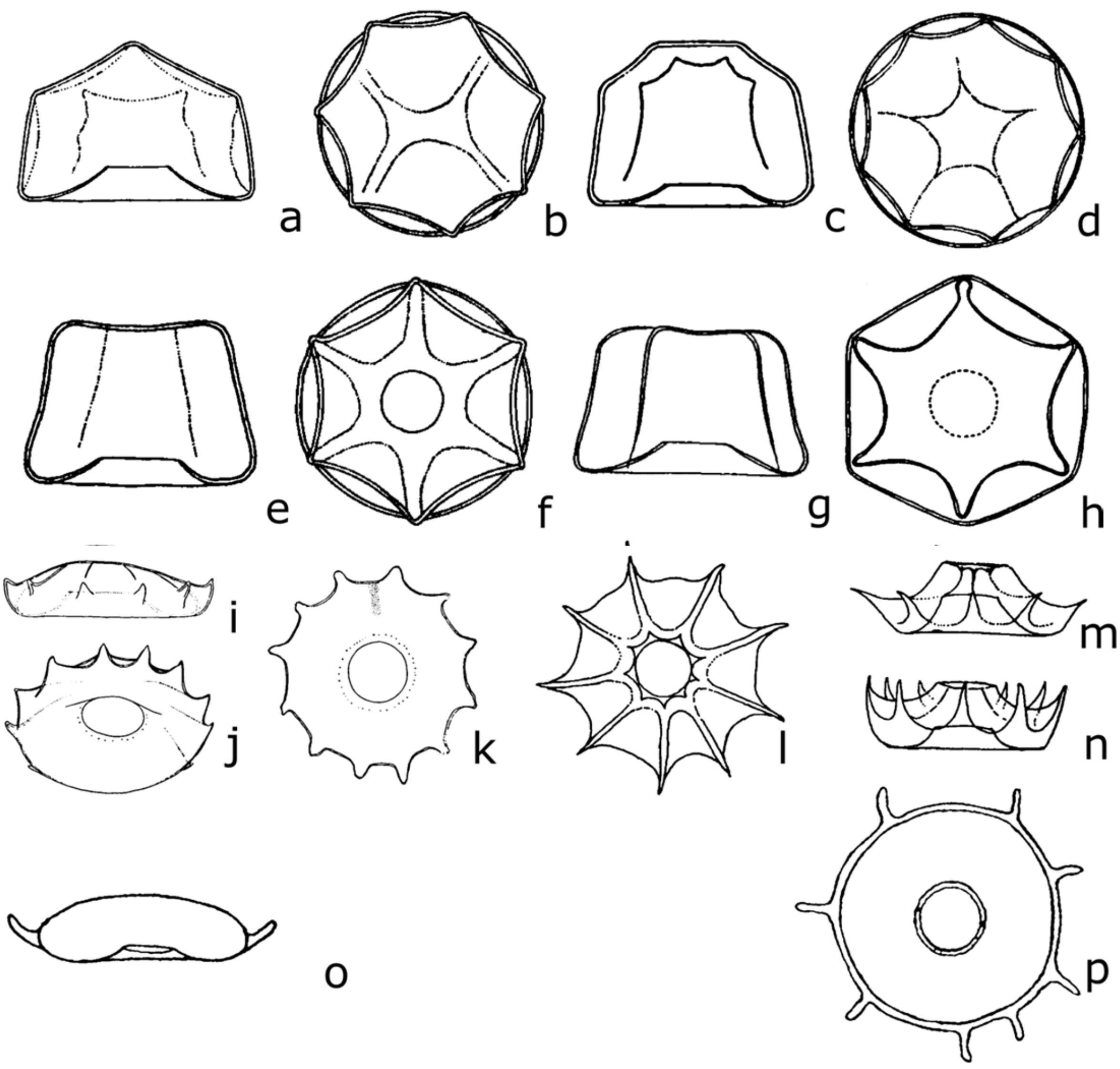

Fig. 2. Genus *Arcella*:
a–d – *A. conica* lateral (a, c) and dorsal (b, d) view (after Deflandre, 1928a); e, f – *A. costata* lateral (e) and aperture (f) view (after Playfair, 1917); g, h – *A. costata angulosa* lateral (g) and aperture (h) view (after Penard, 1902); i–k – *A. dentata* lateral (i), aperture (k) and aperture-lateral (j) view (after Deflandre, 1928a); l–n – *A. dentata trapezica* lateral (m, n) and aperture (l) view (after Deflandre, 1928a); o, p – *A. dentata cashiana* lateral (o) and aperture (p) view (after Deflandre, 1928a)

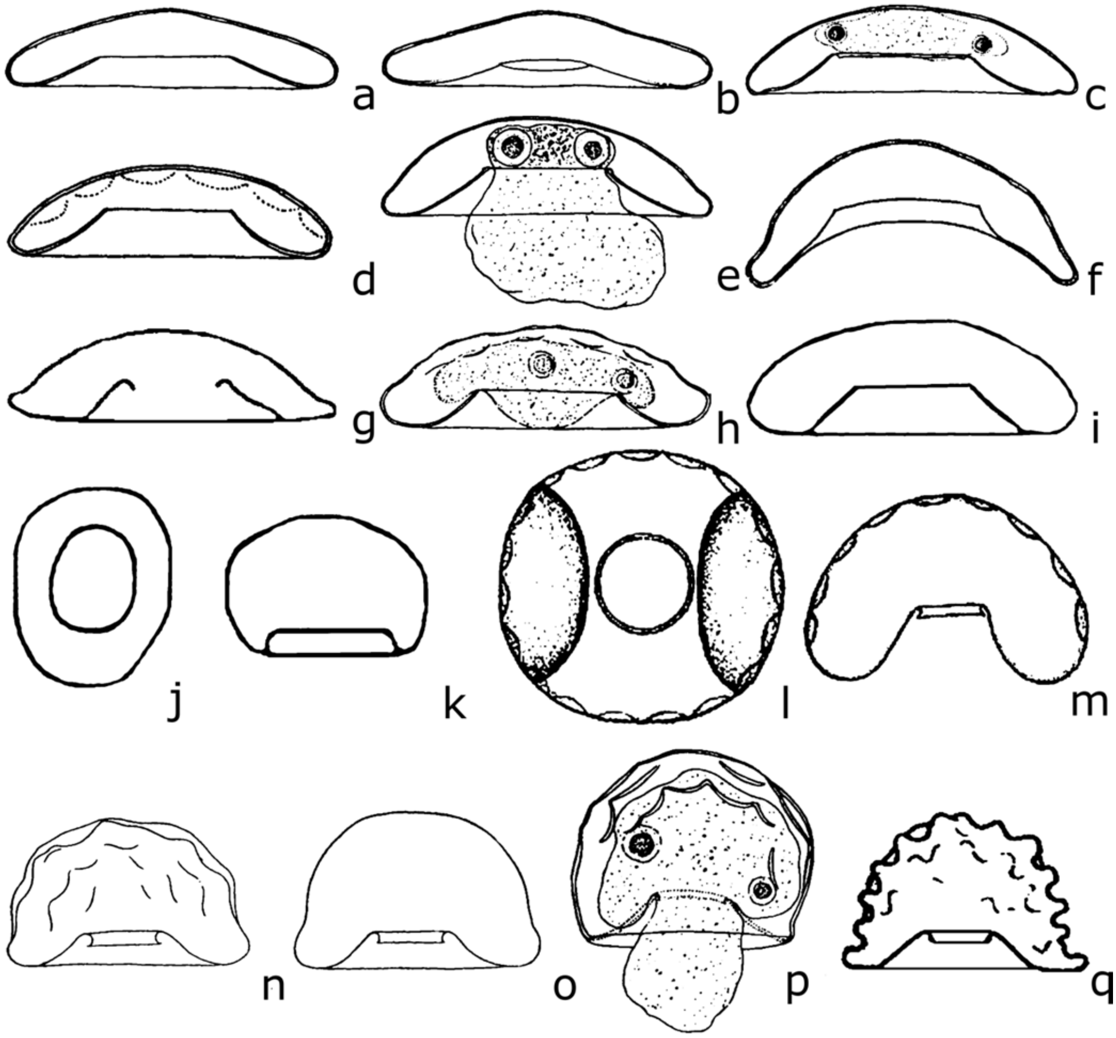

Fig. 3. Genus *Arcella*:

a, b – *A. discoides* lateral view (a – after Deflandre, 1928a; b – after Leidy, 1879); c – *A. discoides difficilis* lateral view (after Deflandre, 1928a); d – *A. discoides foveosa* lateral view (after Playfair, 1917); e – *A. discoides pseudovulgaris* lateral view (after Deflandre, 1928a); f – *A. discoides pseudovulgaris arcuata* lateral view (after Deflandre, 1928a); g – *A. discoides pseudovulgaris tubulata* lateral view (after Décloître, 1976); h – *A. discoides pseudovulgaris undulata* lateral view (after Deflandre, 1928a); i – *A. discoides scutelliformis* lateral view (after Deflandre, 1928a); j, k – *A. elliptica* lateral (k) and aperture (j) view (after Kufferath, 1932); l, m – *A. excavata* lateral (m) and aperture (l) view (after Todorov, Golemansky, 2003); n – *A. gibbosa* lateral view (after Penard, 1890); o – *Arcella gibbosa laevis* lateral view (after Deflandre, 1928a); p – *A. gibbosa mitriformis* lateral view (after Deflandre, 1928a); q – *A. gibbosa tuberosa* lateral view (after Décloître, 1976)

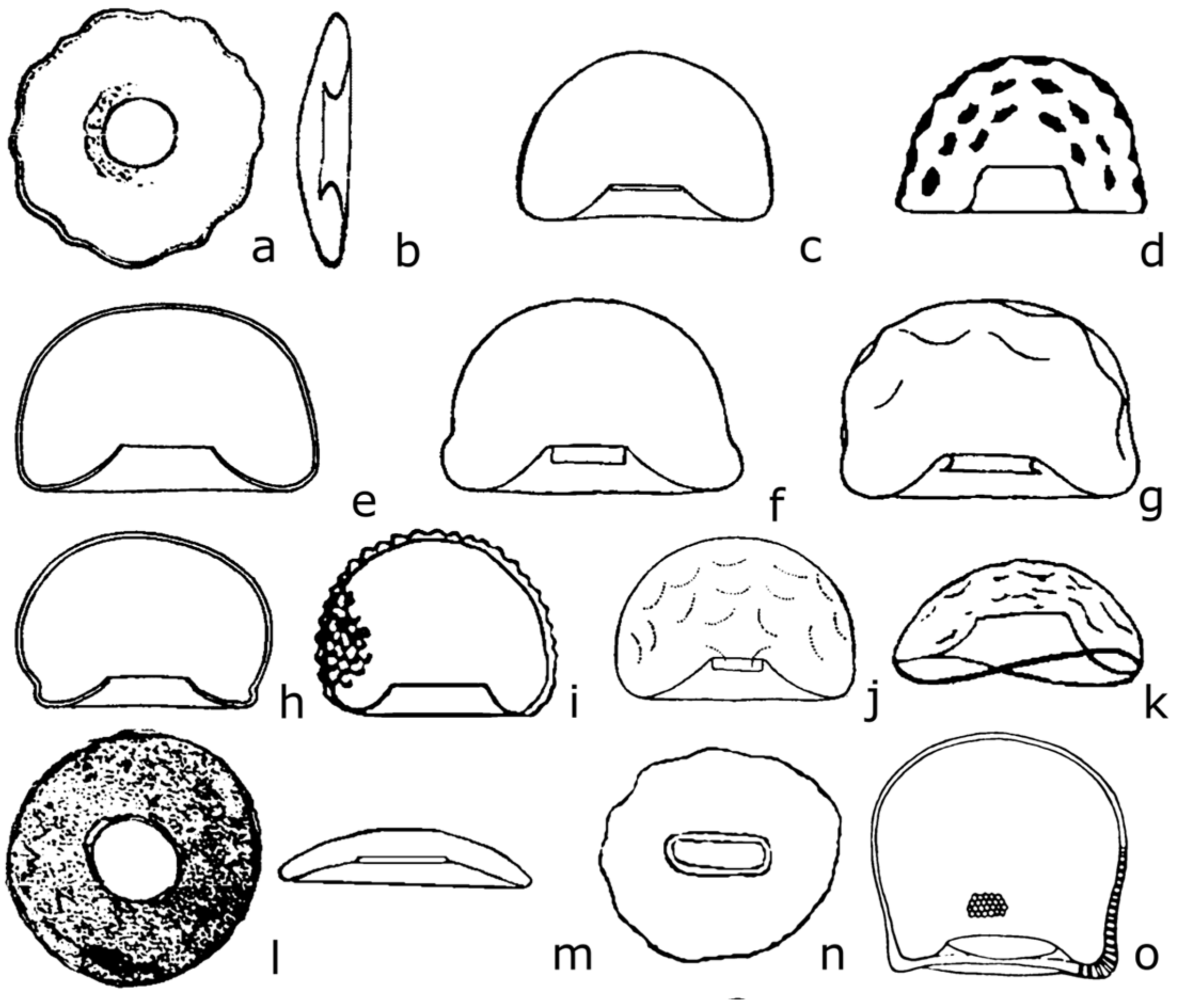

Fig. 4. Genus *Arcella*:
a, b – *A. grospietchi* lateral (b) and aperture (a) view (after Štěpànek, 1963); c – *A. hemisphaerica* lateral view (after Deflandre, 1928a); d – *A. hemisphaerica angulata* lateral view (after Schönborn, 1962a); e – *A. emisphaerica depressa* lateral view (after Playfair, 1917); f – *A. intermedia laevis* lateral view (after Deflandre, 1928a); g – *A. intermedia* lateral view (after Deflandre, 1928a); h – *A. hemisphaerica playfairiana* lateral view (Deflandre, 1928a); i – *A. hemisphaerica tuberculata* lateral view (after Štěpànek, 1963); j – *A. hemisphaerica undulata* lateral view (after Deflandre, 1928a); k – *A. hemisphaerica undulata curvata* lateral view (after Décloître, 1976); l, m – *A. infraterricola* lateral (m) and aperture (l) view (after Chardez, 1971); n – *A. irregularis* lateral view (after Motti, 1961); o – *A. jeanneli* lateral view (after Virieux, 1916)

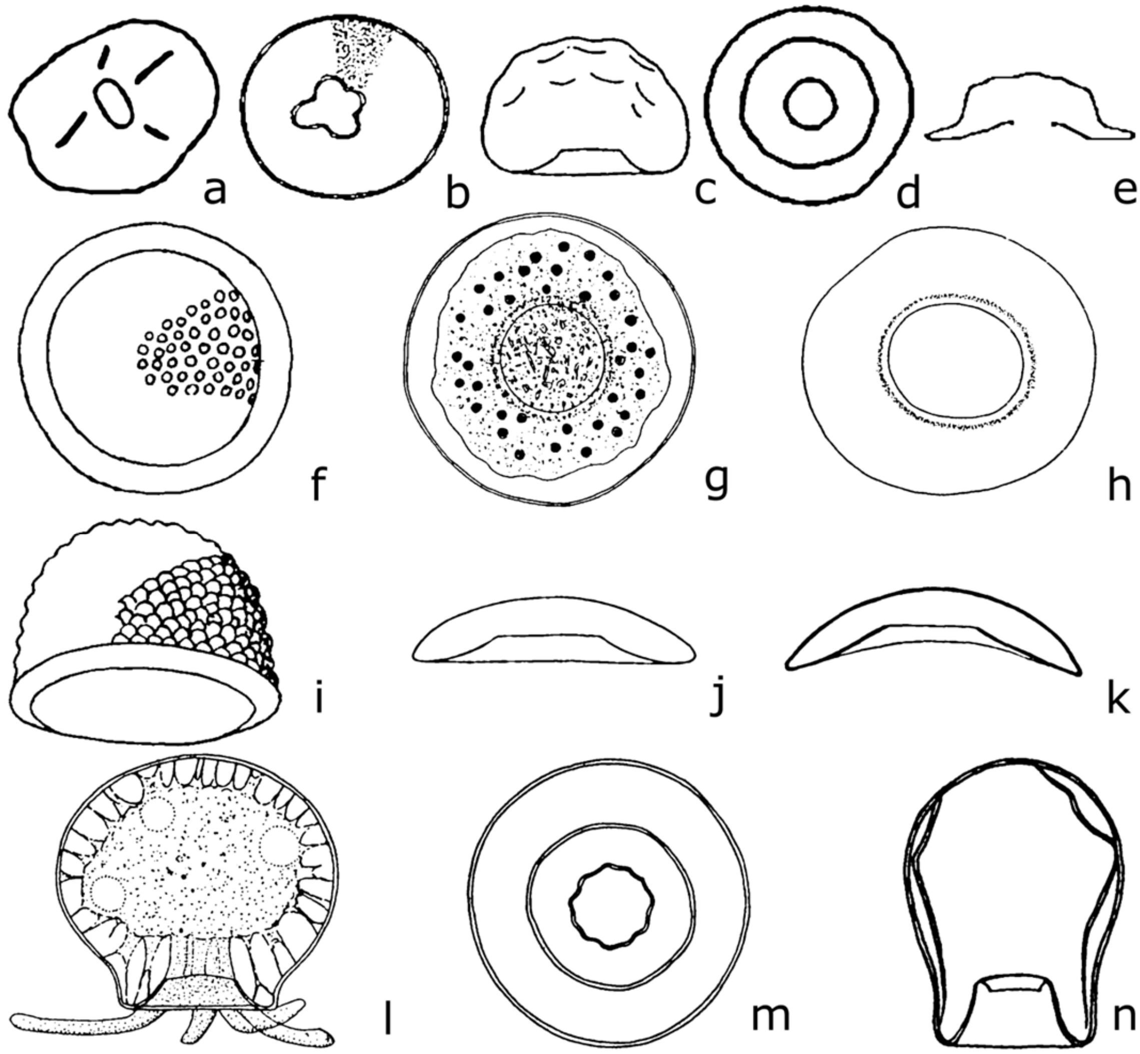

Fig. 5. Genus *Arcella*:
a – *A. lichenophila* aperture view (after Décloître, 1976); b, c – *A. lobostoma* lateral (c) and aperture (b) view (after Deflandre, 1928a); d, e – *A. maggii* lateral (e) and aperture (d) view (after Décloître, 1976); f, i – *A. marginata* lateral (i) and dorsal (f) view (after Daday, 1905); g, j – *A. megastoma* lateral (j) and aperture (g) view (after Penard, 1902); h, k – *A. megastoma arcuata* lateral (k) and aperture (h) view (after Deflandre, 1928a); l, m – *A. mitrata* lateral (l) and aperture (m) view (after Leidy, 1879); n – *A. mitrata pyriformis* lateral view (after Deflandre, 1928a)

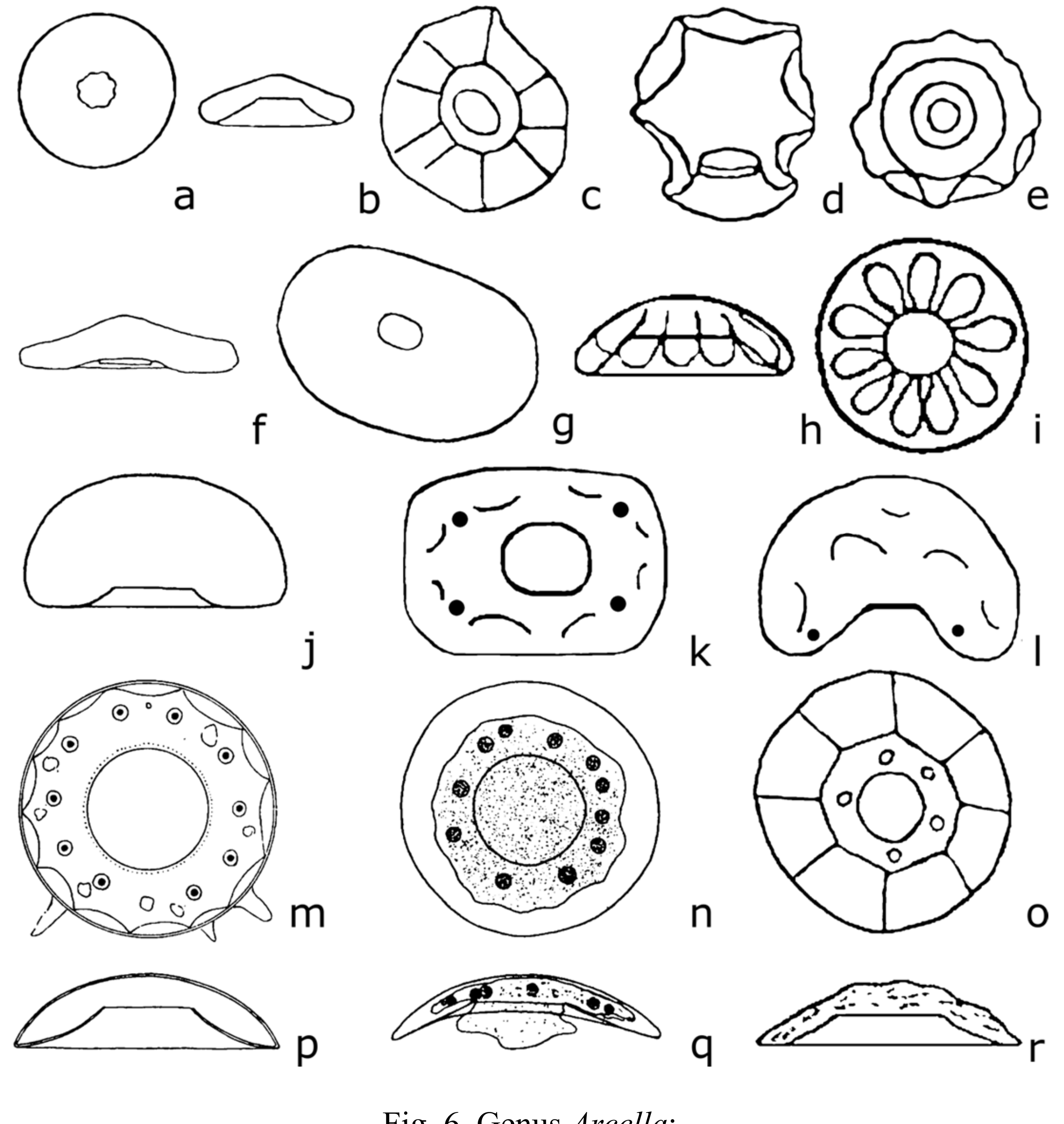

Fig. 6. Genus *Arcella*:
a, b – *A. multilobata* lateral (b) and aperture (a) view (after Golemansky, 1964); c – *A. muscicola* aperture view (after Décloître, 1976); d, e – *A. nordestina* lateral (d) and aperture (e) view (after Décloître, 1976); f, g – *A. ovaliformis* lateral (f) and aperture (g) view (after Chardez, Beyens, 1987); h, i – *A. oyei* lateral (h) and aperture (i) view (after Štėpànek, 1963); j – *A. papyracea* lateral view (after Playfair, 1914); k, l – *A. pentastoma* lateral (l) and aperture (k) view (after Štėpànek, 1963); m, p – *A. polypora* aperture (m) and lateral (p) view (after Deflandre, 1928a); n, q – *A. polypora curvata* lateral (q) and aperture (n) view (after Deflandre, 1928a); o – *A. pseudojurassica* aperture view (after Décloître, 1976); r – *A. polypora undulata* lateral view (after Decloire, 1976)

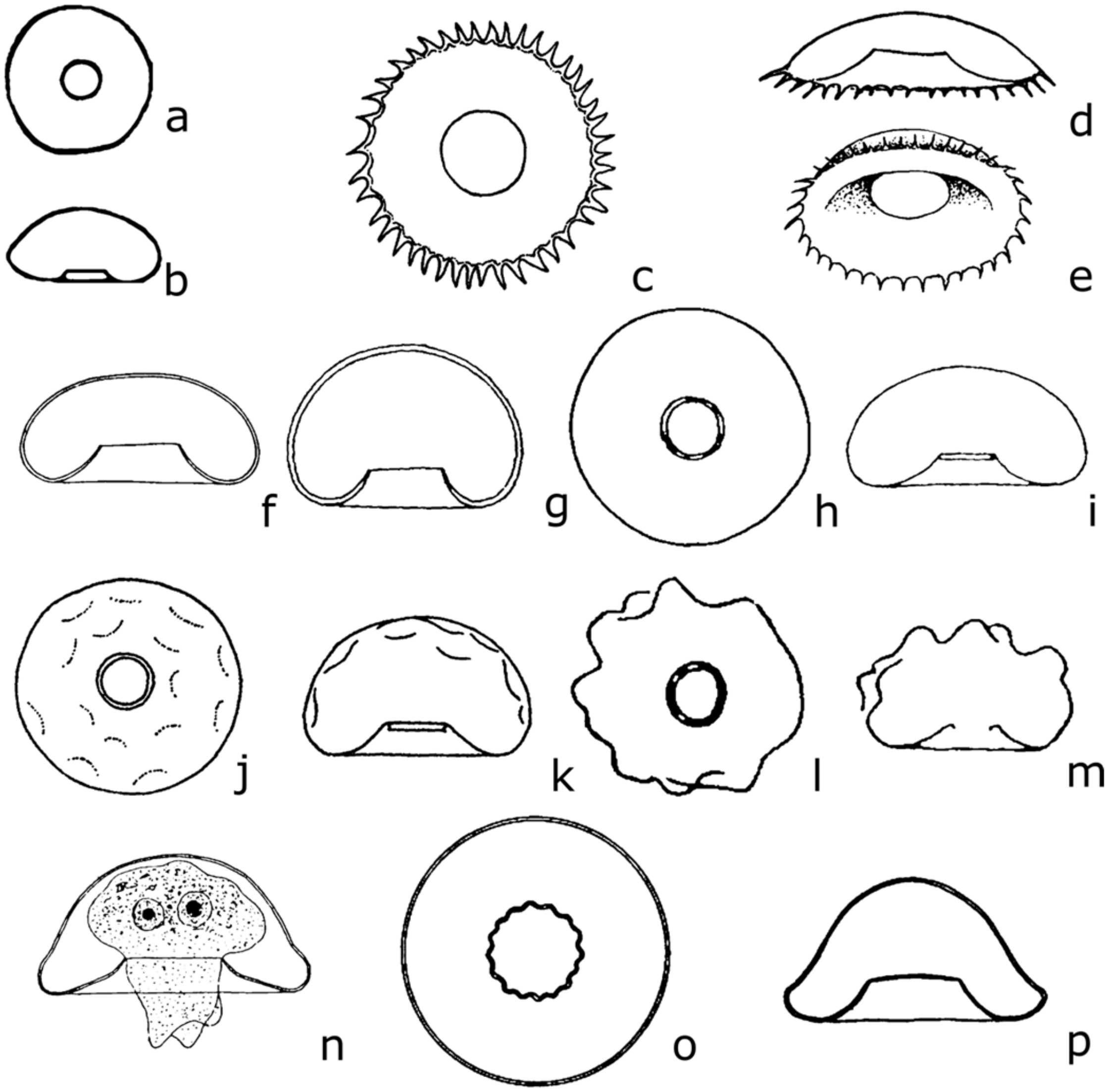

Fig. 7. Genus *Arcella*:
a, b – *A. pygmaea* aperture (a) and lateral (b) view (after Bartoš, 1963); c–e – *A. rota* aperture (c), lateral (d) and aperture-lateral (e) view (after Daday, 1905); f – *A. rotundata* lateral view (after Playfair, 1917); g – *A. rotundata alta* lateral view (after Playfair, 1917); h, i – *A. rotundata stenostoma* lateral (i) and aperture (h) view (after Deflandre, 1928a); j, k – *A. rotundata stenostoma undulata* lateral (k) and aperture (j) view (after Deflandre, 1928a); l, m – *A. tuberosus* aperture (l) and lateral (m) view (after Décloître, 1976); n – *A. vulgaris* lateral view (after Deflandre, 1928a); o, p – *A. vulgaris crenulata* lateral (p) and aperture (o) view (after Deflandre, 1928a)

Genus *Antarcella* Deflandre, 1928, emend. Deflandre, 1953

Shell is circular in frontal view, hemispherical in lateral view, aperture is circular, invaginated. In contrast to *Arcella, Antarcella* has one ovular nucleus. Contractive vacuole 10 to 15 μm in diameter. To distinguish *Antarcella* species from *Arcella* spp., staining of the nucleus is recommended. Ecology: *Sphagnum* mosses. Two species. Type species: *Antarcella atava* (Collin, 1914) (fig. 8).

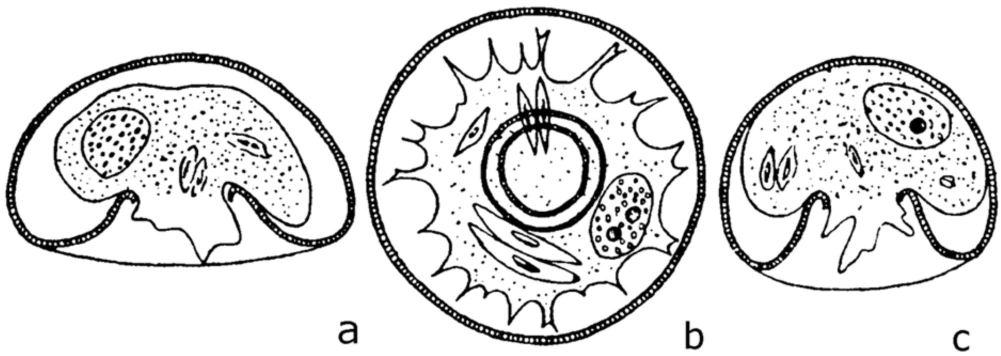

Fig. 8. *Antarcella atava*:
a, c – lateral view; b – apertural view (after Penard, 1917)

Family Netzeliidae Kosakyan et al., 2016

Shell is ovoid, circular in cross-section, aperture is lobed, with a thick organic rim or a necklace made of small idiosomes. Shell is covered by idiosomes, although small sand grains, diatoms or undigested algal cell walls can be used as supplementary building material. These xenosomes are always smoothed and modified by the deposition of silica (Anderson, 1987). The idiosomes often have a nail-like shape. All particles are held in position by perforated cement units and are arranged in a single layer. Outline usually regular, but some species often have protuberances to give a mulberry-like appearance. Recently some spherical *Difflugia* (*D. oviformis, D. tuberculata, D. wailesi, D. tricuspis, D. geospherica,* etc.) that had been found able to produce endogeneous siliceous elements are expected to be removed from *Difflugia*, which is generally incapable to build shell without xenosomes (Ogden, 1979; Gomaa et al., 2017). Type genus: *Netzelia* Ogden, 1979.

Genus *Netzelia* Ogden, 1979

Corresponds to the description of the family. Ecology: freshwater, *Sphagnum* mosses. Type species: *Netzelia oviformis* (Cash, 1909) (fig. 9).

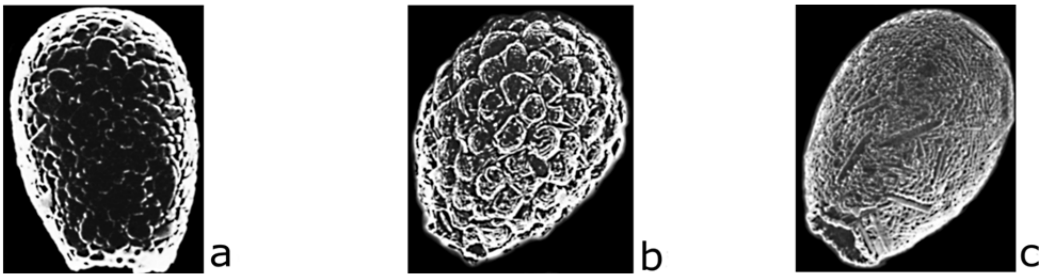

Fig. 9. Genus *Netzelia*:
a – *N. compressa* lateral view (after Dehtiar, 1994); b – *N. tuberculata* lateral view (after Ogden, 1980b); c – *N. wailesi* lateral view (after Ogden, Meisterfield, 1989)

Family Cucurbitellidae Gomaa et al., 2017

Shell is ovoid, circular in cross-section, with distinct apertural collar, dark grey or opaque in color, with regular outline, covered by small to medium mineral grains. Organic cement seldom visible as surface structure. Aperture is terminal, with 3 to 12 lobes, composed of small mineral grains. Collar forms a cavity (frontal camera) which has an inner aperture (circular or lobed) on the level with the main body wall. Nuclear is vesicular, cytoplasm of some species contains zoochlorellae. Type genus: *Cucurbitella* Penard, 1902.

Genus *Cucurbitella* Penard, 1902

Corresponds to the description of the family. Ecology: freshwater. Type species: *Cucurbitella mespiliformis* Penard, 1902 (fig. 10).

Family Centropyxidae Jung, 1942

Bilaterally symmetrical shell, with an eccentric elliptic or circular aperture located on the ventral side; shell with xenosomes.

Key to the genera of the family

1. In apertural view, the main body of the shell is separated from the mouth funnel by a constriction .... **Genus *Conicocassis***

1'. The main body of the shell is not separated by from the moth funnel by a constriction 2

2. Aperture is invaginated 3

2'. Aperture is not invaginated....................... **Genus *Proplagiopyxis***

3. Anterior walls of the aperture are not attach to the dorsal side .... **Genus *Centropyxis***

3'. Anterior walls of the aperture attach to the dorsal side................. .... **Genus *Armipyxis***

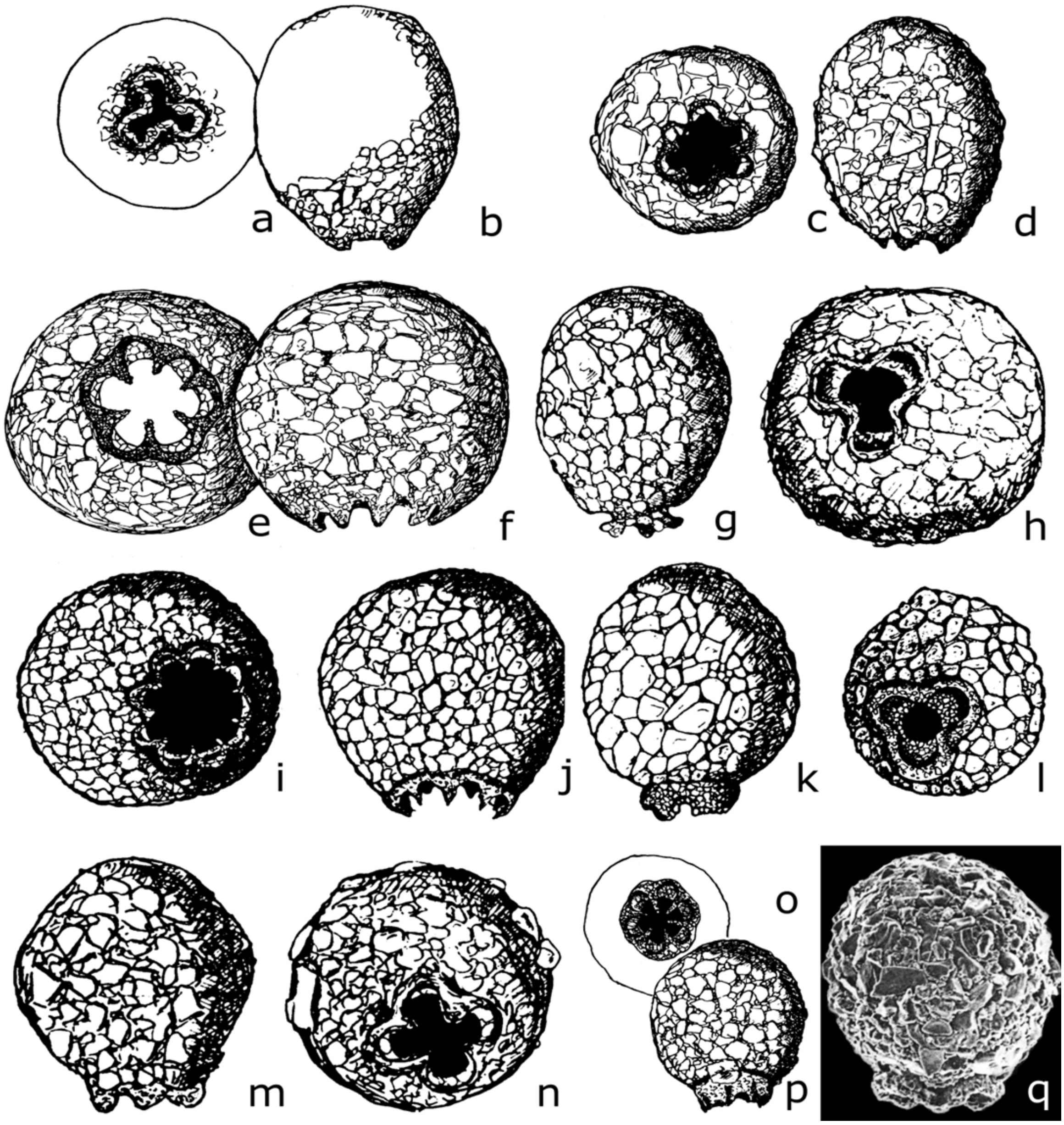

Fig. 10. Genus *Cucurbitella*:
a, b – *C. crateriformis* aperture (a) and lateral (b) view (after Gauthier-Lièvre, Thomas, 1960); c, d – *C. dentata* aperture (c) and lateral (d) view (after Gauthier-Lièvre, Thomas, 1960); e, f – *C. lunaris* aperture (e) and lateral (f) view (after Gauthier-Lièvre, Thomas, 1960); g, h – *C. madagascariensis* aperture (h) and lateral (g) view (after Gauthier-Lièvre, Thomas, 1960); i, j – *C. megastoma* aperture (i) and lateral (j) view (after Gauthier-Lièvre, Thomas, 1960); k, l – *C. mespiliformis* aperture (l) and lateral (k) view (after after Gauthier-Lièvre, Thomas, 1960); m, n – *C. modesta* lateral (m) and aperture (n) view (after Gauthier-Lièvre, Thomas, 1960); o, p – *C. obturata* aperture (o) and lateral (p) view (after Gauthier-Lièvre, Thomas, 1960); q – *C. vlasinensis* lateral view (after Ogden, Meisterfield, 1989)

Genus *Armipyxis* Dekhtiar, 2009

Shell is ovoid, flattened in the lateral view. Aperture is wide, invaginated and slightly eccentric. Anterior walls of the aperture attach to the dorsal side with several appendages creating a complex system of inner partitioning. Shell may or may not be ornamented with spines of varying number and length. Type species: *Armipyxis disoid*es Dekhtiar, 2009 (basionym *Centropyxis discoides* Penard, 1902). The genus also includes *A. mirabilis* (Bartoš, 1940) Dekhtiar, 2009 (basionym *Centropyxis mirabilis* Bartoš, 1940) and *A. gasparella* (Chardez et Beyens, 1988) Dekhtiar, 2009 (basionym *Centropyxis gasparella* Chardez et Beyens, 1988) (fig. 11, 13, 15).

Genus *Centropyxis* Stein, 1857

Shell is circular, irregular circular of ovoid in apertural (or dorsal) view, flattened in the area of the aperture in lateral view. Aperture is located on ventral side, invaginated, eccentric, circular to ovate. The shell is colorless to brown and may or may not be covered by agglutinating material, which varies from mineral grains to organic debris, particularly diatom frustules. Shell may or may not be ornamented with spines of varying number and length. Ecology: freshwater, moss. Type species: *Centropyxis aculeata* (Ehrenberg, 1838) Stein, 1857 (fig. 12–16).

Genus *Conicocassis* Nasser et Patterson, 2015

Two-component shell comprised of an ovoid to subspherical main body and a relatively very large conical to funnel-like and asymmetrically positioned flange extending out from a small circular aperture. The lower shell body of *Conicocassis* is ovoid or subspherical to spherical with a wall composed of polymorphous mineral particles within an organic matrix. The colorless to brown main shell body is topped by a cone-like flange, which extends out from a small circular aperture. The cone-like flange is mostly embossed with broken, or intact, diatoms frustules and quartz particles, and appears to be nearly as large as the main shell body if observed from the apertural view. In some cases, the flange may be characterized by coloration distinct from the main shell body. The attachment area of the apertural flange to the main shell body produces a pronounced constriction in the shell wall that is particularly diagnostic (Nasser, Patterson, 2015). Ecology: freshwater, wet moss. Type species: *Conicocassis pontigulasiformis* (Beyens et Chardez, 1986).

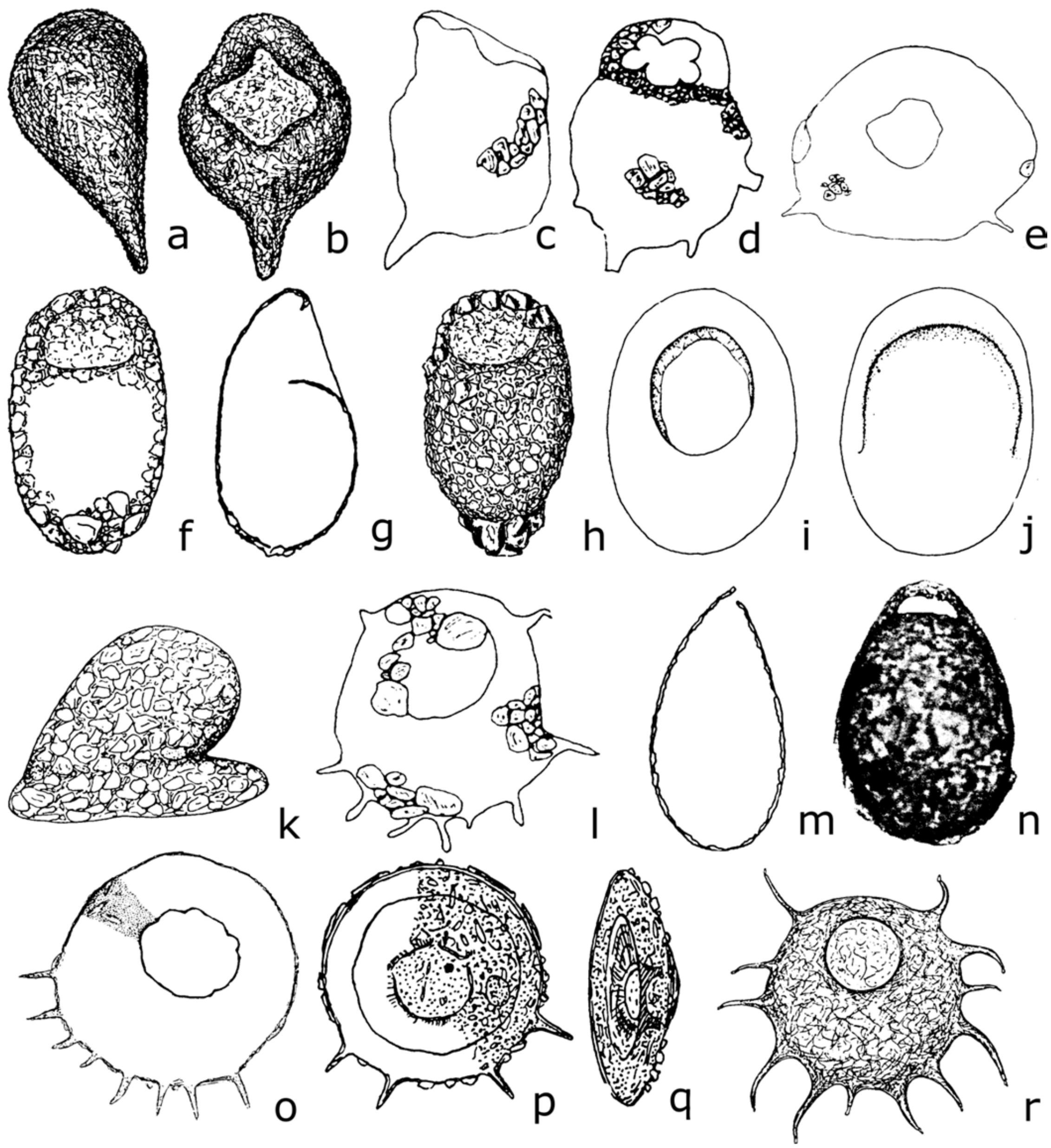

Fig. 11. Genera *Centropyxis* and *Armipyxis*:
a, b – *C. chardezi* lateral (a) and aperture (b) view (after Štěpànek, 1963); c, d – *C. chardeziella* lateral (c) and aperture (d) view (after Laminger, 1973); e – *C. compressa* aperture view (after Laminger, 1973); f–h – *C. constricta* aperture (f, h) and lateral (g) view (after Deflandre, 1929); i–k – *C. cordobensis* aperture (i), dorsal (j) and lateral (k) view (after Vucetich, 1976); l – *C. decloittella* aperture view (after Laminger, 1973); m, n – *C. declivistoma* lateral (m) and aperture (n) view (after Chardez, 1990); o–q – *A. discoides* aperture (o, p) and lateral (q) view (p, q – after Penard, 1890; o – after Deflandre, 1929); r – *A. discoides solari* aperture view (after Štěpànek, 1963)

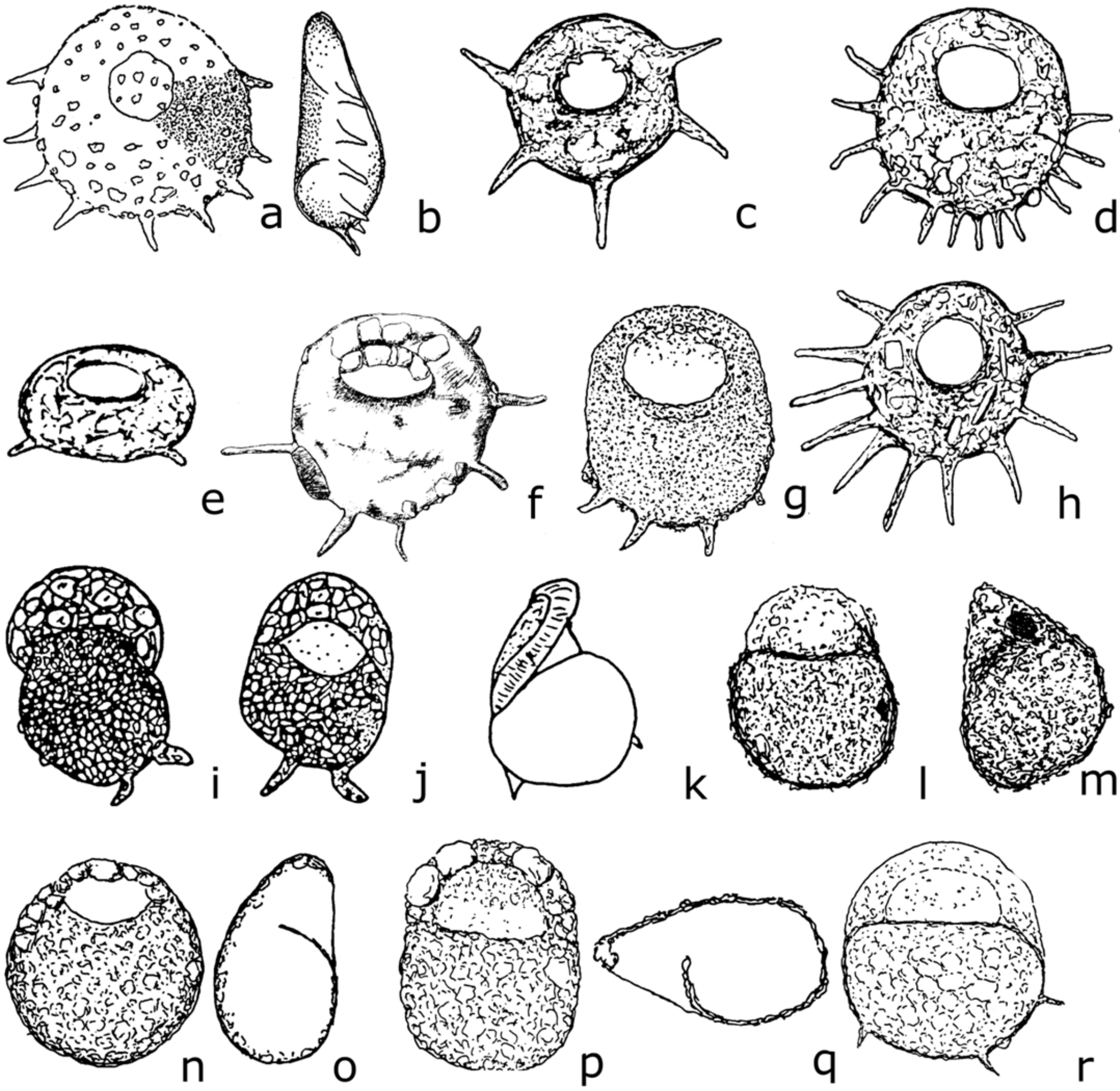

Fig. 12. Genus *Centropyxis*:
a, b – *C. aculeata* aperture (a) and lateral (b) view (after Leidy, 1879); c – *C. aculeata dentistoma* aperture view (after Chardez, 1970); d – *C. aculeata grandis* aperture view (after Chardez, 1970); e – *C. aculeata lata* aperture view (after Chardez, 1970); f – *C. aculeata minima* aperture view (after Oye, 1958); g – *C. aculeata oblonga* aperture view (after Deflandre, 1929); h – *C. aculeata tropica* aperture view (after Chardez, 1970); i–k – *C. adami* dorsal (i), aperture (j) and lateral (k) view (after Laminger, 1971); l, m – *C. aerophila* aperture (l) and lateral (m) view (after Deflandre, 1929); n, o – *C. aerophila sphagnicola* aperture (n) and lateral (o) view (after Deflandre, 1929); p, q – *C. cassis* aperture (p) and lateral (q) view (after Deflandre, 1929); r – *C. cassis spinifera* aperture view (after Deflandre, 1929)

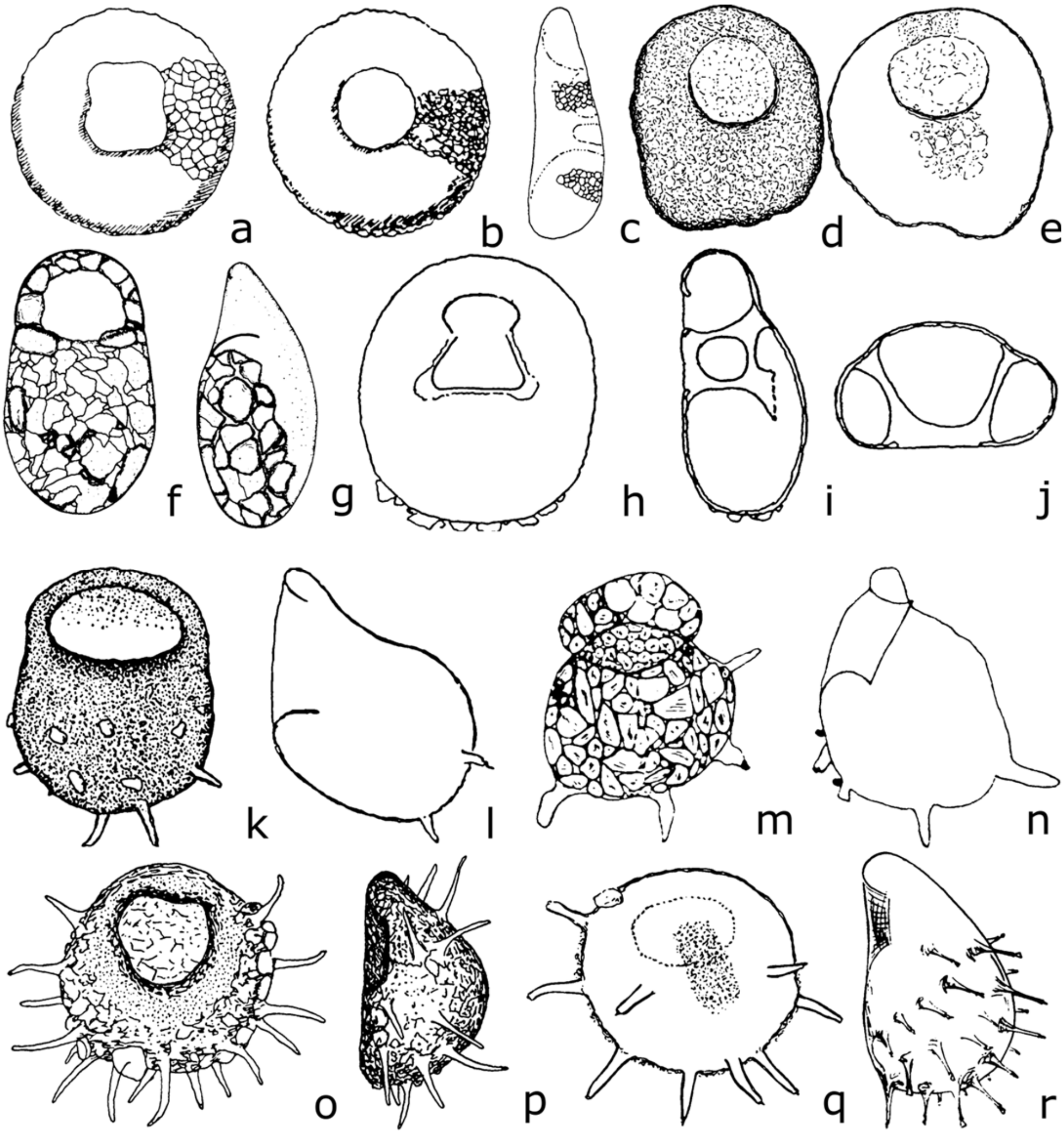

Fig. 13. Genera *Centropyxis* and *Armipyxis*:
a–e – *C. ecornis* apertural (a, b, d, e) and lateral (c) view (a–c after Leidy, 1879; d, e – after Deflandre, 1929); f, g – *C. elongata* aperture (f) and lateral (g) view (after Lüftenegger et al., 1988); h–j – *A. gasparella* aperture (h), lateral (i) and fundus (j) view (after Chardez et al., 1988); k, l – *C. gibba* aperture (k) and lateral (l) view (after Deflandre, 1929); m, n – *C. grelli* aperture (m) and lateral (n) view (after Laminger, 1973); o, p – *C. hemisphaerica* aperture (o) and lateral (p) view (after Wailes, 1913); q, r – *C. hirsuta* aperture (q) and lateral (r) view (q – after Deflandre, 1929; r – after Bartoš, 1954)

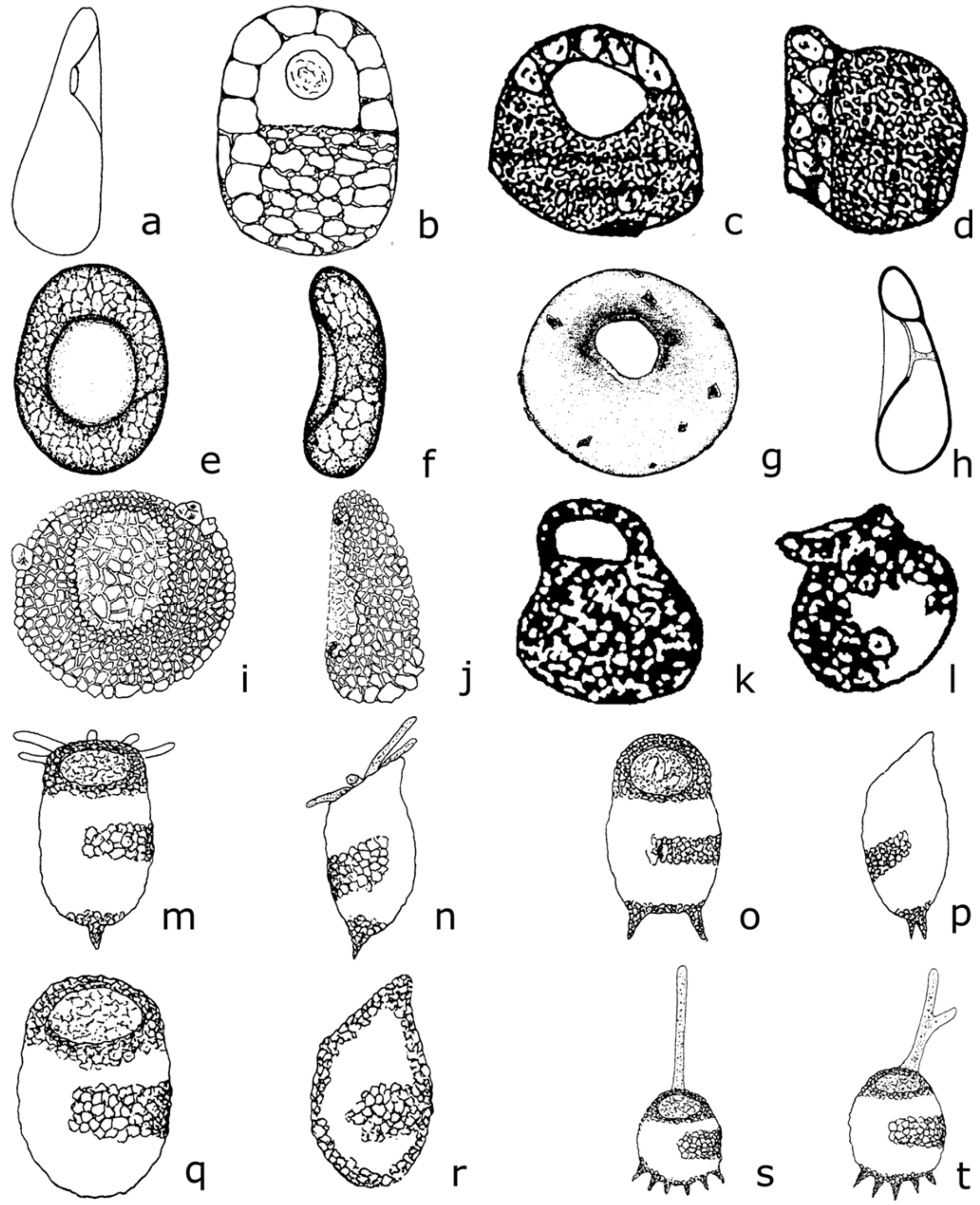

Fig. 14. Genus *Centropyxis*:
a, b – *C. invaginata* lateral (a) and aperture (b) view (after Schönborn, 1966a); c, d – *C. janetscheki* aperture (c) and lateral (d) view (after Laminger, 1971); e, f – *C. kurakchaensis* aperture (e) and lateral (f) view (after Snegovaya, Alekperov, 2005); g, h – *C. laevigata* aperture (g) and lateral (h) view (after Schönborn et al., 1983); i, j – *C. latior* aperture (i) and lateral (j) view (after Bartoš, 1963); k, l – *C. loffleri* aperture (k) and lateral (l) view (after Laminger, 1972); m–r – *C. marsupiformis* aperture (m, o, q) and lateral (n, p, r) view (after Leidy, 1879); s, t – *C. marsupiformis obesa* aperture view (after Leidy, 1879)

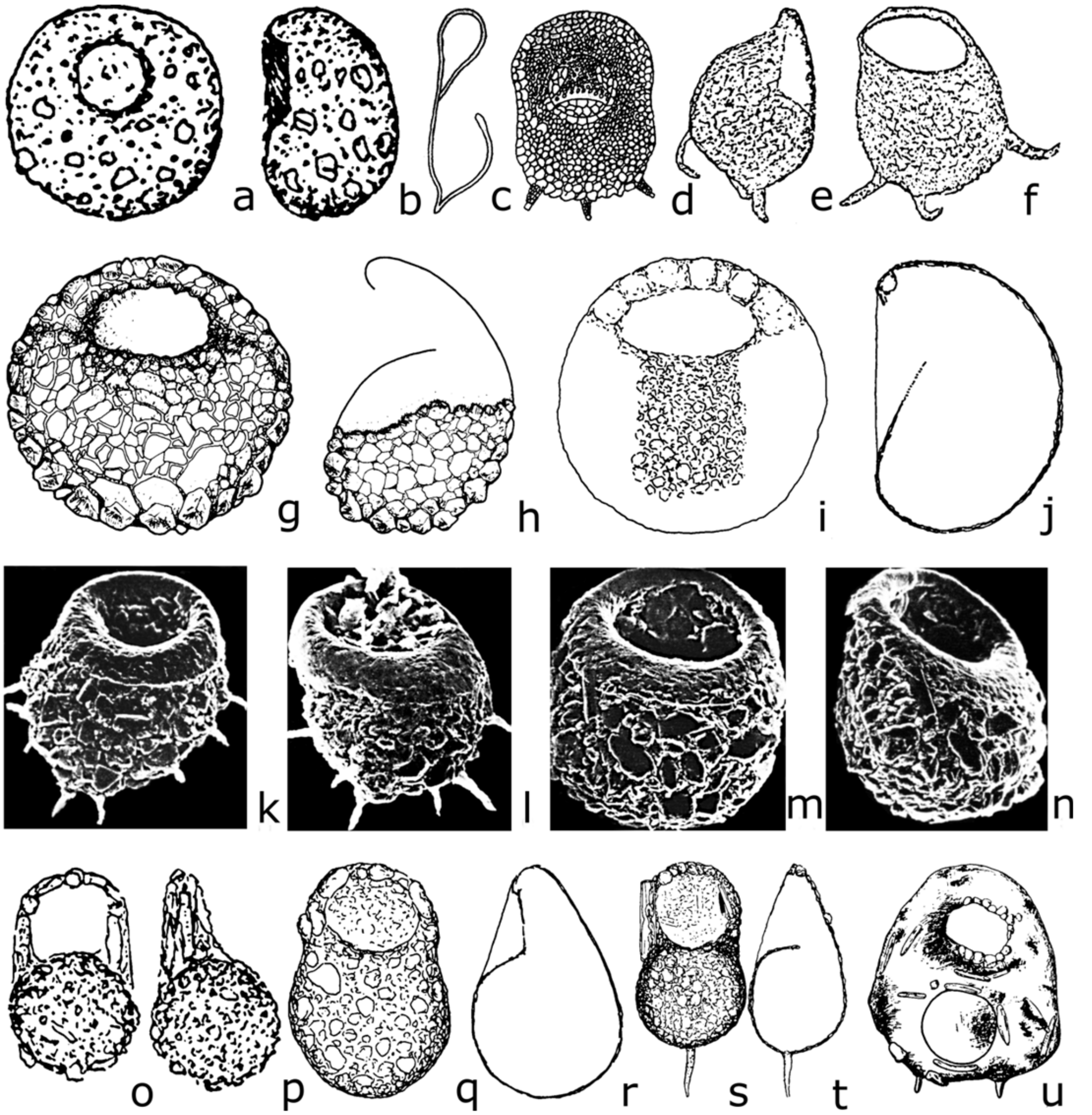

Fig. 15. Genera *Centropyxis* and *Armipyxis*:
a, b – *C. minuta* aperture (a) and lateral (b) view (after Deflandre, 1929); c, d – *A. mirabilis* lateral (c) and aperture (d) view (after Bartoš, 1940); e, f – *C. notonyx* lateral (e) and aperture (f) view (after Jung, 1942); g–j – *C. orbicularis* aperture (g, h) and lateral (h, j) view (g, h – after Lüftenegger et al., 1988; i, j – after Deflandre, 1929); k, l – *C. percolabiensis* aperture (k) and ventral-lateral (l) view (after Dekhtiar, 1994); m, n – *C. percolabiensis inermis* aperture (m) and ventral-lateral (n) view (after Dekhtiar, 1994); o–r – *C. platystoma* aperture (o, q) and lateral (p, r) view (o, p – after Leidy, 1879; q, r – after Deflandre, 1929); s–t – *C. platystoma armata* aperture (s) and lateral (t) view (after Deflandre, 1929); u – *C. pytiformis* aperture view (after Oye, 1958)

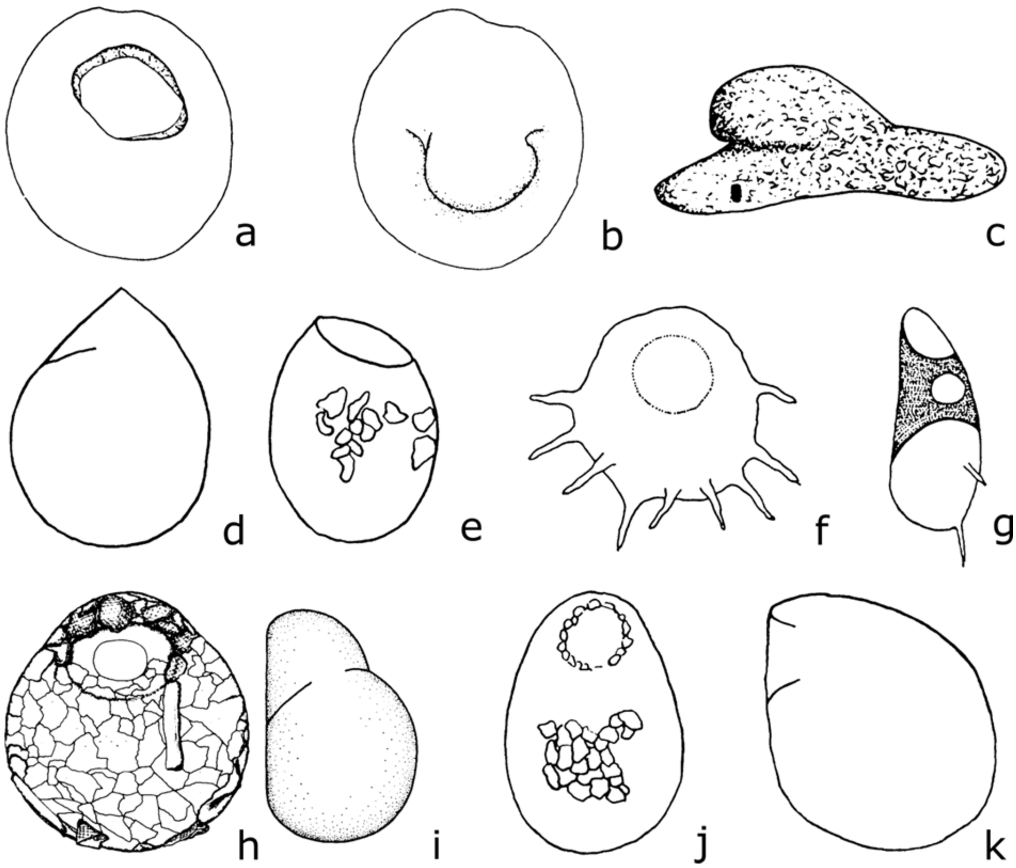

Fig. 16. Genus *Centropyxis*:
a–c – *C. recurvata* aperture (a), dorsal (b) and lateral (c) view (after Vucetich, 1976); d, e – *C. sacciformis* lateral (d) and aperture (e) view (after Décloître, 1954); f, g – *C. spinosa* aperture (f) and lateral (g) view (after Deflandre, 1929); h, i – *C. sylvatica* aperture (h) and lateral (i) view (after Lüftenegger et al., 1988); j, k – *C villiersi* aperture (j) and lateral (k) view (after Décloître, 1954)

Genus *Proplagiopyxis* Schönborn, 1964

Shell is ovoid in frontal view, hemispheric with a slight slope to the aperture in lateral view, brown, xenosomes lacking or rare. Aperture is eccentric, circular, no invagination. Ecology: soil. Monospecific. Type species: *Proplagiopyxis nuda* Schönborn, 1964 (fig. 17).

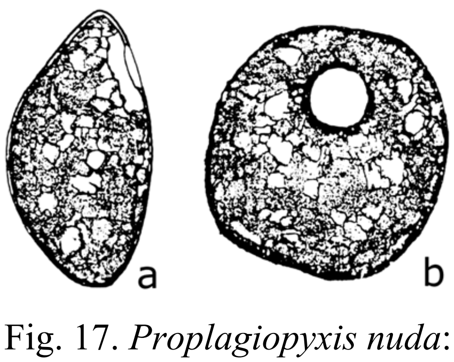

Fig. 17. *Proplagiopyxis nuda*:
a – lateral view; b – aperture view (after Schönborn, 1964)

Family Cryptodifflugiidae Jung, 1942

Shell is hyaline, surface organic or with attached mineral particles. Aperture is terminal or eccentric.

Key to the genera of the family

1. Shell is radially symmetrical, aperture is terminal.. **Genus *Cryptodifflugia***

1'. Shell is bilaterally symmetrical 2

2. Aperture is situated on a well-developed or poorly expressed neck inclined ventrally ....**Genus *Meisterfeldia***

2'. Aperture is a simple perforation in the shell.... **Genus *Wailesella***

Genus *Cryptodifflugia* Penard, 1890

Shell is oval, egg-shaped, pyriform with a short neck, circular or oval cross-section, with adhering foreign particles or smooth surface, colorless, yellow or brown, composed of an outer proteinaceous material usually lined, aperture terminal, circular or oval. Shell walls of some species with two distinct layers: outer surface is think organic, inner layer thick from calcified material (Hedley et al., 1977). Genus *Difflugiella* (Cash, 1904) is now considered to by a synonym of *Criptodifflugia* (Page, 1966). Ecology: freshwater, moss, soil. Type species: *Cryptodifflugia oviformis* Penard, 1890 (fig. 18–24).

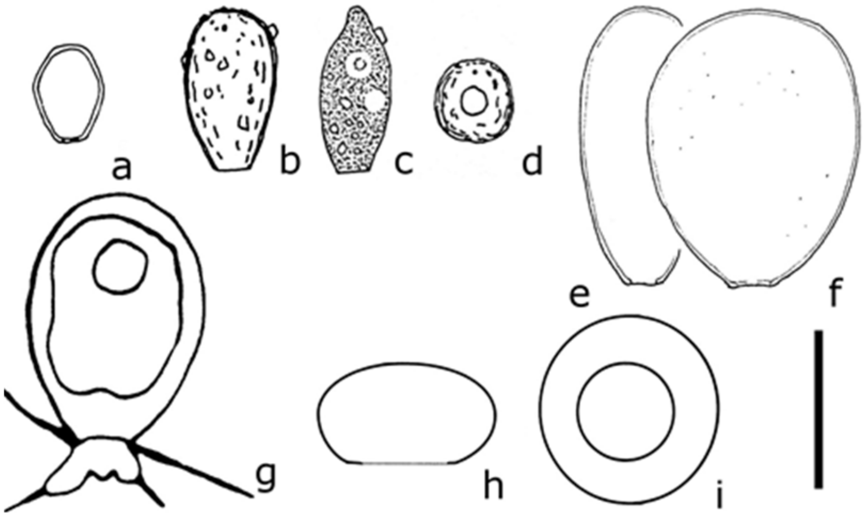

Fig. 18. Genus *Cryptodifflugia*:
a – *C. angulata* lateral view (after Playfair, 1917); b–d – *C. angusta* lateral view (b, c), apertural view (d) (after Schönborn, 1965a); e–f – *C. angustatostoma* narrow side lateral view (e), broad side lateral view (f) (after Beyens, Chardez, 1982); g – *C. apiculata* lateral view, living specimen with cytoplasm (after Cash, 1904); h–i – *C. bassini* lateral view (h), apertural view (i) (after Bobrov, 2001). Scale bar 20 μm

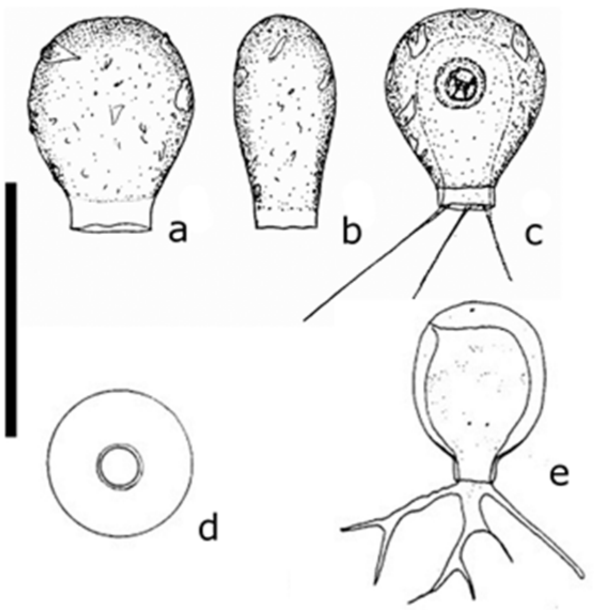

Fig. 19. Genus *Cryptodifflugia*:
a–c – *C. brevicolla* broad side lateral view (a), narrow side lateral view (b), living specimen with cytoplasm (c) (after Golemansky, 1979); d–e – *C. collum* apertural view (d), lateral view of living specimen with cytoplasm (e) (after Chardez, 1971). Scale bar 20 µm

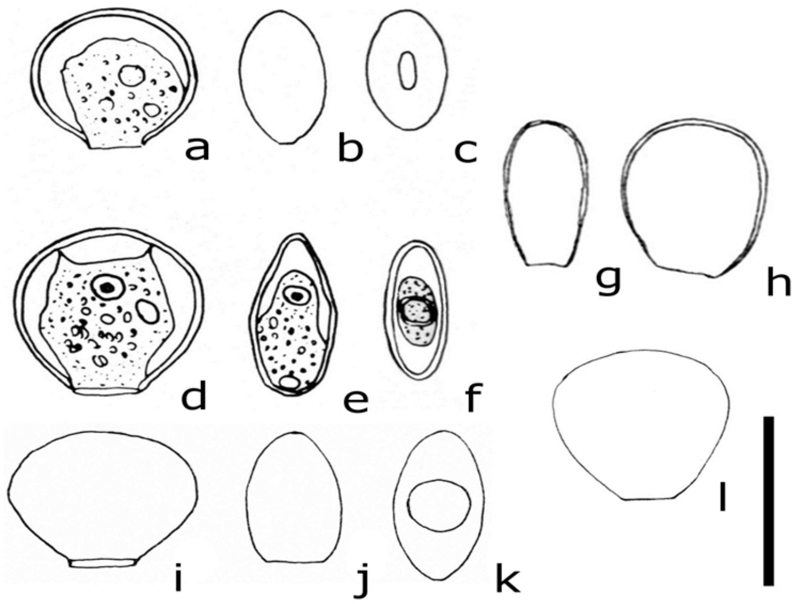

Fig. 20. Genus *Cryptodifflugia*:
a–f – *C. compressa* broad side lateral view (a, d), narrow side lateral view (b, e), apertural view (c, f) (after Penard, 1902); g–h – *C. compressa angustioris* narrow side lateral view (g), broad side lateral view (h) (after Tarnogradsky, 1959); i–k – *C. compressa australis* broad side lateral view (i), narrow side lateral view (j), apertural view (k) (after Palyfair, 1918); l – *C. compressa ovata* lateral view (after Palyfair, 1918). Scale bar 20 µm

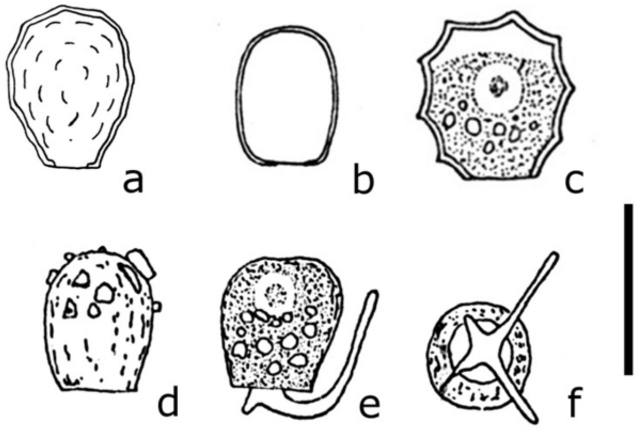

Fig. 21. Genus *Cryptodifflugia*:
a – *C. crenulata* lateral view (after Palyfair, 1918); b – *C. crenulata glabra* lateral view (after Palyfair, 1918); c – *C. crenulata globosa* lateral view (after Palyfair, 1918); d–f – *C. horrida* lateral view of empty shell (d), lateral view of living cell (e), apertural view of living cell (f) (after Schönborn, 1965a). Scale bar 20 μm

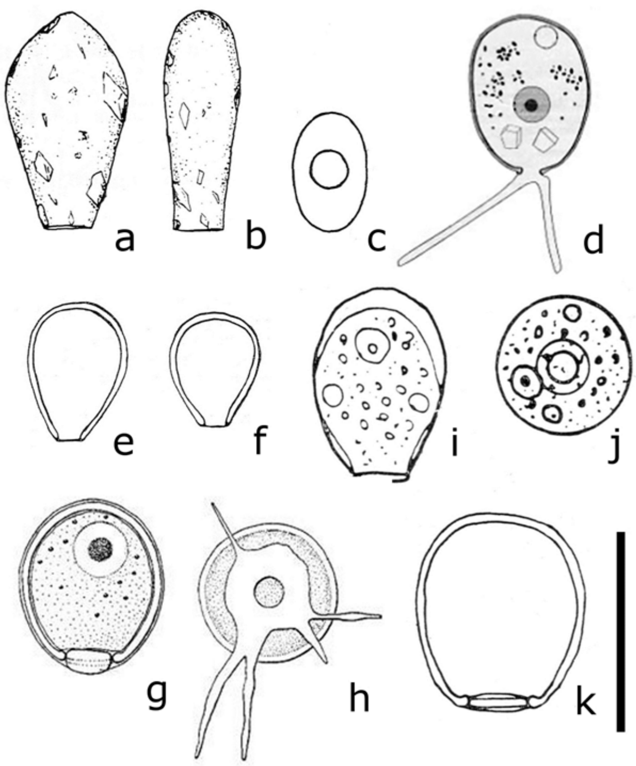

Fig. 22. Genus *Cryptodifflugia*:
a–c – *C. lanceolata* broad side lateral view (a), narrow side lateral view (b), apertural view (c) (after Golemansky, 1970a); d – *C. leachi* lateral view of living cell (after Nicholls, 2006a); e–f – *C. minuta* lateral view (after Palyfair, 1918); g–k *C. oviformis* lateral view of encysted specimen (g), lateral view (i), apertural view (h, j), lateral view of encysted specimen (k) (g–h – after Page, 1966, i–k – after Penard, 1890). Scale bar 20 μm

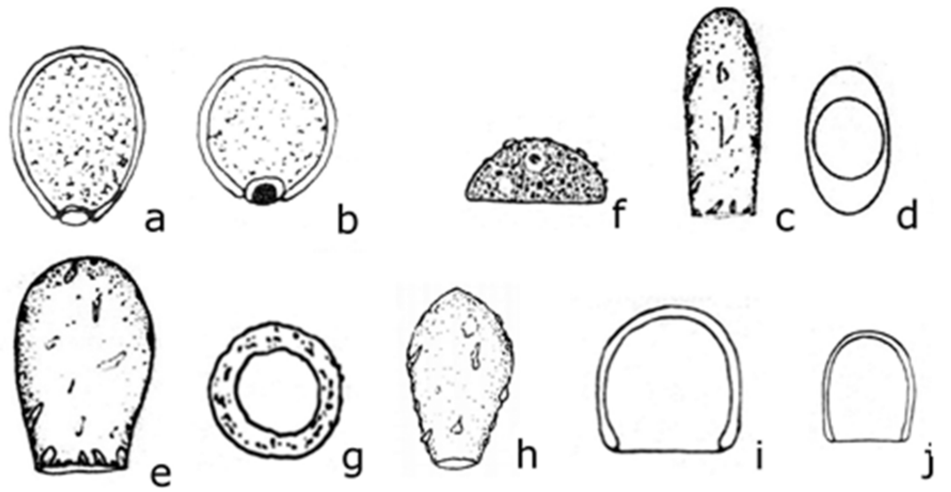

Fig. 23. Genus *Cryptodifflugia*:
a–b – *C. oviformis fusca* lateral view of different specimens (after Penard, 1890); c–e – *C. paludosa* narrow side lateral view (c), apertural view (d), broad side lateral view (e) (after Golemansky, 1981); f–g – *C. patinata* lateral view (f), apertural view (g) (after Schönborn, 1965a); h – *C. psammophila* lateral view (after Golemansky, 1970a); i – *C. pusilla* lateral view (after Palyfair, 1917); j – *C. pusilla* var. *conica* lateral view (after Palyfair, 1917). Scale bar 20 μm

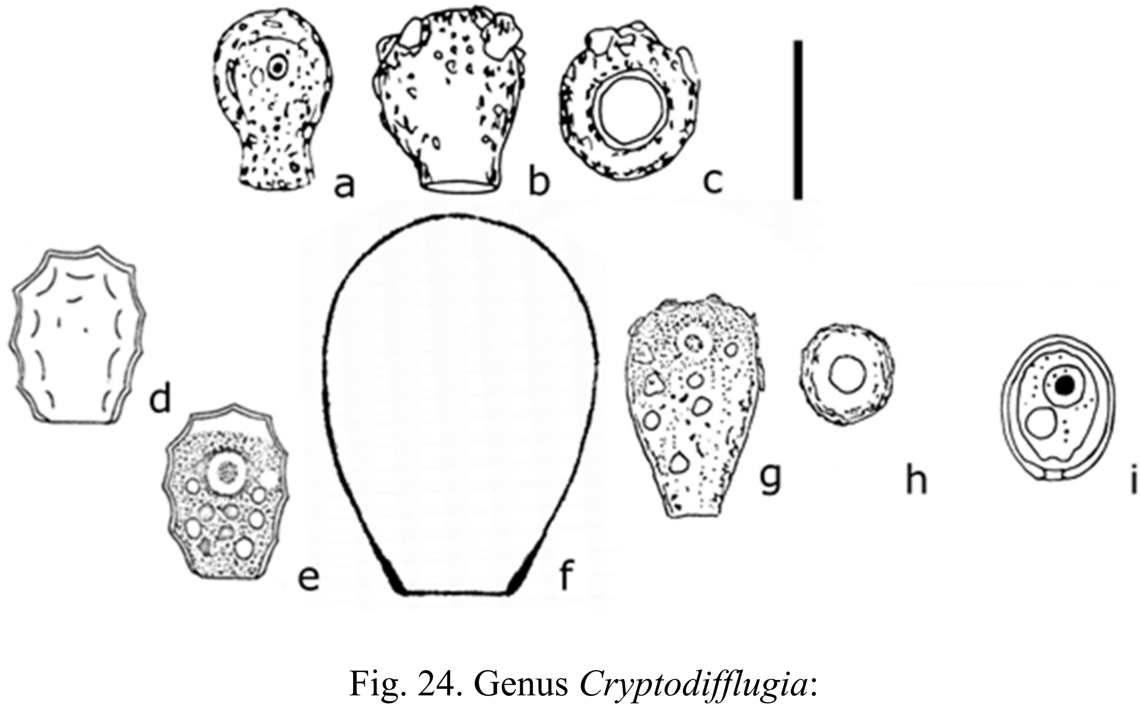

Fig. 24. Genus *Cryptodifflugia*:
a – *C. sacculus* lateral view (after Penard, 1902); b–c – *C. sacculus sakotschawi* lateral view (b), apertural view (c) (after Tarnogradsky, 1959); d–e – *C. splendida* lateral view of different specimens (after Schönborn, 1965a); f – *C. valida* lateral view (after Penard, 1902); g–h – *C. voigti* lateral view (g), apertural view (h) (after Schmidt, 1926); i – *C. vulgaris* lateral view (after Francé, 1913). Scale bar 20 μm

Genus *Meisterfeldia* Bobrov, 2016

Shell is ovoid, more or less laterally compressed; colorless, yellow or brown, composed of proteinaceous material without mineral particles. Aperture circular, subterminal, placed on ventrally and obliquely cut apertural end, or it is situated on a well developed or poorly expressed neck inclined ventrally; sometimes aperture border shows a slight swelling. Ecology: wet mosses, *Sphagnum* mosses, litter, soil. Type species: *Meisterfeldia chibisovi* Bobrov, 2016 (fig. 25).

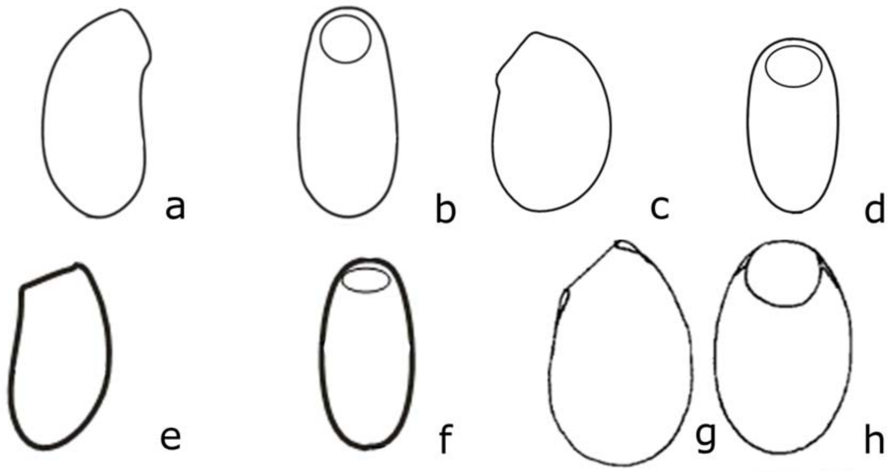

Fig. 25. Genus *Meisterfieldia*:
a, b – *M. chibisovi* lateral (a) and ventral (b) view (after Bobrov, 2016); c, d – *M. wegeneri* lateral (c) and ventral (d) view (after Bobrov, 2016); e, f – *M. polygonia* lateral (e) and ventral (f) view (after Bobrov, 2016); g, h – *M. vanhoornei* lateral (g) and vebtral (h) view (after Beyens et al., 1986)

Genus *Wailesella* Deflandre, 1928

Shell is ovate, chitinoid, in lateral view truncated in the area of aperture; brown or yellow-brown. Aperture is subterminal, circular. Ecology: dry mosses, litter, soil. Monospecific. Type species: *Wailesella eboracensis* Wailes, 1911 (fig. 26).

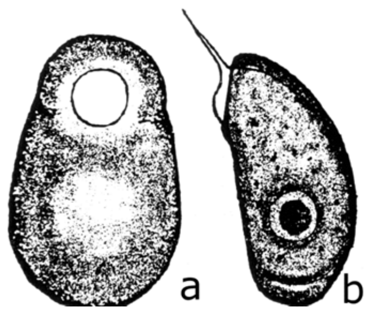

Fig. 26. *Wailesella eboracensis*:
a – apertural view; b – lateral view (after Deflandre, 1928b)

Family Distomatopyxidae Bonnet, 1970

Shell is circular or ovoid in frontal view, hemispheric in lateral view. Aperture is central, elliptical, invaginated and lying at the bottom of a tubular vestibule. The vestibule is partly covered by a diaphragm which is fixed by two bridges forming two crescent-shaped openings at opposite sites. Shell is covered with xenosomes.

Genus *Distomatopyxis* Bonnet, 1964

Shell morphology with characters of the family; covered by mineral particles in an organic cement, smooth surface. Ecology: soils. Type species: *Distomatopyxis couillardi* Bonnet, 1964 (fig. 27).

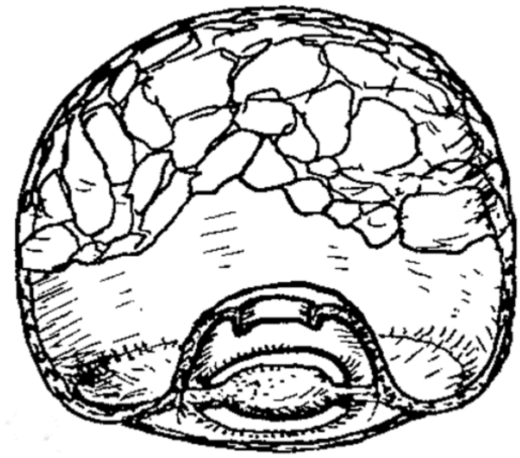

Fig. 27. *Distomatopyxis couillardi*, lateral view
(after Bonnet, 1964)

Family Hyalospheniidae Schultze, 1877, emend. Kosakyan et Lara, 2012

Shell is rigid, colourless or yellowish-brown, flask-vase shaped, oval or pyriform (can be circular or elongated), generally compressed, rarely circular in cross section (e.g. *Longinebela golemanski, Padaungiella nebeloides*). The shell is either entirely self-secreted composed of an organic matrix, or with addition of self-secreted siliceous plates or recycled shell plates of euglyphids, *Quadrulella* or other similar material such as diatom frustules incorporated in the shell. Aperture is terminal and is bordered by a more or less thin organic lip (rim, collar or fringe). Currently, family includes thirteen genera.

Key to the genera of the family

1. Shell is pyriform, with a lateral indentation of both sides in the junction of the main body to the neck (note: neck is not deeply constricted as in genus *Apodera*), shell often organic, hyaline, but sometimes with a rough granulated structure (visible by SEM) or with probably collected euglyphid plates .... **Genus *Alocodera***

1'. Shell is without lateral indentation 2

2. Shell is totally transparent, completely organic without structure, wedge-shaped some species are oval or flask shaped with a more or less long neck .... **Genus *Hyalosphenia***

2'. Shell is composed of different material 3

3. Shell is entirely composed of square plates 4

3'. Shell is composed either of usually oval to circular, rarely square recycled shell plates of small euglyphids (or *Quadrulella* in the case of square plates) or other similar material such as diatom frustules incorporated in the shell (plates sometimes covered by very thick organic layer giving the impression of a chitinoid, clear, organic and non structured shell) or composed of agglutinated particles 5

4. Hollow (not flat short keel as in *Quadrulella alata*) lateral keel is present (note: the origin of square plates is questionable)........................ .... **Genus *Mrabella***

4'. Hollow lateral keel is absent (square plates are self secreted)....... .... **Genus *Quadrulella***

5. Shell is pyriform or flask shaped, composed of euglyphid idiosomes embedded in an unstructured organic cement, or often covered with a thick layer of organic cement giving the shell a smooth appearance. In the broad view two large (2–5µm) and conspicuous pores in depressions connected by internal tubes situated at the base of the neck 6

5'. Shell is lacking pores in depressions connected by internal tube. Shell composed of siliceous plates or diatom frustules, sometimes covered with a thick organic layer giving the impression that the shell is entirely self-secreted organic, hyalinous and non-structured, or composed of agglutinated particles (unique case of *Padaungiella nebeloides*) 7

6. Shell is flask-shaped, often with an elongated neck. Internal side of the neck with conical protuberances visible perpendicular to the shell surface and pointing inwards, visible in light microscope as lines of points ....**Genus *Certesella***

6'. Shell with similar shape (or more pyriform), lacking pointed protuberances in the internal side of the neck .... **Genus *Porosia***

7. Shell is bottle-shaped; neck elongated, with parallel sides or swollen and always very distinct 8

7'. Shell is flask-shaped, pyriform or oval-elongated, neck either absent, short or if long tapering toward the aperture and never clearly separated from the base of the shell.. 9

8. Neck is deeply constricted at the junction with the main body of the shell ....**Genus *Apodera***

8'. No constriction at the base of the neck ....**Genus *Padaungiella***

9. Shell with pair of lateral conical expansions (horns, that can be external, or internal connected with each other with complete or partial horseshoe-like keel) protruding on either side.............. **Genus *Cornutheca***

9'. The lateral horns are absent 10

10. Shell is pyriform or rounded-pyriform (generally the length of the shell is < 140 μm)... **Genus *Nebela***

10'. Shell is elongated pyriform or oval-elongated, lateral sides tapering toward the aperture (generally the length of the shell is > 140 um, with exception of *Gibbocarina gracilis* (L = 90–130 μm) 11

11. Shell with lateral keel.. 12

11'. Lateral keel is absent ....**Genus *Longinebela***

12. Lateral keel is flat.. **Genus *Planocarina***

12'. Lateral keel is hollow.................................**Genus *Gibbocarina***

Genus *Alocodera* Jung, 1942

Shell is pyriform, compressed in cross section, with a well-developed neck separated from the posterior part of the shell by two lateral indentations. Two lateral pores are situated in the indentations. Shell very transparent, yellowish, smooth, covered by small xenosomes. Aperture is arched in the narrow lateral view, surrounded by a thickened rim. Ecology: mosses. Monospecific. Type species: *Alocodera cockayni* (Penard, 1902) (fig. 28).

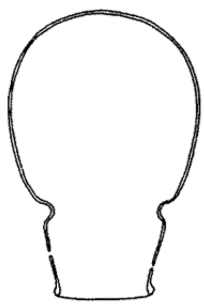

Fig. 28. *Alocodera cockayni*:
broad lateral view (after Deflandre, 1936)

Genus *Apodera* Loeblich et Tappan, 1961

Shell is subspherical or ellipsoidal, compressed in cross section, with a distinct neck separated from the rest of the shell by constriction. The neck tapers from the body towards the aperture. The whole shell is covered by is circular and oval plates of scales, distributed more or less regularly. Aperture is terminal, oval, slightly arched, surrounded by an organic rim. Ecology: mosses, organic soils. Type species: *Apodera vas* Certes, 1889 (fig. 29).

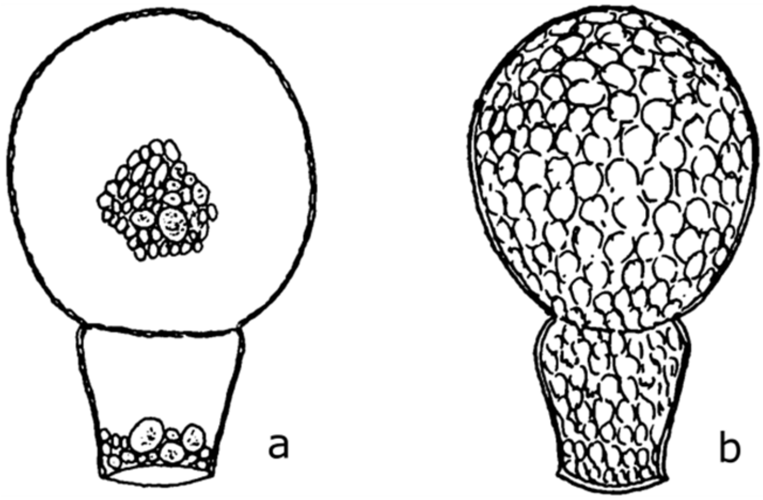

Fig. 29. *Apodera vas*:
a, b – lateral view (a – after Certes, 1889; b – after Penard, 1911)

Genus *Certesella* Loeblich et Tappan, 1961

Shell is pyriform elongated or flask-shaped, compressed in cross section, neck with parallel sides, organic apertural rim. The development of the neck varies among species from slightly to well differentiated. The main characteristics of the genus are the presence of two lateral depressions with large central pores connected by two tubes located at approximately 2/3 of the distance between the fundus of the shell and the aperture, and the presence of internal teeth on the neck giving punctuated impression. Shell composed of collected euglyphid idiosomes in an unstructured cement, transparent. Type species: *Certesella martiali* (Certes, 1889) (fig. 30).

Genus *Cornutheca* Kosakyan et al., 2016

Shell is elongated-pyriform, with a distinct neck, lateral margins tapering towards the aperture. Two lateral horns, pointing towards the posterior part of the shell, either free or connected to the main part of the shell by a lateral keel surrounding the posterior part of the shell. Shell hyaline or slightly yellowish, composed of circular to elongated shell plates probably recycled from euglyphid testate amoeba prey. Members of this genus differ from other hyalospheniid genera in the presence of two lateral horns. Type species: *Cornutheca ansata* (Leidy, 1879) (fig. 31).

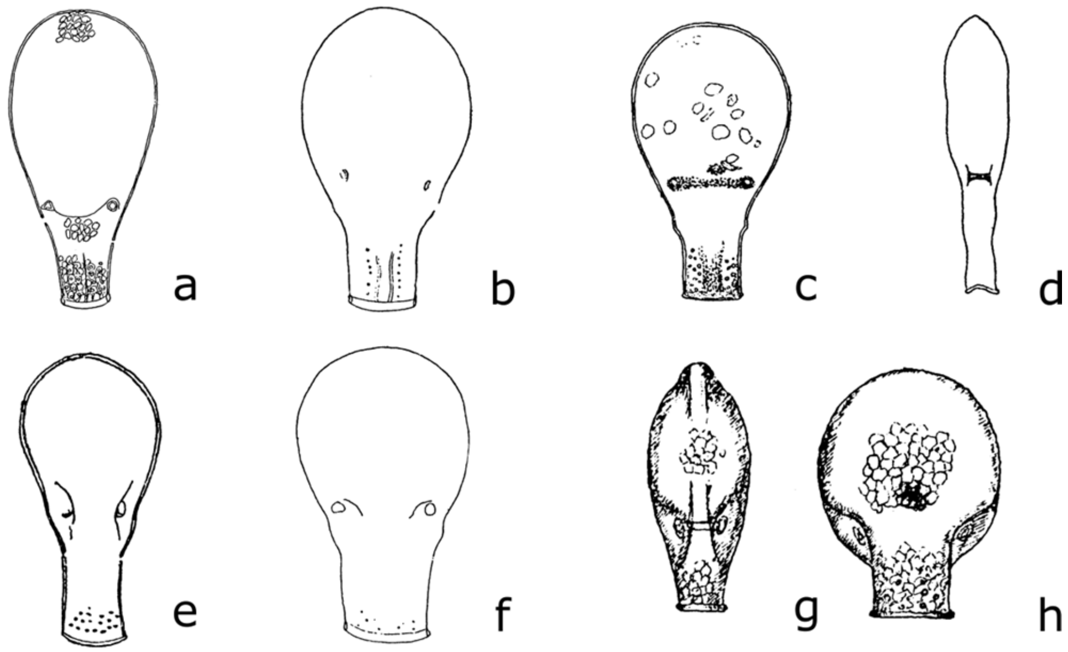

Fig. 30. Genus *Certesella*:
a, b – *C. certesi* lateral view (a – after Certes, 1889; b – after Deflandre, 1936); c–f – *C. martiali* broad (c, e, f) and narrow (d) lateral view (c – after Certes, 1889; d, e – after Penard, 1911; f – after Deflandre, 1936); g, h – *C. murrayi* broad (h) and narrow (g) lateral view (after Wailes, 1913)

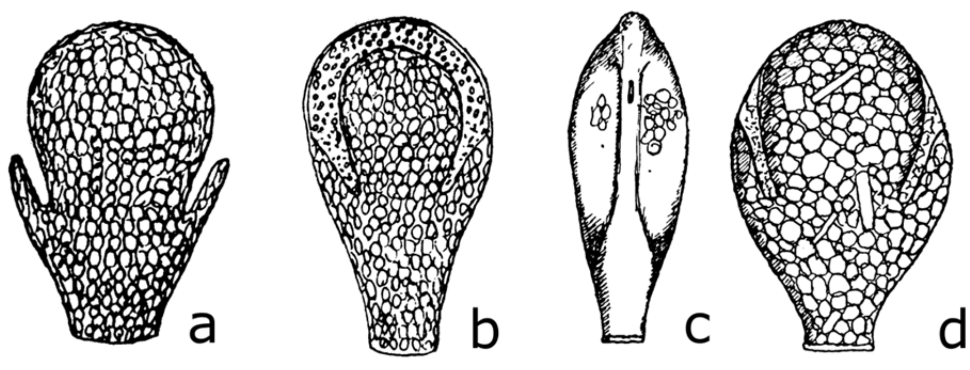

Fig. 31. Genus *Cornutheca*:
a – *C. ansata* lateral view (after Leidy, 1879); b – *C. equicalceus* lateral view (after Leidy, 1879); c, d – *C. saccifera* broad (d) and narrow (c) lateral view (after Wailes, 1913)

Genus *Gibbocarina* Kosakyan et al., 2016

Shell is elongated-pyriform, with the lateral sides tapering towards the aperture, with a hollow tuberous keel surrounding the entire posterior end of the shell. Shell hyaline or slightly yellowish, composed of circular to elongated shell plates, probably recycled from euglyphid testate amoeba prey. Members of this genus differ from those in the genus *Nebela* by the strongly elongated shape of the shell, the presence of a hollow keel and in most cases a larger size. From the members *of Longinebela*, they differ mainly by the presence of a keel. *Gibbocarina* may be confused with *Planocarina*, although in the latter the keel is flat, while in *Gibbocarina* it is hollow (the difference is very obvious when seen in profile). Type species: *Gibbocarina galeata* (Penard, 1890) (fig. 32).

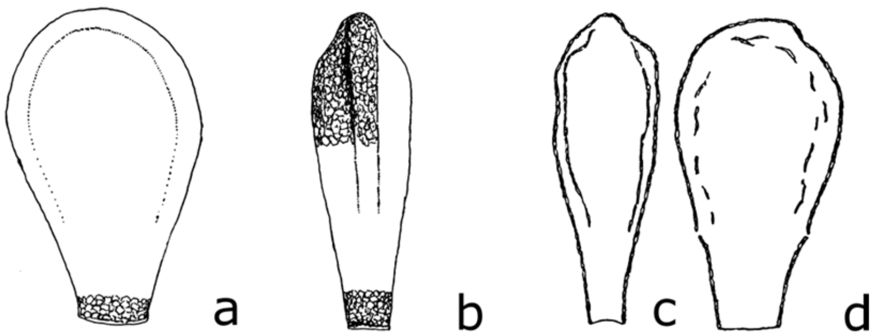

Fig. 32. Genus *Gibbocarina*:
a, b – *G. galeata* broad (a) and narrow (b) lateral view (after Deflandre, 1936);
c, d – *G. gracilis* broad (d) and narrow (c) lateral view (after Deflandre, 1936)

Genus *Hyalosphenia* Stein, 1859

Shell is rounded, ovoid or elongated elliptical or flask shaped, laterally compressed, aperture variable from linear to strongly curved, with or without thickened lip. Shell hyaline or slightly yellowish, with a smooth organic surface (exception: *Hyalosphenia punctata* which has a punctuated surface). Some species contain symbiotic zoochlorellae in cytoplasm. Ecology: freshwater, moss, soils. Type species: *Hyalosphenia ligata* (Tatem, 1870) (fig. 33–34).

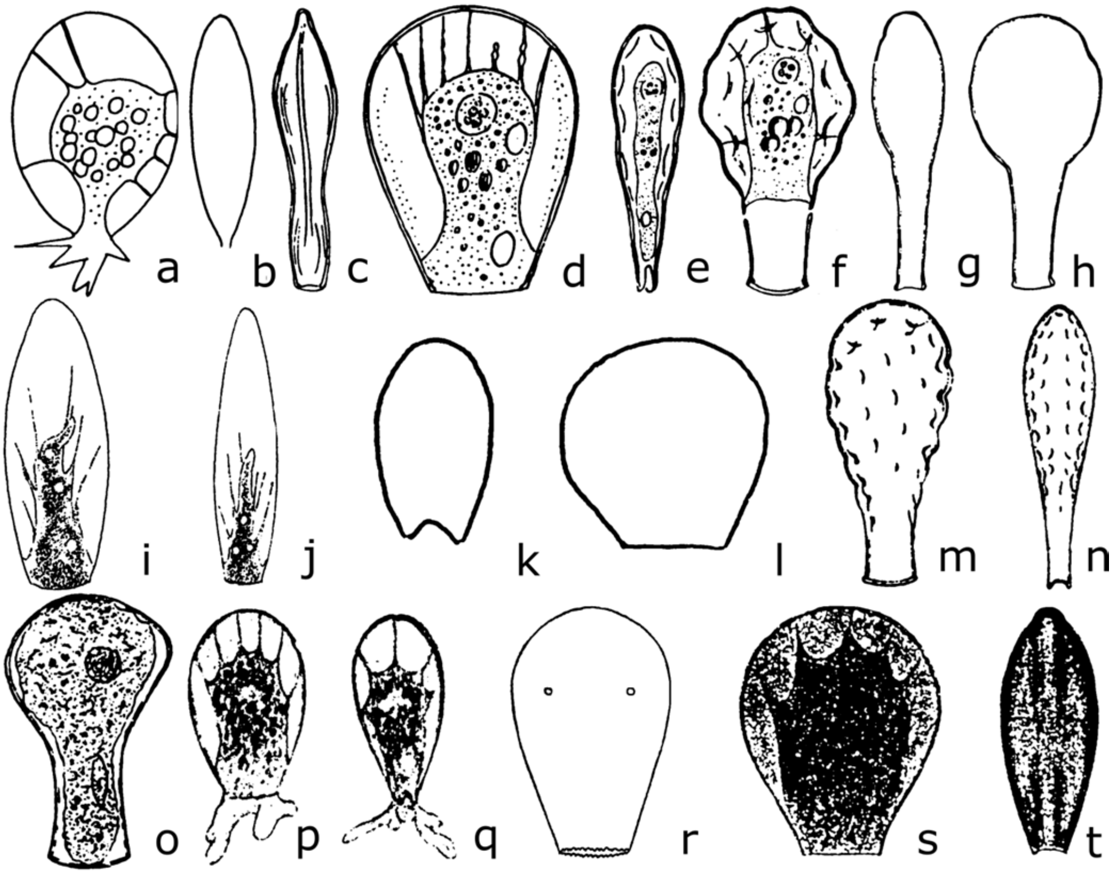

Fig. 33. Genus *Hyalosphenia*:
a, b – *H. angulata* broad (a) and narrow (b) lateral view (after Schouteden, 1905); c, d – *H. cuneata* broad (d) and narrow (c) lateral view (after Penard, 1902); e, f – *H. elegans* broad (f) and narrow (e) lateral view (Penard, 1902); g, h – *H. elegans cylindricollis* broad (h) and narrow (g) lateral view (after Chardez, 1962); i, j – *H. gigantea* broad (i) and narrow (j) lateral view (after Graaf, 1952); k, l – *H. inconspicua* broad (l) and narrow (k) lateral view (after West, 1903); m, n – *H. insecta* broad (m) and narrow (n) lateral view (after Cash, Hopkinson, 1909); o – *H. jirovici* lateral view (after Štěpanėk, 1953); p, q – *H. minuta* broad (p) and narrow (q) lateral view (after Cash, Hopkinson, 1909); r – *H. mraconia* lateral view (after Godeanu, 1972); s, t – *H. ovalis* broad (s) and narrow (t) lateral view (after Cash et al., 1919)

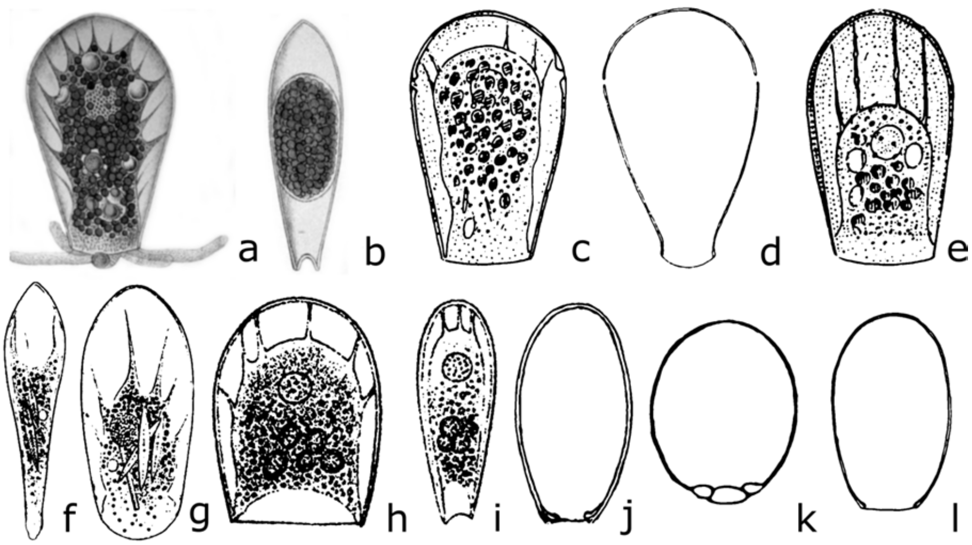

Fig. 34. Genus *Hyalosphenia*:
a–c – *H. papilio* broad (a, c) and narrow (b) lateral view (a, b – after Leidy, 1879; c – after Penard, 1902); d – *H. papilio stenostoma* lateral view (after Deflandre, 1931); e – *H. punctata* lateral view (after Penard, 1902); f, g – *H. penardi* broad (g) and narrow (f) lateral view (after Lauterborn, 1908); h, i – *H. platystoma* broad (h) and narrow (i) lateral view (after Cash, Hopkinson, 1909); j – *H. schoutedeni* lateral view (after Oye, 1926); k – *H. schoutedeni rotundata* lateral view (after Oye, 1958); l – *H. subflava* lateral view (after Bonnet, Thomas, 1960)

Genus *Mrabella* Kosakyan et al., 2016

Shell is elongated-pyriform, laterally compressed, with the lateral sides gradually tapering toward the aperture. Lateral margins distinctly compressed giving the impression of a thick and wide hollow keel. Because of this, the shell is elongated elliptical with the pointed end in the profile. Shell colourless, composed of quadrangular shell plates similar to those in *Quadrulella* species. Type species: *Mrabella subcarinata* (Gauthier-Lièvre, 1957) (fig. 35).

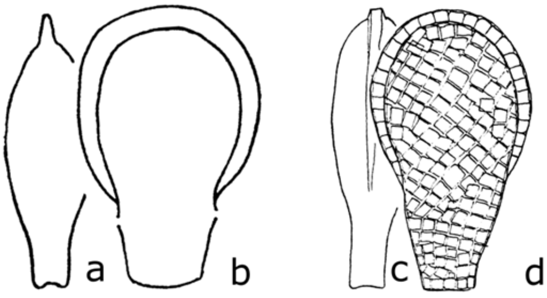

Fig. 35. Genus *Mrabella*:
a, b – *M. plicata* narrow (a) and broad (b) lateral view (after Hoogenraad, de Groot, 1940b); c, d – *M. subcarinata* narrow (c) and broad (d) lateral view (after Gauthier-Lièvre, 1957)

Genus *Nebela* (Leidy, 1874) Kosakyan et al., 2016

Shell is rounded, ovoid-pyriform, or wide-pyriform, rarely with a keel (partial or complete) or other lateral expansions, with or without wavy lateral margins. Aperture is ranging from linear to strongly curved, bordered by a more or less thin organic lip (rim, collar or fringe). Shell is hyaline or slightly yellowish, reinforced with circular to elongated shell plates apparently recycled mostly from euglyphid testate amoeba prey, sometimes also including fragments of diatom frustules or other small mineral elements. Type species: *Nebela collaris* (Ehrenberg, 1848) Leidy, 1879 (fig. 36).

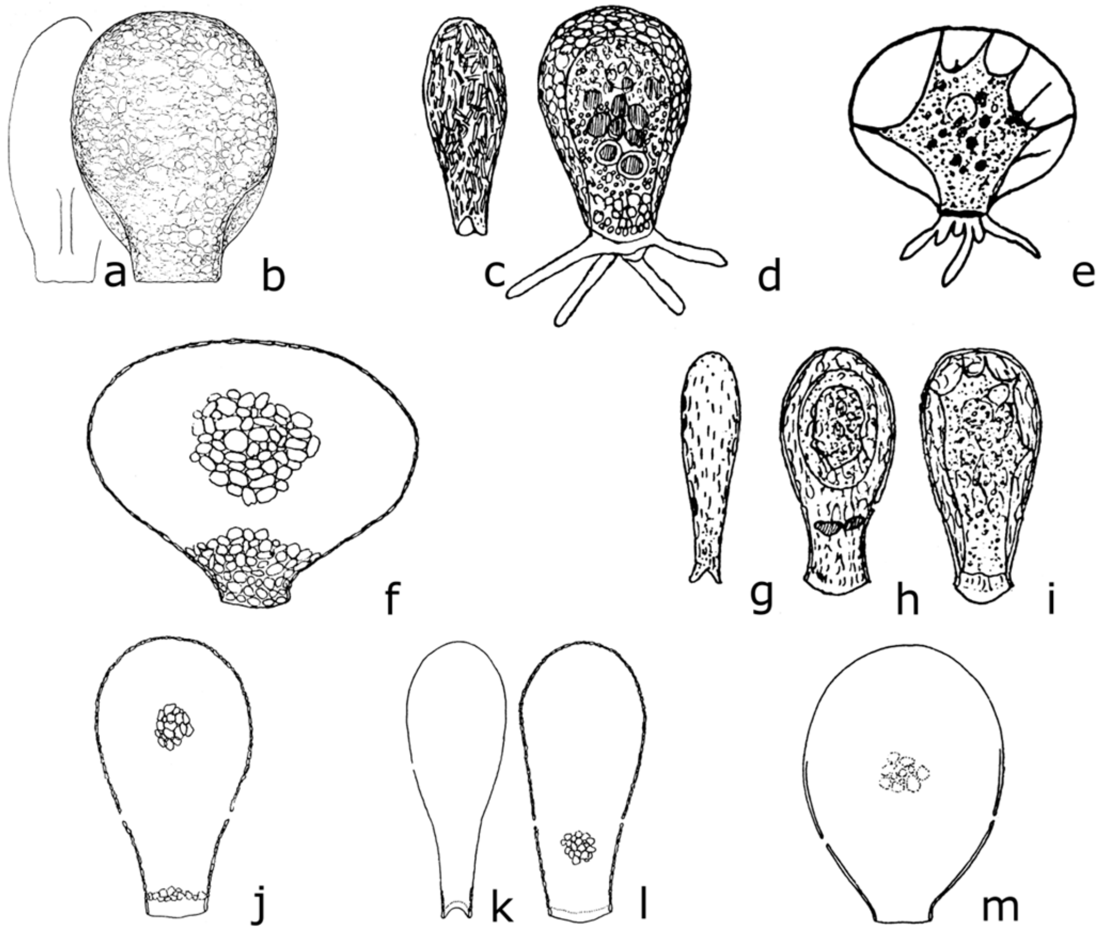

Fig. 36. Genus *Nebela*:
a, b – *N. carinatella* broad (b) and narrow (a) lateral view (after Beyens, Chardez, 1982); c, d – *N. collaris* broad (d) and narrow (c) lateral view (after Penard, 1902); e, f – *N. flabellum* broad lateral view (e – after Cash, Hopkinson, 1909; f – after Deflandre, 1936); g–i – *N. militaris* broad (h, i) and narrow (g) lateral view (after Penard, 1890); j–l – *N. penardiana* broad (j, l) and narrow (k) lateral view (after Deflandre, 1936); m – *N. tincta* lateral view (after Penard, 1890)

Genus *Longinebela* Kosakyan et al., 2016

Shell is elongated-pyriform, with a distinct neck, lateral margins (that can be straight or wavy) tapering towards the aperture. Shell is hyaline or slightly yellowish, composed of circular to elongated shell plates probably recycled from euglyphid testate amoeba prey. Type species: *Longinebela tubulosa* (Penard, 1902) (fig. 37).

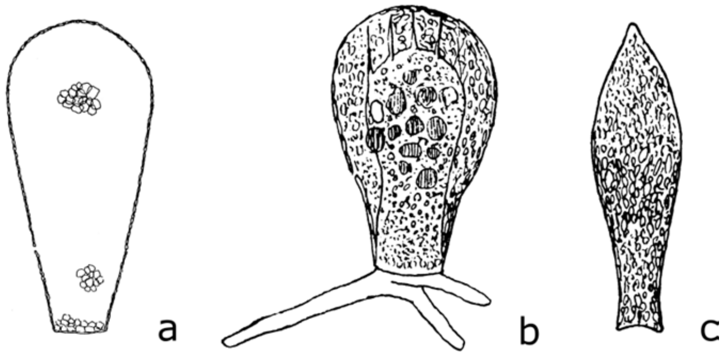

Fig. 37. Genus *Longinebela*:
a – *L. spesiosa* lateral view (after Deflandre, 1936); b, c – *L. tubulosa* broad (b) and narrow (c) lateral view (after Penard, 1902)

Genus *Padaungiella* Lara et Todorov, 2012

Shell is bottle-shaped, compressed, with a distinct elongated. Shell is covered by idiosomes of testate amoeba prey, various forms, randomly located. Aperture is elliptic or oval, surrounded by organic rim or straight cut. Ecology: freshwater, mosses. Type species: *Padaungiella lageniformis* (Penard, 1890) (fig. 38).

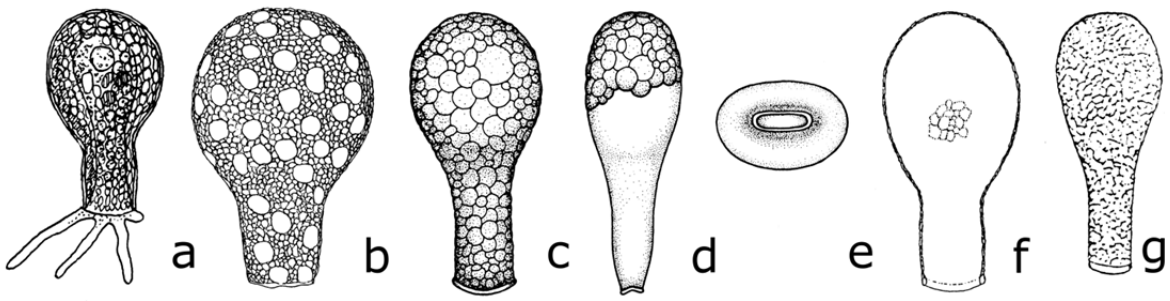

Fig. 38. Genus *Padaungiella*:
a ,b – *P. lageniformis* lateral view (a – after Penard, 1902; b – after Deflandre, 1936); c–e – *P. tubulata* broad (c), narrow (d) lateral and aperture (e) view (after Lüftenegger, Fiossner, 1991); f – *P. wailesi* lateral view (after Deflandre, 1936); g – *P. wetekampi* lateral view (after Jung, 1942)

Genus *Planocarina* Kosakyan et al., 2016

Shell is elongated-pyriform, with a distinct neck, lateral margins tapering towards the aperture. A flat keel surrounds the entire posterior part of the shell. Shell is hyaline or slightly yellowish, composed of circular to elongated shell plates probably recycled from euglyphid testate amoeba prey. Type species: *Planocarina carinata* (Archer, 1867) (fig. 39).

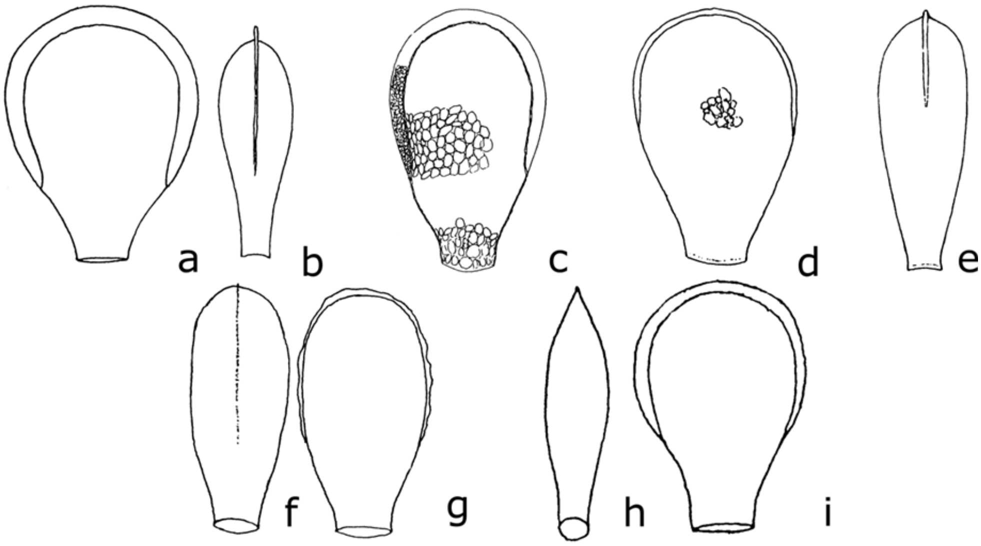

Fig. 39. Genus *Planocarina*:
a–c – *P. carinata* broad (a, c) and narrow (b) lateral view (a, b – after Cash, Hopkinson, 1909; c – after Deflandre, 1936); d, e – *P. marginata* broad (d) and narrow (e) lateral view (after Deflandre, 1936); f, g – *P. maxima* broad (g) and narrow (f) lateral view (after Awerintzew, 1907); h, i – *P. spumosa* broad (i) and narrow (h) lateral view (after Awerintzew, 1907)

Genus *Porosia* (Jung, 1942) Bobrov et Kosakyan, 2015

Shell is pyriform, with rounded posterior end, laterally compressed. In front view two distinct lateral depressions with two large invaginated pores are situated on each side, which are connected by internal tubes as in genus *Certesella*. In profile, small lateral pores can be observed, just anterior to the large pores. The lateral keel can (or cannot) be present surrounding 1/3 of posterior lateral margin (keel is important distinctive character between *Porosia* species: *Porosia bigibbosa* – lacking of lateral keel, *Porosia paracarinata* – presence of lateral keel). Shell is composed of euglyphid shell plates embedded in unstructured cement. Aperture is curved, surrounded with organic lip. Habitat: *Sphagnum* mosses, litter, soil, rare genus. This genus is closely related to *Certesella* but lacks the punctuated neck. Type species: *Porosia bigibbosa* Jung, 1942 (fig. 40).

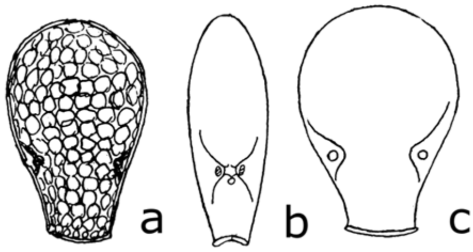

Fig. 40. *Porosia bigibossa*:
a–c – broad (a, c) and narrow (b) lateral view (a – after Penard, 1890; b, c – after Wailes, Penard, 1911)

Genus *Quadrulella* (Cockerell, 1909) Kosakyan et al., 2016

Shell is pyriform, or elongated pyriform, with the lateral sides tapering towards the aperture, with or without distinct neck. Always laterally compressed, elliptical in cross section. Aperture ranging from linear to strongly curved, with or without thickened organic lip. Shell is hyaline, composed of self-secreted square plates. *Quadrulella* differs from *Nebela* and *Hyalosphenia* by the use of square, siliceous self-secreted plates in the construction of the shell. It may be confused with *Mrabella*, which has similar shell shape and square plates. The most distinctive characteristic is the presence of a lateral pronounced hollow keel in the genus *Mrabella* (although *Q. alata* also exhibits a lateral keel, we consider it to be flat and not hollow, even if this detail is not mentioned in the original description of the species), and the fact that square plates of *Quadrulella* are self-secreted, while the origin of square plates of *Mrabella* is unclear. Type species: *Quadrulella symmetrica* (Wallich, 1864) Cockerell, 1909 (fig. 41).

Family Lamtopyxidae Bonnet, 1974

Shell is circular in frontal view; ventral surface is flat, dorsal surface is hemispheric. External aperture is bordered by large teeth, internal opening at the end of deeply invaginated tube, elliptic. Shell is covered with xenosomes.

Genus *Lamtopyxis* Bonnet, 1974

External opening with three to five teeth. The base of apertural tube is reinforced by a more or less quadratic organic frame; the internal opening is bordered by a collar. Shell is composed of flat mineral particles which are held together by unstructured organic cement giving the shell a smooth surface. Ecology: tropical forest soils. Type species: *Lamtopyxis callistoma* Bonnet, 1974 (fig. 42).

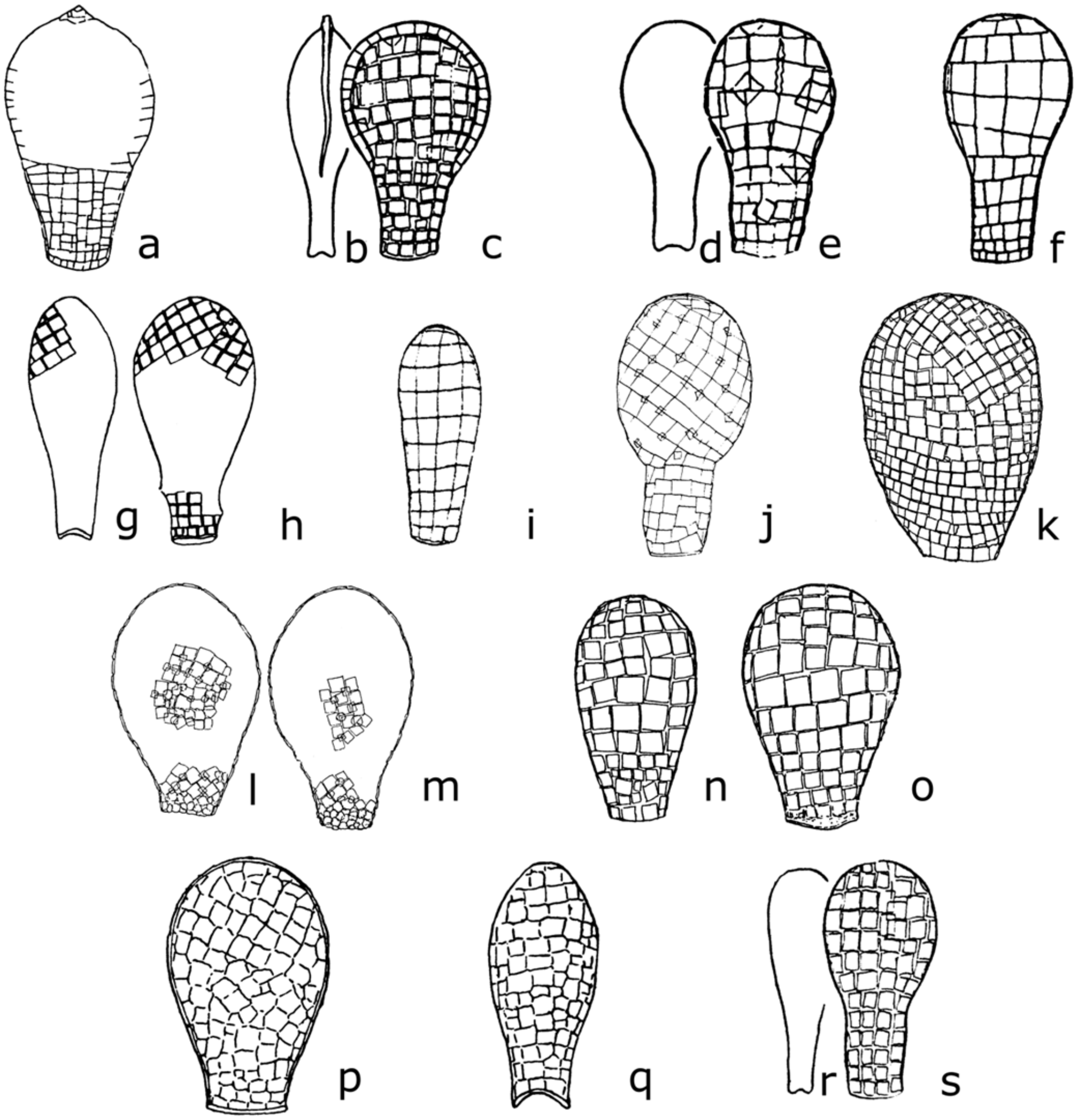

Fig. 41. Genus *Quadrulella*:
a – *Q. acuminata* lateral view (after Oye, 1958); b, c – *Q. alata* narrow (b) and broad (c) lateral view (after Gauthier-Lièvre, 1957); d, e – *Q. camerounensis* narrow (d) and broad (e) lateral view (after Gauthier-Lièvre, 1957); f – *Q. debonti* lateral view (after Gauthier-Lièvre, 1957); g, h – *Q. elegans* narrow (g) and broad (h) lateral view (after Gauthier-Lièvre, 1953); i – *Q. elongata* lateral view (after Chardez, 1967b); j – *Q. lageniformis* lateral view (after Oye, 1949); k – *Q. quadrigera* lateral view (after Deflandre, 1936); l, m – *Q. scutellata* lateral view (after Deflandre, 1936); n, o – *Q. symmetrica* lateral view (after Deflandre, 1936); p, q – *Q. tropica* broad (p) and narrow (q) lateral view (after Wailes, 1912); r, s – *Q. tubulata* narrow (r) and broad (s) lateral view (after Gauthier-Lièvre, 1953)

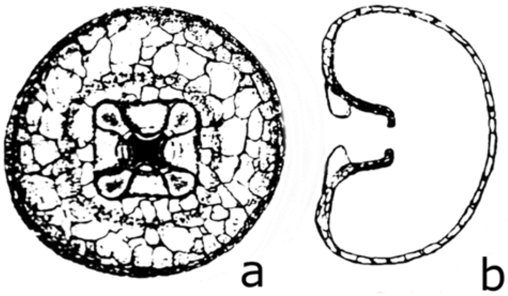

Fig. 42. *Lamtopyxis callistoma*:
a – aperture view; b – lateral view (after Bonnet, 1974)

Family Microchlamyiidae Ogden, 1985, emend. Kudryavtsev et Hausmann, 2007

Shell is proteinaceous, flexible or rigid, finely areolate. Cytoplasm either enclosed in a separate membrane sac with single aperture, attached to the main shell, or the peripheral part of the shell membranous with a single aperture, in which case there is no separate membrane sac between the cell body and shell.

Key to the genera of the family

1. Cytoplasm enclosed in a separate membrane sac with an aperture, attached to the main shell .... **Genus *Microchlamys***

1'. No separate membrane sac between the cell body and the shell, a delicate membrane with an aperture partially covers the cytoplasm on the ventral side only .... **Genus *Spumochlamys***

Genus *Microchlamys* Cockerell, 1911

Flexible organic shells, finely areolated, chitinoid, foldede at the ventral side; transparent, yellow to brown in color. Cell enclosed within a membranous sac, which is fused to the shell at intervals, lost in empty shells. This membrane closes the shell from the ventral side and forms an aperture for the lobopodia. Ecology: freshwater, mosses, soil. Type species: *Microchlamys patella* (Claparéde et Lachmann, 1859) (fig. 43).

Genus *Spumochlamys* Kudryavtsev et Hausmann, 2007

Flexible organic shell with a spongious dorsal part, which becomes thinner towards the margin and ends in a delicate membrane that partially covers the cytoplasm on the ventral side, leaving an aperture through which some cytoplasm can extend. Ecology: brackish waters. Type species: *Spumochlamys iliensis* Kudryavtsev et Hausmann, 2007.

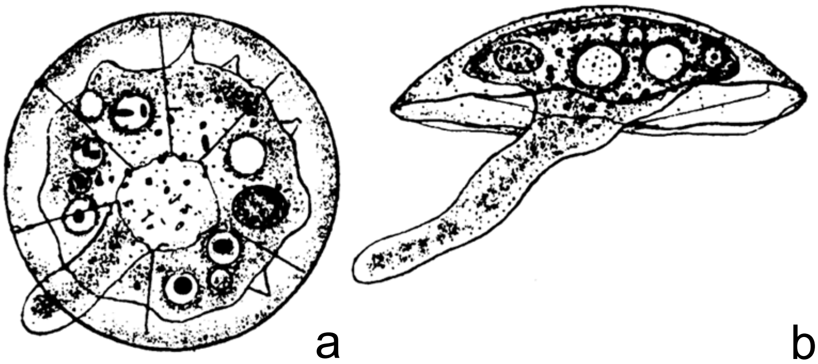

Fig. 43. *Microchlamys patella*:
a – dorsal view; b – lateral view (after Penard, 1902)

Family Microcoryciidae de Saedeleer, 1934

Protenaceous, flexible or semi-rigid shells, not areolate; aperture ventral, distinct, variable.

Key to the genera of the family

1. External layer of shell is gelatinous; usually one nucleus; plasma violet; aperture invaginated .... **Genus *Amphizonella***

1'. Shell is not gelatinous 2

2. Aperture is slit-like... 3

2'. Aperture of variable shape or circular, sometimes wide open 4

3. Shell is pyriform or discoid, plasma violet........ **Genus *Zonomyxa***

3'. Shell is laterally compressed, ovoid in oral view......................... .... **Genus *Parmulina***

4. Dorsal face with mineral particle or attached debris 5

4'. Dorsal face without foreign materials, shell is smooth .... **Genus *Penardochlamys***

5. Shell is hemispheric, bilayered; flexible, wide, ventral aperture.... .... **Genus *Diplochlamys***

5'. Dorsal side is more or less rigid, ventral like a flexible skirt........ .... **Genus *Microcorycea***

Genus *Amphizonella* Greeff, 1866

Shell is more or less round, bilayered pellicle, out layer gelatinous 8–12 μm with fine denticles; inner layer is thin, chitinoid, undulates with internal movements, sac-like. Aperture is invaginated, variable. Pseudopods cyllindroid, finely granular, rounded ends. Movement sluggish. Endoplasm clear, violet; yellow granules in purple vesicles. One ovular nucleus. Ecology: mosses on trees. Monospecific. Type species: *Amphizonella violacea* Greef, 1866 (fig. 44).

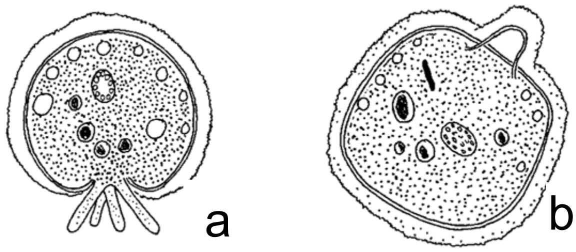

Fig. 44. *Amphizonella violacea*:
a – lateral view (after Penard, 1902); b – dorsal view (after Penard, 1906)

Genus *Diplochlamys* Greeff, 1888

Shell is small, round, grayish-yellow, bilayered; inner hyaline sac enclosing the cell with flexible aperture, outer layer consists of loosely arranged debris. Ecology: mosses, soils. Type species: *Diplochlamus leidyi* Greef, 1888 (fig. 45).

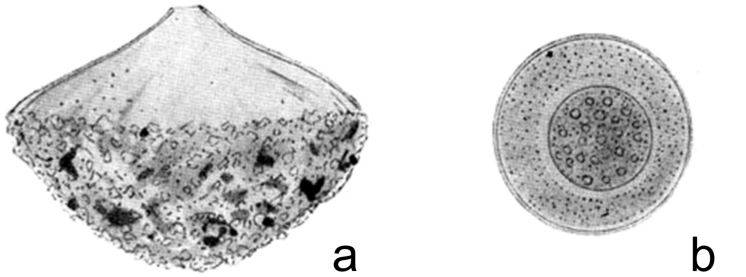

Fig. 45. *Diplochlamys fragilis*:
a – lateral view; b – apertural view (after Penard, 1909)

Genus *Microcorycia* Cockerell, 1911

Shell is flexible and comprised of two parts: upper and lower. The upper shell part is dome-shaped, sometimes with concentric ridges or small horns at the dorsal side; thick and less flexible walls than the lower shell part; maybe covered with small debris or mineral particles. The lower shell part consists of a thin, transparent skin, which shows no structure in the light microscope, can be folded up and is open downwards for extruding pseudopodia. The skin only loosely covers the cell body and can be contracted like a sack. There is a zone of gradual transition from the upper shell part to the lower shell part. Ecology: mosses, soils, freshwater. Type species: *Microcorycia flava* (Greef, 1866) Penard, 1902 (fig. 46).

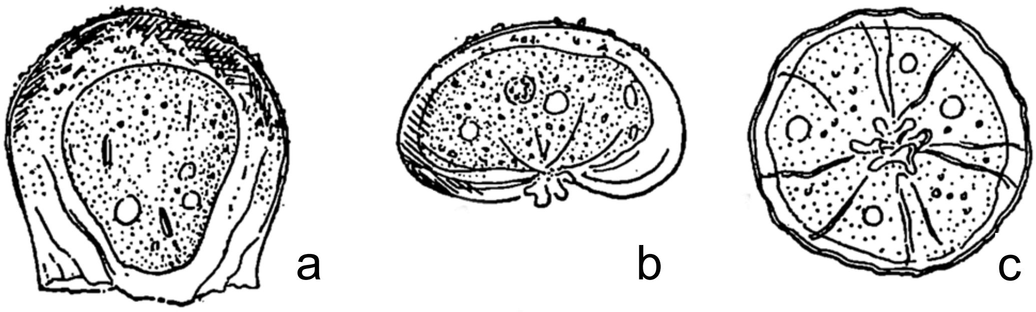

Fig. 46. *Microcorycia flava*:
a – lateral view, lower part of the shell open; b – lateral view, lower part of the shell closed; c – ventral view, lower part of the shell closed (after Penard, 1902)

Genus *Parmulina* Penard, 1902

Shell is ovoid in aperture view, laterally compressed, hemispheric in lateral view; clear, flexible, chitionoid, opaque with attached debris. Aperture is slit-like. Pseudopods rare, bluntly lobate. Endoplasm granular. One vesicular nucleus. Ecology: mosses on trees. Type species: *Parmulina cyathus* Penard, 1902 (fig. 47).

Fig. 47. *Parmulina cyathus*:
a – lateral view; b – dorso-lateral view; c – dorsal view (after Penard, 1902)

Genus *Penardochlamys* Deflandre, 1953

Shell is round, wavy outline, chitionoid, flexible, punctuate. Aperture is circular or wavy, rarely visible, slightly invaginated. Pseudopods cylindroid, finely granular, round ends. Endoplasm granular. Two vesicular nuclei; one or two contractive vacuoles. Ecology: freshwater. Monospecific. Type species: *Penardochlamys arcelloides* (Penard, 1904) (fig. 48).

Genus *Zonomyxa* Nüsslin, 1882

Shell is large, resting form is discoid, locomotive form is pyriform; chitinoid pellicle, without mucilaginous envelope, flexible, follows the movements of the cell. Surface with small temporal perforations trough which plasma threads emerge. Pseudopods single, clear, conical, from slit-like aperture. Endoplasm granular, violet tinted. Ecology: *Sphagnum* or aquatic vegetation. Monospecific. Type species: *Zonomyxa violacea* Greef, 1866 (fig. 49).

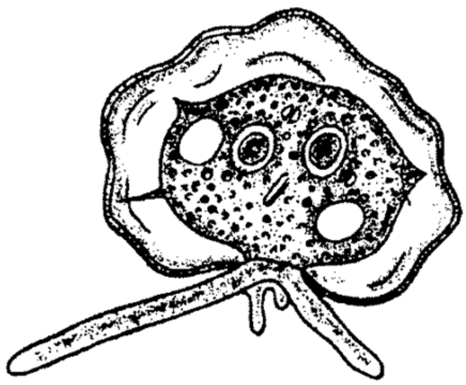

Fig. 48. *Penardochlamys arcelloides*: lateral view (after Penard, 1909)

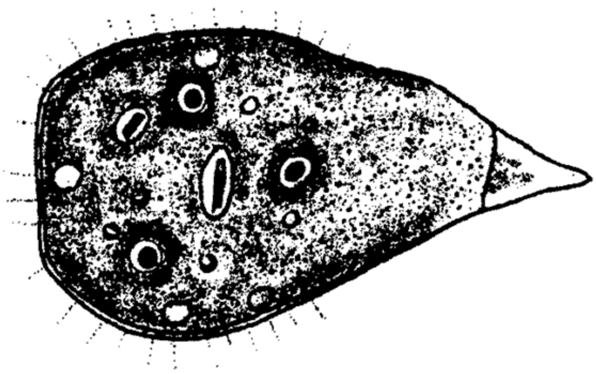

Fig. 49. *Zonomyxa violacea* (after Penard, 1906)

Family Plagiopyxidae Bonnet et Thomas, 1960

Shell is bilaterally symmetrical; aperture is on ventral side, eccentric, cryptostome. Shell is covered by xenosomes.

Key to the genera of the family

1. Anterior lip of aperture is a distinct overhanging hood 6
1'. Aperture is more or less slit-like, no overhanging hood 2
2. Anterior lip of aperture with pores............... **Genus *Bullinularia***
2'. No such pores 3
3. Anterior (dorsal) lip of aperture curves below ventral face ....
.... **Genus *Geoplagiopyxis***
3'. Posterior (ventral) lip of aperture curves below anterior (dorsal) lip, or aperture is an open slit.. 4
4. Aperture is an open slit .... **Genus *Protoplagiopyxis***
4'. Aperture is covered by the anterior lip 5

5. Posterior (venteral) lip connected to the dorsal side of the shell from inside and has an extension towards anterior lip................................ ....**Genus *Paracentropyxis***

5'. No extension of the posterior lip.................. **Genus *Plagiopyxis***

6. Ventral face is rounded ....**Genus *Hoogenraadia***

6'. Ventral face is flattened....................**Genus *Planhoogenraadia***

Genus *Bullinularia* Deflandre, 1953

Shell is ovoid or circular in front view, hemispherical with flattened ventral surface in lateral view; covered by small mineral particles in sheet-like organic cement, smooth, dark brown and opaque. Aperture is eccentric, invaginated, completely or partially hidden by the dorsal apertural lip (cryptostome). A key character is the pores on the dorsal lip, on the apex and, depending on the species, on the ventral side. Ecology: soils, mosses. Type species: *Bullinularia indica* (Penard, 1907) (fig. 50).

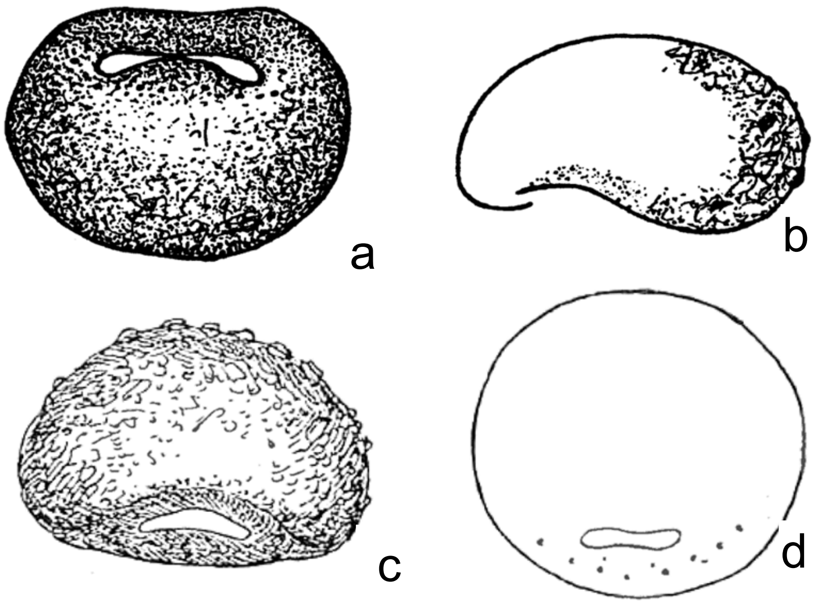

Fig. 50. Genus *Bullinularia*:
a, b – *B. indica* aperture (a) and lateral (b) view (after Geltzer et al., 1995); c, d – *B. minor* aperture view (after Hoogenrad et al., 1948)

Genus *Geoplagiopyxis* Chardez, 1961

Shell is ovoid in frontal view, hemispheric in lateral view; ventral surface slightly vaulted; dorsal face curving below the convex ventral face. Aperture is not easily visible as an irregular slit. Shell composed of amorphous plates without larger mineral particles. Ecology: soil. Type species: *Geoplagiopyxis declivis* Chardez, 1961 (fig. 51).

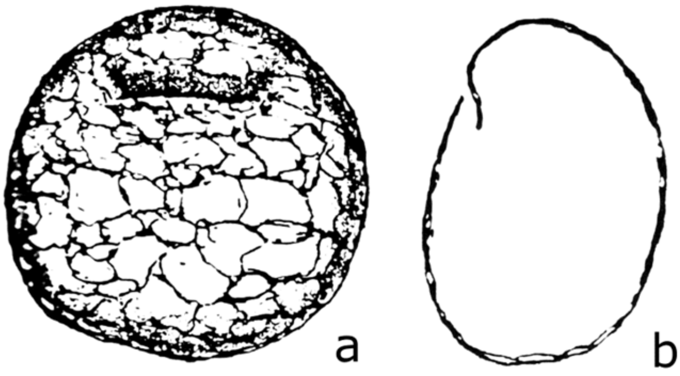

Fig. 51. *Geoplagiopyxis declivus*:
a – apertural view; b – lateral view (after Chardez, 1960)

Genus *Hoogenraadia* Gauthier-Lièvre et Thomas, 1958

Shell is ovoid-globular, overhanging anterior visor with two lateral groves, incurved ventral lip; covered by xenosomes. Ventral face circular. Aperture is more or less circular, partly covered by visor. Ecology: tropical bogs, swamps, soils. Type specie: *Hoogenraadia africana* Gauthier-Lièvre et Thomas, 1958 (fig. 52).

Note: Chardez (1963) has erected a similar perhaps synonymous genus *Gillardella*, which has a much smaller visor.

Genus *Paracentropyxis* Bonnet, 1960

Shell is circular or slightly elliptical in frontal view; at the dorsal face, a groove separates the reminder of the shell from a small visor in from of tapered crescent. Ventral surface is concave; at median level the visor is rounded, forming a buccal cavity, ventral face and the side walls of this vestibulum are connected to the dorsal part of the shell; with small internal opening as in *Centropyxis sylvatica*. The slit-like aperture is hidden by the dorsal lip and an extension of the ventral shell wall (cryptostomia). Shell transparent and composed of exogenous mineral particles, which are embedded in a hyaline cement. Ecology: tropical soils. Monospecific. Type species: *Paracentropyxis mimetica* Bonnet, 1960 (fig. 53).

Note: Dekhtiar (2009) placed the genus *Paracentropyxis* in the family Centropyxidae with species *Paracentropyxis sylvatica* (Deflandre, 1929) Dekhtiar, 2009 (basionym *Centropyxis sylvatica* Deflandre, 1929) and *Paracentropyxis matthesi* (Rauenbusch, 1987) Dekhtiar, 2009 (basionym *Centropyxis matthesi* Rauenbusch, 1987).

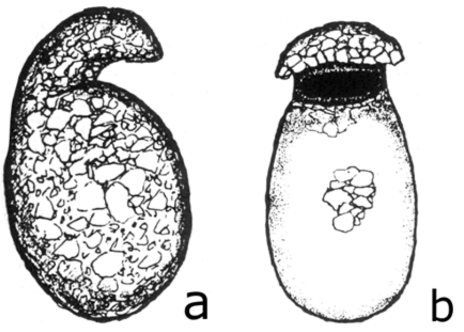

Fig. 52. *Hoogenradia africana:*
a – lateral view; b – apertural view
(Gauthier-Lièvre, Thomas, 1958)

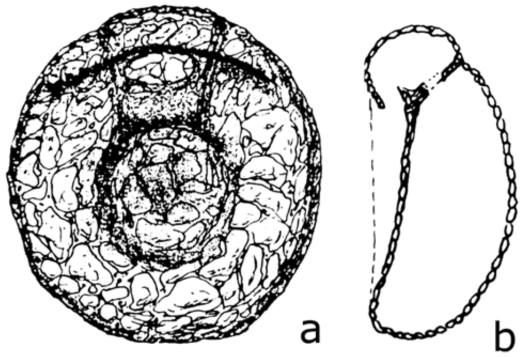

Fig. 53. *Paracentropyxis mimetica*:
a – apertural view; b – lateral view
(after Bonnet, 1960a)

Genus *Plagiopyxis* Penard, 1910

Shell is circular of oval in frontal view, hemispheric in lateral view. Aperture is elongate slit, perpendicular to long axis of the shell; dorsal aperture lip somewhat incurved usually hiding the opening. Ecology: most of the species are edaphobionts (soil-inhabited), some freshwater. Type species: *Plagiopyxis declivis* Bonnet et Thomas, 1955 (fig. 54).

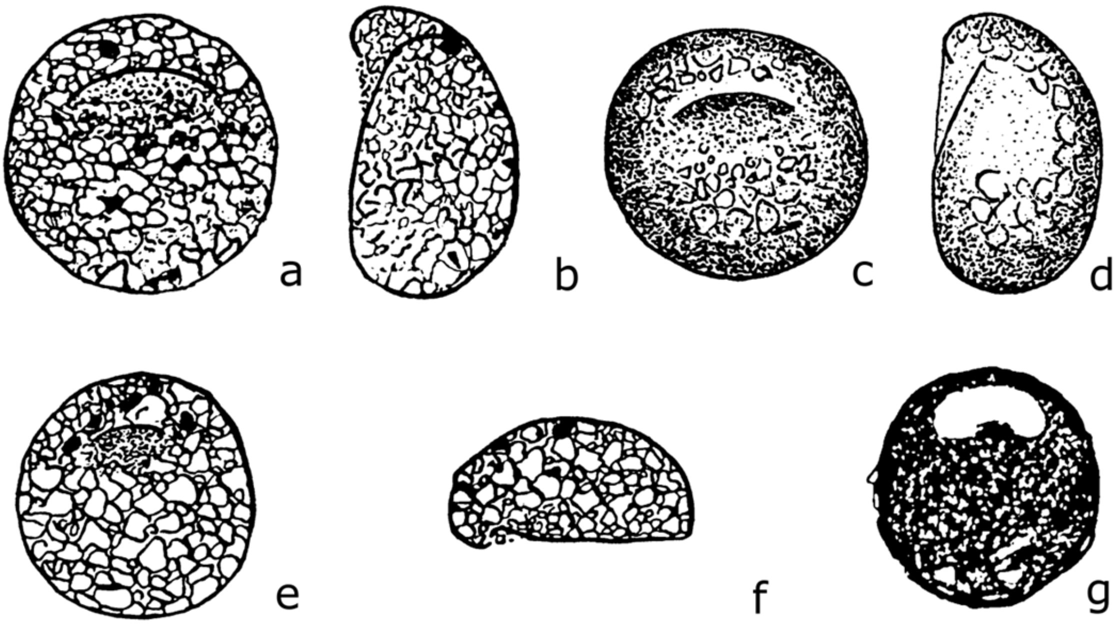

Fig. 54. Genus *Plagiopyxis*:
a, b – *P. callida* aperture (a) and lateral (b) view (after Geltzer et al., 1995);
c, d – *P. declivis* aperture (c) and lateral (d) view (after Geltzer et al., 1995);
e, f – *P. penardi* aperture (e) and lateral (f) view (after Geltzer et al., 1995);
g – *P. labiata* aperture view (after Thomas, 1958a)

Genus *Planhoogenraadia* Bonnet, 1977

Shell is ovoid in frontal view, hemispheric with flat ventral surface and a visor-like extension separated by two groves from the mina body of the shell in lateral view. Aperture is semicircular or elongated oval, located back into the shell, partly covered by the visor-like extension of the dorsal surface. Ecology: soils. Type species: *Planhoogenraadia acuta* Bonnet, 1977 (fig. 55).

Genus *Protoplagiopyxis* Bonnet, 1962

Shell is ovoid in frontal view, hemispheric with anterior flattening in lateral view; covered by extraneous mineral particles. Ventral surface is flattened very clearly and slightly or not inclined. Aperture is a straight or crescent-shaped slit of "plagiostome" type with tendency to "cryptostome" (aperture located inside the shell), no vestibule, but apertural region is well separated by fairly abrupt dorso-ventral depression in the anterior part. Ecology: soils. Type species: *Protoplagiopyxis delamarei* Bonnet, 1962 (fig. 56).

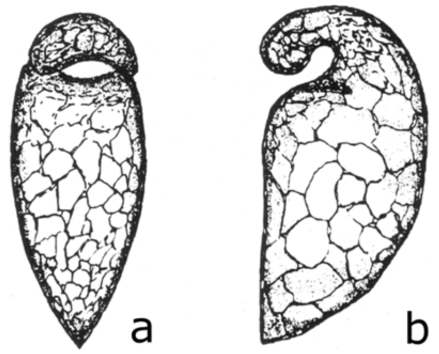

Fig. 55. *Planhoogenradia acuta*: a – apertural view; b – lateral view (Bonnet, 1977)

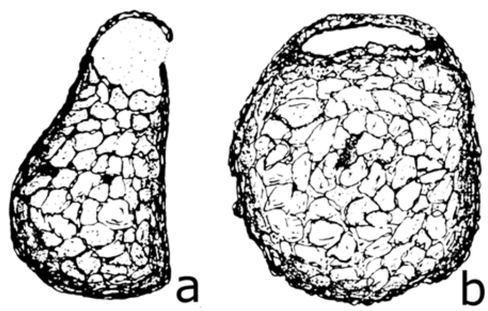

Fig. 56. *Protoplagiopyxis delamarei*: a – lateral view; b – apertural view (Bonnet, 1962)

Family Paraquadrulidae Deflandre, 1953

Shells are composed of endogenously formed rectangular calcite plates embedded in a sheet-like organic cement. The presence of calcite still should be verified.

Key to the genera of the family

1. Shell is radially symmetrical........................**Genus *Paraquadrula***

1'. Shell is bilaterally symmetrical with a bended neck...................... .... **Genus *Lamtoquadrula***

Genus *Lamtoquadrula* Bonnet, 1974

Shell is retort-shaped with bending neck in lateral view; circular cross-section; covered by endogenously secreted square or rectangular plates placed in regular rows. Aperture is circular with a thin transparent organic lip, only visible with phase or interference contrasts. Ecology: soils. Monospecific. Type species: *Lamtoquadrula deflandrei* Bonnet, 1974 (fig. 57).

Genus *Paraquadrula* Deflandre, 1932

Shell is transparent, broad oval, slightly compressed laterally; covered by endogenously secreted square or rectangular plates placed in regular rows. Aperture is terminal, slit-like or irregular. Ecology: freshwater, moss and soil. Type species: *Paraquadrula irregularis* Archer, 1877 (fig. 58).

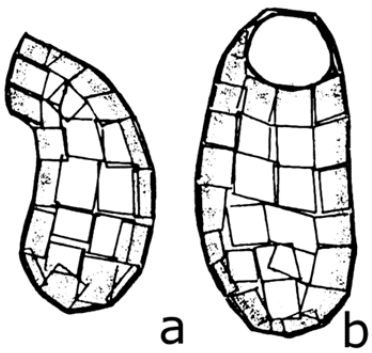

Fig. 57. *Protoplagiopyxis delamarei*:
a – lateral view; b – apertural view (Bonnet, 1962)

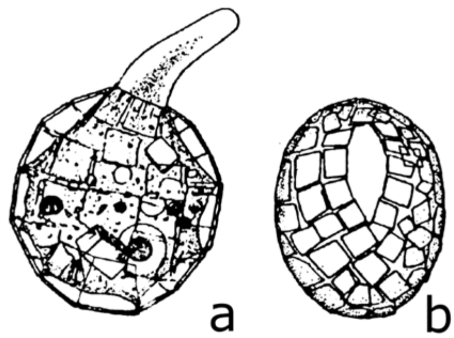

Fig. 58. *Lamtoquadrula deflandrei*:
a – lateral view;
b – aperture view (Bonnet, 1975)

Family Phryganellidae Jung, 1942

Axially symmetrical, agglutinated shells; pseudopodia slightly conical pointed, sometimes branched, may sometimes anastomose. The status of this taxon is unclear, due to insufficient information is available.

Genus *Phryganella* Penard, 1902

Shell is circular in frontal view, hemispherical or higher in lateral view; covered with mineral particles of various size embedded in an organic matrix, which in older specimens can become dark frown due to manganese and iron deposition. Aperture is centrostome, circle, large often about two thirds of the shell diameter, not or only slightly invaginated. Around the aperture and the ventral face, covering particles are small are small giving a regular and smooth outline while larger grains are incorporated at the arboreal pole. Ecology: moss, soils. Type species: *Phryganella nidulus* Penard, 1902 (fig. 59).

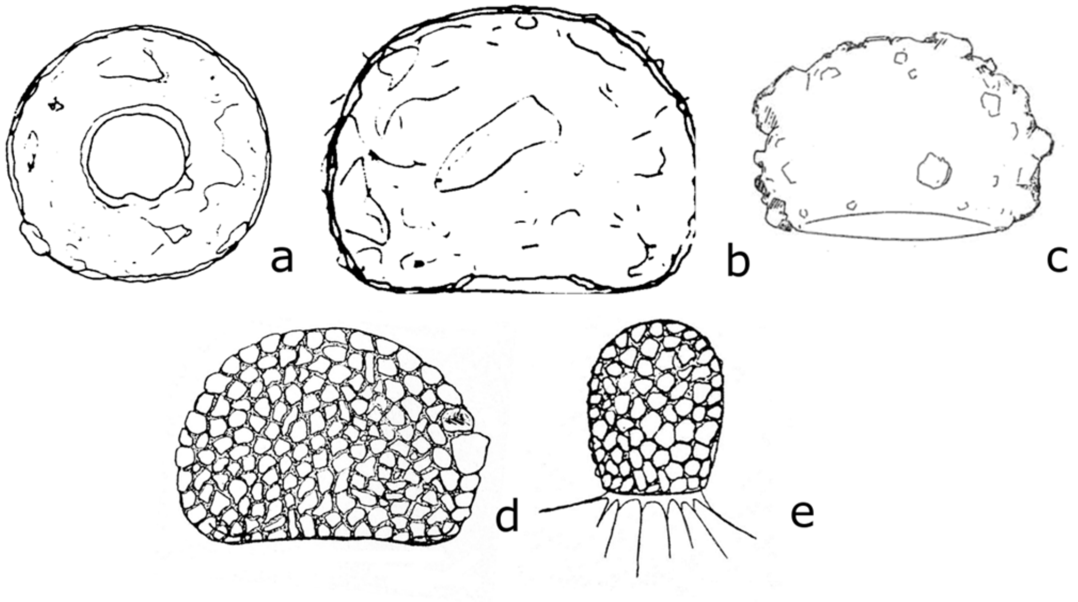

Fig. 59. Genus *Phryganella*:
a, b – *P. acropodia* lateral (b) and aperture (a) view (after Chardez, 1961a); c – *P. microps* lateral view (after Valkanov, 1963); d – *P nidulus* lateral view (after Bartoš, 1954); e – *P. paradoxa* (after Bartoš, 1954)

Family Trigonopyxidae Loeblich et Tappan, 1964

Shell is radially symmetrical, circular in outline; composed of sheet-like proteinaceoius matrix with agglutinated particles; aperture central.

Key to the genera of the family

1. Aperture always with a thickened organic rim; triangular, three-lobed or irregular in shape... **Genus *Trigonopyxis***
1’. Aperture never with a thickened organic rim; circular, irregular, crescent-shaped or with more than five lobes 2
2. Aperture is invaginated 3
2’. Aperture is not invaginated.............................**Genus *Geopyxella***
3. Aperture is circular .... **Genus *Cyclopyxis***
3’. Aperture is crescent-shaped..........................**Genus *Cornuapyxis***

Genus *Cornuapyxis* Coûteaux et Chardez, 1981

Shell is circular in frontal view, hemispherical in lateral view. Dorsal face is covered with small mineral grains, ventral surface is smooth. Aperture is crescent-shaped, slightly invaginated. Ecology: tropical mosses and soils. Type species: *Cornuapyxis lunaristoma* Coûteaux et Chardez, 1981 (fig. 60).

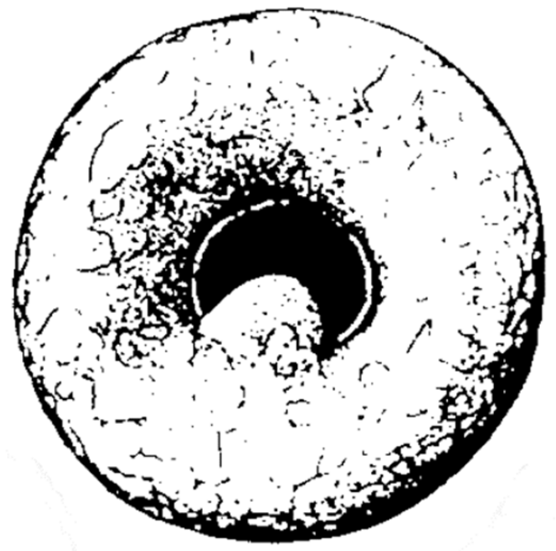

Fig. 60. *Cornuapyxis lunaristoma*:
aperture view (after Coûteaux, Chardez, 1981)

Genus *Cyclopyxis* Deflandre, 1929

Shell is circular in frontal view, hemispherical in lateral view. Dorsal face is often rough, covered by large sand grains, ventral face is smooth. Aperture is invaginated, in most species circular, few species with irregular or lobed aperture; margin never with thick organic rim but often with small mineral particles. Ecology: freshwater, mosses, soils. Type species: *Cyclopyxis arcelloides* (Penard, 1902) (fig. 61, 62).

Genus *Geopyxella* Bonnet et Thomas, 1955

Shell is circular in frontal view, subglobular or hemispherical in lateral view. Dorsal face is covered with thin siliceous particles, ventral surface is smooth. Aperture is not invaginated, circular. Ecology: soil. Type species: *Geopyxella sylvicola* Bonnet et Thomas, 1955 (fig. 63).

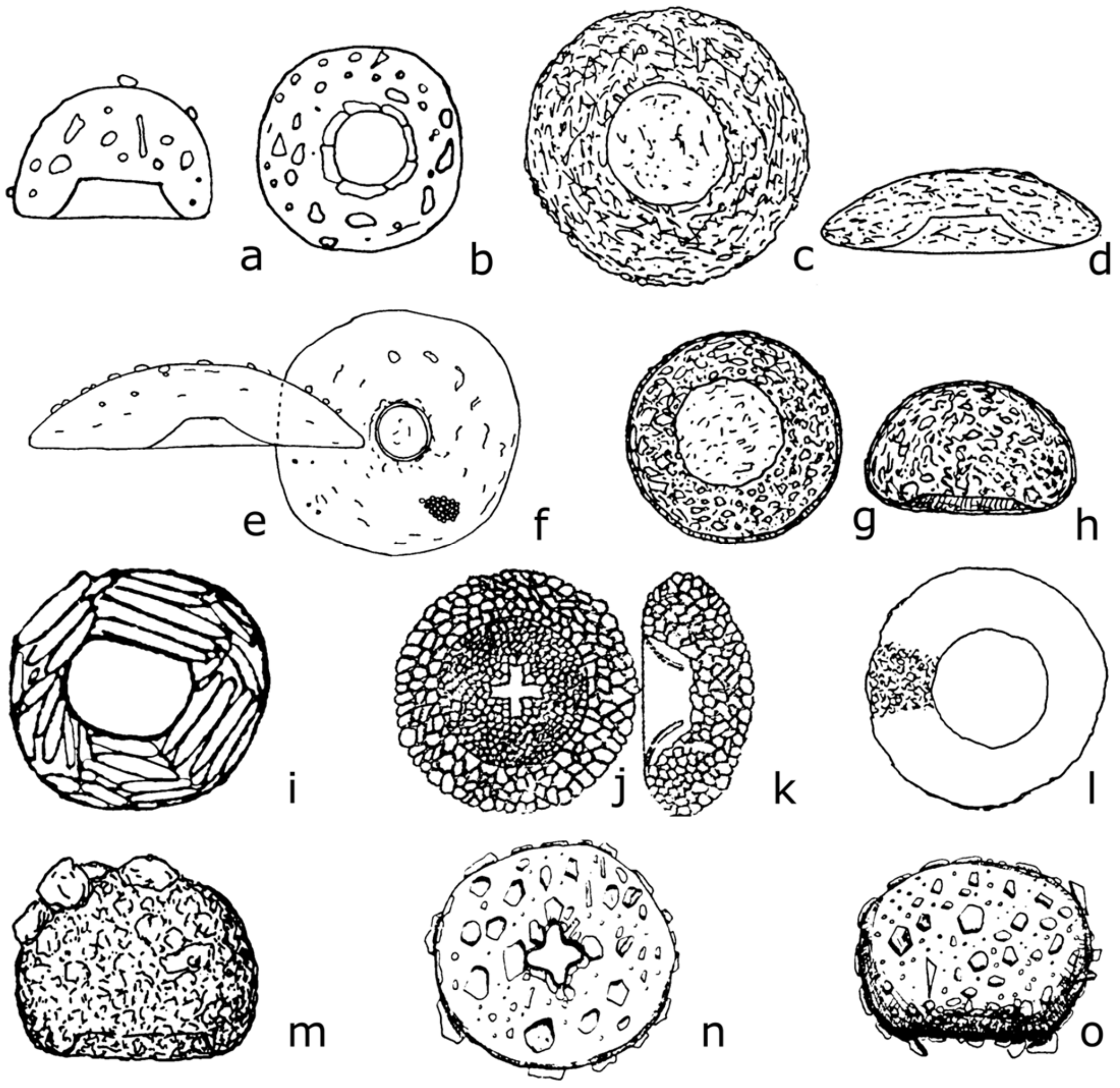

Fig. 61. Genus *Cyclopyxis*:
a, b – *C. amplecta* lateral (a) and aperture (b) view (after Schönborn, 1966a); c, d – *C. aplanata* aperture (c) and lateral (d) view (after Penard, 1911); e, f – *C. aplanata microstoma* lateral (e) and aperture (f) view (after Schönborn, 1966a); g, h – *C. arcelloides* aperture (g) and lateral (h) view (after Penard, 1902); i – *C. bacillifera* aperture view (after Chardez, 1966); j, k – *C. crucistoma* aperture (j) and lateral (k) view (after Bartoš, 1963); l, m – *C. eurystoma* aperture (l) and lateral (m) view (after Deflandre, 1929); n, o – *C. grospietschi* aperture (n) and lateral (o) view (after Schönborn, 1962a)

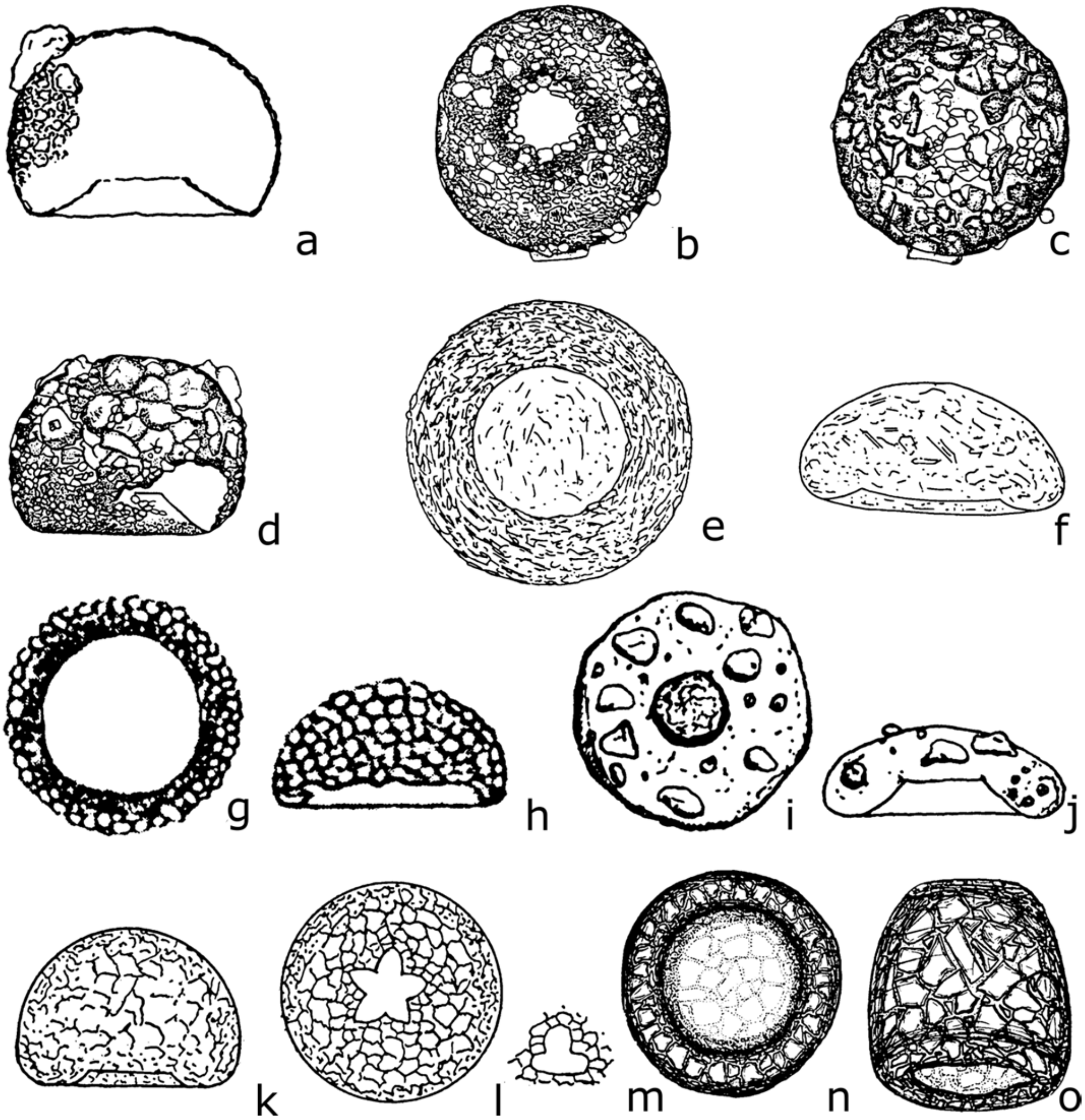

Fig. 62. Genus *Cyclopyxis*:
a–d – *C. kahli* lateral (a, d), aperture (b) and dorsal (c) view (a, b – after Deflandre, 1929; c, d – after Foissner, Korganova, 1995); e, f – *C. penardi* aperture (e) and lateral (f) view (after Penard, 1911); g, h – *C. plana* aperture (g) and lateral (h) view (after Bartoš, 1963); i, j – *C. plana microstoma* lateral (j) and aperture (i) view (after Schönborn, 1966a); k–m – *C. stellata* lateral (k), aperture (l) view and aperture structure (m) (after Wailes, 1927); n, o – *C. tronconica* aperture (n) and lateral (o) view (after Godeanu, 1972)

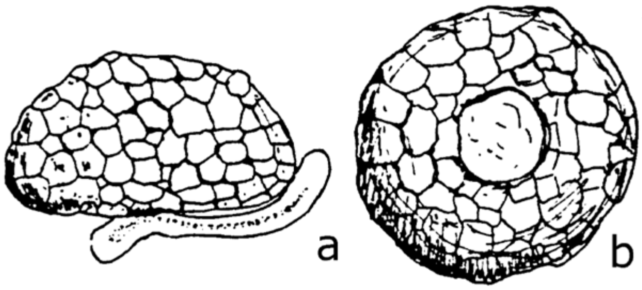

Fig. 63. *Geopyxella aquatica*:
a – lateral view; b – aperture view (Schönborn, 1965c)

Genus *Trigonopyxis* Penard, 1912

Shell is circular in frontal view, hemispherical or higher in lateral view; yellowish or brownish. Dorsal face is covered by xenosomes, ventral face is smooth. Aperture is invaginated, frequently triangular but more often irregular, always surrounded by a ring of organic cement, with a second membranous wall. Ecology: soil, litter, moss. Type species: *Trigonopyxis arcula* (Leidy, 1879) (fig. 64).

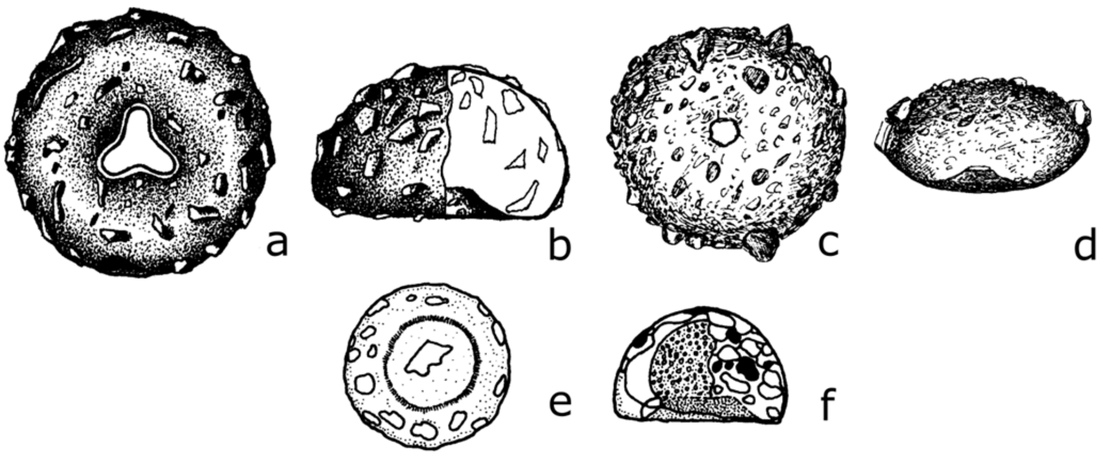

Fig. 64. Genus *Trigonopyxis*:
a, b – *T. arcula* aperture (a) and lateral (b) view (after Bobrov et al., 1995); c, d – *T. microstoma* aperture (c) and lateral (d) view (after Hoogenraad, de Groot, 1948); e, f – *T. minuta* aperture (e) and lateral (f) view (after Schönborn, Peschke, 1988)

INCERTAE SEDIS Arcellinida

Genus *Argynnia* Vucetich, 1974

Shell is ovoid, slightly compressed in cross section; covered with various euglyphid plates mixed with diatom fragments and mineral particles in porous cement, grayish. Aperture is terminal, circular, surrounded by siliceous plates giving a rough outline. Ecology: freshwater, moss, soil. Type species: *Argynnia schwabei* Jung, 1942 (figs 65, 66).

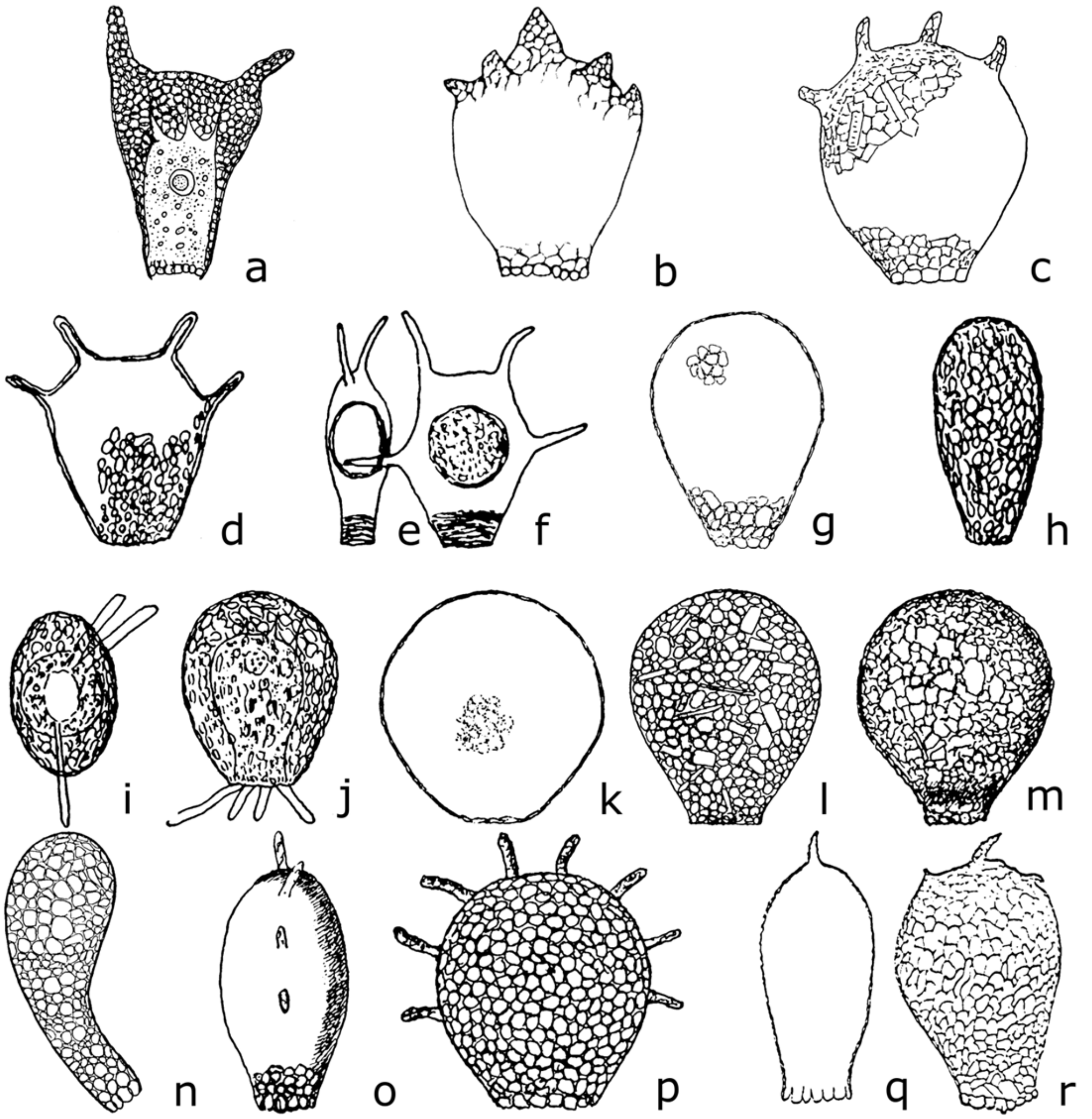

Fig. 65. Genus *Argynnia*:
a – *A. bipes* lateral view (after Wailes, Penard, 1911); b – *A. ertli* lateral view (after Laminger, 1973); c – *A. columbiana* lateral view (after Wailes, 1925); d–f – *A. caudata* broad (d, f) and narrow (e) lateral view (after Leidy, 1879); g–j – *A. dentistoma* broad (g, j), narrow (h) and aperture (i) view (g – after Deflandre, 1936; h–j – after Penard, 1890); k – *A. dentistoma laevis* lateral view (after Deflandre, 1936); l – *A. dentistoma hesperica* lateral view (after Wailes, 1913); m – *A. dentistoma lacustris* lateral view (Wailes, 1912); n – *A. retorta* lateral view (after Chardez, 1958); o, p – *A. spicata* narrow (o) and broad (p) lateral view (after Wailes, 1913); q, r – *A. schwabei* narrow (q) and broad (r) lateral view (after Jung, 1942)

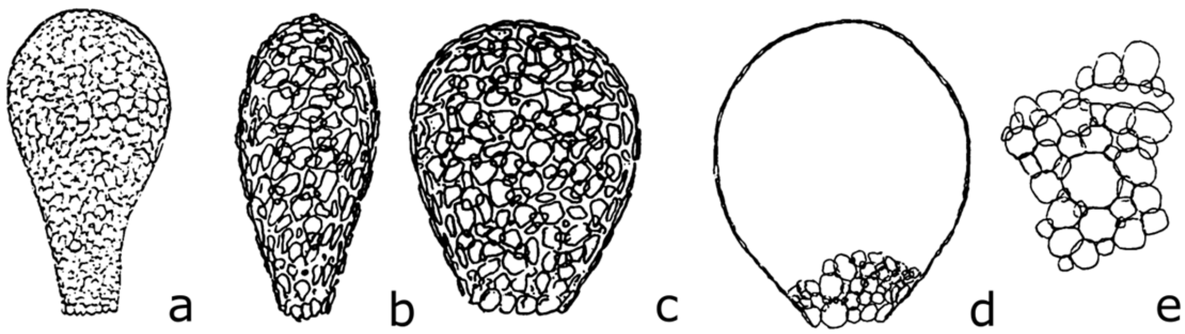

Fig. 66. Genus *Argynnia*:
a – *A. gertrudeana* lateral view (after Jung, 1942); b, c – *A. vitraea* broad (c) and narrow (b) lateral view (after Penard, 1899); d, e – *A. vitraea minor* broad lateral view (d) and shell cover details (e) (after Deflandre, 1936)

Genus *Awerintzewia* Schouteden, 1906

Shell is ovoid, circular or slightly compressed in cross section; covered with irregular, embedded siliceous particles (no idiosomes of other testate amoebae). Aperture is oval, with internally thickened border. Ecology: freshwater, *Sphagnum*. Monospecific. Type species: *Awerintzewia cyclostoma* (Penard, 1902) (fig. 67).

Fig. 67. *Awertintzewia cyclostoma*:
lateral view (after Geltzer et. al., 1995)

Genus *Difflugia* Leclerc, 1815

Shell is agglutinated, with a terminal aperture that is circular, oval, lobed or toothed (but never slit-like), sometimes with a collar or necklace (sensu Ogden, Meisterfeld, 1989; Mazei, Warren, 2012, 2014, 2015) but never with an internal diaphragm. The shell is composed of mineral particles or diatom frustules, collectively called xenosomes that are assembled on structured or sheet-like organic cement. All species of *Difflugia* acquire their xenosomes from their environment. Many select and arrange these xenosomes according to their size and shape in order to construct a shell with a morphology that is unique to that particular species. The nucleus is usually ovular, but in some species it is vesicular. Several freshwater species have green endosymbionts (Meisterfeld, Mitchell, 2008). Type species: *Difflugia proteiformis* Lamarc, 1816 (fig. 68–70).

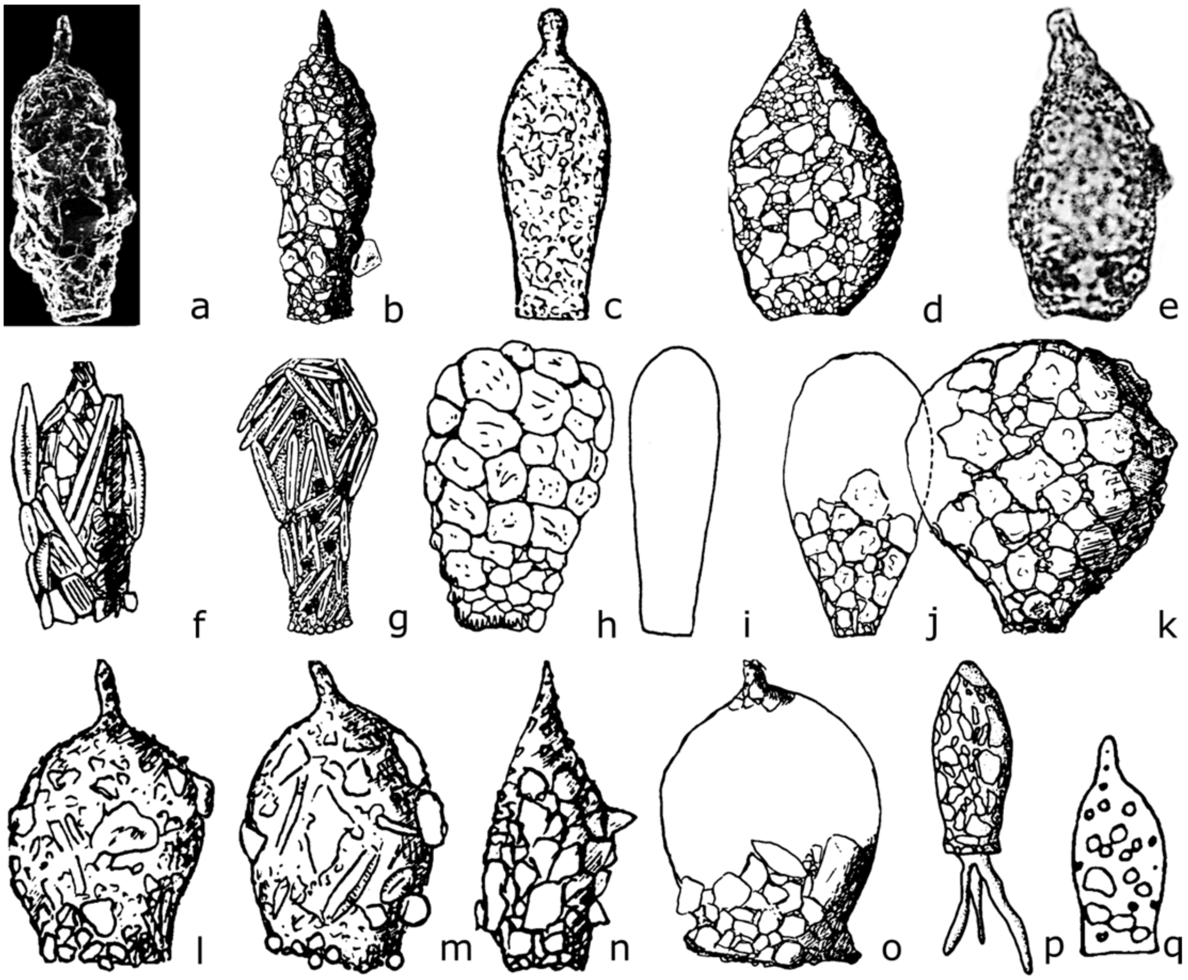

Fig. 68. Genus *Difflugia*:
a, b – *D. acuminata* lateral view (a – after Ogden, 1979; b – after Gauthier-Lièvre, Thomas, 1958); c – *D. acuminata umbilicata* lateral view (after Chardez, 1961); d – *D. acutissima* lateral view (after Gauthier-Lièvre, Thomas, 1958); e – *D. acutissimella* lateral view (after Chardez, 1985); f – *D. bacillariarum* lateral view (after Gauthier-Lièvre, Thomas, 1958); g – *D. bacillifera* lateral view (after Bartoš, 1954); h, i – *D. compressa* broad (h) and narrow (i) lateral view (after Schönborn, 1965a); j, k – *D. compressa africana* narrow (j) and broad (k) lateral view (after Gauthier-Lièvre, Thomas, 1958); l, m – *D. elegans* lateral view (after Gauthier-Lièvre, Thomas, 1958); n – *D. elegans angustata* lateral view (after Gauthier-Lièvre, Thomas, 1958); o – *D. elegans teres* lateral view (after Gauthier-Lièvre, Thomas, 1958); p – *D. elegans parva* lateral view (after Jax, 1985); q – *D. elegans lepida* lateral view (after Schönborn, 1966a)

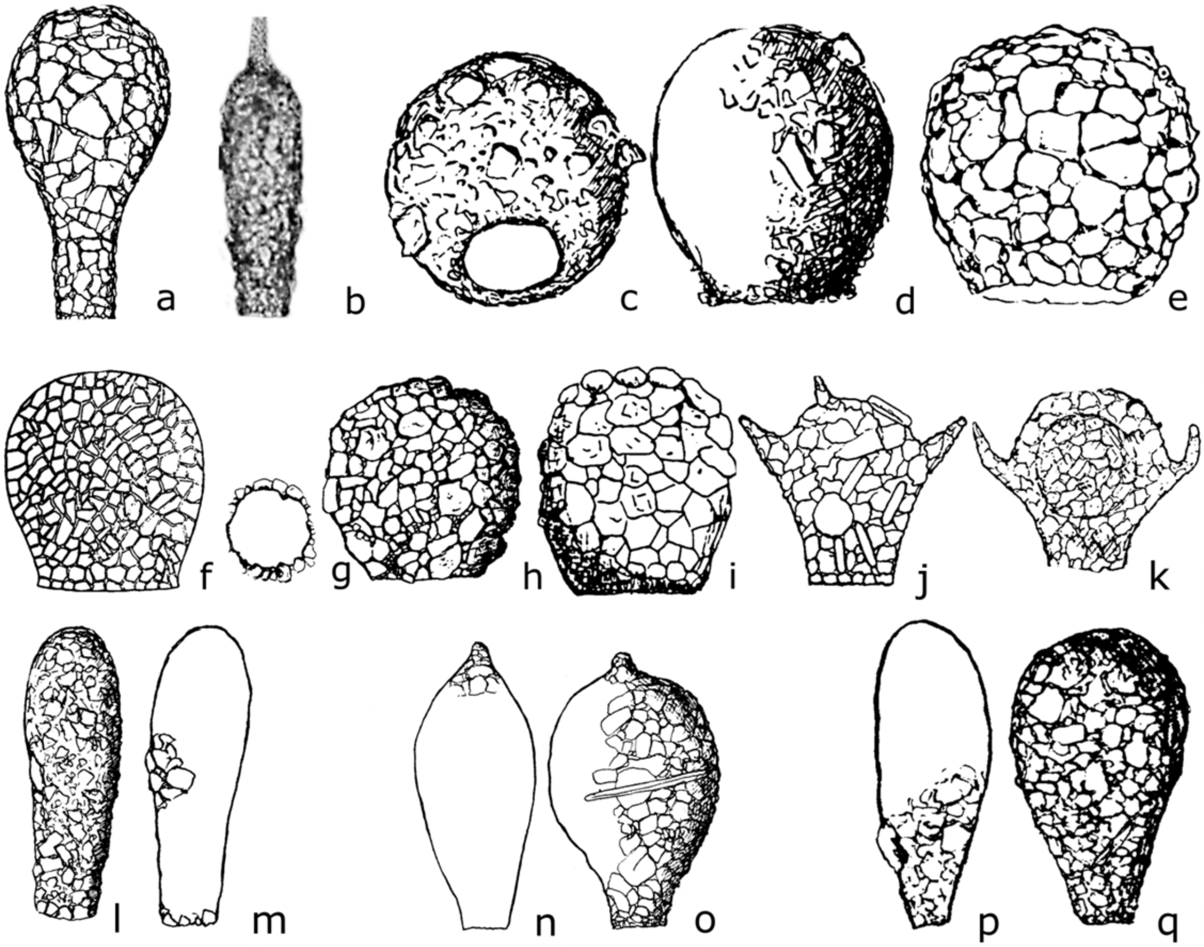

Fig. 69. Genus *Difflugia*:
a – *D. gigantea* lateral view (after Chardez, 1967c); b – *D. gigantea acuminata* lateral view (after Chardez, Gaspar, 1984); c, d – *D. globulosa* apertural (c) and lateral (d) view (after Gauthier-Lièvre, Thomas, 1958); e – *D. globularis* lateral view (after Beyens, Chardez, 1984); f – *D. lebes* lateral view (after Bartoš, 1954); g, h – *D. lebes sphaerica* aperture (g) and lateral view (h) (after Gauthier-Lièvre, Thomas, 1958); i – *D. lebes masurica* lateral view (after Schönborn, 1965a); j, k – *D. leidyi* lateral view (after Wailes, 1912); l, m – *D. linearis* lateral view (after Gauthier-Lièvre, Thomas, 1958); n, o – *D. lingual* narrow (n) and broad (o) lateral view (after Gauthier-Lièvre, Thomas, 1958); p, q – *D. lingula regularis* narrow (p) and broad (q) lateral view (after Gauthier-Lièvre, Thomas, 1958)

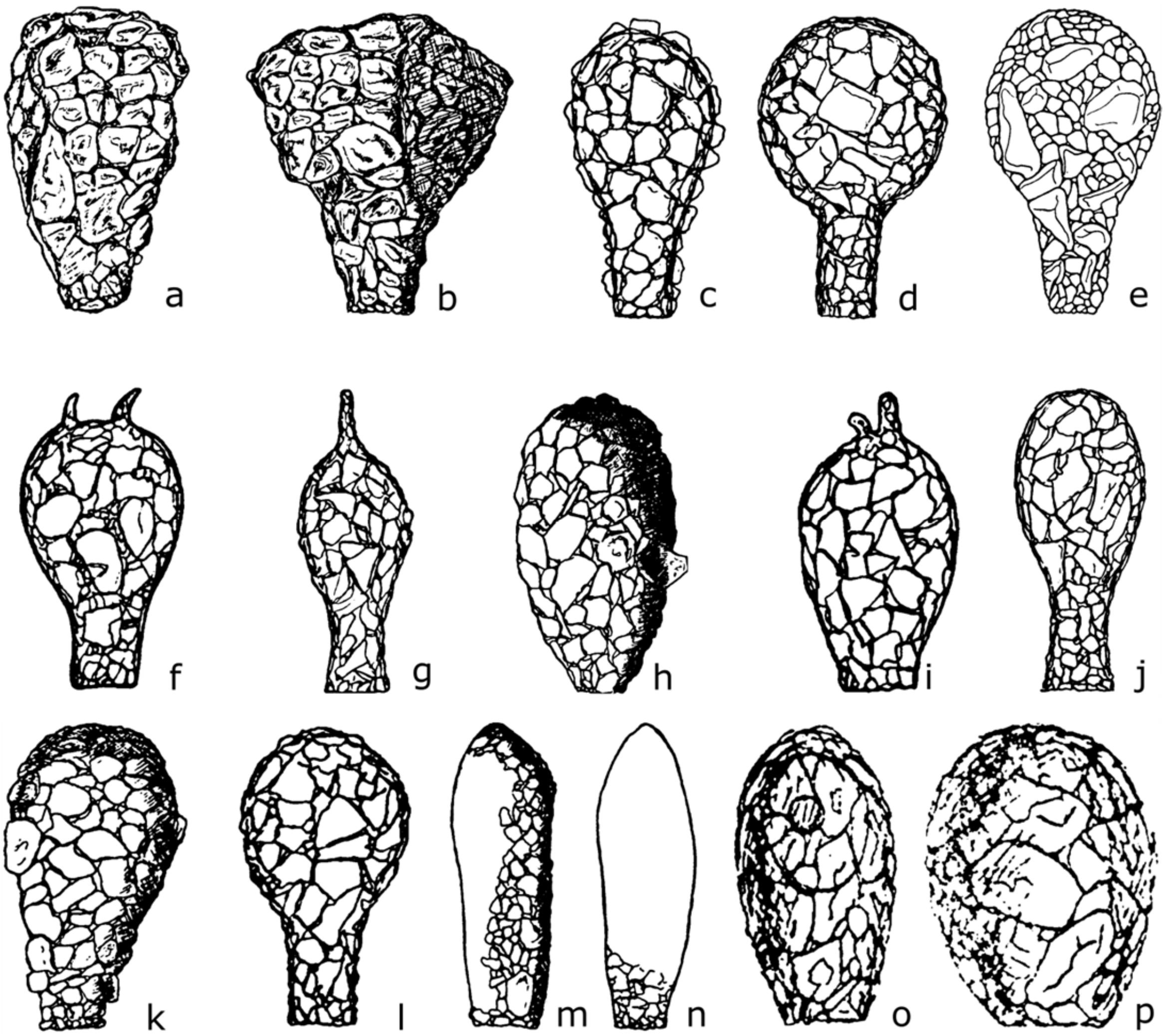

Fig. 70. Genus *Difflugia*:
a, b – *D. nodosa* narrow (a) and broad (b) lateral view (after Gautier-Lièvre, Thomas, 1958); c – *Difflugia oblonga* lateral view (after Chardez, 1967c); d, e – *D. oblonga angusticollis* lateral view (d – after Chardez, 1967c; e – after Štěpánek, 1952); f – *D. oblonga caudata* lateral view (after Chardez, 1967c); g – *D. oblonga cornuta* lateral view (after Chardez, 1967c); h – *D. oblonga incondita* lateral view (after Gauthier-Lièvre, Thomas, 1958); i – *D. oblonga schizocaulis* lateral view (after Chardez, 1967c); j – *D. oblonga stepaneki* lateral view (after Chardez, 1967c); k, l – *D. parva* lateral view (k – after Gauthier-Lièvre, Thomas, 1958; l – after Chardez, 1967c); m, n – *D. paulii* в плане (after Gauthier-Lièvre, Thomas, 1958;); o, p – *D. penardi* lateral view (after Bartoš, 1954)

Genus *Geamphorella* Bonnet, 1959

Shell is ovoid, circular in cross section, covered with amorphous silica elements, tinted clear yellow or grayish white. Aperture is terminal, with a chitionoid collar, slightly widened at the circular aperture.

Ecology: calcareous soils. Monospecific. Type species: *Geamphorella lucida* Bonnet, 1959 (fig. 71).

Note: Décloître (1964) described *Pseudogeamphorella* with a compressed shell. However, the description is too vague.

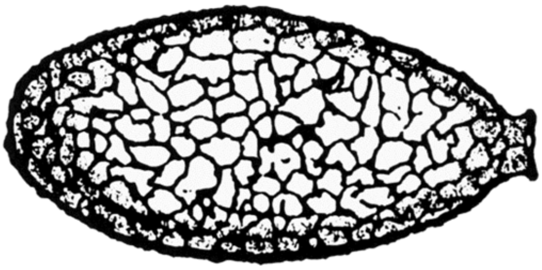

Fig. 71. *Geamphorella lucida*:
lateral view (after Bonnet, 1959)

Genus *Ellipsopyxella* Bonnet, 1975

Shell is elliptic in frontal view, hemispherical in lateral view. Dorsal surface is covered with relatively flat mineral particles (crystalline quartz) giving a smooth surface, ventral surface thicker than the rest of the shell. Aperture is central, circular, not or only weakly invaginated. Ecology: soils. Monospecific. Type species: *Ellipsopyxella regularis* Bonnet, 1975 (fig. 72).

Genus *Ellipsopyxis* Bonnet, 1965

Shell is elliptic in frontal view, semi-elliptic in lateral view on to the large axis; yellowish or clear maroon. Dorsal and lateral surfaces incrusted with small mineral particles, ventral surface is smooth due to organic cement. Aperture is central, elliptical, without or only slight Invagination. Ecology: mainly rich organic tropical soils. Type species: *Ellipsopyxis pauliani* Bonnet, 1965 (fig. 73).

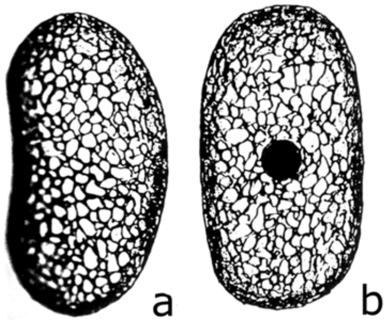

Fig. 72. *Ellipsopyxella regularis*:
a – lateral view; b – aperture view
(after Bonnet, 1975a)

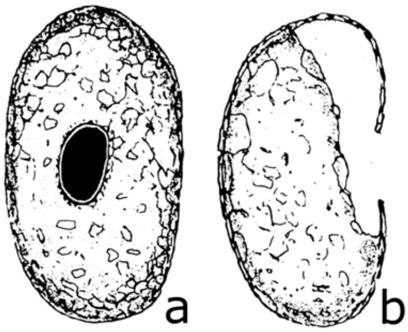

Fig. 73. *Ellipsopyxis pauliani*:
a – aperture view; b – lateral view
(after Bonnet, 1965)

Genus *Heleopera* Leidy, 1879

Shell is ovoid, laterally compressed, composed of collected euglyphid body plates, mineral particles or diatoms. These elements are often coated and reinforced with siliceous material. Besides colorless and yellow, several red or purple species are common. Aperture is terminal, lenticular or slit-like, with thin organic rim, with acute notches at edges. Some species have endosymbiotic zoochlorellae. Ecology: freshwater, moss, soil. Type species: *Heleopera sphagni* (Leidy, 1874) (fig. 74).

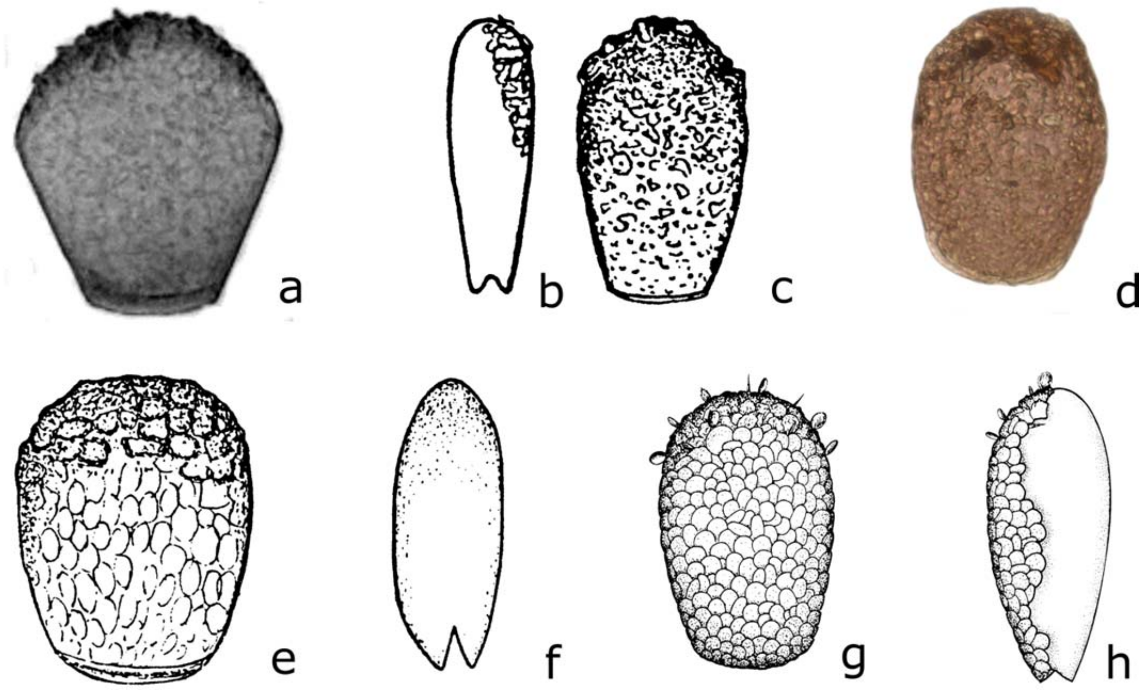

Fig. 74. Genus *Heleopera*:
a – *H. lata* broad lateral view (after Cash et al., 1909); b, c – *H. petricola* narrow (b) and broad (c) lateral view (after Geltzer et al., 1995); d – *H. rosea* broad lateral view; e, f – *H. sphagni* broad (e) and narrow (f) lateral view (after Geltzer et al., 1995); g, h – *H. sylvatica* broad (g) and narrow (h) lateral view (after Lüftenegger, Foissner, 1991)

Genus *Jungia* Loeblich et Tappan, 1961

Shell is globular to ovate, cross section is circular, covered with irregular polygonal or elongate plates. Aperture is terminal, circular, surrounded by sand grains forming a short collar. Ecology: mosses. Type species: *Jungia sudanensis* van Oye, 1949 (fig. 75).

Genus *Lagenodifflugia* Medioli et Scott, 1983

Shell pyriform, with a constriction of the neck, cross section is circular or slightly compressed, composed of mineral particles bounded by a structured organic cement network. In the region of the constriction, the shell is divided in two parts by a diaphragm-like part of the shell wall with a single central opening. Aperture is terminal, circular. Ecology: freshwater, *Sphagnum*. Type species: *Lagenodifflugia vas* (Leidy, 1874) Medioli et Scott, 1983 (fig. 76).

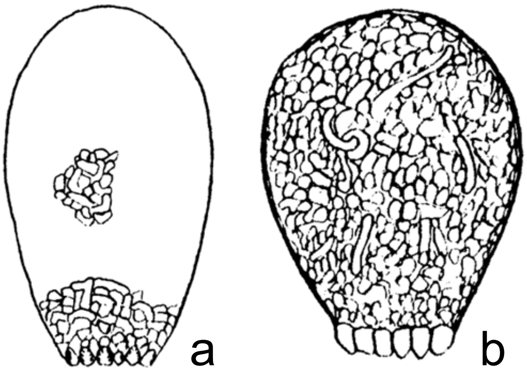

Fig. 75. *Jungia sudanensis*: a – narrow lateral view; b – broad lateral view (after Oye, 1951)

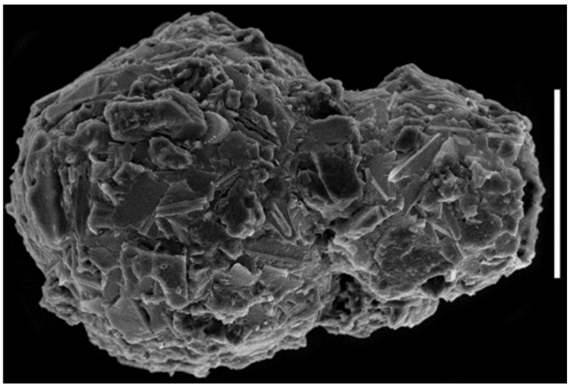

Fig. 76. *Lagenodifflugia montana*: lateral view (after Ogden, Živković, 1983). Scale bar 50 µm

Genus *Leptochlamys* West, 1901

Shell is ovoid or flask-shaped, cross section is circular; completely organic, non-alveolar, no exogenous material. Aperture is terminal, circular, with short collar. Ecology: freshwater. Two species. Type species: *Leptochlamys ampullacea* West, 1901. Also includes *Leptochlamys galippei* Schmidt et al., 2010 described from amber (fig. 77).

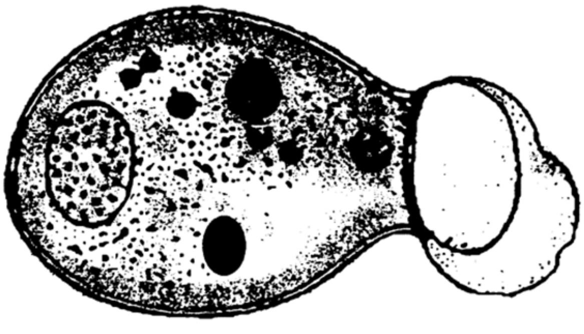

Fig. 77. *Leptochlamys ampullacea*: lateral view (after West, 1901)

Genus *Lesquereusia* Schlumberger, 1845

Shell with asymmetrical neck, more or less attached to the body; composed of endogenous siliceous rods or in some species with collected mineral particles in structured mesh-like cement. Fundus is rounded. Aperture is located at the end of the neck, circular in cross section. Ecology: freshwater. Type species: *Lesquereusia spiralis* (Ehrenberg, 1840) Bütschli, 1888 (fig. 78).

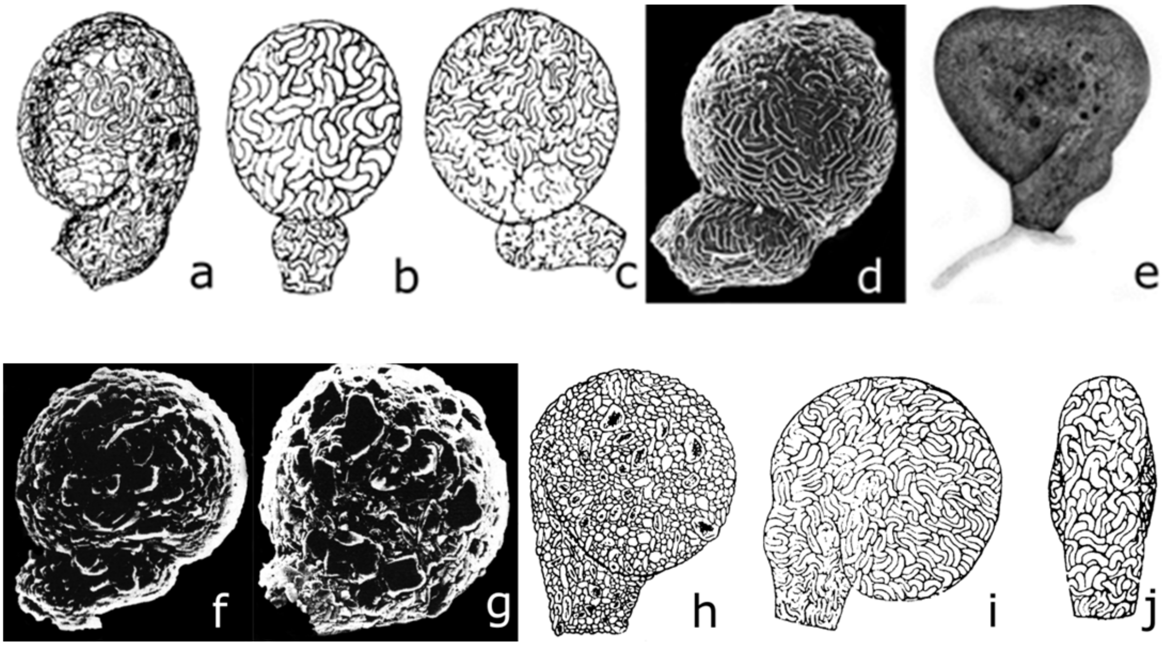

Fig. 78. Genus *Lesquereusia*:
a – *L. combinata* lateral view (after Bartoš, 1954); b–d – *L. epistonium* narrow (b), broad (c, d) lateral view (b, c – after Bartoš, 1954; d – after Ogden, 1984); e – *L. inequalis* lateral view (after Cash, Hopkinson, 1909); f – *L. longicollis* lateral view (after Dekhtiar, 1994); g – *L. longicollis depressa* lateral view (after Dekhtiar, 1994); h – *L. modesta* lateral view (after Bartoš, 1954); i, j – *L. spiralis* broad (i) and narrow (j) lateral view (after Bartoš, 1954)

Genus *Maghrebia* Gauthier-Lièvre et Thomas, 1960

Shell is cylindroid, slightly compressed in cross section, round base; constricted at short neck with four ridges like water jar with handles; covered with embedded siliceous particles. Aperture is terminal, circular. Habitat: tropical freshwater. Monospecific. Type species: *Maghrebia spatulata* Gautier-Lièvre et Thomas, 1958 (fig. 79).

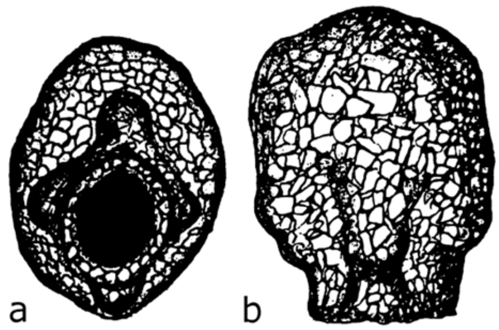

Fig. 79. *Maghrebia spatulata*:
a – aperture view; b – lateral view (after Gauthier-Lièvre, Thomas, 1958)

Genus *Mediolus* Patterson, 2014

Shell is ovoid to subspherical to spheroid; circular in cross-section, about the vertical aperture through the fundus; shell wall comprised of agglutinating particles variously composed of xenogenous mineral grains and/or organic material derived from the ambient environment; agglutinating particles attached together with an organic cement; circular aperture characterized by thin collar of secreted cement with variable number of inward-oriented angular crenulations also composed of cement; delicate spines may be present, spines long and narrow, hollow, and composed of very fine agglutinating particles. Ecology: freshwater. Type species: *Mediolus corona* (Wallich, 1864) (fig. 80).

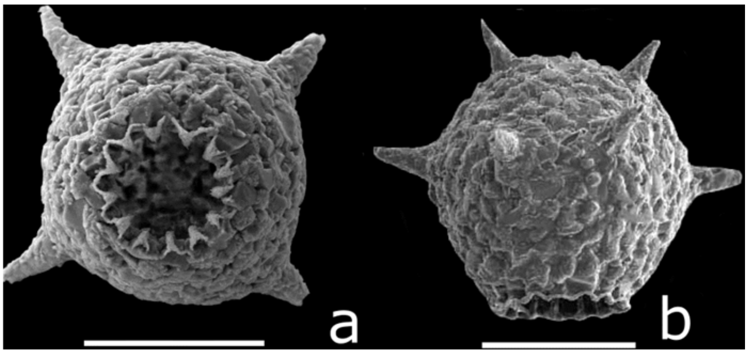

Fig. 80. *Mediolus corona*:
a – aperture view; b – lateral view (after Patterson, 2014). Scale bar 100 μm

Genus *Microquadrula* Golemansky, 1968

Shell is ovoid, circular in cross-section, covered with square or rectangular siliceous plates. Aperture is terminal, circular, truncated. Ecology: moss. Monospecific. Type species: *Microquadrula musciphila* Golemansky, 1968 (fig. 81).

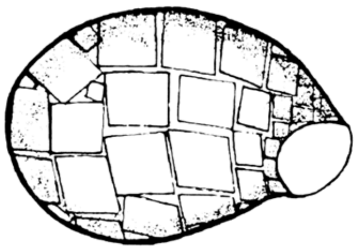

Fig. 81. *Microquadrula musciphila*:
lateral view (after Golemansky, 1968)

Genus *Oopyxis* Jung, 1942

Shell is ovoid, round or oval in cross section, ventral face is never flat; brown. Shell is covered with silica plates, irregular shape. Aperture is subterminal, slightly invaginated, irregular shape, relatively narrow, may be surrounded by large mineral particles. Ecology: freshwater. Type species: *Oopyxis cophostoma* Jung, 1924 (fig. 82).

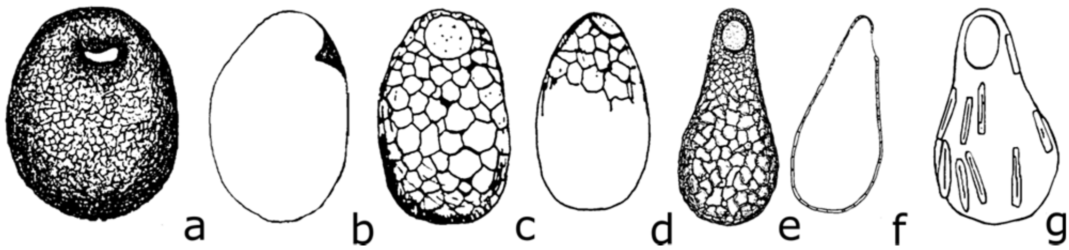

Fig. 82. Genus *Oopyxis*:
a, b – *O. cophostoma* aperture (a) and lateral (b) view (after Jung, 1942); c, d – *O. cyclostoma* aperture (c) and lateral (d) view (after Schönborn, 1965a); e, f – *O. danubialis* aperture (e) and lateral (f) view (after Godeanu, 1972); g – *O. islandica* aperture view (after Décloître, 1966)

Genus *Pentagonia* Gauthier-Lièvre et Thomas, 1960

Shell is pyriform; in cross-section polygonal with three to five lateral swellings sometimes terminating in a horn; fundus with horn; covered with mineral particles. Aperture is terminal circular, with a short collar. Ecology: freshwater. Monospecific. Type species: *Pentagonia maroccana* Gautier-Lièvre et Thomas, 1958 (fig. 83).

Genus *Physochilla* Jung, 1942

Shell is pyriform, slightly compressed; covered with siliceous exogenous plates, grey in color. Aperture is terminal, more or less circular, with collar recurved posteriorly. Ecology: mosses. Type species: *Physochilla griseola* Wailes et Penard, 1911 (fig. 84).

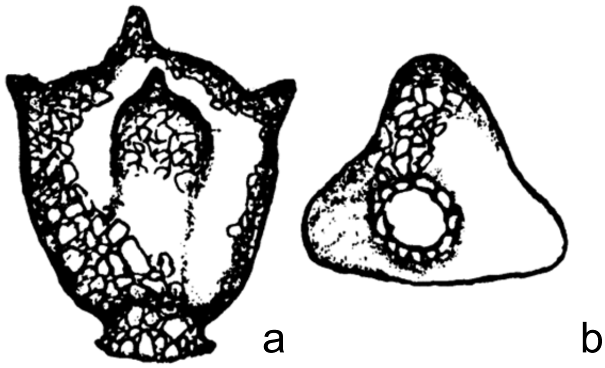

Fig. 83. *Pentagonia maroccana*:
a – lateral view; b – aperture view
(after Gauthier-Lièvre, Thomas, 1958)

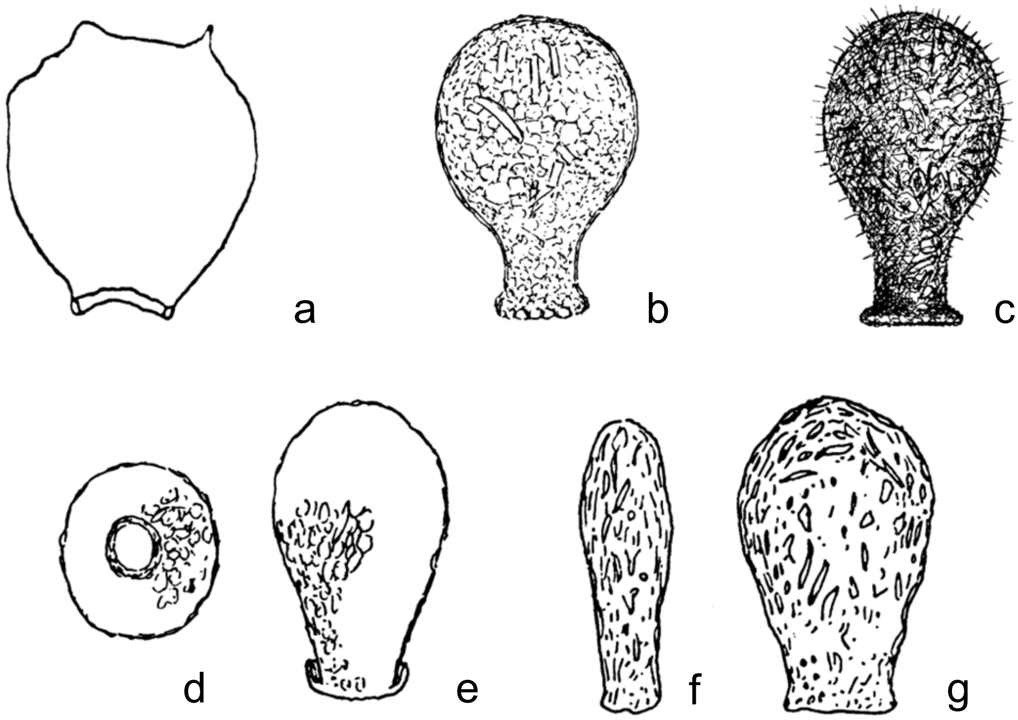

Fig. 84. Genus *Physochilla*:
a – *P. corniculata* lateral view (after Jung, 1942); b – *P. cratera* lateral view (after Wailes, 1912); c – *P. gauthier-lievri* lateral view (after Štěpanėk, 1963); d, e – *P. griseola* aperture (d) and lateral (e) view (after Penard, 1911); f, g – *P. tenella* narrow (f) and broad (g) lateral view (after Penard, 1893)

Genus *Pomoriella* Golemansky, 1970

Shell is flask-shaped, with a bent neck; covered with siliceous, non-overlapping, intrinsic plates. Aperture is terminal, circular. Ecology: interstitial. Type species: *Pomoriella valkanovi* Golemansky, 1970 (fig. 85).

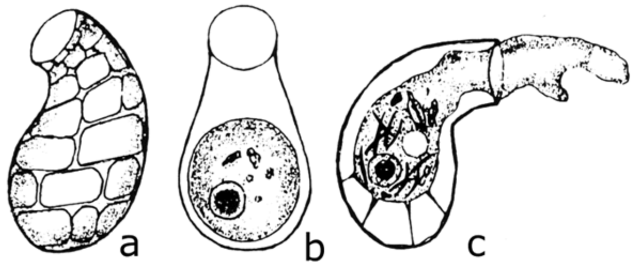

Fig. 85. *Pomoriella valkanovi:*
a – lateral view; b – aperture view; c – lateral view with pseudopodia (after Golemansky, 1970b)

Genus *Pontigulasia* Rhumbler, 1896

Shell is pyriform, circular or slightly compressed in cross-section, sometimes with a constriction between the main body and the neck. In the region of the constriction the shell is divided internally into two parts by a narrow mainly organic bridge with few attached mineral particles, which connects both broad sides. Shell is composed mainly of agglutinate mineral particles with some diatom frustules. Aperture is terminal, circular. Ecology: freshwater, mosses. Type species: *Pontigulasia rhumbleri* Hopkinson, 1919 (fig. 86).

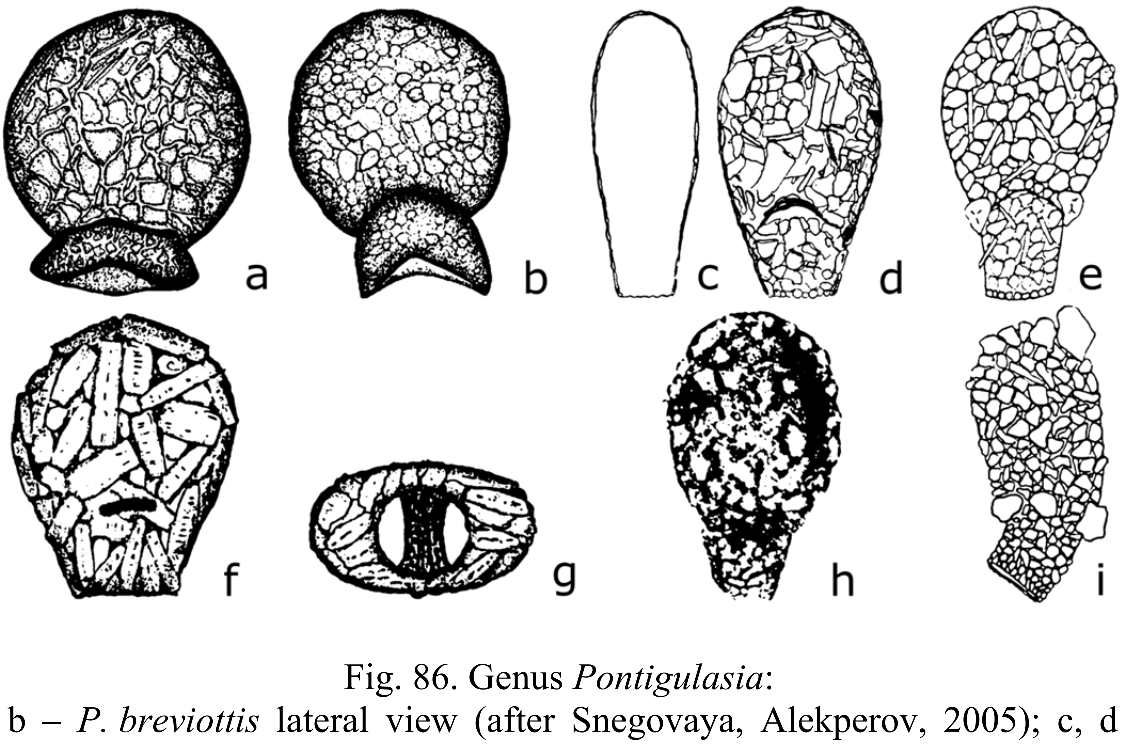

Fig. 86. Genus *Pontigulasia*:
a, b – *P. breviottis* lateral view (after Snegovaya, Alekperov, 2005); c, d – *P. compressoidea* narrow (c) and broad (d) lateral view (after Chardez, 1958); e – *P. incisa* lateral view (after Bartoš, 1954); f, g – *P. rhumbleri* lateral (f) and aperture (g) view (after Cash et al., 1919); h – *P. sarrazinensis* lateral view (after Chardez, Gaspar, 1984); i – *P. spiralis* lateral view (after Bartoš, 1954)

Genus *Protocucurbitella* Gauthier-Lièvre et Thomas, 1960

Shell is agglutinated, ovoid, cross section is round. Aperture is circle, denticulate, surrounded by a diaphragm around peristome. Ecology: freshwater. Type species: *Protocucurbitella coroniformis* Gautier-Lièvre et Thomas, 1960.

Note: The taxonomic status of the genus is unclear and widely discussed (Dekhtiar, 1993; Snegovaya, Alekperov, 2010; Patterson, 2014).

Genus *Pseudocucurbitella* Gauthier-Lièvre et Thomas, 1960

Shell is agglutinated, ovoid, cross section is round. Aperture is circular, surrounded with 3–5 separate lobes forming a short collar. Ecology: freshwater. Type species: *Pseudocucurbitella subangelica* Gauthier-Lièvre & Thomas, 1960.

Note: The taxonomic status of the genus is unclear. Probably it has affinities to lobed *Difflugia* as well as to the genus *Cucurbitella*.

Genus *Pseudawerintzewia* Bonnet, 1959

Shell is oviform, circular in cross section; mainly composed of small siliceous plates, pasted together with abundant brown organic cement and arranged so that the shell surface appears smooth. Aperture is terminal in fattened center of the broader end, small, elliptical or circular, thickened lip, no collar. Ecology: soils. Type species: *Pseudoawerintzewia calcicola* Bonnet, 1959 (fig. 87).

Genus *Pseudonebela* Gauthier-Lièvre, 1953

Shell is flask-like, round in cross section; composed of organic secretion of an apparently smooth cement and agglutination of extraneous particles including diatoms and, more commonly, many rounded plates, and with many small irregular platelets juxtaposed in between the larger rounded plates. Aperture is terminal, surrounded by an organic lip with 3–11 denticulations that give the opening a lobed appearance. Ecology: tropical freshwater. Monospecific. Type species: *Pseudonebela africana* Gautier-Lièvre, 1953 (fig. 88).

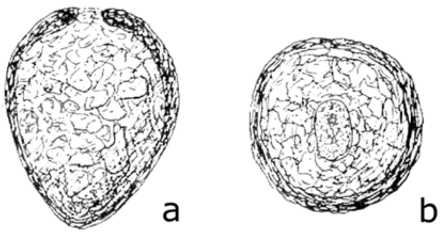

Fig. 87. *Pseudoawerintzewia calciola*: a – lateral view; b – aperture view (after Bonnet, 1959)

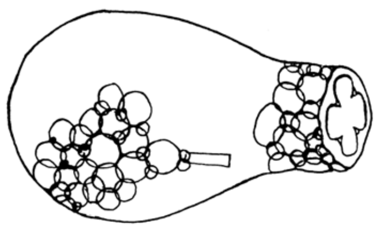

Fig. 88. *Pseudonebela africana*: lateral view (after Gauthier-Lièvre, 1953)

Genus *Pyxidicula* Ehrenberg, 1838

Shell is round in frontal view, hemispheric in lateral view; shell wall areolate, composed of organic, hollow building units, which in older, brown specimens become filled with inorganic material like manganese. Aperture is almost as wide as the diameter of the shell, apertural rim is usually recurved outside. One vesicular nucleus. Ecology: freshwater, soils. Type species: *Pyxidicula operculata* (Agardh, 1827) Ehrenberg, 1834 (fig. 89).

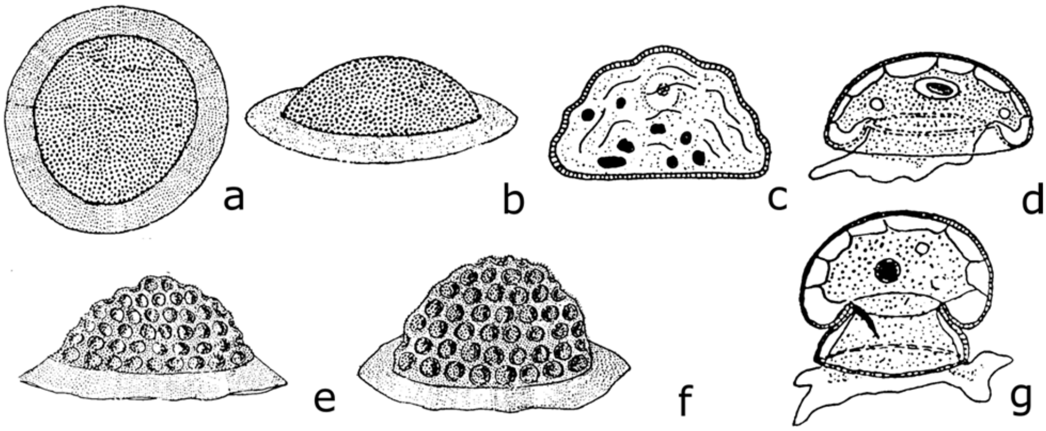

Fig. 89. Genus *Pyxidicula*:
a, b – *P. cymbalum* lateral (b) and dorsal view (a) (after Bartoš, 1954); c – *P. gibbosa* lateral view (after Schönborn, 1966a); d – *P. operculata* lateral view (after Bartoš, 1954); e, f – *P. ornata* (after Bartoš, 1954); g – *P. patens* lateral view (after Bartoš, 1954)

Genus *Schoenbornia* Décloître, 1964

Shell is ovoid, circular in cross section, hyaline, transparent; composed of collected idiosomes of small euglyphids, angular quartz and amorphous siliceous elements. Schönborn et al. (1987) suppose that the latter are produced by amoebae, but this remains unproved. Aperture is terminal, circular. Ecology: soils. Type species: *Schoenbornia humicola* Schönborn, 1964 (fig. 90).

Note: *Heleoporella* Coûteaux, 1978 is probably a synonym of this genus.

Genus *Schwabia* Jung, 1942

Shell is ovoid, circular in cross section, chitinous with small small mineral particles which produce a smooth surface; opaque, grayish, dirt-yellow or brown in color. Aperture is terminal, circular. Ecology: freshwater, soils. Type species: *Schwabia regularis* Jung, 1942 (fig. 91).

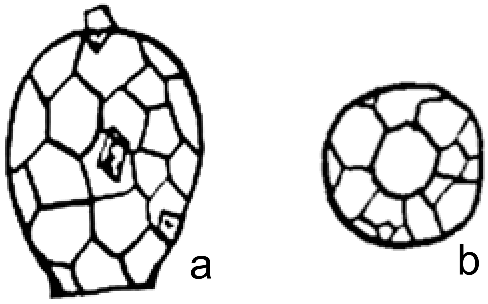

Fig. 90. *Schoenbornia vescicula*:
a – lateral view; b – aperture view
(after Schönborn, 1964)

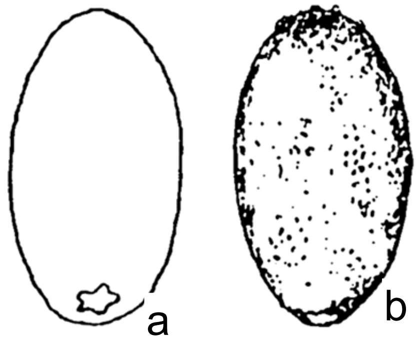

Fig. 91. *Schwabia regularis*:
a – aperture-lateral view; b – lateral
view (after Jung, 1942a)

Genus *Sexangularia* Awerintzew, 1906

Shell is angular in frontal view; polygonal, mostly hexagonal, in cross section, completely organic. Aperture is terminal, circular. Nucleus is vesicular. Ecology: freshwater, *Sphagnum*. Type species: *Sexangularia minutissima* (Penard, 1904) Deflandre, 1931 (fig. 92).

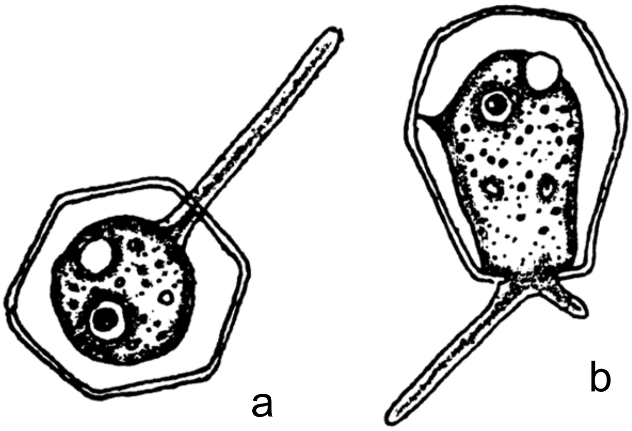

Fig. 92. *Sexangularia minutissima*:
a – aperture view; b – lateral view (after Deflandre, 1953)

Genus *Suiadifflugia* Green, 1975

Shell is sub-spherical, cross section is circular, covered by xenosomes. Aperture is terminal, complex, consisting of a central pore and numerous elongate oval pores radiating around the central pore like the petals of a flower. Ecology: freshwater plants and sediments. Monospecific. Type species: *Suiadifflugia multipora* Green, 1975.

Genus *Zivkovicia* Ogden, 1987

Shell is pyriform, mostly with a distinct constriction of the neck which sometimes can be obscured by larger mineral particles, circular or compressed in cross section, built of agglutinated mineral particles bound by a structured organic cement. The neck is separated from the main body of the shell by an internal mineral diagram with two circular openings. Aperture is terminal, circular. Ecology: freshwater. Type species: *Zivkovicia compressa* (Carter, 1864) (fig. 93).

Fig. 93. Genus *Zivkovicia*:
a, b – *Z. compressa* broad (a) and narrow lateral view (b) (after Cash, Hopkinson, 1909); c, d – *Z. flexa* narrow (c) and broad (d) lateral view (after Cash, Hopkinson, 1909); e – *Z. spectabilis* lateral view (after Bartoš, 1954)

Chapter 3
Order Euglyphida Copeland, 1956, emend. Cavalier-Smith, 1997

Shell is made of organic material; most taxa with secreted silica scales held together by an organic cement; tubular mitochondrial cristae.

Key to the families of the order and genera *incertae sedis*

1. Shell is radially symmetrical; cross section is circular or elliptic 2

1'. Shell is bilaterally symmetrical 12

2. Shell is organic, without scales; if scales present, they are long, with length perpendicular to aperture ....**Family Paulinellidae**

2'. Shell is covered by scales 3

3. Shell with a with a straight cylindrical neck ....**Genus *Ampullataria***

3'. Shell without neck, if present very short 4

4. Fundus with scaly spine of variable length ...**Genus *Pareuglypha***

4'. Fundus is without scaly spine 5

5. Scales are overlapping, regularly distributed...............................6

5'. Scales are non-overleaping, randomly distributed 11

6. Aperture is surrounded by specialized scales...............................7

6'. No specialized type of scales around aperture 9

7. Scales around aperture are denticulate..8

7'. Scales around aperture are small, circular or oval, without teeth.. **Family Sphenoderiidae**

8. Shell surface is tuberculate due to large elongate idiosomes surrounded by smaller idiosomes.......................................**Genus *Pileolus***

8'. Shell surface is flat .... **Family Euglyphidae**

9. Aperture is circular or elongate...10

9'. Aperture is slit-like or slightly arched, located at right angle to the broad diameter, with clear organic rim ....**Genus *Heteroglypha***

10. Shell is compressed in cross section, covered by small oval overlapping scales .... **Family Assulinidae**

10'. Shell cross-section is circular, covered by large, circular overlapping idiosomes ....**Genus *Tracheleuglypha***

11. Idiosomes of two types: large and small ... **Genus *Heteroglypha***
11'. Idiosomes of the same size ....**Genus *Matsakision***
12. Aperture is surrounded by specialized
tooth-shaped scales... **Family Trinematidae**
12'. No specialized tooth shaped scales around aperture............... 13
13. Shell aperture angled, some with collar ....
.... **Family Cyphoderiidae**
13'. Dorsal side the shell forms a small cap over the aperture, sometimes with a narrow organic lip along the edge..................................
.... **Genus *Deharvengia***

Suborder Euglyphina Kosakyan et al., 2016

Comprises the last common ancestor of families Assulinidae, Euglyphidae, Sphenoderiidae and Trinematidae and all its descendants.

Family Assulinidae Lara et al., 2007

Acrostome shell composed of elliptic plates disposed in a regular, alternate pattern; shell strongly compressed; no specialized type of scales around aperture. Includes three genera: *Assulina, Placocista, Valkanovia*.

Key to the genera of the family

1. Aperture is slit-like, biconvex, shell often with
spines..**Genus *Placocista***
1'. Aperture is oval or circular, never with spines 2
2. Aperture is crenulate .... **Genus *Assulina***
2'. Aperture is smooth..**Genus *Valkanovia***

Genus *Assulina* Leidy, 1879

Shell is ovoid or broad oval, flattened, biconvex in cross section, covered by overlapping elliptical idiosomes, clear to brown. Aperture is narrow oval, more or less crenulate, formed by organic margin. Ecology: mosses, soils. Type species: *Assulina seminulum* (Ehrenberg, 1848) Leidy, 1879 (fig. 94,a–k).

Genus *Placocista* Leidy, 1879

Shell is ovoid, flattened, with an acute lateral border; edge may bear many short, often paired, lanceolate spines, cemented between scales. Idiosomes are broad- or long-elliptic, sometimes circular, margins overlap. Aperture is large, narrowly biconvex, with pointed edges, in lateral view incised and surrounded by a thin rim of organic cement. Cytoplasm sometimes contains zoochlorellae. Habitat: mosses. Type species: *Placocista spinosa* (Carter, 1865) (fig. 94,l–y).

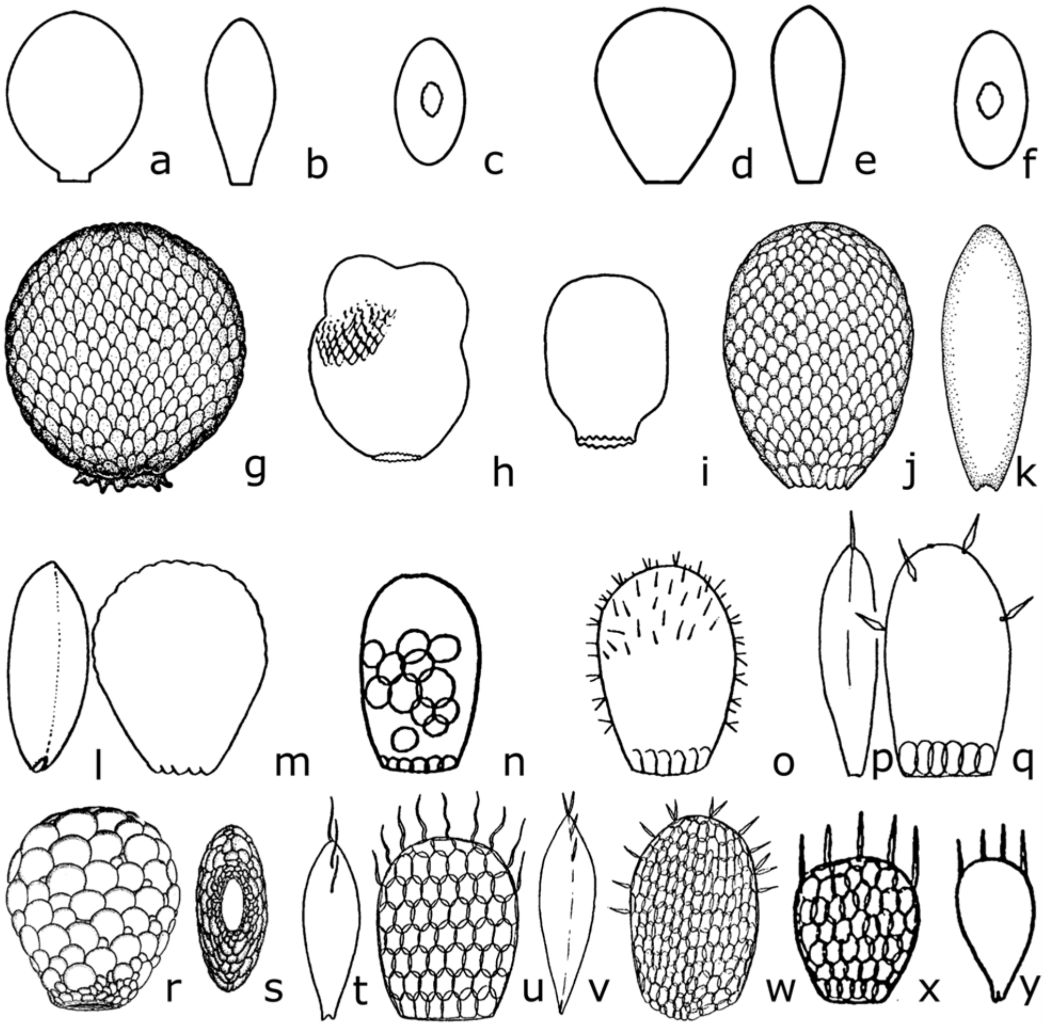

Fig. 94. Genera *Assulina* and *Placocista*:
a–c – *A. collaris* broad (a), narrow (b) lateral and aperture (c) view (after Schönborn, Peschke, 1988); d–g – *A. muscorum* broad (d, g), narrow (e) lateral and aperture (f) view (d–f – after Schönborn, Peschke, 1988; g – after Lüftenegger, Foissner, 1991); h, i – *A. quadratum* broad lateral view (after Oye, 1958); j, k – *A. seminulum* broad (j) and narrow (k) lateral view (after Lüftenegger et al., 1988); l, m – *P. glabra* narrow (l) and broad (m) lateral view (after Jung, 1936); n – *P. glabra minima* broad lateral view (after Décloître, 1955); o – *P. jurassica* broad lateral view (after Penard, 1905); p, q – *P. lapponum* narrow (p) and broad (q) lateral view (after Penard, 1917); r, s – *P. lens* broad lateral (r) and aperture (s) view (after Rauenbush, 1987); t, u – *P. sinuospina* narrow (t) and broad (u) lateral view (after Chardez, 1966); v, w – *P. spinosa* in narrow (v) and broad (w) lateral view (after Chardez, 1966); x, y – *P. ventricosa* broad (x) and narrow (y) lateral view (after Chardez, 1966)

Genus *Valkanovia* Tappan, 1966

Valkanovia is closely related to *Assulina* and differs from it by the smooth aperture edge. The shell is generally colorless. The status of the genus is uncertain as there are transitional forms between the genera. Ecology: soils. Type species: *Valkanovia delicatula* (Valkanov, 1962) Tappan, 1966 (fig. 95).

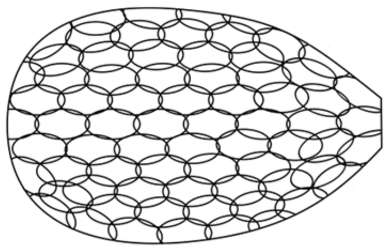

Fig. 95. *Valkanovia delicatula*:
broad lateral view (after Valkanov, 1962)

Family Euglyphidae Wallich, 1864, emend. Lara et al., 2007

Acrostome shell composed of elliptic, sub-rectangular, scutiform, or almost circular body plates which are disposed in a regular, alternate pattern. Aperture is surrounded by denticulate plates (Lara et al., 2007). Includes two genera: *Euglypha, Scutiglypha*.

Key to the genera of the family

1. Body scales are circular or ovoid .... **Genus *Euglypha***
1'. Body scales are scutiform or crenate ....**Genus *Scutiglypha***

Genus *Euglypha* Dujardin, 1841

Shell is radially symmetric, ovoid or long-ovoid, circular or elliptic in cross-section; covered by circular or ovoid endogenous siliceous plates which overlap and usually arranged in longitudinal rows. Sometimes, body scales carry needles or spines. Aperture is terminal (acrostome), circular or ovoid, always surrounded by denticulate plates of various form (oval, circular, rhombic, triangular). Shell is colorless, transparent, rare brownish or yellowish. Ecology: freshwaters, mosses, soils. Type species: *Euglypha tuberculata* Dujardin, 1841(fig. 96–98).

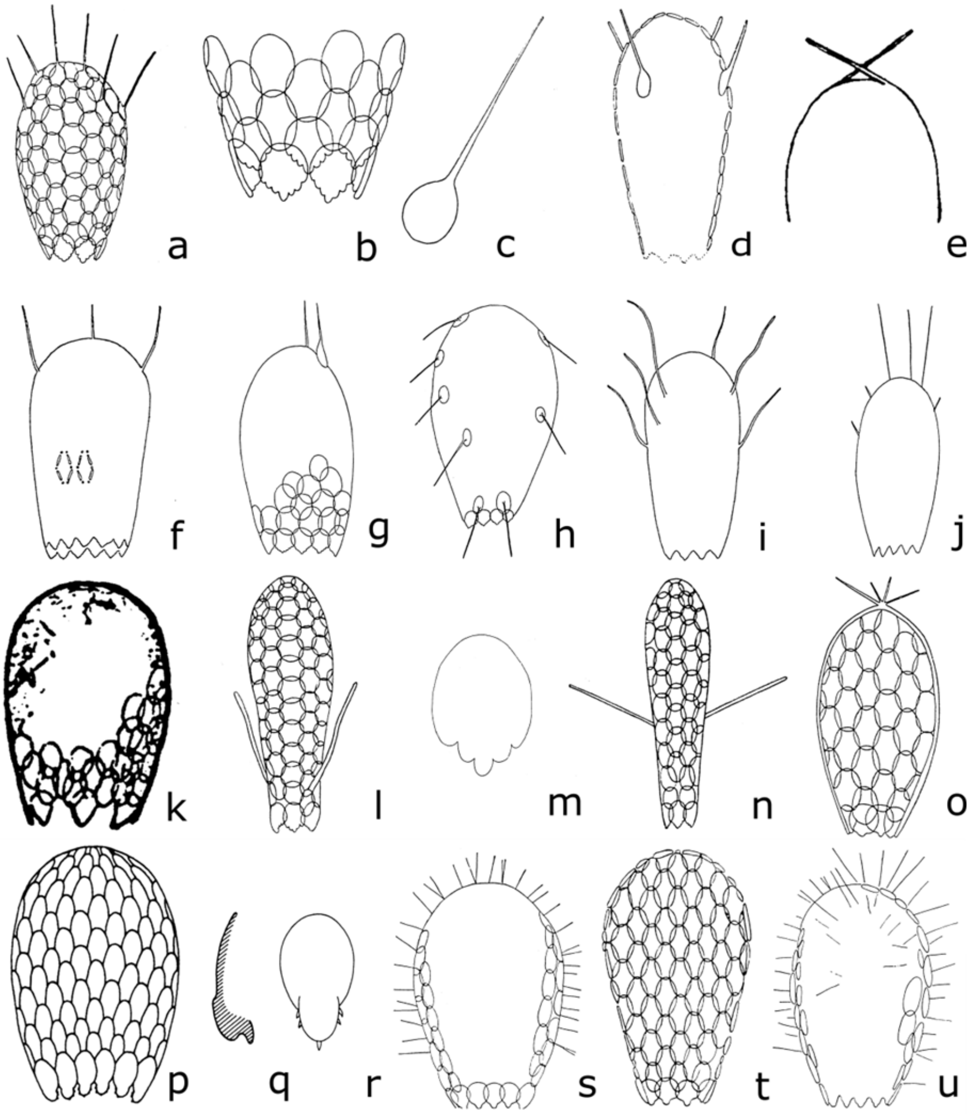

Fig. 96. Genus *Euglypha*:
a–c – *E. acanthophora* lateral view (a), aperture part (b), idiosomes with spine (c) (after Wailes, 1912); d – *E. acanthophora brevispina* lateral view (after Penard, 1902); e – *E. acanthophora cirrata* fundus base with spines (after Wailes, 1912); f – *E. acanthophora cylindracea* lateral view (after Playfair, 1917); g – *E. acanthophora deflandrei* lateral view (after Deflandre, 1956); h – *E. acanthophora equeis* lateral view (after Décloître, 1956); i – *E. acanthophora flexuosa* lateral view (after Penard, 1902); j – *E. acanthophora heterospina* lateral view (after Décloître, 1949); k – *E. anodonta* lateral view (after Geltzer et al., 1995); l, m – *E. brachiata* lateral view (l) and aperture idiosomes (m) (after Leidy, 1879); n – *E. brachiata librata* lateral view (after Wailes, 1912); o – *E. bryophila* lateral view (after Wailes, 1912); p–r – *E. capsiosa* lateral view (p), aperture idiosomes broad (r) and narrow (q) lateral view (after Coûteaux et al., 1979); s – *E. ciliata* lateral view (after Wailes, 1912); t – *E. ciliata glabra* lateral view (after Wailes, 1912); u – *E. ciliata heterospina* lateral view (after Wailes, 1912)

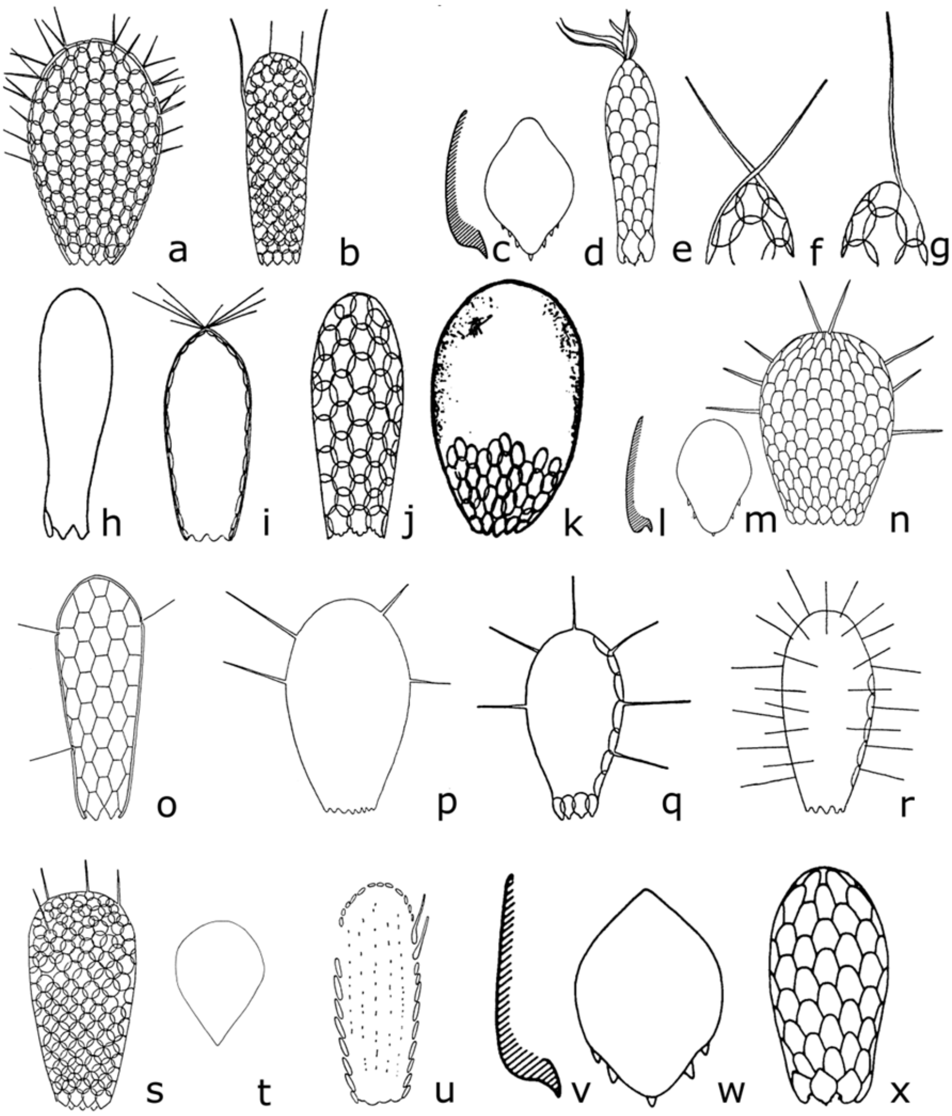

Fig. 97. Genus *Euglypha*:
a – *E. compressa* broad lateral view (after Wailes, 1912); b – *E. crenulata elongata* (after Thomas, 1958b); c–e – *E. cristata* lateral view (e), aperture idiosomes broad (d) and narrow (c) lateral view (after Coûteaux et al., 1979); f, g – *E. cristata acicularis* fundus base (after Wailes, 1912); h – *E. cristata decora* lateral view (after Jung, 1942); i – *E. cristata lanceolata* lateral view (after Playfair, 1917); j – *E. cristata major* lateral view (after Wailes, 1912); k – *E. denticulata* (after Geltzer et al., 1995); l–n – *E. filifera* lateral view (n) and aperture idiosomes broad (m) and narrow (l) lateral view (after Coûteaux et al., 1979); o – *E. filifera cylindracea* lateral view (after Playfair, 1917); p – *E. filifera magna* lateral view (after Oye, 1958); q – *E. filifera pyriformis* lateral view (after Wailes, 1913); r – *E. filifera spinosa* lateral view (after Wailes, 1912); s, t – *E. gauthieri* lateral view (s) and aperture idiosomes (t) (after Thomas, 1958); u – *E. hutchinsoni* (after Oye, 1932); v–x – *E. hyalina* lateral view (x), aperture idiosomes broad (w) and narrow (v) lateral view (after Coûteaux et al., 1979)

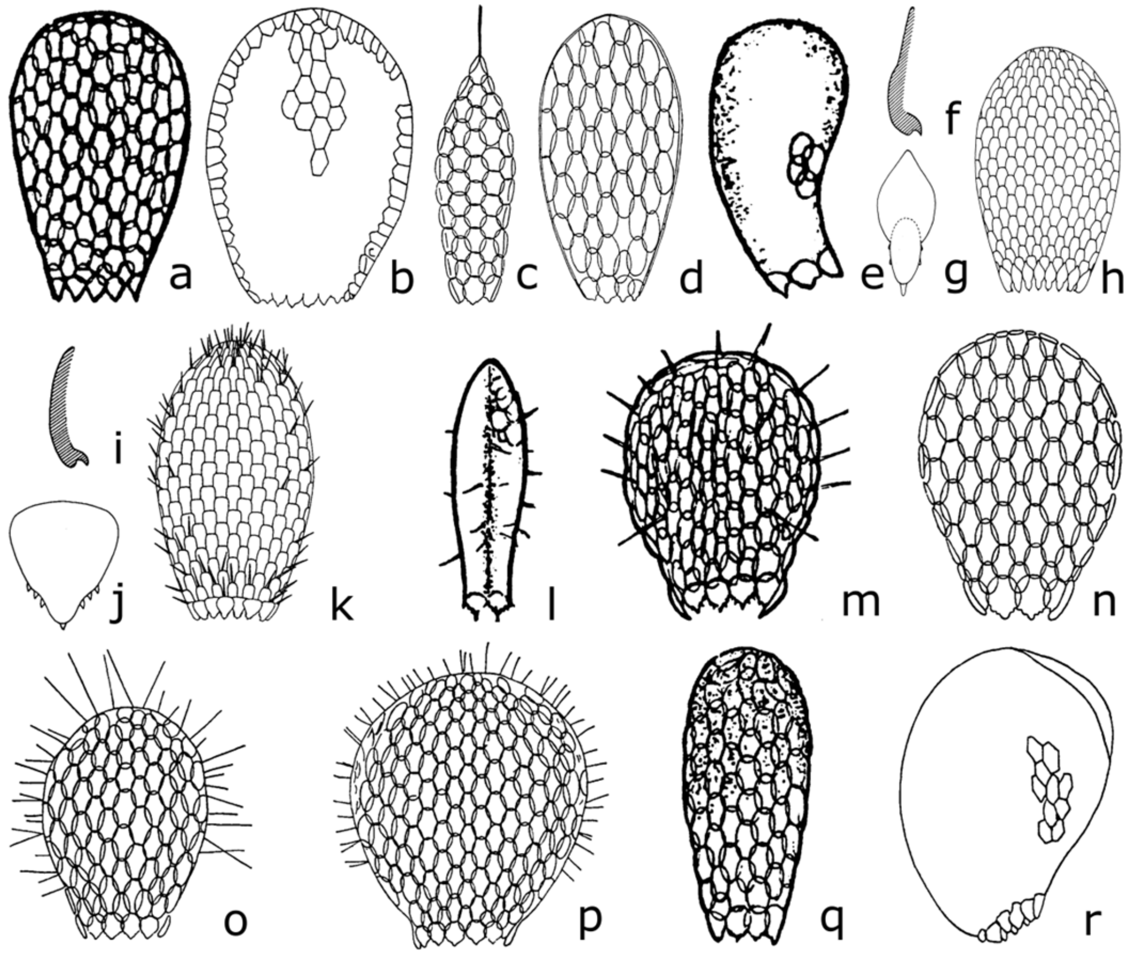

Fig. 98. Genus *Euglypha*:
a – *E. laevis* lateral view (after Geltzer et al., 1995); b – *E. marginata* lateral view (after Oye, 1958); c – *E. mucronata* lateral view (after Leidy, 1879); d – *E. rotunda* lateral view (after Cash et al., 1915); e – *E. rotunda oblique* lateral view (after Geltzer et al., 1995); f–h – *E. simplex* lateral view (h), aperture idiosomes broad (g) and narrow (f) lateral view (after Coûteaux et al., 1979); i–m – *E. strigosa* broad (k, m), narrow (l) lateral view, aperture idiosomes broad (j) and narrow (i) lateral view (i–j – after Coûteaux et al., 1979; l, m – after Geltzer et al., 1995); n – *E. strigosa glabra* lateral view (after Wailes, 1912); o – *E. strigosa heterospina* lateral view (after Wailes, 1912); p – *E. strigosa muscorum* lateral view (after Wailes, 1912); q – *E. tuberculata* lateral view (after Geltzer et al., 1995); r – *E. van oyei* lateral view (after Oye, 1958)

Genus *Scutiglypha* Foissner et Schiller, 2001

Body scales are scutiform or crenate. Ecology: freshwaters, mosses, soils. Type species: *Scutiglypha crenulata* Wailes, 1912 (basionym: *Euglypha crenulata* Wailes, 1912) (fig. 99).

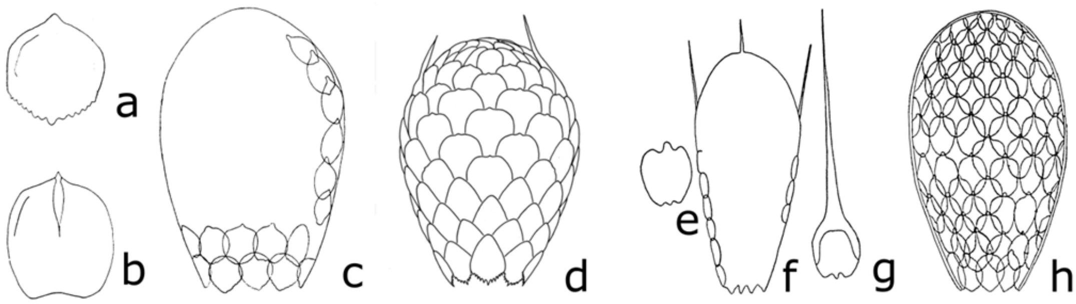

Fig. 99. Genus *Scutiglypha*:
a–c – *S. aspera* lateral view (c), aperture idiosome (a) and parietal idiosome (b) (after Penard, 1902); d – *S. cabrolae* lateral view (after Smet, Gibson, 2009); e–g – *S. crenulata* lateral view (f), parietal idiosome with spine (g) and without spine (e) (after Wailes, 1912); h – *S. scutigera* lateral view (after Penard, 1912)

Family Sphenoderiidae Chatelain, 2013

Shell is covered with self-secreted circular to elliptical silica scales that can be of different sizes and shapes, but without indentations. Aperture is surrounded with small circular or oval scales. Because usually one side ("ventral") of the aperture is shorter the opening lies subterminal. Includes two genera: *Sphenoderia, Trachelocorythion.*

Key to the genera of the family

1. Cross section of the shell is circular or oval.................................
....**Genus *Sphenoderia***

1'. Shell is compressed in cross- section...
.... **Genus *Tracheleocorythion***

Genus *Sphenoderia* Schlumberger, 1845

Scales of one or more types on the main body the shell, aperture slit-like, mostly surrounded by a collar that comprises small scales that can be sometimes invaginated (*S. sphaerica*). Circular or oval cross section (e.g. *S. compressa, S. labiata*). Ecology: freshwater, moss, soils. Type species: *Sphenoderia lenta* Schlumberger, 1845 (fig. 100).

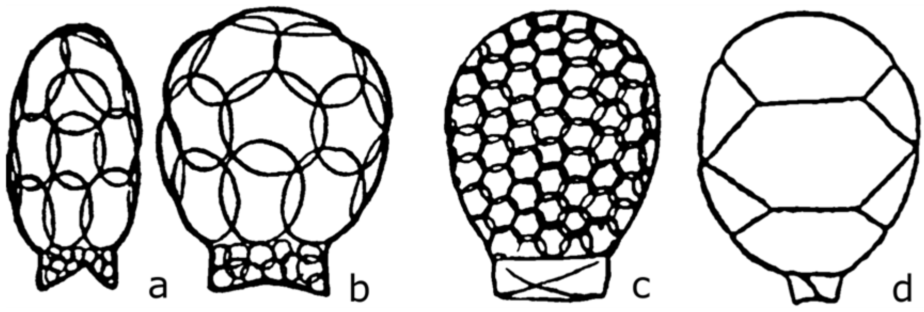

Fig. 100. Genus *Sphenoderia*:
a, b – *S. fissirostris* narrow (a) and broad (b) lateral view (after Geltzer et al., 1995); c – *S. lenta* broad lateral view (after Bartoš, 1954); d – *S. macrolepsis* broad lateral view (after Bartoš, 1954)

Genus *Trachelocorythion* Bonnet, 1979

Main body of the shell is covered by scales of regular size and shape; flattened cross section. The upper lip of the aperture larger than the lower resulting in a slightly subterminal opening, no collar. Ecology: dry soils to forest litter and *Sphagnum* mosses. Monospecific. Type species: *Trachelocorythion pulchellum* (Penard, 1890) Bonnet, 1979 (fig. 101).

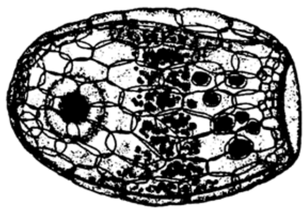

Fig. 101. *Trachelocorythion pulchellum*:
ventral view (after Meisterfeld, 2002b)

Family Trinematidae (Hoogenraad et de Groot, 1940) Adl et al., 2012

Shell with bilateral symmetry; scales oval or circular, sometimes of both types; specialized tooth-shaped scales around the aperture; aperture invaginated in some taxa. Includes four genera: *Corythion, Playfairina, Puytoracia, Trinema*.

Key to the genera of the family

1. Aperture is invaginated (lateral view)...2
1’. Aperture is not invaginated .... **Genus *Playfairina***
2. Body plates are usually of two sizes, the smaller plates filling the gaps between the larger ones..2

2’. Body plates are elongate oval, usually of the same size .... **Genus *Corythion***
3. Body scales are circular ....**Genus *Trinema***
3’. Body scales are elliptical ....**Genus *Puytoracia***

Genus *Corythion* Tarànek, 1881

In ventral view, the shell is ovoid; in lateral view the shell is compressed; cross-section lenticular lateral margins often slightly acute. Shell is covered by on type of body plates: circular, rectangular, imbricated, irregularly distributed but at lateral margins in rows. Aperture is invaginated, oval, semicircular or circular, surrounded by plates with one central tooth. Some species have short organic or siliceous spines. Type species: *Corythion dubium* Tarànek, 1881(fig. 102,a–i).

Genus *Playfairina* Thomas, 1961

Shell is circular in cross section, tapering towards the aperture; fundus rounded or pointed. Shell is covered large and small idiosomes, arrangement in most cases as in *Trinema*. Aperture is circular, not invaginated, surrounded by one row of denticulated marginal plates. Pseudopoida are unknown, but doe to the homologies in shell morphology *Playfairina* is placed here. Two species. Ecology: mosses, soils. Type species: *Playfairina caudata* (Playfair, 1917) Thomas, 1961 (fig. 102,j).

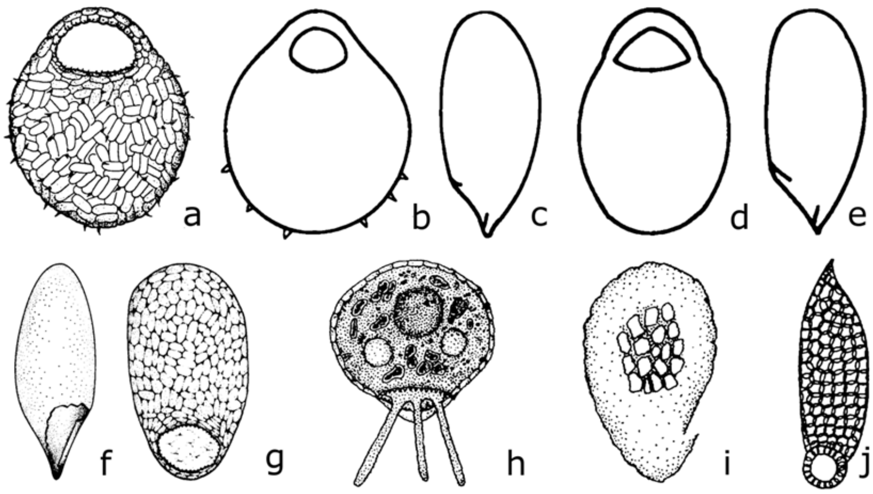

Fig. 102. Genera *Corythion* and *Playfairina*:
a–c – *C. asperulum* aperture (a, b) and lateral view (c) (a – after Lüftenegger, Foissner, 1991; b, c – after Schönborn, Peschke, 1998); d–g – *C. dubium* aperture (d, g) and lateral view (e, f) (d, e – after Schönborn, Peschke, 1998; f, g – after Lüftenegger et al., 1988); h, i – *C. orbicularis* aperture (h) and lateral view (i) (after Iudina, 1996); j – *P. cauduta* aperture view (after Thomas, 1961)

Genus *Trinema* Dujardin, 1841

In ventral view, shell is ovoid or broad oval, sometimes with almost parallel sides. In lateral view, the dorsal side is arched or flattened towards the aperture, ventral side is either flat or concave. Shell is covered by body-scales of two types: large circular plates and smaller circular or broad elliptical scales in between, overlapping. Aperture is sub-terminal or ventral, circular or oval, invaginated, surrounded by rows of toothed apertural plates. Ecology: freshwaters, mosses, soils. Type species: *Trinema enchelys* (Ehrenberg, 1838) Leidy, 1878 (fig. 103, 104,a–i).

Genus *Puytoracia* Bonnet, 1970

The genus is closely related to shell shape and size to genus *Trinema* and is distinguished by the presence of elliptical scales, covering the shell. Aperture is invaginated (Santibáñeza et al., 2011). Ecology: mosses, soils. Type species: *Puytoracia bergeri* Bonnet, 1970 (fig. 104,j–l).

Family Cyphoderiidae de Saedeleer, 1934

Scales are circular, oval or kidney-shaped, juxtaposed or imbricated; apertural end of the shell is angled, sometimes aperture is surrounded by collar. Includes six genera: *Campascus, Corythionella, Cyphoderia, Messemvriella, Pseudocorythion, Schaudinnula*.

Key to the genera of the family

1. Aperture is surrounded by a collar or a funnel............................ 3
1’. Aperture is without a collar or a funnel..................................... 2
2. Cross-section of the shell is circular .... **Genus *Cyphoderia***
2’. Cross-section is triangular .... **Genus *Schaudinnula***
3. Apertural collar is made of organic matrix of the shell................ 4
3’. Apertural collar is hyaline, fragile and rapidly disappears in empty shell .... **Genus *Campascus***
4. Fundus is rounded 5
4’. Fundus is pointed.................................. **Genus *Pseudocorythion***
5. Shell is dorso-ventrally compressed .... **Genus *Corythionella***
5’. Shell is circular in cross section .... **Genus *Messemvriella***

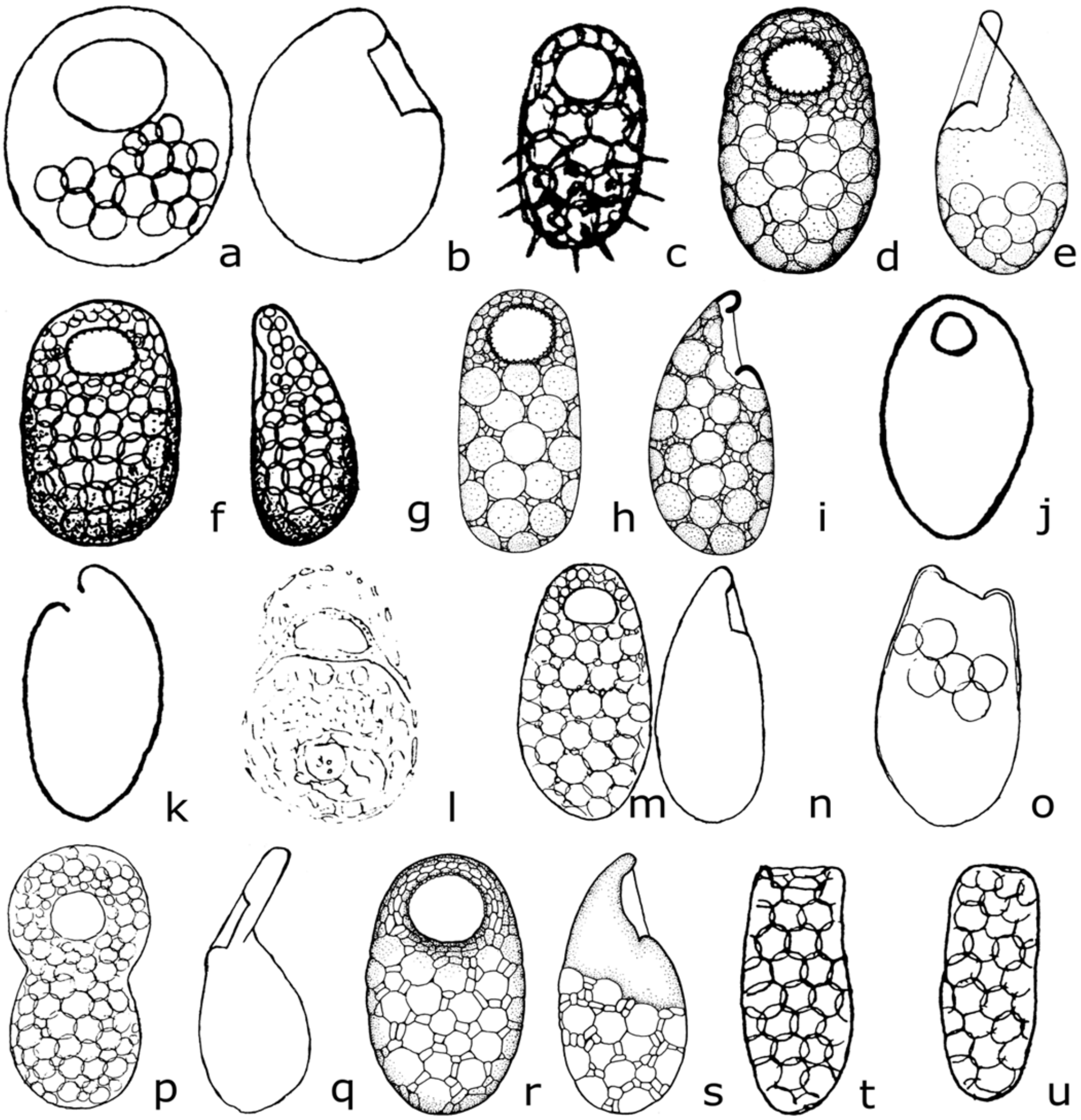

Fig. 103. Genus *Trinema*:
a, b – *T. chardezi* aperture (a) and lateral view (b) (after Décloître, 1981); c – *T. ciliata* aperture view (after Štěpànek, 1963); d–g – *T. complanatum* aperture (d, f) and lateral view (e, g) (d, e – after Lüftenegger et al., 1988; f, g – after Geltzer et al., 1995); h, i – *T. enchelys* aperture (h) and lateral view (i) (after Lüftenegger et al., 1988); j, k – *T. enchelys biconvex* aperture (j) and lateral view (k) (after Awerintzew, 1907); l – *T. galeata* (after Penard, 1890); m, n – *T. grandis* aperture (m) and lateral view (n) (after Chardez, 1960); o – *Trinema intermedia* lateral view (Décloître, 1965); p, q – *T. leidyi* aperture (p) and lateral view (q) (after Décloître, 1981); r, s – *T. lineare* aperture (r) and lateral view (s) (after Lüftenegger et al., 1988); t, u – *T. lineare truncatum* aperture (t) and lateral view (u) (after Chardez, 1964)

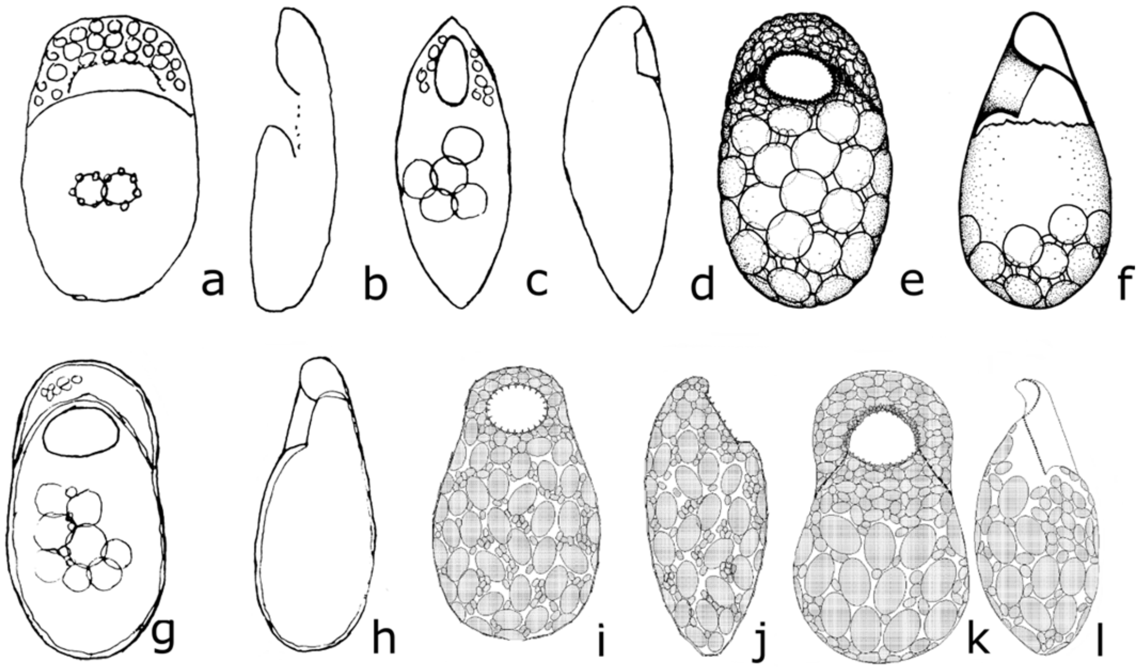

Fig. 104. Genera *Trinema* and *Puytoracia*:
a, b – *T. lincostoma* aperture (a) and lateral view (b) (after Décloître, 1962c); c, d – *T. navicularis* aperture (c) and lateral view (d) (after Décloître, 1973); e–h – *T. penardi* aperture (e, g) and lateral view (f, h) (d, e – after Lüftenegger et al., 1988; g, h – after Thomas, Chardez, 1958); i, j – *P. bergeri* aperture (i) and lateral view (j); k, l – *P. bonneti* aperture (k) and lateral view (l) (after Nicholls, 2006b)

Genus *Campascus* Leidy, 1879

Shell is broadly ovoid; in cross-section circular, ovoid or triangular. Neck is cylindrical, curved. Fundus is rounded or with up to three projections. Aperture is circular, surrounded by a characteristic hyaline collar. Composition of the shell is variable; some species have circular, other amorphous, siliceous scales sometimes mixed with mineral particles, usually not regularly arranged. Ecology: freshwater and marine. Type species: *Campascus cornutus* Leidy, 1879 (fig. 105).

Genus *Corythionella* Golemansky, 1970

Shell is ovoid, dorso-ventrally compressed; fundus is rounded. Aperture is circular, located on the ventral side, surrounded by large circular collar. Shell is covered with elongate, siliceous idiosomes, irregularly arranged as in *Corythion*, the plates of the collar are smaller (Nicholls, 2009b). Ecology: marine and freshwater interstitial. Type species: *Corythionella pontica* Golemansky, 1970 (fig. 106).

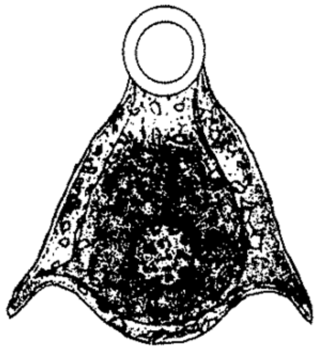

Fig. 105. *Campascus cornutus*: ventral view (after Leidy, 1879)

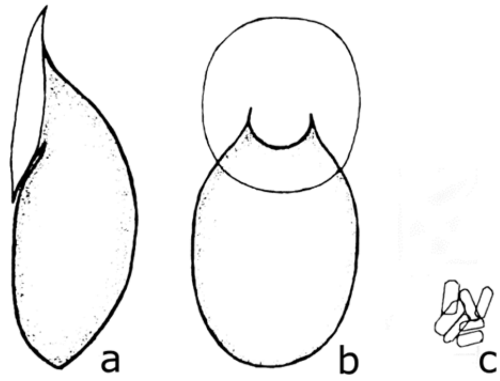

Fig. 106. *Corythionella pontica*: a – lateral view; b – apertural view; c – shell plates (after Golemansky, 1970b)

Genus *Cyphoderia* Schlumberger, 1845

Shell is retort-shaped laterally; ovoid in ventral and dorsal views, usually circular in cross-section, sometimes slightly compressed. Fundus is round or tapered to mammillate tip. Aperture is circular without a collar. Shell is covered by small circular or triangular plates, either adjoining or overlapping on organic matrix depending on species. Endoplasm contains refractive grains. Ecology: marine interstitial, freshwater and moss. Type species: *Cyphoderia ampulla* (Ehrenberg, 1840) Leidy, 1879 (fig. 107).

Genus *Messemvriella* Golemansky, 1973

Shell is retort-shaped laterally, ovoid in ventral and dorsal view, circular in cross section. Fundus is round. Shell is covered with regularly overlapping siliceous scales. Aperture is subterminal, circular, surrounded by a collar, which is less developed than in *Corythionella*. Ecology: marine interstitial. Type species: *Messemvriella filose* Golemansky, 1972 (fig. 108).

Genus *Pseudocorythion* Valkanov, 1970

Shell is ovoid in ventral view, tapering at both ends, slightly flattened dorso-ventrally. Fundus carries a small pointed spine of variable length. Shell is covered with small or oval overlapping plates which are randomly arranged. Aperture is located on the ventral side; surrounded by a large circular collar of the same size as the maximum breadth of the shell. Outer edge of the collar is with very thin organic rim. Ecology: marine interstitial. Type species: *Pseudocorythion acutum* (Wailes, 1927) (fig. 109).

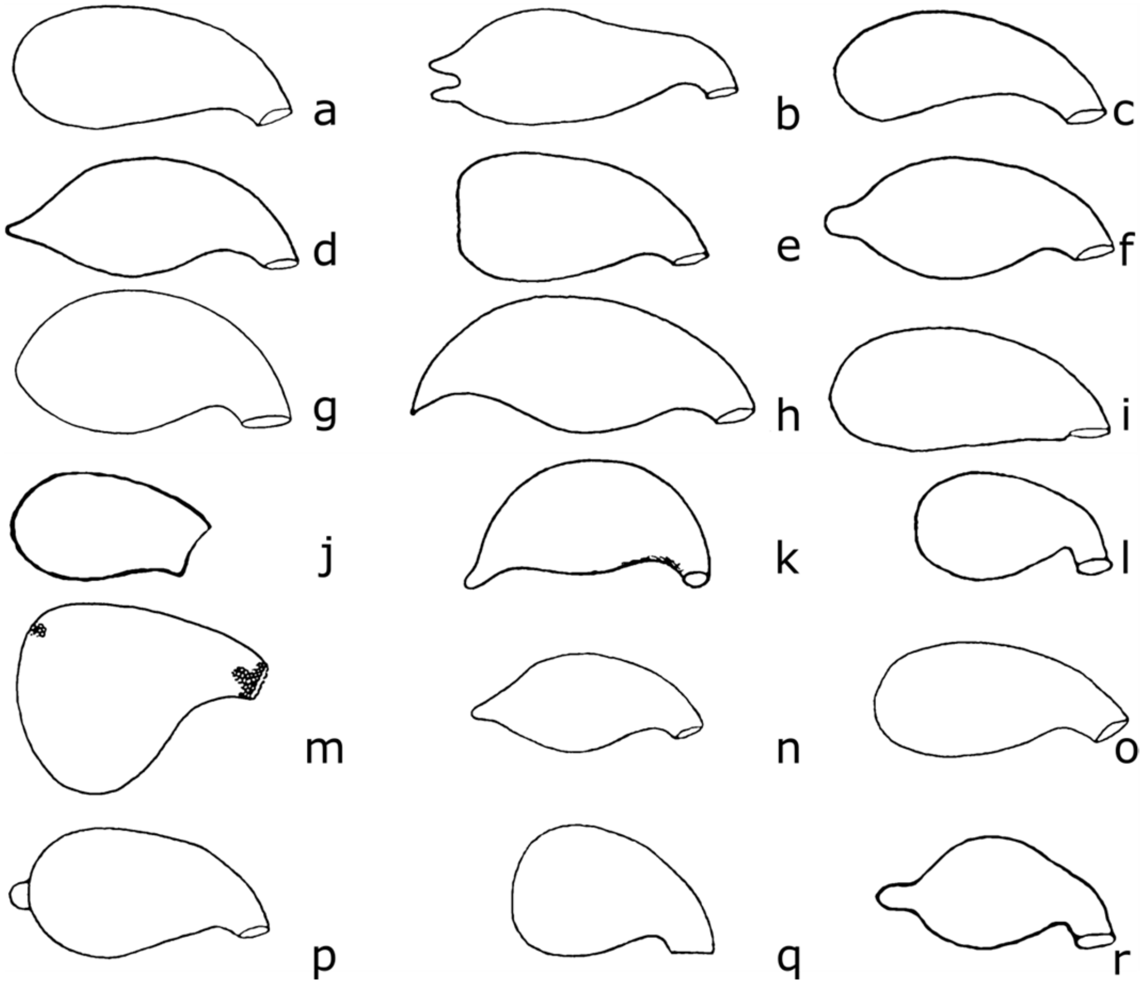

Fig. 107. Genus *Cyphoderia*:
a – *C. ampulla* lateral view (after Chardez, 1991); b – *C. ampulla bicornis* lateral view (after Chardez, 1991); c – *C. ampulla crassa* lateral view (after Chardez, 1991); d – *C. ampulla papillata* lateral view (after Chardez, 1991); e – *C. ampulla thomasi* lateral view (after Chardez, 1991); f – *C. ampulla virtae* lateral view (after Chardez, 1991); g – *C. bonetti* lateral view (after Štěpànek, 1967); h – *C. calceolus* lateral view (after Chardez, 1991); i – *C. compressa* lateral view (after Chardez, 1991); j – *C. loevis* lateral view (after Chardez, 1991); k – *C. lunata* lateral view (after Štěpànek, 1967); l – *C. perlucidus* lateral view (after Chardez, 1991); m – *C. schonborni* lateral view (after Laminger, 1973); n, o – *C. trochus* lateral view (after Chardez, 1991); p – *C. trochus amphoralis* lateral view (after Chardez, 1991); q – *C. ventricosa* lateral view (after Chardez, 1991); r – *C. venustus* lateral view (after Chardez, 1991)

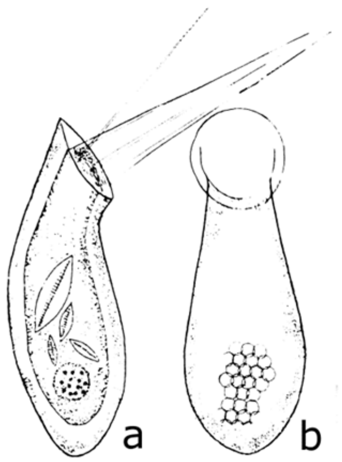

Fig. 108. *Messemvriella filose*:
a – lateral view; b – apertural view
(after Golemansky, 1973)

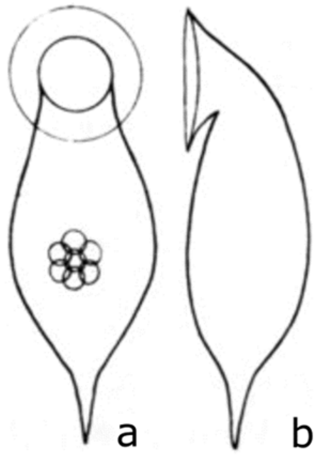

Fig. 109. *Pseudocorythion acutum*:
a – aperture view; b – lateral view
(after Wailes, 1927)

Genus *Schaudinnula* Awerintzew, 1907

Shell is retort-shaped ventrally, neck is bent more or less, fundus is pointed; cross-section is triangular. Shell is covered with circular overlapping idiosomes forming hexagonal structure. Aperture is circular, without a hyaline collar. Ecology: freshwater. Type species: *Schaudinnula arcelloides* Awerintzew, 1907 (fig. 110).

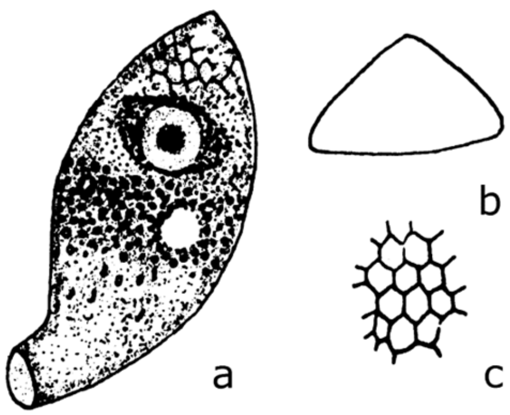

Fig. 110. *Schaudinnula arcelloides*:
a – lateral view; b, c – cover (after Schönborn, 1965a)

Family Paulinellidae de Saedeleer, 1934, emend. Adl et al., 2012

Pyriform, uncompressed shape; scales, when present, long, with length perpendicular to aperture. Includes three genera: *Micropyxidiella*, *Ovulinata, Paulinella.*

Key to the genera of the family

1. Shell is covered with siliceous rectangular plates, scarcely overlapping, arranged in circumferential longitudinal rows..**Genus *Paulinella***

1'.Shell is entirely organic without self-secreted scales or mineral particles 2

2. Fundus is pointed...................................**Genus *Micropyxidiella***

2'.Fundus is rounded... **Genus *Ovulinata***

Genus *Micropyxidiella* Tarnawski et Lara, 2015

Testate amoebae with filamentous pseudopodia, entirely organic shell (without self-secreted scales or mineral particles). Shell is ovoid, transparent and comparable to the related species of *Ovulinata parva*. Shell with a pointed end, reminding of certain members of genus *Difflugia* such as *D. acuminata*, clearly visible under scanning electron microscopy, but not under light microscopy. Aperture is terminal, slit-like. Large round nucleus (about 20 % of shell length). Ecology: soil. Monospecific. Type species: *Micropyxidiella edaphonis* Tarnawski et Lara, 2015.

Genus *Ovulinata* Anderson et al., 1997

Shell is ovoid, small (15 µm), organic, lacking scales or mineral particles, aperture is terminal, circular to oval, pseudopodia filose, hyaline (sometimes branched), long tapering to a point, arising directly from aperture or from the periphery of a web of hyaline cytoplasm emergent from the aperture. Mitochondria with tubular cristae. Ecology: marine interstitial. Type species: *Ovulinata parva* Anderson et al., 1997.

Note: After original description (Anderson et al., 1996, 1997) Howe et al. (2011) placed the genus to a new family Ovulinatidae. Diagnosis: filose amoebae with ovoid organic shell, lacking scales or mineral particles, aperture is circular to oval; pseudopodia hyaline, sometimes branched, long, tapering to a point, arising directly from aperture or fromweb of hyaline cytoplasm emergent from it. Differs from its sister family Paulinellidae by lacking silica scales or plastid-like enslaved cyanobacterium. Type genus: *Ovulinata* Anderson, Rogerson et Hannah, 1997. This new family is essential because the trees show that *Ovulinata* was previously wrongly classified in Pseudodifflugiidae (Thecofilosea) and must be transferred to Imbricatea and Euglyphida. It differs so radically from *Paulinella* that it cannot be included in the same family.

Genus *Paulinella* Lauterborn, 1895

Shell is ovoid, covered with siliceous rectangular plates with slightly rounded, scarcely overlapping ends, arranged in circumferential longitudinal rows; in apertural view the plates form a counter-clockwise spiral, with one pentagonal scale at the aboral pole. Aperture is terminal or suberminal, circular or oval, sometimes located on the end of a small neck. Cytoplasm usually contains two sausage-like endosymbionts of cyanobacterial origin. Ecology: marine, brackish water and freshwater plants. Type species: *Paulinella chromatophora* Lauterborn, 1895 (fig. 111).

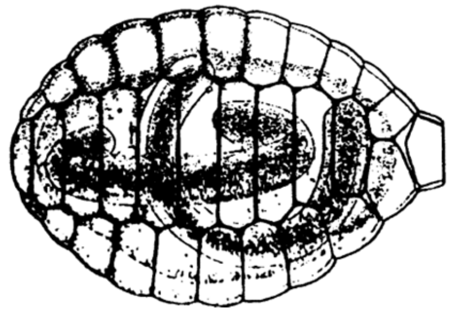

Fig. 111. *Paulinella chromatophora*: lateral view (after Saedeleer, 1934)

INCERTAE SEDIS Euglyphida

Genus *Ampullataria* van Oye, 1956

Shell is ellipsoid, circular in cross-section, with a cylindrical neck, covered by oval overlapping scales which appear polygonal. Neck scales are irregular at aperture. Aperture is circular, terminal. Ecology: moss. Type species: *Ampullataria rotunda* van Oye, 1956 (fig. 112).

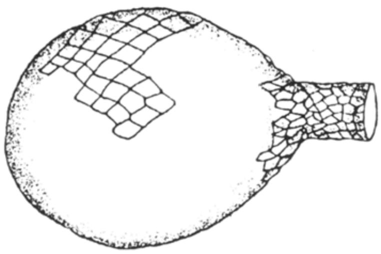

Fig. 112. *Ampullataria rotunda*: lateral view (after Oye, 1956)

Genus *Deharvengia* Bonnet, 1979, emend. Bobrov et al., 2012

Shell is transparent, oval or ovoid in the broad view, circular to narrow elliptical in the cross-section. Aperture elliptic or narrow elliptic, the ventral side is cut at about 6/7 of the length of the entire shell and is surrounded by a thin organic lip. On the dorsal side the shell forms a small cap over the aperture, sometimes with a narrow organic lip along the edge. Shell is covered by elongate-elliptic idiosomes. Transparent clavate spines may be present on each side of the shell (Bobrov et al., 2012). Ecology: freshwater, soils. Type species*: Deharvengia papuensis* Bonnet, 1979 (fig. 113).

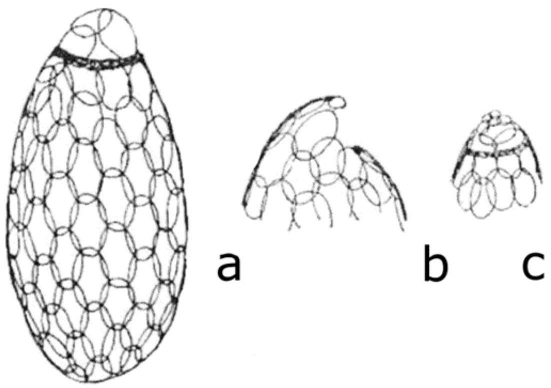

Fig. 113. *Deharvengia papuensis*:
a – apertural view; b, c – aperture (after Bonnet, 1979)

Genus *Euglyphidion* Bonnet, 1960

Shell is ovoid, circular in cross-section, sides taper. Aperture is terminal, circular or broadly ovoid. Shell is covered by siliceous two types of plates which do not overlap, distributed chaotically. Ecology: soils. Monospecific. Type species: *Euglyphidion enigmaticum* Bonnet, 1960 (fig. 114).

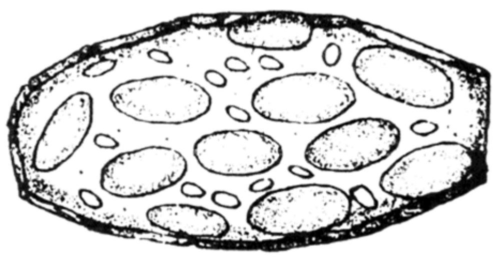

Fig. 114. *Euglyphidion enigmaticum*:
lateral view (after Bonnet, 1960b)

Genus *Heteroglypha* Thomas et Gauthier-Lièvre, 1959

Shell is wedge-shaped, fundus is rounded, sides sub-parallel, anterior end only slighlty smaller than fundus. In lateral view, shell is tapered almost to point at apertural end. Aperture is terminal, slit-like or slightly arched, located at right angle to the broad diameter, with clear organic rim. Scales are elliptical, arranged as in *Euglypha*. Ecology: freshwater. Type species: *Heteroglypha delicatula* Thomas et Gauthier-Lièvre, 1959 (fig. 115).

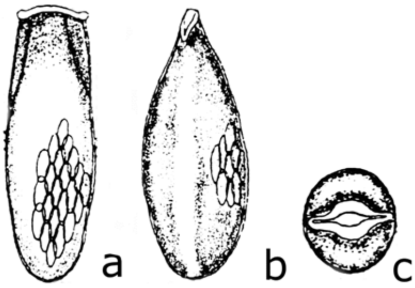

Fig. 115. *Heteroglypha delicatula*:
a – broad lateral view; b – narrow lateral view; c – apertural view
(after Thomas, Gauthier-Lièvre, 1959a)

Genus *Matsakision* Bonnet, 1967

Shell is transparent, long ovoid, slightly compressed, perpendicularly truncated near the aperture area. Shell is covered by elliptic plates, not overlapping, although sometimes may be connected, located on light yellow hyaline cement. Aperture is terminal, oval, surrounded by small organic collar, hardly visible. Pseudopodia are not reported. Ecology: terrestrial mosses. Type species: *Matsakision cassagnaui* Bonnet, 1967.

Genus *Pareuglypha* Penard, 1902

Shell is ovoid, tapered toward aperture, yellowish; fundus with scaly spine of variable length. Shell is covered by small, circular or ovoid scales, slightly overlapping, randomly distributed. Aperture is terminal, circular. Ecology: freshwater. Type species: *Pareuglypha reticulata* Penard, 1902 (fig. 116).

Genus *Pileolus* Coûteaux et Chardez, 1981

Shell is acrostome, covered by two types of idiosomes. Large elongate idiosomes are thickened in the middle that gives tuberculated view to the shell. Small elongate idiosomes fill the gaps between the larger ones. Aperture is circular, with a collar turned up and outside, surrounded by small elongated plates with a single tooth. Monospecific. Ecology: soil. Type species: *Pileolus tuberosus* Coûteaux et Chardez, 1981(fig. 117).

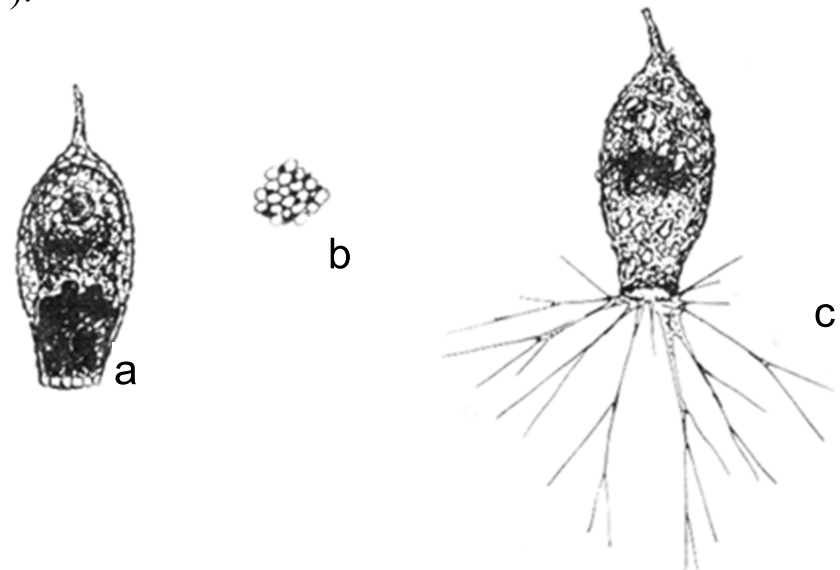

Fig. 116. *Pareuglypha reticulata*:
a – lateral view; b – cover; c – lateral view with filopodia (after Penard, 1902)

Genus *Tracheleuglypha* Deflandre, 1928

Shell is ovoid, cross-section is circular, covered by large, circular overlapping idiosomes; colourless, transparent. Aperture is terminal, circular, sometimes may be surrounded by a small denticulate collar made of the organic material of the shell. Nucleus is ovular. Ecology: freshwater, moss and soil. Type species: *Tracheleuglypha dentata* Deflandre, 1938 (fig. 118).

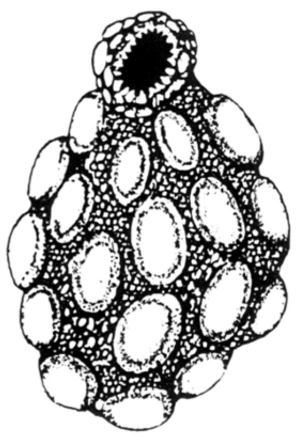

Fig. 117. *Pileolus tuberosus:* apertural view (after Coûteaux, Chardez, 1981)

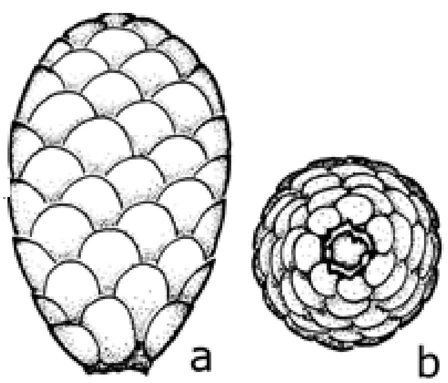

Fig. 118. *Tracheeuglypha dentata*: a – lateral view; b – apertural view (after Lüftenegger, Foissner, 1991)

Chapter 4
Order Amphitremida Poche, 1913, emend. Gomaa, Mitchell et Lara, 2013

Pseudopods are filamentous, sometimes anastomosing and branching. Shell is rigid, with two apertures located in front of each other on the main axis of symmetry of the shell.

Family Amphitremidae Poche, 1913

Shell is elliptic or barrel like in the broad lateral view and compressed in the narrow lateral view; either organic or with attached exogenous material. Two apertures are located in front of each other on the main axis of symmetry of the shell. Cytoplasm contains symbiotic zoochlorellae.

Key to the genera of the family

1. Shells with attached endogenous material..... **Genus *Amphitrema***

1’. Shells without any covering particles (smooth surface, completely organic).. **Genus *Arherella***

Genus *Amphitrema* Archer, 1869

Shell is elliptic in the broad lateral view, compressed in the narrow lateral view, covered by exogenous particles (diatom frustules, flagellate cysts etc.). A patterned cement network can be seen sometimes by scanning electron microscopy. Two elliptic apertures, with or without short collar, are located on the opposite sides of the shell. Type species: *Amphitrema wringhtianum* Archer, 1869 (fig. 119).

Genus *Archerella* Loeblich et Tappan, 1961

Shell is elliptic in the broad lateral view and compressed in the narrow lateral view. Covering elements are absent. Two elliptic apertures are located at the opposite sides of the shell and surrounded by short, very thin collars. Shell is often brown due to iron accumulation. Type species: *Archerella flavum* Archer, 1877 (fig. 120).

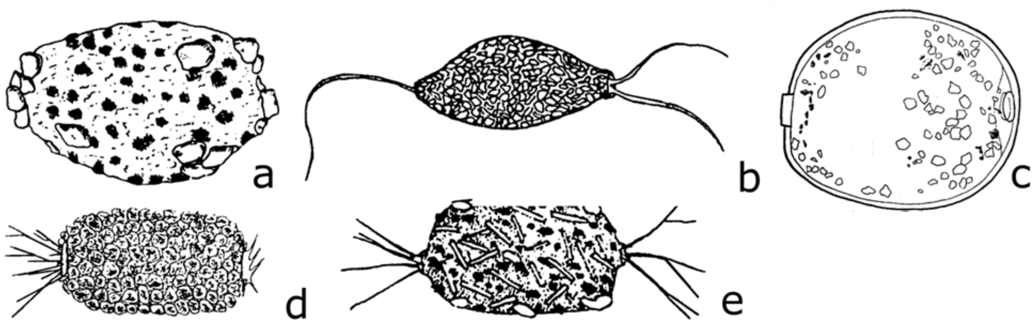

Fig. 119. Genus *Amphitrema*:
a – *A. congolense* lateral view (after Oye, 1958); b – *A. lemanense* lateral view with pseudopodia (after Bartoš, 1954); c – *A. paparoensis* lateral view (after Oye, 1958); d – *A. stenostoma* lateral view (after Bartoš, 1954); e – *A. Wring-htianum* lateral view (after Bartoš, 1954)

Fig. 120. Genus *Archerella*:
a – *A. flavum* broad lateral view (after Schönborn, 1966a); b – *A. jollyi* broad lateral view (after Oye, 1958)

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with the Keys to Genera

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