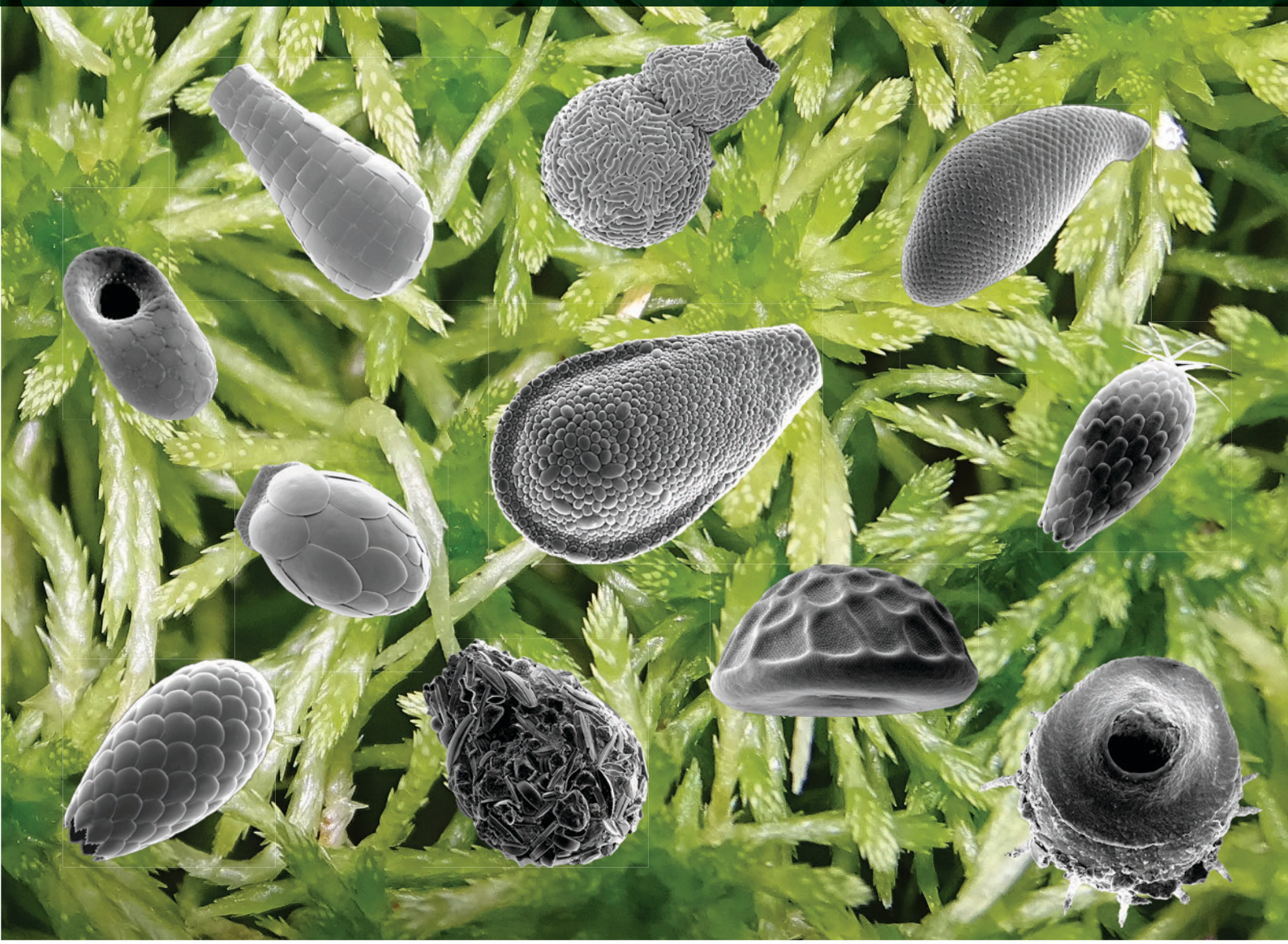
AN ATLAS OF SPHAGNUM-DWELLING TESTATE AMOEBAE IN BULGARIA

Milcho Todorov & Nikola Bankov



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Milcho Todorov & Nikola Bankov

Institute of Biodiversity and Ecosystem Research
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INTRODUCTION

Testate amoebae is a term used to unite those free-living, unicellular eukaryotes which ameboid cell is covered by an extracellular shell (test), mostly with a single main opening, and which extrude lobose or filose pseudopodia. Testate amoebae are traditionally divided into two main groups based on the morphology of pseudopodia – Arcellinida (with lobose pseudopodia) and Euglyphida (with filose pseudopodia) (Meisterfeld 2002 a, b). The progress in the molecular phylogeny and phylogenomics, as a result of accumulation of much new DNA data over the last decade, have led to major revisions in the classification of most groups of organisms, including testate amoebae. Currently, it is known that testate amoebae are a polyphyletic assemblage of at least three major, unrelated taxonomic groups of unicellular eukaryotes: Amoebozoa, Stramenopiles and Cercozoa (Adl et al. 2012, 2019).

Testate amoebae are worldwide distributed and occur from the tropics to polar regions. They are present in most terrestrial and freshwater environments, as well as in brackish and marine habitats, but are especially abundant and diverse in the *Sphagnum* mosses. The studies on this group have significantly increased over the past two decades due to their increasing use in different applied aspects. Testate amoebae are a good model for taxonomy and evolutionary studies because of their abundance, diversity and presence of a shell, which is a reliable taxonomic feature used in diagnostic of the species. They are considered as valuable bioindicators for ecological and environmental monitoring studies, in particular, as proxies for hydrological changes, and therefore, for paleoclimate reconstruction in peatlands (Charman and Warner 1997, Mitchell et al. 2000, Booth 2002, 2007, Lamentowicz and Mitchell 2005, Qin et al. 2013, Payne et al. 2016). The fact that different species have distinct ecological requirements and after death of the amoebae their shells remain well preserved in peat and sediment makes them excellent microfossils and extremely valuable in micro-paleontological studies for palaeoenvironmental reconstructions (Tolonen 1986, Charman et al. 1998, 2001, Charman 2001, Mitchell et al. 2008, Swindles et al. 2009, 2015). Testate amoebae are very sensitive and quickly respond to environmental changes, such as water table depth, dryness, atmospheric pollution, deforestation and other human activities, and this makes them valuable biomonitors for current environmental health (Booth 2007, Nguyen-Viet et al. 2007, Payne et al. 2012, Nasser et al. 2016). Also, it has been shown that testate amoebae play an important role in the cycling of carbon, nitrogen and silica in terrestrial ecosystems (Schröter et al. 2003, Aoki et al. 2007, Jassey et al. 2015).

The studies on the Sphagnum-dwelling testate amoebae in Bulgaria started in the beginning of the 20th century, when Pateff (1924, 1928) published his works on freshwater Rhizopoda in this country. He recorded a total of 118 rhizopods, of which 52 testate amoebae from the *Sphagnum* mosses in the Rila, Rhodopes and Vitosha Mountains. Later, Valkanov (1932, 1934) published results of his studies on the fauna of the alpine lakes in the Rila and Pirin Mountains, and recorded many testate amoebae, which are typical inhabitants of the peat mosses. Unfortunately, no distinction was

made between the species found in the lakes and in the *Sphagnum* mosses along the shores of the lakes. In the 1960s and 1970s several reports on the testate amoebae in the Vitosha, Rhodopes and Pirin Mountains were published (Golemansky 1965, 1966, 1968, 1974), including a lot of data on the Sphagnum-dwelling testate amoebae. In the end of the 20th and beginning of the 21th century, the number of publications concerning various aspects of taxonomy, systematics, morphology and ecology of the sphagnicolous testate amoebae in Bulgaria increased considerably (Golemansky and Todorov 1985, 1990, 1993, 2006, Todorov 1993, 2004, 2005, 2010, Todorov and Golemansky 1995, 2000, Golemansky et al. 2006, Todorov et al. 2009, 2010, 2018, Heger et al. 2010, Kosakyan et al. 2012, Bankov et al. 2018).

The aim of this atlas is to present summarised information and to illustrate comprehensively the shell morphology and structure of the majority of recorded Sphagnum-dwelling testate amoebae in Bulgaria. Since most of these species appear to be widely distributed in Europe, as well as in many other regions of the world, the atlas may be of interest to all researchers on testate amoebae and can also be used by specialists in ecology, hydrobiology, palaeoecology and environmental monitoring.

SHELL MORPHOLOGY

Shells are the main taxonomic feature of testate amoebae and they are extremely diverse in shape, size and composition. Bonnet (1975) classified testate amoebae into sixteen morphological types according to the shape and symmetry of their shells and structure of the aperture (Fig. 1). It was shown that different morphological types are closely related to the nature of habitats and that different types can be used as indicators in ecological studies or to suggest phylogenetic relationships (Chardez 1967, Bonnet 1975, Chardez & Lambert 1981). For example, in aquatic habitats and wet mosses predominate species with a terminal and comparatively large aperture of the arcella (ARC - Arcella), acrostomic (ACS - Difflugia, ACA - Cyphoderia) and trachelostomic (TRAS - Cucurbitella, TRAA - Lesquereusia) morphological types. In habitats where the amoebae are subject to frequent droughts, e. g. aerophilic and epiphytic mosses and soils, the aperture is reduced to a slit-like opening (ACC – Assulina, Heleopera), is covered by an anterior visor or lip (PLS – Centropyxis plagiostoma, PLV – Centropyxis aerophila, CRS – Geoplagiopyxis, CRV – Plagiopyxis callida) or is highly modified, complex structure of the propylostomic (PRO – Lamtopyxis) and diplostomic (DIP – Distomatopyxis) morphological types. Finally, inhabitants of the coastal marine interstitial are adapted to the specific conditions in this environment, they have shells of the cotylostomic type (COT – Psammonobiotidae), with an enlarged collar around the aperture, used for fixation and stabilisation of the shell in the continuous tides and outflow of the water.

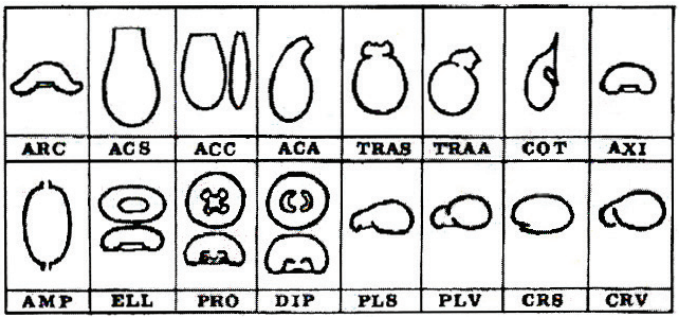


Fig. 1. Morphological types of testate amoebae shells: ARC – arcella; ACS – simple acrostomy; ACC – compressed acrostomy; ACA arched acrostomy; TRAS – simple trachelostomy; TRAA – arched trachelostomy; COT – cotylostomy; AXI – axial; AMP – amphystomy; ELL – ellipsostomy; PRO – propylostomy; DIP – diplostomy; PLS – simple plagiostomy; PLV – plagiostomy with visor; CRS – simple cryptostomy; CRV – cryptostomy with visor (After Bonnet, 1975).

According to the shell composition, there are four main types of shells: proteinaceous, agglutinate, siliceous and calcareous (Ogden and Hedley 1980, Meisterfeld 2002a).

Proteinaceous shells can be divided into three types: 1) shells in which the wall is more or less a flexible membrane (Microcoryciidae); 2) shells with a smooth and rigid homogeneous coat composed of mucoprotein (Hyalosphenia); 3) shells, constructed of numerous regularly arranged, hollow building units or alveoli (Arcellidae) (Fig. 2).

Agglutinate shells may be divided into two types. The shells of the first type have either a structured or sheet-like or-

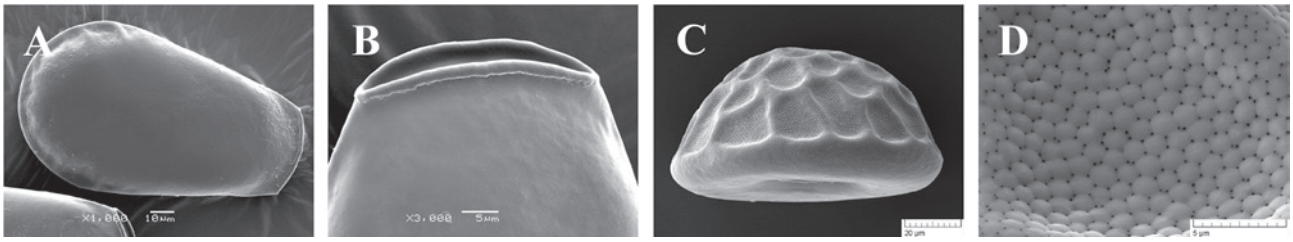


Fig. 2. Testate amoebae with proteinaceous shells: (A, B) *Hyalosphenia papilio* – shell composed of mucoprotein; (C, D) *Arcella gibbosa* – shell composed of numerous hollow building units (alveoli).

ganic cement matrix in which foreign material from the environment (xenosomes), such as quartz grains or diatom frustules, is incorporated (most of Difflugiidae). It is noteworthy that the structure of the organic cement has valuable importance for the taxonomy and distinction of the species in this group. The second type of agglutinate shells is characteristic for most representatives of the families Hyalospheniidae and Heleoperidae. Their shells are composed of siliceous shell-plates with different shape and size, embedded in a sheet-like organic cement matrix. It is important to note that the species with such shells do not make their own shell-plates but obtain them by predation mainly on small euglyphids (Fig. 3).

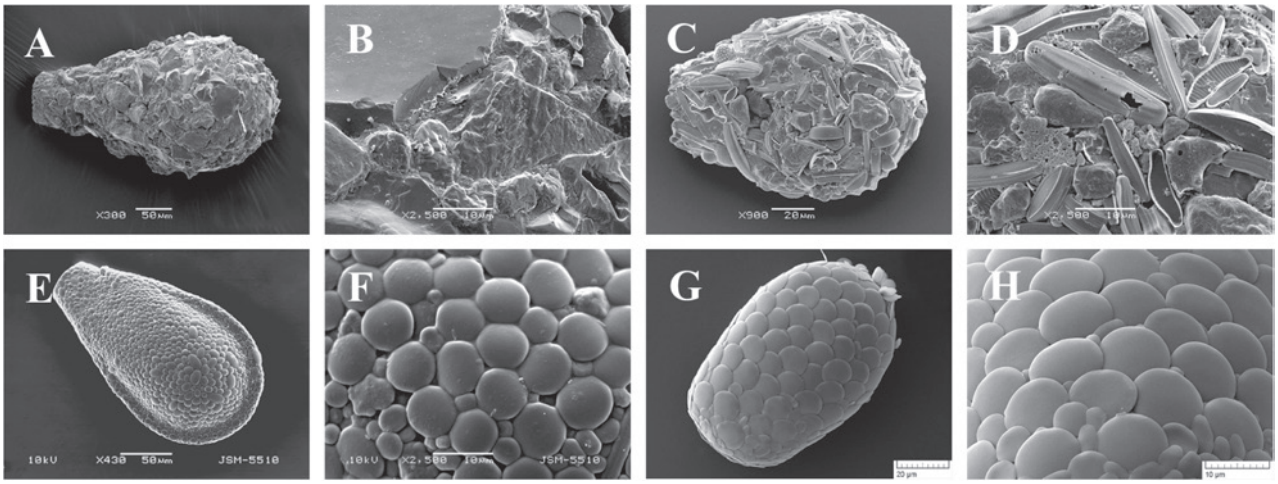


Fig. 3. Testate amoebae with agglutinate shells: (A-D) shells composed of foreign material from the environment (xenosomes); (A, B) *Difflugia oblonga*; (C, D) *Pontigulasia rhumbleri*; (E-H) shells composed of siliceous shell-plates with different shape and size, obtained by predation mainly on small euglyphids; (E, F) *Gibbocarina galeata*; (G, H) *Heleopera sylvatica.*

Siliceous shells are composed of endogenous siliceous shell-plates (idiosomes) which are produced by the amoebae themselves. These structural elements are formed and stored in the parent's cytoplasm prior to cell division, and are used in the division process to construct the daughter shell, identical to the parent. The shape, size and arrangement of the siliceous shell-plates (idiosomes) are

species specific and have valuable taxonomic significance. The idiosomes are too different in shape and vary from oval or circular in the euglyphids (Euglyphida), through rods in *Lesquereusia*, and nail-like in *Netzelia* to quadrangular in *Quadrulella* (Fig. 4).

Calcareous shells are the least presented and are characteristic to only two genera *Paraquadrula* and *Cryptodifflugia*. The first one has quadrangular calcite shell-plates embedded in a sheet-like organic cement matrix. The second has a smooth shell surface and the wall is composed of two layers, a thin organic outer layer and a thick inner layer of amorphous calcium phosphate (Hedley et al. 1977).

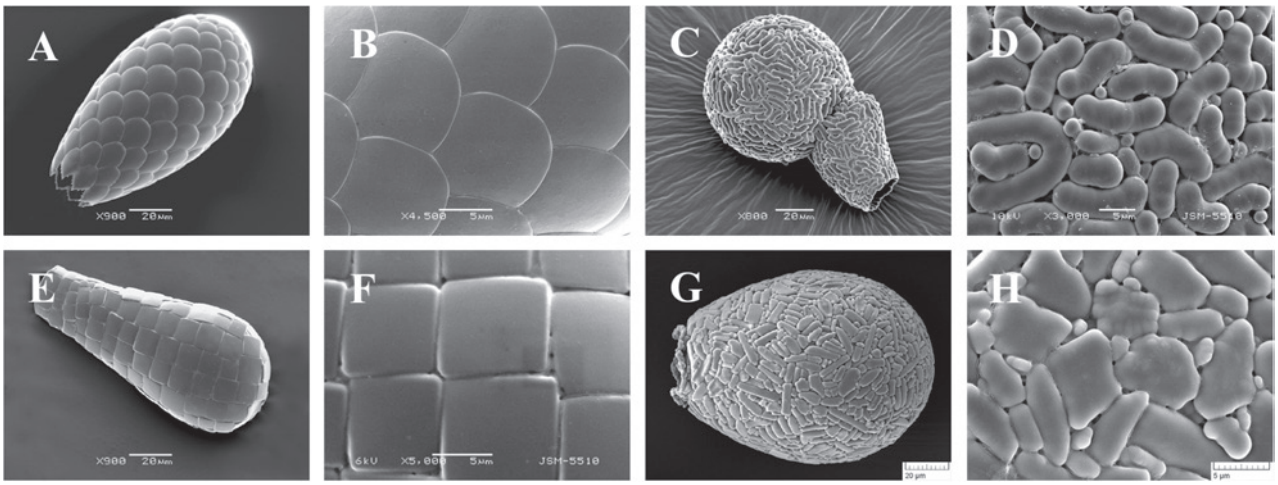


Fig. 4 . Testate amoebae with siliceous shells composed of self-produced siliceous shell-plates (idiosomes): (A, B) *Euglypha tuberculata*; (C, D) *Lesquereusia epistomium*; (E, F) *Quadrulella longicollis*; (G, H) *Netzelia oviformis*.

CYTOPLASM

Some species of testate amoebae are described only on the basis of empty shells and their biology is totally unknown. Most of the species with agglutinate shells, composed of quartz grains (xenosomes), have poorly studied cell morphology because their shells are opaque and robust, with thick walls, which prevent the study of the cytoplasm by light and transmission electron microscopy. Thus, much of our knowledge on the cell structure of testate amoebae is mainly due to the studies of species with proteinaceous, siliceous or calcareous shells (Charret 1964, Hedley and Ogden 1973, 1974, Hedley et al. 1974, 1977, Netzel 1975, 1983, Harrison et al. 1976, Bonnet et al. 1981, Golemansky et al. 1987, Ogden and Coûteaux 1987, Anderson 1990, Ogden 1991).

In general, the cell of testate amoebae is surrounded by a thin and elastic plasmalemma with numerous microtubules and microfilaments, lying beneath it and having function of a cytoskeletal structure. The cytoplasm is usually divided into two zones. The anterior zone is a granular cytoplasm and

includes many food and digestive vacuoles, numerous mitochondria and peripherally located vesicles containing organic cement. The posterior zone is a dense cytoplasm, which contains nucleus, surrounded by a compact mass of granular endoplasmic reticulum, numerous ribosomes, one or more Golgi complexes, as well as several contractile vacuoles located laterally of the nucleus, close to the plasmalemma (Ogden and Hedley 1980, Meisterfeld 2002a). Most species have one nucleus and rarely the nuclei are two (many *Arcella* species), about ten to twenty (*Arcella polypora*), up to several tens or hundreds (*Arcella megastoma, Difflugia urceolata, Phryganella nidulus*, etc.). The nuclei of testate amoebae are two main types, according to the classification of Raikov (1982): vesicular nuclei with one large, central nucleolus and ovular nuclei with several to many small nucleoli (Fig. 5). In the smaller euglyphids (e.g. *Corythion, Euglypha, Sphenoderia, Trinema*) the cytoplasm usually fills the whole shell, while in larger species (Hyalospheniidae, Difflugiidae) it fills about a half or two-third of the shell and the cell is attached to the posterior part of the shell wall with numerous thin cytoplasmic strands (epipodes) (Fig. 6).

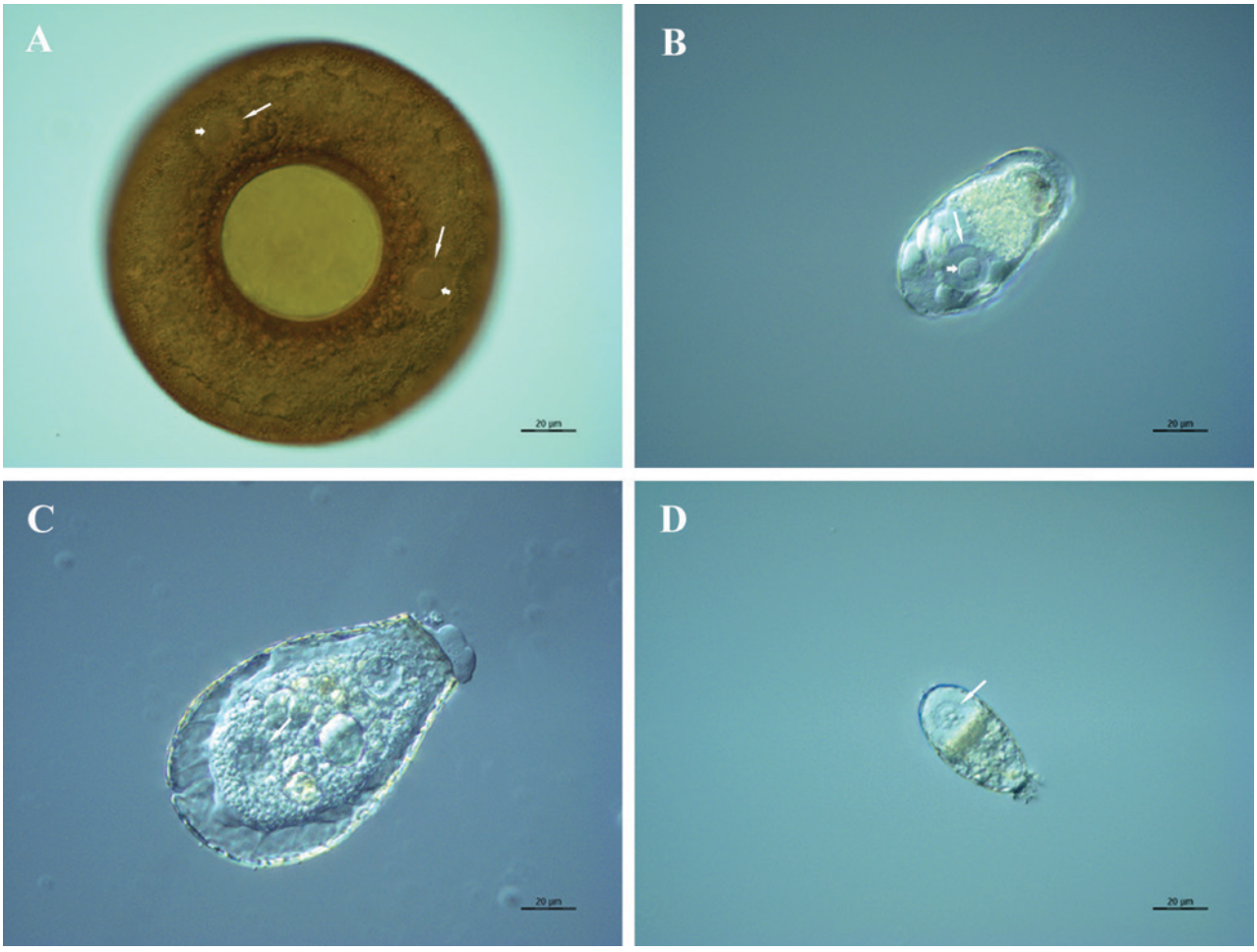


Fig. 5. Nuclei of testate amoebae: (A, B) vesicular nuclei of *Arcella discoides* (A) and *Trinema galeata* (B); (C, D) ovular nuclei of *Nebela collaris* (C) and *Tracheleuglypha dentata* (D) (large arrows – nucleus, small arrows – nucleolus).

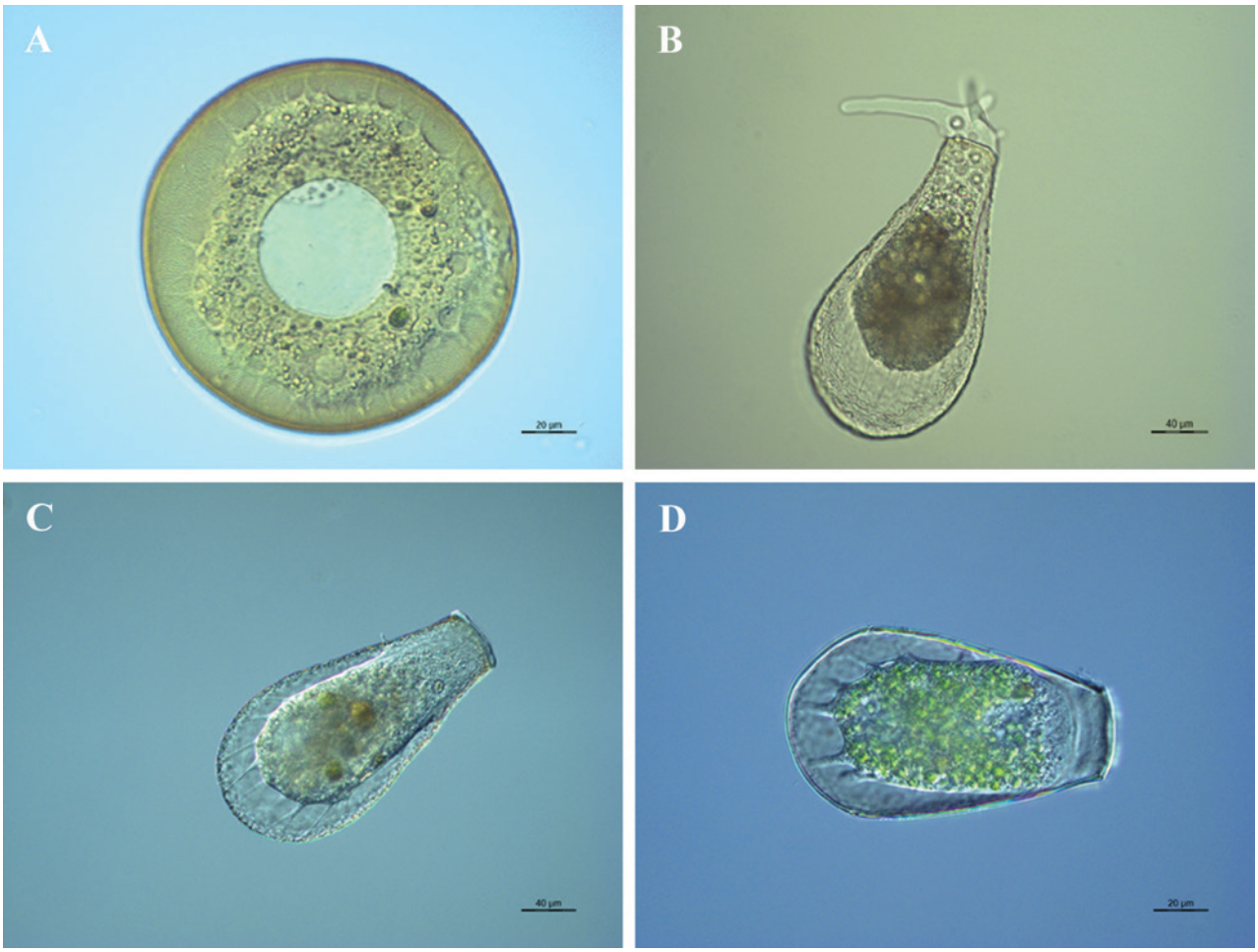


Fig. 6. Thin cytoplasmic strands (epipodes) attaching the cell to the shell wall: (A) *Arcella discoides*; (B) *Gibbocarina galeata*; (C) *Longinebela tubulosa*; (D) *Hyalosphenia papilio*.

PSEUDOPODIA

The movement of testate amoebae is accomplished by a steady flow of the cytoplasm, which involves the extension and retraction of pseudopodia through the shell aperture (pseudostome) and creep on the substrate. The pseudopodia have different shape and mode of activity and for a long time they have been used as a main feature in the classification of testate amoebae. There are three main types of pseudopodia: endolobopodia, ectolobopodia (reticulo-lobopodia) and filopodia. The endolobopodia are thick, digitate and granular pseudopodia with rounded ends, characteristic for most species of the order Arcellinida (suborders Sphaerothecina and Difflugina). The ectolobopodia (reticulo-lobopodia) are completely hyaline, conical, pointed, sometimes branched and may anastomose. They are presented in the suborder Phryganellina (*Cryptodifflugia, Meisterfeldia, Phryganella, Wailesella*). The filopodia are hyaline, filamentous, thin, straight, finely pointed, sometimes branched and are presented in all the Euglyphida (Fig. 7).

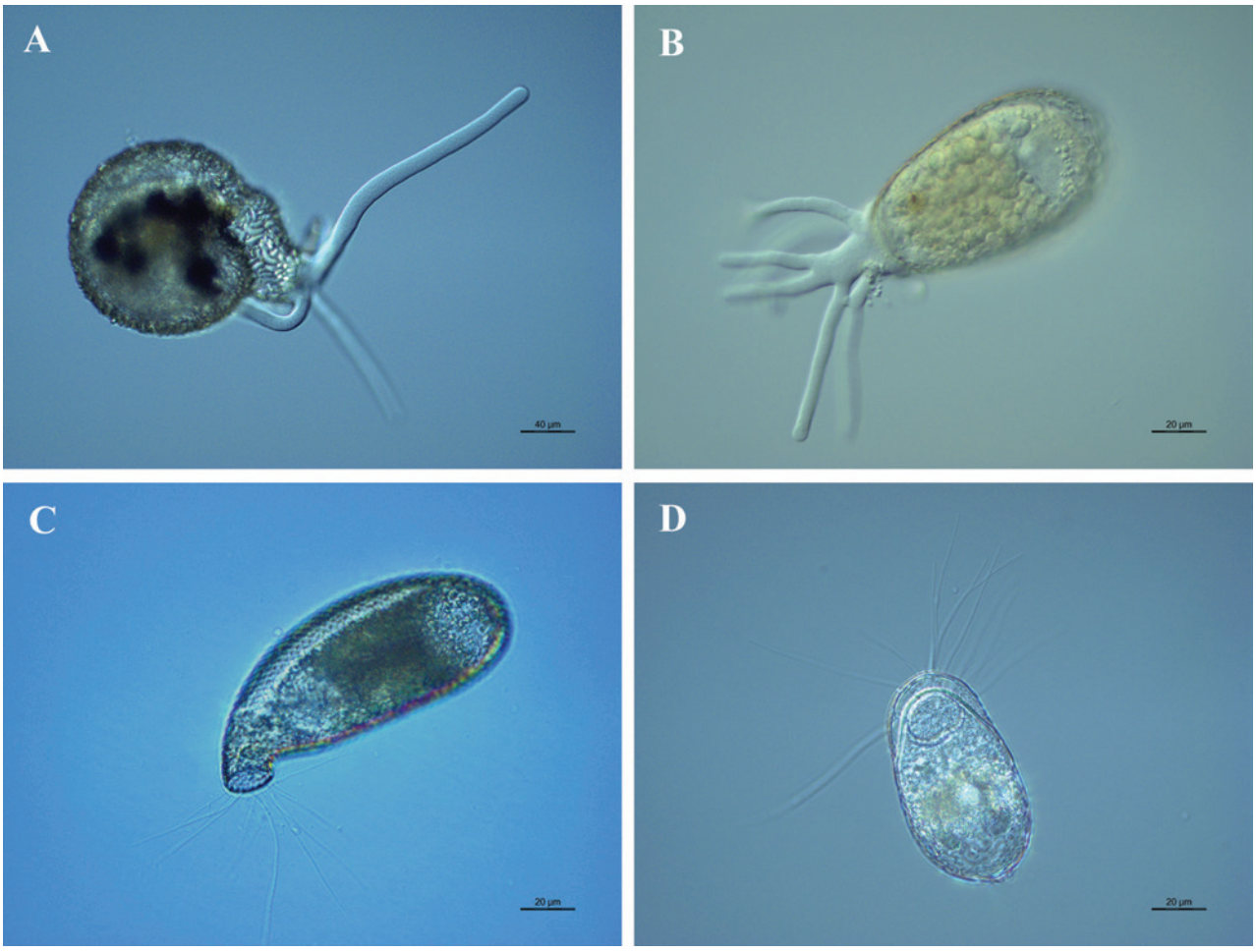


Fig. 7. Pseudopodia of testate amoebae: (A, B) endolobopodia of *Lesquereusia gibbosa* (A) and *Heleopera sylvatica* (B); (C, D) filopodia of *Cyphoderia ampulla* (C) and *Trinema galeata* (D).

REPRODUCTION

Testate amoebae normally reproduce by binary fission, with a replication of the parent. Firstly, an identical daughter-cell is constructed and after that the fission takes place usually as a closed orto-mitosis (Ogden 1979, Ogden and Coûteaux 1987, Raikov and Mignot 1991) (Fig. 8). The doubling time of the amoebae is between two and twelve days depending on the species and environmental conditions, usually shorter in a laboratory than in natural conditions (Heal 1964, Hedley and Ogden 1974, Hedley et al. 1974, 1977, Ogden 1989). It was believed for a long time that testate amoebae are reproduced only asexually. In the late 19th and early 20th century the reports in which are provided evidence for the presence of sexuality in testate amoebae are scarce (Jikeli 1884, Blochmann 1888, Penard, 1902, Awerintzew 1906, Reukauf 1912, Dunkerly 1923, Dangeard 1937). Later, Valkanov (1962, 1966) studied in detail the reproduction in testate amoebae and distinguished four types of

Fig. 8. Reproduction of testate amoebae by binary fission: (A) *Sphenoderia lenta*; (B) *Heleopera sylvatica*; (D) *Arcella dentata* (the shell of parent is dark-brown because the alveoli are enriched with iron, used to strengthen the shell wall; this inorganic material is not usually present in the alveoli of young animals and their shells are light yellowish).

copulation: 1) type *Difflugia* in which the cytoplasm of one individual passes entirely into the shell of the other individual, where the two cells merge and forme a zigocyst (sexual cyst) – widely distributed in the genera *Centropyxis, Difflugia, Lesquereusia, Nebela, Pontigulasia, Sphenoderia, Trinema*, etc.); 2) type *Pyxidicula* in which two individuals merge and form a zigocyst in the space between the two shells – in *Pyxidicula* and *Phryganella*; 3) type *Euglypha*, where the cytoplasm of the copulated individuals goes out of the shells, merge and compose a new larger shell, in which the zigocyst remains – in *Assulina, Euglypha, Valkanovia*, etc.; 4) type *Clypeolina* which is the most specific and occurs only in *Clypeolina*, which shell is composed of two valves. The individuals in copulation touch laterally, the inner valves of each of them disintegrate, the cells merge and form the zygocyst, which is covered by a shell, composed of the outer valves of the copulated individuals. Lüftenegger and Foissner (1991) established the presence of plasmogamy and karyogamy with subsequent cyst formation in *Paraquadrula*. Mignot and Raikov (1992) provided new evidence for the meiosis in testate amoebae, studying in details the meiosis and autogamy in the cyst of *Arcella*. Iudina and Sukhanova (2000) studied the cytoplasmic fusion and karyogamy in *Corythion delamarei* and documented division of the synkaryon into four nuclei and formation of four daughter cells as a result of meiosis. Currently, there is clear evidence that testate amoebae, as well as many other microbial eukaryotes, can reproduce also sexually (Lahr et al. 2011, Tekle et al. 2017, Hofstatter et al. 2018).

CYSTS

Besides the reproductive cysts testate amoebae can produce resistant and short-time cysts as a protection against unfavorable conditions in the environment, such as drought, extremal temperatures, lack of food or anaerobiosis. Usually, the resistant cysts are formed within the shell and are contained

within a thick organic membrane. During encystment the amoebae reduce the volume of cytoplasm and number of organelles, and in such encysted state they can survive for a long time (several months). In the period of desiccation, many soil- and moss-dwelling species form short-time cysts (precists), which differ from the resistant cysts by their relatively thin membrane enclosing the cell and by their ability to pass quickly into active life when appropriate conditions in the environment occur. Often, testate amoebae forming cysts additionally seal the shell aperture with a plug of siliceous or extraneous particles (Fig. 9).

Fig. 9. Cysts of testate amoebae: (A, B) short-time cysts of *Heleopera rosea* (A) and *Hyalosphenia papilio* (B); (C) resistant cyst of *Nebela collaris* and additional sealing of the shell aperture with a plug of siliceous and extraneous particles.

FEEDING

Testate amoebae are mostly phagotrophic organisms feeding on bacteria, algae and fungi, thus playing an important role in nutrient recycling in the aquatic and terrestrial ecosystems. Some larger species (mostly Hyalospheniidae) are predators preying on other protozoa, such as the euglyphid testate amoebae and naked amoebae, or small metazoan organisms, such as the nematodes and rotifers (Yeates and Foissner 1995, Ogden 1989, Gilbert et al. 2000, Han et al. 2008). At the same time, testate amoebae can be preyed on by nematodes, earthworms, collembolans and mites, thus re-entering the classical food chain (Bamforth and Lousier 1995, Wilkinson and Mitchell 2010). Significantly less are the mixotrophic testate amoebae, which are capable of building a symbiotic relationship with the phototrophic algae (zoochlorellae) and combine both phagotrophy and phototrophy (e.g. *Amphitrema, Archerella, Difflugia* and *Hyalosphenia*) (Fig. 10). The host heterotrophic species usually supply their symbiotic algal cells with nitrogen and CO_2, and in turn, the algae supply their hosts with photosynthetic products, such as maltose and oxygen (Esteban et al. 2010, Summerer et al. 2007). In some *Difflugia* species this symbiotic relationship can be facultative and the host can shift to heterotrophic nutrition if exposed to prolonged

darkness or if the environment lacks symbionts. Most frequently, the symbiotic relationship is obligatory and the host can no longer survive without its symbionts. Schönborn (1965) showed experimentally that *Archerella flavum* and *Hyalosphenia papilio* can not survive for long periods in the dark. His study also demonstrated that *A. flavum* depends entirely on the symbiotic algae for its nutrition requirements, while *H. papilio* provides up to 40% of the required nutrients from photosynthetic products of the algae and the rest through phagotrophy.

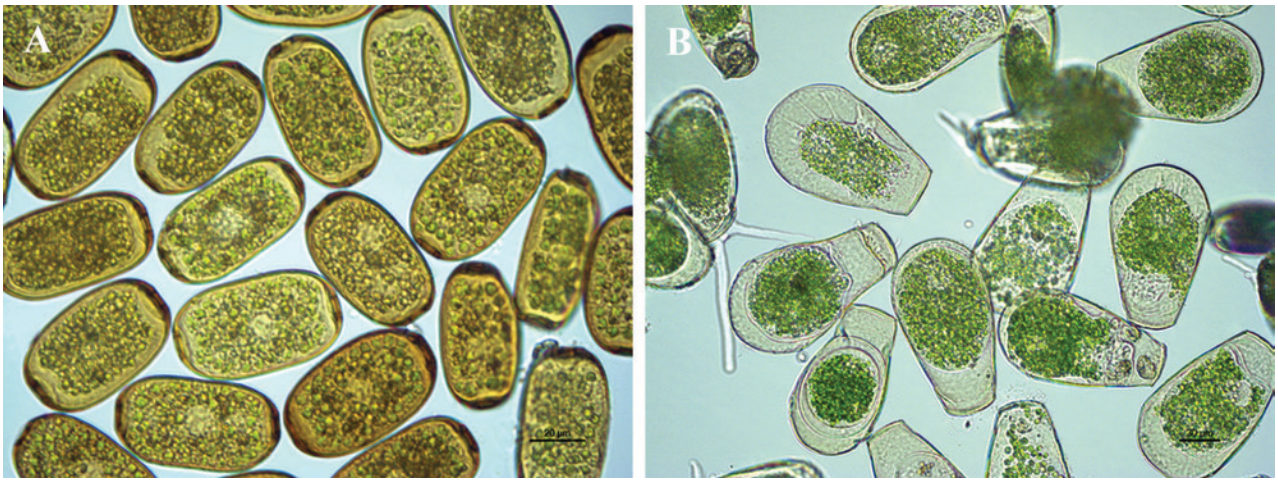


Fig. 10. Symbiotic relationship of testate amoebae with phototrophic algae (zoochlorellae): (A) *Archerella flavum*; (B) *Hyalosphenia papilio*.

MATERIALS AND METHODS

The presented data on species diversity and distribution of the Sphagnum-dwelling testate amoebae were based on the review of all available literature from Bulgaria. In addition, we included unpublished data from our studies in the period 2016 – 2018.

The material for the present study was extracted from wet *Sphagnum* mosses, collected at the mountains Western Stara Planina, Rhodopes, Vitosha, Rila and Pirin. A total of 126 samples of testate amoebae from 23 localities were collected and examined. Testate amoebae were extracted from fresh *Sphagnum* mosses at the sampling site and concentrated by sieving (350 μm). The resulting fraction (50 ml) was observed with optical microscope "Amplival" (Zeiss-Jena) using 40x objective and 10x oculars lens. The light micrographs (LM) were taken using an Axio Imager M2-Carl Zeiss compound microscope with a digital camera (ProgRes C7) and specialised software (CapturePro Software 2.8). Most of the pictures for illustration of the pseudopodia and nuclei of the live individuals were taken with differential interference contrast (DIC).

The morphometric characterisation of the species was made using our own measurements of individuals isolated from the wet *Sphagnum* mosses, collected during this study. The following basic characters were measured: arithmetic mean; median (M); standard deviation (SD); standard error of mean (SE); coefficient of variation in % (CV); and extreme values (Min and Max). The statistical analysis was performed using the STATISTICA Software, Version 10.0 (StatSoft 2010).

For the scanning electron microscopy (SEM) the specimens were isolated by searching through small isolates of material in a petri dish. The specimens were extracted using a glass micropipette, washed several times in distilled water, and then individual shells were positioned with a single-hair brush on a previously mounted double-sided adhesive tape on a standard aluminium stub and air-dried. The shells were coated evenly with gold in a vacuum coating unit. The photomicrographs were obtained using scanning electron microscopes JEOL JSM-5510 and LYRA/TESCAN 5007, operating at 10 kV.

CLASSIFICATION

The classification of testate amoebae at higher ranks follows Adl et al. (2019). Taxonomic revision of some genera and families, as well as numerous taxonomic and nomenclature changes, based on recent molecular studies and subsequent phylogenetic reconstructions, have also been taken into account (Lara et al. 2007, Mazei and Warren 2012, 2014, 2015, Kosakyan et al. 2012, 2016a, 2016b, Chatelain et al. 2013, Gomaa et al. 2013, 2017, Lahr et al. 2013, 2019, Bobrov 2016, Blandenier et al. 2017, Dumack et al. 2017, Duckert et al. 2018).

EUKARYOTES

Domain **Amorphea** Adl et al., 2012
Supergroup **Amoebozoa** Lühe, 1913, sensu Cavalier-Smith, 1998
Phylum **Tubulinea** Smirnov et al., 2005
Class **Corycida** Kang et al., 2017
Genus *Amphizonella* Greeff, 1866
Genus *Diplochlamys* Greeff, 1888
Class **Elardia** Kang et al., 2017
Order **Arcellinida** Kent, 1880
Suborder **Glutinoconcha** Lahr et al. 2019
Infraorder **Sphaerothecina** Kosakyan et al., 2016
Family **Arcellidae** Ehrenberg, 1843
Genus *Antarcella* Deflandre, 1928
Genus *Arcella* Ehrenberg, 1830
Family **Netzeliidae** Kosakyan et al., 2016
Genus *Cyclopyxis* Deflandre, 1929
Genus *Netzelia* Ogden, 1979
***Incertae sedis* Sphaerothecina**, Genera: *Cornuapyxis* Coûteaux et Chardez, 1981; *Cucurbitella* Penard, 1902; *Distomatopyxis* Bonnet, 1964; *Ellipsopyxella* Bonnet, 1975; *Ellipsopyxis* Bonnet, 1965; *Geopyxella* Bonnet et Thomas, 1955; *Lamtopyxis* Bonnet, 1974; *Protocucurbitella* Gauthier-Lièvre et Thomas, 1960; *Suiadifflugia* Green, 1975; *Trigonopyxis* Penard, 1912.
Infraorder **Longithecina** Lahr et al., 2019
Family **Difflugiidae** Wallich, 1864
Genus *Difflugia* Leclerc, 1815
Genus *Pseudonebela* Gauthier-Lièvre, 1953
Family **Lesquereusiidae** Jung, 1942

Genus *Lesquereusia* Schlumberger, 1845
Genus *Microquadrula* Golemansky, 1968
Genus *Paraquadrula* Deflandre, 1932
Genus *Pomoriella* Golemansky, 1970
Infraorder **Excentrostoma** Lahr et al., 2019
Family **Centropyxidae** Jung, 1942
Genus *Centropyxis* Stein, 1857
Genus *Proplagiopyxis* Schönborn, 1964
Family **Plagiopyxidae** Bonnet et Thomas, 1960
Genus *Bullinularia* (Penard, 1907) Deflandre, 1953
Genus *Geoplagiopyxis* Chardez,1961
Genus *Hoogenraadia* Gauthier-Lièvre et Thomas, 1958
Genus *Paracentropyxis* Bonnet, 1960
Genus *Plagiopyxis* Penard, 1910
Genus *Planhoogenraadia* Bonnet, 1977
Genus *Protoplagiopyxis* Bonnet, 1962
***Incertae sedis* Excentrostoma**, Genera: *Conicocassis* Nasser and Patterson, 2015; *Oopyxis* Jung, 1942.
Infraorder **Hyalospheniformes** Lahr et al., 2019
Family **Hyalospheniidae** Schultze, 1977, emend. Kosakyan and Lara, 2012
Genus *Alabasta* Duckert et al., 2018
Genus *Alocodera* Jung, 1942
Genus *Apodera* Loeblich and Tappan, 1961
Genus *Certesella* Loeblich and Tappan,1961
Genus *Cornutheca* Kosakyan et al., 2016
Genus *Gibbocarina* Kosakyan et al., 2016
Genus *Hyalosphenia* Stein, 1859
Genus *Longinebela* Kosakyan et al., 2016
Genus *Mrabella* Kosakyan et al., 2016
Genus *Nebela* Leidy, 1874
Genus *Padaungiella* Lara and Todorov, 2012
Genus *Planocarina* Kosakyan et al., 2016
Genus *Porosia* Jung, 1942
Genus *Quadrulella* Cockerell, 1909
Infraorder **Volnustoma** Lahr et al., 2019
Family **Heleoperidae** Jung, 1942
Genus *Heleopera* Leidy, 1879
Suborder **Organoconcha** Lahr et al., 2019

Family **Microchlamyidae** Ogden, 1985
Genus *Microchlamys* Cockerell, 1911
Genus *Spumochlamys* Kudryavtsev and Hausmann, 2007
Genus *Pyxidicula* Ehrenberg, 1838
Suborder **Phryganellina** Bovee, 1985
Family **Phryganellidae** Jung, 1942
Genus *Phryganella* Penard, 1902
Family **Cryptodifflugiidae** Jung, 1942
Genus *Cryptodifflugia* Penard, 1890
Genus *Meisterfeldia* Bobrov, 2016
Genus *Wailesella* Deflandre,1928

***Incertae sedis* Arcellinida**, Genera: *Argynnia* Vucetich, 1974; *Awerintzewia* Schouteden, 1906; *Geamphorella* Bonnet, 1959; *Jungia* Loeblich and Tappan, 1961; *Lagenodifflugia* Medioli and Scott, 1983; *Lamtoquadrula* Bonnet, 1974; *Leptochlamys* West, 1901; *Maghrebia* Gauthier-Lièvre et Thomas, 1958; *Pentagonia* Gauthier-Lièvre et Thomas, 1958 ; *Physochila* Jung, 1942; *Pontigulasia* Rhumbler, 1896; *Pseudawerintzewia* Bonnet, 1959; *Schoenbornia* Decloitre, 1964; *Schwabia* Jung, 1942; *Sexangularia* Awerintzew, 1906, *Zivkovicia* Ogden, 1987.

***Incertae sedis* Amoebozoa**, Genera: *Microcorycia* Cockerell, 1911; *Parmulina* Penard, 1902; *Penardochlamys* Deflandre, 1953; *Zonomyxa* Nüsslin, 1882

Domain **Diaphoretickes** Adl et al., 2012
Supergroup **Sar** Burki et al., 2008, emend. Adl et al., 2012
Phylum **Stramenopiles** Patterson, 1989, emend. Adl et al., 2005
Class **Labyrinthulomycetes** Dick, 2001
Order **Amphitremida** Poch, 1913, emend. Gomaa et al., 2013
Family **Amphitrematidae** Poch, 1913
Genus *Amphitrema* Archer, 1869
Genus *Archerella* Loeblich and Tappan, 1961
Genus *Paramphitrema* Valkanov, 1970

Supergroup **Rhizaria** Cavalier-Smith, 2002
Phylum **Cercozoa** Cavalier-Smith, 1998, emend. Adl et al., 2005; emend. Cavalier-Smith, 2018
Class **Thecofilosea** Cavalier-Smith, 2003, emend. Cavalier-Smith, 2011
Order **Cryomonadida** Cavalier-Smith, 1993
Family **Rhogostomidae** Dumack et al., 2017
Genus *Capsellina* Penard, 1909
Genus *Rhogostoma* Belar, 1921

Genus *Sacciforma* Dumack et al., 2017

Order **Tectofilosida** Cavalier-Smith, 2003

Family **Chlamydophryidae** de Saedeleer, 1934

Genus *Chlamydophrys* Cienkowsky, 1876

Genus *Clypeolina* Penard, 1902

Genus *Diaphorodon* Archer, 1869

Genus *Lecythium* Hertwig and Lesser, 1874

Genus *Leptochlamydophris* Belar, 1921

Family **Pseudodifflugiidae** de Saedeleer, 1934

Genus *Pseudodifflugia* Schlumberger, 1845

Class **Silicofilosea** Adl et al., 2005, emend. Adl et al., 2012

Order **Thaumatomonadida** Shirkina, 1987

Family **Thaumatomonadidae** Hollande, 1952

Genus *Penardeugenia* Deflandre, 1958

Order **Euglyphida** Copeland, 1956, emend. Cavalier-Smith, 1997

Family **Assulinidae** Lara et al., 2007

Genus *Assulina* Ehrenberg, 1872

Genus *Placocista* Leidy, 1879

Genus *Valkanovia* Tappan, 1966

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

Genus *Euglypha* Dujardin, 1841

Genus *Scutiglypha* Foissner and Schiller, 2001

Family **Sphenoderiidae** Chatelain et al., 2013

Genus *Deharvengia* Bonnet, 1979

Genus *Sphenoderia* Schlumberger, 1845

Genus *Trachelocorythion* Bonnet, 1979

Family **Trinematidae** Hoogenraad and De Groot,1940, emend Adl et al., 2012

Genus *Corythion* Taranek, 1881

Genus *Pileolus* Coûteaux et Chardez, 1981

Genus *Playfairina* Thomas, 1961

Genus *Puytoracia* Bonnet, 1970

Genus *Trinema* Dujardin, 1841

Family **Cyphoderiidae** de Saedeleer, 1934

Genus *Campascus* Leidy, 1877

Genus *Chardezia* Golemansky, 1970

Genus *Corythionella* Golemansky, 1970

Genus *Cyphoderia* Schlumberger, 1845

Genus *Messemvriella* Golemansky, 1973

Genus *Pseudocorythion* Valkanov, 1970

Genus *Schaudinnula* Awerintzev, 1907

Family **Paulinellidae** de Saedeller 1934, emend. Adl et al. 2012

Genus *Micropyxidiella* Tarnawski and Lara, 2015

Genus *Ovulinata* Anderson, Rogerson & Hannah, 1997

Genus *Paulinella* Lauterborn, 1895

***Incertae sedis* Euglyphida**, Genera: *Ampullataria* van Oye, 1956; *Euglyphidion* Bonnet, 1960; *Heteroglypha* Thomas et Gauthier-Lièvre, 1959; *Matsakision* Bonnet, 1967; *Pareuglypha* Penard, 1902; *Tracheleuglypa* Deflandre, 1928

***Incertae sedis* Cercozoa**:

Family **Psammonobiotidae** Golemansky, 1974, emend. Meisterfeld, 2002

Genus *Alepiella* Golemansky, 1970

Genus *Centropyxiella* Valkanov, 1970

Genus *Edaphonobiotus* Schönborn, Foissner and Meisterfeld, 1983

Genus *Micramphora* Valkanov, 1970

Genus *Micropsammella* Golemansky, 1970

Genus *Nadinella* Penard, 1902

Genus *Ogdeniella* Golemansky, 1982

Genus *Psammonobiotus* Golemansky, 1967

Genus *Propsammonobiotus* Golemansky, 1991

Family **Volutellidae** Sudzuki, 1979

Genus *Pseudovolutella* Sudzuki, 1979

Genus *Volutella* Chardez, 1977

***Incertae sedis* Cercozoa**, Genera: *Feuerbornia* Jung, 1942; *Frenzelina* Penard, 1902; *Lesquerella* Chardez et Thomas, 1980; *Rhumbleriella* Golemansky, 1970

LIST OF SPHAGNUM-DWELLING TESTATE AMOEBAE RECORDED IN BULGARIA

Prior to our investigation, the number of known Sphagnum-dwelling testate amoebae in Bulgaria was 171 (Bankov et al. 2018). Present study increases the number with 4 species and this group currently comprises 175 species classified into 45 genera, 20 families, six orders, five classes and three phyla. The species are presented in a systematic order, according to the classification in the previous chapter.

Varieties and forms recorded from Bulgaria are not included separately in the atlas, despite the fact that, according to the International Code of Zoological Nomenclature, article 45.6.3, when the name was published before 1961 using the abbreviation 'var.' or 'f.', it is deemed to be subspecific rather than infrasubspecific. However, due to the fact that many of these taxa have not sufficiently detailed descriptions and in many cases they are described on a basis of traits that do not have much taxonomic significance (small differences in size, the presence or absence of spines/cornes and their number, the number of lobes of the aperture, etc.) these taxa remain with unclear taxonomic status. So, until the clarifying of their status with the help of combined morphological and molecular approaches and full confirmation of their validity, we prefere to adopt a conservative position and consider these taxa as the product of the phenotipic plasticity of a nominal species. Nevertheless, in the next chapter "Species descriptions and illustrations" to each nominal species, in 'Notes', we have included all the records for these infrasubspecific taxa, in the event that some of them may be raised in rank in the future.

AMOEBOZOA

Family Arcellidae

Genus *Arcella*

- *Arcella arenaria* Greeff, 1866
- *Arcella bathystoma* Deflandre, 1928
- *Arcella catinus* Penard, 1890
- *Arcella dentata* Ehrenberg, 1838
- *Arcella discoides* Ehrenberg, 1871
- *Arcella gibbosa* Penard, 1890
- *Arcella hemisphaerica* Perty, 1852
- *Arcella intermedia* (Deflandre, 1928) Tsyganov and Mazei, 2006

- ▹ *Arcella rotundata* Playfair, 1918
- ▹ *Arcella vulgaris* Ehrenberg, 1830

Family Netzeliidae

Genus *Cyclopyxis*

- ▹ *Cyclopyxis arcelloides* (Penard, 1902) Deflandre, 1929
- ▹ *Cyclopyxis eurystoma* Deflandre, 1929
- ▹ *Cyclopyxis kahli* Deflandre, 1929
- ▹ *Cyclopyxis pirini* Golemansky, 1974
- ▹ *Cyclopyxis puteus* Thomas, 1960

Genus *Netzelia*

- ▹ *Netzelia oviformis* (Cash, 1909) Ogden, 1979
- ▹ *Netzelia tuberculata* (Wallich, 1864) Netzel, 1983

***Incertae sedis* Sphaerothecina**

Genus *Trigonopyxis*

- ▹ *Trigonopyxis arcula* (Leidy, 1879) Penard, 1912

Family Difflugiidae

Genus *Difflugia*

- ▹ *Difflugia acuminata* Ehrenberg, 1838
- ▹ *Difflugia ampullula* Playfair, 1918
- ▹ *Difflugia angulostoma* Gauthier-Lièvre and Thomas, 1958
- ▹ *Difflugia bacillariarum* Perty, 1849
- ▹ *Difflugia brevicolla* Cash, 1909
- ▹ *Difflugia bryophila* (Penard, 1902) Jung, 1942
- ▹ *Difflugia distenda* Ogden, 1983
- ▹ *Difflugia elegans* Penard, 1890
- ▹ *Difflugia glans* Penard, 1902
- ▹ *Difflugia globulosa* Dujardin, 1837
- ▹ *Difflugia hiraethogii* Ogden, 1983
- ▹ *Difflugia lanceolata* Penard,1890
- ▹ *Difflugia lobostoma* Leidy, 1874
- ▹ *Difflugia lucida* Penard, 1890
- ▹ *Difflugia mammillaris* Penard, 1893
- ▹ *Difflugia mica* Frenzel, 1892
- ▹ *Difflugia microclaviformis* (Kourov, 1925) Ogden, 1983
- ▹ *Difflugia minuta* Rampi, 1950
- ▹ *Difflugia molesta* Penard, 1902
- ▹ *Difflugia oblonga* Ehrenberg, 1838

- *Difflugia penardi* Hopkinson,1909
- *Difflugia petricola* Cash, 1909
- *Difflugia pristis* Penard, 1902
- *Difflugia pulex* Penard, 1902
- *Difflugia pyriformis* Perty, 1849
- *Difflugia rotunda* (Chardez, 1956) Ogden, 1983
- *Difflugia rubescens* Penard, 1891
- *Difflugia stoutii* Ogden, 1983
- *Difflugia subaequalis* Penard, 1910
- *Difflugia urceolata* Carter, 1864
- *Difflugia ventricosa* Deflandre, 1926
- *Difflugia viscidula* Penard, 1902

Family Lesquereusiidae

Genus *Lesquereusia*

- *Lesquereusia epistomium* Penard, 1902
- *Lesquereusia gibbosa* Thomas et Gauthier-Lièvre, 1859
- *Lesquereusia modesta* Rhumbler, 1896
- *Lesquereusia spiralis* (Ehrenberg, 1840) Bütschli, 1880

Family Centropyxidae

Genus *Centropyxis*

- *Centropyxis aculeata* (Ehrenberg, 1830) Stein, 1857
- *Centropyxis aerophila* Deflandre, 1929
- *Centropyxis cassis* (Wallich, 1864) Deflandre, 1929
- *Centropyxis constricta* (Ehrenberg, 1838) Penard, 1902
- *Centropyxis cryptostoma* Bonnet, 1959
- *Centropyxis discoides* (Penard, 1890) Deflandre, 1929
- *Centropyxis ecornis* (Ehrenberg, 1841) Leidy, 1879
- *Centropyxis elongata* (Penard, 1890) Thomas, 1959
- *Centropyxis gibba* Deflandre, 1929
- *Centropyxis hirsuta* Deflandre, 1929
- *Centropyxis laevigata* Penard, 1890
- *Centropyxis minuta* Deflandre, 1929
- *Centropyxis orbicularis* Deflandre, 1929
- *Centropyxis plagiostoma* Bonnet et Thomas, 1955
- *Centropyxis platystoma* (Penard, 1890) Deflandre, 1929
- *Centropyxis spinosa* (Cash, 1905) Deflandre, 1929
- *Centropyxis sylvatica* (Deflandre, 1929) Bonnet et Thomas, 1955

Family Plagiopyxidae

Genus *Bullinularia*

- *Bullinularia indica* (Penard, 1907) Deflandre, 1953

Genus *Plagiopyxis*

- *Plagiopyxis callida* Penard, 1910
- *Plagiopyxis declivis* Thomas, 1955
- *Plagiopyxis glyphostoma* Bonnet, 1959
- *Plagiopyxis labiata* Penard, 1910
- *Plagiopyxis minuta* Bonnet, 1959
- *Plagiopyxis oblonga* (Bonnet et Thomas, 1955)

Family Hyalospheniidae

Genus Alabasta

- *Alabasta militaris* (Penard, 1890) Duckert, Blandenier, Kosakyan and Singer, 2018

Genus *Gibbocarina*

- *Gibbocarina galeata* (Penard, 1890) Kosakyan, Lahr, Mulot, Meisterfeld, Mitchell and Lara, 2016

Genus *Hyalosphenia*

- *Hyalosphenia elegans* (Leidy, 1874) Leidy, 1879
- *Hyalosphenia papilio* (Leidy, 1874) Leidy, 1875

Genus *Longinebela*

- *Longinebela ampulla* Todorov, Bankov and Ganeva, 2018
- *Longinebela golemanskyi* (Todorov, 2010) Kosakyan, Lahr, Mulot, Meisterfeld, Mitchell and Lara, 2016
- *Longinebela penardiana* (Deflandre, 1936) Kosakyan, Lahr, Mulot, Meisterfeld, Mitchell and Lara, 2016
- *Longinebela speciosa* (Deflandre, 1936) Kosakyan, Lahr, Mulot, Meisterfeld, Mitchell and Lara, 2016
- *Longinebela tubulosa* (Penard, 1902) Kosakyan, Lahr, Mulot, Meisterfeld, Mitchell and Lara, 2016

Genus *Nebela*

- *Nebela aliciae* Mitchell et Lara, 2013
- *Nebela collaris* (Ehrenberg 1848) Leidy, 1879
- *Nebela flabellulum* Leidy, 1874
- *Nebela guttata* Kosakyan and Lara, 2013
- *Nebela pechorensis* Kosakyan et Mitchell, 2013
- *Nebela rotunda* Penard, 1890
- *Nebela tincta* (Leidy, 1879) Awerintzew, 1906

Genus *Padaungiella*

- *Padaungiella americana* (Taranek, 1882)
- *Padaungiella lageniformis* (Penard, 1890) Lara et Todorov, 2012
- *Padaungiella nebeloides* (Gauthier-Lièvre et Thomas, 1958) Lara et Todorov, 2012
- *Padaungiella tubulata* (Brown, 1911) Lara et Todorov, 2012
- *Padaungiella wailesi* (Deflandre, 1936) Lara et Todorov, 2012

Genus *Planocarina*

- *Planocarina carinata* (Archer, 1867) Kosakyan, Lahr, Mulot, Meisterfeld, Mitchell and Lara, 2016

Genus *Quadrulella*

- *Quadrulella longicollis* (Taranek, 1882)
- *Quadrulella symmetrica* (Wallich, 1864) Cockerell, 1909
- *Quadrulella tubulata* Gauthier-Lièvre, 1953
- *Quadrulella variabilis* Kosakyan, Lahr, Mulot, Meisterfeld, Mitchell and Lara, 2016

Family Heleoperidae

Genus *Heleopera*

- *Heleopera petricola* Leidy, 1879
- *Heleopera rosea* Penard, 1890
- *Heleopera sphagni* (Leidy, 1874)
- *Heleopera sylvatica* Penard, 1890

Family Microchlamyidae

Genus *Microchlamys*

- *Microchlamys patella* (Claparede and Lachmann, 1859) Cockerell, 1911

Genus *Pyxidicula*

- *Pyxidicula patens* (Claparede and Lachmann, 1858)

Family Phryganellidae

Genus *Phryganella*

- *Phryganella acropodia* (Hertwig and Lesser, 1874) Hopkinson, 1909
- *Phryganella hemisphaerica* (Penard, 1890) Penard, 1902
- *Phryganella nidulus* Penard, 1902
- *Phryganella paradoxa* Penard, 1902

Family Cryptodifflugiidae

Genus *Cryptodifflugia*

- *Cryptodifflugia compressa* Penard, 1902
- *Cryptodifflugia oviformis* Penard, 1890

Genus *Wailesella*

- *Wailesella eboracensis* (Wailes and Penard, 1911) Deflandre, 1928

***Incertae sedis* Arcellinida**

Genus *Argynnia*

- ▹ *Argynnia bipes* (Carter, 1870) Murray, 1870
- ▹ *Argynnia dentistoma* (Penard, 1890)
- ▹ *Argynnia vitraea* (Penard, 1899)

Genus *Awerintzewia*

- ▹ *Awerintzewia cyclostoma* (Penard, 1902) Schouteden, 1906

Genus *Lagenodifflugia*

- ▹ *Lagenodifflugia bryophila* (Penard, 1902) Ogden, 1987
- ▹ *Lagenodifflugia montana* (Ogden and Zivkovic, 1983) Ogden, 1987
- ▹ *Lagenodifflugia vas* (Leidy, 1874) Medioli and Scott, 1983

Genus *Pontigulasia*

Pontigulasia elisa (Penard, 1893) Schouteden, 1906

Pontigulasia rhumbleri Hopkinson, 1919

Genus *Zivkovicia*

- ▹ *Zivkovicia compressa* (Carter, 1864)
- ▹ *Zivkovicia spectabilis* (Penard, 1902) Ogden, 1987

***Incertae sedis* Amoebozoa**

Genus *Microcorycia*

- ▹ *Microcorycia flava* (Greeff, 1866), emend. Penard, 1902

STRAMENOPILES

Family Amphitrematidae

Genus *Archerella*

- ▹ *Archerella flavum* (Archer, 1877) Loeblich and Tappan, 1961

CERCOZOA

Family Chlamydophryidae

Genus *Lecythium*

- ▹ *Lecythium mutabilis* (Bailey, 1853)

Family Pseudodifflugiidae

Genus *Pseudodifflugia*

- ▹ *Pseudodifflugia fascicularis* Penard, 1902
- ▹ *Pseudodifflugia gracilis* Schlumberger, 1845

Family Assulinidae

Genus *Assulina*

- ▹ *Assulina muscorum* Greeff, 1888

- *Assulina seminulum* (Ehrenberg, 1848) Leidy, 1879

Genus *Placocista*

- *Placocista glabra* Penard, 1906
- *Placocista spinosa* (Carter, 1865) Leidy, 1879

Family Euglyphidae

Genus *Euglypha*

- *Euglypha acanthophora* (Ehrenberg, 1841) Perty, 1849
- *Euglypha aspera* Penard, 1899
- *Euglypha bryophila* Brown, 1911
- *Euglypha ciliata* (Ehrenberg, 1848), Leidy, 1878
- *Euglypha compressa* Carter, 1864
- *Euglypha cristata* Leidy, 1874
- *Euglypha denticulata* Brown, 1912
- *Euglypha filifera* Penard, 1890
- *Euglypha laevis* (Ehrenberg, 1845) Perty, 1849
- *Euglypha rotunda* Wailes and Penard, 1911
- *Euglypha strigosa* (Ehrenberg, 1871) Leidy, 1878
- *Euglypha tuberculata* Dujardin, 1841

Genus *Scutiglypha*

- *Scutiglypha crenulata* (Wailes, 1912) Foissner and Schiller, 2001

Family Sphenoderiidae

Genus *Sphenoderia*

- *Sphenoderia fissirostris* Penard, 1890
- *Sphenoderia labiata* Thomas et Gauthier-Lièvre, 1959
- *Sphenoderia lenta* Schlumberger, 1845
- *Sphenoderia minuta* Deflandre, 1931
- *Sphenoderia ovoidea* Jung, 1942
- *Sphenoderia splendida* (Playfair, 1917) Deflandre, 1931

Genus *Trachelocorythion*

- *Trachelocorythion pulchellum* (Penard, 1890) Bonnet, 1979

Family Trinematidae

Genus *Corythion*

- *Corythion constricta* (Certes, 1889) Jung, 1942
- *Corythion delamarei* Bonnet et Thomas, 1960
- *Corythion dubium* Taránek, 1881

Genus *Playfairina*

- *Playfairina valkanovi* Golemansky, 1966

Genus *Trinema*

- ▹ *Trinema complanatum* Penard, 1890
- ▹ *Trinema enchelys* (Ehrenberg, 1838) Leidy, 1878
- ▹ *Trinema galeata* (Penard, 1890) Jung, 1942
- ▹ *Trinema grandis* (Chardez, 1960) Golemansky, 1963
- ▹ *Trinema lineare* Penard, 1890

Family Cyphoderiidae

Genus *Campascus*

- ▹ *Campascus minutus* Penard, 1899
- ▹ *Campascus triqueter* Penard, 1891

Genus *Cyphoderia*

- ▹ *Cyphoderia amphoralis* (Wailes and Penard, 1911)
- ▹ *Cyphoderia ampulla* (Ehrenberg, 1840) Leidy, 1878
- ▹ *Cyphoderia major* (Penard, 1891)

Family Paulinellidae

Genus *Paulinella*

- ▹ *Paulinella chromatophora* Lauterborn, 1895

***Incertae sedis* Euglyphida**

Genus *Pareuglypha*

- ▹ *Pareuglypha reticulata* Penard, 1902

Genus *Tracheleuglypha*

- ▹ *Tracheleuglypha acolla* Bonnet et Thomas, 1955
- ▹ *Tracheleuglypha dentata* (Moniez, 1888) Deflandre, 1928

SPECIES DESCRIPTIONS AND ILLUSTRATIONS

A total of 120 species are described in the atlas, including most of the characteristic sphagnicolous testate amoebae, as well as some rare or accidentally found in *Sphagnum* mosses species. The following information is given for each species: description; ecology; geographical distribution; distribution in *Sphagnum* mosses in Bulgaria and relevant literature sources; morphometric characterisation; taxonomic notes (if necessary); synonymous names (if available); original publication and publication where last revision is made (if any).

Each species is illustrated by nine micrographs, primarily on scanning electron microscope (SEM), to receive information about the shell ultrastructure. Micrographs taken on light microscope (LM) are additionally given for most of them to illustrate the cytoplasm and pseudopodia of live individuals.

In measurements of the species in which the aboral protuberances or horns (spines) are present, the length includes these appendages when they are part of the shell matrix (e.g. *Centropyxis, Difflugia, Pareuglypha*), but excludes them when they are specialised shell components (e.g. *Euglypha*).

Arcella arenaria Greeff, 1866

Original description: Greeff 1866, *Archiv für Mikroskopische Anatomie***,** 2, p. 330, Taf. XVIII, Fig. 16.

Synonyms: *Arcella aureola* Maggi, 1883; *Arcella microstoma* Penard, 1890.

Description: Shell yellow or light brown, circular, with depressed aboral region and conical in lateral view (Fig. 11 A-G). Apertural surface smooth, with small pores around the basal border (Fig. 11 D, H). Shell composed of very small organic alveoli of about 0.5-0.6 μm in diameter (Fig. 11 I). Aperture invaginated, circular, bordered by a distinct lip and corone of about ten to fifteen large pores (Fig. 11 D, H). Cytoplasm abundant, does not fills the whole shell; often amoebae are encysted with large spheroidal cyst and characteristic rejected apertural side (Fig. 11 G). Two typical vesicular nuclei of about 20 μm, with a single central nucleolus. Pseudopodia few, large, rarely exceed the basal border; movement slow, with sliding on the substrate.

Notes: *A. arenaria* is similar to *A. catinus*, but these two species may be distinguished by the size (*A. catinus* is bigger, with larger aperture), number of apertural pores (10-15 in *A. arenaria*, versus 18-35 in *A. catinus*), as well as by theirs ecology: *A. arenaria* inhabits mostly aerophilic and dry habitats, whereas *A. catinus* occurs in wet habitats, mainly wet *Sphagnum* mosses.

Ecology: Common in aerophilic mosses and litter in deciduous forests, very rare in *Sphagnum*.

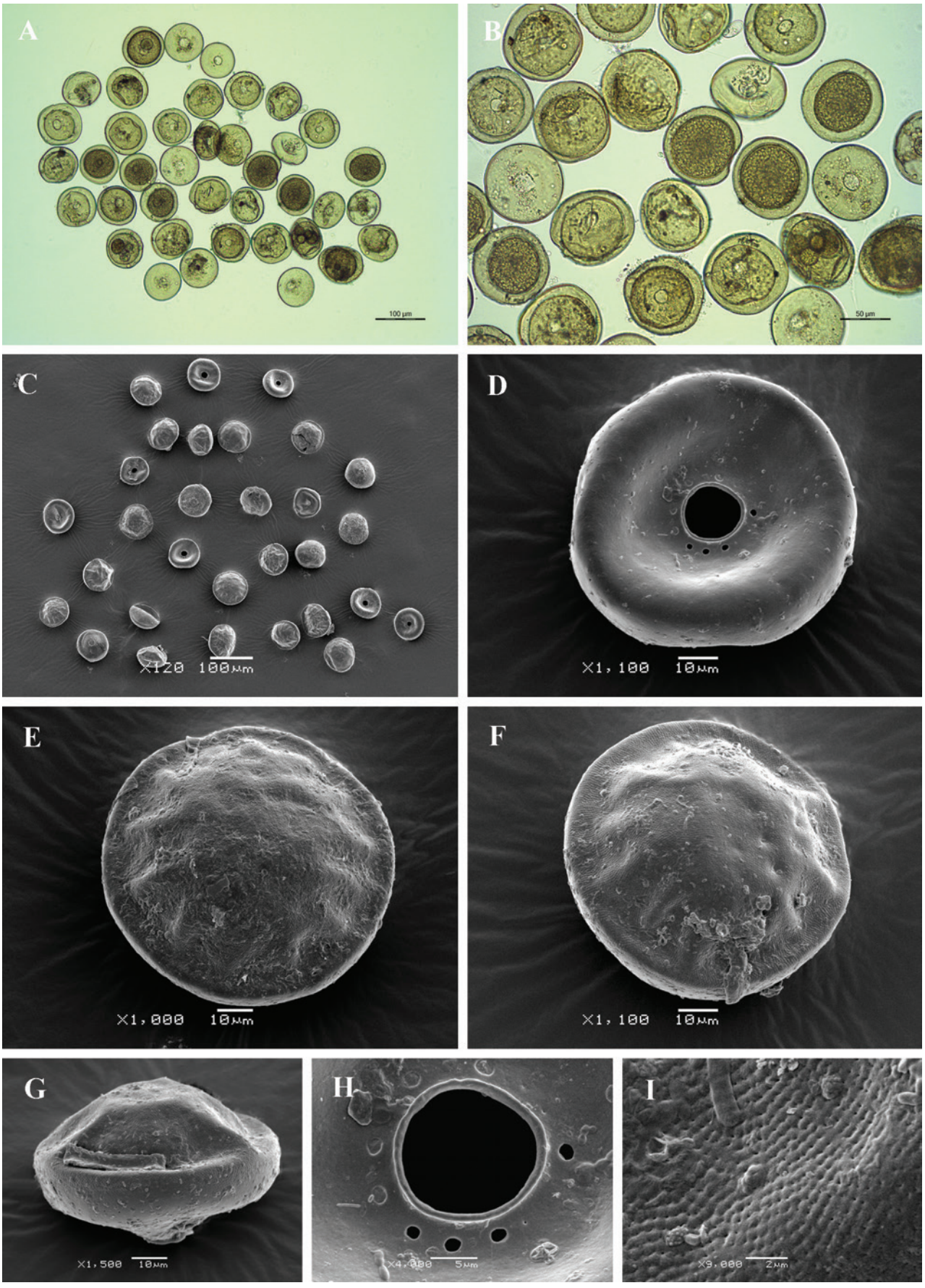
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1990).

Table 1. *Arcella arenaria*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	93.4	89.8	12.65	2.31	14.01	70	119	30
Diameter of aperture	17.4	17.1	3.88	0.71	22.32	13	28	30
Depth	29.6	27.6	4.66	1.41	15.77	26	40	11
Aperture/Diameter ratio	0.19	0.19	0.03	0.006	15.97	0.1	0.3	30
Depth/Diameter ratio	0.32	0.29	0.09	0.03	28.30	0.3	0.6	11

Fig. 11. Light (A, B) and scanning electron (C-I) micrographs of *Arcella arenaria*. (A-C) View of many specimens showing variability in shape and size of the shell. (D) Apertural view to show smooth apertural surface. (E-F) Aboral view showing depressed segments of surface. (G) Lateral view. (H) Close up view of aperture to show distinct apertural lip and surrounding large pores. (I) Portion of shell surface showing small organic alveoli on the aboral surface.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Arcella bathystoma Deflandre, 1928

Original description: Deflandre 1928, *Archiv für Protistenkunde*, 64, p. 237, Fig. 242-243.

Description: Shell yellow or light brown, circular in apertural and dorsal view; with a shallow domed or conical aboral region in lateral view, and sides running evenly down at slightly rounded angles to the apertural side (Fig. 12 A-F). Apertural surface and basal border smooth (Fig. 12 C, D); aboral surface with series of fine depressions of about 5-8 μm, inconspicuous at small magnification (Fig. 12 E, H-I). Shell composed of regularly arranged small organic alveoli of about 0.6-0.8 μm (Fig. 12 H, I). Aperture deeply invaginated, up to half of the depth, circular and bordered by a very small lip and about ten to twenty large pores, sometimes not well visible (Fig. 12 G). Cytoplasm does not fills the whole shell; cell fixed with numerous fine epipodes at the shell wall; two typical vesicular nuclei with a single central nucleolus. Pseudopodia three to four, short, finger-like, rarely exceed the basal border; movement slow, with sliding on the substrate.

Ecology: In *Sphagnum*, rare, low population density.

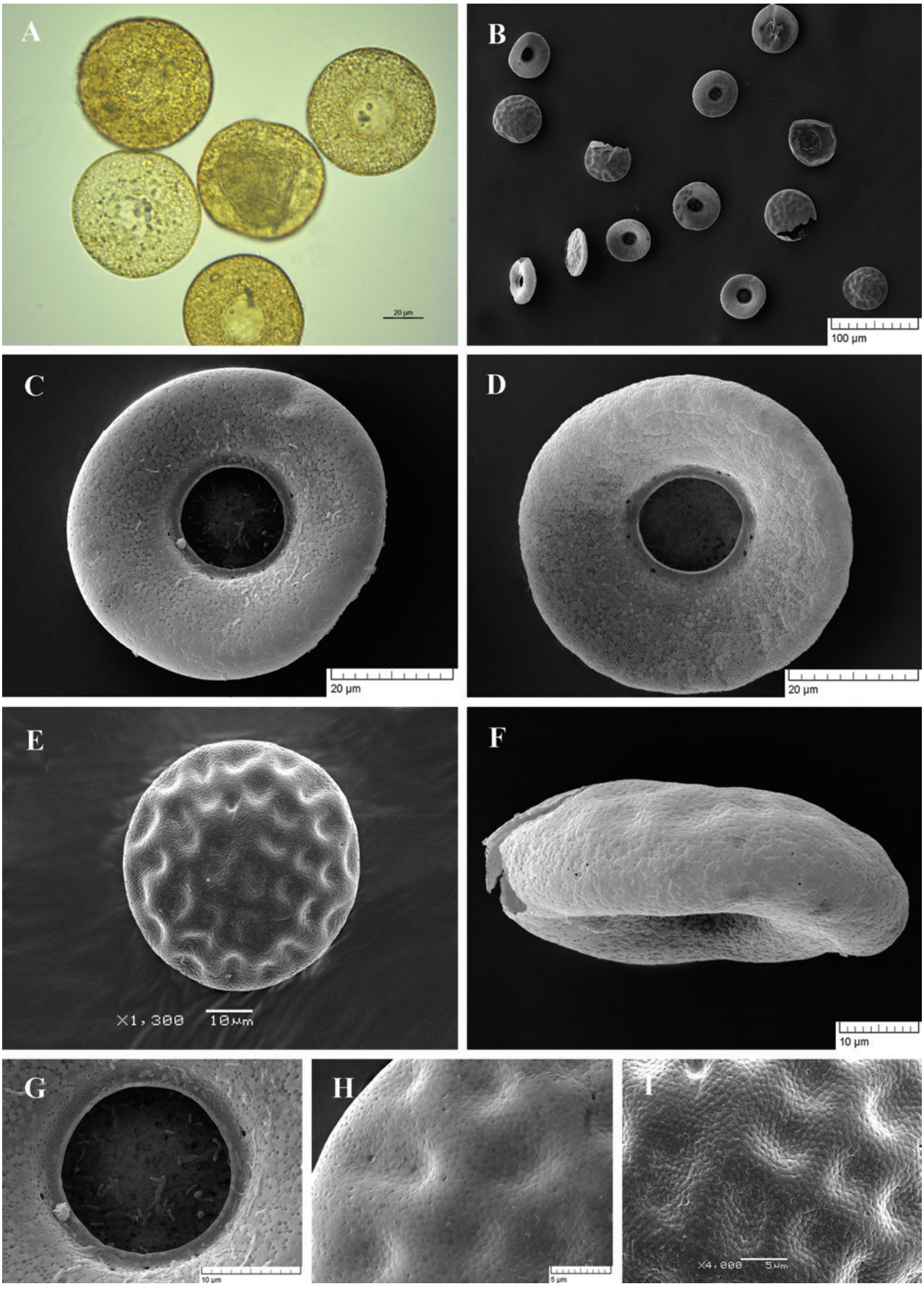
Geographical distribution: Possible cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rila Mts. (Bankov et al. 2018).

Table 2. *Arcella bathystoma*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	62.7	60.3	7.54	1.14	12.02	52	78	44
Diameter of aperture	21.1	21.1	3.06	0.46	14.49	14	29	44
Depth	24.4	24.2	5.03	0.83	20.6	16	35	37
Aperture/Diameter ratio	0.34	0.34	0.03	0.005	10.27	0.2	0.4	44
Depth/Diameter ratio	0.39	0.38	0.06	0.010	16.16	0.24	0.53	37

Fig. 12. Light (A) and scanning electron (B-I) micrographs of *Arcella bathystoma*. (A-B) View of several specimens showing general shape of the shell. (C, D) Apertural view of two specimens to show deeply invaginated and comparatively large aperture. (E) Dorsal view showing regular depressions on aboral shell surface. (F) Lateral view. (G) Close up view of aperture to show apertural lip and surrounding large pores. (H, I) Portion of shell surface showing arrangement of the organic alveoli and regular depressions on the aboral surface of the shell.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Arcella catinus Penard, 1890

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Gen*ève, 31, p. 154, Pl. V, fig. 78 à 92.

Synonyms: *Arcella vulgaris* Leidy, 1879 (in part); *Arcella artocrea* Penard, 1902; *Arcella vulgaris* var. *compressa* Cash, 1905; *Arcella catinus* var. *australis* Playfair, 1918

Description: Shell yellow or light brown, too variable in shape - circular, oval, triangular, quadrangular, more or less irregular in apertural and dorsal view (Fig. 13 A-F); with depressed aboral region and trapezoidal in lateral view (Fig. 13 G). Apertural surface smooth, with small pores around the basal border (Fig. 13 F); dorsally divided into segments by folding of the surface, with view of polygon or a star (Fig. 13 C-E, H). Shell composed of very small organic alveoli of about 0.5-0.6 μm (Fig. 13 H). Aperture s invaginated, circular or oval, bordered by a distinct lip and corone of about fifty to twenty large pores (Fig. 13 F, I). Cytoplasm abundant but not fill the whole shell; often amoebae are encysted, with large spheroidal cyst and characteristic rejected apertural side; two typical vesicular nuclei of about 16-18 μm, with a single central nucleolus. Pseudopodia few, large, exceed the basal border; movement slow, with sliding on the substrate.

Notes: *A. catinus* is similar to *A. arenaria*, but these two species may be distinguished by the size (*A. catinus* is bigger, with larger aperture), number of apertural pores (10-15 in *A. arenaria*, versus 18-35 in *A. catinus*), as well as by theirs ecology: *A. arenaria* inhabits mostly aerophilic and dry habitats, whereas *A. catinus* occurs mainly in *Sphagnum* mosses.

Ecology: Frequent in wet *Sphagnum* mosses.

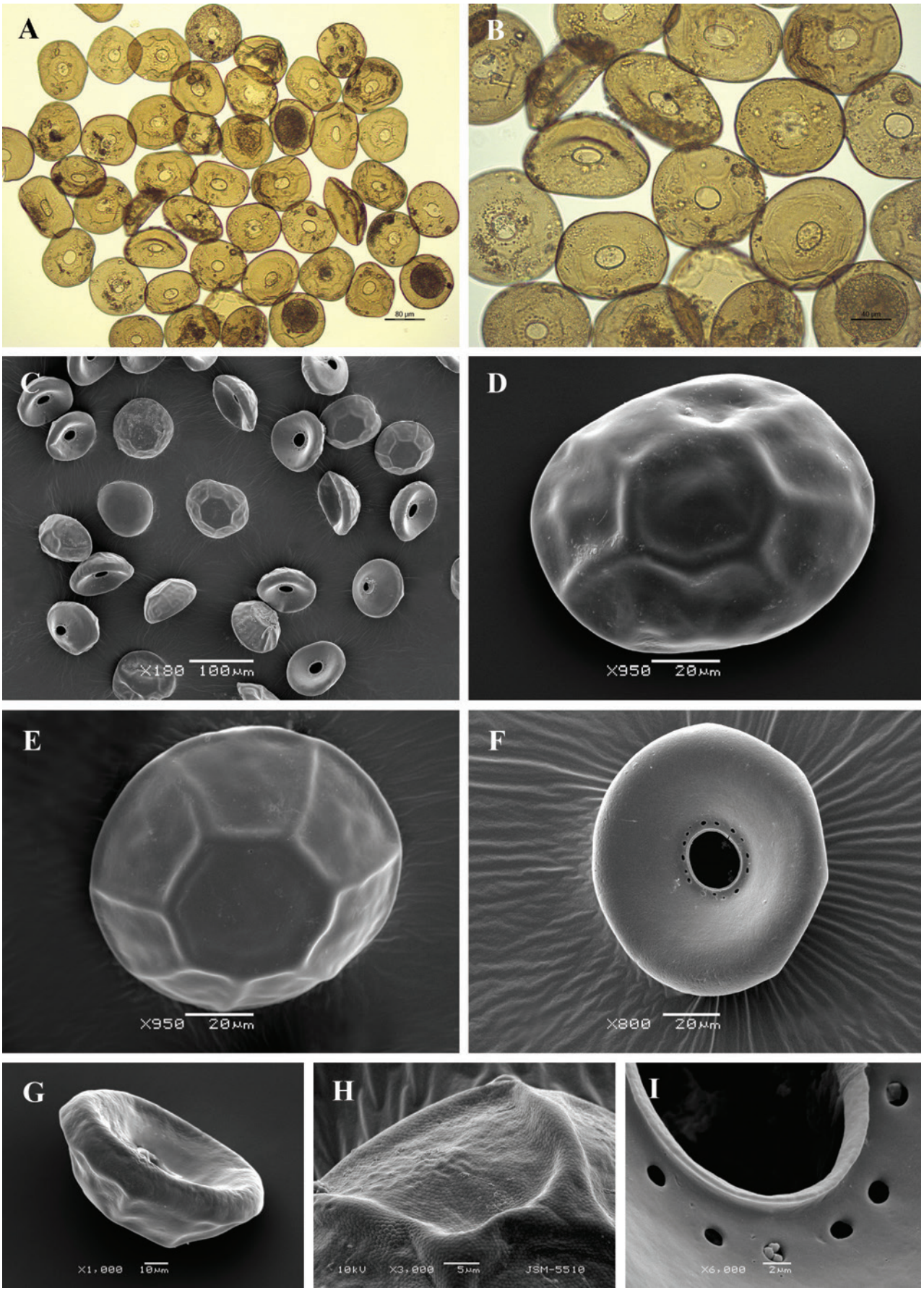
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1928, Golemansky 1965, Golemansky and Todorov 1990, Todorov 1993, Todorov and Golemansky 1995; Bankov et al. 2018).

Table 3. *Arcella catinus*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	120.6	119.8	9.74	1.78	8.07	101	137	30
Breadth	100.3	100.2	8.16	1.49	8.14	86	120	30
Depth	52.7	53.8	7.04	1.35	13.4	36	68	27
Large axis of aperture	29.4	30.6	3.70	0.67	12.6	22	37	30
Small axis of aperture	23.0	22.7	3.22	0.59	14.0	16	30	30
Depth/Length ratio	0.44	0.44	0.06	0.011	13.18	0.3	0.6	27

Fig. 13. Light (A, B) and scanning electron (C-I) micrographs of *Arcella catinus*. (A-C) View of many specimens showing variability in shape and size of the shell. (C-E) Dorsal view to illustrate depressed aboral region and foldings of the surface; (F) Apertural view to show smooth apertural surface; (G) Lateral view showing characteristic trapezoidal shape. (H) Portion of shell surface showing small organic alveoli and foldings of the aboral surface. (I) Close up view of aperture to show distinct apertural lip and surrounding large pores.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Arcella dentata Ehrenberg, 1830

Original description: Ehrenberg 1830, *Abhandlungen der Königlichen Akademie der Wissenszchaften zu Berlin*, p. 40.

Synonyms: *Arcella stellaris* Perty, 1852; *Arcella Okeni* Perty, 1852; *Arcella stellata* Ehrenberg, 1854

Description: Shell colorless in young and yellow or brown in older individuals; circular and more or less dentate seen from above or below (Fig. 14 A-E). In lateral view resembles a crown with evenly rounded top and turned-up rim edged with conical points of variable length. Shallow conical aboral region, frequently depressed at summit, with a series of radiating ridges curving to the points of the rim (Fig. 14 F, I). Number of ridges varies, usually from nine to fourteen. Shell depth about one third of the shell diameter. Apertural surface invaginated, usually smooth, with numerous small pores. Aperture invaginated, circular, with small lip and surrounded by about forty to sixty large pores (Fig. 14 E, G). Shell composed of small round alveoli of about 1 μm in diameter (Fig. 14 H). Cell does not fill the shell, fixed at the shell wall with many small epipodes; usually one, rarely few, short granular endolobopodia and two typical vesicular nuclei with one large central nucleolus (Fig 14 C).

Ecology: Weakly mineralized peat bogs and lakes, *Sphagnum* spp.; comparatively rare and usually with a low density.

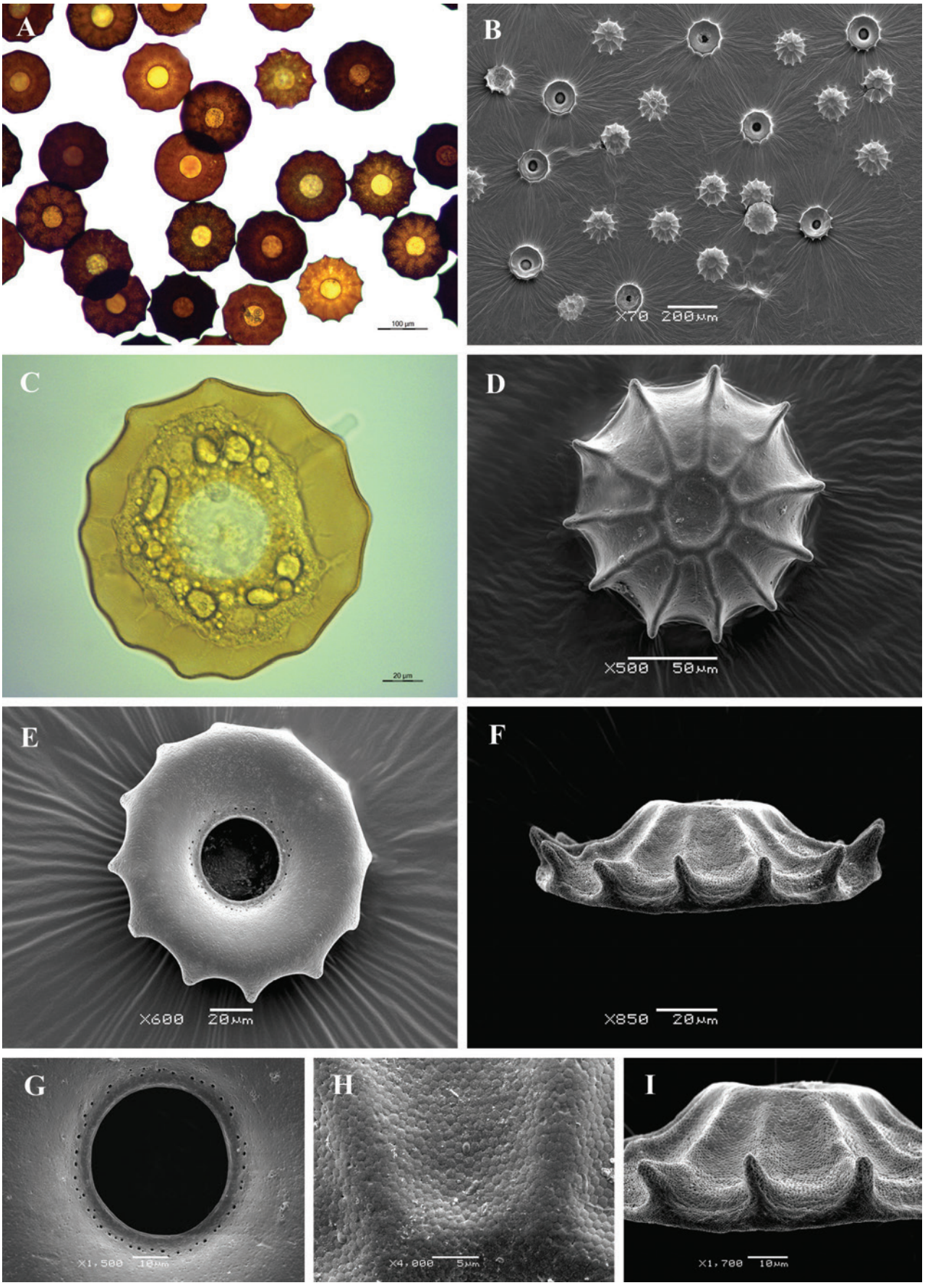
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mt. (Bankov et al. 2018); Rhodopes Mt. (Pateff 1924, Golemansky et al. 2006).

Table 4. *Arcella dentata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	140.0	141.0	10.20	1.19	7.29	96	161	73
Diameter of aperture	44.9	44.5	4.27	0.50	9.52	35	58	72
Depth	37.8	37.4	2.92	0.81	7.72	33	44	13
Aperture/Diameter ratio	0.32	0.32	0.03	0.004	9.32	0.3	0.4	72
Depth/Diameter ratio	0.27	0.26	0.02	0.004	6.08	0.2	0.3	13

Fig. 14. Light (A, C) and scanning electron (B, D-I) micrographs of *Arcella dentata*. (A, B) View of many specimens showing variability in shape and size of the shell. (C) View of live specimen illustrating two typical vesicular nuclei with one large central nucleolus, numerous small epipodes and granular endolobopodia. (D) Dodsal view showing shell depression on top and radiating ridges. (E) Apertural view. (F) Lateral view showing characteristic crown resembling shell. (G) View of aperture to illustrate small lip and surrounding large pores. (H) Portion of shell surface to show structuring alveoli and small pores. (I) Lateral view showing highly flattened shell with turned-up rim edged with conical point.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Arcella discoides Ehrenberg, 1871

Original description: Ehrenberg 1871, *Abhandlungen der Königliche Akademie der Wissenshaften zu Berlin (1871)*, p. 259, Taf. III, fig. 1.

Synonyms: *Arcella discoidea* Ehrenberg, 1843.

Description: Shell yellow or brown, circular, with shallow conical aboral region and basal border, discoid in lateral view (Fig. 15 A-F). Composed of very small organic alveoli of about 0.5-0.7 μm in diameter (Fig. 15 G-I). Aperture large, slightly invaginated, circular, bordered by a thin lip and corone of about fifty to seventy large pores (Fig. 15 D, G, H). Cytoplasm abundant, not fills the whole shell, attached to the walls with numerous short epipodes; two typical vesicular nuclei of about 20 μm in diameter with a single large, central nucleolus. Pseudopodia numerous, short, rarely exceed the basal border; movement slow, with sliding on the substrate (Fig. 15 A-C).

Ecology: Common in freshwater standing bodies, among aquatic vegetation, less frequent in *Sphagnum*.

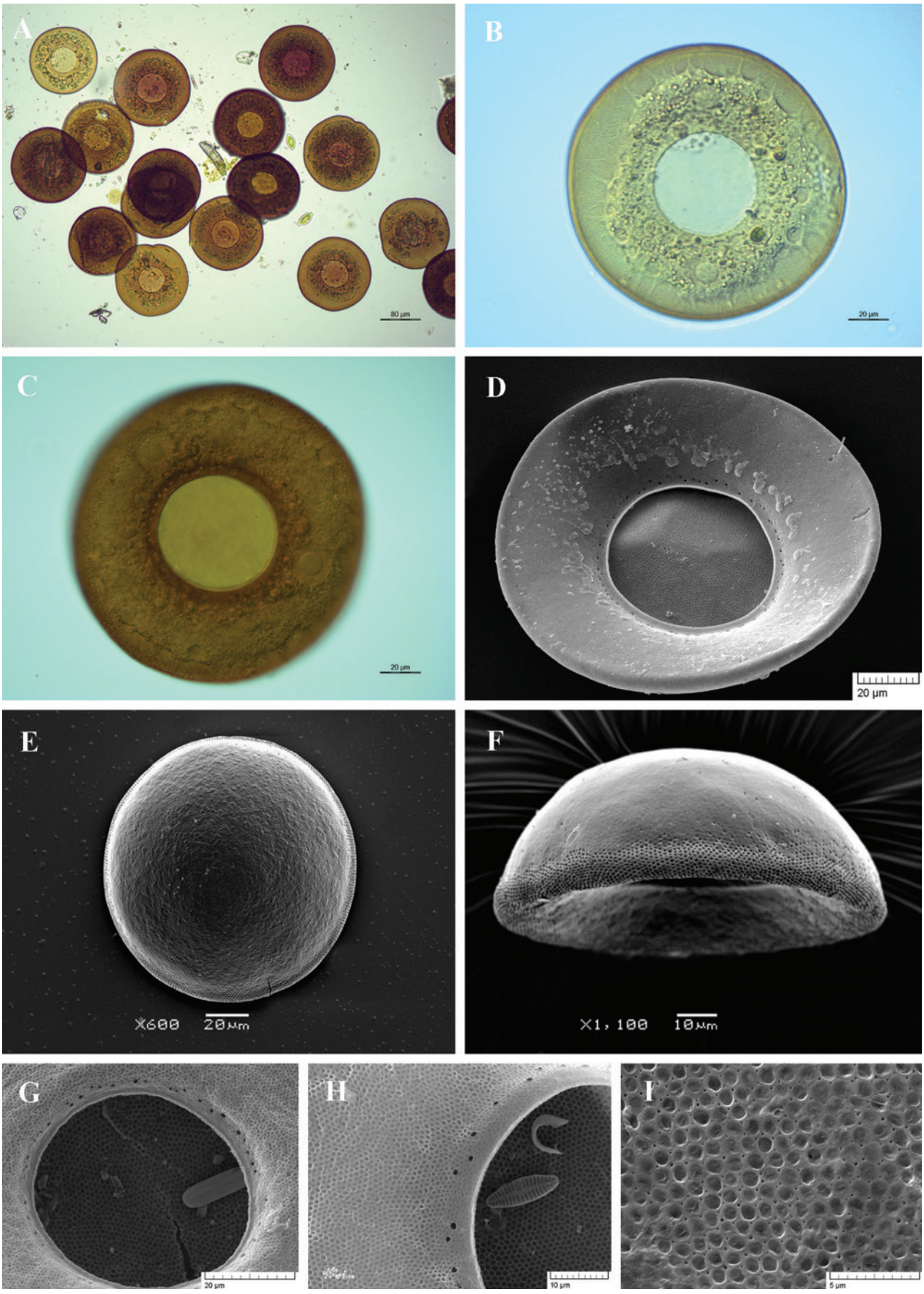
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky 1968, Golemansky et al. 2006); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemanskly 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 5. *Arcella discoides*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	116.2	117.9	14.63	2.63	12.59	91	144	31
Diameter of aperture	44.2	43.6	8.64	1.25	15.48	34	60	30
Depth	36.8	37.5	4.59	1.32	12.45	28	44	12
Aperture/Diameter ratio	0.38	0.37	0.04	0.007	9.39	0.3	0.5	30
Depth/Diameter ratio	0.34	0.33	0.05	0.01	13.52	0.2	0.4	12

Fig. 15. Light (A-C) and scanning electron (D-I) micrographs of *Arcella discoides*. (A) View of many specimens showing variability in shape and size of the shell. (B, C) View of live specimens illustrating numerous short epipodes and two typical vesicular nuclei with one large central nucleolus. (D) Apertural view to show smooth apertural surface, large aperture and surrounding numerous pores. (E) Aboral view. (F) Lateral view. (G, H) Close up view of aperture to show its circular outline, thin apertural lip and numerous surrounding large pores. (I) Portion of shell surface showing small organic alveoli on the aboral surface.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Arcella gibbosa Penard, 1890

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 155, Pl. V, fig. 96 à 99, Pl. VI, fig. 1.

Description: Shell yellow or brown, circular, with depressed aboral region and domed or hemispherical in lateral view (Fig. 16 A-G). Apertural surface and the basal collar are smooth (Fig. 16 B, D, F). Shell composed of small organic alveoli of about 1-1,2 μm in diameter (Fig. 16 G-I). Aperture invaginated, circular, bordered by a distinct lip (Fig. 16 B, D, G). Cytoplasm abundant, does not fills the whole shell; cell attached to the walls with numerous short epipodes; two typical vesicular nuclei with a single central nucleolus. Pseudopodia numerous, short, rarely exceed the basal border; movement slow, with sliding on the substrate (Fig 16 A, C).

Ecology: In freshwater standing bodies, among aquatic vegetation, rare in *Sphagnum*.

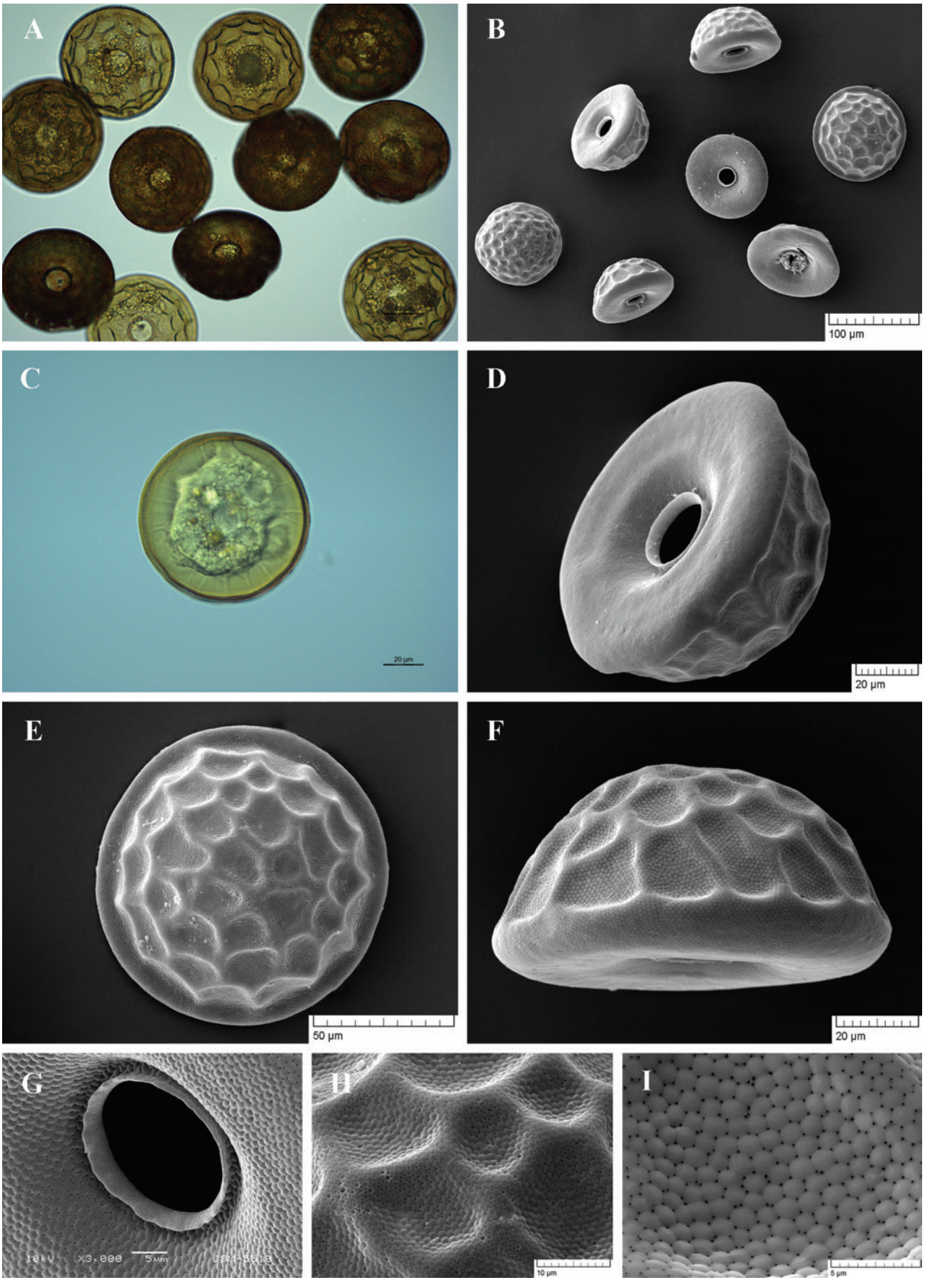
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Golemansky et al. 2006); **Vitosha Mts.** (Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 6. *Arcella gibbosa*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	98,7	98,6	4,79	1,05	4,85	91	106	21
Diameter of aperture	20,9	20,6	1,64	0,36	7,85	19	25	21
Depth	52,5	52,3	1,80	0,39	3,43	49	57	21
Aperture/Diameter ratio	0,21	0,21	0,008	0,002	3,81	0,20	0,23	21
Depth/Diameter ratio	0,53	0,53	0,017	0,004	3,21	0,50	0,56	21

Fig. 16. Light (A, C) and scanning electron (B, D-I) micrographs of *Arcella gibbosa*. (A, B) View of many specimens showing variability in shape and size of the shell. (C) View of live specimen illustrating numerous short epipodes and two typical vesicular nuclei with one large central nucleolus. (D) Latero-apertural view to show smooth apertural surface and invagited aperture. (E) Dorsal view showing depressed segments of the surface. (F) Lateral view. (G) Close up view of aperture to show distinct apertural lip. (H) Close up view of aboral side showing depressed segments of the surface. (I) Portion of shell surface showing small organic alveoli and numerous surrounding small pores.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Arcella hemisphaerica Perty, 1852

Original description: Perty 1852, *Zur Kenntnis kleinster Lebensformen*, p. 186, T. 9, fig. 5.

Synonyms: *Arcella vulgaris* var. *hemisphaerica* Wailes, 1918

Description: Shell yellow or brown, smooth or irregular, circular in apertural or aboral view, hemispherical in lateral view; with sides running evenly down at nearly right or slightly rounded angles to the apertural side (Fig. 17 A-H); composed of comparatively large organic alveoli, easily collapsed when the shell is dryied, with numerous small pores (Fig. 17 I). Aperture slightly invaginated, circular and bordered by a small lip (Fig. 17 D, E, I). Cytoplasm does not fill the shell, cell fixed with numerous fine epipodes at the shell walls; two vesicular nuclei with a single large, central and spherical nucleolus (Fig. 17 C). Pseudopodia usually two to four, short, finger-like, rarely go beyond the edge of the shell; movement slow, with sliding on the substrate.

Notes: The species has been recorded in both as nominal species and as infrasubspecific taxon *Arcella hemisphaerica* f. *undulata* Deflandre, 1928 (Rhodopes Mts., Rila Mts.).

Ecology: Common in stagnant freshwater bodies, in littoral zone among aquatic vegetation, less frequent in *Sphagnum*.

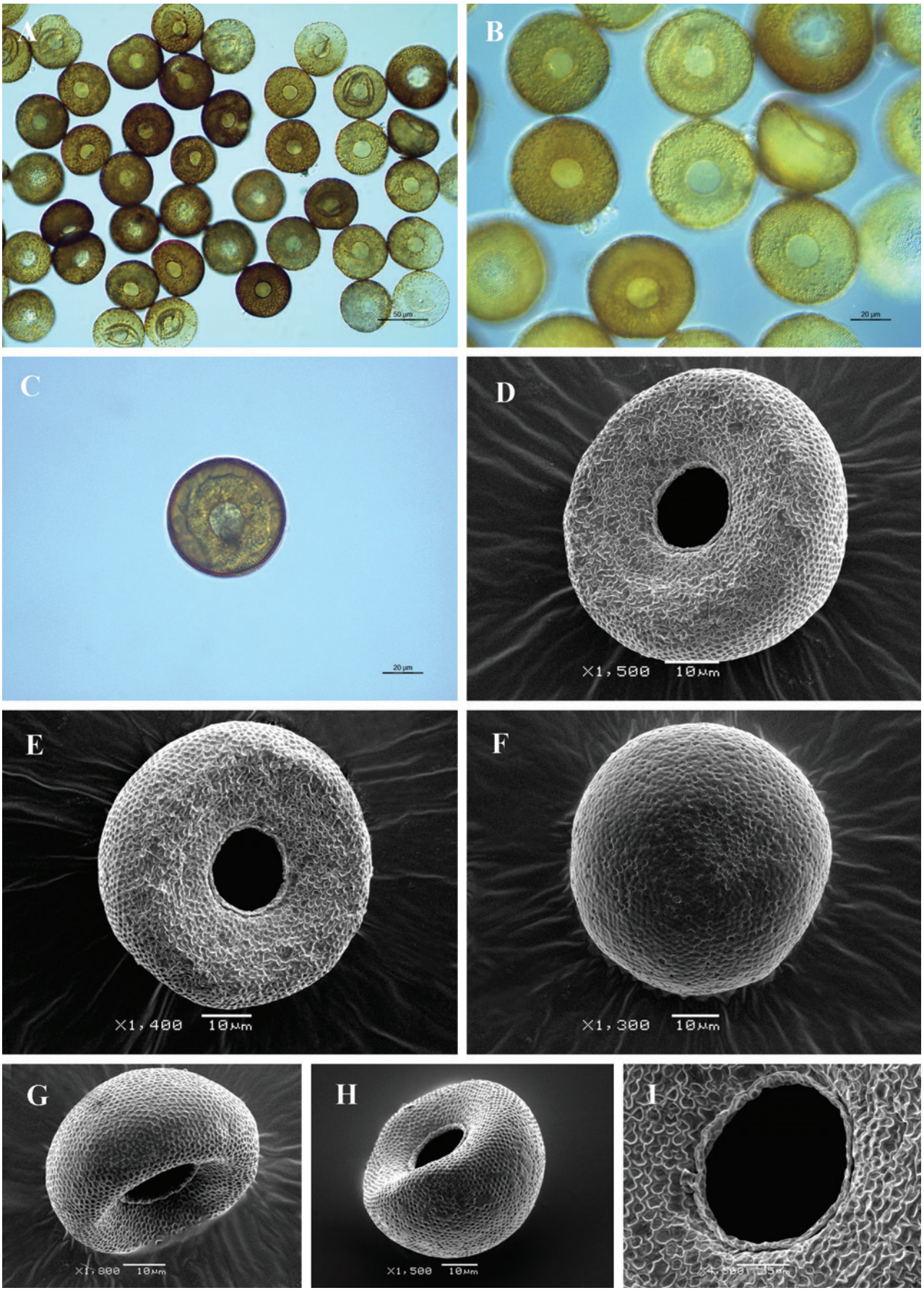
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Todorov 2004, Bankov et al. 2018); **Vitosha Mts.** (Bankov et al. 2018).

Table 7. *Arcella hemisphaerica*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	57.4	54.7	6.66	1.03	11.60	49	71	42
Diameter of aperture	17.9	18.2	2.91	0.45	16.26	12	26	42
Depth	31.3	30.1	6.10	1.76	19.51	25	43	12
Aperture/Diameter ratio	0.31	0.30	0.04	0.006	11.56	0.3	0.4	42
Depth/Diameter ratio	0.57	0.56	0.06	0.018	10.91	0.5	0.7	12

Fig. 17. Light (A-C) and scanning electron (D-I) micrographs of *Arcella hemisphaerica*. (A, B) View of many specimens showing variability in shape and size of the shell. (C) View of live specimen illustrating numerous short epipodes and two typical vesicular nuclei with one large central nucleolus. (D, E) Apertural view of two specimens. (F) Dorsal view. (G, H) Latero-apertural view. (I) Close up view of aperture showing the apertural lip, irregular shell surface caused by drying of the shell and collapsed alveoli, as well as numerous small pores.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Arcella intermedia (Deflandre, 1928) Tsyganov and Mazei, 2006

Original description: Deflandre 1928, *Archiv für Protistenkunde*, 64, p. 215-216, Fig. 238-240; **Last revision**: Tsiganov and Mazei 2006, *Protistology*, 4 (4), p. 367, Fig. 5e.

Synonyms: *Arcella hemisphaerica* var. *intermedia* f. *undulata* Deflandre, 1928

Description: Shell yellow or brown, circular in apertural and dorsal view, domed or hemispherical in lateral view; with sides running evenly down by broadly rounded angles to the apertural side (Fig. 18 A-F). Apertural surface and basal border smooth (Fig. 18 C, D); aboral surface with series of regular depressions of about 10-15 μm (Fig. 18 E, F). Shell composed of regularly arranged hexagonal alveoli (about 1-1.5 μm), with numerous small pores (Fig. 18 H, I). Aperture invaginated, circular and bordered by a distinct lip (Fig. 18 G). Cytoplasm does not fills the whole shell; cell is fixed with numerous fine epipodes at the shell walls; binucleate, typical vesicular nuclei with a single central nucleolus. Pseudopodia few, very short, finger-like, usually does not exceed the basal border; movement slow, with sliding on the substrate.

Ecology: Common in stagnant freshwater bodies, among submerged aquatic vegetation; less common in *Sphagnum*.

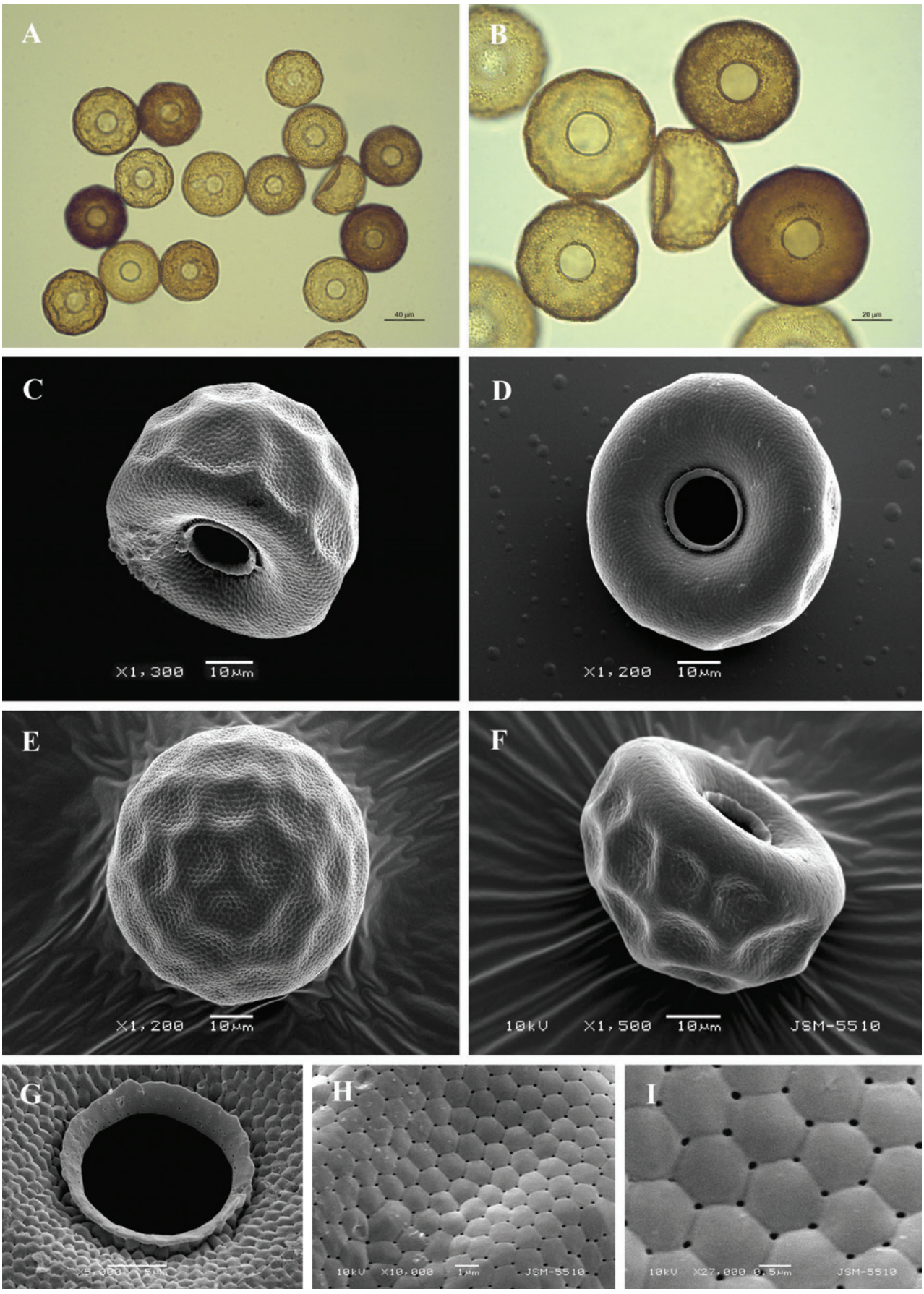
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rila Mts.** (Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Bankov et al. 2018).

Table 8. *Arcella intermedia*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	60.9	60.5	3.71	0.60	6.09	53	69	38
Diameter of aperture	16.0	16.0	1.49	0.24	9.33	14	23	38
Depth	34.0	34.0	2.46	0.40	7.21	29	39	37
Aperture/Diameter ratio	0.26	0.26	0.02	0.004	8.41	0.2	0.4	38
Depth/Diameter ratio	0.56	0.55	0.05	0.008	8.45	0.5	0.7	37

Fig. 18. Light (A, B) and scanning electron (C-I) micrographs of *Arcella intermedia*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C) Latero-apertural view showing apertural invagination. (D) Apertural view to show smooth apertural surface. (E) Dorsal view showing regular depressions on aboral surface of the shell. (F) Lateral view. (G) Close up view of aperture to show the apertural lip. (H, I) Portion of shell surface showing regularity in arrangement of the organic hexagonal alveoli and numerous small pores.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10kV ×27,000 0.5µm JSM-5510

Arcella rotundata Playfair, 1918

Original description: Playfair 1918, *Proceedings of the Linnean Society of New South Wales*, 42, p. 637, Pl. XXXIV, fig. 1.

Description: Shell yellow or brown, smooth, thin and fragile, circular in ventral view, domed or hemispherical in lateral view; margin of the dome without basal angles and merging into the base in a broadly rounded curve (Fig. 19 A-G); composed of many organic alveoli, arranged in a single layer and surrounded by numerous small pores (Fig. 19 I). Aperture invaginated, circular and bordered by a distinct lip (Fig. 19 C-E, H). Cytoplasm does not fill the shell; cell fixed with numerous short epipodes at the shell walls; two vesicular nuclei with a single large, central and spherical nucleolus. Pseudopodia usually three or four, short, finger-like; movement slow, with sliding on the substrate.

Notes: Besides the nominal species two infrasubspecific taxa have also been recorded in Bulgaria: *Arcella rotundata* var. *stenostoma* Deflandre, 1928 (Vitosha Mts.) and *Arcella rotundata* var. *stenostoma* f. *undulata* Deflandre, 1928 (Rhodopes Mts., Vitosha Mts.).

Ecology: Common in standing freshwater bodies, among submerged aquatic vegetation; less frequent in *Sphagnum*.

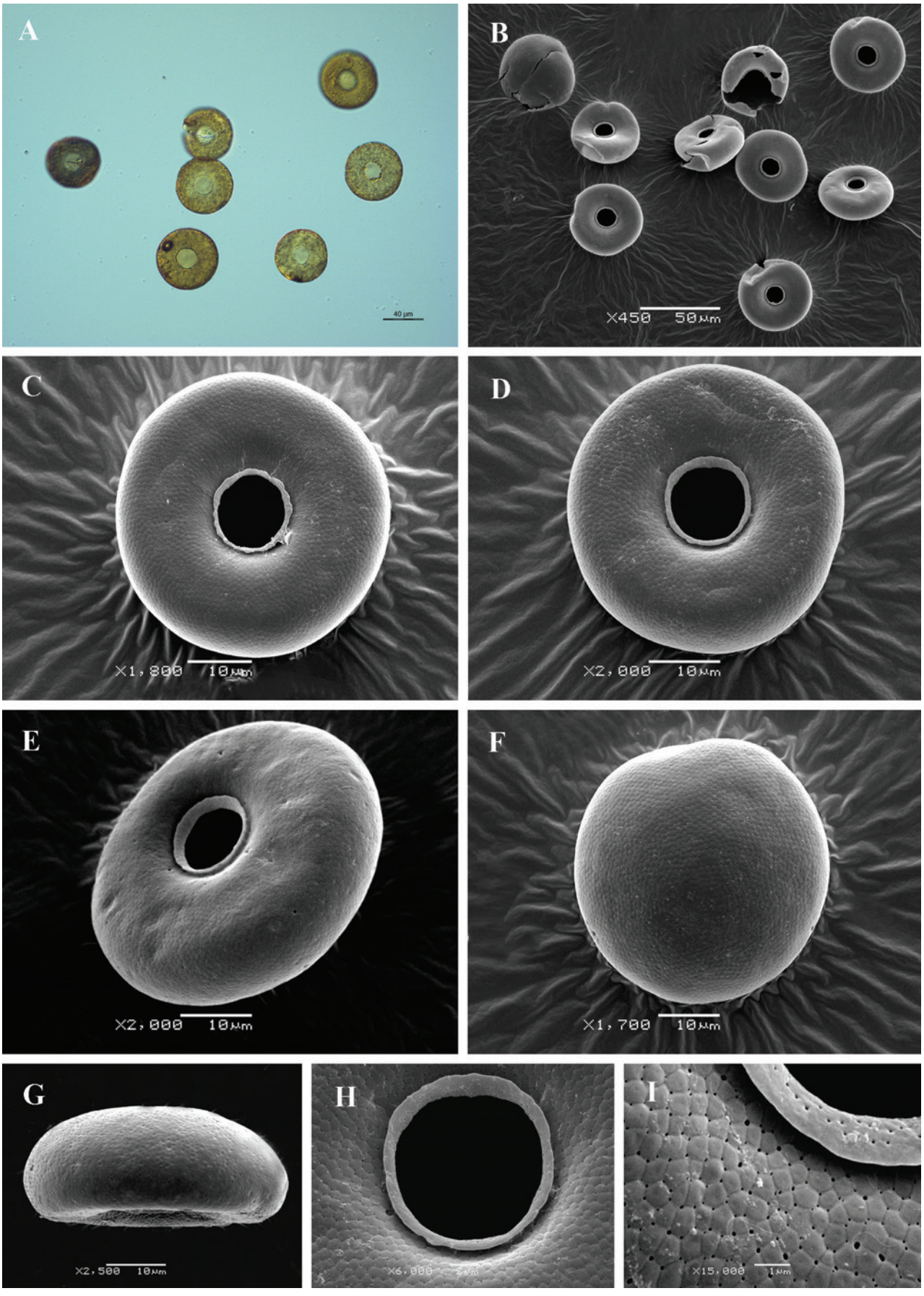
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2004, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); (Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 9. *Arcella rotundata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	49.4	48.5	3.58	0.65	7.24	44	57	30
Diameter of aperture	14.5	13.9	2.58	0.47	17.8	10	21	30
Depth	30.0	23.1	3.26	0.59	13.6	19	31	30
Aperture/Diameter ratio	0.29	0.29	0.05	0.01	17.72	0.2	0.4	30
Depth/Diameter ratio	0.49	0.49	0.06	0.01	11.8	0.38	0.64	30

Fig. 19. Light (A) and scanning electron (B-I) micrographs of *Arcella rotundata*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C-D) Apertural view of two specimens. (E) Latero-apertural view. (F) Dorsal view. (G) Lateral view. (H) Close up view of aperture showing the bordering lip. (I) Portion of shell surface to show arrangement of organic alveoli and numerous small pores.


A
40 µm
B
X450 50µm
C
X1,800 10µm
D
X2,000 10µm
E
X2,000 10µm
F
X1,700 10µm
G
X2,500 10µm
H
X6,000 2µm
I
X15,000 1µm

Arcella vulgaris Ehrenberg, 1830

Original description: Ehrenberg 1830, *Abhandlungen der Königlichen Akademie der Wissenszchaften zu Berlin*, p. 40, 53, 61, 69, 70, 75, Taf. I, Fig. VI (1-3).

Description: Shell yellow or brown, circular and domed or hemispherical in lateral view, with pronounced basal collar (Fig. 20 A-G). Apertural surface and the basal collar smooth (Fig. 20 B, D, F). Shell composed of small organic alveoli of about 1-1,2 μm in diameter (Fig. 20 I). Aperture invaginated, circular, bordered by a distinct lip (Fig. 20 B, D, G, H). Cytoplasm abundant, does not fills the whole shell; cell fixed with numerous short epipodes at the shell walls; two typical vesicular nuclei with a single central nucleolus. Pseudopodia numerous, short, rarely exceed the basal border; movement slow, with sliding on the substrate (Fig 20 C).

Ecology: Common in freshwater standing bodies, among aquatic vegetation, less frequent in *Sphagnum*.

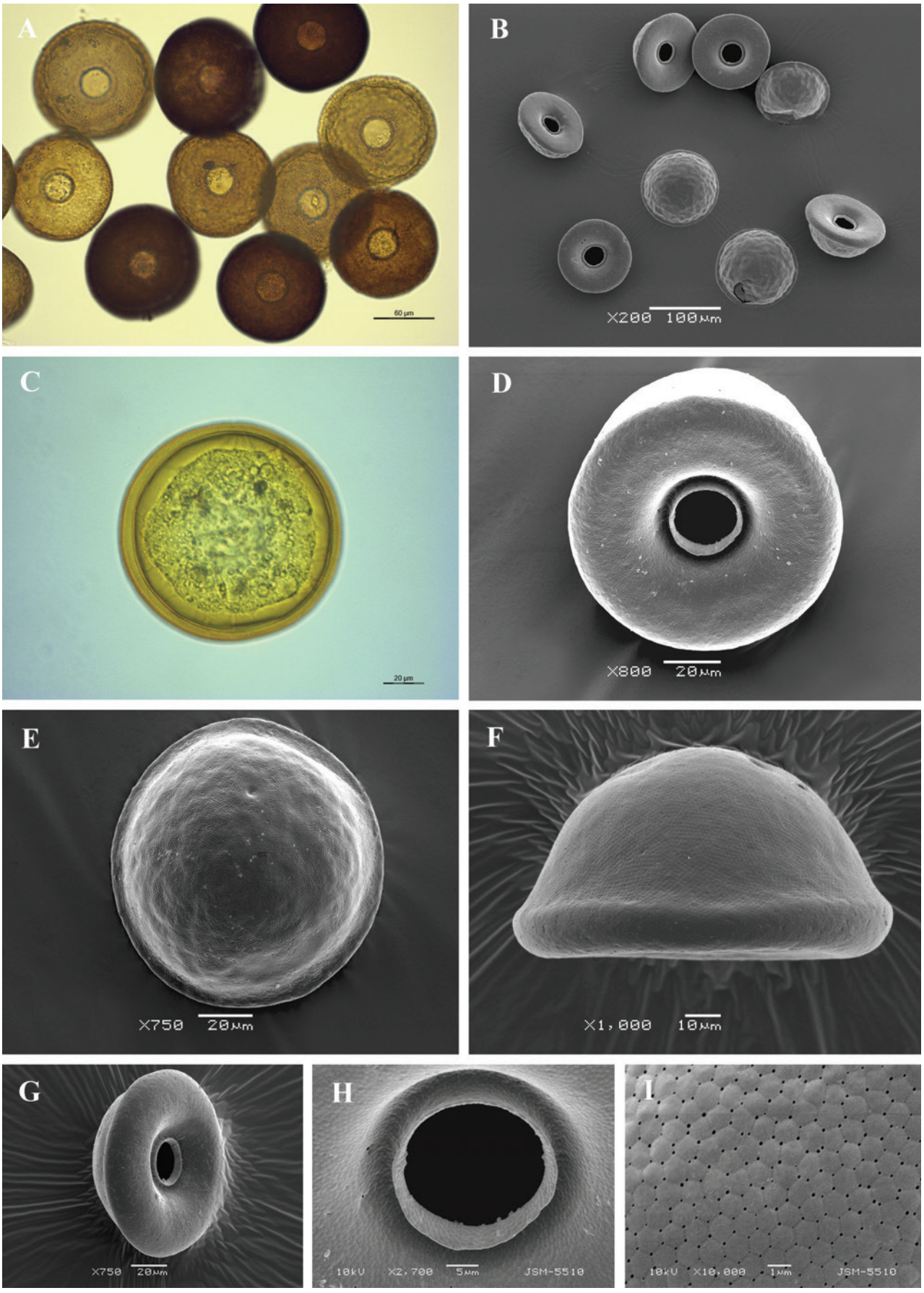
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Pateff 1924, Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky, 2000); **Vitosha Mts.** (Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 10. *Arcella vulgaris*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	116.1	118.2	11.70	1.74	10.07	87	139	45
Diameter of aperture	35.9	38.2	6.50	1.02	18.10	23	49	41
Depth	62.7	62.4	4.48	1.16	7.14	57	74	15
Aperture/Diameter ratio	0.30	0.31	0.04	0.006	12.96	0.2	0.4	41
Depth/Diameter ratio	0.59	0.58	0.05	0.01	8.13	0.5	0.7	15

Fig. 20. Light (A, C) and scanning electron (B, D-I) micrographs of *Arcella vulgaris*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C) View of live specimen illustrating numerous short epipodes and two typical vesicular nuclei with one large central nucleolus. (D) Apertural view to show smooth apertural surface and deeply invaginated aperture with pronounced apertural lip. (E) Dorsal view. (F, G) Lateral view showing a basal collar. (H) Close up view of aperture to show distinct apertural lip. (I) Portion of shell surface showing small organic alveoli and numerous surrounding small pores.


A
60 µm
B
X200 100µm
C
20 µm
D
X800 20µm
E
X750 20µm
F
X1,000 10µm
G
X750 20µm
H
10kV X2,700 5µm JSM-5510
I
10kV X10,000 1µm JSM-5510

Cyclopyxis eurystoma Deflandre, 1929

Original description: Deflandre 1929, *Archiv für Protistenkunde*, 67, p. 371, fig. 168 à 171.

Synonyms: *Centropyxis (Cyclopyxis) eurystoma* Deflandre, 1929.

Description: Shell yellow or brown, circular in apertural and aboral views, hemispherical in lateral view (Fig. 21 A-F); composed mainly of small to medium pieces of quartz, so arranged to give a well defined and regular outline with a rough surface (Fig. 21 C-F). Shell components usually in close contact with each other, organic cement rarely visible between particles (Fig. 21 E, F, I). Aperture circular, central, well defined and bordered by smooth band of organic cement (Fig. 21 G, H).

Ecology: Frequent in soils, mosses and forest litter, rare in *Sphagnum*.

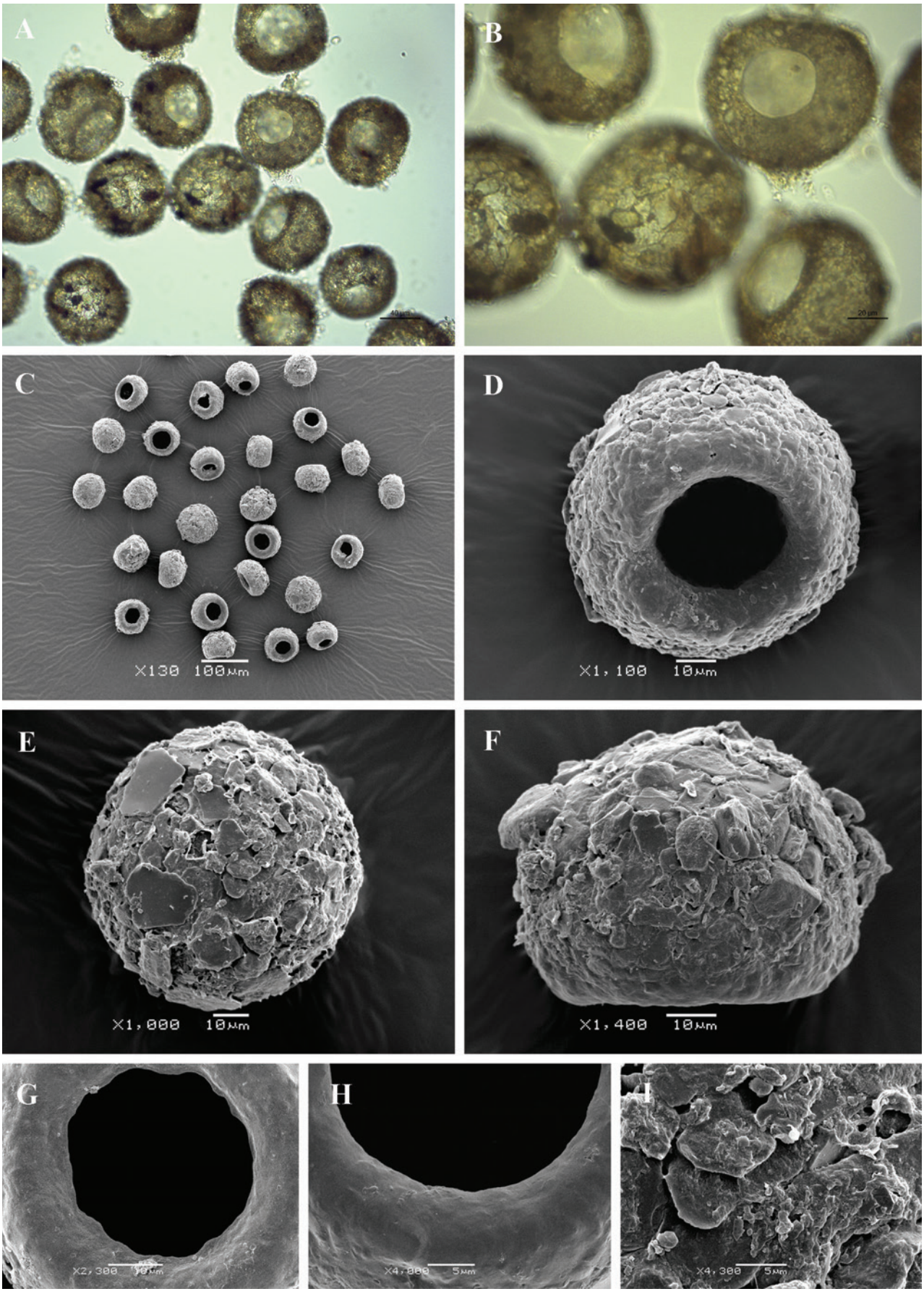
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rila Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Bankov et al. 2018).

Table 11. *Cyclopyxis eurystoma*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	59.3	57.5	7.14	1.28	12.03	50	78	31
Depth	42.9	42.9	5.98	1.11	13.93	33	56	29
Diameter of aperture	28.7	28.7	5.05	0.91	17.59	21	40	31
Depth/Diameter ratio	0.73	0.73	0.1	0.02	14.05	0.5	0.9	29
Aperture/Diameter ratio	0.48	0.48	0.05	0.009	9.99	0.4	0.6	31

Fig. 21. Light (A, B) and scanning electron (C-I) micrographs of *Cyclopyxis eurystoma*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D) Apertural view showing general shape. (E) Dorsal view. (F) Lateral view. (G) Close up view of aperture. (H) Close up view of smooth apertural surface. (I) Detail of aboral side of the shell to illustrate its rough surface, covered with large pieces of quartz.


A
B
C
X130 100µm
D
X1,100 10µm
E
X1,000 10µm
F
X1,400 10µm
G
H
X4,800 5µm
I
X4,300 5µm

Cyclopyxis kahli Deflandre, 1929

Original description: Deflandre 1929, *Archiv für Protistenkunde*, 67, p. 370, fig. 164 à 167.

Synonyms: *Centropyxis (Cyclopyxis) eurystoma* Deflandre, 1929.

Description: Shell yellow or brown, circular in apertural and aboral views, hemispherical in lateral view (Fig. 22 A-G); composed mainly of small to medium pieces of quartz, so arranged to give a well defined and regular outline with a rough aboral surface and smooth apertural surface (Fig. 22 C-F). Shell components usually in close contact with each other, organic cement rarely visible between particles (Fig. 22 D-I). Aperture circular, central, well defined and bordered by quartz particles (Fig. 22 D, E, H).

Ecology: Frequent in soils, mosses and forest litter, rare in *Sphagnum*.

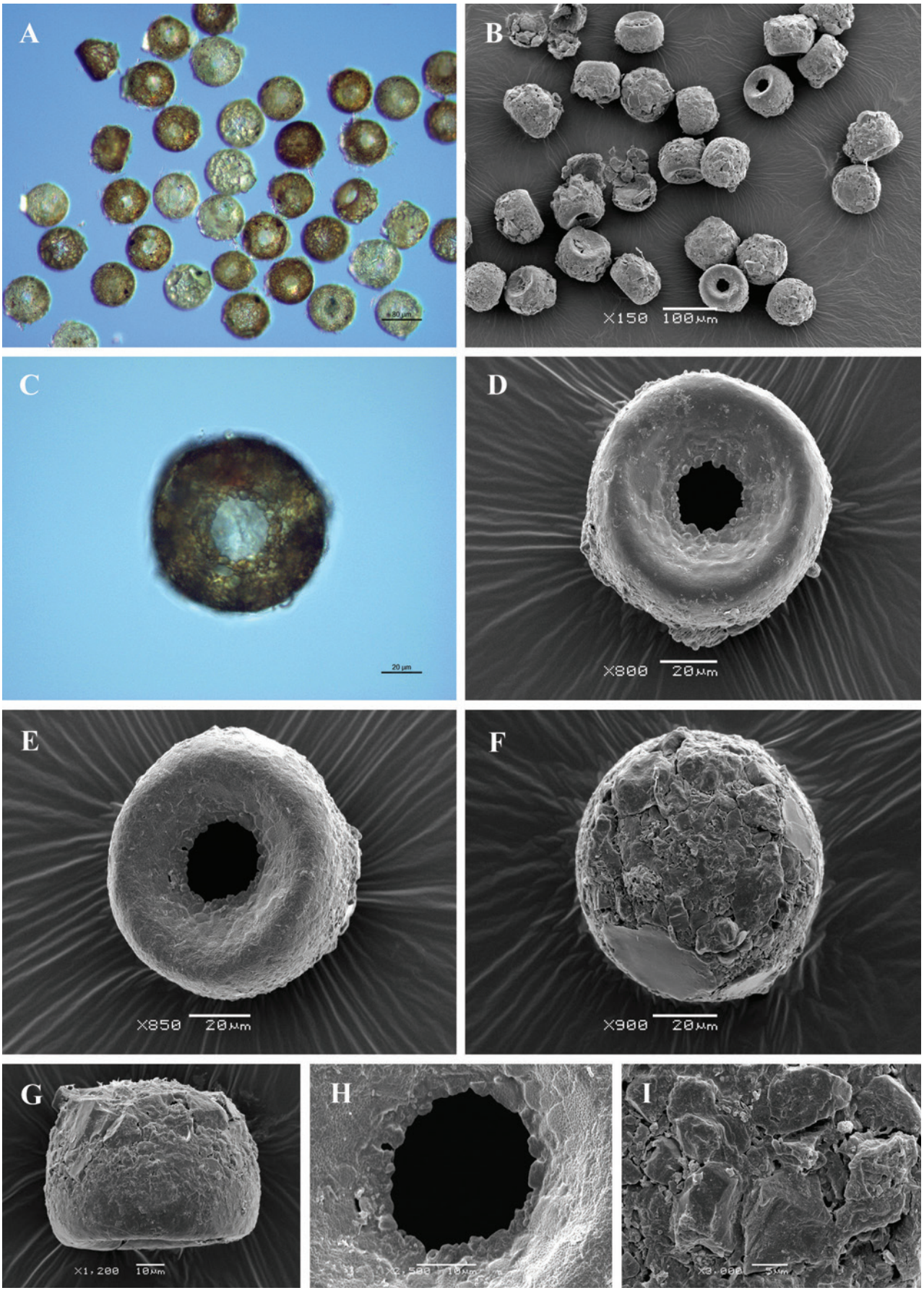
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1985, 1990, Bankov et al. 2018).

Table 12. *Cyclopyxis kahli*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	87.9	88.7	8.31	1.49	9.56	71	106	31
Depth	60.7	59.5	7.96	1.45	13.11	46	88	30
Diameter of aperture	28.8	29.4	4.41	0.79	15.34	20	39	31
Depth/Diameter ratio	0.33	0.33	0.04	0.007	12.35	0.3	0.5	31
Aperture/Diameter ratio	0.69	0.70	0.07	0.01	10.46	0.6	0.9	30

Fig. 22. Light (A, C) and scanning electron (B, D-I) micrographs of *Cyclopyxis kahli*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C-E) Apertural view of three specimens showing general shape. (F) Dorsal view. (G) Lateral view. (H) Close up view of aperture to illustrate its denticulate rim and smooth apertural surface. (I) Detail of aboral side of the shell to illustrate its rough surface, covered with large pieces of quartz.


A
B
X150 100µm
C
20 µm
D
X800 20µm
E
X850 20µm
F
X900 20µm
G
X1,200 10µm
H
I

Cyclopyxis puteus Thomas, 1960

Original description: Thomas 1960, *Bulletin de la Société de Pharmacie de Bordeaux*, 99, p. 14, fig. 1-4.

Description: Shell yellow or brown, circular in apertural and aboral views, hemispherical in lateral view (Fig. 23 A-G); composed mainly of small to medium pieces of quartz, embedded in deep layer of organic cement and so arranged to give a well defined and regular outline with a smooth surface (Fig. 23 C-G). Organic cement with numerous small pores on the apertural and lateral surface (Fig. 23 E, I). Aperture circular, central, well defined and deeply invaginated, forming an apertural tube and internal apertural opening (Fig. 23 D-F, H).

Ecology: In soils, mosses and forest litter, rarely and accidentally in *Sphagnum*.

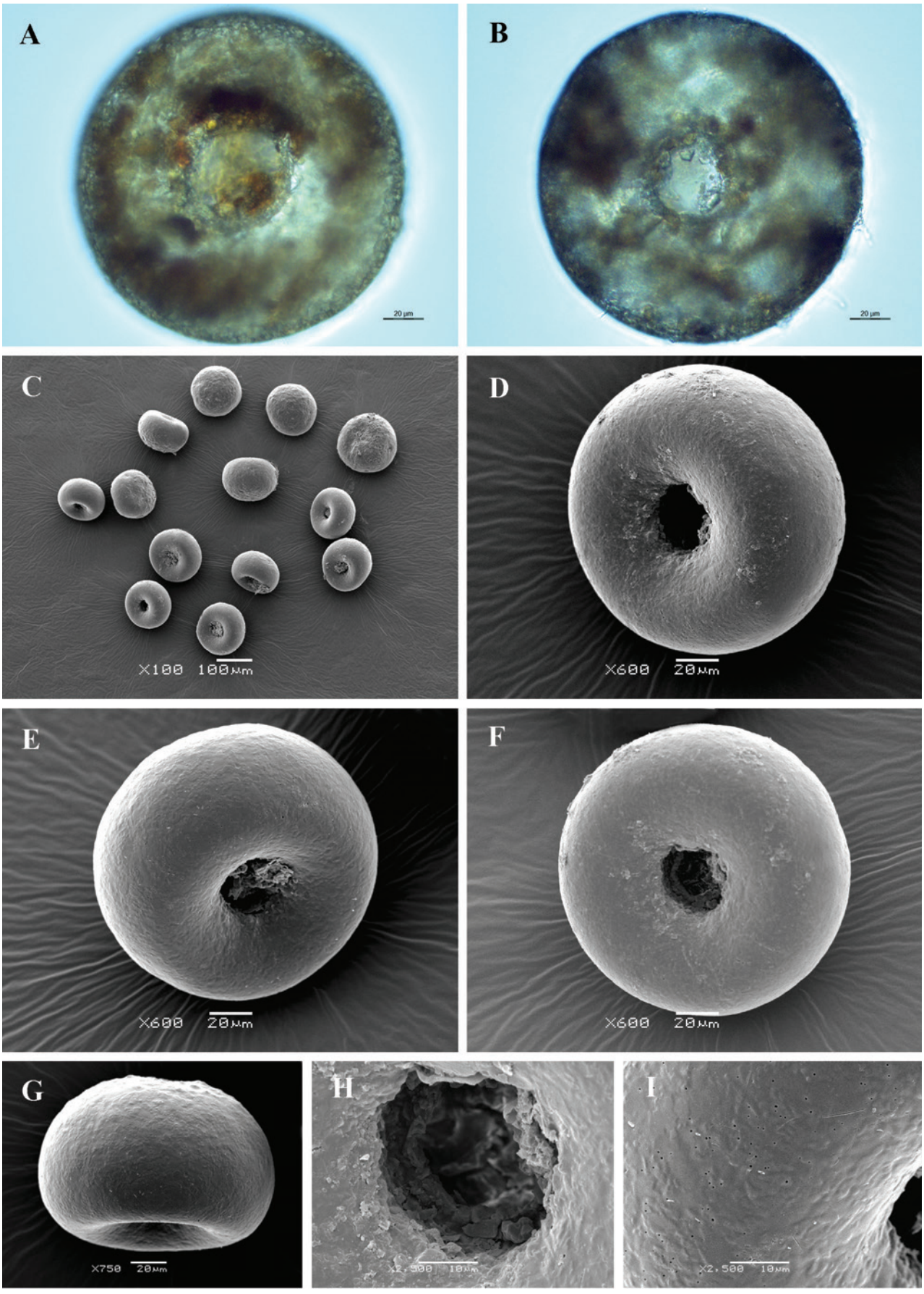
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rila Mts. (Bankov et al. 2018).

Table 13. *Cyclopyxis puteus*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	155.7	155.4	9.26	1.16	5.95	133	179	64
Diameter of aperture	44.5	44.6	4.14	0.59	9.31	32	54	53
Internal opening	32.5	32.7	3.32	0.86	10.22	27	38	15
Depth	105.1	107.5	9.54	2.88	9.08	94	120	11
Aperture/Diameter ratio	0.28	0.29	0.02	0.003	7.02	0.2	0.3	37
Depth/Diameter ratio	0.70	0.70	0.03	0.01	4.56	0.6	0.8	11

Fig. 23. Light (A, B) and scanning electron (C-I) micrographs of *Cyclopyxis puteus*. (A, B) Light micrographs showing general shape. (C) View of many specimens to illustrate variability in shape and size of the shell (D-F) Apertural view of three specimens showing smooth apertural surface and deeply invaginated aperture. (G) Lateral view. (H) Close up view of aperture to illustrate its apertural tube and internal opening. (I) Detail of apertural side to illustrate its smooth surface and numerous pores in the organic cement.


A
20 µm
B
20 µm
C
X100 100µm
D
X600 20µm
E
X600 20µm
F
X600 20µm
G
X750 20µm
H
X2,500 10µm
I
X2,500 10µm

Netzelia oviformis (Cash, 1909) Ogden, 1979

Original description: Cash and Hopkinson 1909, *The British Freshwater Rhizopoda and Heliozoa*. Vol. II, p. 52, Pl. XX, figs. 8-12; **Last revision**:Ogden 1979, *Bulletin of the British Museum (Natural History),* Zoology series, 36, p. 206.

Synonyms: *Difflugia proteiformis* subsp. *globularis* var. *tuberculata* Wallich, 1864; *Difflugia tuberculata* Archer, 1867; *Difflugia lobostoma* Leidy, 1879 (in part); *Nebela tuberculata* Owen and Jones, 1976; *Difflugia tricuspis* Medioli and Scott, 1983 (in part).

Description: Shell yellowish or brownish, circular in apertural and aboral views, ovoid or sub-spherical in lateral view (Fig. 24 A-F); composed of small siliceous particles, mixed with diatom frustules and boud by cement to produce a smooth surface (Fig. 24 D-I). Shell components usually in close contact with each other, small pores in the organic cement often seen (Fig. 24 H, I). Aperture terminal, with three or four lobes, bordered by a thick collar of organic cement or small siliceous particles (Fig. 24 D-H). Cytoplasm does not fills the whole shell; cell fixed with numerous long epipodes at the shell walls (Fig 24 C). Pseudopodia usually two to four, long, fast moving (Fig 24 A).

Ecology: Frequent in freshwater standing bodies, among aquatic vegetation, accidentally in *Sphagnum*.

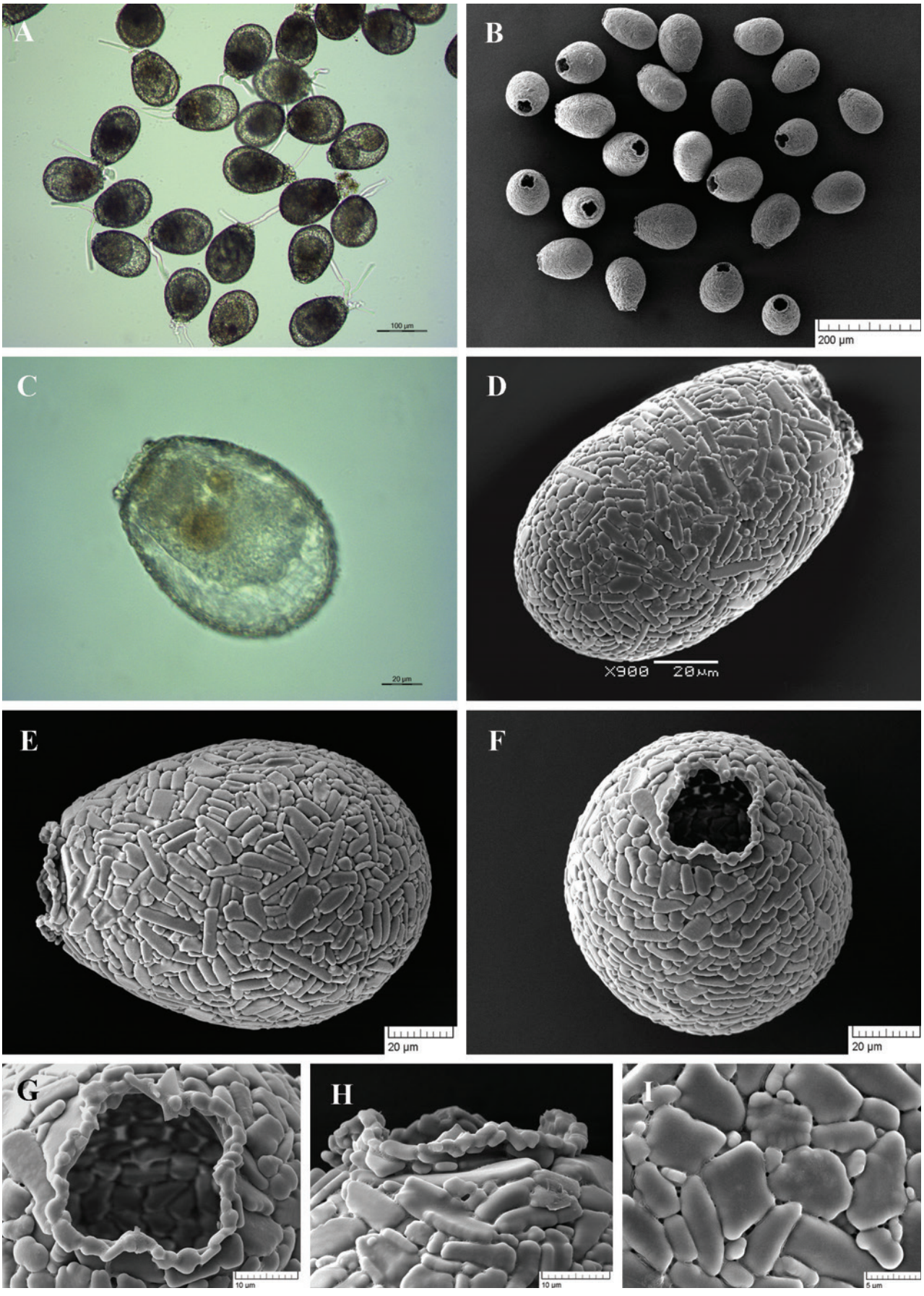
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Todorov 2004).

Table 14. *Netzelia oviformis*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	103.3	102.0	11.88	1.73	11.50	85	129	47
Breadth	78.5	80.0	8.16	1.19	10.39	66	93	47
Diameter of aperture	25.9	25.0	2.68	0.39	10.34	22	33	47
Breadth /Length ratio	0.76	0.76	0.03	0.005	4.43	0.6	0.9	47
Aperture/Diameter ratio	0.33	0.34	0.03	0.004	8.12	0.3	0.4	47

Fig. 24. Light (A, C) and scanning electron (B, D-I) micrographs of *Netzelia oviformis*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen to show numerous epipodes. (D, E) Lateral views of two specimens to show general shape. (F) Apertural view. (G) Close up view of aperture to illustrate four lobes of aperture and narrow collar of small siliceous particles. (H) Close up view of a narrow collar of small pieces of quartz. (H) Detail of shell surface to illustrate regular arrangement of siliceous particles.


A
100 µm
B
200 µm
C
20 µm
D
X900 20µm
E
20 µm
F
20 µm
G
10 µm
H
10 µm
I
5 µm

Netzelia tuberculata (Wallich, 1864) Netzel, 1983

Original description: Wallich 1864, *Annals and Magazine of Natural History*, 13, p. 241, Pl. XV, fig. 4g, Pl. XVI, fig. 18; **Last revision:** Netzel 1983, *Archiv für Protistenkunde*, 127, p. 377.

Synonyms: *Difflugia proteiformis* subsp. *globularis* var. *tuberculata* Wallich, 1864; *Difflugia tuberculata* Archer, 1867; *Difflugia lobostoma* Leidy, 1879 (in part); *Nebela tuberculata* Owen and Jones, 1976; *Difflugia tricuspis* Medioli and Scott, 1983 (in part).

Description: Shell brownish, opaque, circular in apertural and aboral views, ovoid or spherical in lateral view (Fig. 25 A-E); composed of small quartz particles, aggregated in regularly arranged protrubences (Fig. 25 B, D-H). Shell components usually in close contact with each other, single meshs of organic cement rarely visible between particles (Fig. 25 I). Aperture terminal, lobed and bordered by a collar of small pieces of quartz (Fig. 25 D-G). Cytoplasm does not fills the whole shell; cell fixed with numerous long epipodes at the shell walls. Pseudopodia usually two to four, long, fast moving (Fig 25 A, C).

Ecology: Frequent in freshwater standing bodies, accidentally in *Sphagnum*.

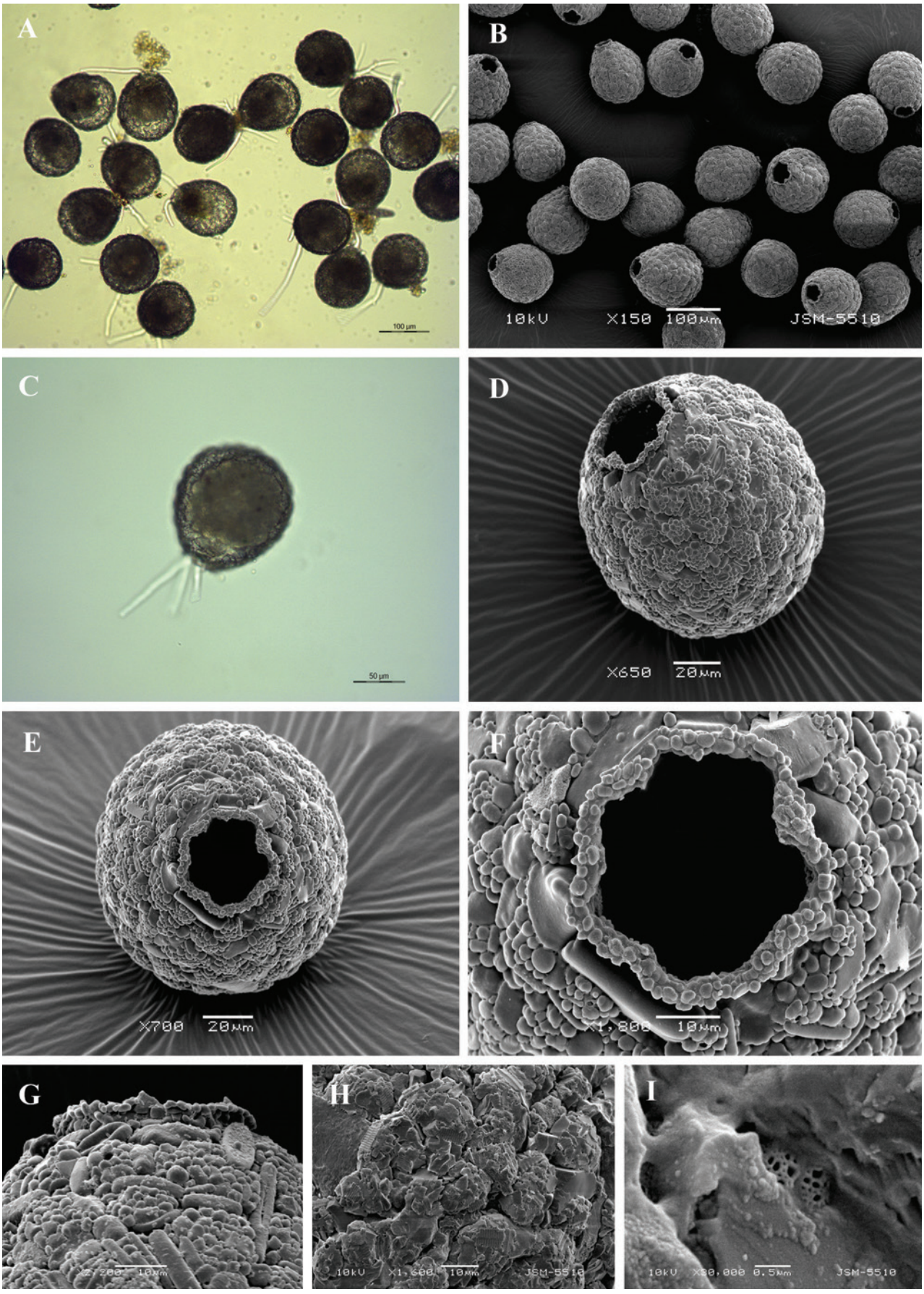
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Todorov 2004).

Table 15. *Netzelia tuberculata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	123.9	119.5	12.48	1.60	10.07	111	153	61
Breadth	112.4	106.5	12.06	1.54	10.73	99	146	61
Diameter of aperture	34.4	33.5	3.86	0.49	11.24	29	42	61
Breadth /Length ratio	0.91	0.91	0.03	0.004	3.44	0.83	0.97	61
Aperture/Diameter ratio	0.31	0.30	0.03	0.004	11.04	0.2	0.4	61

Fig. 25. Light (A, C) and scanning electron (B, D-I) micrographs of *Netzelia tuberculata*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen to show protruding pseudopods from the aperture. (D) Lateral view. (E) Apertural view showing general shape, as well as multilobed aperture. (F) Close up view of aperture to illustrate a narrow collar of small pieces of quartz and lobed aperture. (G) Close up view of a narrow collar of small pieces of quartz. (H) Detail of aboral side of the shell to illustrate regular arrangement of small protrubences. (I) Close up view of organic cement.


A
100 µm
B
10kV X150 100µm JSM-5510
C
50 µm
D
X650 20µm
E
X700 20µm
F
X1,800 10µm
G
H
10kV X1,600 10µm JSM-5510
I
10kV X30,000 0.5µm JSM-5510

Trigonopyxis arcula (Leidy, 1879) Penard, 1912

Original description: Leidy 1879, *Report of the United States Geological Survey of the Territories*, 12, p. 116, Pl. XV, figs. 34-37, Pl. XVI, figs. 30, 31; **Last revision:** Penard 1912, *Revue Suisse de Zoologie*, 20, p. 9, Pl. 1, Figs. 6-8.

Synonyms: *Difflugia arcula* Leidy, 1879; *Cystidina arcula* (Leidy, 1879) Volz, 1929.

Description: Shell yellow or brown, circular in apertural and aboral views, hemispherical in lateral view (Fig. 26 A-F); composed mainly of small to medium flattish partticles, embedded in deep layer of organic cement on the apertural side, large and rough pieces of quartz on the aboral side (Fig. 26 D-F). Organic cement with numerous small pores on the apertural and lateral surface (Fig. 26 D, I). Aperture usualy triangular or quadrangular, sometimes with irregular outline, central, invaginated, and surrounded by a small collar of orgenic cement (Fig. 26 D, G, H).

Ecology: In soils, mosses and forest litter, very rarely in *Sphagnum*.

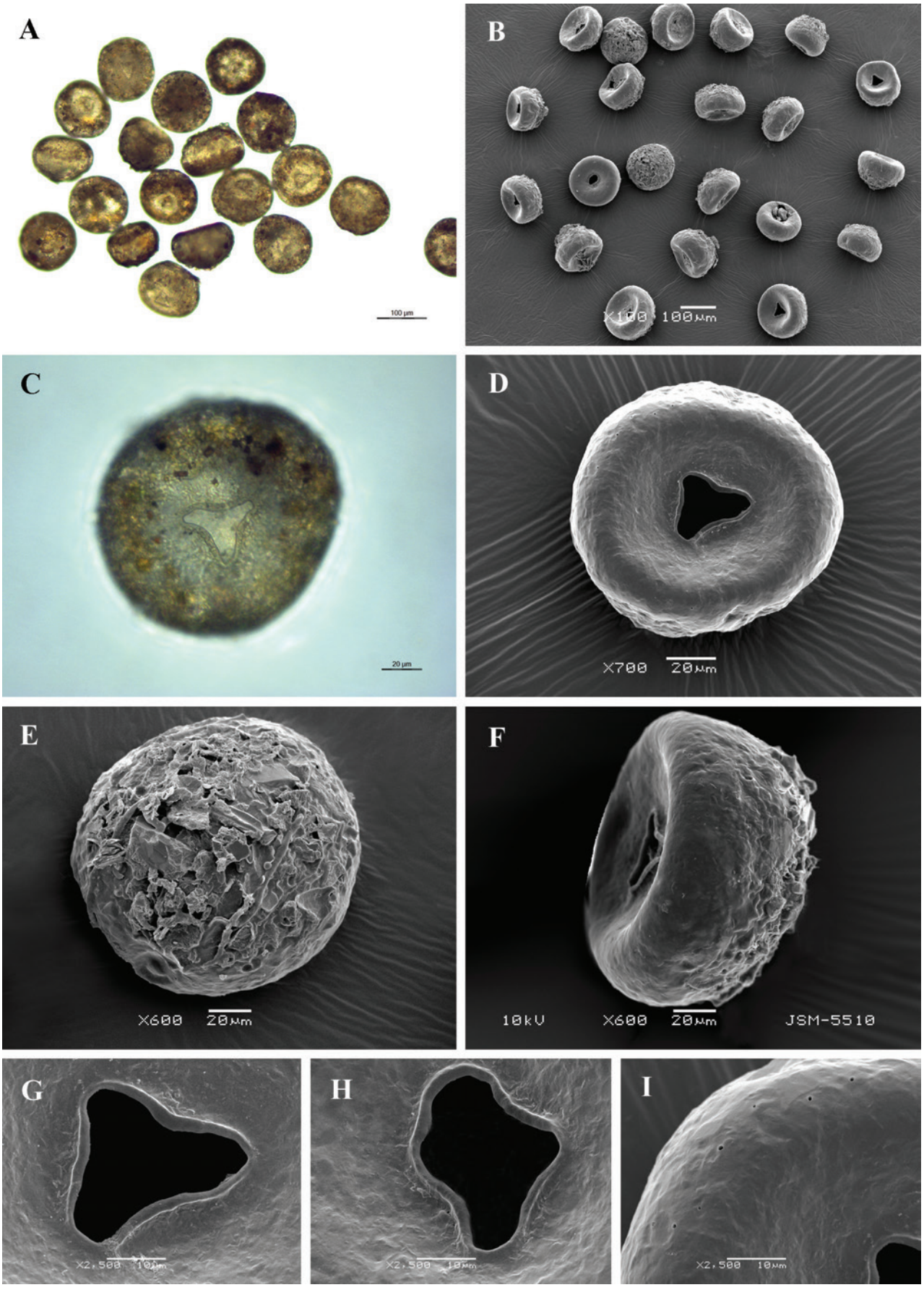
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rila Mts. (Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1990, Bankov et al. 2018).

Table 16. *Trigonopyxis arcula*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	99.9	97.0	9.05	1.51	9.05	86	133	36
Diameter of aperture	26.2	26.0	4.15	0.80	15.84	20	35	27
Depth	59.9	58.5	8.95	2.00	14.93	47	74	20
Depth/Diameter ratio	0.60	0.59	0.08	0.02	12.90	0.5	0.8	20
Aperture/Diameter ratio	0.26	0.26	0.03	0.006	12.47	0.2	0.3	27

Fig. 26. Light (A, C) and scanning electron (B, D-I) micrographs of *Trigonopyxis arcula*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Apertural view of two specimens showing smooth apertural surface and characteristic triangular aperture. (E) Dorsal view. (F) Lateral view. (G, H) Close up views of aperture to illustrate its variability in shape. (I) Detail of apertural side to illustrate its smooth surface and numerous pores in the organic cement.


A
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C
20 µm
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X700 20µm
E
X600 20µm
F
10kV X600 20µm JSM-5510
G
X2,500 10µm
H
X2,500 10µm
I
X2,500 10µm

Difflugia acuminata Ehrenberg, 1838

Original description: Ehrenberg 1838, *Die Infusionthierchen als vollkommene Organismen*, p. 131, Taf. IX, fig. 3.

Synonyms: *Difflugia curvicaulis* Penard, 1899; *Difflugia acuminata* var. *umbilicata* Penard, 1902; *Difflugia venusta* Ogden, 1983

Description: Shell brown, opaque, cylindrical or elongate pyriforme, with a pointed or acuminate aboral region, circular in transverse section (Fig. 27 A-H); with rough surface and covered mainly of medium to large quartz particles, occasionally with fragment of diatom frustules (Fig. 27 B, C, E). Areas of organic cement usually well seen in the shell matrix as a network, the mesh of which about 1-1,2 μm in diameter and the walls about 180-250 nm thick, each mesh enclosure having a smaller network with a mesh about 100-150 nm in diameter (Fig. 27 I). Aperture circular, well defined; surrounding rim covered with a regularly arranged small particles or chrysomonad cysts (Fig. 27 E-G). Cytoplasm abundant, fulfilled with many granules, without symbiotic zoochlorellae; one large ovular nucleus and many nucleoli. Pseudopodia usually one or two, long and fast moving (Fig. 27 A, D).

Notes: The species has been recorded in both as nominal species and as synonym *D. venusta* (Rhodopes Mts.).

Ecology: Frequent in freshwater habitats, less common in *Sphagnum*.

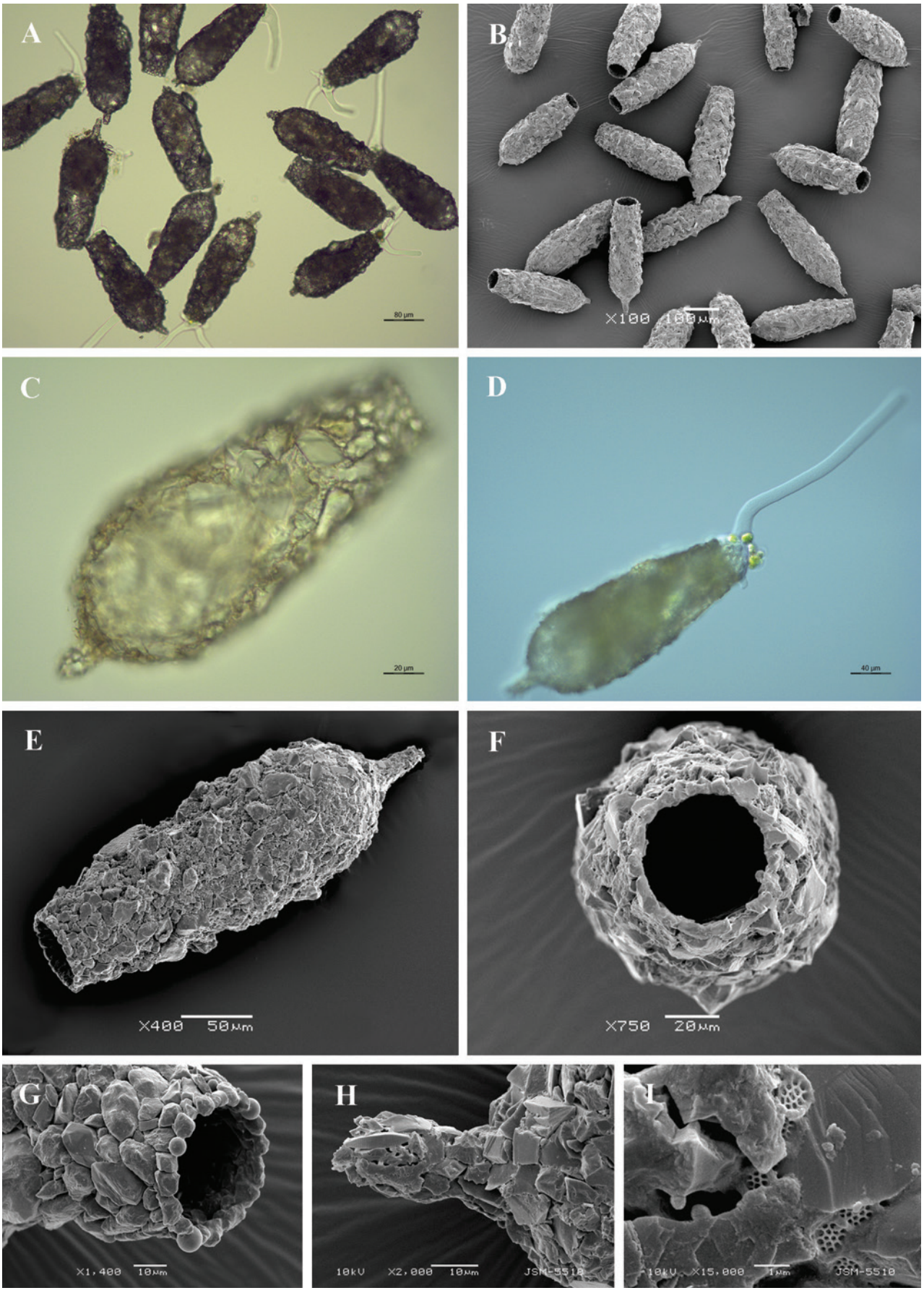
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Bankov et al. 2018).

Table 17. *Difflugia acuminata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	248.8	230.7	49.44	5.95	19.87	169.5	346.0	69
Breadth	94.9	96.0	5.80	0.70	6.10	82.0	110.3	69
Diameter of aperture	45.6	45.0	6.71	0.81	14.72	30.6	62.1	69
Length of aboral horn	27.8	26.1	9.47	1.68	34.12	13.0	57.0	69
Breadth/Length ratio	0.39	0.41	0.07	0.009	17.93	0.3	0.5	69
Aperture/Breadth ratio	0.48	0.49	0.07	0.008	14.09	0.3	0.6	69

Fig. 27. Light (A, C, D) and scanning electron (B, E-I) micrographs of *Difflugia acuminata*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, E) Lateral views of two specimens showing general shell shape. (D) View of live specimen to illustrate a single long endolobopodia. (F) Apertural view showing regular apertural outline. (G) Latero-apertural view to show apertural rim and surrounding, regularly arranged small particles (H) View of acuminate aboral region. (I) Detail of organic cement network.


A
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F
X750 20µm
G
X1,400 10µm
H
10kU X2,000 10µm JSM-5510
I
10kU X15,000 1µm JSM-5510

Difflugia ampullula Playfair, 1918

Original description: Playfair 1918, *Proceedings of the Linnean Society of New South Wales*, 42, p. 650, Pl. XXXVII, fig. 10, 11.

Description: Shell transparent, ovoid, circular in transverse section, tapering evenly from the mid-body position towards the aperture and rounded aboral region (Fig. 28 A-D); composed mainly of small to medium pieces of quartz, so arranged to give a well defined and regular outline with a smooth surface (Fig. 28 C-F). Shell components usually in close contact with each other, only small areas of organic cement are visible between particles; cement in form of a network of small meshes of about 300-400 nm in diameter (Fig. 28 I). Aperture circular, well defined by the surrounding slightly raised collar of small particles (Fig. 28 E-H).

Ecology: Frequent in freshwater sediments, less common in *Sphagnum*.

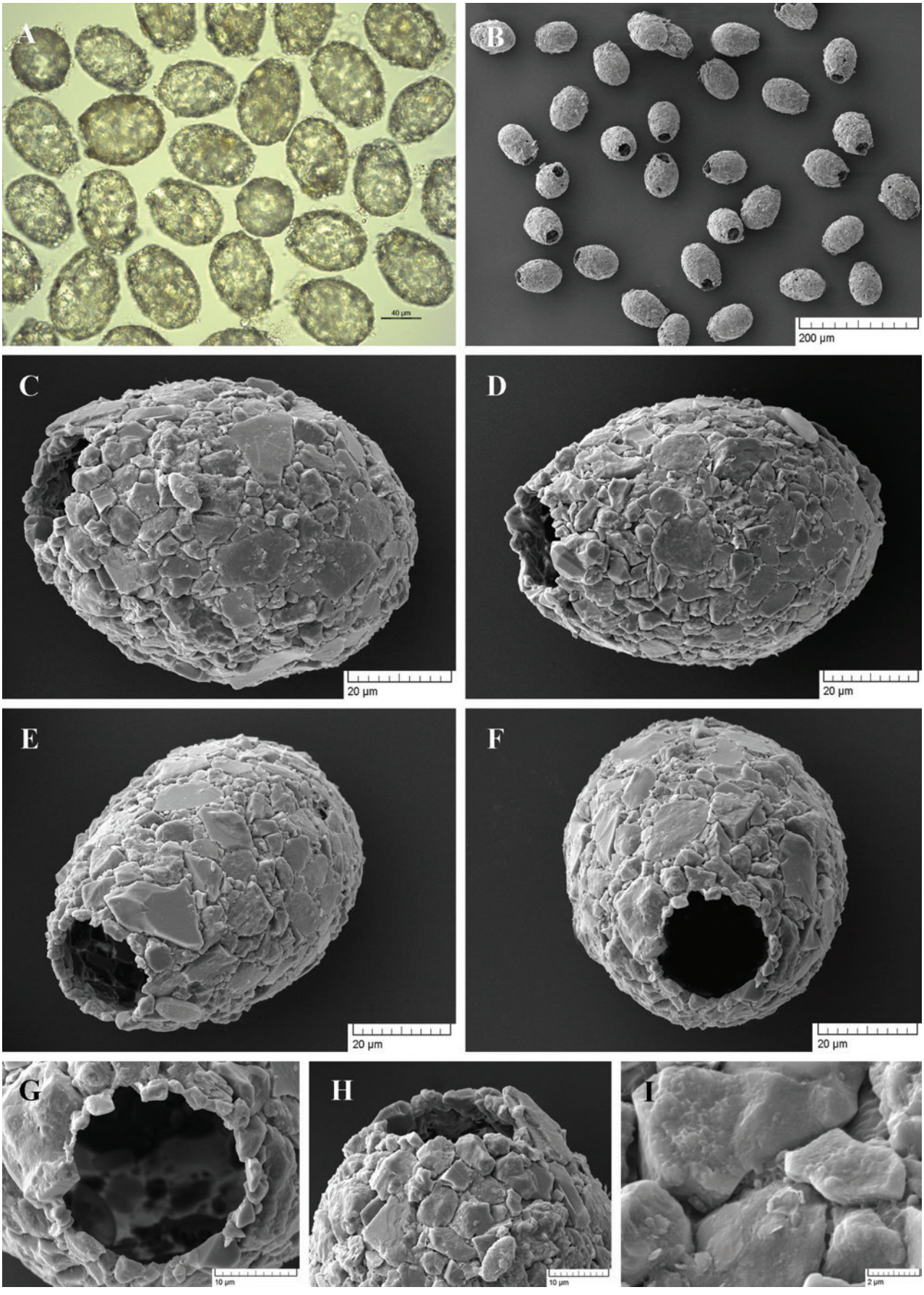
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rila Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Bankov et al. 2018).

Table 18. *Difflugia ampullula*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	80.2	80.0	3.28	0.60	4.08	75	88	30
Breadth	59.6	60.0	2.81	0.51	4.72	54	65	30
Diameter of aperture	22.6	23.0	1.76	0.32	7.78	18	26	30
Breadth/Length ratio	0.74	0.74	0.04	0.007	5.02	0.7	0.8	30
Aperture/Breadth ratio	0.38	0.38	0.03	0.006	8.22	0.3	0.4	30

Fig. 28. Light (A) and scanning electron (B-I) micrographs of *Difflugia ampullula*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C-D) Lateral view of two specimens showing regular outline and smooth shell surface. (E-F) Latero-apertural view to illustrate small collar. (G) Apertural view to show irregular edge of the collar. (H) Lateral view of apertural region. (I) Portion of shell surface to show arrangement of particles and small areas of organic cement in form of a network of small meshes.


A
40 µm
B
200 µm
C
20 µm
D
20 µm
E
20 µm
F
20 µm
G
10 µm
H
10 µm
I
2 µm

Difflugia bryophila (Penard, 1902) Jung, 1942

Original description: Penard 1902, Faune Rhizopodique du Bassin du Léman, p. 221, fig. 7 (p. 218); **Last revision**: Jung 1942, *Archv f*ür *Protistenkdunde,* 95, p. 275, Abb. 1.

Synonyms: *Difflugia pyriformis* var. *bryophila* Penard, 1902; *Difflugia oblonga* var. *longicollis* Gassowsky, 1936; *Difflugia longicollis* (Gassowsky, 1936) Ogden and Hedley, 1980; *Difflugia gassowskii* Ogden, 1983.

Description: Shell brown, opaque, pyriform, with sides tapering evenly to the aperture or forming a distinct short neck about one-third of the body length; rounded aboral region and circular transverse section (Fig. 29 A-D); rough, covered mainly of small to medium quartz particles, occasionally with fragment of diatom frustules or chrysomonad cysts (Fig. 29 C-H). Shell components usually in close contact with each other, only small areas of organic cement is seen infrequently as an open network; mesh about 500-750 μm in diameter, without well pronounced walls. Each mesh enclosure covered by inner strands of cement which form a smaller mesh with different size (Fig. 29 I). Aperture roughly circular, surrounding rim covered by small particles or flagellate cysts (Fig. 29 E-G). Cytoplasm abundant, fills almost whole shell, without symbiotic zoochlorellae; one large ovular nucleus and a few nucleoli (Fig. 29 A-B). Pseudopodia usually one or two, long, fast moving.

Notes: The species has been recorded in both as nominal species and as synonym *D. gassowskii* (Rhodopes Mts., Rila Mts., Vitosha Mts.).

Ecology: Frequent in freshwater habitats and in *Sphagnum*.

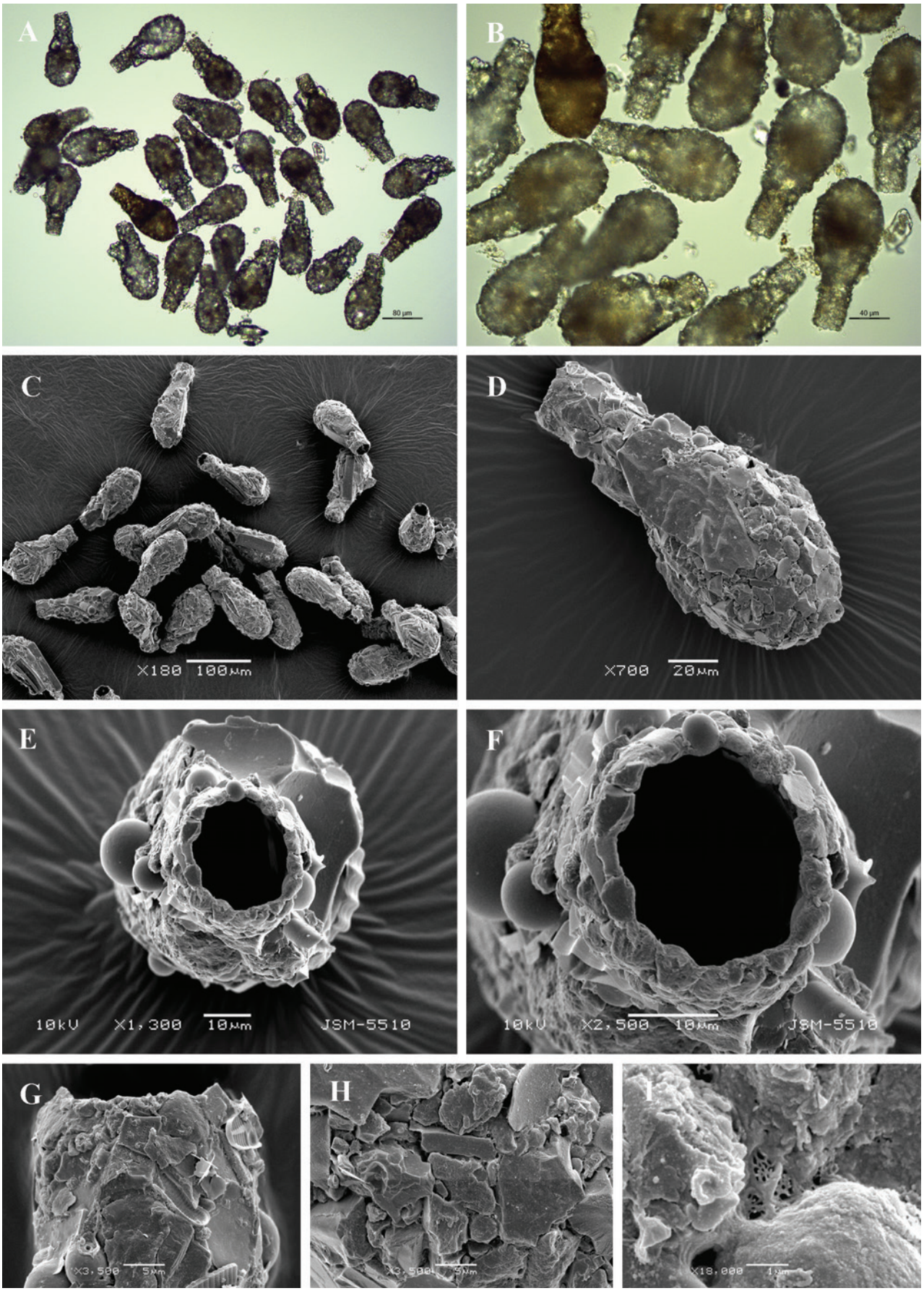
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 19. *Difflugia bryophila*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	129.4	129.1	10.54	1.89	8.15	109.9	148.8	31
Breadth	61.1	60.1	6.64	1.19	10.88	52.8	78.3	31
Diameter of aperture	25.6	25.4	2.90	0.52	11.30	21.1	31.3	31
Breadth/Length ratio	0.47	0.48	0.05	0.009	10.07	0.4	0.6	31
Aperture/Breadth ratio	0.42	0.44	0.06	0.010	13.12	0.3	0.5	31

Fig. 29. Light (A, B) and scanning electron (C-I) micrographs of *Difflugia bryophila*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D) Lateral view showing rough surface of the shell. (E) Apertural view. (F) Close up view of aperture to show bordering particles. (G) Lateral view of apertural rim showing its irregularity (H) Portion of shell to show arrangement of particles and rough surface of the shell. (I) Detail of organic cement network.


A
80 µm
B
40 µm
C
X180 100µm
D
X700 20µm
E
10kV X1,300 10µm JSM-5510
F
10kV X2,500 10µm JSM-5510
G
X3,500 5µm
H
X3,500 5µm
I
X18,000 1µm

Difflugia elegans Penard, 1890

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 140, Pl. IV, fig. 4 à 11.

Synonyms: *Difflugia amphoralis* Hopkinson, 1909; *Difflugia australis* (Playfair, 1918) Gauthier-Lièvre et Thomas, 1958; *Difflugia borodini* Gassowsky, 1936; *Difflugia elegans* f. *bicornis* Jung, 1936; *Difflugia elegans* f. *tricornis* Jung, 1936; *Difflugia juzephiniensis* Dekhtyar, 1993; *Difflugia leidyi* Wailes, 1912; *Difflugia Solowetskii* Mereschkowsky, 1877; *Difflugia tricornis* (Jung, 1936) Ogden, 1983; *Difflugia varians* Penard, 1902

Description: Shell yellowish-brownish, ovoid, with slightly pronounced neck near the aperture; aboral extremity tapering evenly to short tubular horn; uncompressed, with circular transverse section (Fig. 30 A-F); covered mainly of small to medium quartz particles, mixed with diatom frustules or chrysomonad cysts, with rough surface (Fig. 30 D-F). Small areas of organic cement usually well seen in shell matrix as a network, with mesh 300-450 nm in diameter and dividing walls about 150-280 nm thick (Fig. 30 I). Aperture circular, surrounded by irregularly arranged small particles, diatoms or chrysomonad cysts, often clogged with aggregation of quartz particles (Fig. 30 E-H). Cytoplasm granular, does not fills the whole shell, without symbiotic zoochlorellae; active amoebae infrequently seen, live specimens frequently encysted, cysts round, brown, with thick organic wall, occupying central region (Fig. 30 A). Pseudopodia numerous, thin, short, fast moving.

Notes: The species has been recorded in both as nominal species and as synonym *D. amphoralis* (Rila Mts., Vitosha Mts.).

Ecology: Frequent in freshwater habitats, as well as in *Sphagnum*.

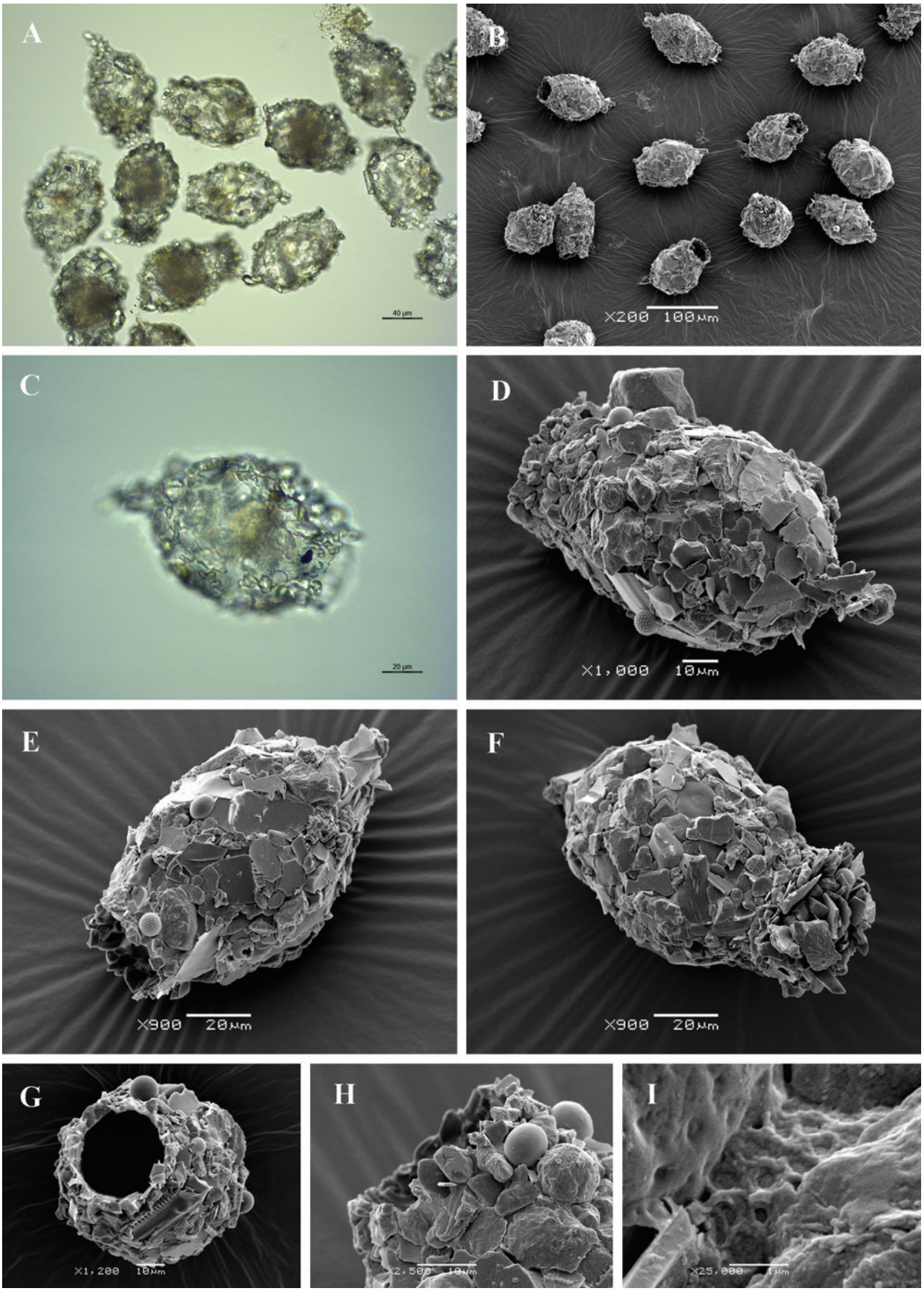
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018) **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 20. *Difflugia elegans*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	107.0	106.8	11.21	1.95	10.48	81	128	33
Breadth	69.7	67.8	9.18	1.60	13.17	54	95	33
Diameter of aperture	30.6	30.0	5.07	0.88	16.57	22	41	33
Length of horn	15.6	14.9	7.70	1.68	49.40	4.4	39.6	21
Breadth/Length ratio	0.65	0.64	0.08	0.013	11.56	0.5	0.8	33
Aperture/Breadth ratio	0.44	0.44	0.08	0.014	18.03	0.3	0.6	33

Fig. 30. Light (A, C) and scanning electron (B, D-I) micrographs of *Difflugia elegans*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C-E) Lateral view of three specimens. (F) View of specimen with clogged aperture. (G) Apertural view. (H) Lateral view of apertural region. (I) Detail of organic cement network.


A
40 µm
B
X200 100µm
C
20 µm
D
X1,000 10µm
E
X900 20µm
F
X900 20µm
G
X1,200 10µm
H
X2,500 10µm
I
X25,000 1µm

Difflugia globulosa Dujardin, 1837

Original description: Dujardin 1837, *Annales des sciences Naturelles, Zoologie*, 8, p. 311, Pl. IX, fig. 1a, b.

Synonyms: *Difflugia proteiformis* Ehrenberg, 1838 subsp. *globularis* Wallich, 1864; *Difflugia globularis* (Wallich, 1864) Leidy, 1877; *Difflugia chardezi* Godeanu, 1972.

Description: Shell yellowish-brownish, opaque, circular in apertural and aboral views, spherical or hemispherical in lateral view (Fig. 31 A-F); composed mainly of small to medium pieces of quartz, mixed with diatom frustoles, with rough surface (Fig. 31 C-I). Shell components usually in close contact with each other, organic cement rarely visible between particles (Fig. 31 G- I). Aperture terminal, circular, central, surrounded by pieces of quartz (Fig. 31 C, D, G, H).

Ecology: Frequent in freshwater standing bodies, as well as in *Sphagnum*.

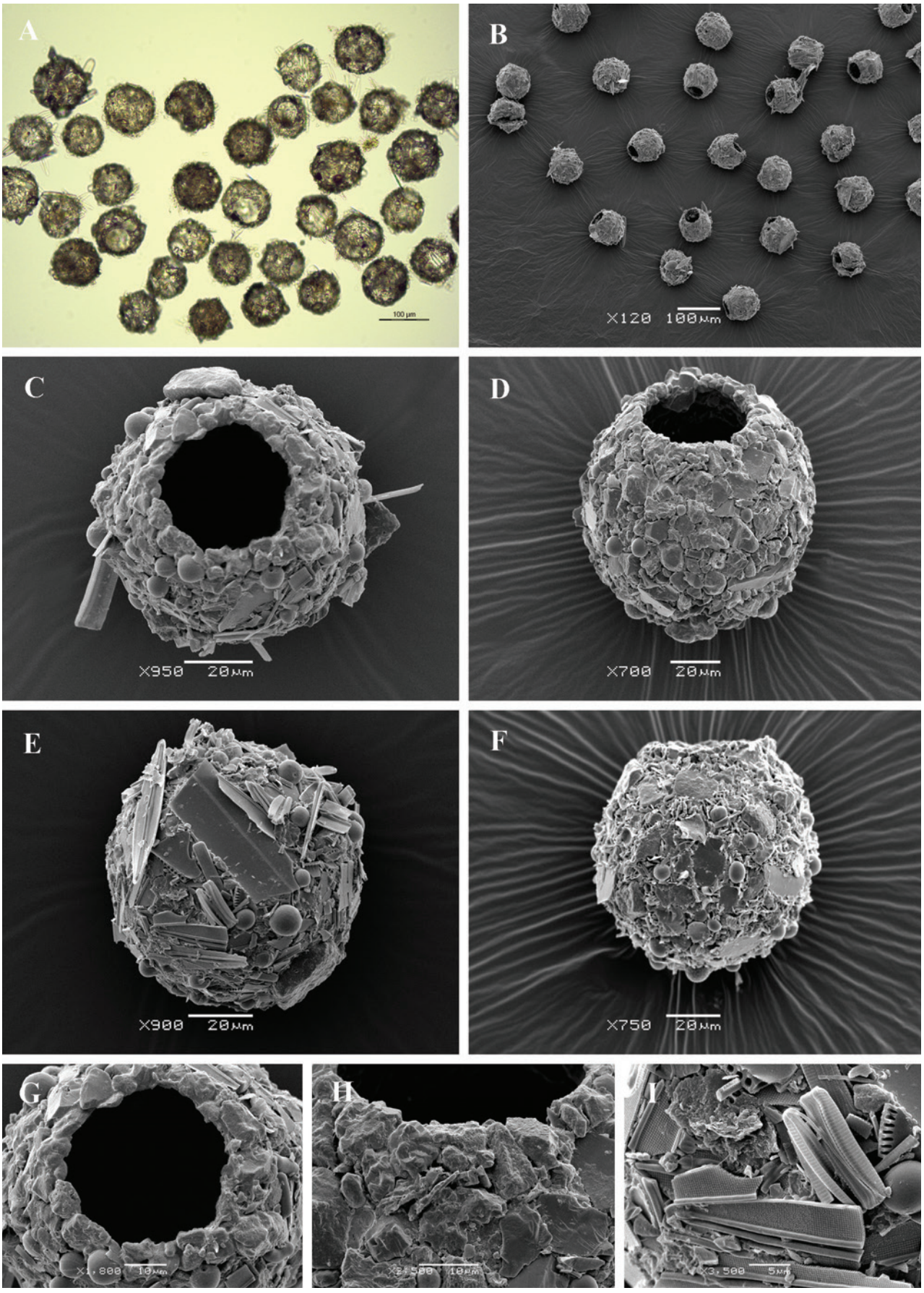
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2004, 2005); **Vitosha Mts.** (Todorov 1993, Golemansky and Todorov 1985, 1990, Todorov and Golemansky 1995).

Table 21. *Difflugia globulosa*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	85.3	83.8	6.29	1.14	7.35	76	100	30
Depth	77.9	78.1	7.06	1.44	9.07	66	96	24
Diameter of aperture	36.9	36.9	3.30	0.60	8.94	31	44	30
Depth/Diameter ratio	0.92	0.93	0.05	0.01	5.93	0.8	1.0	24
Aperture/Diameter ratio	0.43	0.43	0.04	0.007	8.33	0.4	0.5	30

Fig. 31. Light (A) and scanning electron (B-I) micrographs of *Difflugia globulosa*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C-D) Apertural view of two specimens showing general shape. (E) Dorsal view. (F) Lateral view. (G, H) Close up views of aperture to illustrate its rough rim and circular outline. (I) Detail of aboral side of the shell to illustrate its rough surface, covered with sand grains and diatom frustules.


A
100 µm
B
X120 100µm
C
X950 20µm
D
X700 20µm
E
X900 20µm
F
X750 20µm
G
H
I

Difflugia hiraethogii Ogden, 1983

Original description: Ogden 1983, *Bulletin of the British Museum (Natural History),* Zoology series, 44 (1), p. 59, Figs, 41, 42.

Description: Shell transparent or yellow, pyriform, rounded aborally and tapering towards the aperture forming a distinct short neck (Fig. 32 A-D); laterally compressed, except the neck region, with almost parallel sides, oval transverse section of the main body and circular neck (Fig. 32 E); composed mainly of flattish pieces of quartz, with a smooth appearance, except the neck region composed of angular qurtz and rough (Fig. 32 C-D, H). Organic cement in form of a network of fused rings, as a part of the shell matrix; rings with an internal diameter of about 300 nm and thickness of the wall of about 250 nm (Fig. 32 I). Aperture large, roughly circular, with irregular outline depending on the arrangement of the surrounding angular particles of quartz (Fig. 32 F-G). Cytoplasm abundant, without symbiotic zoochlorellae. Active amoebae infrequently seen, usually live specimens are encysted, cysts round, brown, with thick organic wall, occupying rounded aboral region (Fig. 32 A-B). Pseudopodia usually two-three, digitiform, slow moving.

Ecology: Frequent in *Sphagnum*.

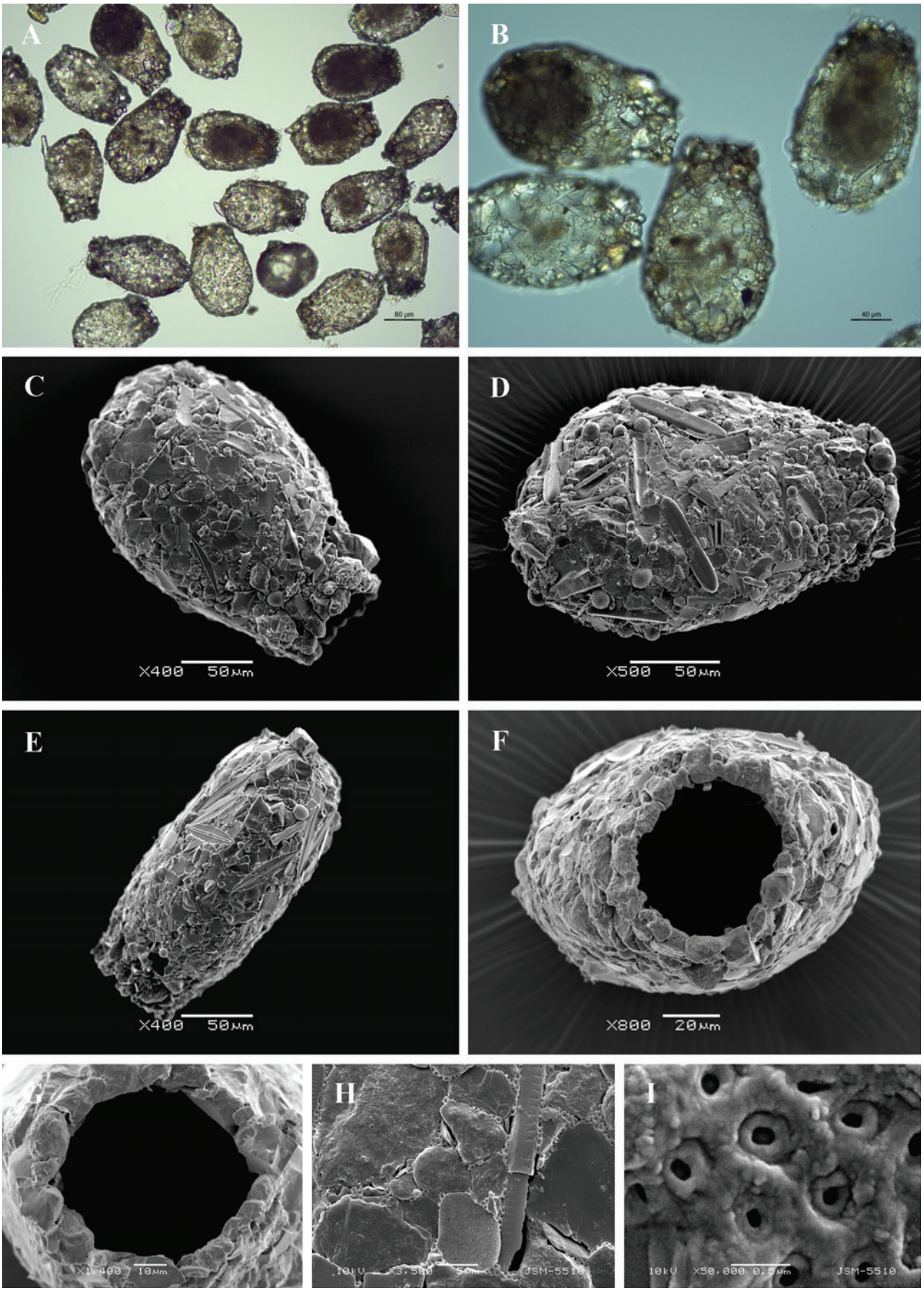
Geographical distribution: Not well studied, probably cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Bankov et al. 2018).

Table 22. *Difflugia hiraethogii* Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	207.1	206.0	20.90	3.48	10.09	174	254	36
Breadth	133.3	130.5	9.80	1.63	7.35	106	157	36
Diameter of aperture	61.5	58.4	9.20	1.53	14.98	52	86	36
Depth	90.1	89.0	7.59	1.28	8.42	81	118	35
Breadth/Length ratio	0.65	0.65	0.05	0.008	7.41	0.6	0.7	36
Aperture/Breadth ratio	0.46	0.44	0.05	0.008	11.06	0.4	0.6	36

Fig. 32. Light (A, B) and scanning electron (C-I) micrographs of *Difflugia hiraethogii*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C, D) Broad lateral view of two individuals illustrating pyriform shape and distinct short neck. (E) Lateral view to show compression of the shell. (F) Apertural view (G) Close up view of aperture showing its irregular outline and surrounding angular particles of quartz. (H) Portion of shell to show arrangement of flattish particles to give a smooth surface. (I) Detail of organic cement network.


A
80 µm
B
40 µm
C
X400 50µm
D
X500 50µm
E
X400 50µm
F
X800 20µm
G
X1,400 10µm
H
10kV X3,500 5µm JSM-5510
I
10kV X50,000 0.5µm JSM-5510

Difflugia lanceolata Penard, 1890

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 145, Pl. IV, fig. 59 à 60.

Description: Shell transparent, elongate, circular in transverse section, tapering from the widest diameter, situated usually at two-thirds of the shell length from the aperture, with rounded aboral region, rarely tapering at both ends (Fig. 33 A-F); smooth, thin, composed mainly of small to medium flattish pieces of quartz and occasional fragment of diatom frustules, so arranged to give a well defined and regular outline with surface appearing as though it is polished (Fig. 33 C-F). Shell components usually in close contact with each other, with only small areas of organic cement between them (Fig. 33 H). Cement as a network of small perforated rings about 350-500 nm in diameter; the perforation about 100-150 nm and wall about 150-300 nm in thickness (Fig. 33 I). Aperture circular, well defined, surrounding rim covered with a thin layer of organic cement (Fig. 33 G). Cytoplasm abundant, fulfilled with many brilliant, colorless granules, without symbiotic zoochlorellae; one large ovular nucleus, about 25-30 μm in diameter, many nucleoli. Pseudopodia usually one or two, long, fast moving (Fig. 33 I).

Ecology: Frequent in freshwater sediments, less common in *Sphagnum*.

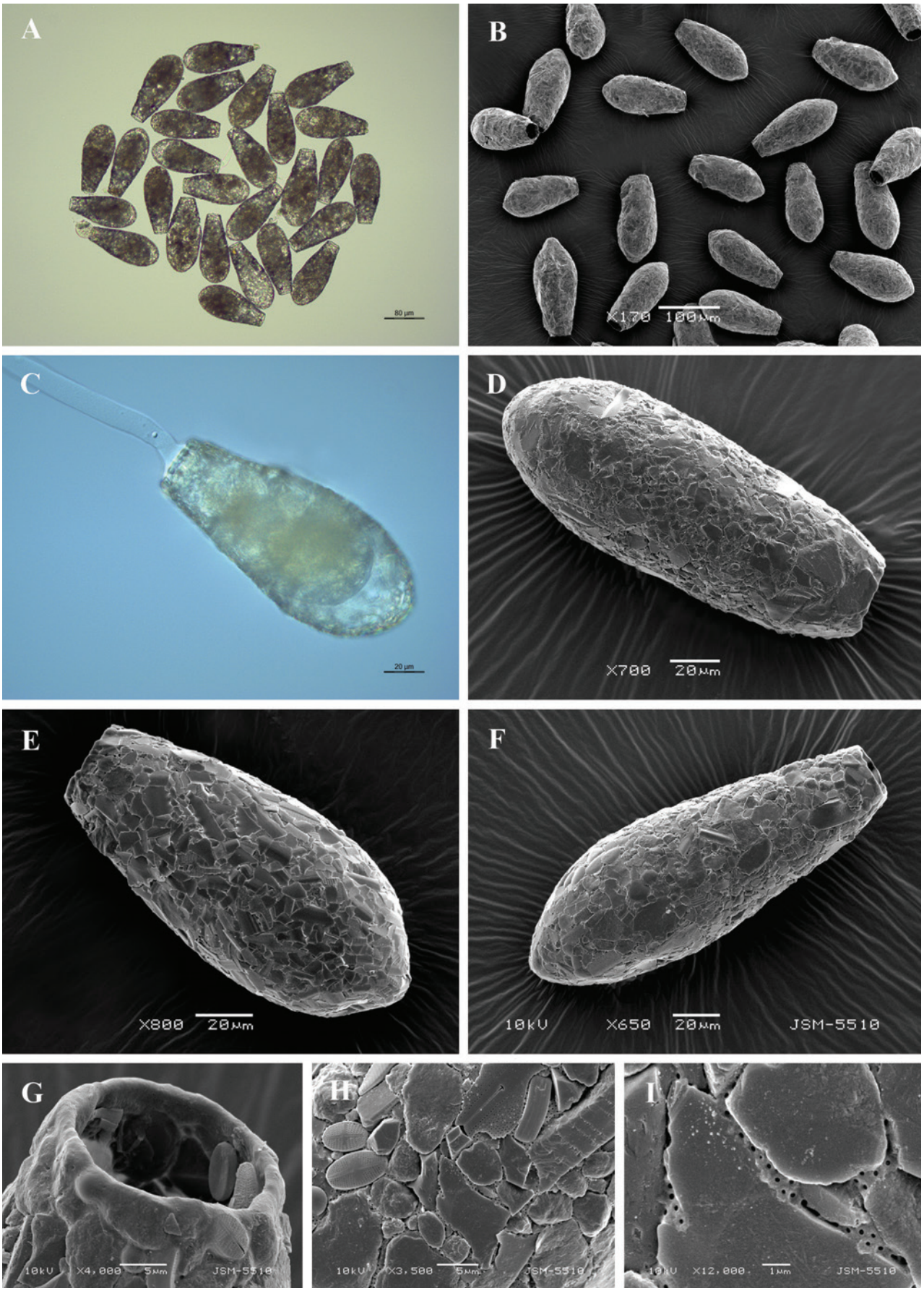
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1990).

Table 23. *Difflugia lanceolata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	155.9	153.5	15.44	1.96	9.90	127	179	62
Breadth	66.7	66.0	5.14	0.65	7.71	58	77	62
Diameter of aperture	27.7	27.0	2.68	0.34	9.68	23	36	62
Breadth/Length ratio	0.43	0.42	0.02	0.003	4.65	0.39	0.49	62
Aperture/Breadth ratio	0.42	0.41	0.03	0.003	7.14	0.36	0.50	62

Fig. 33. Light (A, C) and scanning electron (B, D-I) micrographs of *Difflugia lanceolata*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen to illustrate a single long endolobopodia. (D-F) View of three specimens to show variability of shell shape. (G) Apertural view showing aperture outline and thin organic collar. (H) Portion of shell to show arrangement of siliceous particles to give a smooth surface. (I) Detail of organic cement network.


A
80 µm
B
X170 100µm
C
20 µm
D
X700 20µm
E
X800 20µm
F
10kV X650 20µm JSM-5510
G
10kV X4,000 5µm JSM-5510
H
10kV X3,500 5µm JSM-5510
I
10kV X12,000 1µm JSM-5510

Difflugia lobostoma Leidy, 1874

Original description: Leidy 1874a, *Proceedings of the Academy of Natural Sciences of Philadelphia***,** 26, p. 79.

Description: Shell yellowish or brownish, opaque, circular in apertural and aboral views, spherical or hemispherical in lateral view (Fig. 34 A-F); composed mainly of small to medium pieces of quartz, with a rough surface (Fig. 34 D-I). Shell components usually in close contact with each other, organic cement rarely visible between particles (Fig. 34 G- I). Aperture terminal, tri- or four lobed, central, surrounded by collar of small pieces of quartz (Fig. 34 E-H). Cytoplasm abundant, with symbiotic zoochlorellae (Fig. 34 A). Pseudopodia numerous, long, thin, fast moving (Fig. 34 C).

Ecology: Frequent in freshwater standing bodies, accidentally in *Sphagnum*.

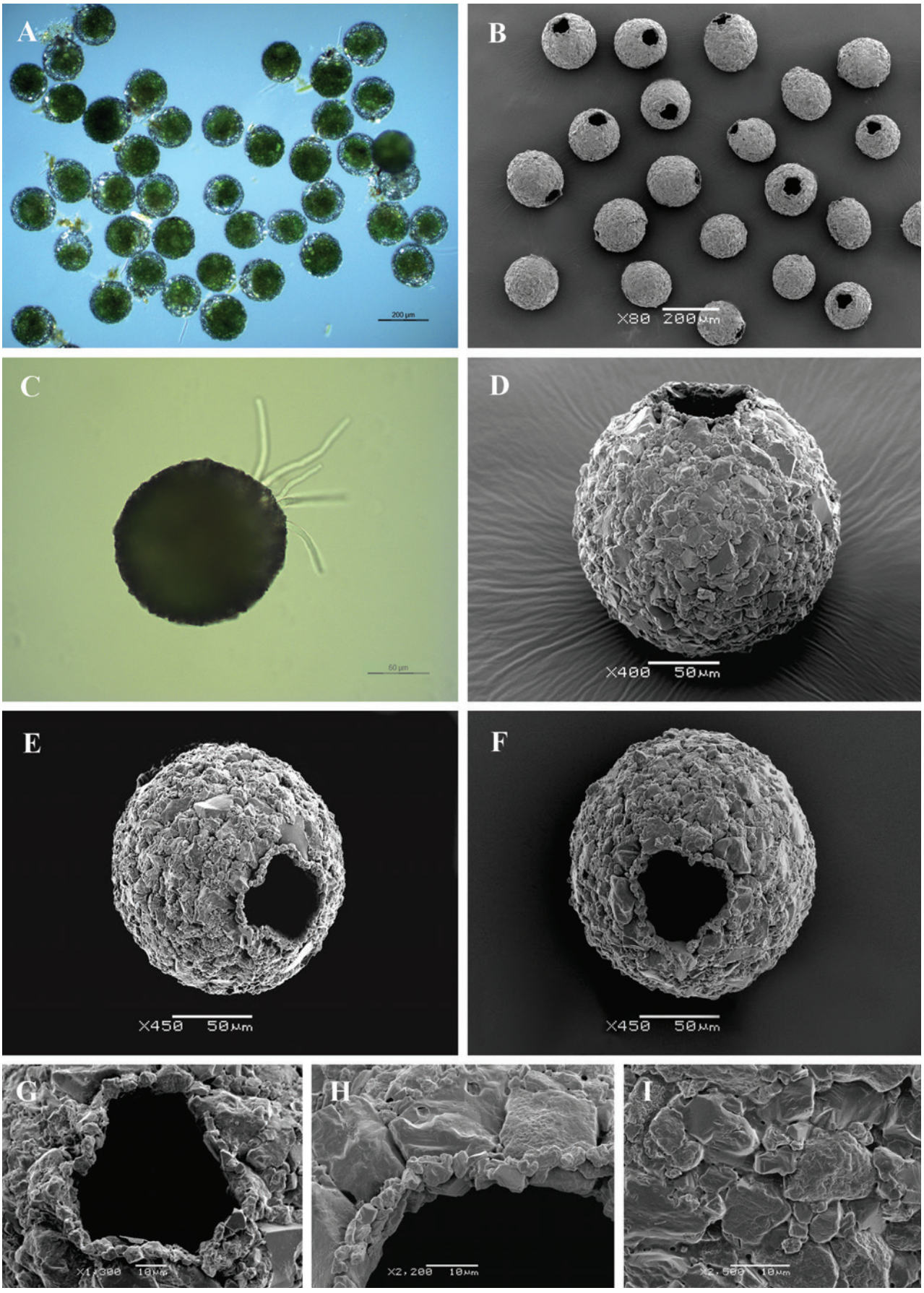
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Golemansky 1968, Golemansky et al. 2006).

Table 24. *Difflugia lobostoma*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	173.9	173.0	12.16	2.22	6.99	150	198	30
Depth	166.3	161.5	12.41	2.27	7.46	147	191	30
Diameter of aperture	56.8	54.0	6.02	1.10	10.61	47	69	30
Depth/Diameter ratio	0.96	0.95	0.06	0.01	6.23	0.8	1.2	30
Aperture/Diameter ratio	0.33	0.32	0.02	0.003	5.75	0.3	0.4	30

Fig. 34. Light (A, C) and scanning electron (B, D-I) micrographs of *Difflugia lobostoma*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen to illustrate numerous pseudopodia. (D) Lateral view. (E, F) Apertural view of two specimens showing general shape, as well as tri- and four lobed aperture. (G, H) Close up views of aperture to illustrate its rough rim and trilobed aperture. (I) Portion of shell to illustrate its rough surface, covered with sand grains.


A
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B
X80 200µm
C
60 µm
D
X400 50µm
E
X450 50µm
F
X450 50µm
G
X1,300 10µm
H
X2,200 10µm
I
X2,500 10µm

Difflugia lucida Penard, 1890

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 145, Pl. IV, fig. 52 à 58

Description: Shell hyaline, ovoid, rounded aborally and tapering gradually towards the aperture (Fig. 35A-D); laterally strongly compressed, with elliptical transverse section (Fig. 35 F); composed mainly of flattish, not overlapping siliceous particles, so arranged to give it a smooth appearance (Fig. 35 D-I). Organic cement in the form of a network of rings, usually well seen as a part of the shell matrix; rings with internal diameter of about 400-500 nm and thickness of walls of about 100 nm (Fig. 35 I). Aperture elliptical, with irregular outline depending on arrangement of the surrounding flattish particles of quartz (Fig. 35 E, G). Cytoplasm abundant, fills most of the shell, without symbiotic zoochlorellae; one small ovular nucleus, about 10 μm in diameter, many nucleoli. Pseudopodia few, usually two or three, long, thin, fast moving.

Ecology: Frequent in mosses, soil and forest litter, as well as in *Sphagnum*.

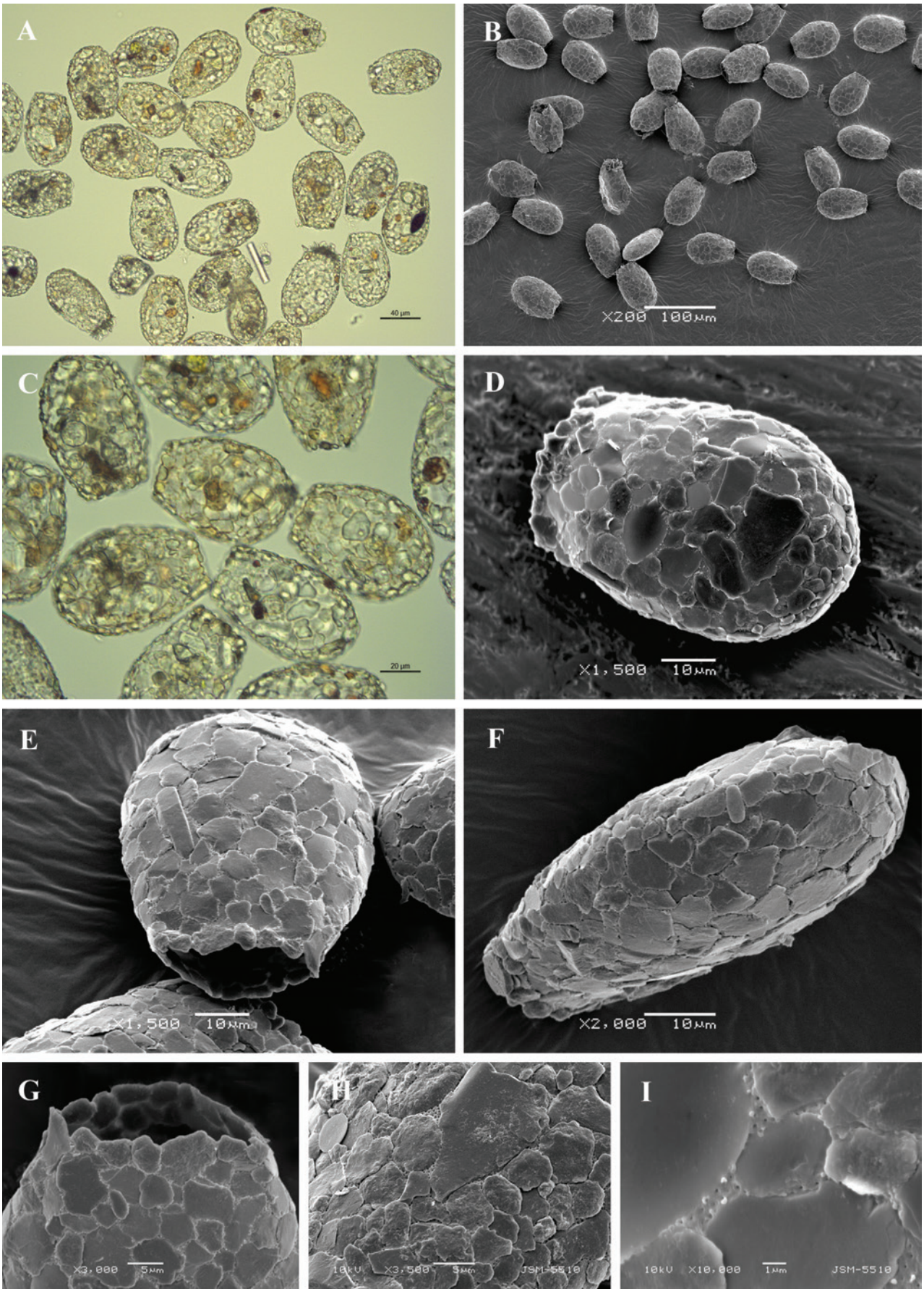
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 25. *Difflugia lucida* Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	73.5	73.2	4.62	0.82	6.29	65	83	32
Breadth	46.7	47.1	4.01	0.71	8.59	33	56	32
Large axis of aperture	29.2	29.5	4.12	0.73	14.08	20	41	32
Depth	30.5	30.8	3.78	0.81	12.38	22	36	22
Breadth/Length ratio	0.64	0.64	0.07	0.012	10.85	0.5	0.9	32
Aperture/Breadth ratio	0.63	0.63	0.06	0.011	10.30	0.5	0.8	32

Fig. 35. Light (A, C) and scanning electron (B, D-I) micrographs of *Difflugia lucida*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D) Broad lateral view illustrating smooth shell surface. (E) Apertural view to show elliptical aperture. (F) Lateral view to show compression of the shell. (G) Broad lateral view of aperture to show surrounding and irregularly arranged particles of quartz, giving to it a rough outline. (H) Portion of shell to show arrangement of flattish particles to give a smooth surface. (I) Detail of organic cement network.


A
40 µm
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X200 100µm
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X1,500 10µm
E
X1,500 10µm
F
X2,000 10µm
G
X3,000 5µm
H
10kV X3,500 5µm JSM-5510
I
10kV X10,000 1µm JSM-5510

Difflugia oblonga Ehrenberg, 1831

Original description: Ehrenberg 1831, *Abhandlungen der Königlichen Akademie der Wissenszchaften zu Berlin*, 31, p. 90.

Synonyms: *Difflugia bacillifera* Penard, 1890; *Difflugia lacustris* (Penard, 1899) Ogden, 1983; *Difflugia oblonga* f. *cyphodera* Jung, 1942; *Difflugia oblong*a var. *incondita* Gauthier-Lièvre et Thomas, 1958; *Difflugia oblonga* var. *lacustris* Cash and Hopkinson, 1909; *Difflugia oblonga* var. *parva* Thomas, 1954; *Difflugia parva* (Thomas, 1954) Ogden, 1983; *Difflugia pyriformis* var. *lacustris* Penard, 1899

Description: Shell brown, opaque, pyriform, with sides tapering evenly to the aperture or forming a distinct neck about one-third of the body length, with rounded aboral region and circular transverse section (Fig. 36 A-E); covered mainly of medium to large quartz particles, rough (Fig. 36 B, E, H). Areas of organic cement usually well seen in the shell matrix as a network with open mesh having a diameter of 50-150 nm and dividing walls about 180-300 nm thick (Fig. 36 H, I). Aperture circular, surrounding rim covered by small particles (Fig. 36 F-H). Cytoplasm abundant, fills almost whole shell, without symbiotic zoochlorellae; one large ovular nucleus, numerous nucleoli. Pseudopodia usually one or two, long, fast moving. (Fig. 36 A, C, D).

Notes: Besides the nominal species, the synonyms *D. parva* (Rhodopes Mts., Rila Mts., Vitosha Mts.), *D. lacustris* (Rhodopes Mts., Vitosha Mts.), *D. bacillifera* (Rila Mts., Vitosha Mts.) and infrasubspecific taxa *D. oblonga* var. *lacustris* (Vitosha Mts.) and *D. oblonga* var. *parva* (Rila Mts., Vitosha Mts.) have also been recorded. According to us the synonymization of *D. parva* and *D. bacillifera* with *D. oblonga* needs confirmation with molecular methods.

Ecology: Frequent in freshwater habitats, as well as in *Sphagnum*.

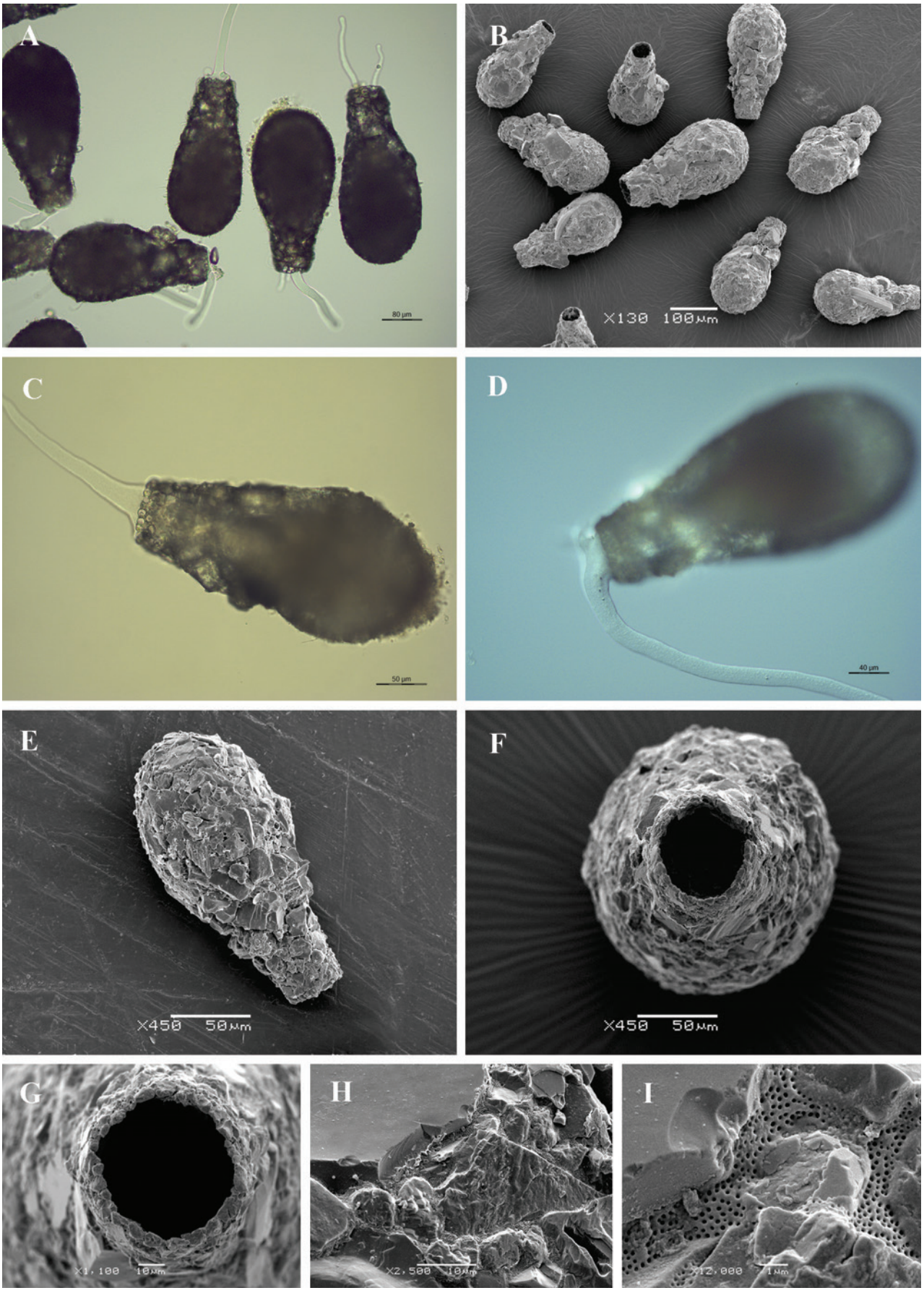
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 26. *Difflugia oblonga*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	242.7	238.7	46.5	8.49	19.16	180	341	30
Breadth	130.4	121.6	30.4	5.55	12.3	94	199	30
Diameter of aperture	45.9	45.9	8.0	1.47	17.53	31	61	30
Breadth/Length ratio	0.54	0.54	0.05	0.01	10.01	0.4	0.6	30
Aperture/Breadth ratio	0.36	0.36	0.06	0.01	17.06	0.3	0.6	30

Fig. 36. Light (A, C, D) and scanning electron (B, E-I) micrographs of *Difflugia oblonga*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C, D) View of two live specimens to illustrate a single long endolobopodia. (E) Lateral view. (F) Apertural view. (G) Close up view of aperture. (H) Portion of shell to show arrangement of particles and rough surface of the shell. (I) Detail of organic cement network.


A
80 µm
B
X130 100µm
C
50 µm
D
40 µm
E
X450 50µm
F
X450 50µm
G
X1,100 10µm
H
X2,500 10µm
I
X12,000 1µm

Difflugia penardi Hopkinson, 1909

Original description: Cash and Hopkinson 1909. *The British Freshwater Rhizopoda and Heliozoa*. Vol. II, p. 14, Pl. XVIII, figs. 4-6.

Synonyms: *Difflugia fallax* Penard, 1890; *Difflugia pyriformis* var. *tenuis* Penard, 1890; *Difflugia manicata* Penard, 1902; *Difflugia oblonga* var. *tenuis* Wailes and Penard, 1911; *Difflugia tenuis* (Penard, 1890) Ogden, 1983.

Description: Shell yellow or brown, elongate or ovoid, with sides tapering evenly and gradually from rounded aboral region towards to aperture, circular in transverse section (Fig. 37 A-C); covered mainly of small to medium quartz particles, occasionally with fragment of diatom frustules or chrysomonad cysts, rough (Fig. 37 D-F). Shell components usually in close contact with each other, organic cement is seen infrequently (Fig. 37 I). Aperture small, circular, surrounding rim covered by small particles or flagellate cysts (Fig. 37 F-H). Cytoplasm not abundant, fills about half of the shell; fulfilled with brilliant, colorless granules, rarely has a few symbiotic zoochlorellae; one vesicular nucleus, about 12-15 μm in diameter, one central nucleolus. Pseudopodia usually two or three, long, thin, sometimes flattened and expanded, slow moving.

Notes: The species has been recorded in both as nominal species and as synonym *Difflugia manicata* (Rhodopes Mts., Rila Mts., Vitosha Mts.).

Ecology: Frequent in freshwater habitats and in *Sphagnum*.

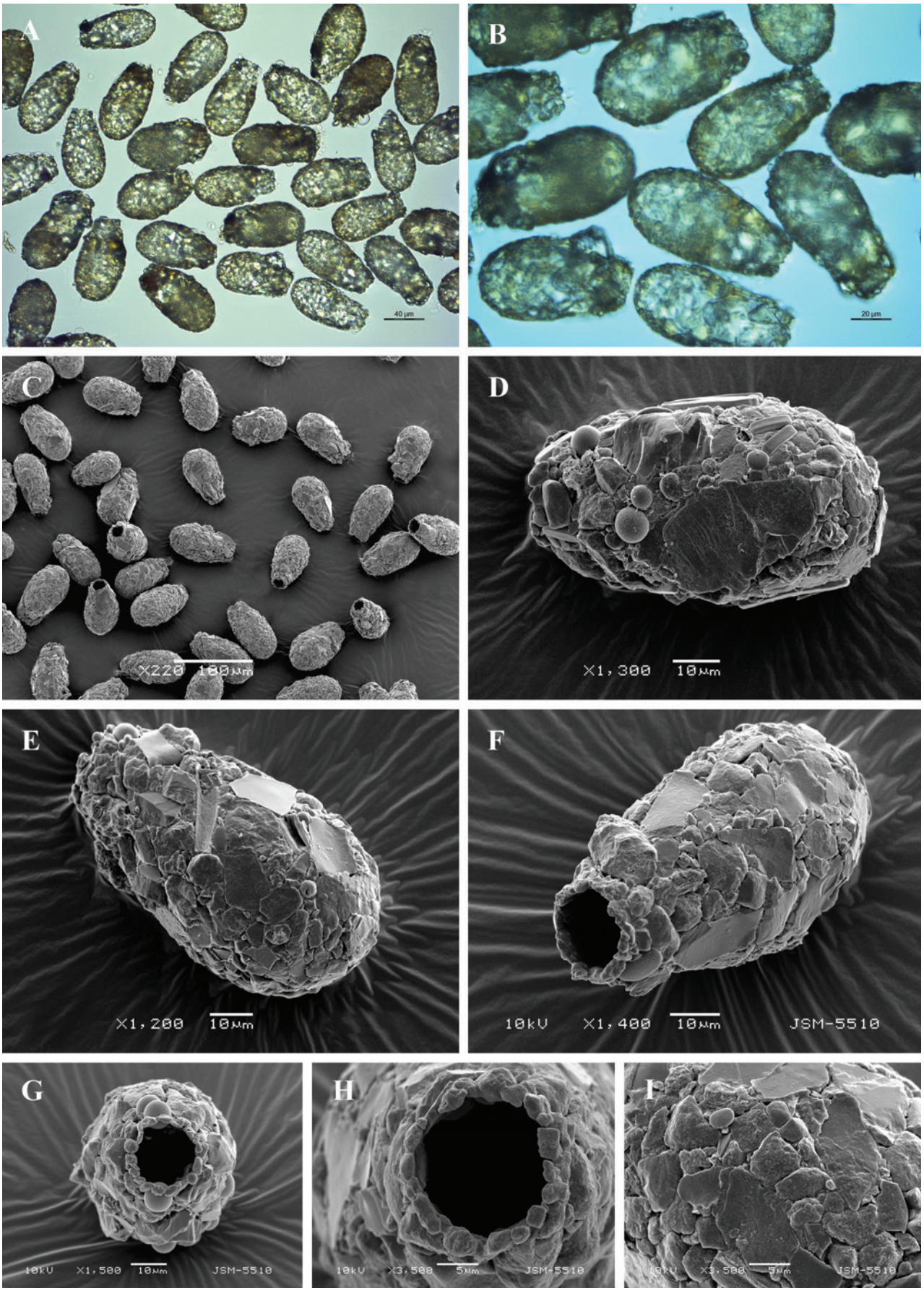
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2004, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 27. *Difflugia penardi*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	83.0	81.0	7.90	1.37	9.51	74	101	33
Breadth	45.2	45.1	5.42	0.94	11.99	38	62	33
Diameter of aperture	22.9	21.5	4.95	0.86	21.7	15	37	33
Breadth/Length ratio	0.55	0.55	0.06	0.010	10.62	0.4	0.7	33
Aperture/Breadth ratio	0.50	0.50	0.10	0.018	20.03	0.3	0.8	33

Fig. 37. Light (A, B) and scanning electron (C-I) micrographs of *Difflugia penardi*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D-E) Lateral view of two specimens showing rough surface of the shell. (F) Latero-apertural view. (G) Apertural view. (H) Close up view of aperture to show bordering small particles. (I) Portion of shell to illustrate arrangement of particles and rough surface of the shell.


A
40 µm
B
20 µm
C
X220 100µm
D
X1,300 10µm
E
X1,200 10µm
F
10kV X1,400 10µm JSM-5510
G
10kV X1,500 10µm JSM-5510
H
10kV X3,500 5µm JSM-5510
I
10kV X3,500 5µm JSM-5510

Difflugia pulex Penard, 1902

Original description: Penard 1902, Faune Rhizopodique du Bassin du Léman, p. 229, fig. 1 à 8 (p. 230).

Synonyms: *Difflugia minuta* var. *minor* Godeanu, 1972; *Difflugia ovalisina* Beyens et Chardez, 1994.

Description: Shell transparent, ovoid, circular in transverse section, tapering evenly from the mid-body position towards the aperture, with rounded aboral region (Fig. 38 A-F); composed of small to medium flattish pieces of quartz, mixed with pieces of diatom frustules, with rough surface (Fig. 38 A-F). Shell components usually in close contact with each other; only small areas of organic cement with single small pores are visible between particles (Fig. 38 H, I). Aperture circular, with irregular outline, surrounded by quartz particles of different size (Fig. 38 F, G).

Ecology: Frequent in freshwater sediments and in *Sphagnum*.

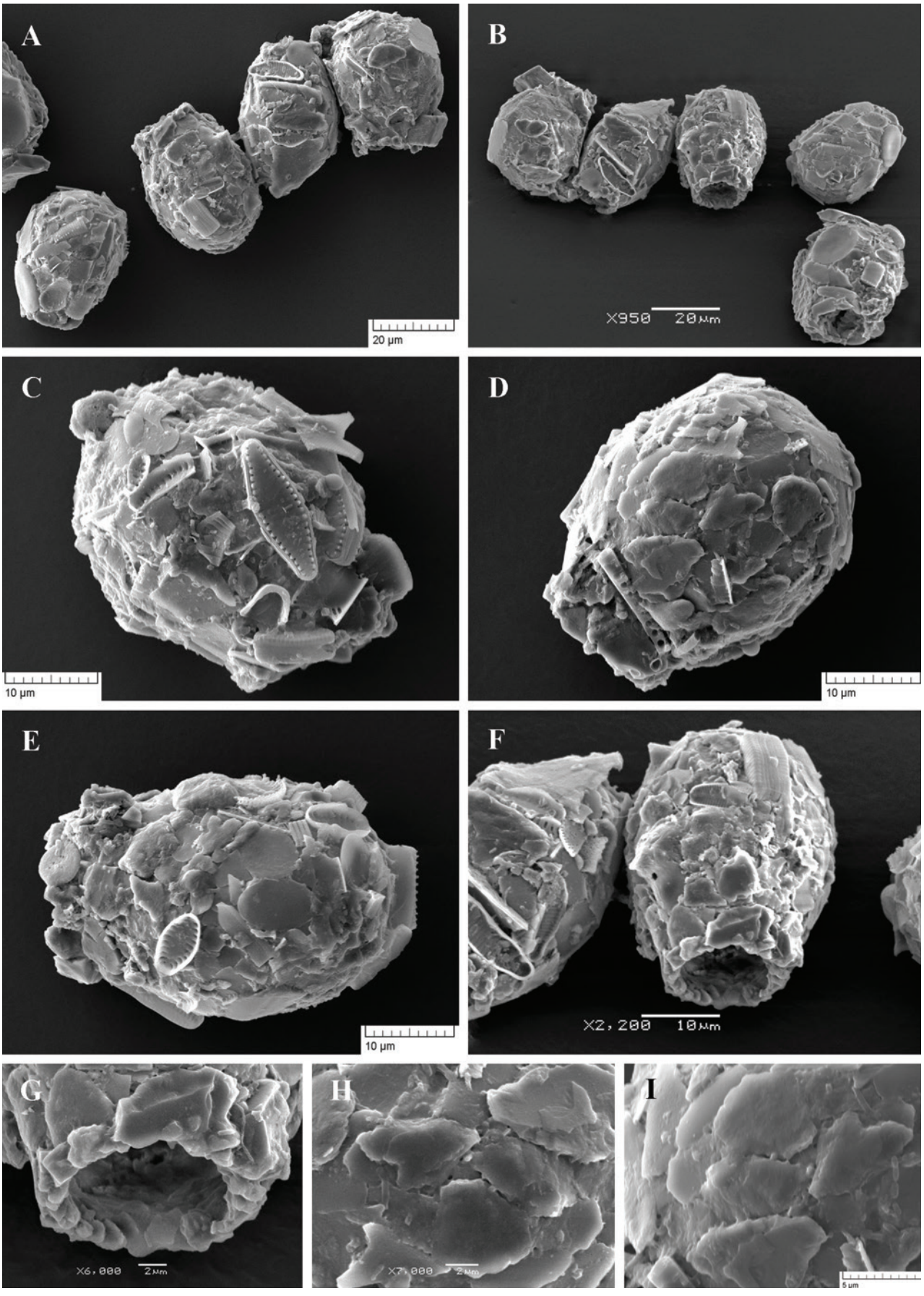
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky and Todorov 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 28. *Difflugia pulex*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	38.1	38.7	3.81	0.95	10.00	27	43	16
Width	27.4	27.9	4.26	1.06	15.56	17	36	16
Aperture diameter	12.9	13.7	1.69	0.42	13.05	10	15	16
Width/Length ratio	0.72	0.73	0.08	0.02	11.67	0.6	0.9	16
Aperture diameter/Width ratio	0.48	0.48	0.06	0.02	12.85	0.4	0.6	16

Fig. 38. Scanning electron micrographs of *Difflugia pulex*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C-E) Lateral view of three specimens showing different shape and shell structure. (F) Latero-apertural view. (G) Apertural view to show its irregular edge. (H, I) Portion of shell surface to show arrangement of flattish particles and small areas of organic cement with single small pores.


A
20 µm
B
X950 20µm
C
10 µm
D
10 µm
E
10 µm
F
X2,200 10µm
G
X6,000 2µm
H
X7,000 2µm
I
5 µm

Difflugia pyriformis Perty, 1849

Original description: Perty 1849, *Mittheilungen der Naturforschenden Gesellschaft in Bern*, no 164-165, p. 168.

Description: Shell brown, opaque, pyriform, with sides tapering evenly to the aperture or forming a distinct neck about one-third of the body length; rounded aboral region and circular transverse section (Fig. 39 A-F); rough, covered mainly of medium to large quartz particles (Fig. 39 D-F). Areas of organic cement are usually well seen in the shell matrix as a network with the open mesh having a diameter of 50-150 nm and dividing walls about 150-300 nm thick (Fig. 39 I). Aperture circular, surrounding rim covered by small particles (Fig. 39 F, G). Cytoplasm abundant, fills the whole shell, fulfilled with numerous symbiotic zoochlorellae; one large ovular nucleus, numerous nucleoli. Pseudopodia usually one or two, long, fast moving. (Fig. 39 A, C).

Ecology: Frequent in freshwater standing bodies, accidentally in *Sphagnum*.

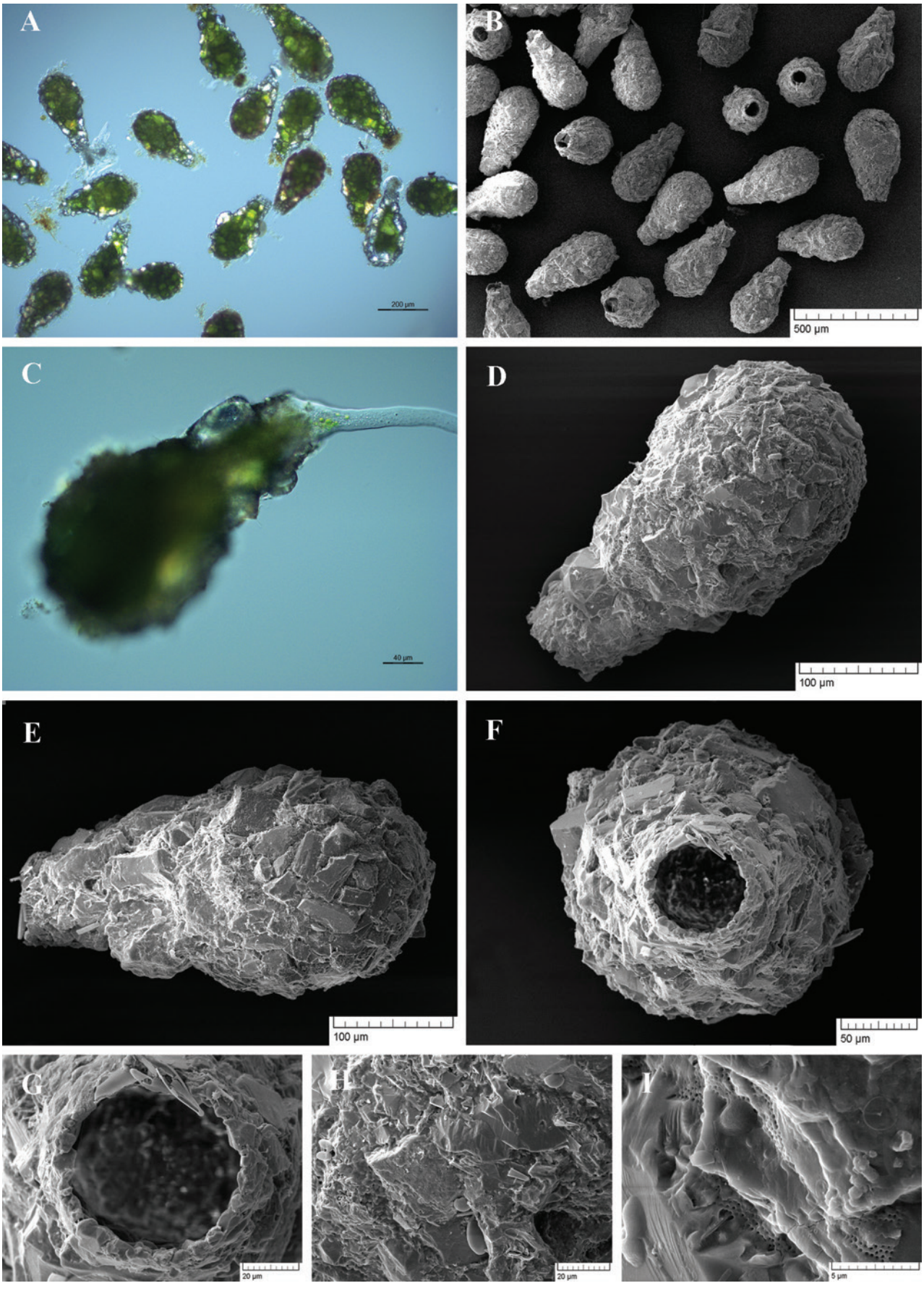
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Pateff 1924); **Rila Mts.** (Pateff 1924); **Vitosha Mts.** (Pateff 1924).

Table 29. *Difflugia pyriformis*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	342.2	344.7	20.18	3.19	5.90	297	383	40
Width	195.9	196.6	13.09	2.07	6.68	152	225	40
Aperture diameter	64.6	63.6	7.20	1.14	11.15	47	78	40
Width/Length ratio	0.57	0.58	0.04	0.007	7.83	0.4	0.7	40
Aperture diameter/Width ratio	0.33	0.32	0.04	0.006	11.89	0.3	0.4	40

Fig. 39. Light (A, C) and scanning electron (B, D-I) micrographs of *Difflugia pyriformis*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen to illustrate a single long endolobopodia and granular cytoplasm with symbiotic zoochlorelae. (D, E) Lateral views of two individuals to show general shape. (F) Apertural view. (G) Close up view of aperture showing its circular outline and surrounding small particles of quartz. (H) Portion of shell to show arrangement of particles and rough surface of the shell. (I) Detail of organic cement network.


A
200 µm
B
500 µm
C
40 µm
D
100 µm
E
100 µm
F
50 µm
G
20 µm
H
20 µm
I
5 µm

Difflugia rubescens Penard, 1891

Original description: Penard 1891b, *The American Naturalist*, 25, p. 1075.

Description: Shell yellow or brown, transparent, pyriform, with sides tapering evenly and gradually from rounded aboral region towards to aperture, circular in transverse section (Fig. 40 A-E); rough, covered mainly of small to medium quartz particles usually mixed with fragments of diatom frustules or chrysomonad cysts (Fig. 40 D-F). Shell components usually in close contact with each other, organic cement visible infrequently (Fig. 40 I). Aperture roughly circular, bordered by an organic collar with crenulated inner margin and forming tooth-like structures (Fig. 40 F-H). Cytoplasm not abundant, fills about half of the shell, fulfilled with many orange-red colored granules; one vesicular nucleus about 10 μm in diameter, one small central nucleolus. Active amoebae infrequently seen, usually live specimens are encysted, cysts round, brown, with thick organic wall, occupying rounded aboral region. Pseudopodia usually one or two, short, digitiform, sometimes flattened, slow moving.

Ecology: Frequent in *Sphagnum*.

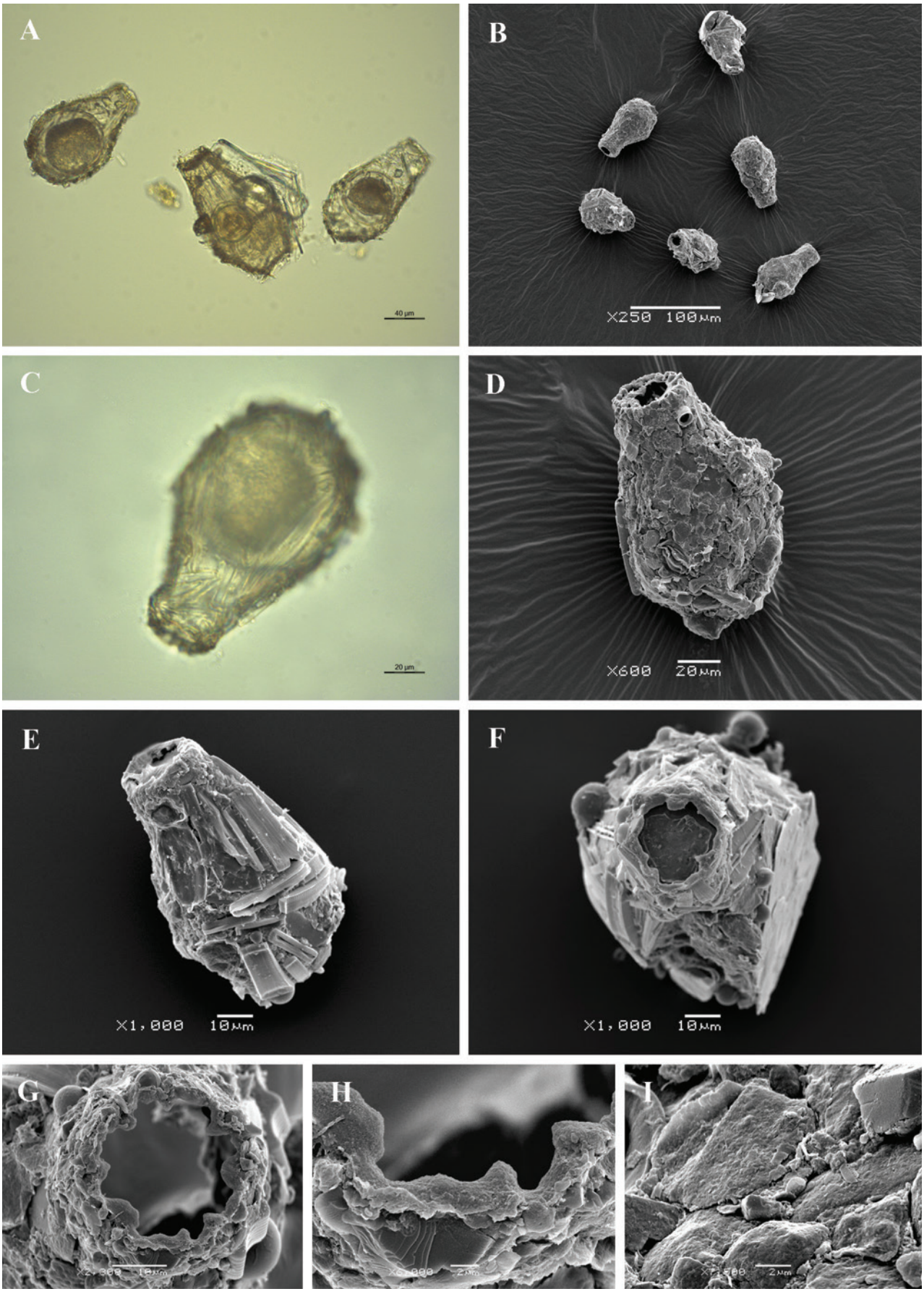
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rila Mts.** (Pateff 1924, Golemansky and Todorov 1993, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 30. *Difflugia rubescens*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	72.7	71.1	7.50	1.22	10.31	56	91	38
Breadth	45.4	46.2	5.73	0.93	12.63	32	59	38
Diameter of aperture	20.1	20.5	3.62	0.59	18.02	13	27	38
Breadth/Length ratio	0.63	0.63	0.07	0.012	11.46	0.5	0.7	38
Aperture/Breadth ratio	0.44	0.45	0.06	0.010	13.33	0.3	0.5	38

Fig. 40. Light (A, C) and scanning electron (B, D-I) micrographs of *Difflugia rubescens*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C) View of encysted specimen. (D-E) Lateral view of two specimens to illustrate rough surface of the shell. (F) Apertural view. (G-H) Close up view of aperture showing the bordering crenulated organic collar. (I) Portion of shell to show arrangement of particles and rough surface of the shell.


A
40 µm
B
X250 100µm
C
20 µm
D
X600 20µm
E
X1,000 10µm
F
X1,000 10µm
G
H
I

Difflugia urceolata Carter, 1864

Original description: Carter 1864, *Annals and Magazine of Natural History***,** 13, p. 27, Pl. I, fig. 7.

Synonyms: *Difflugia urceolata* var. *olla* Leidy, 1879; *Difflugia urceolata var. sphaerica* Playfair, 1917.

Description: Shell large, opaque, ovoid or circular, sometimes with irregular aboral protruberances and a pronounced thick apical collar (Fig. 41 A-E); composed of a mixture of small and large pieces of quartz, so arranged to give it a relatively smooth and regular outline (Fig. 41 A-E). Shell components usually in close contact with each other, organic cement rarely visible between particles (Fig. 41 I). Aperture circular, well defined, with requlat outline, surrounded by a collar made of small quartz particles (Fig. 41 C, E-H). Cytoplasm not abundant, fills about half of the shell, usually fulfilled with green algae. Multinucleate, about 50 or more nuclei, each of them with many nucleoli. Pseudopodia numerous, long, thin, fast moving.

Ecology: Common in freshwater sediments, incidentally in *Sphagnum*.

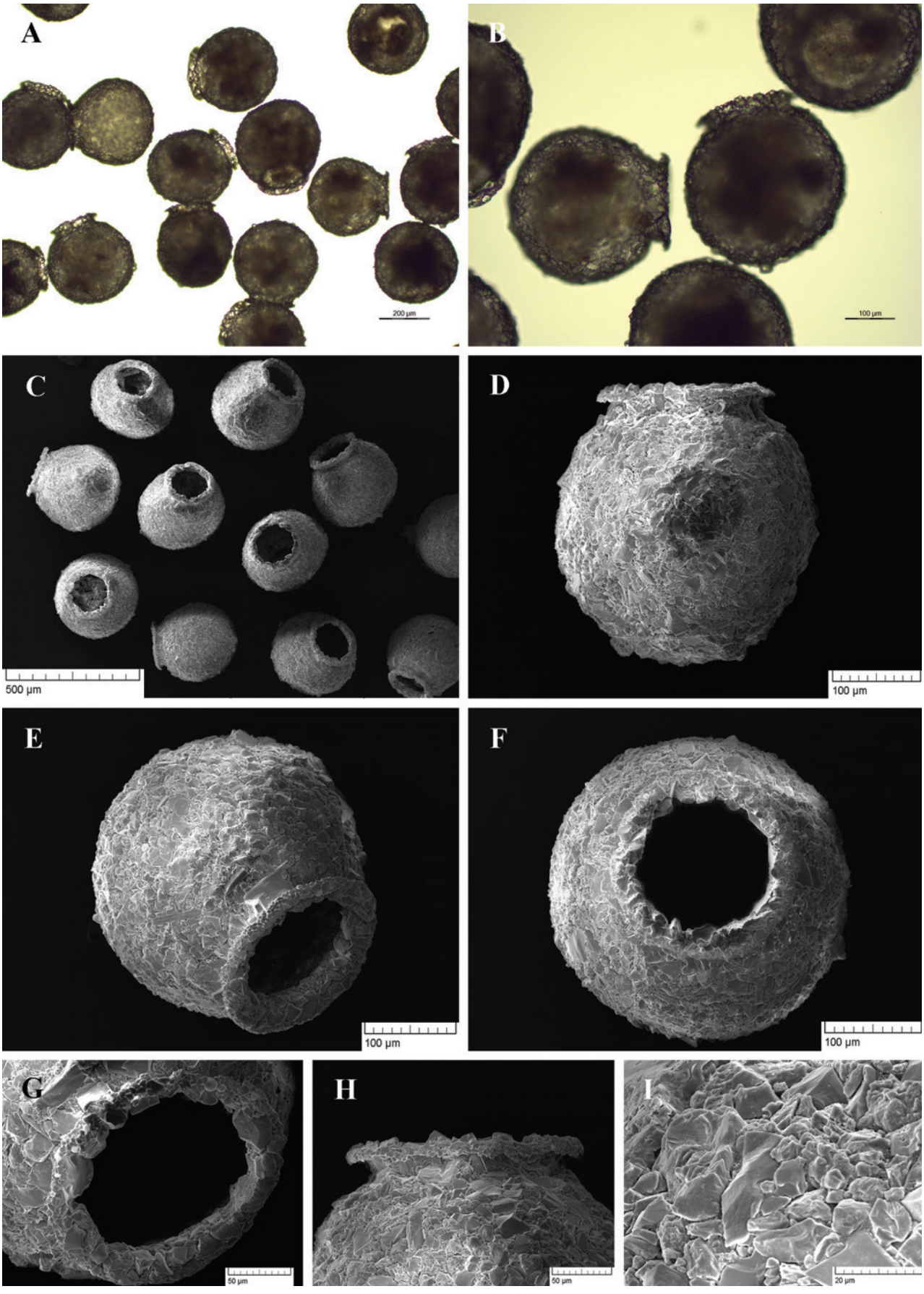
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky et al. 2006).

Table 31. *Difflugia urceolata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	295.0	296.2	33.60	5.68	11.39	219	378	35
Breadth	253.7	244.7	37.71	6.37	14.86	176	342	35
Diameter of aperture	161.5	156.0	15.96	2.70	9.89	133	186	35
Breadth/Length ratio	0.86	0.85	0.07	0.01	7.70	0.75	0.98	35
Aperture/Breadth ratio	0.65	0.65	0.1	0.02	15.97	0.4	0.9	35

Fig. 41. Light (A, B) and scanning electron (C-I) micrographs of *Difflugia urceolata*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D) Lateral view. (E) Latero-apertural view. (F) Apertural view. (G) Close up view of aperture to show its regular outline. (H) Lateral view of apertural region to illustrate the surrounding collar made of small quartz particles. (I) Portion of shell to show arrangement of particles and rough surface of the shell.


A
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C
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E
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100 µm
G
50 µm
H
50 µm
I
20 µm

Difflugia viscidula Penard, 1902

Original description: Penard 1902, Faune Rhizopodique du Bassin du Léman, p. 259, fig. 1 à 4 (p. 260).

Synonyms: *Difflugia lemani* Blanc, 1892; *Difflugia histrio* Penard, 1908; *Difflugia lemani* var. *palustris* Chardez, 1956; *Difflugia lebes* var. *masurica* Schönborn, 1965; *Difflugia lebes* var. *bretschkoi* Laminger, 1971; *Difflugia finstertaliensis* Laminger, 1971.

Description: Shell large, opaque, ovoid, circular in transverse section, tapering evenly from the mid-body position towards the aperture, with rounded aboral region (Fig. 42 A-E); composed of a mixture of small and large pieces of quartz, rarely included diatom frustules (Fig. 42 A-E). Shell components usually in close contact with each other, organic cement rarely visible between particles (Fig. 42 I). Aperture circular, well defined, with requlars outline, surrounded by small particles (Fig. 42 E-H). Cytoplasm does not fills the whole shell, usually fulfilled with brown granules (Fig. 42 A, C, D); one large ovular nucleus with many nucleoli. Pseudopodia few, short, thin, very slow moving, rarely visible; sometimes large part of cytoplasm protrude out from the aperture forming flattened, fan-shaped disc with short pseudopodia, adhered to the substrate (Fig. 42 C, D).

Notes: The species has been recorded as nominal species, as synonym *D. lemani*, as infrasubspecific taxon *D. lemani* var. *palustris* and as *Difflugia* sp. (Vitosha Mts.).

Ecology: Common in freshwater sediments, less frequent in *Sphagnum*.

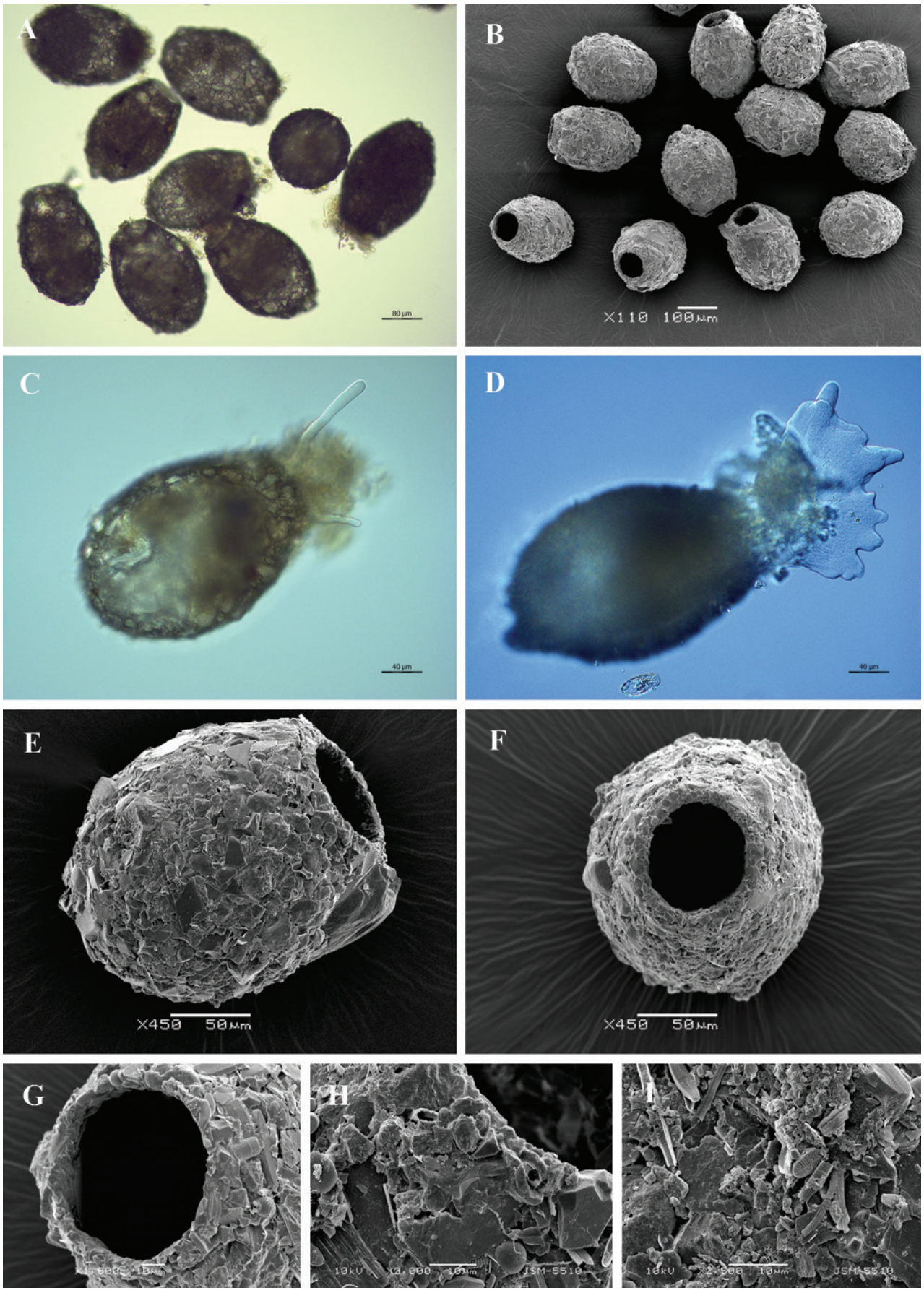
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Vitosha Mts.** (Pateff 1928, Golemansky 1965, Golemansky and Todorov 1985, 1990).

Table 32. *Difflugia viscidula*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	230.9	228.7	15.18	2.77	6.57	200	267	30
Breadth	171.2	170.0	12.16	2.22	7.10	149	204	30
Diameter of aperture	86.1	86.0	14.44	2.64	16.78	64	108	30
Breadth/Length ratio	0.74	0.75	0.06	0.01	8.72	0.6	0.9	30
Aperture/Breadth ratio	0.50	0.51	0.08	0.01	15.87	0.4	0.6	30

Fig. 42. Light (A, C, D) and scanning electron (B, E-I) micrographs of *Difflugia viscidula*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C-D) Lateral view of two live specimens showing different types of pseudopodia. (E) Lateral view. (F) Apertural view. (G) Close up view of aperture to show its regular outline. (H) Lateral view of apertural region. (I) Portion of shell to show arrangement of particles and rough surface of the shell.


A
80 µm
B
X110 100µm
C
40 µm
D
40 µm
E
X450 50µm
F
X450 50µm
G
H
10kV X3,000 10µm JSM-5510
I
10kV X3,000 10µm JSM-5510

Lesquereusia epistomium Penard, 1902

Original description: Penard 1902, Faune Rhizopodique du Bassin du Léman, p. 331, fig. 1 à 3.

Description: Shell colourless, transparent, consists of two parts, an ovoid or globular body and an oblique, long neck, clearly separated from each other with deep groove (Fig. 43 A-D); main body almost uncompressed laterally, with circular or oval transverse section; neck uncompressed with a circular aperture (Fig. 43 D-F); composed of characteristic siliceous vermiform rods, adhering at their edges but do not overlapping (Fig. 43 D-G); rods embedded by a network of organic cement with rosette-like pattern and meshes of about 600-800 nm in diameter; each mesh possess internal small network with irregular pores of about 60-140 nm (Fig. 43 H-I). Aperture circular, surrounded by siliceous rods, without organic collar (Fig. 43 D-F). Cytoplasm fulfilled with numerous brown granules, does not fills the whole shell; one large ovular nucleus with numerous small nucleoli; pseudopodia usually one or two, large, long and fast moving (Fig. 43 A, C).

Synonyms: *Lecquereusia jurassica* var. *epistomium* Penard, 1893; *Lecquereusia epistomium* Penard, 1902.

Ecology: Common in *Sphagnum*.

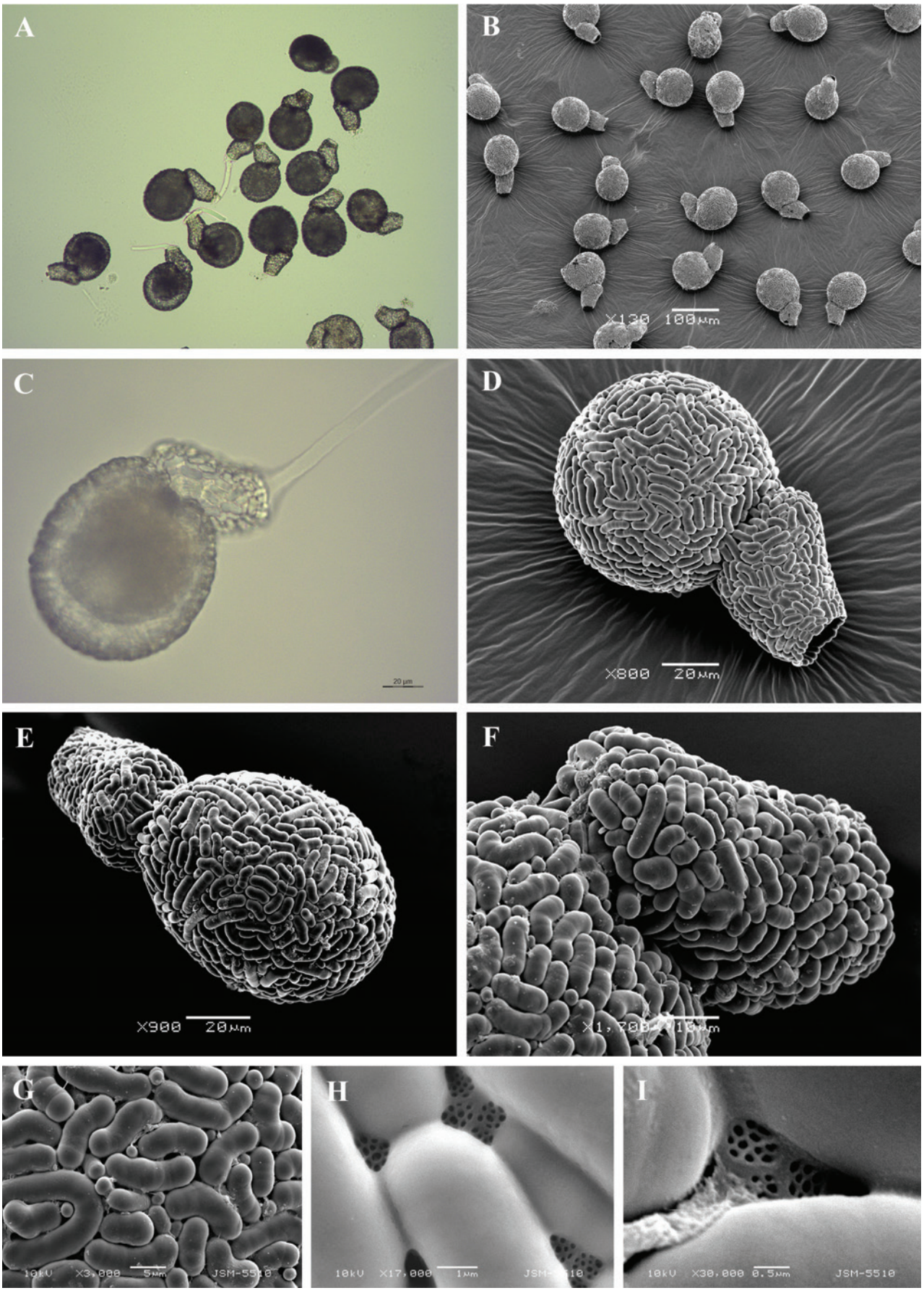
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: **Pirin Mts.** (Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 33. *Lesquereusia epistomium*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	122.0	121.4	6.94	1.25	5.69	104	138	31
Breadth	86.5	85.9	7.42	1.35	8.58	72	105	30
Diameter of aperture	23.3	22.6	3.57	0.65	15.30	19	33	30
Depth	73.1	72.0	5.02	1.26	6.87	66	86	16
Breadth/Length ratio	0.71	0.70	0.04	0.008	6.14	0.6	0.8	29
Aperture/Breadth ratio	0.27	0.26	0.04	0.007	14.35	0.2	0.4	30

Fig. 43. Light (A, C) and scanning electron (B, D-I) micrographs of *Lesquereusia epistomium*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen to illustrate granular cytoplasm and long pseudopodia. (D) Broad lateral view to show general shape. (E) Narrow lateral view to illustrate clear distinction between body and neck. (F) Lateral view of apertural region. (G) Detail of shell surface showing shape and arrangement of siliceous curved rods. (H, I) Close up view of network of organic cement and porous structure of meshes.


A
B
X130 100µm
C
20 µm
D
X800 20µm
E
X900 20µm
F
G
10kV X3,000 5µm JSM-5510
H
10kV X17,000 1µm
I
10kV X30,000 0.5µm JSM-5510

Lesquereusia gibbosa Thomas and Gauthier-Lièvre, 1859

Original description: Thomas and Gauthier-Lièvre 1959b, *Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord*, 50, p. 44, Fig. 6 a, b, c, Pl. I – 31.

Description: Shell colourless, transparent, unsymmetrically-ovoid or pyriforme, with globular body and an oblique neck, clearly separated from the body with deep ventral groove and well-expressed fold of the dorsal side, forming an internal opening (Fig. 44 A-D); main body slightly compressed laterally, with oval transverse section; neck uncompressed, with circular aperture (Fig. 44 F, G); composed of characteristic siliceous vermiform rods, sometimes mixed with single sand grains; all particles adhering at their edges, do not overlap, embedded by a network of organic cement with a distinctive rosette-like pattern; meshes of about 500-800 nm in diameter; each mesh has an internal small network with irregular pores of about 80-100 nm (Fig. 44 D-I). Aperture circular, surrounded by siliceous rods, without organic collar (Fig. 44 D-G). Cytoplasm fulfilled with numerous brown granules, does not fills the whole shell; one large ovular nucleus with numerous small nucleoli; pseudopodia usually two or three, large, long, fast moving (Fig. 44 A, C).

Notes: *Lesquereusia gibbosa* differs from *L. spiralis* by its larger size, shorter and voluminous rods, structure of meshes of the organic cement and presence of a well-expressed fold of the dorsal side.

Ecology: In *Sphagnum*, less frequent.

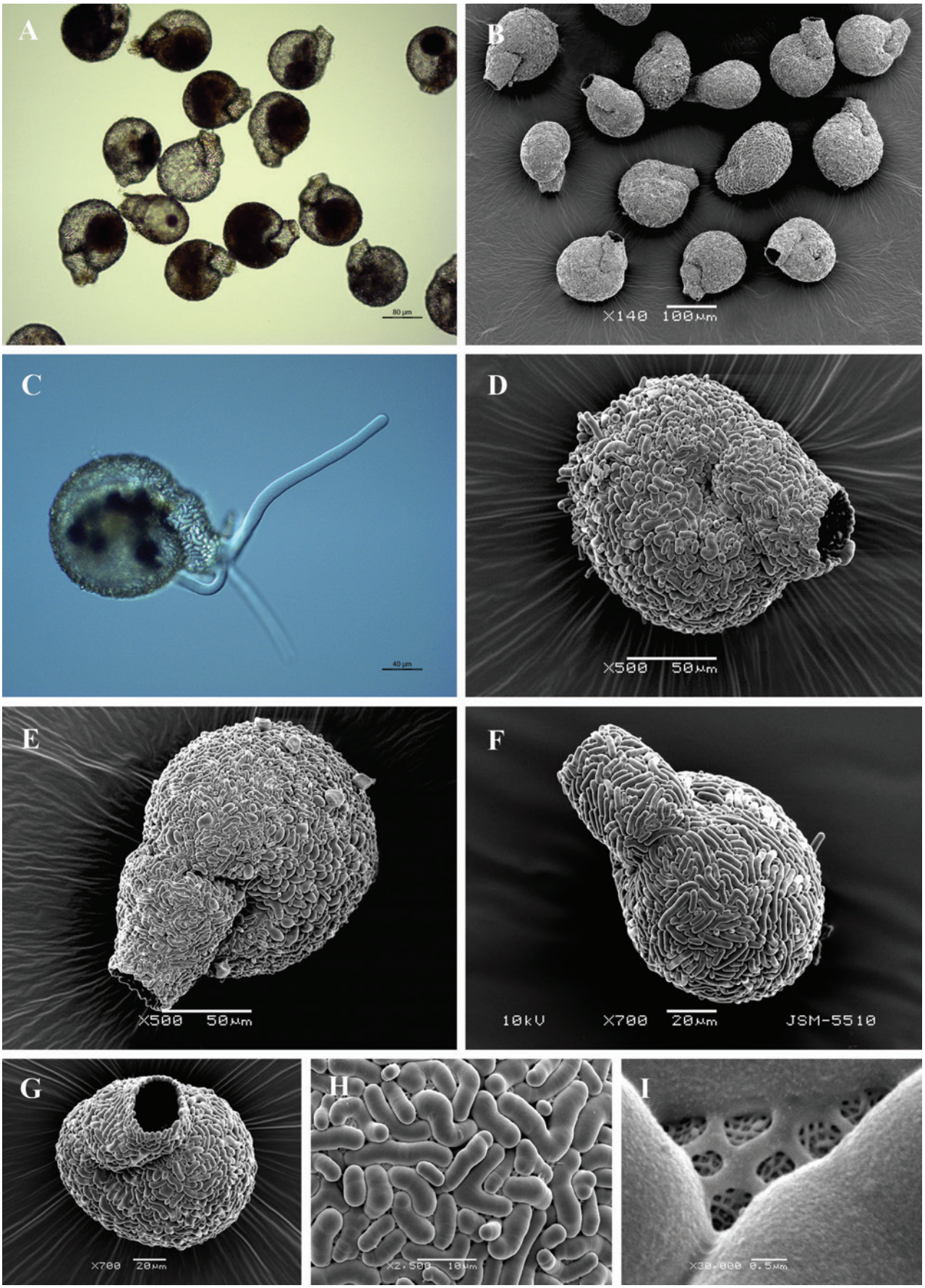
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: **Pirin Mts.** (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky and Todorov 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 34. *Lesquereusia gibbosa*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	149.2	148.4	11.72	1.95	7.85	131	188	36
Breadth	125.5	125.0	10.21	1.86	8.14	96	140	30
Diameter of aperture	31.3	32.0	3.81	0.63	12.17	20	39	37
Depth	95.9	96.2	7.73	2.07	8.06	74	110	14
Breadth/Length ratio	0.84	0.84	0.05	0.008	5.38	0.72	0.95	30
Aperture/Breadth ratio	0.25	0.25	0.03	0.006	12.03	0.2	0.3	29

Fig. 44. Light (A, C) and scanning electron (B, D-I) micrographs of *Lesquereusia gibbosa*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen showing granular cytoplasm and long pseudopodia. (D, E) Broad lateral view of two individuals to show general shape. (F) Narrow lateral view. (G) Apertural view. (H) Detail of shell surface showing shape and arrangement of siliceous curved rods and network of organic cement. (I) Close up view of a network of organic cement.


A
80 µm
B
X140 100µm
C
40 µm
D
X500 50µm
E
X500 50µm
F
10kV X700 20µm JSM-5510
G
X700 20µm
H
X2,500 10µm
I
X30,000 0.5µm

Lesquereusia modesta Rhumbler, 1896

Original description: Rhumbler 1896, *Zeitschrift für Wissenschaftliche Zoologie*, 61 (1), p. 101, Pl. IV, fig. 2.

Synonyms: *Difflugia spiralis* Leidy, 1879 (in part).

Description: Shell colourless, unsymmetrically-ovoid or circular, with globular body and short, oblique neck, separated with groove (Fig. 45 A-D); main body compressed laterally, with oval transverse section; neck uncompressed, with circular aperture (Fig. 45 C-E); composed mainly of small to medium grains of quartz mixed with a small number of siliceous vermiform rods (Fig. 45 C-G). Structural particles embedded by network of organic cement with a distinctive rosette-like pattern; meshes of about 500-600 nm in diameter; each mesh has an internal small network with twelve to eighteen irregular oppenings of about 70-150 nm (Fig. 45 G-I). Aperture circular, denticulate, surrounded by small particles of quartz, without organic collar (Fig. 45 D-F). Cytoplasm dark, fulfilled with brown granules, does not fills the whole shell; one large ovular nucleus with numerous nucleoli; pseudopodia usually one or two, large, long, fast moving.

Notes: *Lesquereusia modesta* is similar to *L. spiralis* by shell shape and size, but clearly differs from it by structure of the shell, which is rough and composed mainly of small to medium pieces of quartz.

Ecology: In standing freshwater basins, less frequent in *Sphagnum*.

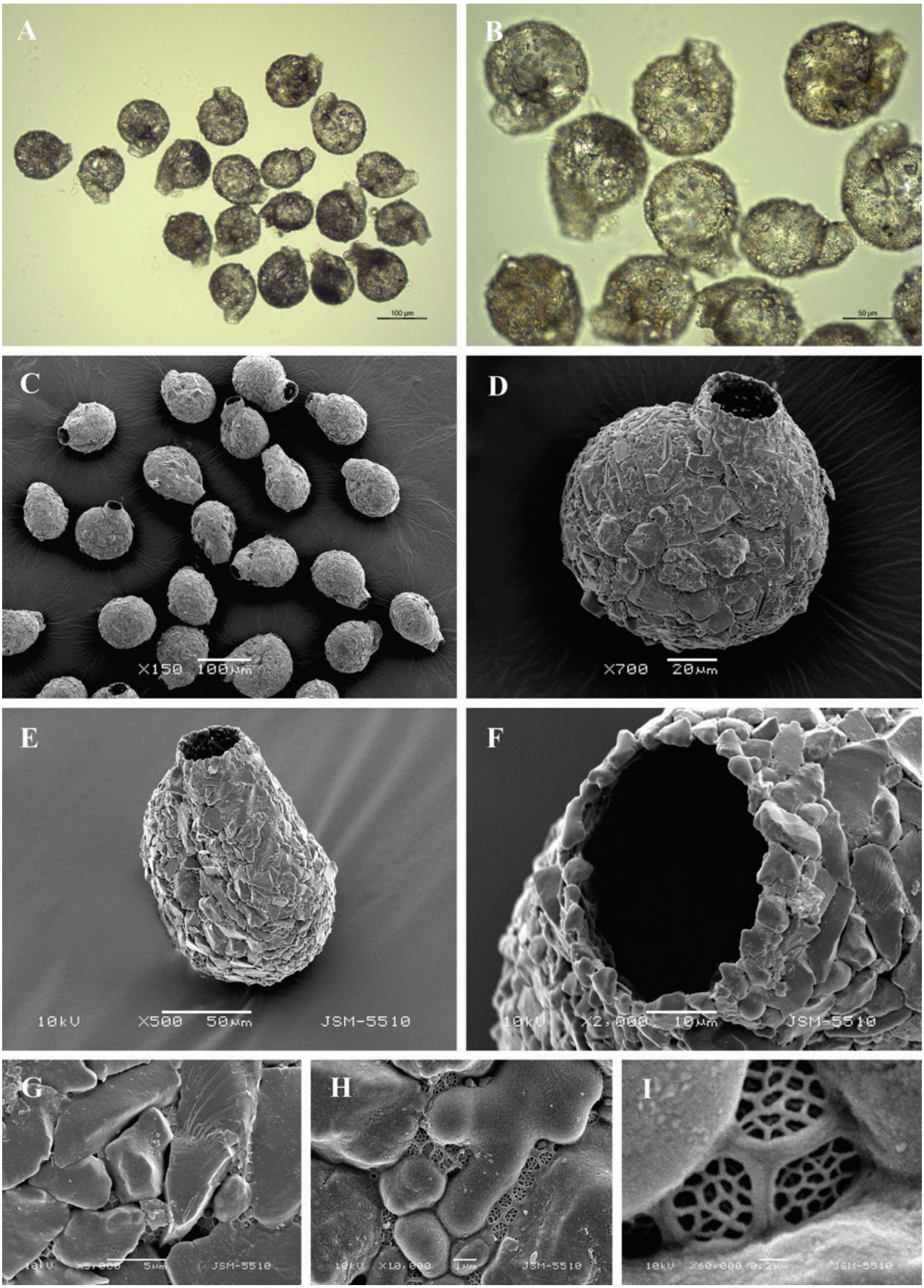
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: **Pirin Mts.** (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 35. *Lesquereusia modesta*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	126.2	125.9	8.14	1.40	6.45	111	144	34
Breadth	104.0	102.5	9.57	1.75	9.20	85	120	30
Diameter of aperture	30.2	29.8	4.39	0.76	14.56	23	38	33
Depth	87.7	86.5	6.51	1.53	7.42	76	99	18
Breadth/Length ratio	0.82	0.82	0.05	0.009	6.22	0.7	0.9	30
Aperture/Breadth ratio	0.29	0.29	0.04	0.007	12.62	0.2	0.4	30

Fig. 45. Light (A, B) and scanning electron (C-I) micrographs of *Lesquereusia modesta*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D) Broad lateral view. (E) Narrow lateral view. (F) Close up view of aperture showing its circular outline and bordering small particles of quartz. (G) Detail of shell surface showing shape and arrangement of sand grains of quartz. (H, I) Close up view of a network of organic cement and porous structure of meshes.


A
100 µm
B
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C
X150 100µm
D
X700 20µm
E
10kV X500 50µm JSM-5510
F
10kV X2,000 10µm JSM-5510
G
10kV X5,000 5µm JSM-5510
H
10kV X10,000 1µm JSM-5510
I
10kV X60,000 0.2µm JSM-5510

Lesquereusia spiralis (Ehrenberg, 1840) Bütschli, 1880

Original description: Ehrenberg 1840, *Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königliche Preussischen Akademie der Wissenschaften zu Berlin*, 5, p. 199; **Last revision:** Bütschli 1880, Protozoa. In: Bronn's Their-Reichs, I, 1, Taf. III, fig. 9.

Synonyms: *Difflugia spiralis* Ehrenberg, 1840; *Lecquereusia jurassica* Schlumberger, 1845; *Difflugia helix* Cohn, 1853.

Description: Shell colourless, transparent, unsymmetrically-ovoid or pyriforme, with globular body and short, oblique neck, separated with deep groove (Fig. 46 A-D); main body compressed laterally, with oval transverse section; neck uncompressed, with circular aperture (Fig. 46 E-G); composed of characteristic siliceous vermiform rods, adhering at their edges, non-overlapping, embedded by network of organic cement with a distinctive rosette-like pattern; meshes of about 400-500 nm in diameter; each mesh has an internal small network with eight to ten pores of about 30-50 nm (Fig. 46 D-I). Aperture circular, surrounded by siliceous rods, without organic collar (Fig. 46 F-H). Cytoplasm fulfilled with brown granules, does not fills the whole shell; one large ovular nucleus with numerous small nucleoli; pseudopodia usually one or two, large, long, fast moving (Fig. 46 A, C).

Ecology: Common in *Sphagnum*.

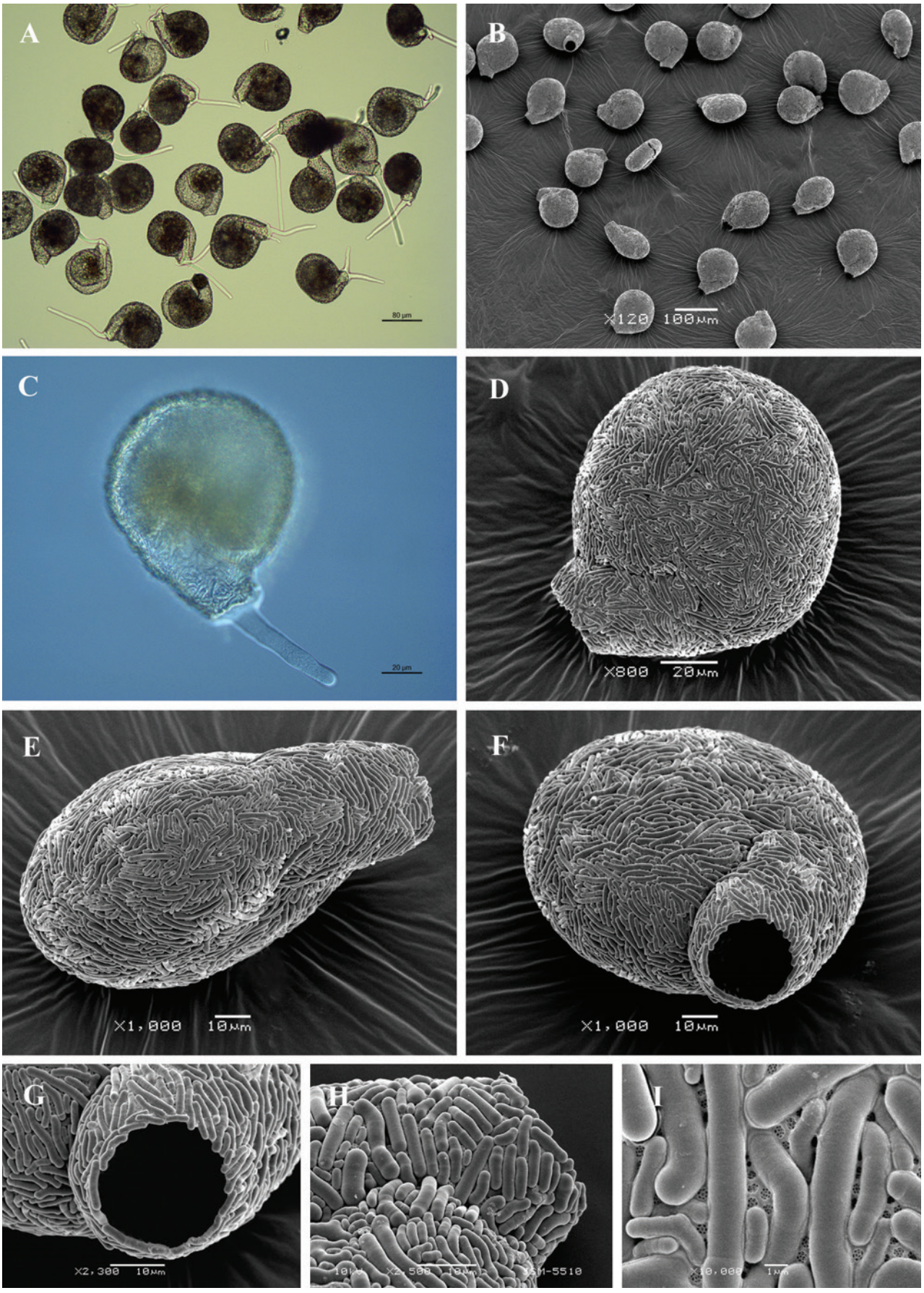
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: **Pirin Mts.** (Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 36. *Lesquereusia spiralis*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	114.7	113.5	8.81	1.53	7.68	102	146	33
Breadth	96.8	97.4	7.18	1.29	7.42	82	121	31
Diameter of aperture	25.9	26.0	2.35	0.41	9.05	21	32	33
Depth	72.0	71.9	5.62	1.40	7.81	63	90	16
Breadth/Length ratio	0.85	0.84	0.05	0.01	6.38	0.75	0.96	31
Aperture/Breadth ratio	0.27	0.27	0.02	0.004	7.51	0.2	0.3	31

Fig. 46. Light (A, C) and scanning electron (B, D-I) micrographs of *Lesquereusia spiralis*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen showing granular cytoplasm and pseudopodia. (D) Broad lateral view. (E) Narrow lateral view. (F) Apertural view (G) Close up view of aperture to show its circular outline and bordering siliceous rods. (H) Lateral view of apertural region. (I) Detail of shell surface showing shape and arrangement of siliceous curved rods and network of organic cement.


A
80 µm
B
×120 100µm
C
20 µm
D
×800 20µm
E
×1,000 10µm
F
×1,000 10µm
G
×2,300 10µm
H
×2,500 10µm
I
×10,000 1µm

Centropyxis aculeata (Ehrenberg, 1830) Stein, 1857

Original description: Ehrenberg 1830, *Abhandlungen der Königlichen Akademie der Wissenszchaften zu Berlin*, p. 40; **Last revision:** Stein 1857, *Abhandlungen der Königlich Böhmischen Gesellschaft der Wissenschaften,* 10, p. 43.

Synonyms: *Arcella aculeata* Ehrenberg, 1830; *Difflugia aculeata* Perty, 1852; *Echinopyxis aculeata* Claparède et Lachmann, 1859.

Description: Shell yellowish-brownish, ovoid or circular, usually with about four to eight lateral spines (Fig. 47 A-F); main body spherical in lateral view and tappers towards the aperture (Fig. 47 F); composed of small sand grains and diatom frustules, with rough surface; only the region around the aperture is smooth and covered mainly of organic cement (Fig. 47 C, D, G). Aperture large, circular or oval, invaginated and sub-terminal (Fig. 47 A-D).

Notes: Besides the nominal species two infrasubspecific taxa *Centropyxis aculeata* var. *oblonga* Deflandre, 1929 and *Centropyxis aculeata* var. *grandis* Deflandre, 1929 have also been recorded.

Ecology: Common in *Sphagnum* and standing freshwater bodies, among submerged aquatic vegetation.

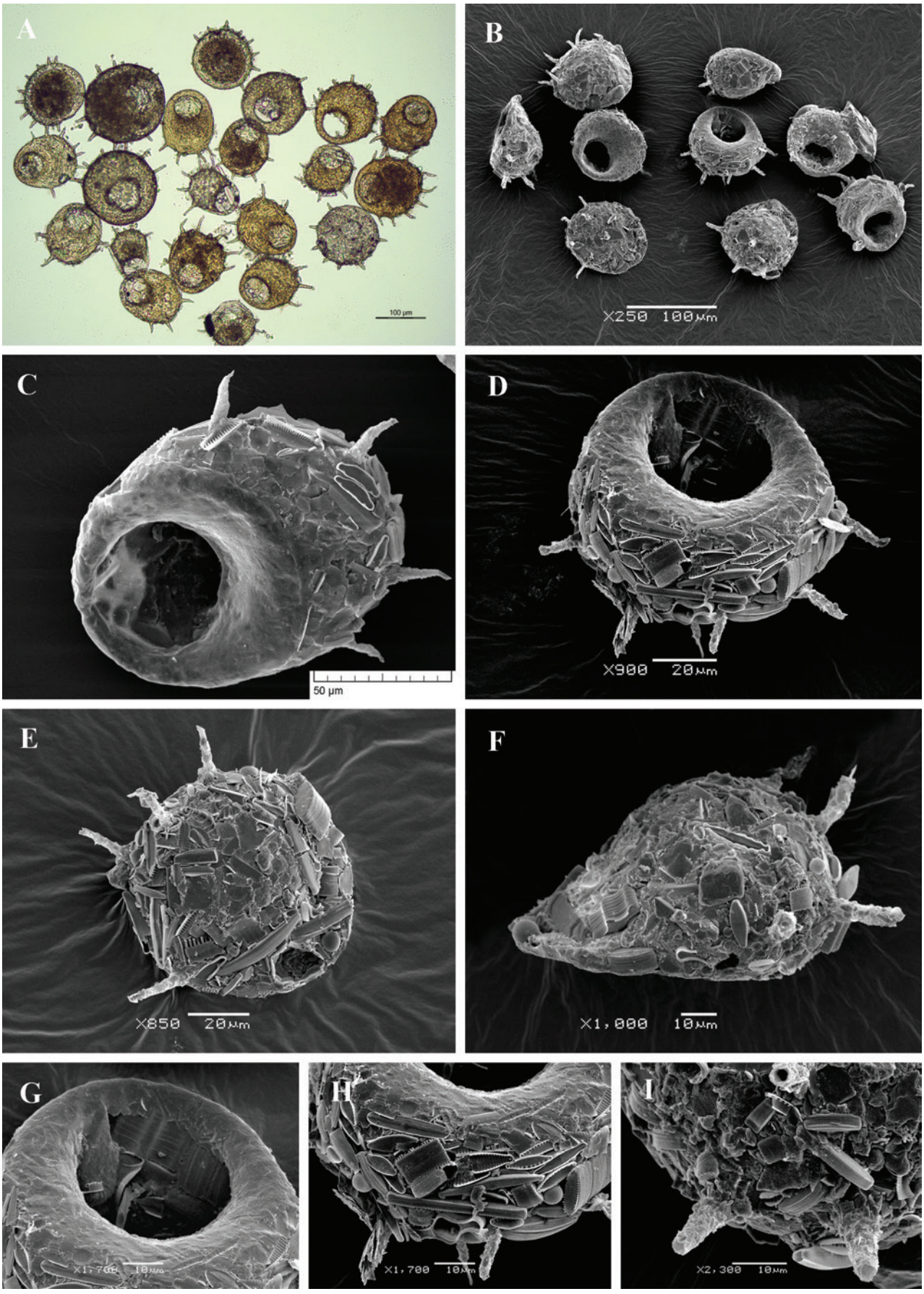
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, 2004, 2005, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 37. *Centropyxis aculeata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	128.1	126.7	14.22	2.60	11.10	98	165	30
Breadth	94.0	96.1	19.41	3.54	20.64	58	133	30
Diameter of aperture	45.8	46.3	7.08	1.29	15.47	33	58	30
Depth	60.9	61.6	7.40	2.05	12.15	48	78	13
Spines	24.0	23.1	6.88	1.26	28.72	10	35	30
Breadth/Length ratio	0.73	0.73	0.1	0.02	15.13	0.50	0.99	30
Aperture/Breadth ratio	0.50	0.48	0.08	0.02	16.98	0.3	0.7	30

Fig. 47. Light (A) and scanning electron (B-I) micrographs of *Centropyxis aculeata*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Apertural view of two specimens to illustrate general shape and shell structure. (E) Aboral view. (F) Lateral view. (G) Close up view of aperture to illustrate its circular shape and smooth surface around the aperture. (H, I) Details of posterior end of the shell to illustrate its rough surface, covered with sand grains and diatom frustules.


A
100 µm
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X250 100µm
C
50 µm
D
X900 20µm
E
X850 20µm
F
X1,000 10µm
G
H
X1,700 10µm
I
X2,300 10µm

Centropyxis aerophila Deflandre, 1929

Original description: Deflandre 1929, *Archiv für Protistenkunde*, 67, p. 330, fig. 11 à 21.

Synonyms: *Difflugia constricta* Ehrenberg, 1838; *Arcella arctiscon* Ehrenberg, 1854.

Description: Shell yellowish-brownish, ovoid, considerably flattened in the apertural region (Fig. 48 A-E); main body spherical in lateral view and tappers towards the aperture to form an apertural rim (Fig. 48 F); shell with rough surface, composed of small to medium extraneous particles; only the region around the aperture is smooth and covered mainly of organic cement (Fig. 48 G, H). Aperture large, oval, invaginated and sub-terminal (Fig. 48 D, G, H).

Notes: Besides the nominal species, the infrasubspecific taxon *Centropyxis aerophila* var. *sphagnicola* Deflandre, 1929 has also been recorded (Rila Mts., Vitosha Mts.).

Ecology: Ubiquitous.

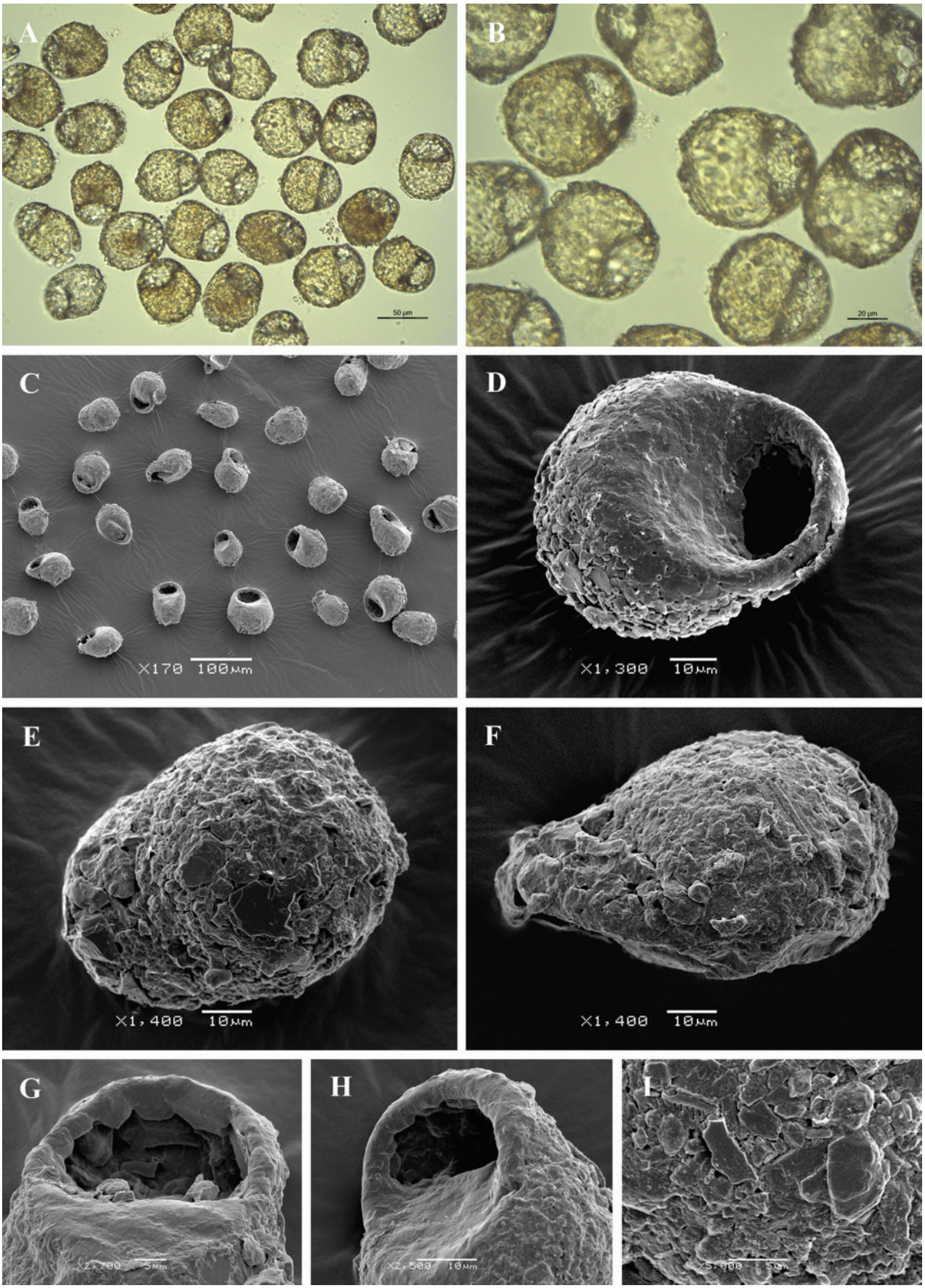
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, 2004, 2005, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 38. *Centropyxis aerophila*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	70.0	69.0	6.76	1.21	9.66	59	86	31
Breadth	57.6	56.2	5.85	1.05	10.15	49	72	31
Large axis of aperture	30.3	30.8	4.73	0.85	15.62	22	39	31
Depth	42.8	40.7	5.92	1.21	13.83	37	59	24
Breadth/Length ratio	0.82	0.82	0.05	0.01	6.44	0.7	0.9	31
Aperture/Breadth ratio	0.53	0.53	0.07	0.01	13.3	0.4	0.7	31

Fig. 48. Light (A, B) and scanning electron (C-I) micrographs of *Centropyxis aerophila*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D) Apertural view to illustrate general shape and shell structure. (E) Dorsal view. (F) Lateral view. (G, H) Close up view of aperture to illustrate its oval shape and smooth surface around the aperture. (I) Detail of dorsal side to illustrate its rough surface, covered with small to medium sand grains.


A
50 µm
B
20 µm
C
X170 100µm
D
X1,300 10µm
E
X1,400 10µm
F
X1,400 10µm
G
H
I

Centropyxis cassis (Wallich, 1864) Deflandre, 1929

Original description: Wallich 1864, *Annals and Magazine of Natural History***,** 13, p. 240-241, Pl. XV, Fig. 5b & 5c, Pl. XVI, Fig. 6; **Last revision:** Deflandre 1929, *Archiv für Protistenkunde*, 67, p. 335, fig. 35 à 40 (p. 336).

Synonyms: *Difflugia cassis* Wallich, 1864.

Description: Shell yellowish-brownish, roughly ovoid, with almost parallel sides and rounded edges (Fig. 49 A-D); main body spherical in lateral view and tappers gradually towards the aperture, without forming clear distinction between body and apertural rim (Fig. 49 F, F); with rough surface and composed of small to medium extraneous particles; only the region around the aperture is smooth and covered mainly of flattish particles embedded in a thick layer of organic cement (Fig. 49 B-I). Aperture large, oval, invaginated and sub-terminal (Fig. 49 B, C, G).

Ecology: Ubiquitous.

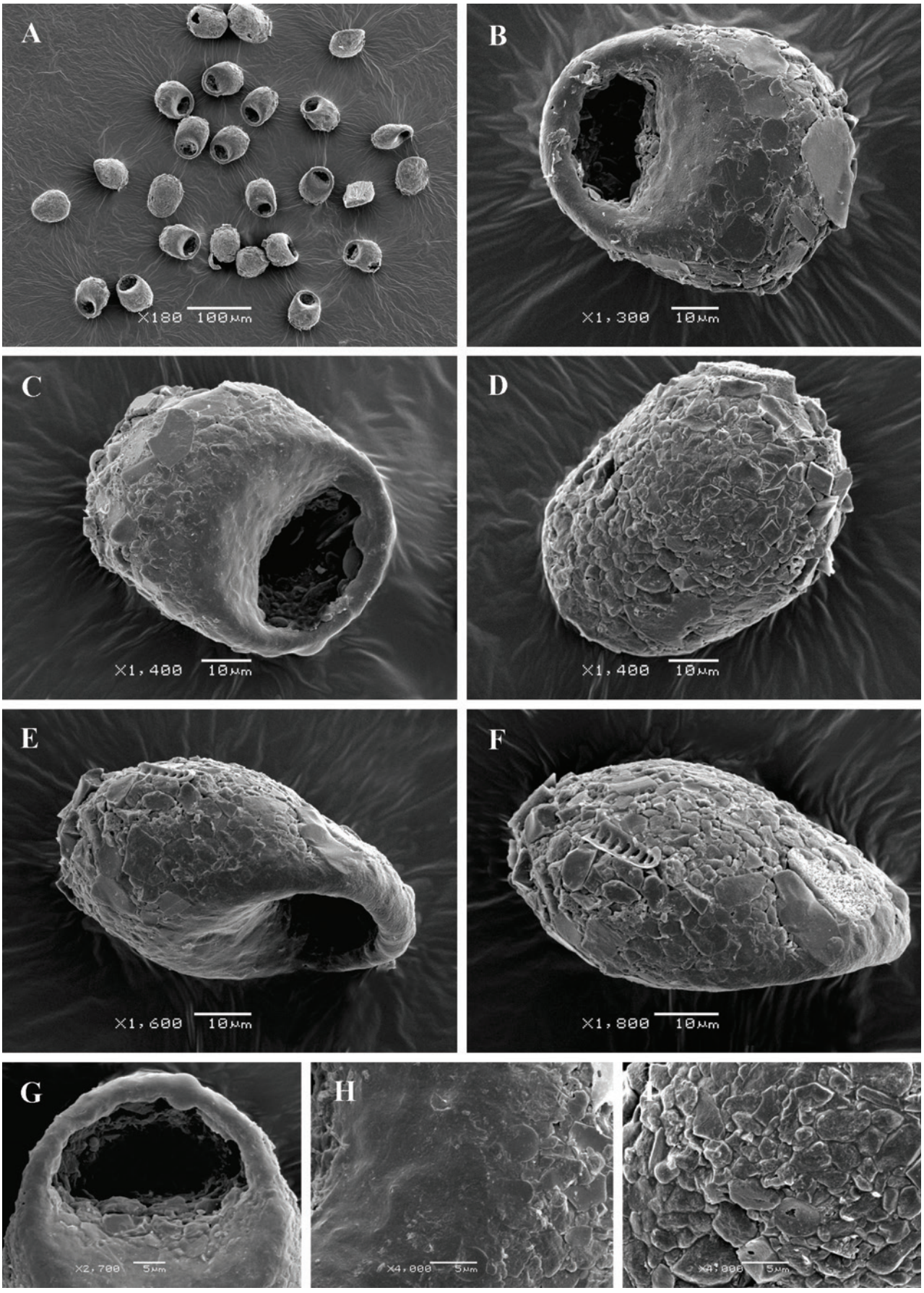
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov 2004, 2005, Todorov and Golemansky 2000, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 39. *Centropyxis cassis*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	68.0	66.9	5.90	1.08	8.67	60	82	30
Breadth	54.6	52.5	5.80	1.06	10.62	47	68	30
Large axis of aperture	30.4	29.4	4.50	0.82	14.79	24	41	30
Depth	42.2	39.7	7.72	2.06	18.28	32	58	14
Breadth/Length ratio	0.80	0.81	0.04	0.008	5.28	0.7	0.9	30
Aperture/Breadth ratio	0.56	0.55	0.04	0.008	7.87	0.5	0.7	30

Fig. 49. Scanning electron micrographs of *Centropyxis cassis*. (A) View of many specimens showing variability in shape and size of the shell. (B, C) Apertural view of two specimens to illustrate general shape and shell structure. (D) Dorsal view. (E) Latero-apertural view. (F) Latero-dorsal view. (G) Close up view of aperture to illustrate its oval shape and smooth surface around the aperture. (H) Detail of apertural side to illustrate its smooth surface. (I) Detail of dorsal side to illustrate its rough surface, covered with small to medium sand grains.


A
X180 100µm
B
X1,300 10µm
C
X1,400 10µm
D
X1,400 10µm
E
X1,600 10µm
F
X1,800 10µm
G
X2,700 5µm
H
X4,000 5µm
I
X4,000 5µm

Centropyxis constricta (Ehrenberg, 1841) Penard, 1902

Original description: Ehrenberg 1841, *Abhandlungen der Königliche Akademie der Wissenschaften zu Berlin*, p. 410, Taf. IV, I-New York, Fig. 35, V-Kotzebue's Sund, Fig. 1; **Last revision:** Penard 1902, Faune Rhizopodique du Bassin du Léman, pp. 298-301, fig. 1, 2.

Synonyms: *Arcella constricta* Ehrenberg, 1841; *Difflugia constricta* Leidy, 1879 (in part).

Description: Shell yellowish-brownish, elongated-ovoid, rounded posteriorly and tapered gradually towards the aperture (Fig. 50 A-D); main body spherical in lateral view, flattened slyghtly towards the aperture, without forming clear distinction between body and apertural rim (Fig. 50 C-F); with rough surface and composed of small to medium extraneous particles; usually with a few large quartz particles on the posterior apex; region around the aperture smooth and covered mainly of flattish particles embedded in a thick layer of organic cement (Fig. 50 C-I). Aperture large, oval, invaginated and sub-terminal (Fig. 50 C, D, G).

Ecology: Frequent in mosses, forest litter and soils, rare in *Sphagnum*.

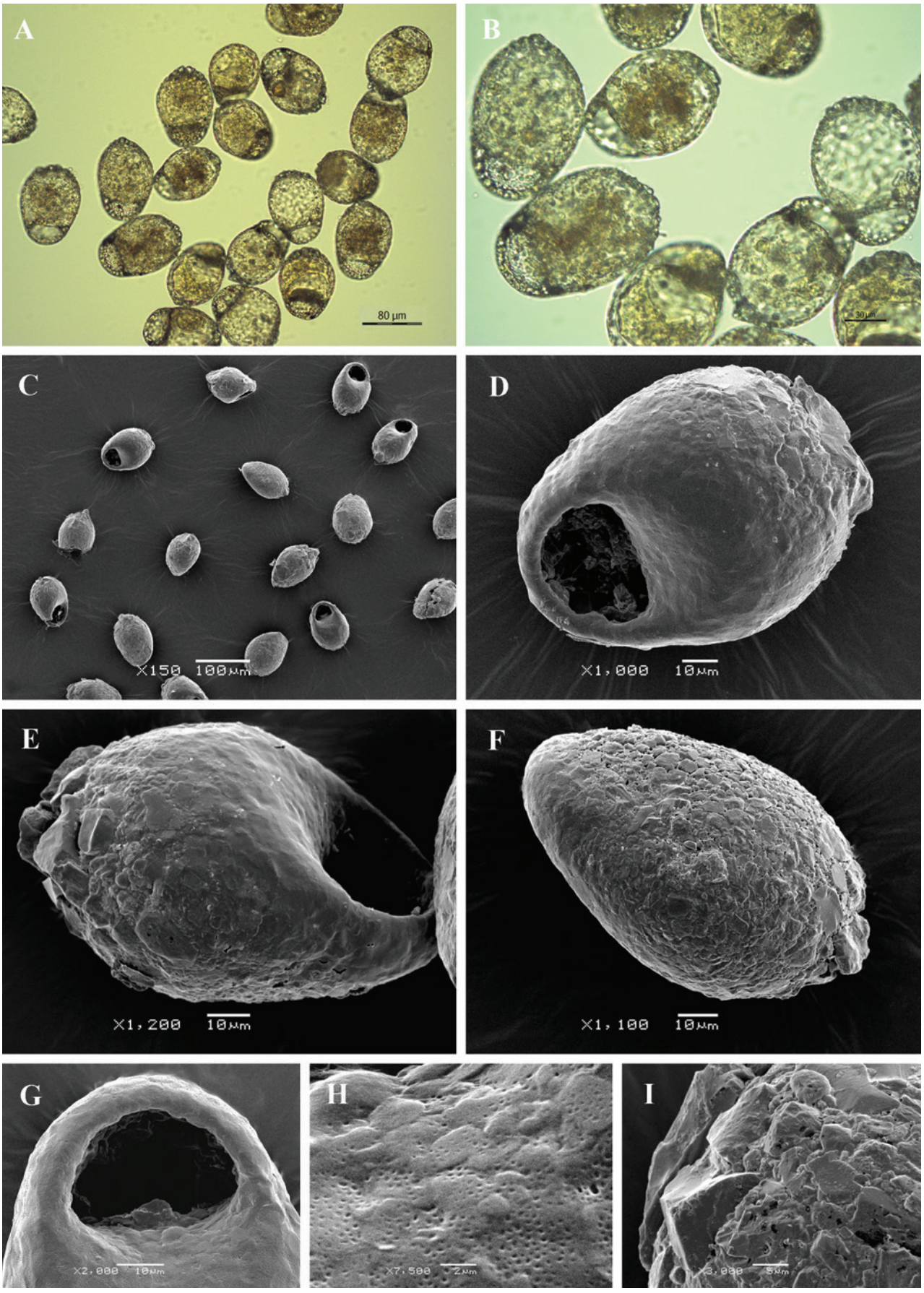
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1990, Bankov et al. 2018).

Table 40. *Centropyxis constricta*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	107.0	106.0	9.94	1.68	9.30	87	126	35
Breadth	74.3	74.8	4.63	0.83	6.23	65	88	31
Large axis of aperture	38.7	39.6	4.40	0.82	11.37	30	50	29
Depth	70.5	71.0	7.85	1.96	11.14	46	80	16
Breadth/Length ratio	0.69	0.70	0.05	0.009	7.38	0.6	0.8	31
Aperture/Breadth ratio	0.52	0.53	0.06	0.01	11.24	0.4	0.7	29

Fig. 50. Light (A, B) and scanning electron (C-I) micrographs of *Centropyxis constricta*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D) Apertural view to illustrate general shape and shell structure. (E) Latero-apertural view. (F) Latero-dorsal view. (G) Close up view of aperture to show its oval shape and smooth surface around the aperture. (H) Detail of apertural side showing its smooth surface. (I) Detail of dorsal side to illustrate its rough surface, covered with small to medium sand grains.


A
80 µm
B
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X150 100µm
D
X1,000 10µm
E
X1,200 10µm
F
X1,100 10µm
G
X2,000 10µm
H
X7,500 2µm
I
X3,000 5µm

Centropyxis discoides (Penard, 1890) Deflandre, 1929

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 150, Pl. V, fig. 38 à 41; **Last revision:** Deflandre 1929, *Archiv für Protistenkunde*, 67, p. 351, fig. 104 à 107.

Synonyms: *Centropyxis aculeata* var. *discoides* Penard, 1890

Description: Shell yellow or brown, circular and usually with numerous spines on the lateral margins (Fig. 51 A-F); in lateral view considerably compressed, discoid (Fig. 51 B, F); with smooth apertural surface and rough dorsal surface; composed of sand grains mixed with diatom frustules; region around the aperture covered mainly of flattish particles embedded in a thick layer of organic cement (Fig. 51 D-I). Aperture large, invaginated, circular, central or subcentral (Fig. 51 A-D).

Ecology: Common in *Sphagnum* and standing freshwater bodies, among submerged aquatic vegetation.

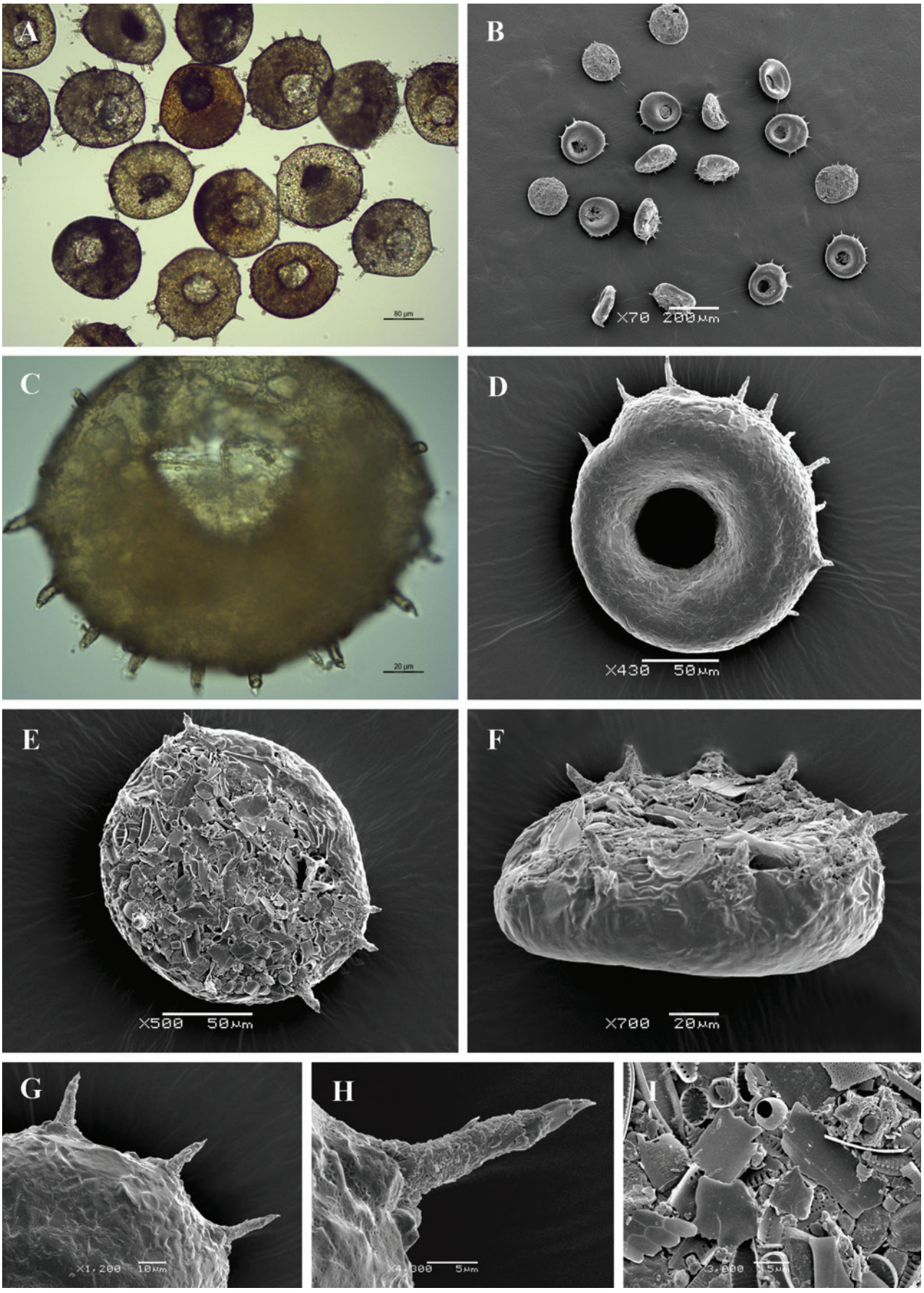
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1990, Bankov et al. 2018).

Table 41. *Centropyxis discoides*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	168.5	164.7	16.68	2.95	9.90	141	207	32
Diameter of aperture	54.1	51.6	10.28	1.82	19.02	36	76	32
Depth	67.2	66.4	11.19	2.50	16.65	51	95	20
Spines	17.3	17.1	5.71	1.04	32.94	8	36	30
Aperture/Diameter ratio	0.31	0.31	0.04	0.007	13.15	0.3	0.4	32
Depth/Diameter ratio	0.39	0.39	0.07	0.02	17.19	0.2	0.5	20

Fig. 51. Light (A, C) and scanning electron (B, D-I) micrographs of *Centropyxis discoides*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Apertural view of two specimens to illustrate general shape and shell structure. (E) Dorsal view. (F) Lateral view. (G) Close up view showing smooth apertural surface and disposition of spines on the lateral margin. (H) Close up view of a single spine to show its structure. (I) Detail of dorsal side of the shell to illustrate its rough surface, covered with sand grains and diatom frustules.


A
80 µm
B
X70 200µm
C
20 µm
D
X430 50µm
E
X500 50µm
F
X700 20µm
G
X1,200 10µm
H
X4,800 5µm
I
X3,000 5µm

Centropyxis ecornis (Ehrenberg, 1841) Leidy, 1879

Original description: Ehrenberg 1841, *Abhandlungen der Königliche Akademie der Wissenschaften zu Berlin*, p. 410, Taf. III, I-Real del monte, Fig. 46; **Last revision:** Leidy 1879, *Report of the United States Geological Survey of the Territories*, 12, p. 181, Pl. XXX, figs. 20-34, Pl. XXXI, figs. 33, 34, Pl. XXXII, figs. 35, 36.

Synonyms: *Arcella ecorn*is Ehrenberg, 1841.

Description: Shell yellow or brown, circular (Fig. 52 A-E); in lateral view compressed; aboral region sub-spherical and tapers slightly to the apertural rim (Fig. 52 F); with smooth apertural surface and rough dorsal surface; composed of sand grains mixed with diatom frustules; region around the aperture covered mainly of flattish particles embedded in a thick layer of organic cement (Fig. 52 G, H). Aperture large, invaginated, oval or circular, sometimes with irregular outline, sub-terminal (Fig. 52 A-D, G).

Ecology: Frequent in *Sphagnum* and standing freshwater bodies.

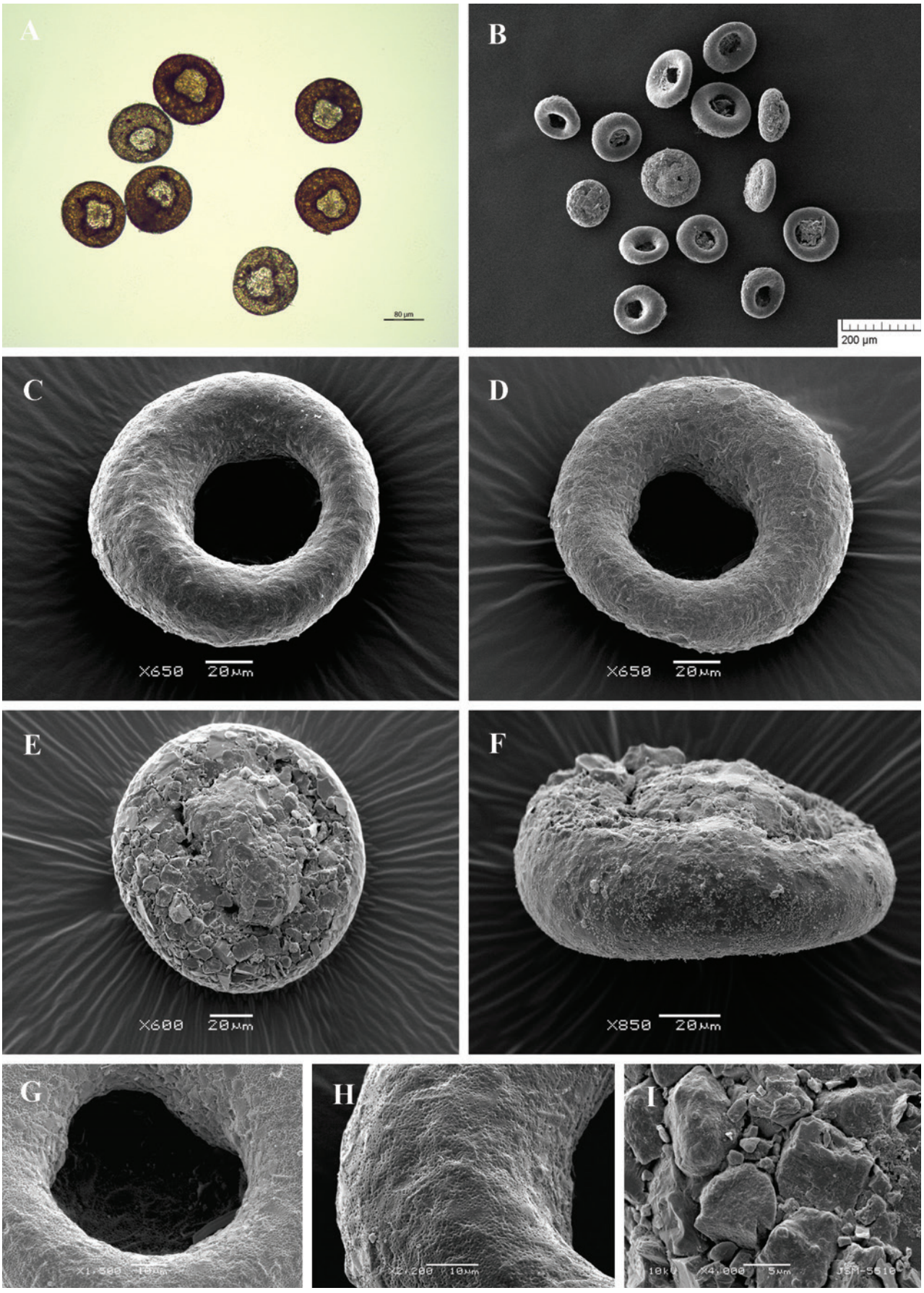
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 42. *Centropyxis ecornis*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	137.7	138.3	9.96	1.73	7.23	122	154	33
Diameter of aperture	63.7	63.2	7.69	1.40	12.07	50	83	30
Depth	73.7	76.4	7.67	2.31	10.40	55	81	11
Aperture/Diameter ratio	0.46	0.46	0.04	0.008	9.48	0.4	0.6	30
Depth/Diameter ratio	0.52	0.53	0.06	0.02	10.33	0.4	0.6	11

Fig. 52. Light (A) and scanning electron (B-I) micrographs of *Centropyxis ecornis*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C, D) Apertural view of two specimens showing general shape and shell structure. (E) Dorsal view. (F) Lateral view. (G) Close up view of aperture to show its irregular outline. (H) Detail of smooth apertural surface. (I) Detail of dorsal side of the shell to illustrate its rough surface, covered with sand grains.


A
80 µm
B
200 µm
C
X650 20µm
D
X650 20µm
E
X600 20µm
F
X850 20µm
G
H
I

Centropyxis elongata (Penard, 1890) Thomas, 1959

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 149, Pl. V, fig. 17-20; **Last revision:** Thomas 1959, *Procès-Verbaux de la Société Linneénne de Bordeaux*, 97, p. 35, Pl. II, fig. 22-26, 28-31, 34.

Synonyms: *Difflugia constricta* var. *elongata* Penard, 1890.

Description: Shell yellow or brown, elongate (Fig. 53 A-E); in lateral view rounded, sub-spherical in the aboral region and considerably compressed in the apertural region (Fig. 53 F); with smooth apertural surface and rough dorsal surface; composed of flattish pieces of quartz occasionally mixed with diatom frustules; region around the aperture covered mainly of flattish particles embedded in a thick layer of organic cement (Fig. 53 C-I). Aperture large, invaginated, oval or circular, sub-terminal (Fig. 53 B-D, G).

Notes: *C. elongata* is similar to *C. platystoma* but differs from it by the more elongated and flattened shell as well as by the absence of a sharp border between the main body and the visor when viewed laterally.

Ecology: Frequent in mosses, forest litter and soils, rare in *Sphagnum*.

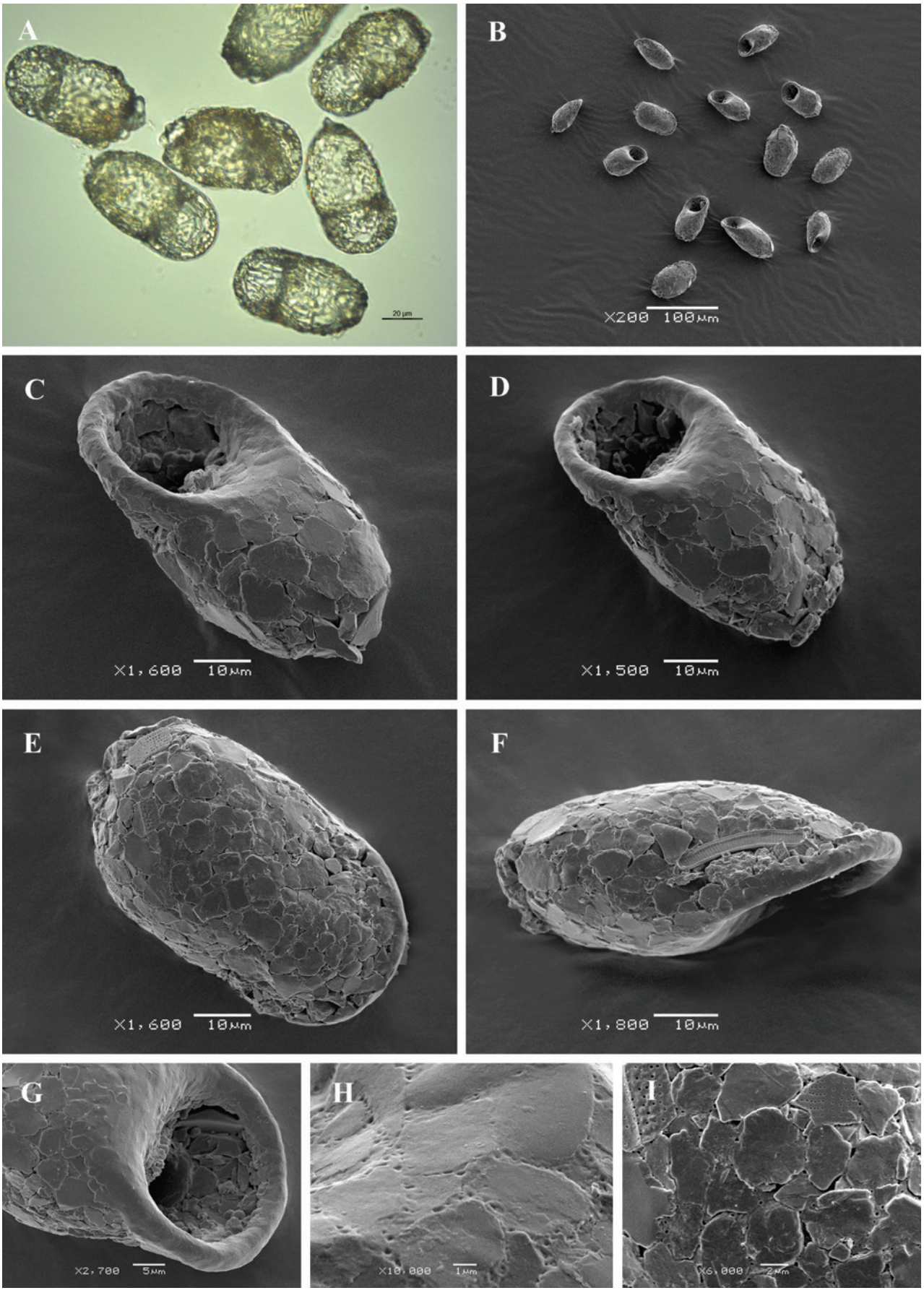
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Bankov et al. 2018); **Vitosha Mts.** (Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995).

Table 43. *Centropyxis elongata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	68.2	69.2	6.59	0.95	9.67	64	81	48
Breadth	38.7	40.3	4.94	0.71	12.76	22	46	48
Diameter of aperture	23.1	22.8	3.12	0.45	13.53	16	30	48
Depth	33.4	34.1	3.98	0.64	11.90	27	41	39
Breadth/Length ratio	0.57	0.57	0.06	0.009	10.71	0.3	0.7	48
Aperture/Breadth ratio	0.60	0.60	0.08	0.01	13.18	0.5	0.96	48

Fig. 53. Light (A) and scanning electron (B-I) micrographs of *Centropyxis elongata*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C, D) Apertural view of two specimens to show general shape and shell structure. (E) Dorsal view. (F) Lateral view. (G) Close up view of aperture. (H) Detail of smooth apertural surface. (I) Detail of aboral side of the shell to illustrate its rough surface, covered with flattish particles.


A
20 µm
B
X200 100µm
C
X1,600 10µm
D
X1,500 10µm
E
X1,600 10µm
F
X1,800 10µm
G
X2,700 5µm
H
X10,000 1µm
I
X6,000 2µm

Centropyxis gibba Deflandre, 1929

Original description: Deflandre 1929, *Archiv für Protistenkunde*, 67, p. 357, fig. 118 à 120.

Description: Shell colorless or yellowish, ovoid or circular, usually with about four to eight lateral spines (Fig. 54 A-F); main body spherical in lateral view and considerably compressed towards the aperture (Fig. 54 F); with rough surface, composed mainly of diatom frustules; region around the aperture smooth and covered mainly of organic cement (Fig. 54 C-I). Aperture large, circular or oval, invaginated and sub-terminal (Fig. 54 C-D, G).

Ecology: In *Sphagnum* and standing freshwater bodies, among submerged aquatic vegetation, very rare.

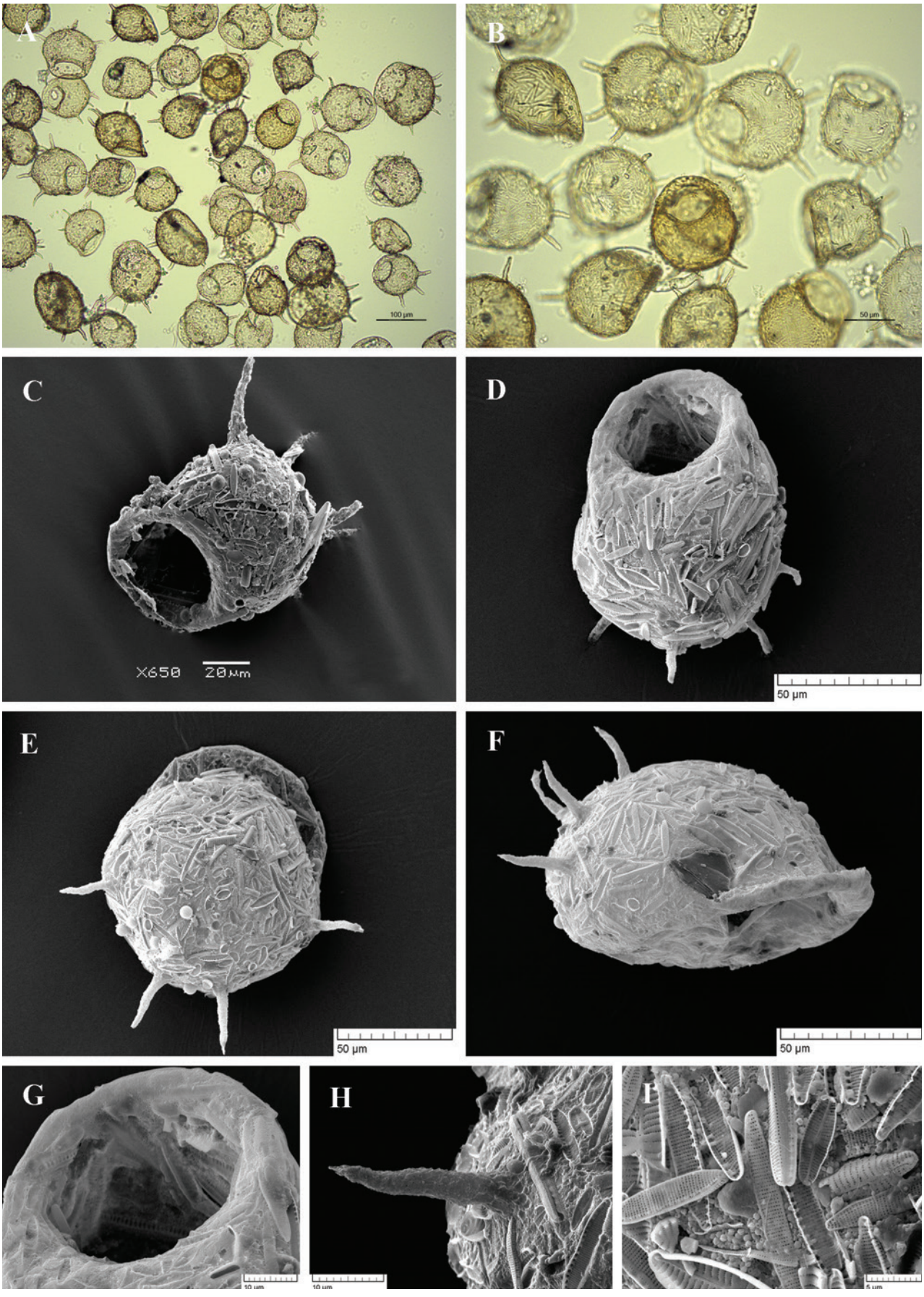
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Golemansky et al. 2006); **Rila Mts.** (Todorov 2005).

Table 44. *Centropyxis gibba*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	127.0	126.2	13.22	2.34	10.41	105	152	32
Breadth	92.8	90.0	9.83	1.77	10.60	74	116	31
Diameter of aperture	48.9	48.3	5.93	1.05	12.11	37	63	32
Depth	77.6	80.6	9.55	2.88	12.31	62	93	11
Spines	26.4	26.8	5.66	1.03	21.46	15	38	30
Breadth/Length ratio	0.74	0.74	0.06	0.01	8.62	0.60	0.95	30
Aperture/Breadth ratio	0.53	0.52	0.05	0.009	9.05	0.4	0.6	30

Fig. 54. Light (A, B) and scanning electron (C-I) micrographs of *Centropyxis gibba*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Apertural view of two specimens to illustrate general shape and shell structure. (E) Dorsal view. (F) Lateral view. (G) Close up view of aperture to illustrate its circular shape and smooth surface around the aperture. (H) Close up view of a single spine to show its structure. (I) Detail of dorsal side of the shell to illustrate its rough surface, covered mainly with diatom frustules.


A
100 µm
B
50 µm
C
X650 20µm
D
50 µm
E
50 µm
F
50 µm
G
H
I

Centropyxis laevigata Penard, 1890

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 151, Pl. V, fig. 42 à 44; 49 à 55.

Description: Shell colorless or yellowish, roughly circular (Fig. 55 A-E); main body spherical in lateral view and considerably compressed towards the aperture (Fig. 55 F); with rough surface and composed mainly of sand grains; only the region around the aperture is smooth and covered of organic cement (Fig. 55 C-I). Aperture large, circular or oval, invaginated, central or sub-central (Fig. 55 C-D, G).

Ecology: Frequent in aerophilic mosses and soils, very rare in *Sphagnum*.

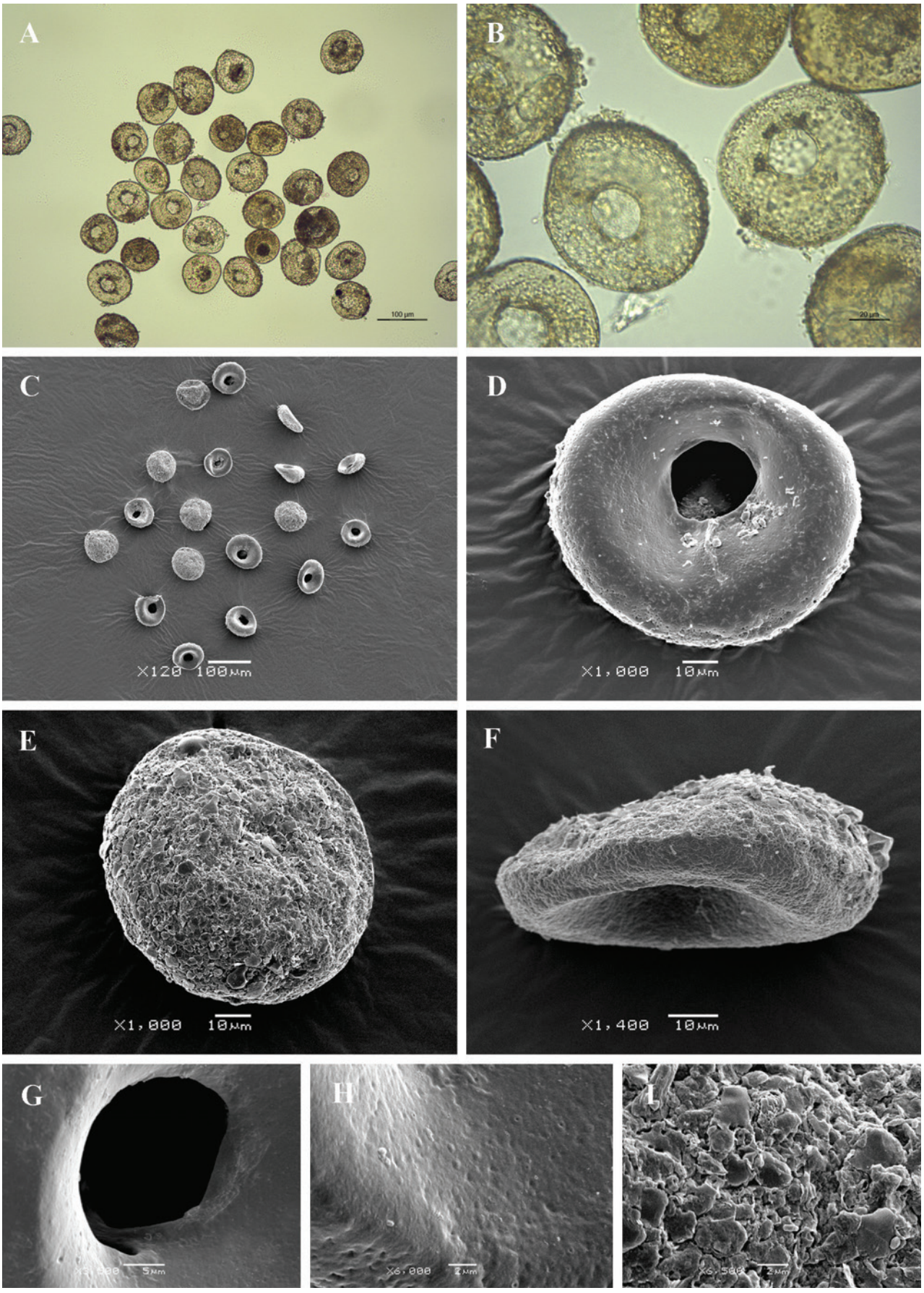
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Golemansky et al. 2006).

Table 45. *Centropyxis laevigata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	80.9	80.5	6.69	1.05	8.28	71	99	41
Diameter of aperture	25.5	25.0	3.99	0.72	15.63	18	34	31
Depth	36.5	36.2	3.49	1.05	9.57	32	43	11
Aperture/Diameter ratio	0.31	0.31	0.04	0.007	12.95	0.2	0.5	31
Depth/Diameter ratio	0.47	0.45	0.06	0.02	13.03	0.4	0.6	11

Fig. 55. Light (A, B) and scanning electron (C-I) micrographs of *Centropyxis laevigata*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D) Apertural view to show general shape and shell structure. (E) Dorsal view. (F) Lateral view. (G) Close up view of aperture showing its circular shape and smooth surface around the aperture. (H) Detail of smooth apertural surface. (I) Detail of dorsal side of the shell to illustrate its rough surface, covered with sand grains.


A
100 µm
B
20 µm
C
×120 100µm
D
×1,000 10µm
E
×1,000 10µm
F
×1,400 10µm
G
5µm
H
×6,000 2µm
I
×6,500 2µm

Centropyxis orbicularis Deflandre, 1929

Original description: Deflandre 1929, *Archiv für Protistenkunde*, 67, p. 334, fig. 31 à 34.

Description: Shell yellow or brown, circular (Fig. 56 A-E); in lateral view almost uncompressed, spherical (Fig. 56 F); with smooth surface and composed mainly of flattish particles embedded in thick layer of organic cement, most abundant in the region around the aperture (Fig. 56 C-I). Aperture elliptical or oval, invaginated, sub-terminal (Fig. 56 C-D, G).

Ecology: Frequent in forest mosses and soils, very rare in *Sphagnum*.

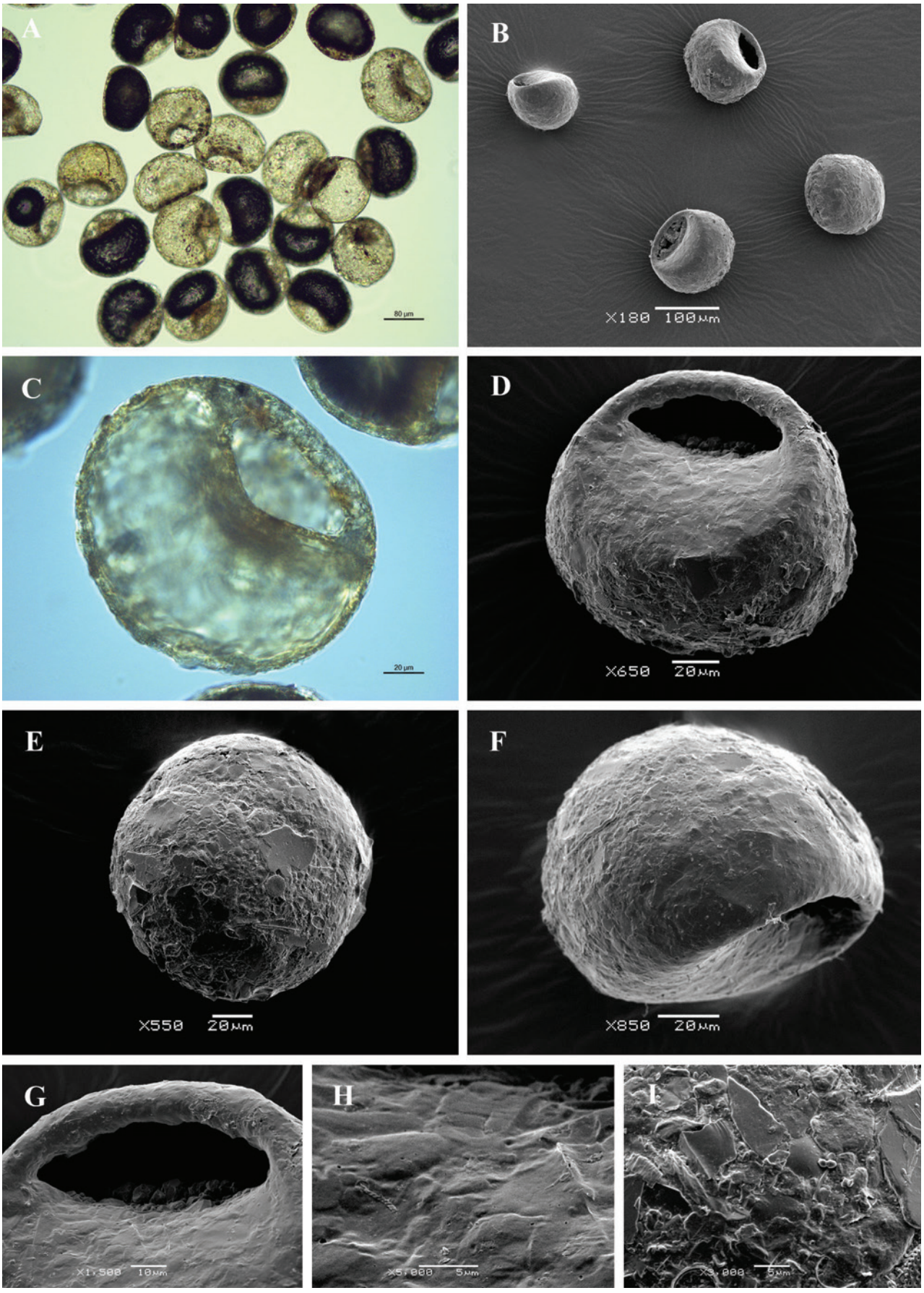
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rila Mts.** (Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018).

Table 46. *Centropyxis orbicularis*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	138.3	139.8	10.09	1.84	7.30	115	155	30
Diameter of aperture	71.9	71.0	7.57	1.38	10.51	55	83	30
Depth	89.0	90.6	5.47	1.65	6.14	74	94	11
Aperture/Diameter ratio	0.52	0.52	0.05	0.01	10.50	0.4	0.6	30
Depth/Diameter ratio	0.67	0.65	0.05	0.02	8.15	0.6	0.8	11

Fig. 56. Light (A, C) and scanning electron (B, D-I) micrographs of *Centropyxis orbicularis*. (A-B) View of several specimens to illustrate variability in shape and size of the shell. (C, D) Apertural view showing general shape and shell structure. (E) Dorsal view. (F) Lateral view. (G) Close up view of aperture to illustrate its oval or elliptical shape and smooth surface around the aperture. (H) Detail of smooth apertural surface. (I) Detail of dorsal side of the shell to illustrate its rough surface, covered mainly with flattish particles.


A
80 µm
B
X180 100µm
C
20 µm
D
X650 20µm
E
X550 20µm
F
X850 20µm
G
X1,500 10µm
H
X5,000 5µm
I
X5,000 5µm

Centropyxis plagiostoma Bonnet and Thomas, 1955

Original description: Bonnet et Thomas 1955, *Bulletin de la Société d'Histoire Naturelle de Toulouse*, 90, p. 415, fig. 18, 19.

Description: Shell yellow or brown, circular (Fig. 57 A-F); in lateral view compressed and hemispherical (Fig. 57 G); with smooth apertural surface and rough dorsal surface; composed of small to medium pieces of quartz; region around the aperture covered mainly of flattish particles embedded in a thick layer of organic cement (Fig. 57 G, H). Aperture small, slightly invaginated, denticulated and surrounded by several large pieces of quartz, sub-terminal (Fig. 57 D-E, H).

Ecology: Frequent in forest mosses, litter and soils, very rare in *Sphagnum*.

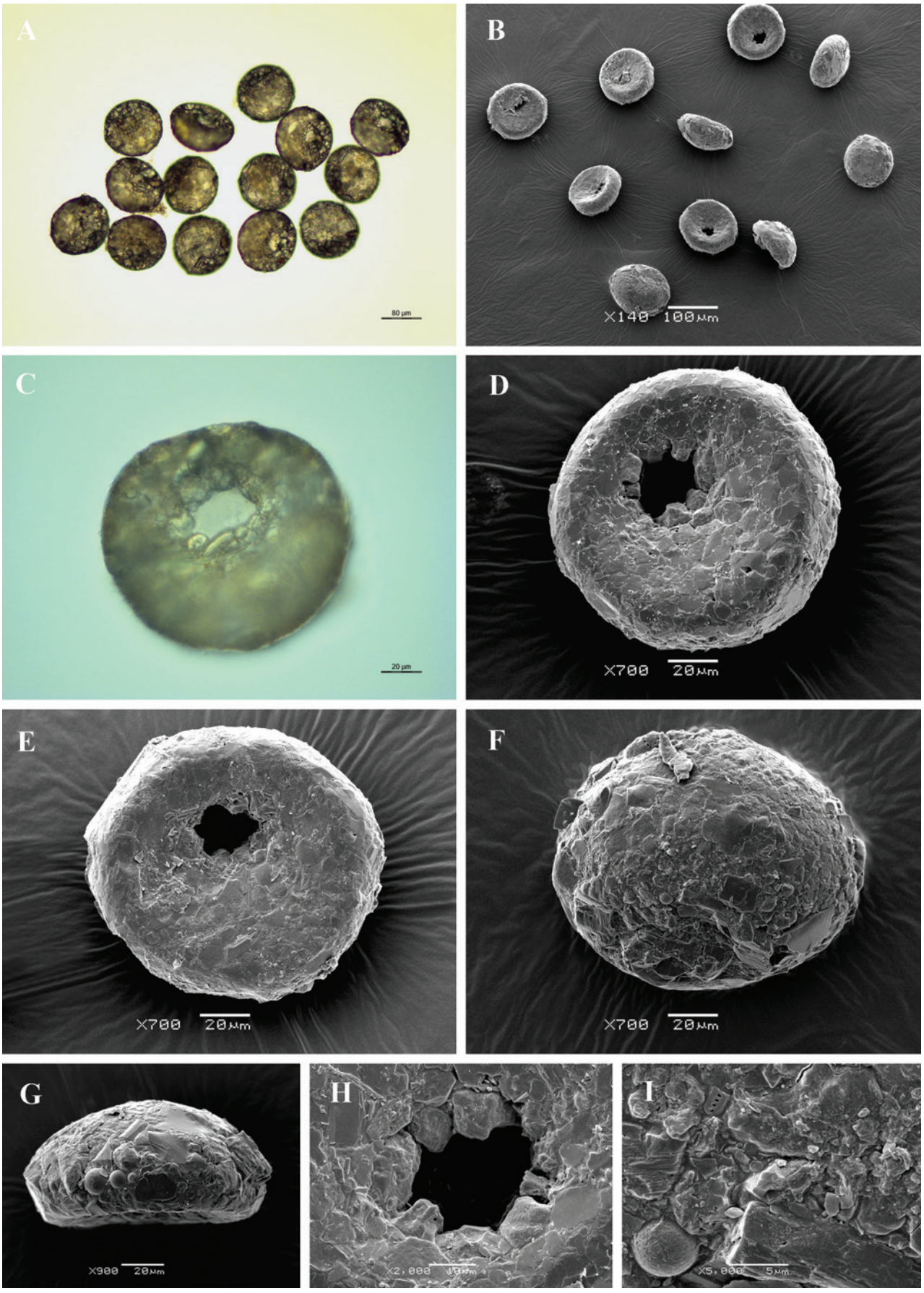
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993).

Table 47. *Centropyxis plagiostoma*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	119.8	120.0	5.20	0.93	4.34	111	131	31
Diameter of aperture	29.2	29.2	3.99	0.83	13.68	22	35	23
Depth	63.4	63.3	3.71	1.12	5.85	58	69	11
Aperture/Diameter ratio	0.24	0.24	0.03	0.007	13.04	0.2	0.3	23
Depth/Diameter ratio	0.52	0.52	0.04	0.01	7.08	0.5	0.6	11

Fig. 57. Light (A, C) and scanning electron (B, D-I) micrographs of *Centropyxis plagiostoma*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C-E) Apertural view of three specimens showing general shape and shell structure. (F) Dorsal view. (G) Lateral view. (H) Close up view of aperture to illustrate its denticulate shape. (I) Detail of dorsal side of the shell to illustrate its rough surface, covered with pieces of quartz.


A
80 µm
B
X140 100µm
C
20 µm
D
X700 20µm
E
X700 20µm
F
X700 20µm
G
X900 20µm
H
X2,000
I
X5,000 5µm

Centropyxis platystoma (Penard, 1890) Deflandre, 1929

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 143, Pl. IV, fig. 35 à 37; **Last revision:** Deflandre 1929, *Archiv für Protistenkunde*, 67, p. 338, fig. 43 à 57.

Synonyms: *Difflugia platystoma* Penard, 1890; *Difflugia constricta* p. p. Leidy, 1879, PL. XVIII, figs. 20-21; *Difflugia constricta* p. p. Penard, 1902, p. 299, figs. 8, 11, 12.

Description: Shell yellow or brown, elongate (Fig. 58 A-E); rounded in lateral view, sub-spherical in aboral region and considerably compressed in apertural region (Fig. 58 F); with smooth apertural surface and rough dorsal surface; composed of small to medium pieces of quartz occasionally mixed with diatom frustules; region around the aperture covered mainly of flattish particles embedded in a thick layer of organic cement (Fig. 58 E, H). Aperture large, invaginated, oval or circular, sub-terminal (Fig. 58 A-D, E, H).

Notes: *C. platystoma* is similar to *C. elongata* but differs from it by the rounded and subspherical aboral region, highly compressed visor and sharp border between the main body and the visor when viewed laterally.

Ecology: Frequent in *Sphagnum* and standing freshwater bodies, among submerged aquatic vegetation.

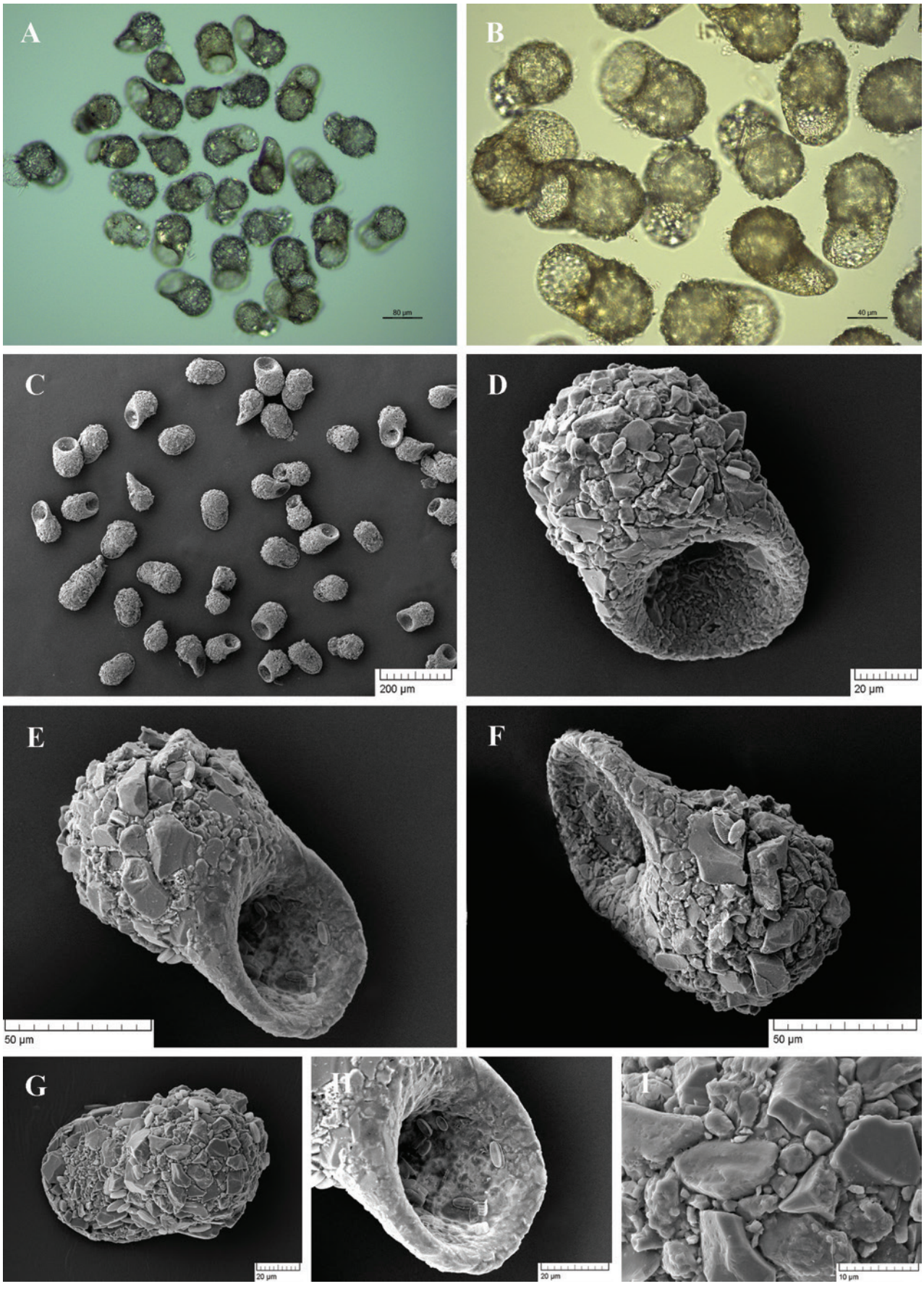
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 48. *Centropyxis platystoma*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	115.0	114.6	6.90	1.09	6.00	101	132	40
Breadth	78.6	80.0	6.10	1.10	7.76	64	88	31
Diameter of aperture	42.6	42.4	3.80	0.69	8.93	35	51	30
Depth	72.7	73.5	3.07	0.93	4.23	68	77	11
Breadth/Length ratio	0.69	0.69	0.05	0.008	6.70	0.6	0.8	31
Aperture/Breadth ratio	0.37	0.37	0.03	0.005	7.90	0.3	0.5	30

Fig. 58. Light (A, B) and scanning electron (C-I) micrographs of *Centropyxis platystoma*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D, E) Apertural view of two specimens showing general shape and shell structure. (F) Lateral view. (G) Dorsal view. (H) Close up view of aperture. (I) Detail of dorsal side of the shell to illustrate its rough surface, covered with medium to large pieces of quartz.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80 µm
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200 µm
D
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E
50 µm
F
50 µm
G
20 µm
H
20 µm
I
10 µm

Centropyxis spinosa (Cash, 1905) Deflandre, 1929

Original description: Cash and Hopkinson 1905, *The British freshwater Rhizopoda and Heliozoa,* Vol. I, p. 135, fig. 26, Pl. XVI, fig. 15; **Last revision:** Deflandre 1929, *Archiv für Protistenkunde*, 67, p. 353, fig. 108 à 111.

Synonyms: *Centropyxis aculeata* var. *spinosa* Cash, 1905.

Description: Shell yellowish-brownish, ovoid or circular, usually with four to ten lateral spines (Fig. 59 A-E).); in lateral view considerably compressed, discoid (Fig. 59 E, F); with comparatively smooth surface, composed of small sand grains, flattisg pieces of quartz and diatom frustules; region around the aperture smooth and covered mainly of organic cement (Fig. 59 B-F). Aperture large, circular or oval, invaginated and sub-terminal (Fig. 59 C, D, G).

Ecology: In *Sphagnum* and standing freshwater bodies, among submerged aquatic vegetation, rare.

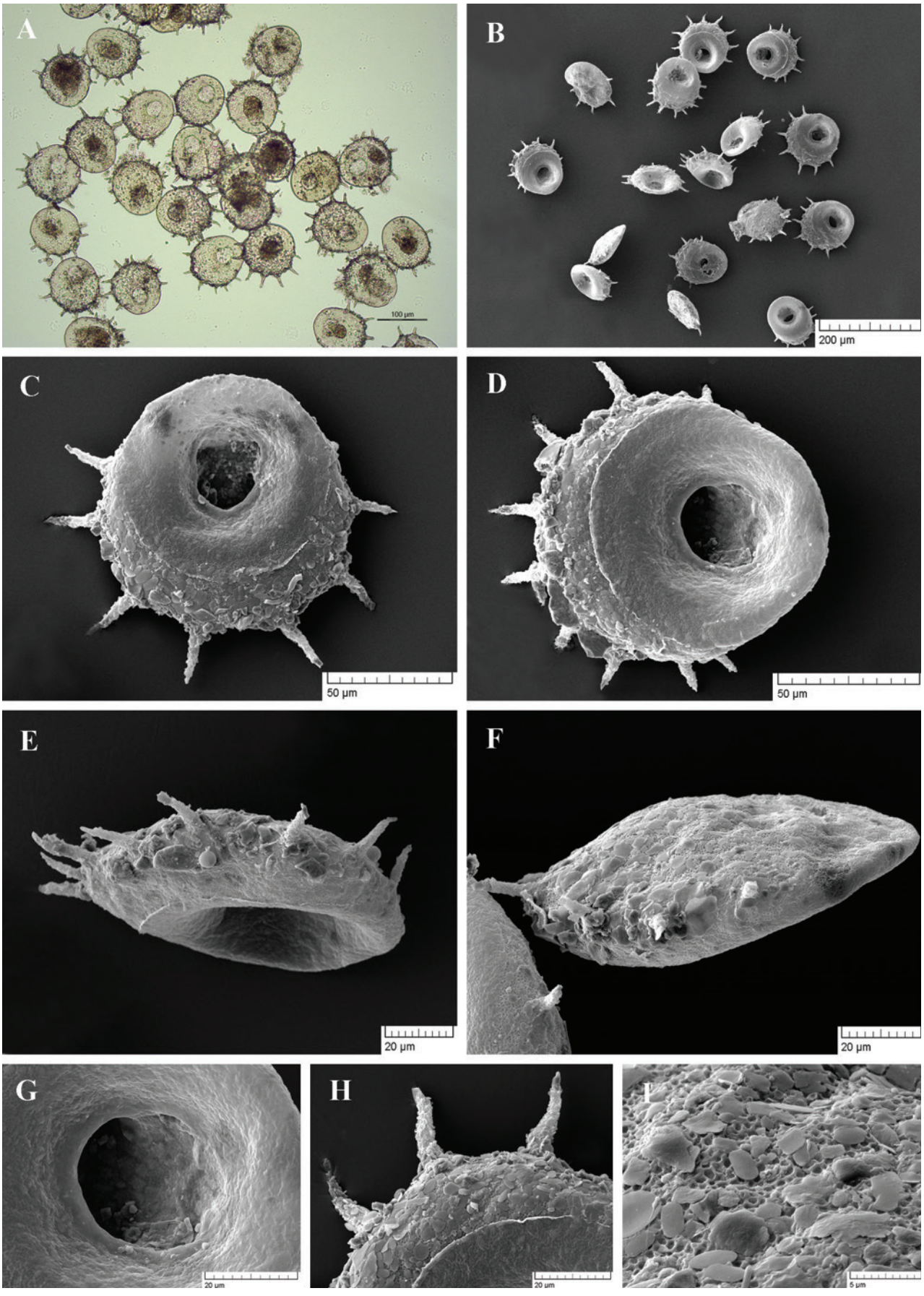
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Vitosha Mts.** (Todorov 1993, Todorov and Golemansky 1995).

Table 49. *Centropyxis spinosa*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	123.0	124.2	7.13	1.22	5.80	107	136	34
Diameter of aperture	32.6	32.6	2.33	0.43	7.15	28	37	30
Depth	43.1	42.5	1.70	0.85	3.95	42	46	4
Spines	19.8	19.8	3.03	0.52	15.29	14	28	34
Aperture/Diameter ratio	0.26	0.26	0.02	0.004	8.12	0.2	0.3	30
Depth/Diameter ratio	0.38	0.38	0.009	0.005	2.43	0.37	0.39	4

Fig. 59. Light (A) and scanning electron (B-I) micrographs of *Centropyxis spinosa*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Apertural view of two specimens to show general shape and shell structure. (E) Lateral view. (F) Latero-dorsal view. (G) Close up view of aperture showing its circular shape and smooth surface around the aperture. (H) Detail of posterior end of the shell to illustrate shape and structure of spines. (I) Detail of dorsal side of the shell showing its rough surface, covered mainly with flattish particles.


A
100 µm
B
200 µm
C
50 µm
D
50 µm
E
20 µm
F
20 µm
G
20 µm
H
20 µm
I
5 µm

Bullinularia indica (Penard, 1907) Deflandre, 1953

Original description: Penard 1907, *Journal of the Royal Microscopical Society*, p. 274-277, Pl. XIV, Figs. 1-4; **Last revision:** Deflandre 1953, *Traité de Zoologie*, v. I, fasc. II, p. 97, Pl. 1.

Synonyms: *Bulinella indica* Penard, 1907; *Bullinula indica* Penard, 1911.

Description: Shell dark brown, opaque, oval or circular in apertural and aboral views, hemispherical in lateral view (Fig. 60 A-F); composed mainly of small to medium flattish partticles, embedded in deep layer of organic cement on apertural side and large pieces of quartz on dorsal side (Fig. 60 D-F, I). Aperture narrow and elongated slit, with depressed inner lip and incurved outer lip with median extension, sub-terminal, invaginated, surrounded by numerous large pores (Fig. 60 D, G, H).

Ecology: Aerophilic, frequent in brown mosses, very rare in *Sphagnum*.

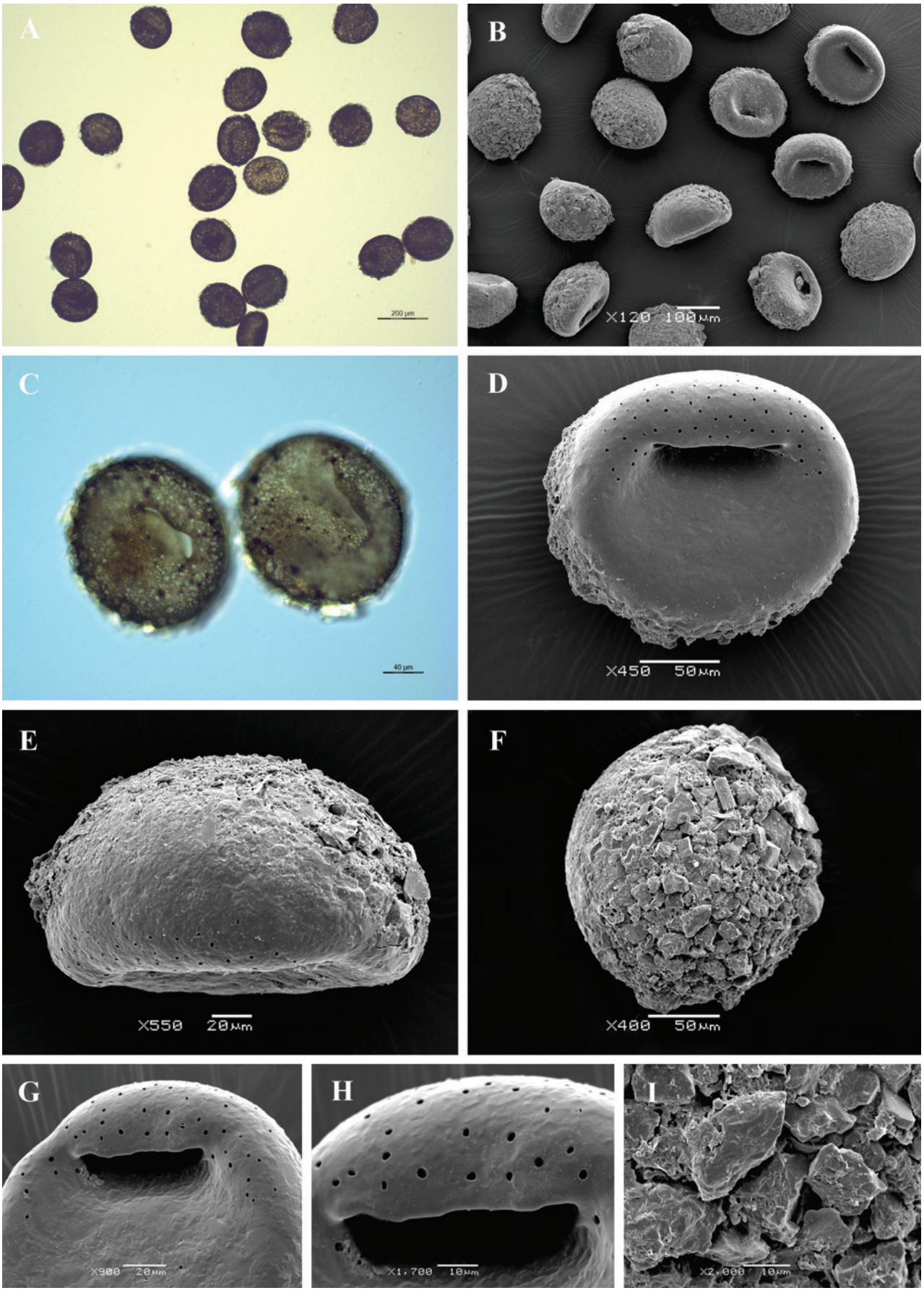
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rila Mts.** (Bankov et al. 2018).

Table 50. *Bullinularia indica*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	160.3	161.8	8.99	1.57	5.61	136	175	33
Breadth	183.1	183.6	10.61	1.62	5.80	156	206	34
Large axis of aperture	80.4	82.8	9.12	1.56	11.35	57	93	34
Depth	117.6	117.1	9.65	2.91	8.20	100	132	11
Breadth/Length ratio	1.14	1.14	0.05	0.009	4.35	1.1	1.3	33
Aperture/Breadth ratio	0.44	0.44	0.04	0.007	9.50	0.4	0.5	34

Fig. 60. Light (A, C) and scanning electron (B, D-I) micrographs of *Bullinularia indica*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Apertural views showing smooth apertural surface, characteristic aperture and large surrounding pores. (E) Lateral view. (F) Dorsal view. (G, H) Close up views of aperture to show its characteristic shape as an narrow, elongated slit. (I) Detail of dorsal side of the shell to illustrate its rough surface, covered with large pieces of quartz.


A
200 µm
B
X120 100µm
C
40 µm
D
X450 50µm
E
X550 20µm
F
X400 50µm
G
X900 20µm
H
X1,700 10µm
I
X2,000 10µm

Plagiopyxis callida Penard, 1910

Original description: Penard 1910, *Revue Suisse de Zoologie*, 18, p. 936, fig. 8-10.

Synonyms: *Bullinula indica* var. *callida* Jung, 1936.

Description: Shell yellow or brown, opaque, oval or circular in apertural and dorsal views, hemispherical in lateral view (Fig. 61 A-G); composed mainly of small to medium flattish particles, embedded in a thick layer of organic cement, smooth (Fig. 61 C- I). Aperture elliptical or oval, sub-terminal and invaginated; with deeply invaginated ventral side, partly covered by dorsal side (Fig. 61 A-D, H).

Ecology: Frequent in soils and brown mosses, accidentally in *Sphagnum*.

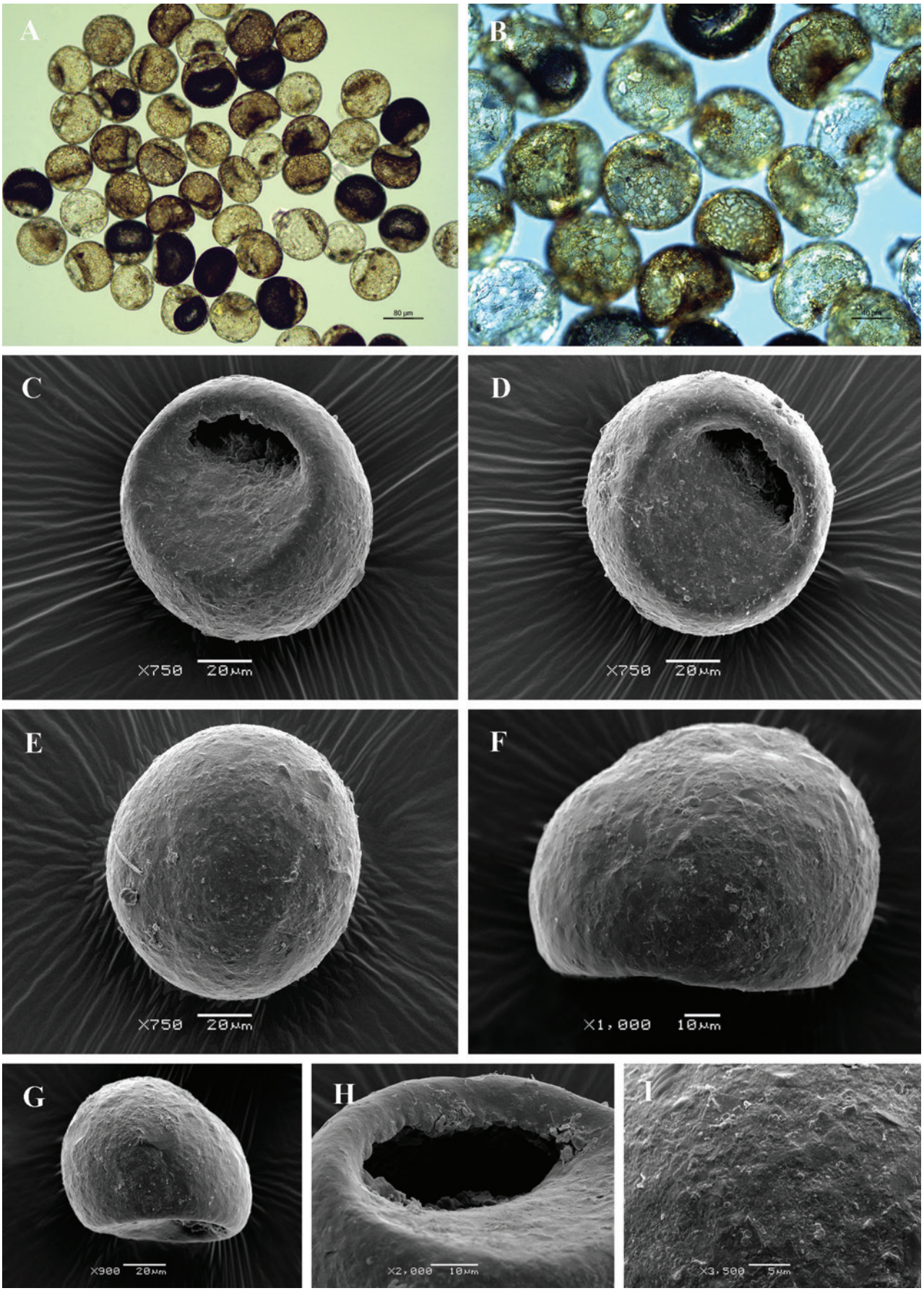
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rila Mts.** (Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Bankov et al. 2018).

Table 51. *Plagiopyxis callida*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	97.5	97.8	4.04	0.64	4.15	87	107	40
Breadth	98.9	101.6	8.89	1.48	8.99	70	107	36
Large axis of aperture	52.3	53.7	6.14	1.25	11.75	40	61	24
Depth	70.2	69.6	6.16	1.78	8.78	57	78	12
Breadth/Length ratio	1.01	1.03	0.08	0.01	7.52	0.7	1.1	32
Aperture/Breadth ratio	0.54	0.55	0.04	0.009	7.75	0.4	0.6	24

Fig. 61. Light (A, B) and scanning electron (C-I) micrographs of *Plagiopyxis callida*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Apertural view showing general shape. (E) Dorsal view (F, G) Lateral view. (H) Close up view of aperture showing its oval shape and smooth apertural surface. (I) Detail of dorsal side of the shell to illustrate its smooth surface, covered with flattish particles embedded in a thick layer of organic cement.


A
80 µm
B
C
X750 20µm
D
X750 20µm
E
X750 20µm
F
X1,000 10µm
G
X900 20µm
H
X2,000 10µm
I
X3,500 5µm

Plagiopyxis declivis Bonnet et Thomas, 1955

Original description: Bonnet et Thomas 1955, *Bulletin de la Société d'Histoire Naturelle de Toulouse*, 90, p. 420, fig. 10-11.

Description: Shell colorless or yellowish, circular or broadly oval in apertural and aboral views, hemispherical in lateral view (Fig. 62 A-G); smooth, with regular outline, composed mainly of small to medium flattish partticles, embedded in a thick layer of organic cement on apertural side and large pieces of quartz on dorsal side (Fig. 62 D- I). Aperture narrow and elongated slit, sub-terminal, invaginated; its ventral side is slightly invaginated and partly covered by dorsal side (Fig. 62 D, F-H).

Ecology: Frequent in soils and brown mosses, accidentally in *Sphagnum*.

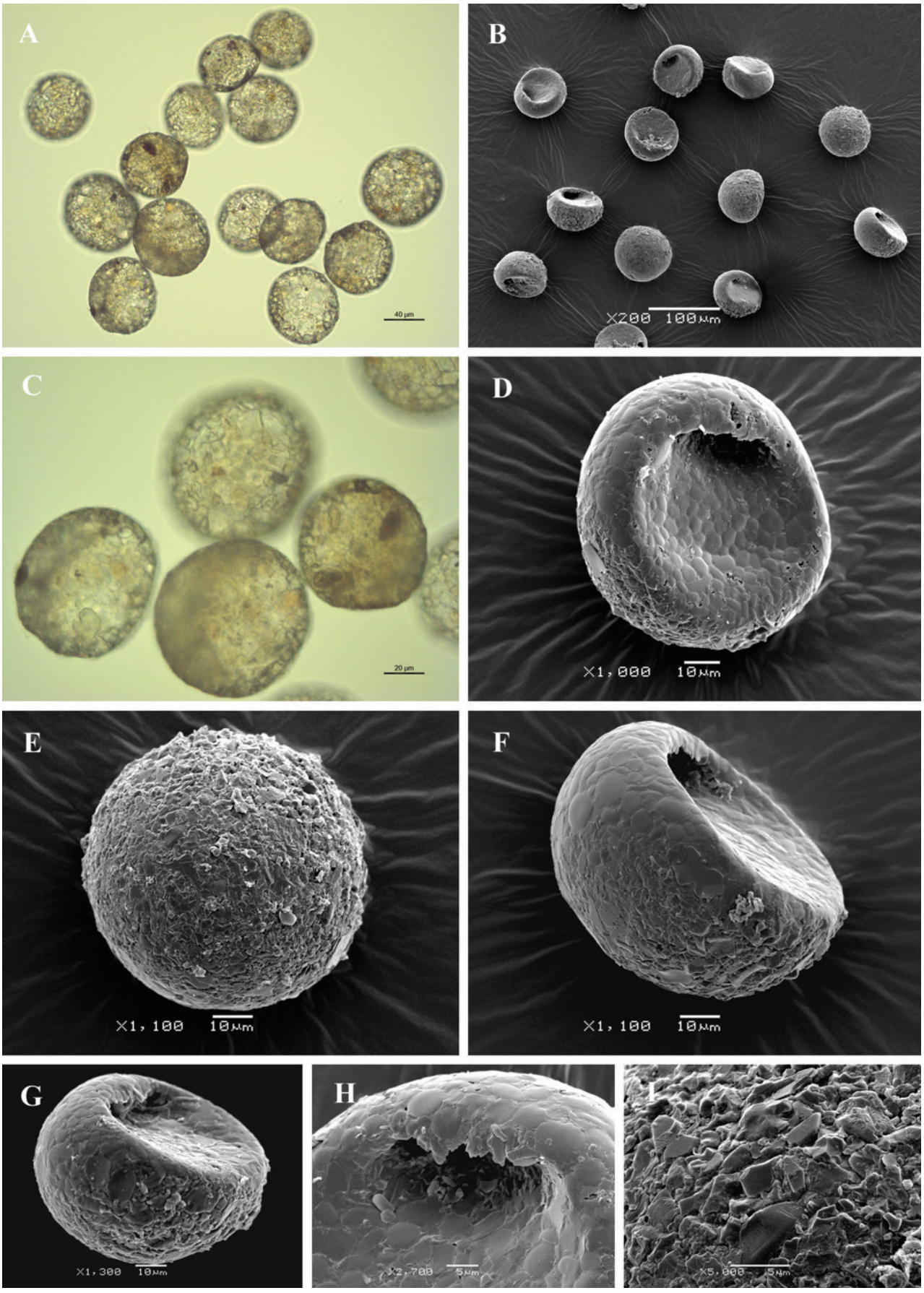
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 52. *Plagiopyxis declivis*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	75.1	76.0	4.29	0.73	5.71	65	82	35
Breadth	76.2	77.0	4.37	0.83	5.73	66	82	28
Large axis of aperture	27.6	27.0	3.70	0.87	13.4	23	34	24
Depth	37.7	38.5	2.67	0.85	7.10	33	41	10
Breadth/Length ratio	1.00	1.01	0.04	0.007	3.61	0.9	1.1	26
Aperture/Breadth ratio	0.37	0.37	0.04	0.009	10.04	0.3	0.4	17

Fig. 62. Light (A, C) and scanning electron (B, D-I) micrographs of *Plagiopyxis declivis*. (A-C) View of several specimens to illustrate variability in shape and size of the shell. (D) Apertural view showing general shape. (E) Dorsal view (F, G) Lateral views. (H) Close up view of aperture showing its shape as a narrow slit and smooth apertural surface. (I) Detail of dorsal side of the shell to illustrate its rough surface, covered with pieces of quartz.


A
40 µm
B
X200 100µm
C
20 µm
D
X1,000 10µm
E
X1,100 10µm
F
X1,100 10µm
G
X1,300 10µm
H
X2,700 5µm
I
X5,000 5µm

Alabasta militaris (Penard, 1890) Duckert, Blandenier, Kosakyan and Singer, 2018

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 164, Pl. VII, fig. 16 à 22; **Last revision:** Duckert et al. 2018, *European Journal of Protistology*, 66, p. 162, fig. 1 A-D.

Synonyms: *Nebela collaris* Leidy, 1879 (pars); *Nebela militaris* Penard, 1890.

Description: Shell colourless, transparent, elongate-ovoid or pyriform, with sides tapering evenly and gradually from rounded aboral region towards to aperture, forming short neck (Fig. 63 A-E); laterally compressed, with oval transverse section; with two lateral pores, not always well visible; composed of a mixture of oval, circular or rarely quadrangular, slightly overlapping shell-plates (Fig. 63 D-I). Aperture is an elongate slit, strongly curved, fan-shaped in broad view and deeply concave when viewed laterally, bordered by a thick collar of organic cement (Fig. 63 D-G). Cytoplasm granular, fills almost whole shell; cell attached to the posterior part of the shell wall with short epipodes; one ovular nucleus and numerous small nucleoli.

Notes: The species has been recorded as *Nebela militaris.*

Ecology: Aerophilic, in dry *Sphagnum,* as well as in brown mosses and forest litter.

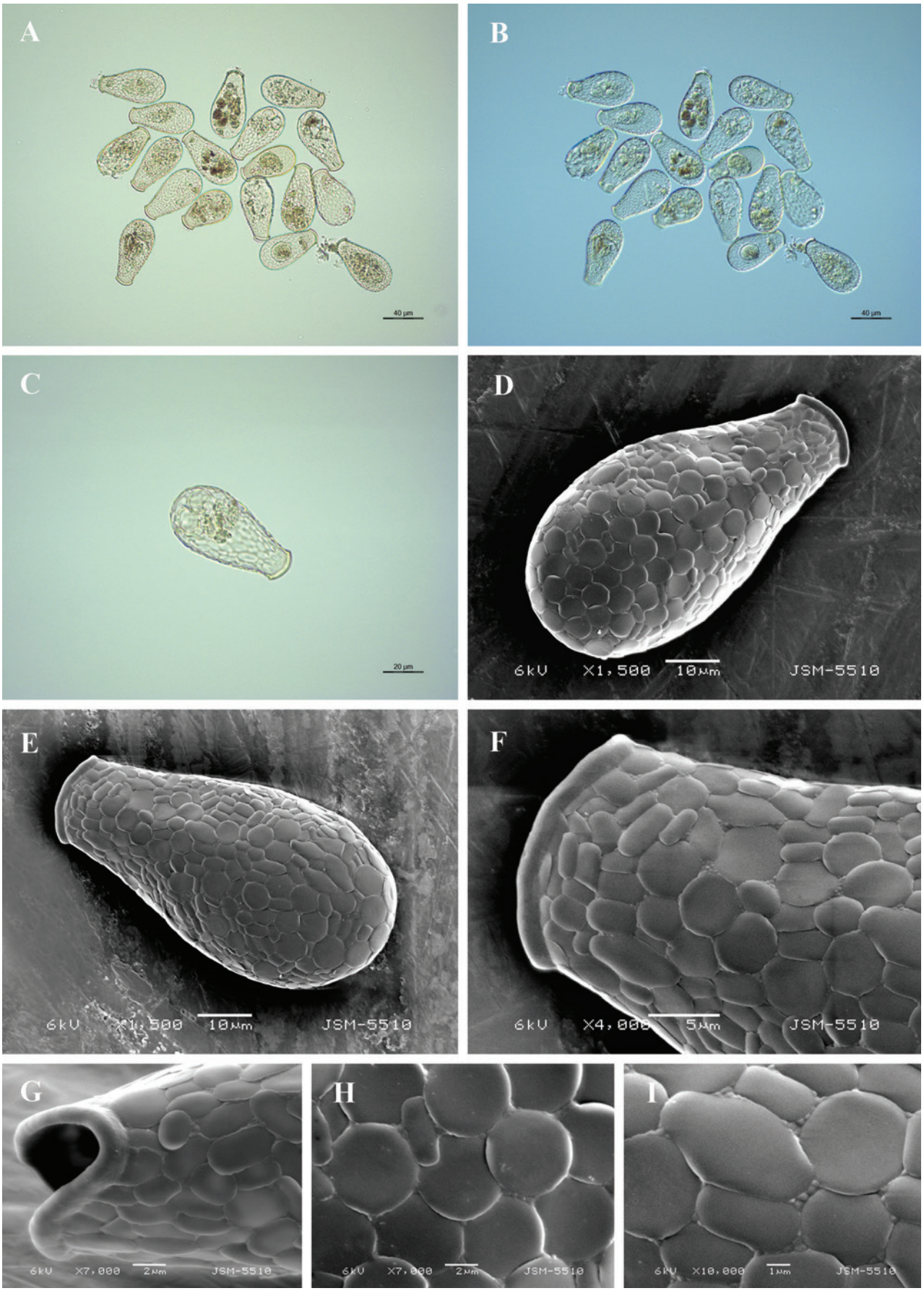
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: **Pirin Mts.** (Bankov et al. 2018); **Rila Mts.** (Pateff 1924, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 53. *Alabasta militaris*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	70.1	68.5	5.45	0.98	7.77	62	87	31
Breadth	37.1	37.1	2.24	0.40	6.01	34	44	31
Large axis of aperture	17.9	18.5	1.89	0.34	10.56	12	20	31
Depth	23.5	23.0	2.96	0.69	12.59	21	32	18
Breadth/Length ratio	0.53	0.54	0.03	0.006	6.46	0.4	0.6	31
Aperture/Breadth ratio	0.48	0.49	0.05	0.009	10.47	0.3	0.5	31

Fig. 63. Light (A-C) and scanning electron (D-I) micrographs of *Alabasta militaris*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C-E) Broad lateral view of three individuals to show the general shape. (F) Broad lateral view of apertural region showing strongly curved, fan-shaped aperture. (G) Narrow lateral view of aperture to illustrate its deep lateral notch and thick collar of organic cement. (H, I) Details of shell surface showing different shape and arrangement of shell-plates.


A
40 µm
B
40 µm
C
20 µm
D
6kV X1,500 10µm JSM-5510
E
6kV X1,500 10µm JSM-5510
F
6kV X4,000 5µm JSM-5510
G
6kV X7,000 2µm JSM-5510
H
6kV X7,000 2µm JSM-5510
I
6kV X10,000 1µm JSM-5510

Gibbocarina galeata (Penard, 1890) Kosakyan, Lahr, Mulot, Meisterfeld, Mitchell and Lara, 2016

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 161, Pl. VI, fig. 78 à 84.; **Last revision:** Kosakyan et al. 2016, *Cladistics*, 32, p. 16.

Synonyms: *Nebela galeata* Penard, 1890.

Description: Shell colourless, transparent, pyriform, with sides tapering evenly and gradually from rounded aboral region towards to aperture (Fig. 64 A-F); laterally compressed, with oval to ellipsoidal transverse section; has pronounced lateral margin or hollow tuberous keel, surrounding posterior end of the shell, and two lateral pores (Fig. 64 E-F, H); composed mainly of small, oval or circular, non-overlapping shell-plates, arranged haphazardly (Fig. 64 D-H). Aperture oval, slightly convex frontally and concave laterally, bordered by a thin collar of organic cement (Fig. 64 D-G, I). Cytoplasm granular, does not fills the whole shell, with numerous food vacuoles; cell attached to the posterior part of the shell wall with clearly visible long and thin epipodes; pseudopodia usually one or two, large, long, fast moving (Fig. 64 A, C).

Notes: The species has been recorded in both as nominal species and as synonym *N. galeata.*

Ecology: Common in *Sphagnum*.

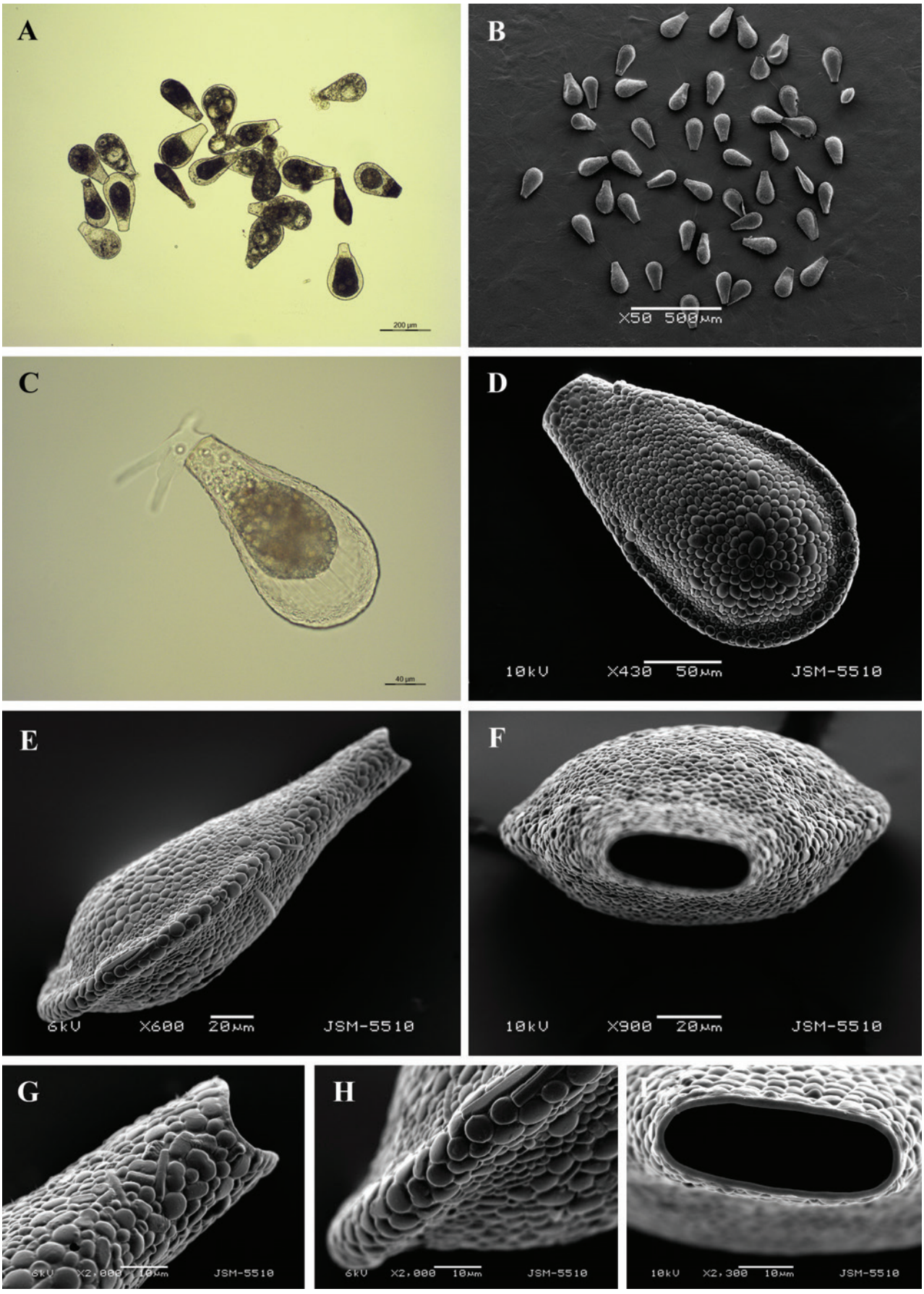
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 54. *Gibbocarina galeata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	193.2	190.8	17.93	3.27	9.28	168	250	30
Breadth	115.7	114.5	18.02	3.29	15.58	83	158	30
Large axis of aperture	40.4	39.6	4.73	0.86	11.71	28	52	30
Depth	63.4	65.2	4.95	1.08	7.81	55	73	21
Breadth/Length ratio	0.60	0.59	0.07	0.01	11.06	0.5	0.7	30
Aperture/Breadth ratio	0.35	0.35	0.05	0.009	13.36	0.3	0.4	30

Fig. 64. Light (A, C) and scanning electron (B, D-I) micrographs of *Gibbocarina galeata*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen to show granular cytoplasm, pseudopodia and epipodes. (D) Broad lateral view showing general shape. (E) Narrow lateral view to illustrate hollow tuberous keel. (F) Apertural view. (G) Lateral view of aperture. (H) Close up view of tuberous keel surrounding posterior end of the shell. (I) Close up view of aperture showing its oval outline and thin apertural collar.


A
200 µm
B
X50 500µm
C
40 µm
D
10kV X430 50µm JSM-5510
E
6kV X600 20µm JSM-5510
F
10kV X900 20µm JSM-5510
G
6kV X2,000 10µm JSM-5510
H
6kV X2,000 10µm JSM-5510
10kV X2,300 10µm JSM-5510

Hyalosphenia papilio (Leidy, 1874) Leidy, 1875

Original description: Leidy 1874, *Proceedings of the Academy of Natural Sciences of Philadelphia*, 26, p. 156; **Last revision:** Leidy 1875, *Proceedings of the Academy of Natural Sciences of Philadelphia*, 27, p. 415.

Synonyms: *Difflugia (Catharia) papilio* Leidy, 1874.

Description: Shell yellowish-brownish, transparent, smooth, ovoid, with sides tapering evenly and gradually from rounded aboral region towards to aperture; laterally compressed, elliptical in transverse section; with two or more pores on lateral margins (Fig. 65 A-G). Aperture terminal, broad, elliptical, slightly convex frontally and concave laterally, bordered by a thick collar of organic cement (Fig. 65 F-I). Cytoplasm granular, fills about two-thirds of the shell, always with numerous symbiotic zoochlorellae; cell attached to the posterior part of the shell wall with numerous epipodes; one large ovular nucleus and many small nucleoli; encysted specimens frequently seen, cysts round or ovale, with thick organic wall, occupying central region of the shell (Fig. 65 A-C, E). Pseudopodia usually two to three, rarely numerous, long, digitiform, fast moving (Fig. 65 B-D).

Ecology: Common in *Sphagnum*.

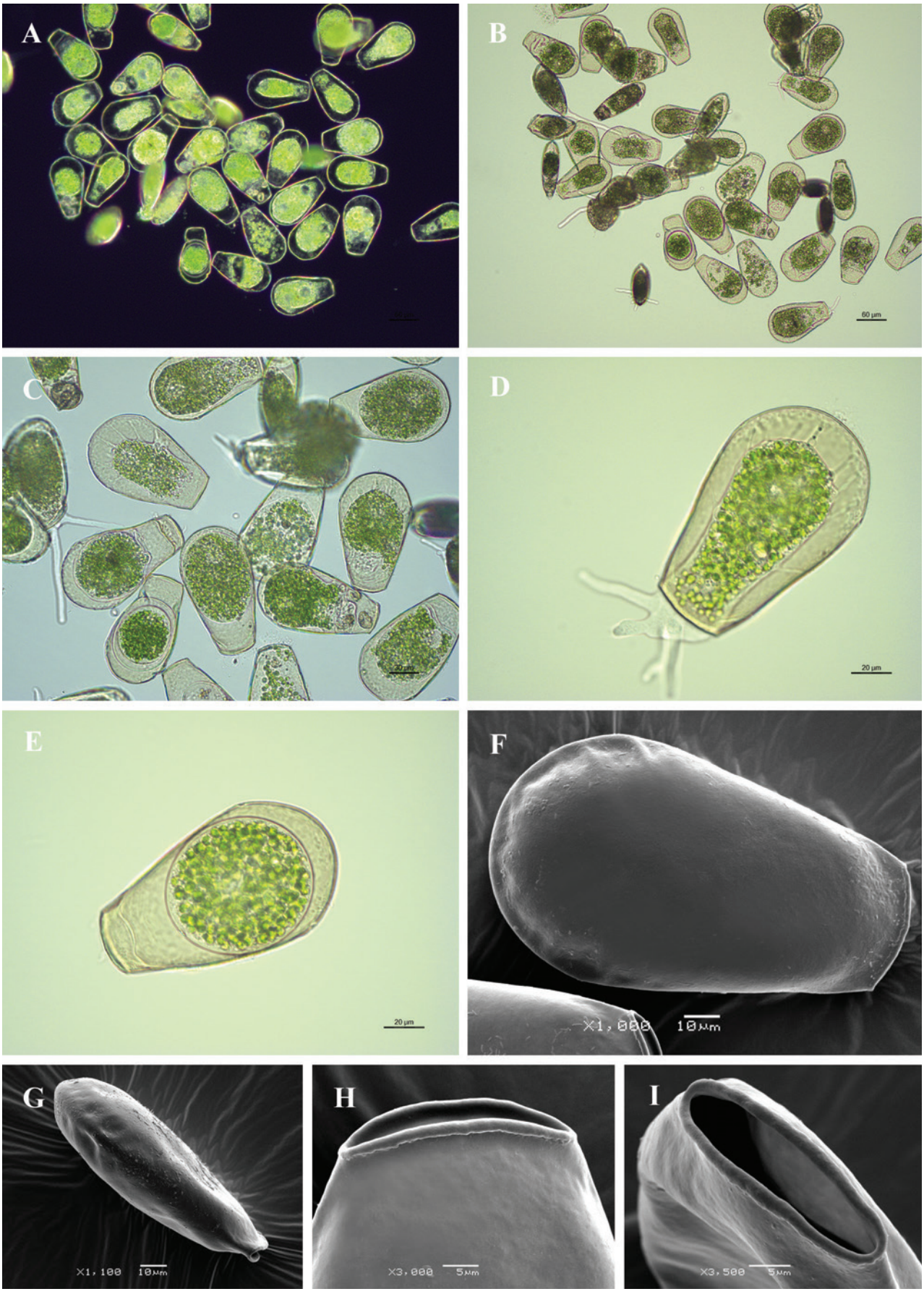
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mt. (Bankov et al. 2018); **Rhodopes Mt.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mt.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mt.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 55. *Hyalosphenia papilio*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	116.4	116.7	5.72	1.03	4.92	106	129	31
Breadth	68.8	69.1	6.07	1.03	8.82	54	82	31
Large axis of aperture	33.0	33.1	3.39	0.61	10.27	27	40	31
Depth	38.9	38.9	3.43	0.66	8.82	33	44	27
Breadth/Length ratio	0.59	0.59	0.04	0.007	7.00	0.5	0.7	31
Aperture/Breadth ratio	0.48	0.48	0.04	0.007	7.64	0.4	0.6	31

Fig. 65. Light (A-E) and scanning electron (F-I) micrographs of *Hyalosphenia papilio*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D) View of live specimen to illustrate the cytoplasm with symbiotic zoochlorellae, pseudopodia and epipodes. (E) View of encysted specimen showing round cyst. (F) Broad lateral view. (G) Narrow lateral view. (H) Broad lateral view of apertural region. (I) Close up view of aperture to illustrate its elliptical shape and bordering thick collar of organic cement.


A
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C
20 µm
D
20 µm
E
20 µm
F
X1,000 10µm
G
X1,100 10µm
H
X3,000 5µm
I
X3,500 5µm

Longinebela ampulla Todorov, Bankov and Ganeva, 2018

Original description: Todorov et al. 2018, *Acta zoologica bulg*arica, 70 (3), p. 287, Fig. 1 A-D, Fig. 3 A-C.

Description: Shell colourless, elongated-cylindrical, with distinct short neck and rounded aboral region (Fig. 66 A-E); laterally flattened only in the region of neck; all remaining part of the shell almost uncompressed laterally, without lateral margins and lateral pores (Fig. 66 E); composed mainly of small, oval, rarely circular shell-plates, arranged regularly without overlapping and embedded in thick layer of organic cement; their outer part appears to be covered with layer of cement, thus edges are not clearly defined (Fig. 66 G, I). Aperture oval, truncate but not convex, bordered by a thin collar of organic cement (Fig. 66 H).

Notes: *L. ampulla* can clearly be discriminated from *L. penardiana* by its elongated cylindrical shell, almost uncompressed laterally and flattened in the region of the neck only; absence of lateral margins and lateral pores; view of the aperture which is not convex but rather truncate and not concave in lateral view; structure of the shell which is composed mainly of small oval, rarely circular shell plates, embedded in a thick layer of organic cement.

Ecology: *L. ampulla* is found in wet moss *Sphagnum flexuosum*, growing on a small mire in a mixed deciduous forest of beech (*Fagus sylvatica* L.) and birch (*Betula pendula* L.); rare species with a low density.

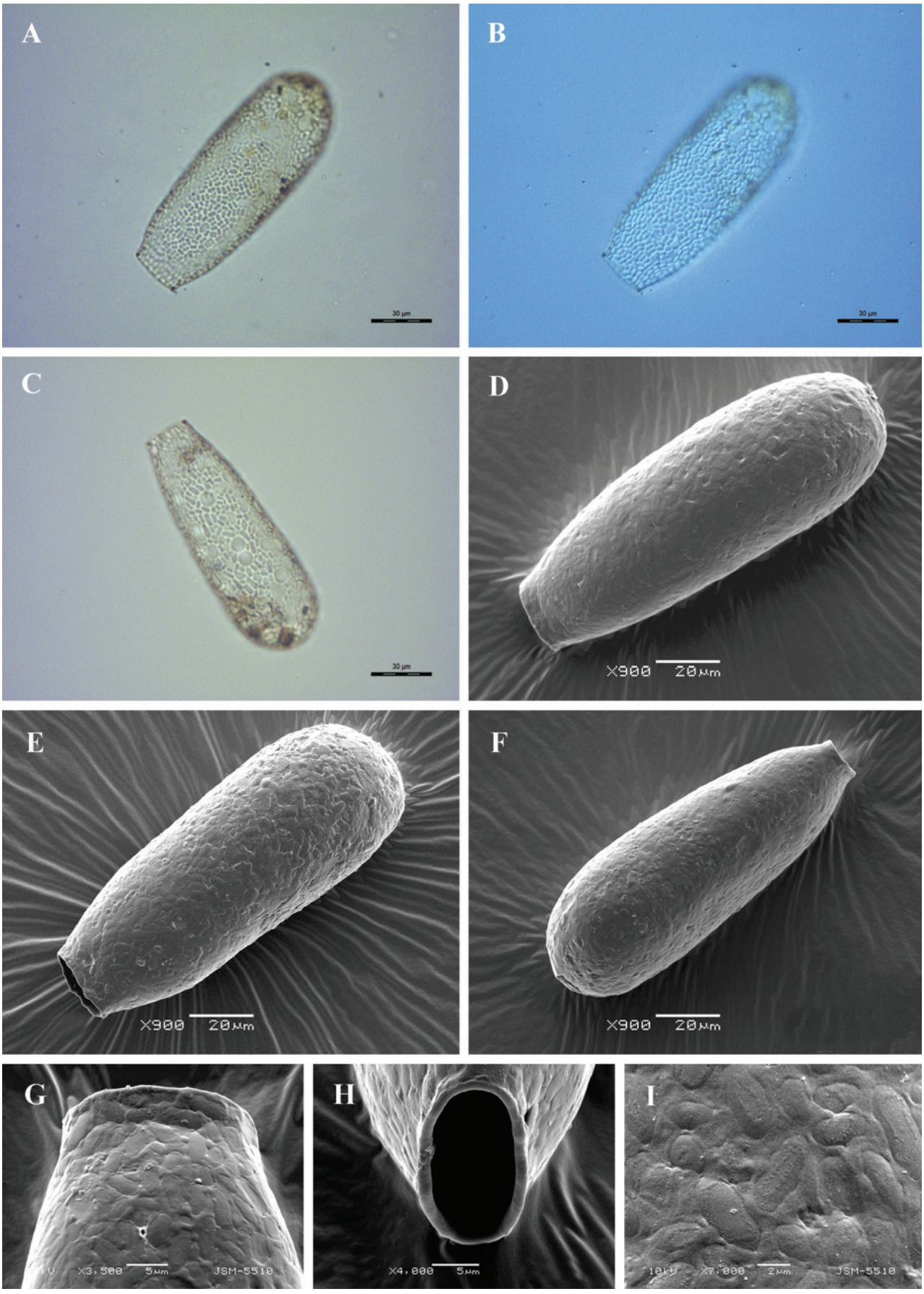
Geographical distribution: Recently described from Bulgaria; unknown distribution.

Distribution in *Sphagnum* mosses in Bulgaria: Stara Planina Mts. (Todorov et al. 2018).

Table 56. *Longinebela ampulla*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	125.8	125.9	3.53	0.61	2.81	117	131	33
Breadth	45.9	45.6	1.92	0.33	4.18	43	51	33
Depth	43.2	43.2	0.82	0.16	1.90	42	45	27
Large axis of aperture	23.5	23.7	1.37	0.24	5.83	21	27	33
Small axis of aperture	12.4	11.9	1.32	0.25	10.6	10	16	27
Length of neck	6.6	6.5	1.05	0.18	15.9	5	9	27
Breadth/Length ratio	0.36	0.36	0.01	0.002	2.78	0.35	0.39	33
Depth/Breadth ratio	0.95	0.95	0.02	0.003	2.10	0.92	0.99	27

Fig. 66. Light (A-C) and scanning electron (D-I) micrographs of *Longinebela ampulla*. (A-E) Broad lateral views to illustrate characteristic form of the ampoule. (F) Narrow lateral view showing absence of lateral compression, lateral margins and pores. (G) Broad lateral view of the apertural region to show distinct short neck and shell strucrure. (H) Apertural view showing aperture outline and thin apertural collar. (I) Detail of shell surface showing shell plates and abundant organic cement.


A
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G
X3,500 5µm JSM-5510
H
X4,000 5µm
I
10kV X7,000 2µm JSM-5510

Longinebela golemanskyi (Todorov, 2010) Kosakyan, Lahr, Mulot, Meisterfeld, Mitchell and Lara, 2016

Original description: Todorov 2010, *Acta Protozoologica*, 49, p. 38, Figs. 1-12; **Last revision:** Kosakyan et al. 2016, *Cladistics*, 32, p. 16.

Synonyms: *Nebela golemanskyi* Todorov, 2010.

Description: Shell colourless, transparent, pyriform, with sides tapering evenly and gradually from rounded aboral region towards to aperture, forming short neck (Fig. 67 A, C-E); almost uncompressed laterally, with circular or broadly oval transverse section; without lateral margins and lateral pores (Fig. 67 C-F); with thick wall, composed of voluminous, globular or rarely elongated, rounded siliceous shell-plates (Fig. 67 C-I); large parts of organic cement, in a forme of small beads usually well visible between plates (Fig. 67 H-I). Aperture roughly circular to oval, truncate, bordered by a thin collar of organic cement (Fig. 67 E-H).

Notes: *Longinebela golemanskyi* differs from *L. speciosa* by its uncompressed shell, characteristic voluminous shell-plates, absence of lateral margins and roughly circular, non convex but truncate aperture. The species has been recorded in both as nominal species and as *N. golemanskyi*.

Ecology: In *Sphagnum*, very rare.

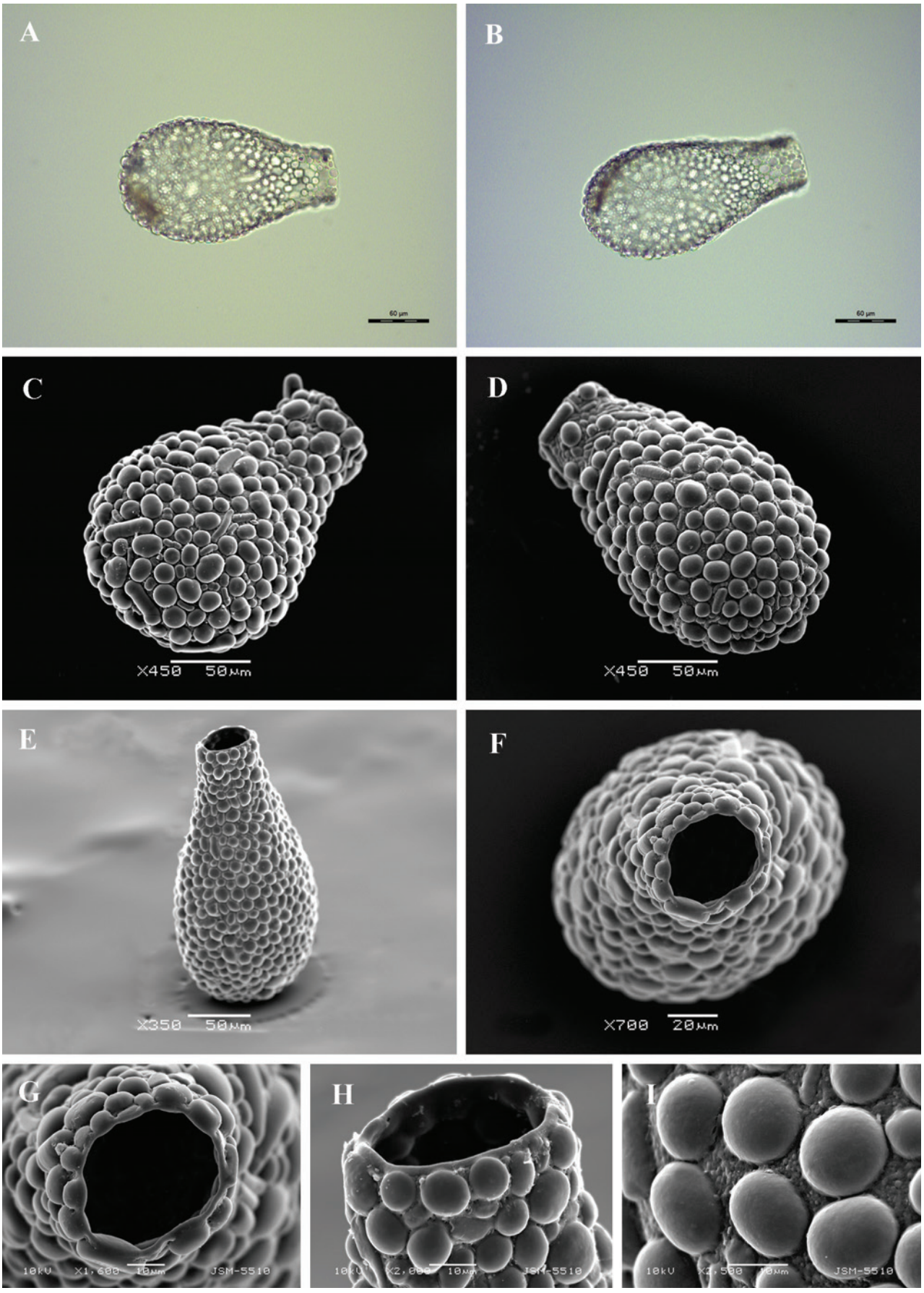
Geographical distribution: Recently described from Bulgaria; unknown distribution.

Distribution in *Sphagnum* mosses in Bulgaria: Vitosha Mts. (Todorov 2010, Bankov et al. 2018).

Table 57. *Longinebela golemanskyi*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	212.8	212.5	9.47	1.58	4.45	198	239	36
Breadth	118.0	117.8	5.77	0.96	4.89	105	132	36
Large axis of aperture	39.2	39.0	2.31	0.38	5.90	36	45	36
Depth	94.8	94.5	3.28	0.67	3.46	89	100	24
Breadth /Length ratio	0.56	0.56	0.03	0.005	5.41	0.5	0.6	36
Aperture/Breadth ratio	0.33	0.33	0.02	0.003	6.22	0.3	0.4	36

Fig. 67. Light (A, B) and scanning electron (C-I) micrographs of *Longinebela golemanskyi*. (A-D) Broad lateral view to illustrate general shape and characteristic voluminous siliceous shell-plates. (E) Latero-apertural view. (F) Apertural view. (G) Close up view of aperture showing aperture outline and collar of organic cement. (H) Lateral view of apertural region. (I) Detail of shell surface showing shape and arrangement of shell-plates.


A
B
C
X450 50µm
D
X450 50µm
E
X350 50µm
F
X700 20µm
G
H
I

Longinebela penardiana (Deflandre, 1936) Kosakyan, Lahr, Mulot, Meisterfeld, Mitchell and Lara, 2016

Original description: Deflandre 1936, *Annales de Protistologie*, 5, p. 257, fig. 87 à 89, PL. XIX, fig. 1 à 9, Pl. XX, fig. 1, 2, 4, 5, 7; **Last revision:** Kosakyan et al. 2016, *Cladistics*, 32, p. 16.

Synonyms: *Nebela penardiana* Deflandre, 1936.

Description: Shell colourless or brownish, transparent, elongate-pyriform, with sides tapering evenly and gradually from rounded aboral region towards to aperture (Fig. 68 A-D); laterally compressed, with oval transverse section; with small lateral margins and two lateral pores usually well visible on the first third of lateral margins (Fig. 68 C, D; composed of small, oval, circular or rarely quadrangular, overlapping shell-plates, arranged haphazardly (Fig. 68 D-G). Aperture oval, slightly convex frontally and concave laterally, bordered by a collar of organic cement (Fig. 68 E, F, H, I). Cytoplasm granular, fills about two-thirds of the shell; cell attached to the posterior part of the shell wall with clearly visible epipodes. Pseudopodia usually one or two, large, long, fast moving (Fig. 68 A, C).

Notes: The species has been recorded in both as nominal species and as *N. penardiana.*

Ecology: Common in *Sphagnum*.

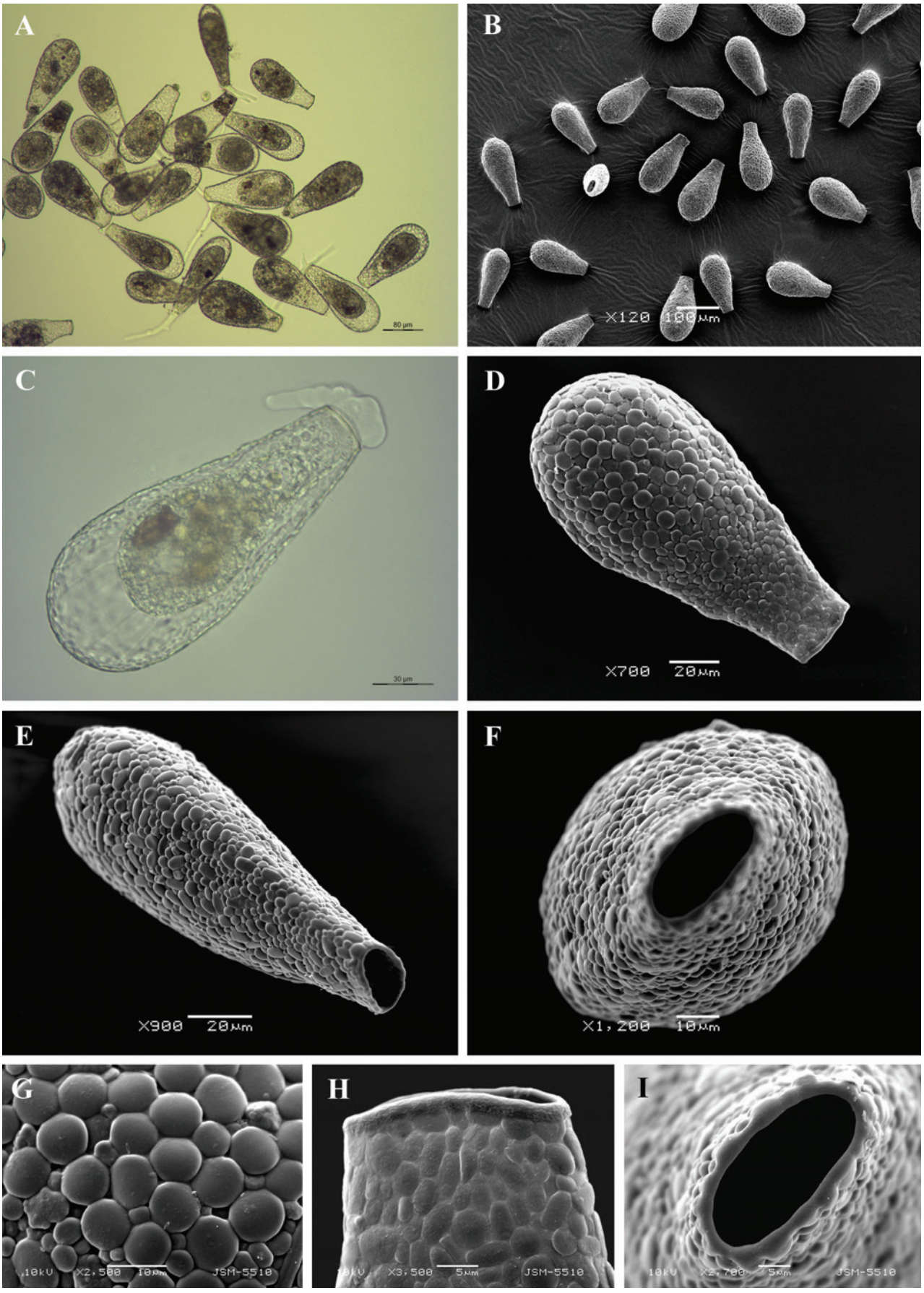
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Kosakyan et al. 2012, Bankov et al. 2018).

Table 58. *Longinebela penardiana*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	156.3	151.1	12.92	2.10	8.27	138	189	38
Breadth	71.7	69.6	8.59	1.39	11.97	55	87	38
Large axis of aperture	28.7	28.5	2.52	0.41	8.80	22	34	38
Depth	53.4	51.1	6.58	1.65	12.32	46	71	16
Breadth/Length ratio	0.46	0.46	0.04	0.006	8.10	0.4	0.5	38
Aperture/Breadth ratio	0.40	0.40	0.05	0.007	11.17	0.3	0.5	38

Fig. 68. Light (A, C) and scanning electron (B, D-I) micrographs of *Longinebela penardiana*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen showing granular cytoplasm, pseudopodia and epipodes. (D) Broad lateral view to show general shape and arrangement of shell-plates. (E) Lateral view. (F) Apertural view. (G) Detail of shell surface showing shape and arrangement of shell-plates. (H) Broad lateral view of apertural region. (I) Close up view of aperture to show aperture outline and collar of organic cement.


A
80 µm
B
X120 100µm
C
30 µm
D
X700 20µm
E
X900 20µm
F
X1,200 10µm
G
10kV X2,500 10µm JSM-5510
H
10kV X3,500 5µm JSM-5510
I
10kV X2,700 5µm JSM-5510

Longinebela speciosa (Deflandre, 1936) Kosakyan, Lahr, Mulot, Meisterfeld, Mitchell and Lara, 2016

Original description: Deflandre 1936, *Annales de Protistologie*, 5, p. 259, Pl. XX, fig. 3, 6, 8; **Last revision:** Kosakyan et al. 2016, *Cladistics*, 32, p. 16.

Synonyms: *Nebela speciosa* Deflandre, 1936.

Description: Shell colourless or brownish, transparent, elongated-pyriform, with sides tapering evenly and gradually from rounded aboral region towards to aperture (Fig. 69 A-D); slightly compressed laterally, with oval transverse section; with small lateral margins which do not extend around the aboral region, two lateral pores on the first one third of lateral margins (Fig. 69 E, F); composed of small, oval, circular or rarely quadrangular, overlapping shell-plates, arranged haphazardly (Fig. 69 D-H). Aperture oval, slightly convex frontally and concave laterally, bordered by a collar of organic cement (Fig. 69 F-I). Cytoplasm fulfilled with many dark-brown granules, fills about two-thirds of the shell; cell attached to the posterior part of the shell wall with numerous, clearly visible epipodes; pseudopodia usually three to five, large, not very long, fast moving (Fig. 69 A, C).

Notes: The species has been recorded in both as nominal species and as *N. speciosa*.

Ecology: Common in *Sphagnum*.

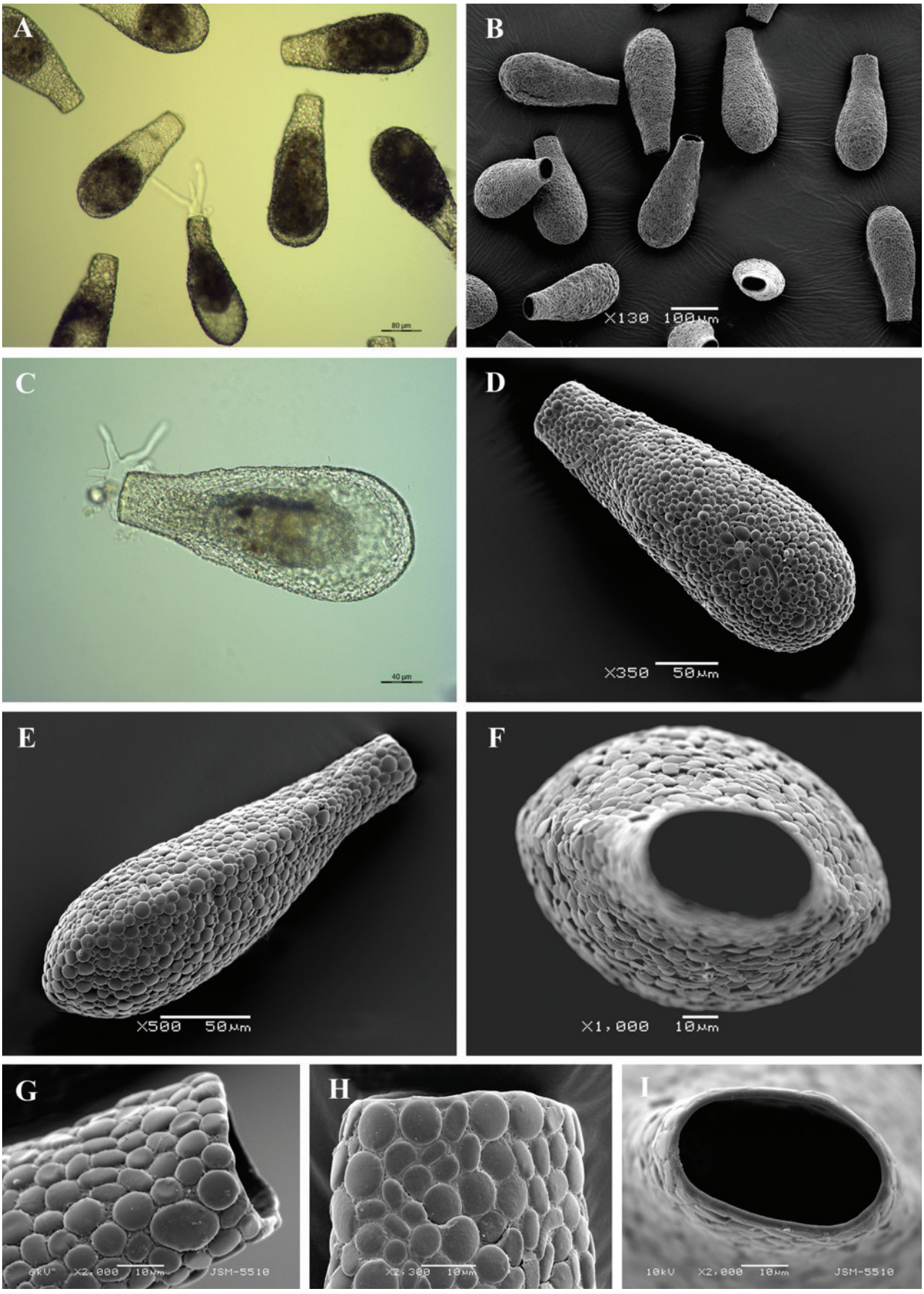
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Kosakyan et al. 2012, Bankov et al. 2018).

Table 59. *Longinebela speciosa*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	259.9	261.5	10.80	1.94	4.15	241	284	31
Breadth	116.1	116.6	7.95	1.43	6.85	99	138	31
Large axis of aperture	48.2	48.4	3.48	0.62	7.21	39	54	31
Depth	90.1	88.5	6.29	1.26	6.96	81	102	25
Breadth/Length ratio	0.45	0.44	0.03	0.006	7.73	0.4	0.5	31
Aperture/Breadth ratio	0.42	0.42	0.03	0.006	7.77	0.3	0.5	31

Fig. 69. Light (A, C) and scanning electron (B, D-I) micrographs of *Longinebela speciosa*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen showing granular cytoplasm, pseudopodia and epipodes. (D) Broad lateral view showing general shape and arrangement of shell-plates. (E) Lateral view. (F) Apertural view. (G) Narrow lateral view of apertural region to show laterally concave aperture. (H) Broad lateral view of apertural region. (I) Close up view of aperture showing aperture outline and collar of organic cement.


A
80 µm
B
X130 100µm
C
40 µm
D
X350 50µm
E
X500 50µm
F
X1,000 10µm
G
9kU X2,000 10µm JSM-5510
H
X2,300 10µm
I
10kU X2,000 10µm JSM-5510

Longinebela tubulosa (Penard, 1890) Kosakyan, Lahr, Mulot, Meisterfeld, Mitchell and Lara, 2016

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 159; **Last revision:** Kosakyan et al. 2016, *Cladistics*, 32, p. 16.

Synonyms: *Nebela tubulosa* Penard, 1890.

Description: Shell yellow or brown, transparent, pyriform, with sides tapering evenly and gradually from rounded aboral region towards to aperture, forming short neck (Fig. 70 A-E); laterally compressed, oval transverse section; with lateral margins beginning at the base of the neck and extending all around; two lateral pores usually present on the first one third of lateral margins (Fig. 70 F); composed mainly of small, oval or circular, overlapping shell-plates, arranged haphazardly and embedded in thick layer of organic cement (Fig. 70 D, E, G, I). Aperture oval, slightly convex, bordered by a thin collar of organic cement (Fig. 70 G, H). Cytoplasm granular, fills about two-thirds of the shell; cell attached to the posterior part of the shell wall with clearly visible epipodes; one large ovular nucleus and numerous nucleoli; pseudopodia usually one or two, large, long, fast moving (Fig. 70 A-C).

Notes: The species has been recorded in both as nominal species and as synonym *N. tubulosa* (Rila Mts., Stara Planina Mts., Vitosha Mts.).

Ecology: Common in *Sphagnum*.

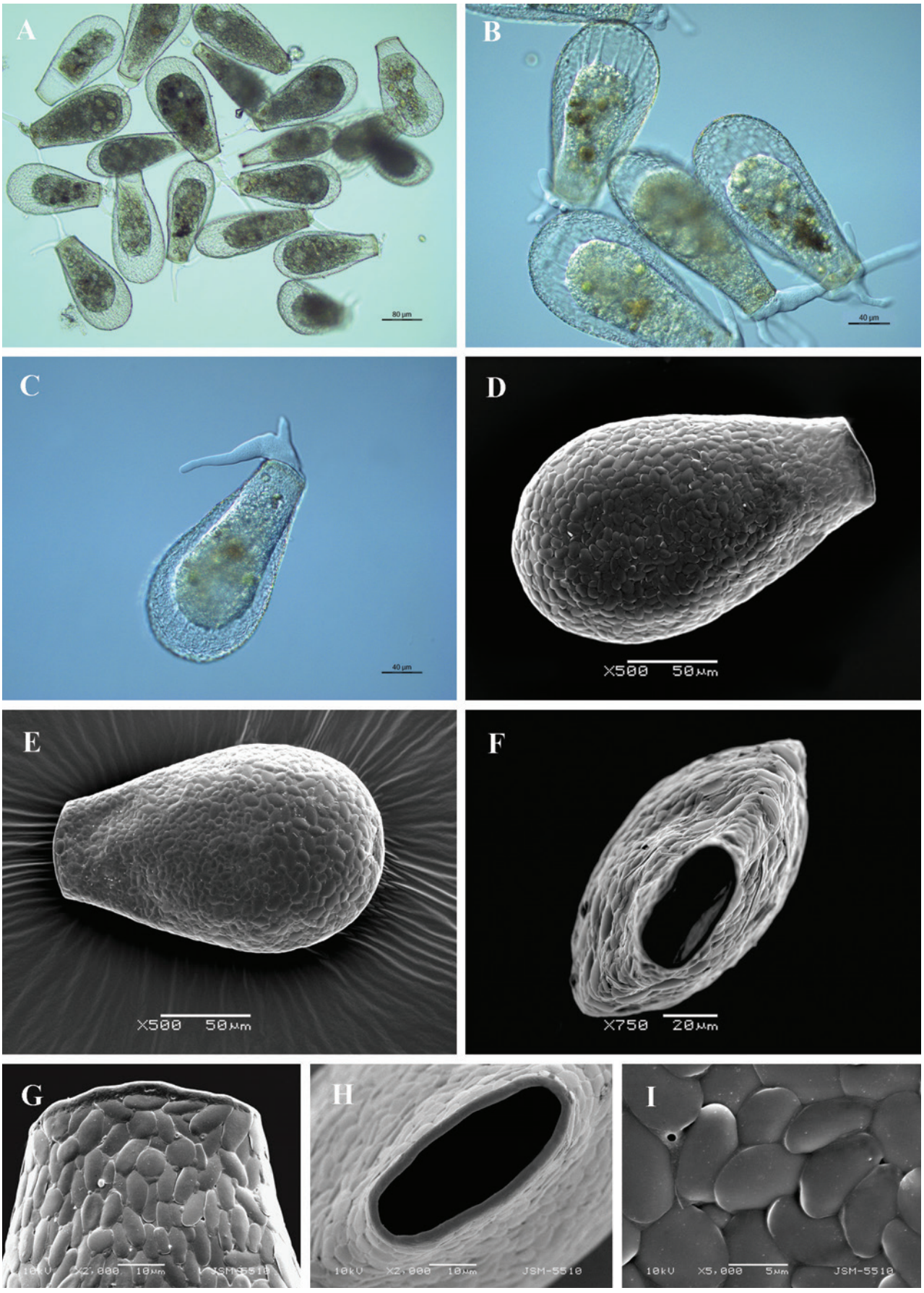
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Todorov 1993, Todorov and Golemansky 1995, Kosakyan et al. 2012, Bankov et al. 2018).

Table 60. *Longinebela tubulosa*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	226.6	224.2	25.37	4.49	11.20	189	282	32
Breadth	125.3	117.3	21.17	3.74	16.90	92	168	32
Large axis of aperture	53.8	52.4	8.17	1.44	15.18	42	68	32
Depth	68.3	65.6	8.98	2.40	13.14	57	85	14
Breadth/Length ratio	0.55	0.55	0.05	0.008	8.67	0.4	0.7	32
Aperture/Breadth ratio	0.43	0.43	0.03	0.006	8.04	0.4	0.5	32

Fig. 70. Light (A-C) and scanning electron (D-I) micrographs of *Longinebela tubulosa*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen showing granular cytoplasm, pseudopodia and epipodes. (D, E) Broad lateral view to show general shape and arrangement of shell-plates. (F) Apertural view. (G) Broad lateral view of apertural region. (H) Close up view of aperture to show aperture outline and thin apertural collar. (I) Detail of shell surface showing shape and arrangement of shell-plates.


A
80 µm
B
40 µm
C
40 µm
D
X500 50µm
E
X500 50µm
F
X750 20µm
G
10kV X2,000 10µm JSM-5510
H
10kV X2,000 10µm JSM-5510
I
10kV X5,000 5µm JSM-5510

Nebela aliciae Mitchell et Lara, 2013

Original description: Kosakyan et al. 2013, *European Journal of Protistology*, 49 (2), p. 234, Figs. 6A, B, 7A.

Description: Shell colorless or yellowish, transparent, ovoid or pyriform, with broadly rounded aboral region and well-expressed lateral keel of about 5-6 μm wide (Fig. 71 A-D, G, H); laterally compressed, with oval transverse section, two well visible lateral pores (Fig. 71 A-C); composed of small, oval or circular, slightly overlapping shell-plates, arranged haphazardly and embedded in thick layer of organic cement (Fig. 71 A- I). Aperture oval, slightly convex or truncate, bordered by a thin collar of organic cement (Fig. 71 A, B, E, F).

Ecology: In *Sphagnum*, rare.

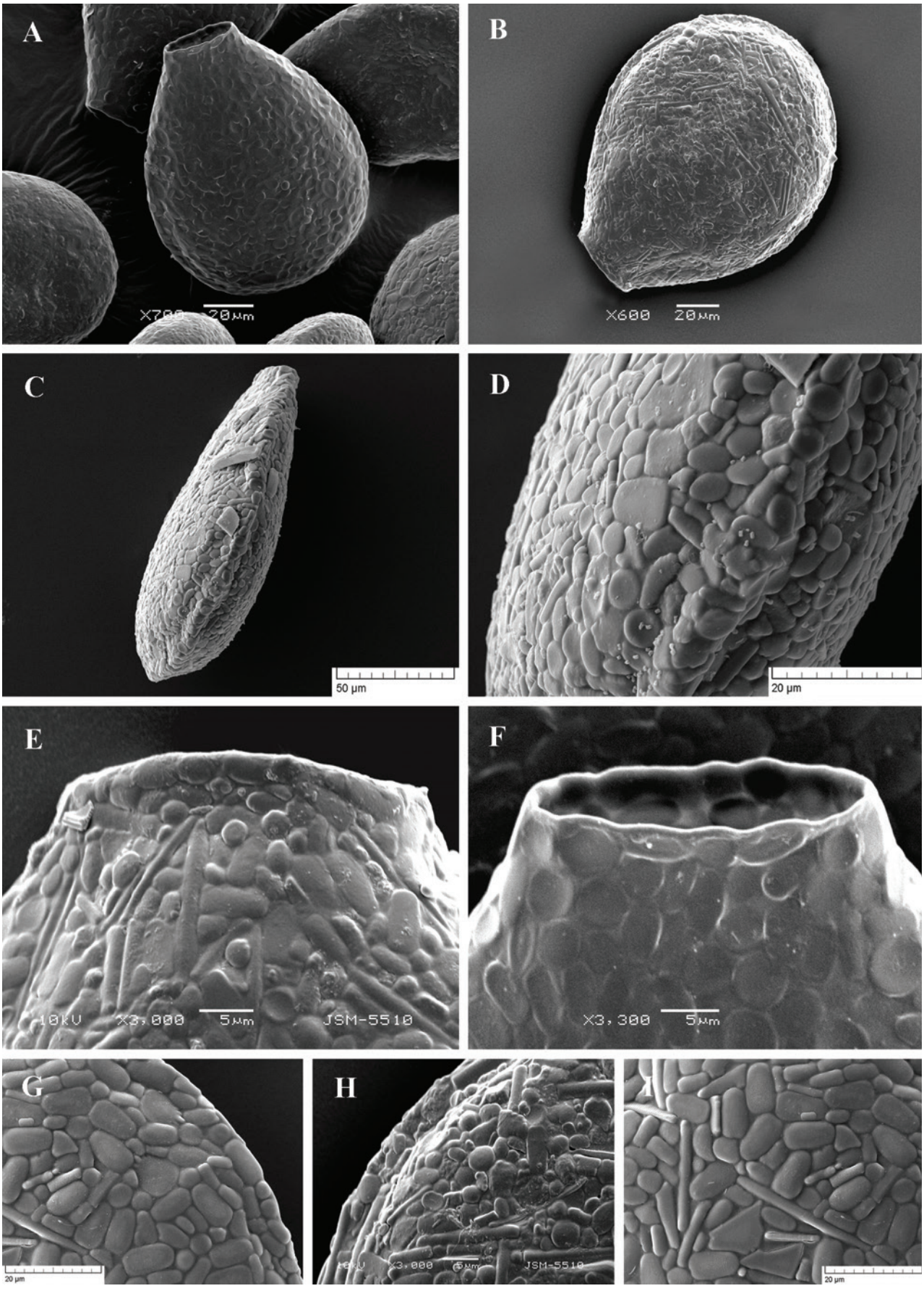
Geographical distribution: Recently described from Costa Rica, still unknown.

Distribution in *Sphagnum* mosses in Bulgaria: **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Bankov et al. 2018).

Table 61. *Nebela aliciae*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	134.3	136.1	16.27	5.75	12.12	109	155	8
Breadth	111.3	112.8	12.70	4.80	11.40	88	127	7
Large axis of aperture	32.4	33.0	3.22	1.22	9.93	27	37	7
Depth	52.6	52.6	3.39	2.40	6.45	50	55	2
Breadth/Length ratio	0.82	0.82	0.05	0.02	5.60	0.8	0.9	7
Aperture/Breadth ratio	0.29	0.29	0.02	0.008	7.55	0.25	0.32	7

Fig. 71. Scanning electron micrographs of *Nebela aliciae*. (A, B) Broad lateral views of two specimens to illustrate general shape. (C) Narrow lateral view to show lateral keel. (D) Close up view of lateral keel showing its structure. (E, F) Broad lateral view of apertural region to illustrate aperture outline and collar of organic cement. (G, H) Close up view of lateral keel. (I) Detail of shell surface showing shape and arrangement of shell-plates.


A
X700 20µm
B
X600 20µm
C
50 µm
D
20 µm
E
10kV X3,000 5µm JSM-5510
F
X3,300 5µm
G
20 µm
H
I
20 µm

Nebela collaris (Ehrenberg, 1848) Leidy, 1879

Original description: Ehrenberg 1848a, *Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königliche Preussischen Akademie der Wissenschaften zu Berlin*, 13, p. 218; **Last revision:** Leidy 1879, *Report of the United States Geological Survey of the Territories*, 12, p. 145, Pl. XXII, figs. 1-10, 13-15, 17-20, Pl. XXVI, fig. 11.

Synonyms: *Difflugia collaris* Ehrenberg, 1848; *Difflugia cancellata* Ehrenberg, 1848; *Difflugia reticulata* Ehrenberg, 1848; *Difflugia carpio* Ehrenberg, 1854; *Difflugia laxa* Ehrenberg, 1871; *Difflugia cellulifera* Ehrenberg, 1874; *Nebela numata* Leidy, 1874; *Nebela bohemica* Taranek, 1882; *Nebela sphagnophila* (Steinecke) Van Oye, 1933; *Nebela tincta* var. *major* Deflandre, 1936; *Nebela tincta* f. *stenostoma* Jung, 1936.

Description: Shell colourless, transparent, ovoid, with sides tapering evenly and gradually from rounded aboral region towards to aperture, sometimes forming short neck (Fig. 72 A-E); laterally compressed, oval transverse section; with two lateral pores usually well visible (Fig. 72 F); composed of small, oval, circular or rarely quadrangular shell-plates, arranged regularly, do not overlapping (Fig. 72 E-F, G, I). Aperture oval, slightly convex or truncate, bordered by a thin collar of organic cement (Fig. 72 E-H). Cytoplasm granular, fills almost whole shell; cell attached to the posterior part of the shell wall with clearly visible epipodes; one large ovular nucleus and numerous small nucleoli; pseudopodia usually three to five, large, long, fast moving (Fig. 72 A, C, D).

Ecology: Common in *Sphagnum,* as well as in brown mosses and forest litter.

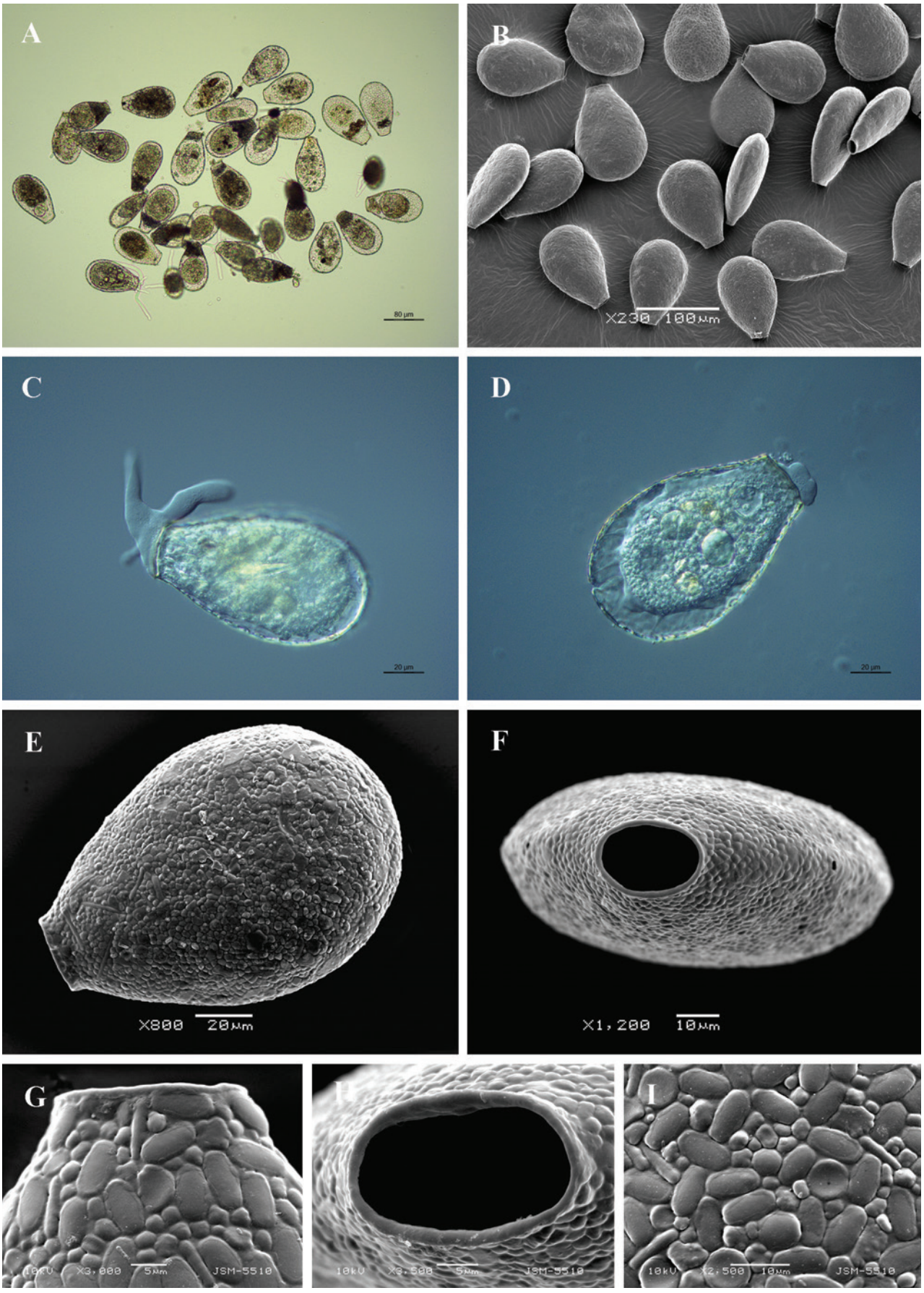
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: **Pirin Mts.** (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Kosakyan et al. 2012; Bankov et al. 2018).

Table 62. *Nebela collaris*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	118,3	118,0	4,99	0,91	4,22	110	130	30
Breadth	76,0	75,1	5,15	0,94	6,78	67	85	30
Large axis of aperture	26,4	26,7	2,56	0,47	9,68	20	35	30
Depth	42,5	42,7	3,88	0,89	9,14	36	50	19
Breadth/Length ratio	0,64	0,64	0,04	0,007	6,48	0,5	0,7	30
Aperture/Breadth ratio	0,35	0,35	0,03	0,005	8,50	0.3	0,4	30

Fig. 72. Light (A, C, D) and scanning electron (B, E-I) micrographs of *Nebela collaris*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) View of live specimens showing granular cytoplasm, pseudopodia and epipodes. (E) Broad lateral view. (F) Apertural view. (G) Broad lateral view of apertural region. (H) Close up view of aperture showing aperture outline and collar of organic cement. (I) Detail of shell surface showing shape and arrangement of shell-plates.


A
80 µm
B
X230 100µm
C
20 µm
D
20 µm
E
X800 20µm
F
X1,200 10µm
G
10kV X3,000 5µm JSM-5510
H
10kV X3,500 5µm JSM-5510
I
10kV X2,500 10µm JSM-5510

Nebela flabellulum Leidy, 1874

Original description: Leidy 1874b, *Proceedings of the Academy of Natural Sciences of Philadelphia*, 26, p. 157.

Synonyms: *Difflugia (Nebela) flabellulum* Leidy, 1874.

Description: Shell colourless, transparent, circular or ellipsoidal, wider than long, with broadly rounded aboral region and well-defined short neck (Fig. 73 A-E); laterally compressed, oval transverse section, with two lateral pores usually well visible (Fig. 73 F); composed of small, oval or circular, overlapping shell-plates, arranged haphazardly and embedded in thick layer of organic cement (Fig. 73 C-F, H, I). Aperture oval, slightly convex or truncate, bordered by a thin collar of organic cement (Fig. 73 C-H). Cytoplasm granular, with numerous food vacuoles, fills about two-thirds of the shell; cell attached to the posterior part of the shell wall with numerous, clearly visible epipodes; pseudopodia usually three to five, large, long and fast moving.

Notes: *Nebela flabellulum* differs from *N. tincta* and *N. collaris* mainly by being wider than long.

Ecology: In *Sphagnum,* very rare in Bulgaria.

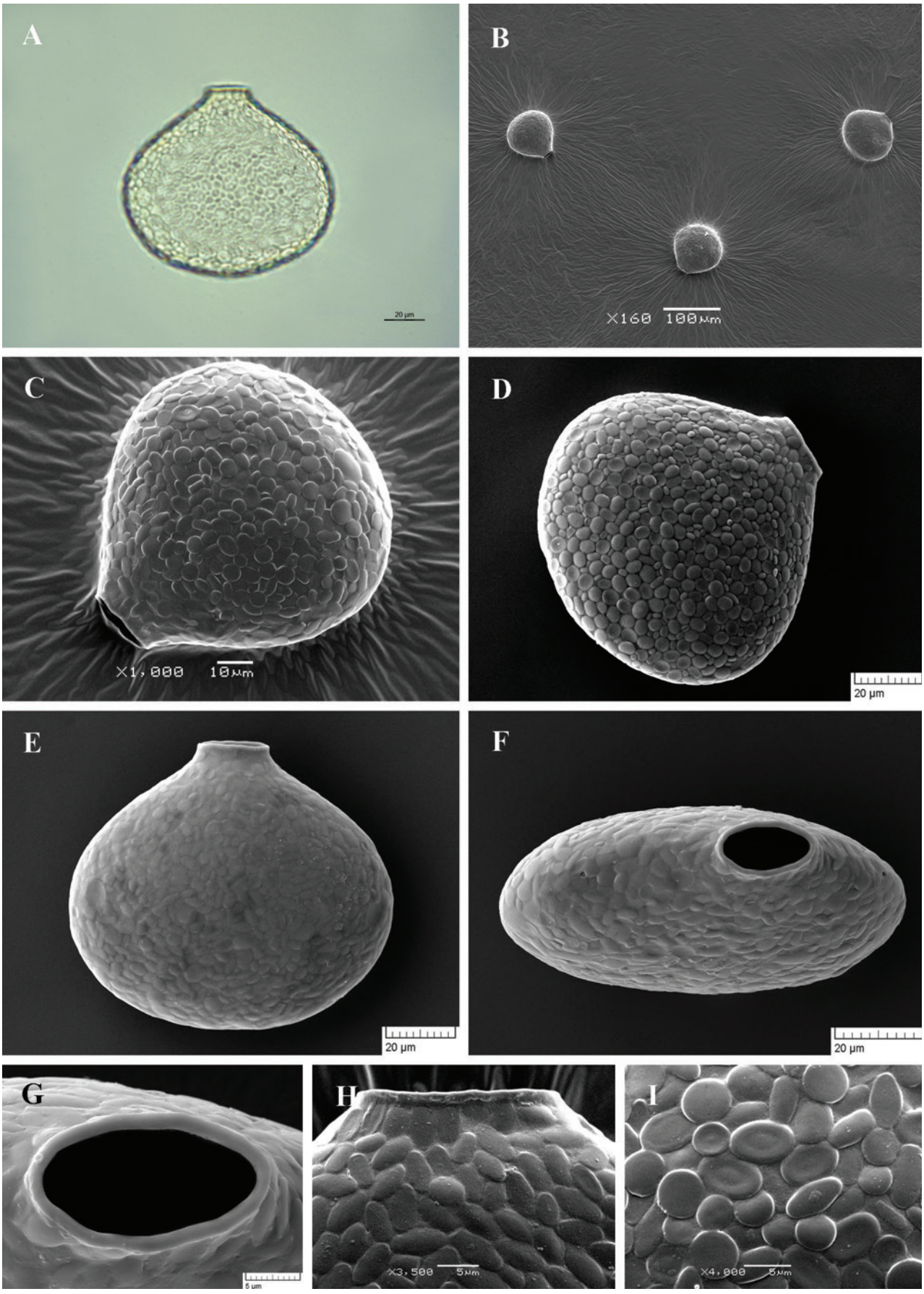
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Stara Planina Mts.** (Bankov et al. 2018).

Table 63. *Nebela flabellulum*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	88.5	87	4.84	1.34	5.47	82	99	13
Breadth	93.1	92.2	7.04	1.82	7.56	84	105	15
Large axis of aperture	19.6	19.8	1.92	0.50	9.81	17	23	15
Depth	43	43				43	43	1
Breadth/Length ratio	1.05	1.06	0.05	0.01	4.52	0.98	1.11	13
Aperture/Breadth ratio	0.21	0.21	0.02	0.005	9.23	0.2	0.3	15

Fig. 73. Light (A) and scanning electron (B-I) micrographs of *Nebela flabellulum*. (A-E) View of different specimens to illustrate variability in shape and size of the shell. (F) Apertural view. (G) Close up view of aperture showing aperture outline and collar of organic cement. (H) Broad lateral view of apertural region. (I) Detail of shell surface showing shape and arrangement of shell-plates.


A
20 µm
B
×160 100µm
C
×1,000 10µm
D
20 µm
E
20 µm
F
20 µm
G
5 µm
H
×3,500 5µm
I
×4,000 5µm

Nebela tincta (Leidy, 1879) Awerintzew, 1906

Original description: Leidy 1879, *Report of the United States Geological Survey of the Territories*, 12, p. 138, Pl. XX, figs. 11-17; **Last revision:** Awerintzew 1906, *Trudui Imperatorskago Sankt Peterburgskago Obshchestva Estestvoispitateleì,* 36 (2), p. 249.

Synonyms: *Hyalosphenia tincta* Leidy, 1879; *Nebela bursella* Vejdovsky, 1882; *Nebela minor* Penard, 1902; *Nebela parvula* Cash, 1909.

Description: Shell yellowish, transparent, ovoid, with broadly rounded aboral region and well-defined short neck (Fig. 74 A-D); laterally compressed, with oval transverse section; two well visible lateral pores (Fig. 74 E, F); composed of small, oval or circular, overlapping shell-plates, arranged haphazardly and embedded in thick layer of organic cement (Fig. 74 D-F, H, I). Aperture oval, slightly convex or truncate, bordered by a thin collar of organic cement (Fig. 74 C-H). Cytoplasm granular, with numerous food vacuoles, fills about two-thirds of the shell; one large ovular nucleus and numerous small nucleoli; pseudopodia usually three to six, not very long, fast moving.

Notes: The species has been recorded in both as nominal species and as synonyms *N. bursella*, *N. minor* and *N. parvula.*

Ecology: In *Sphagnum,* as well as in brown mosses and forest litter.

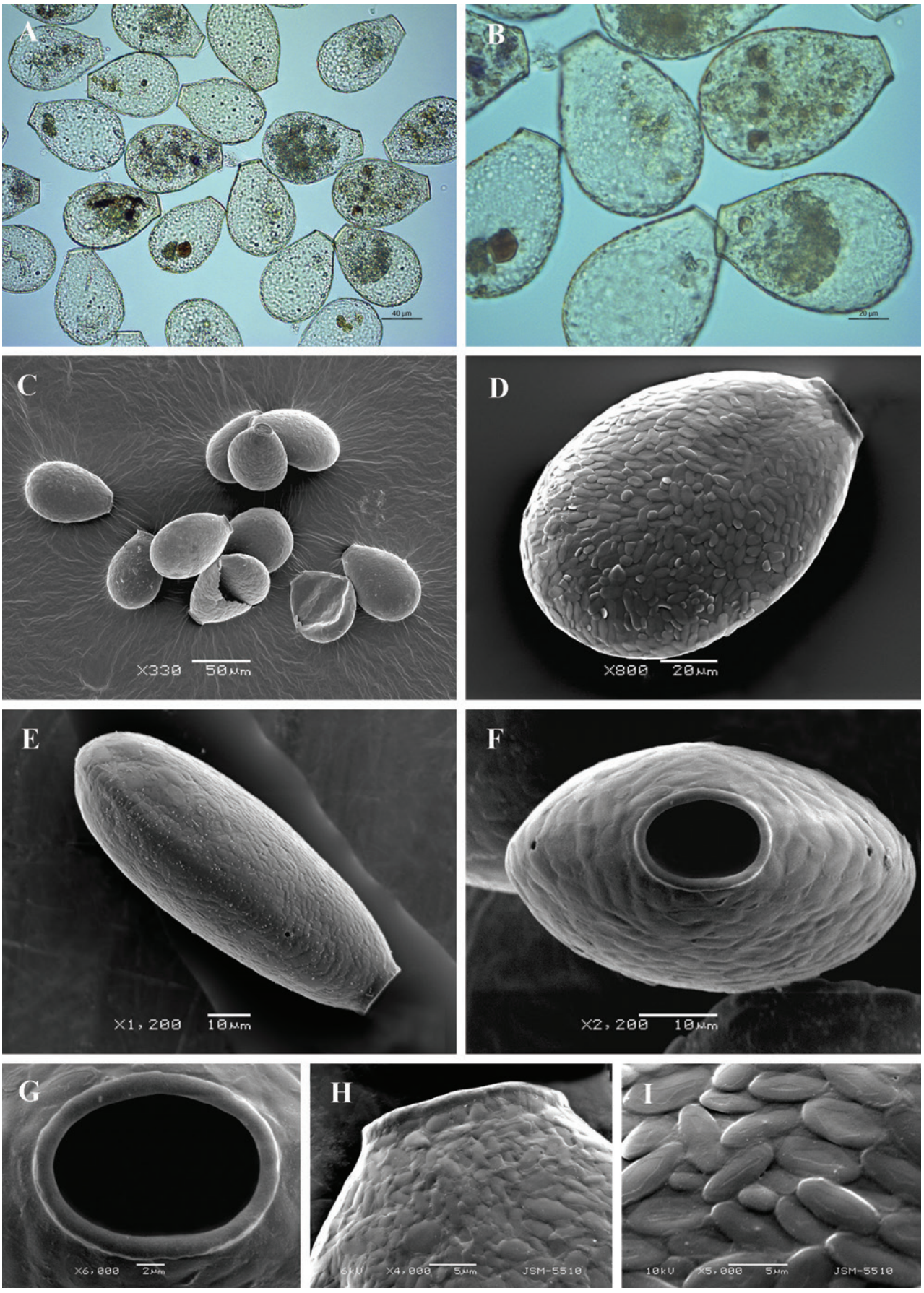
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: **Pirin Mts.** (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Golemansky and Todorov 1993, Todorov and Golemansky 2000, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 64. *Nebela tincta*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	80.6	80.6	5.18	0.95	6.43	71	90	30
Breadth	58.5	58.6	3.49	0.64	5.96	52	67	30
Large axis of aperture	17.5	17.4	1.71	0.31	9.77	15	21	30
Depth	34.5	34.5	2.03	0.64	5.89	30	37	10
Breadth/Length ratio	0.73	0.72	0.03	0.005	4.13	0.7	0.8	30
Aperture/Breadth ratio	0.30	0.29	0.02	0,005	8.34	0.3	0,4	30

Fig. 74. Light (A, B) and scanning electron (C-I) micrographs of *Nebela tincta*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D) Broad lateral view to show general shape (E) Narrow lateral view. (F) Apertural view showing lateral pores. (G) Close up view of aperture to illustrate aperture outline and collar of organic cement. (H) Broad lateral view of apertural region. (I) Detail of shell surface showing shape and arrangement of shell-plates.


A
40 µm
B
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C
X330 50µm
D
X800 20µm
E
X1,200 10µm
F
X2,200 10µm
G
X6,000 2µm
H
6kV X4,000 5µm JSM-5510
I
10kV X5,000 5µm JSM-5510

Padaungiella lageniformis (Penard, 1890) Lara et Todorov, 2012

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 158, Pl. VI, fig. 50 à 61; **Last revision:** Kosakyan et al. 2012, *Protist*, 163, p. 430, Fig. 6 A.

Synonyms: *Nebela lageniformis* Penard, 1890.

Description: Shell colourless, transparent, flask-shaped, with rounded aboral region and distinct long neck (Fig. 75 A-E); slightly compressed laterally, with oval transverse section and without lateral borders and lateral pores (Fig. 75 F); composed of small, oval, circular or quadrangular, overlapping shell-plates, arranged haphazardly (Fig. 75 D-F, I). Aperture oval, slightly convex frontally and concave laterally, bordered by a collar of organic cement (Fig. 75 D-H). Cytoplasm fulfilled with many granules and food vacuoles, fills almost whole shell; one large ovular nucleus and numerous small nucleoli; pseudopodia usually three to five, large, not very long, fast moving (Fig. 75 A, C).

Notes: The species has been recorded in both as nominal species and as *N. lageniformis.*

Ecology: Common in *Sphagnum*, rarely in forest litter and soils.

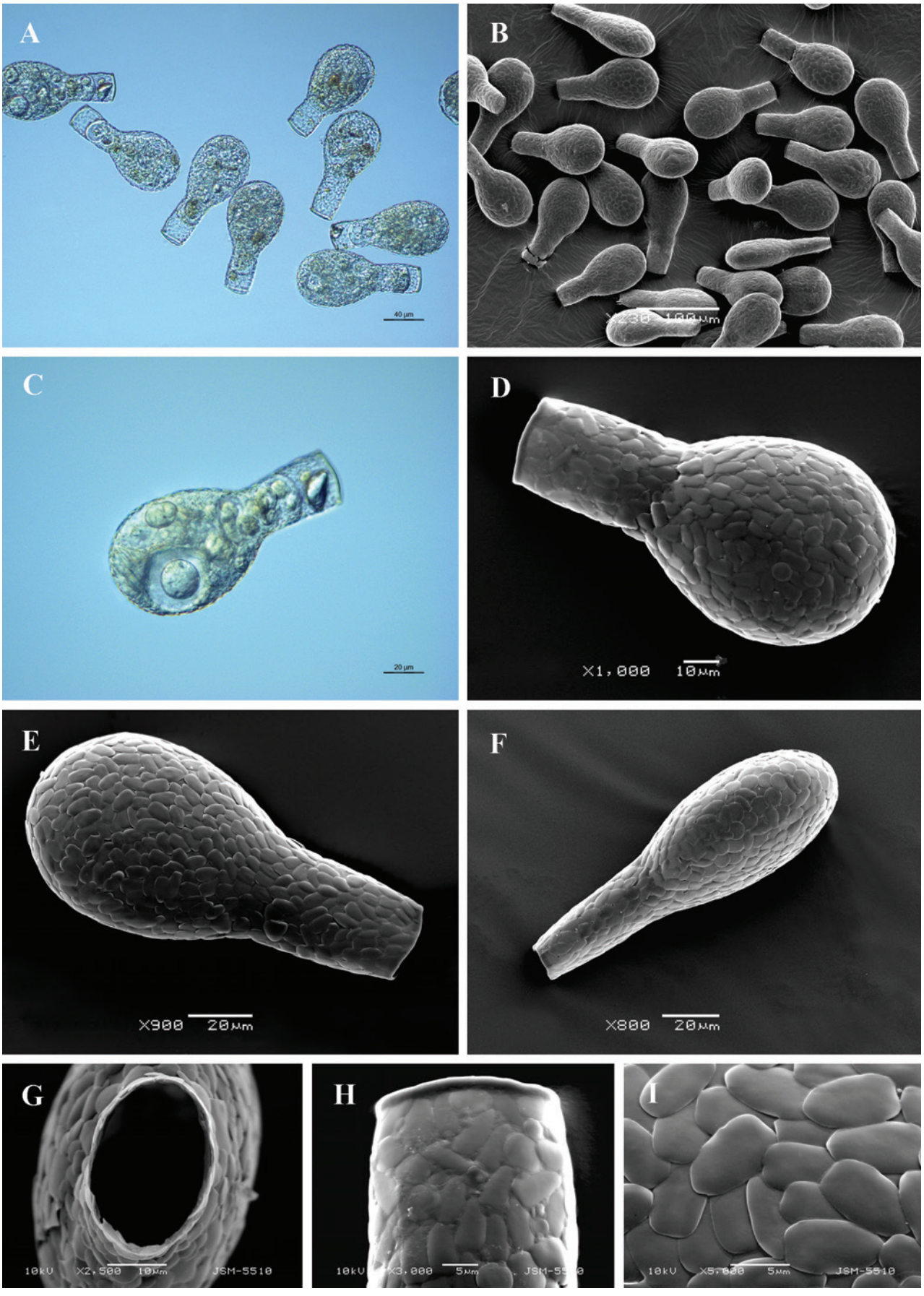
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Kosakyan et al. 2012).

Table 65. *Padaungiella lageniformis*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	118.9	120.3	8.42	1.51	7.08	101	136	31
Breadth	57.8	58.0	3.74	0.67	6.47	46	66	31
Large axis of aperture	24.4	24.4	2.08	0.37	8.52	21	29	31
Depth	39.2	38.6	3.26	0.90	8.32	34	46	13
Breadth/Length ratio	0.49	0.49	0.04	0.007	7.54	0.4	0.6	31
Aperture/Breadth ratio	0.42	0.42	0.03	0.005	7.26	0.4	0.5	31

Fig. 75. Light (A, C) and scanning electron (B, D-I) micrographs of *Padaungiella lageniformis*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen showing granular cytoplasm fulfilled with many food vacuoles and large nucleus. (D, E) Broad lateral view of two individuals showing general shape and arrangement of shell-plates. (F) Narrow lateral view. (F) Apertural view. (H) Broad lateral view of apertural region showing a thin collar of organic cement. (I) Detail of shell surface showing shape and arrangement of shell-plates.


A
40 µm
B
×230 100µm
C
20 µm
D
×1,000 10µm
E
×900 20µm
F
×800 20µm
G
10kV X2,500 10µm JSM-5510
H
10kV X3,000 5µm
I
10kV X5,000 5µm JSM-5510

Padaungiella nebeloides (Gauthier-Lièvre and Thomas, 1958) Lara et Todorov, 2012

Original description: Gauthier-Lièvre et Thomas 1958, *Archiv für Protistenkunde*, 103, p. 341, Fig. 54; **Last revision:** Kosakyan et al. 2012, *Protist*, 163, p. 430, Fig. 6 G, H.

Synonyms: *Difflugia nebeloides* Gauthier-Lièvre and Thomas, 1958; *Nebela nebeloides* (Gauthier-Lièvre and Thomas, 1958) Todorov, Golemansky and Meisterfeld, 2010.

Description: Shell yellowish-brawnish, elongated-pyriform, rounded aborally, tapering evenly towards to aperture and forming distinct neck in the anterior one third of the shell (Fig. 76 A-D); uncompressed, with circular transverse section (Fig. 76 E); composed of various in size oval, circular and quadrangular, overlapping shell-plates, arranged haphazardly, sometimes mixed with small to medium flattish pieces of quartz (Fig. 76 C, D, F, H). Organic cement is frequently seen between shell-plates; small single pores of about 200-250 nm in diameter usually well visible in the cement (Fig. 76 F, I). Aperture with irregular outline, bordered by a thick collar of organic cement, with an uneven and undulating rim (Fig. 76 C-G).

Notes: The species has been recorded in both as nominal species and as *N. nebeloides*. It should be noted that Mazei and Waren (2014) erroneously synonymized *D. nebeloides* with *D. linearis* (Penard, 1890) Gautier-Lièvre et Thomas, 1958, because they have not taken into account the fact that this species has recently been transferred from the genus *Difflugia* into the genus *Nebela* (Todorov et al. 2010) and subsequently in the newly described genus *Padaungiella* (Kosakyan et al., 2012).

Ecology: Common in *Sphagnum*.

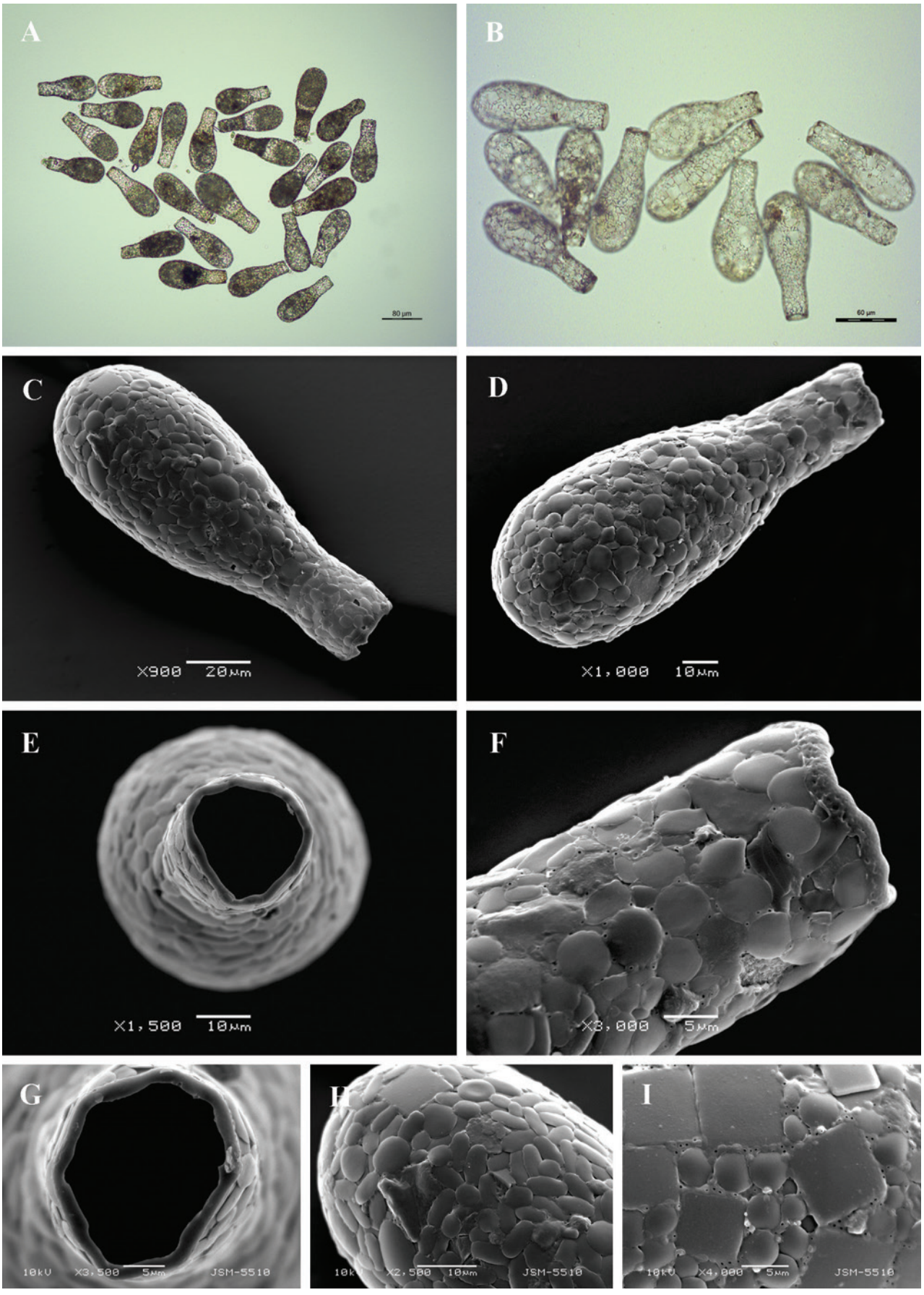
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rila Mts.** (Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Todorov et al. 2010, Bankov et al. 2018).

Table 66. *Padaungiella nebeloides*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	124.9	124.4	6.47	0.59	5.18	113	148	125
Breadth	48.6	48.0	3.17	0.28	6.53	43	59	125
Diameter of aperture	20.0	19.0	2.84	0.25	14.24	17	38	125
Breadth/Length ratio	0.39	0.39	0.02	0.002	5.40	0.3	0.5	125
Aperture/Breadth ratio	0.41	0.40	0.04	0.004	10.73	0.3	0.6	125

Fig. 76. Light (A, B) and scanning electron (C-I) micrographs of *Padaungiella nebeloides*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Broad lateral view of two individuals showing general shape. (E) Apertural view. (F) Broad lateral view of apertural region showing a thick collar of organic cement and uneven, undulating rim. (G) Close up view of aperture to show its irregular outline. (H) Detail of shell surface showing shape and arrangement of shell-plates. (I) Detail of shell surface to illustrate small pores in the organic cement.


A
80 µm
B
60 µm
C
X900 20µm
D
X1,000 10µm
E
X1,500 10µm
F
X8,000 5µm
G
10kV X3,500 5µm JSM-5510
H
10kV X2,500 10µm JSM-5510
I
10kV X4,000 5µm JSM-5510

Padaungiella tubulata (Brown, 1910) Lara et Todorov, 2012

Original description: Brown 1910, *Journal of the Linnean Society of London, Zoology*, 30, p. 365, Pl. 50, figs. 9-10; **Last revision:** Kosakyan et al. 2012, *Protist*, 163, p. 430.

Synonyms: *Nebela militaris* var. *tubulata* Brown, 1910; *Nebela tubulata* Brown, 1911.

Description: Shell colourless, transparent, flask-shaped, with rounded or ovoid aboral region and distinct long, thin neck with parallel sides (Fig. 77 A-E); slightly compressed laterally, with oval transverse section, without lateral borders and lateral pores (Fig. 77 F); composed of small, oval or circular, slightly overlapping shell-plates, arranged haphazardly (Fig. 77 D, E, G-I). Aperture oval, convex frontally and concave laterally, bordered by a thick collar of organic cement (Fig. 77 B, D-F). Cytoplasm granular, fills almost whole shell. Pseudopodia usually a few, large, not very long, fast moving.

Notes: The species has been recorded in both as nominal species and as *N. tubulata*.

Ecology: Common in *Sphagnum*.

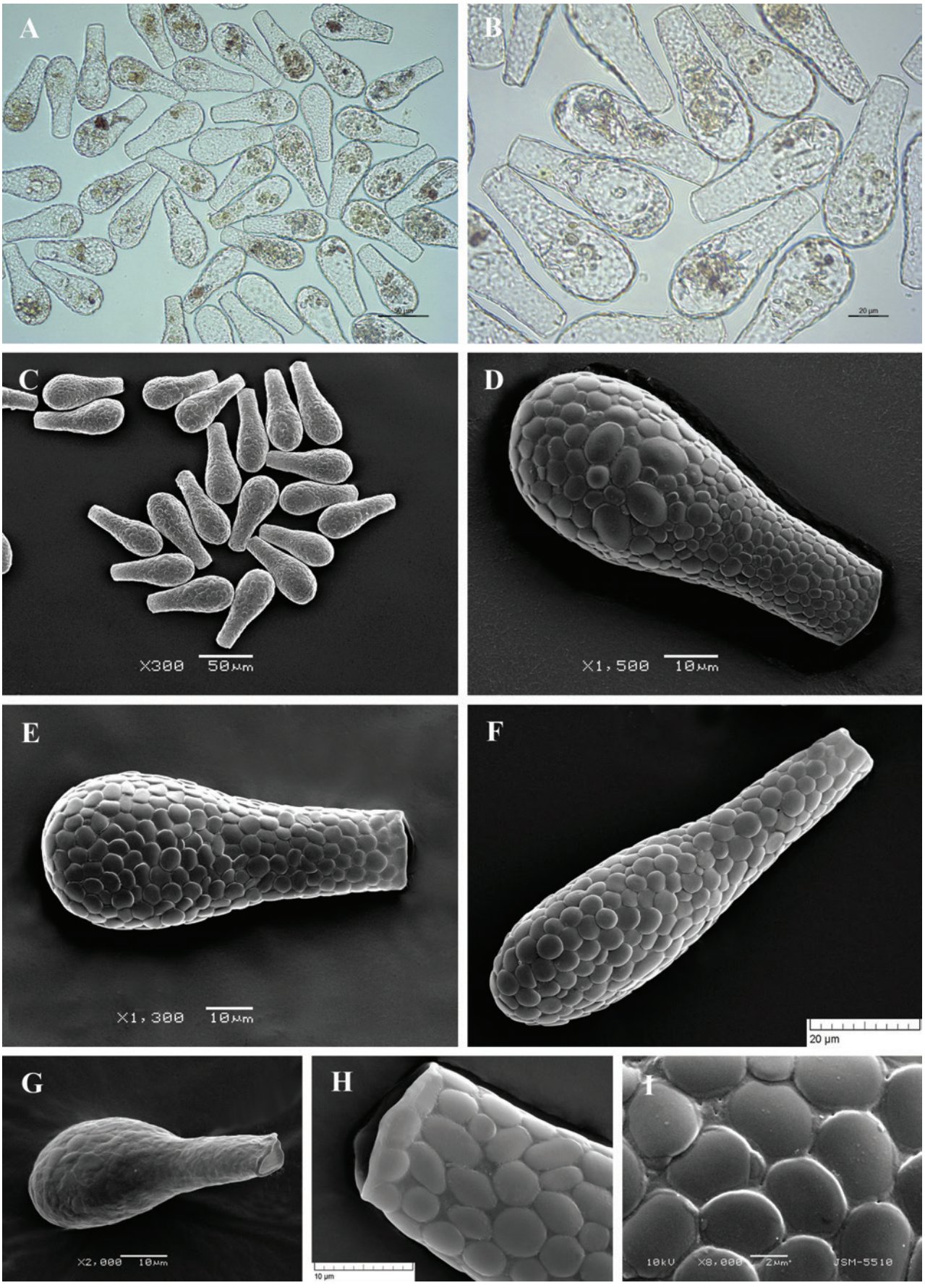
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 67. *Padaungiella tubulata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	82.9	83.0	4.28	0.77	5.17	74	90	31
Breadth	35.6	36.0	2.60	0.47	7.28	31	40	31
Large axis of aperture	15.8	16.0	1.59	0.29	10.11	11	19	31
Depth	25.8	26.0	1.70	0.40	6.58	23	29	18
Breadth/Length ratio	0.43	0.43	0.03	0.005	6.36	0.4	0.5	31
Aperture/Breadth ratio	0.44	0.44	0.05	0.009	10.87	0.3	0.6	31

Fig. 77. Light (A, B) and scanning electron (C-I) micrographs of *Padaungiella tubulata*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D, E) Broad lateral view of two individuals showing general shape and arrangement of shell-plates. (F) Lateral view. (G) Latero-apertural view. (H) Broad lateral view of apertural region showing a thin collar of organic cement and convex border of the aperture. (I) Detail of shell surface showing shape and arrangement of shell-plates.


A
B
C
X300 50µm
D
X1,500 10µm
E
X1,300 10µm
F
20 µm
G
X2,000 10µm
H
10 µm
I
10kU X8,000 2µm* JSM-5510

Padaungiella wailesi (Deflandre, 1936) Lara et Todorov, 2012

Original description: Deflandre 1936, *Annales de Protistologie*, 5, p. 265, Fig. 100, 103 (p. 262), Pl. XXII, fig. 6 à 9, PL. XXIII, fig. 1 à 4; **Last revision:** Kosakyan et al. 2012, *Protist*, 163, p. 430, Fig. 6 E, F.

Synonyms: *Nebela wailesi* Deflandre, 1936.

Description: Shell colourless, transparent, flask-shaped, with rounded aboral region, elliptic body and distinct neck of about one third of the total length (Fig. 78 A-E); slightly compressed laterally, with oval transverse section, without lateral borders and lateral pores (Fig. 78 F); composed of different in shape and size oval, circular or rarely quadrangular, overlapping shell-plates, arranged haphazardly (Fig. 78 C-E, I). Aperture oval, slightly convex frontally and concave laterally, bordered by a thick collar of organic cement (Fig. 78 D-H). Cytoplasm granular, usually with many food vacuoles, does not fills the whole shell. Pseudopodia usually one or two, large, not very long, fast moving. (Fig. 78 A, B).

Notes: The species has been recorded by the synonymous name *N. wailesi*. *Padaungiella wailesi* is very similar to *P. lageniformis* but differs from it by the smaller size, shorter neck, not so pronounced boundary betweem elliptic body and neck, as well as by its ecological preferences.

Ecology: Common in litter, mosses and soils in deciduous forests, rare in *Sphagnum*.

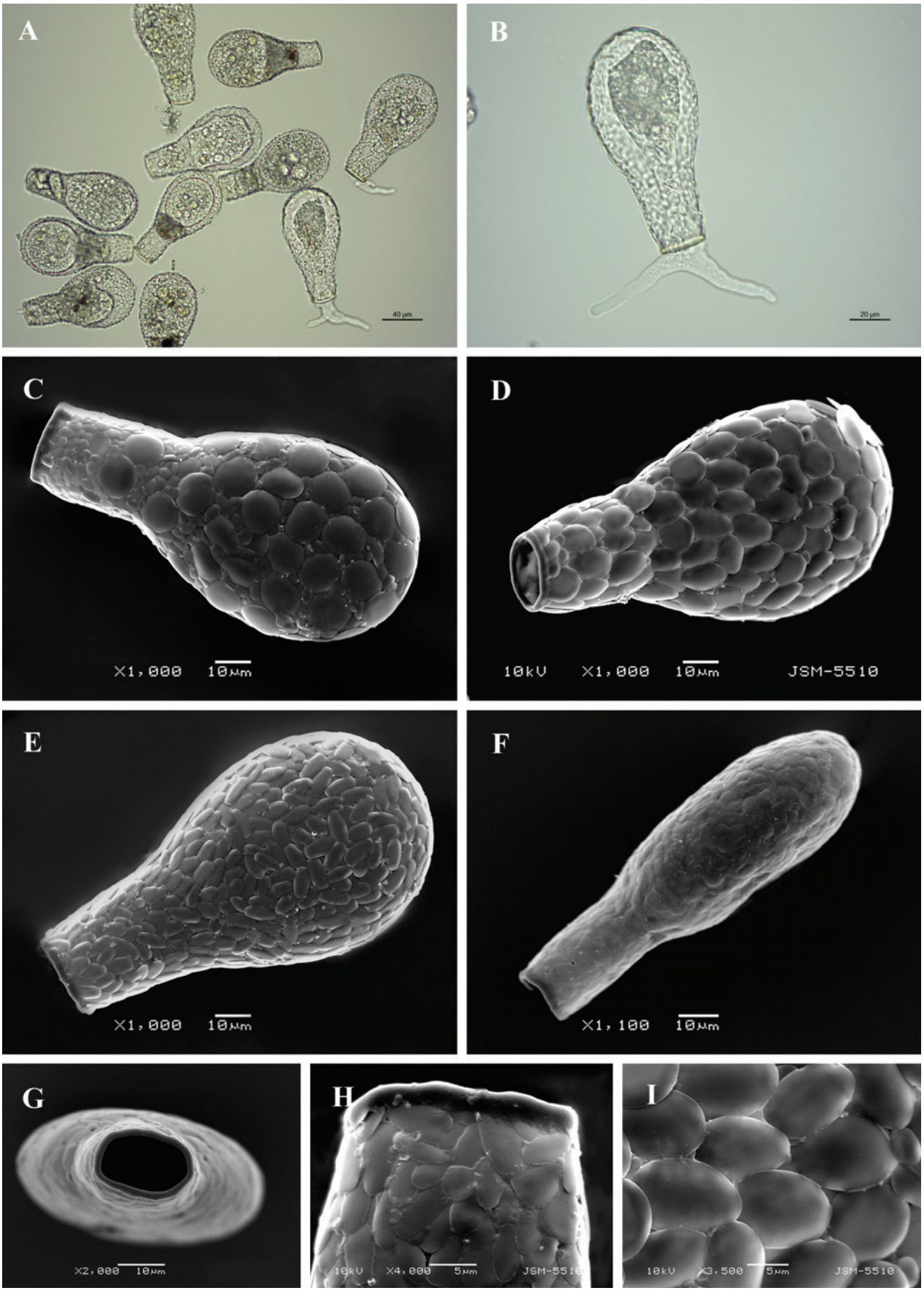
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Golemansky et al. 2006).

Table 68. *Padaungiella wailesi*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	107,6	106,5	5,25	0,91	4,88	95	117	33
Breadth	55,4	55,2	1,78	0,31	3,21	52	58	33
Large axis of aperture	21,2	21,4	1,22	0,21	5,75	19	24	33
Depth	30,7	30,7	1,21	0,21	3,94	28	33	33
Breadth/Length ratio	0,52	0,52	0,02	0,003	3,85	0,49	0,55	33
Aperture/Breadth ratio	0,38	0,38	0,02	0,004	5,26	0,33	0,42	33

Fig. 78. Light (A, B) and scanning electron (C-I) micrographs of *Padaungiella wailesi*. (A) View of several specimens to illustrate variability in shape and size of the shell. (B) View of live specimen showing granular cytoplasm and pseudopodia. (C-E) Broad lateral view of three specimens showing different shape and size of shell-plates. (F) Narrow lateral view. (G) Apertural view. (H) Broad lateral view of apertural region showing a thick collar of organic cement. (I) Detail of shell surface showing shape and arrangement of shell-plates.


A
40 µm
B
20 µm
C
X1,000 10µm
D
10kV X1,000 10µm JSM-5510
E
X1,000 10µm
F
X1,100 10µm
G
X2,000 10µm
H
10kV X4,000 5µm JSM-5510
I
10kV X3,500 5µm JSM-5510

Planocarina carinata (Archer, 1867) Kosakyan, Lahr, Mulot, Meisterfeld, Mitchell and Lara, 2016

Original description: Archer 1867, *Quarterly Journal of Microscopical Science*, 7, p. 178; **Last revision:** Kosakyan et al. 2016, *Cladistics*, 32, p. 17.

Synonyms: *Nebela carinata* (Archer, 1867) Leidy, 1879.

Description: Shell colourless, transparent, pyriform, with sides tapering evenly and gradually from rounded aboral region towards to aperture (Fig. 79 A-E); laterally compressed, oval to ellipsoidal transverse section; with pronounced flattened lateral margin, surrounding almost entirely the shell, two lateral pores (Fig. 79 F-G); composed mainly of small, oval or circular, mainly flattish, slightly overlapping shell-plates, arranged haphazardly and embedded in thick layer of organic cement (Fig. 79 E-I). Aperture oval, slightly convex or truncate, bordered by thin collar of organic cement (Fig. 79 E-H).

Notes: *Planocarina carinata* differs from *P. marginata* and *G. galeata* by the pronounced, broad and strongly flattened lateral margin. The species has been recorded in both as nominal species and as synonym *N. carinata*.

Ecology: In *Sphagnum*, very rare in Bulgaria.

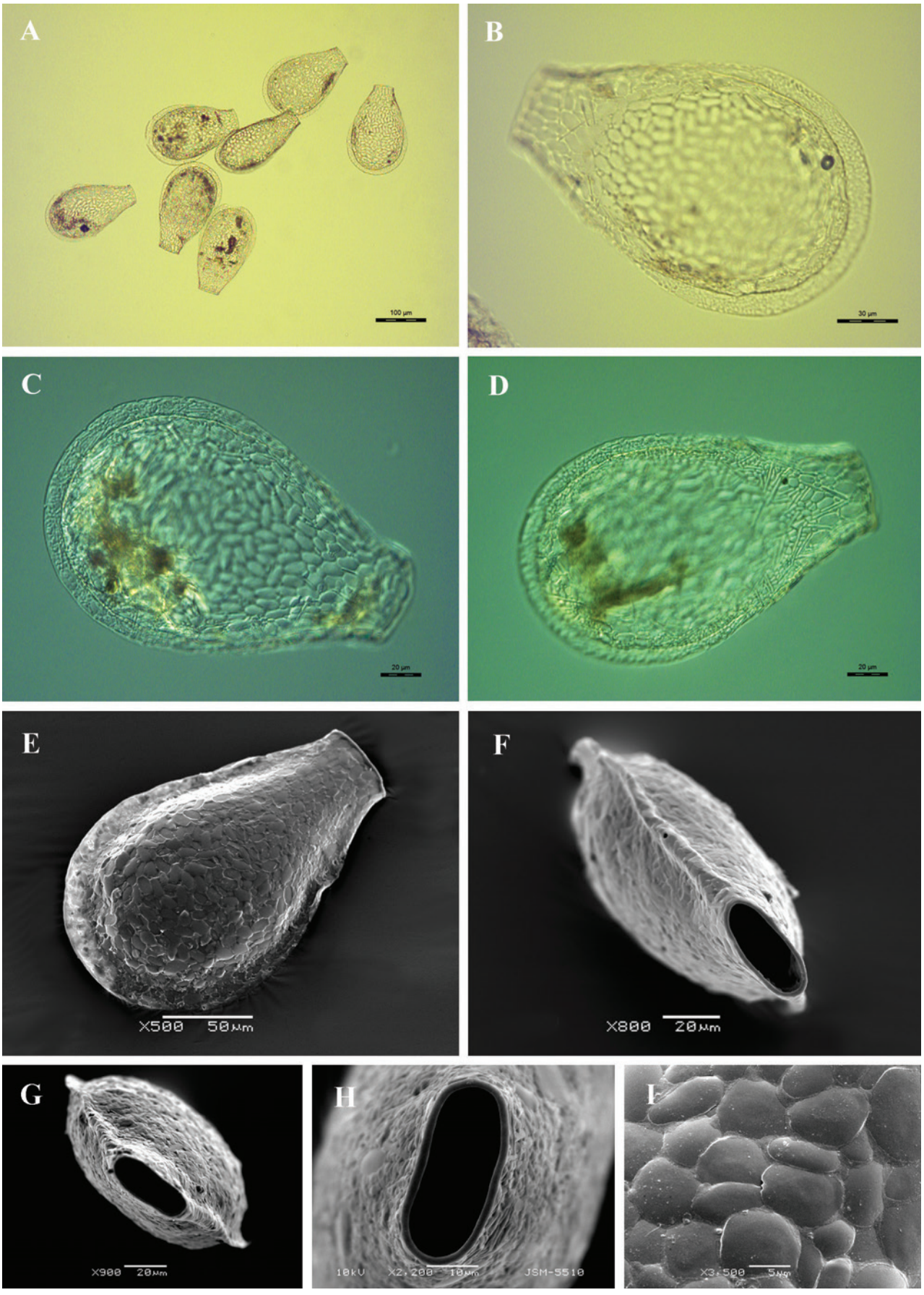
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: **Rila Mts.** (Golemansky and Todorov 1993); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995).

Table 69. *Planocarina carinata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	184.2	185.6	9.48	1.40	5.15	156	204	46
Breadth	119.3	119.5	8.02	1.18	6.72	102	133	46
Large axis of aperture	40.4	40.6	2.42	0.36	5.99	36	47	46
Depth	64.2	64.0	3.77	1.68	5.87	60	70	5
Breadth/Length ratio	0.65	0.65	0.03	0.005	4.61	0.6	0.8	46
Aperture/Breadth ratio	0.34	0.33	0.03	0.004	8.82	0.3	0.4	46

Fig. 79. Light (A-D) and scanning electron (E-I) micrographs of *Planocarina carinata*. (A) View of several specimens to illustrate variability in shape and size of the shell. (B-E) Broad lateral view of four specimens showing general shape and distinct flattened lateral margin. (F) Latero-apertural view to illustrate flattened lateral margin and lateral pore. (G) Apertural view. (H) Close up view of aperture showing its oval outline and thin apertural collar. (I) Detail of shell surface to illustrate shape and arrangement of shell-plates in thick layer of organic cement.


A
100 µm
B
30 µm
C
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D
20 µm
E
X500 50µm
F
X800 20µm
G
X900 20µm
H
10kV X2,200 10µm JSM-5510
I
X3,500 5µm

Quadrulella longicollis (Taranek, 1882)

Original description: Taranek 1882, *Abhandlungen der Königlich Böhmischen Gesellschaft der Wissenschaften*, 11, p. 48, Taf. IV, fig. 19; **Last revision:** Kosakyan et al. 2012, p. 429, Fig. 5D.

Synonyms: *Quadrulella symmetrica* var. *longicollis* Taranek, 1882.

Description: Shell colourless, transparent, elongate-pyriform, with sides tapering evenly and gradually from rounded aboral region towards to aperture, forming long neck; laterally compressed, with oval transverse section (Fig. 80 A-E); composed of quadrangular shell-plates with different size, smaller near the aperture, usually arranged in rows (Fig. 80 C-F, I). Aperture terminal, oval, slightly convex frontally and concave laterally, bordered by a thin collar of organic cement (Fig. 80 C, D, F-H). Cytoplasm granular, fills about two-thirds of the shell, with numerous food vacuoles; one large ovular nucleus with a few small nucleoli. Pseudopodia usually one or two, long, digitiform, fast moving.

Notes: The species has been recorded in both as nominal species and as *Quadrulella symmetrica* var. *longicollis*. *Quadrulella longicollis* differs from *Q. symmetrica* by its larger size and by the elongated shell with pronounced long neck (B/L ratio 0.3-0.5 versus 0.5-0.7).

Ecology: Common in *Sphagnum*.

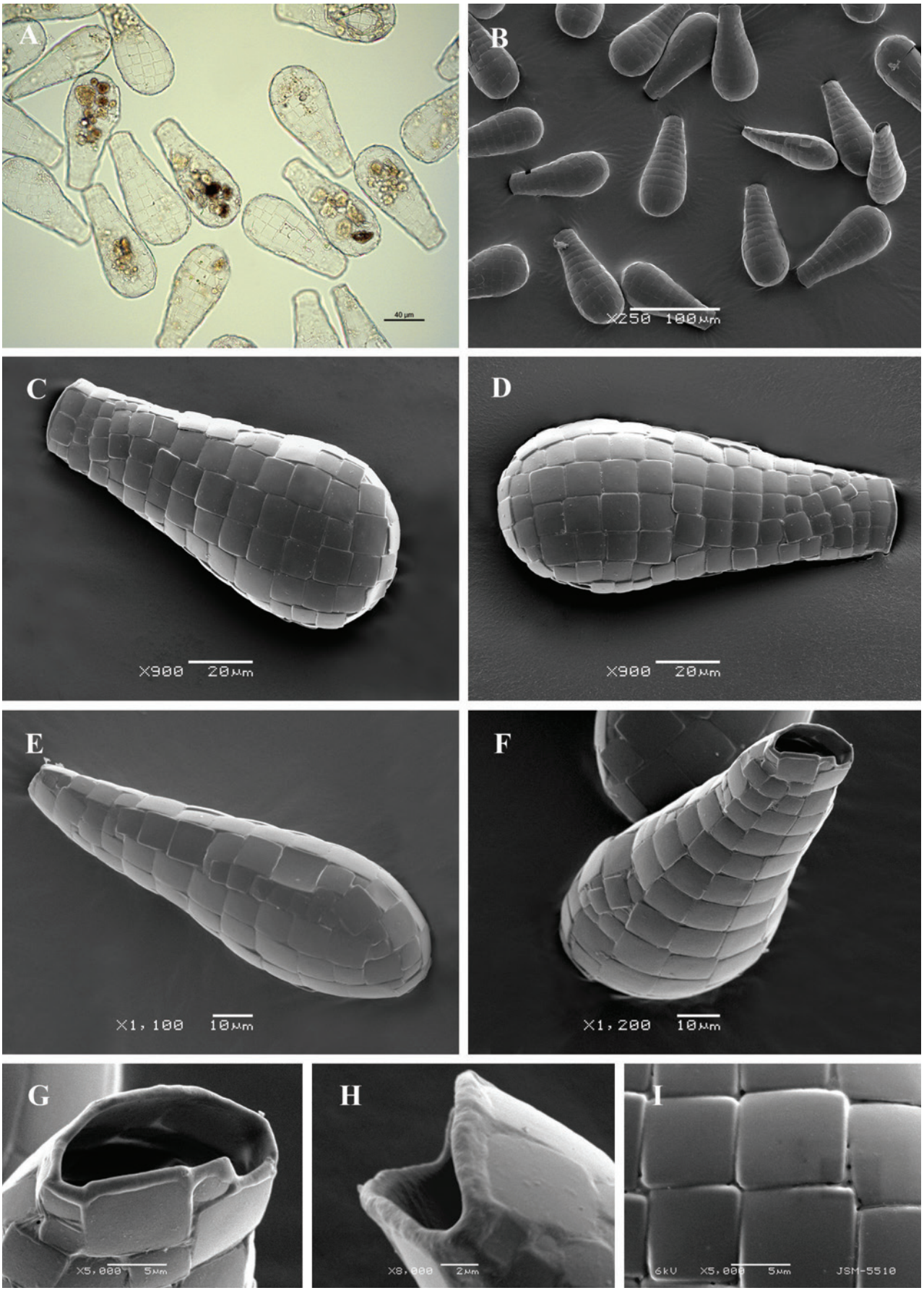
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Kosakyan et al. 2012, Bankov et al. 2018).

Table 70. *Quadrulella longicollis*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	120.0	119.6	10.63	1.94	8.86	103	156	30
Breadth	53.5	54.1	4.95	0.90	9.25	42	62	30
Aperture width	23.5	23.7	2.84	0.52	12.08	18	30	30
Depth	38.8	38.1	3.99	1.07	10.28	32	46	14
Breadth/Length ratio	0.45	0.46	0.04	0.008	9.63	0.3	0.5	30
Aperture/Breadth ratio	0.44	0.44	0.05	0.01	12.36	0.4	0.6	30

Fig. 80. Light (A) and scanning electron (B-I) micrographs of *Quadrulella longicollis*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Broad lateral view of two individuals to show the general shape. (E) Narrow lateral view. (F) Apertural view. (G) Close up view of aperture to illustrate its elliptical shape and bordering thin collar of organic cement (H) Lateral view of aperture. (I) Detail of shell surface showing shape and arrangement of shell-plates.


A
40 µm
B
X250 100µm
C
X900 20µm
D
X900 20µm
E
X1,100 10µm
F
X1,200 10µm
G
X5,000 5µm
H
X8,000 2µm
I
6kV X5,000 5µm JSM-5510

Quadrulella symmetrica (Wallich, 1863) Cockerell, 1909

Original description: Wallich 1863, *Annals and Magazine of Natural History*, ser. 3, v. 12, no 72, p. 458, Pl. 8, fig. 16; **Last revision:** Cockerell 1909, *Zoologischer Anzriger*, 34: p. 565.

Synonyms: *Difflugia proteiformis* var. *symmetrica* Wallich, 1863; *Difflugia pyriformis* var. *symmetrica* Wallich, 1864; *Difflugia symmetrica* Wallich, 1864; *Assulina assulata* Ehrenberg, 1871; *Assulina leptolepis* Ehrenberg, 1871; *Difflugia assulata* Ehrenberg, 1871; *Difflugia carolensis* Ehrenberg, 1871; *Quadrula symmetrica* Schulze, 1875; *Nebela (Quadrulella) symmetrica* Deflandre, 1936.

Description: Shell colourless, transparent, ovoid or pyriform, with sides tapering evenly and gradually from rounded aboral region towards to aperture; laterally compressed, with oval transverse section (Fig. 81 A-E); composed of quadrangular shell-plates with different size, smaller near the aperture, usually arranged in rows (Fig. 81 D-F, I). Aperture terminal, oval, slightly convex frontally and concave laterally, bordered by a thin collar of organic cement (Fig. 81 E-H). Cytoplasm granular, fills about two-thirds of the shell, with numerous food vacuoles; one large ovular nucleus and numerous small nucleoli; pseudopodia usually one or two, long, digitiform, fast moving (Fig. 81 A, C).

Notes: Besides the nominal species, the infrasubspecific taxon *Quadrulella symmetrica* var. *irregularis* Wailes et Penard, 1911 has also been recorded.

Ecology: Common in *Sphagnum*.

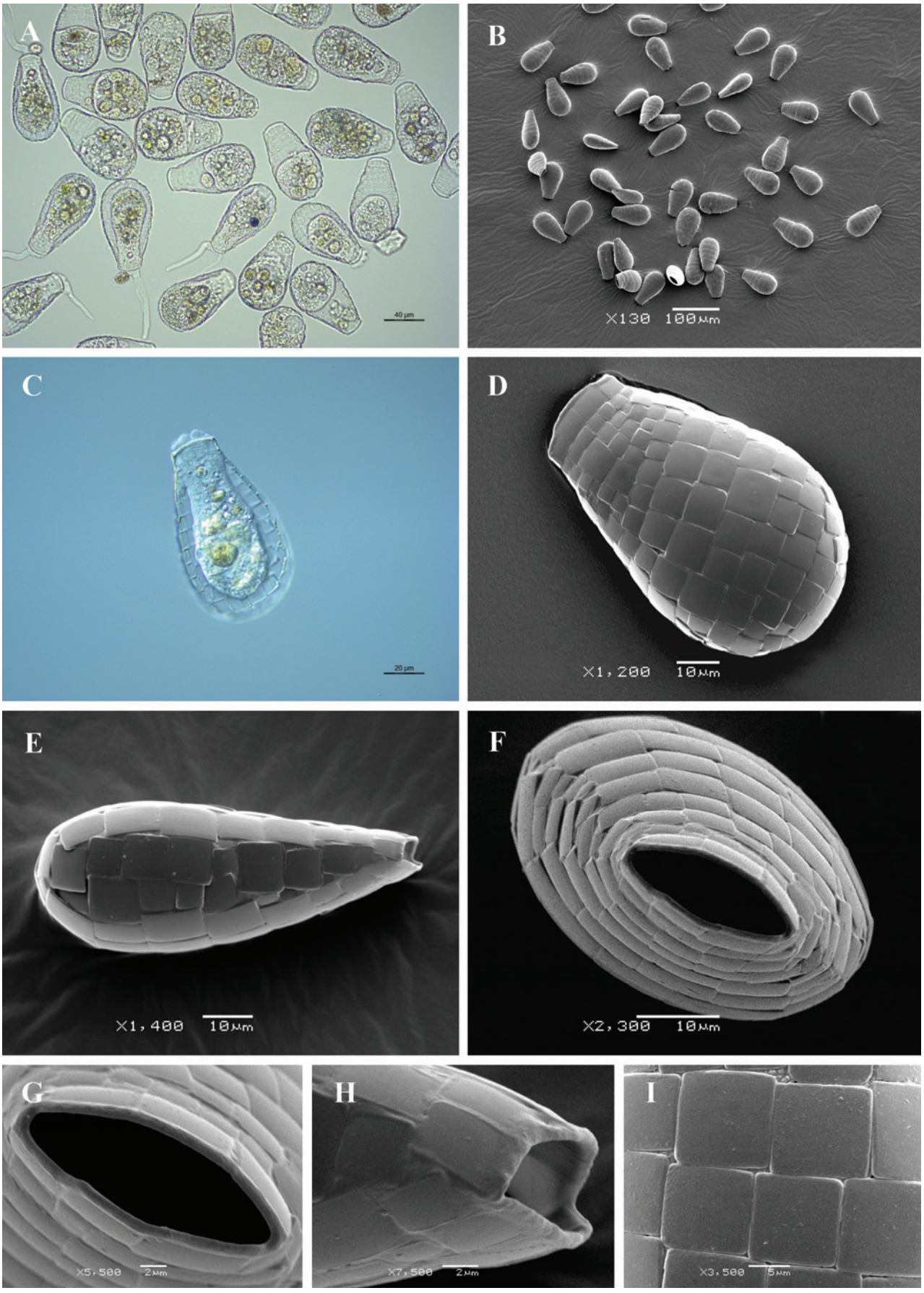
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Kosakyan et al. 2012, Bankov et al. 2018).

Table 71. *Quadrulella symmetrica*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	84,5	84,5	4,47	0,67	5,29	72	93	44
Breadth	47,2	47,0	3,68	0,55	7,80	41	59	44
Aperture width	21,7	21,6	1,65	0,25	7,60	19	26	44
Depth	32,3	32,0	4,74	1,01	14,67	22	43	22
Breadth/Length ratio	0,56	0,56	0,04	0,007	7,14	0,47	0,66	44
Aperture/Breadth ratio	0,46	0,46	0,03	0,005	6,52	0,38	0,55	44

Fig. 81. Light (A, C) and scanning electron (B, D-I) micrographs of *Quadrulella symmetrica*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen to show granular cytoplasm. (D) Broad lateral view. (E) Narrow lateral view. (F) Apertural view. (G) Close up view of aperture to illustrate its elliptical shape and bordering thin collar of organic cement (H) Lateral view of aperture. (I) Detail of shell surface showing shape and arrangement of shell-plates.


A
40 µm
B
X130 100µm
C
20 µm
D
X1,200 10µm
E
X1,400 10µm
F
X2,300 10µm
G
X5,500 2µm
H
X7,500 2µm
I
X3,500 5µm

Quadrulella variabilis Kosakyan, Lahr, Mulot, Meisterfeld, Mitchell and Lara, 2016

Original description: Kosakyan et al. 2016, *Cladistics*, 32, p. 15, Fig. 2.

Description: Shell colourless, transparent, elongate-pyriform, with sides tapering evenly and gradually from rounded aboral region towards to aperture, sometimes forming long neck; laterally compressed, with oval to ellipsoidal transverse section (Fig. 82 A-F); composed of quadrangular shell-plates with different size, smaller near the aperture, usually arranged in rows (Fig. 82 C-F, I). Aperture terminal, oval, slightly convex frontally and concave laterally, bordered by a thin collar of organic cement (Fig. 82 C-E, G, H). Cytoplasm granular, fills about two-thirds of the shell, with numerous food vacuoles (Fig. 82 A). Pseudopodia usually one or two, long, digitiform, fast moving.

Notes: *Quadrulella variabilis* differs from *Q. symmetrica* by the smaller size of the shell and shell-plates and from *Q. longicollis* by about two times smaller shell and not so well defined long neck.

Ecology: In *Sphagnum*.

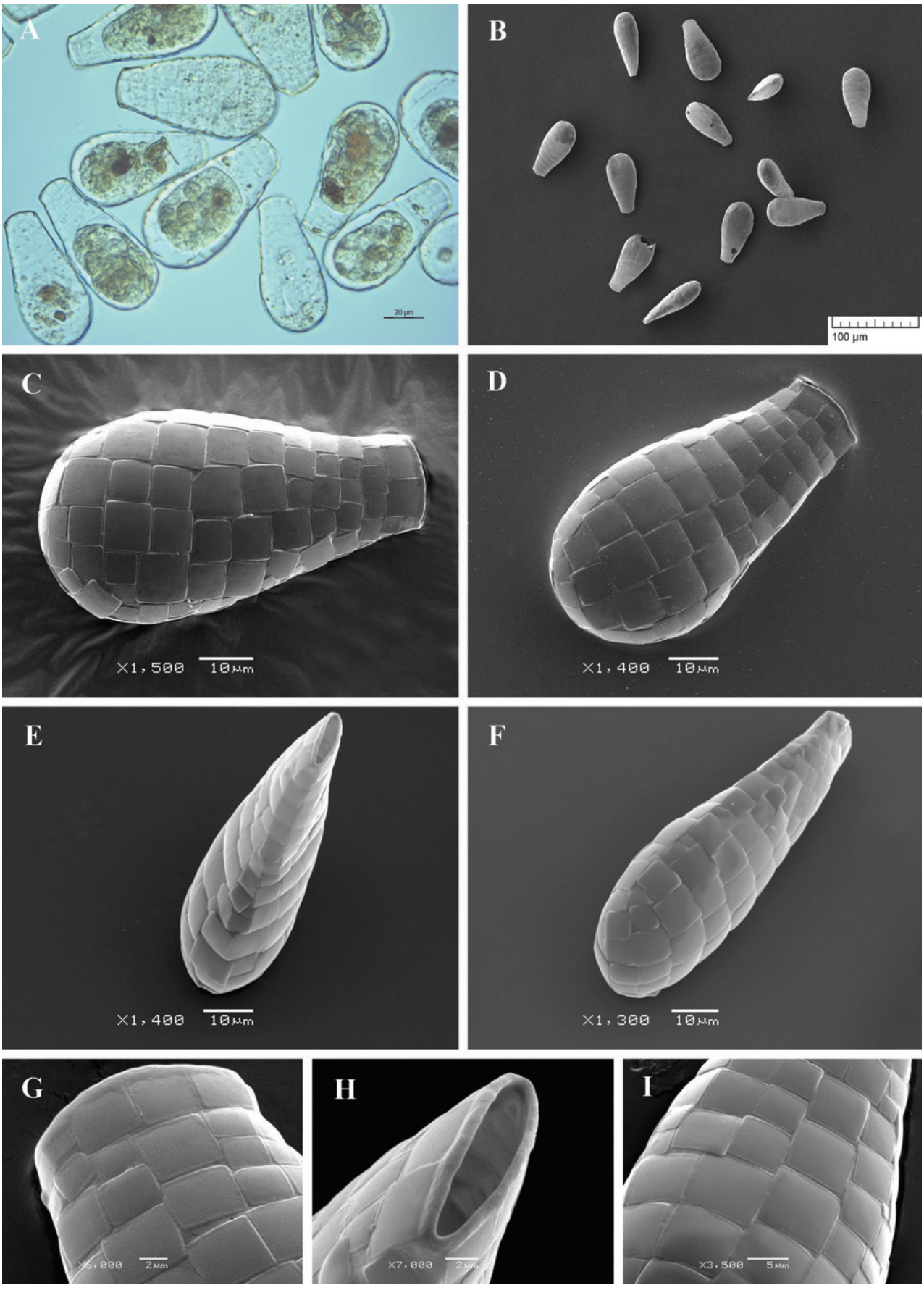
Geographical distribution: Recently described from Switzerland, still unknown.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rila Mts.** (Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Bankov et al. 2018).

Table 72. *Quadrulella variabilis*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	72,4	72,1	3,02	0,51	4,17	67	80	35
Breadth	38,3	38,9	2,49	0,42	6,50	32	42	35
Aperture width	17,4	17,8	1,11	0,19	6,38	14	19	35
Depth	28,8	28,4	1,24	0,32	4,31	27	31	15
Breadth/Length ratio	0,53	0,54	0,04	0,006	7,55	0,41	0,59	35
Aperture/Breadth ratio	0,45	0,45	0,02	0,004	4,44	0,40	0,54	35

Fig. 82. Light (A) and scanning electron (B-I) micrographs of *Quadrulella variabilis*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Broad lateral view of two specimens to show the general shape. (E) Latero-apertural view. (F) Narrow lateral view. (G) Lateral view of aperture. (H) Close up view of aperture to illustrate its elliptical shape and bordering thin collar of organic cement (I) Detail of shell surface showing shape and arrangement of shell-plates.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F
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G
×5,000 2µm
H
×7,000 2µm
I
×3,500 5µm

Heleopera petricola Leidy, 1879

Original description: Leidy 1879, *Report of the United States Geological Survey of the Territories*, 12, p. 165, Pl. XXVI, figs. 12-20.

Description: Shell transparent, colorless, sometimes brownish or purple, ovoid; with rounded aboral region and almost parallel or slightly convex lateral margins; laterally compressed, elliptical in transverse section (Fig. 83 A-F). Anterior half of the shell smooth and composed of siliceous shell-plates; posterior part rough, covered mainly of small to medium quartz particles, mixed with fragments of diatom frustules (Fig. 83 C-E). Aperture terminal, broad, elliptical, slightly convex, with acute commissures and bordered by a thin collar of organic cement (Fig. 83 E-I). Cytoplasm abundant, fills about two-thirds of the shell, without symbiotic zoochlorellae; one large ovular nucleus and many small nucleoli; encysted specimens frequently seen, cysts round or ovale, brown, with thick organic wall, occupying central region of the shell; pseudopodia numerous, short, digitiform, slow moving. (Fig. 83 A, B).

Ecology: Frequent in *Sphagnum*.

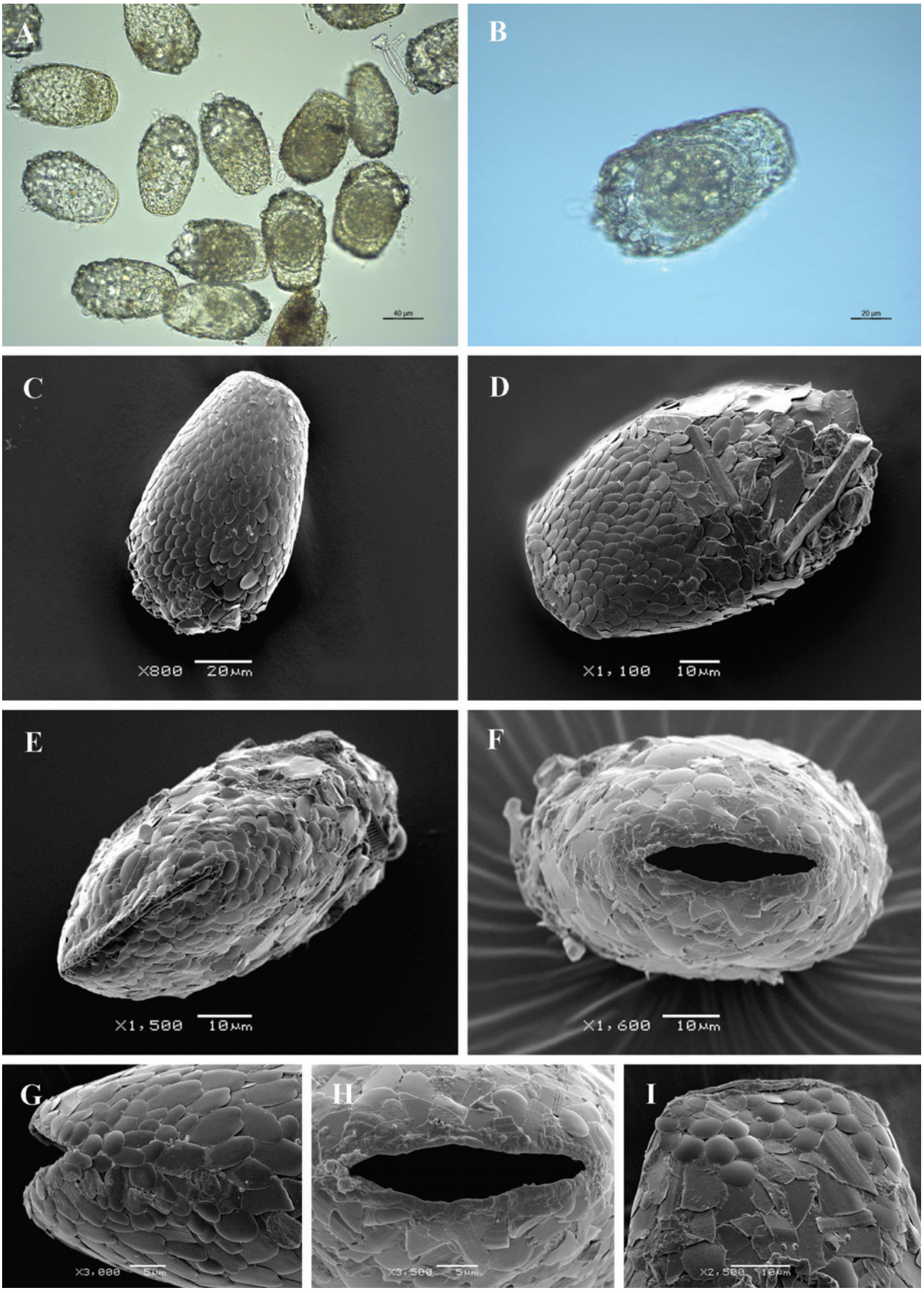
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 73. *Heleopera petricola*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	97,9	98,2	7,52	1,33	7,68	78	111	32
Breadth	63,3	63,0	6,92	1,22	10,9	51	80	32
Large axis of aperture	35,6	35,3	4,46	0,79	12,5	27	43	32
Depth	43,3	42,9	3,76	0,97	8,68	37	49	15
Breadth/Length ratio	0,6	0,6	0,07	0,01	11,67	0,48	0,78	32
Aperture/Breadth ratio	0,6	0,5	0,08	0,01	13,33	0,41	0,74	32

Fig. 83. Light (A, B) and scanning electron (C-I) micrographs of *Heleopera petricola*. (A) View of several specimens to illustrate variability in shape and size of the shell. (B) View of encysted specimen. (C-D) Broad lateral view of two specimens showing variability of shell structure. (E) Apertural view to show narrow, closed aperture of encysted specimen. (F) Apertural view showing elliptical aperture with acute commissures. (G) Lateral view of aperture. (H) Close up view of aperture showing the bordering thin collar of organic cement. (I) Portion of shell to show arrangement of particles in anterior part of the shell.


A
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D
X1,100 10µm
E
X1,500 10µm
F
X1,600 10µm
G
X3,000 5µm
H
X3,500 5µm
I
X2,500 10µm

Heleopera rosea Penard, 1890

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 166, Pl. VII, fig. 59 à 78.

Description: Shell transparent, reddish or purple, ovoid, with sides tapering evenly and gradually from rounded aboral region towards to aperture, laterally compressed, elliptical in transverse section (Fig. 84 A-E). Anterior half of the shell smooth and composed of siliceous shell-plates, posterior part rough, covered of small to medium mainly flattish quartz particles (Fig. 84 D-I). Aperture terminal, slightly convex, thin linear slit, bordered by thin transparent band of organic cement, with pronounced acute commissures laterally (Fig. 84 C-G). Cytoplasm abundant, fills about two-thirds of the shell, without symbiotic zoochlorellae; one large ovular nucleus and many nucleoli; encysted specimens frequently seen, cysts round or ovale, brown, with thick organic wall, occupying central region of the shell (Fig. 84 A, C). Pseudopodia numerous, short, digitiform, slow moving.

Ecology: Common in *Sphagnum*.

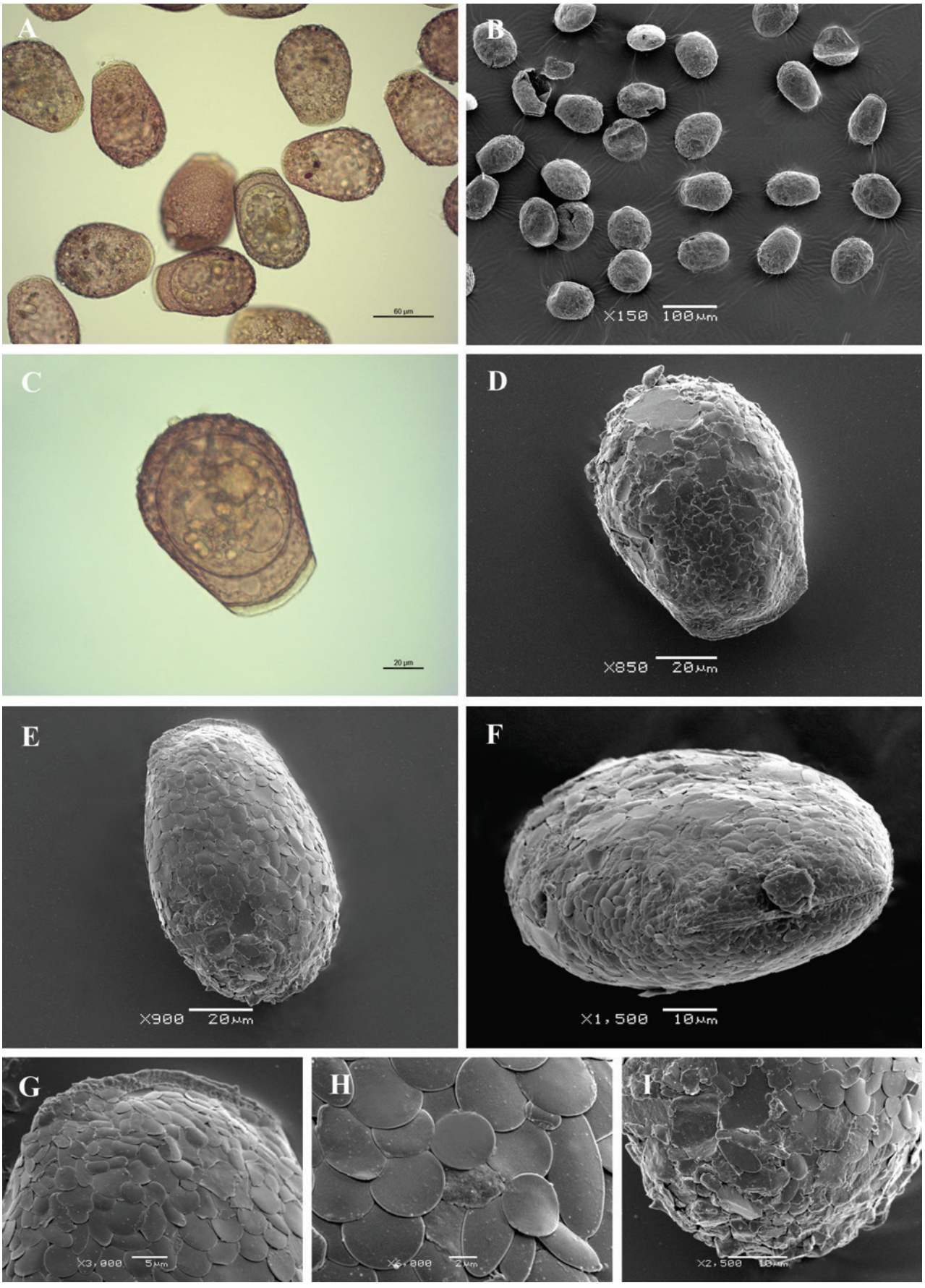
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 74. *Heleopera rosea*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	101,0	102,0	6,55	1,20	6,49	90	116	30
Breadth	69,7	71,0	6,51	1,19	9,34	56	80	30
Large axis of aperture	38,9	39,9	5,59	1,02	14,39	28	49	30
Depth	45,0	44,5	3,23	0,67	7,19	40	51	23
Breadth/Length ratio	0,69	0,68	0,06	0,01	8,60	0,6	0,9	30
Aperture/Breadth ratio	0,56	0,56	0,07	0,07	12,69	0.4	0,7	30

Fig. 84. Light (A, C) and scanning electron (B, D-I) micrographs of *Heleopera rosea*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of encysted specimen. (D, E) Broad lateral view of two specimens showing variability of shell structure. (F) Apertural view to show a narrow, closed aperture of encysted specimen. (G) Broad lateral view of aperture showing the bordering thin band of organic cement. (H) Portion of anterior part of the shell to show its smooth surface, composed of siliceous shell-plates. (I) Portion of posterior part of the shell to show its rough surface, covered mainly by flattish quartz particles.


A
60 µm
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C
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X850 20µm
E
X900 20µm
F
X1,500 10µm
G
X3,000 5µm
H
X6,000 2µm
I
X2,500 10µm

Heleopera sphagni (Leidy, 1874)

Original description: Leidy 1874b, *Proceedings of the Academy of Natural Sciences of Philadelphia***,** 26, p. 157.

Synonyms: *Difflugia (Nebela) sphagni* Leidy, 1874; *Nebela sphagni* Leidy, 1876; *Heleopera picta* Leidy, 1879.

Description: Shell transparent, yellow or brown, ovoid, with sides tapering evenly and gradually from rounded aboral region towards to aperture, laterally compressed, with elliptical transverse section (Fig. 85 A-E). Anterior half of the shell smooth, composed of siliceous shell-plates, posterior part rough, covered of small to medium mainly flattish quartz particles (Fig. 85 A-D). Aperture terminal, broad, elliptical, slightly convex, laterally concave, with acute commissures, bordered by thin collar of organic cement (Fig. 85 A-G). Cytoplasm does not fills the whole shell, always fulfilled with symbiotic zoochlorellae; encysted specimens frequently seen, cysts round, with zoochlorellae and thick organic wall, occupying central region of the shell. Pseudopodia numerous, long, digitiform, sometimes bifurcated, slow moving.

Ecology: In *Sphagnum*, very rare in Bulgaria.

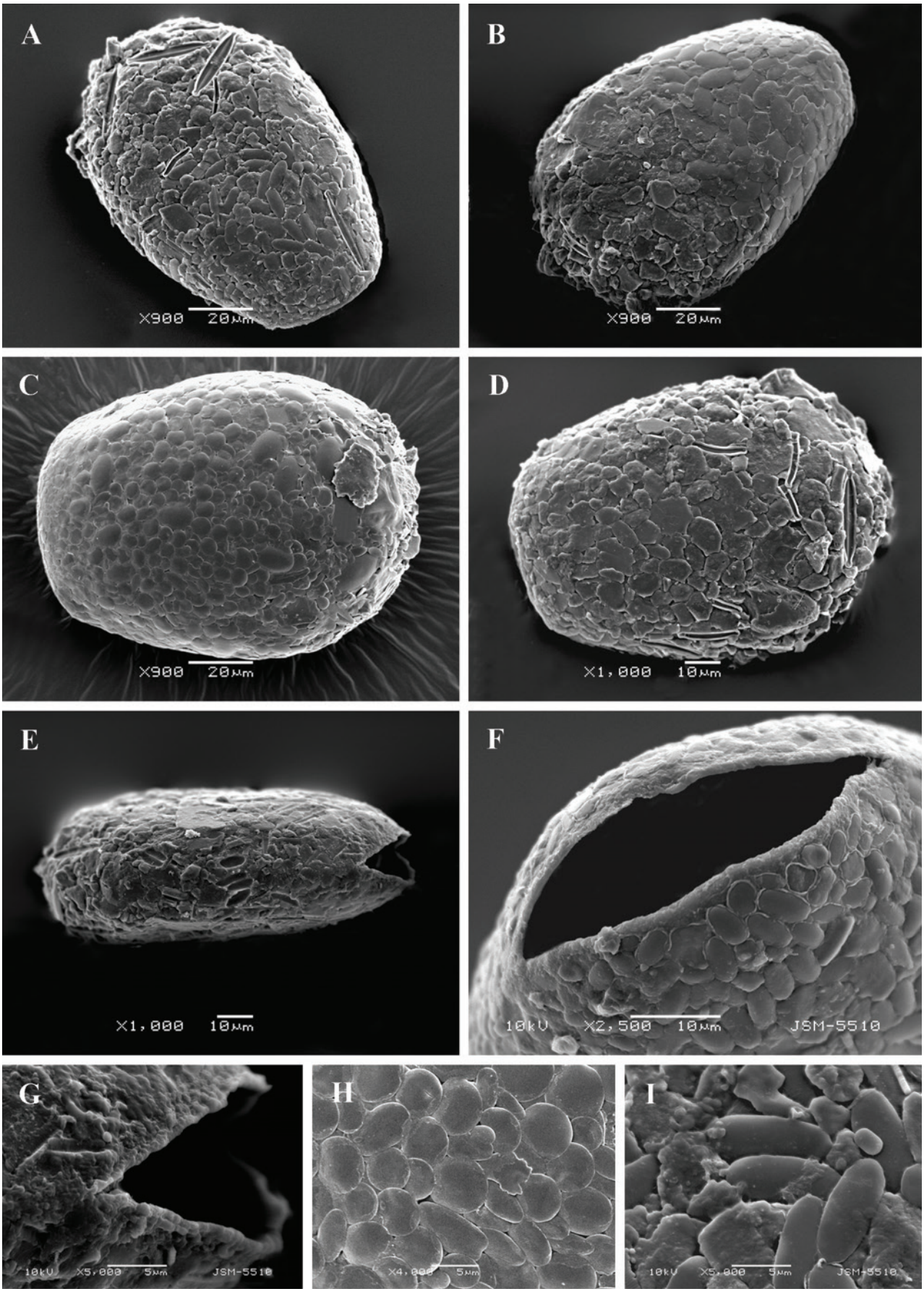
Geographical distribution: Probably cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993).

Table 75. *Heleopera sphagni*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	107,1	106,4	3,32	0,78	3,10	103	117	18
Breadth	76,4	74,8	4,01	0,95	5,25	73	89	18
Large axis of aperture	45,2	43,7	3,68	0,87	8,14	42	55	18
Depth	44,3	43,7	2,00	0,53	4,51	42	49	14
Breadth/Length ratio	0,7	0,7	0,02	0,005	2,86	0,68	0,76	18
Aperture/Breadth ratio	0,6	0,6	0,02	0,005	3,33	0,56	0,64	18

Fig. 85. Scanning electron micrographs of *Heleopera sphagni*. (A-D) Broad lateral view of four specimens to illustrate variability in shape and structure of the shell. (E) Narrow lateral view. (F) Close up view of aperture to show a narrow elliptical aperture. (G) Lateral view showing acute commissures of aperture. (H, I) Details of shell surface showing differences in shape and arrangement of shell-plates.


A
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X900 20µm
C
X900 20µm
D
X1,000 10µm
E
X1,000 10µm
F
10kV X2,500 10µm JSM-5510
G
10kV X5,000 5µm JSM-5510
H
X4,000 5µm
I
10kV X5,000 5µm JSM-5510

Heleopera sylvatica Penard, 1890

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 168, Pl. VII, fig. 79 à 94.

Description: Shell transparent, colorless or yellowish, ovoid, with sides tapering evenly and gradually from rounded aboral region towards to aperture (Fig. 86 A-D); laterally compressed, with oval transverse section (Fig. 86 E-G); composed of different in size circular, overlapping, siliceous shell-plates, usually arranged regularly to give smooth outline (Fig. 86 D-G, I); sometimes with attached few siliceous plates on the margin of aboral region (Fig. 86 B, D, F). Aperture terminal, broad, elliptical, slightly convex, laterally concave, with acute commissures, bordered by thin collar of organic cement (Fig. 86 D-H). Cytoplasm abundant, fills almost whole shell, without symbiotic zoochlorellae; one large ovular nucleus, few small nucleoli; encysted specimens frequently seen, cysts large, round or oval, dark-brown, with thick organic wall, occupying central region of the shell; pseudopodia numerous, usually six to eight, long, digitiform, slow moving (Fig. 86 A, C).

Ecology: Frequent in soil mosses and litter in deciduous forests, very rare in *Sphagnum*.

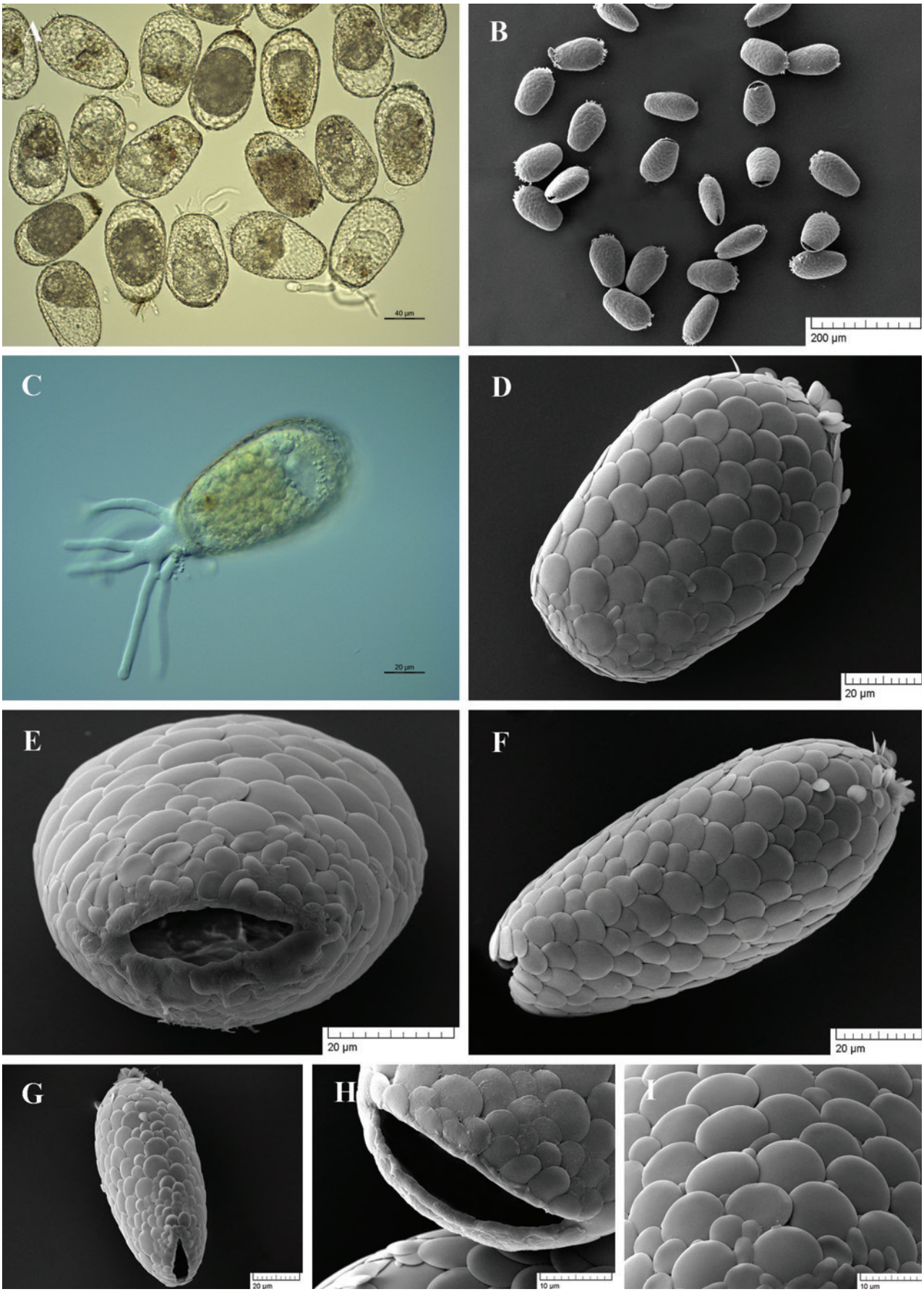
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov 2005, Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1990).

Table 76. *Heleopera sylvatica*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	97.8	98.2	5.51	0.92	5.64	88	108	36
Breadth	63.2	63.2	3.96	0.66	6.27	54	74	36
Large axis of aperture	38.3	37.6	4.56	0.76	11.92	30	48	36
Depth	42.2	42.3	1.31	0.35	3.10	40	44	14
Breadth/Length ratio	0.65	0.64	0.04	0.006	6.02	0.6	0.7	36
Aperture/Breadth ratio	0.61	0.61	0.06	0.01	10.11	0.5	0,7	36

Fig. 86. Light (A, C) and scanning electron (B, D-I) micrographs of *Heleopera sylvatica*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen showing granular cytoplasm and numerous pseudopodia. (D) Broad lateral view showing shape and regular arrangement of shell-plates. (E) Apertural view to show a narrow, elliptical aperture. (F) Lateral view showing acute commissures of the aperture. (G) Latero-apertural view. (H) Close up view of elliptical aperture to show the bordering thin collar of organic cement. (I) Detail of shell surface showing shape and arrangement of shell-plates.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Phryganella acropodia (Hertwig and Lesser, 1874) Hopkinson, 1909

Original description: Hertwig and Lesser 1874, *Archiv für mikroskopische Anatomie*, 10, p. 107, Taf. II, fig. 6; **Last revision:** Cash and Hopkinson 1909, *The British Freshwater Rhizopoda and Heliozoa*. Vol. II. Rhizopoda, p. 74, Pl. XX, figs. 13, 14.

Synonyms: *Difflugia acropodia* Hertwig and Lesser, 1874.

Description: Shell yellowish or brownish, circular in apertural and aboral views, hemispherical in lateral view (Fig. 87 A-F); composed mainly of small to medium pieces of quartz, so arranged to give a well defined and regular outline, with rough aboral surface and smooth apertural surface (Fig. 87 C-F). Shell components usually in close contact with each other, organic cement rarely visible between particles (Fig. 87 E, F, I). Aperture circular, central, slightly or non invaginated, with rim of organic cement (Fig. 87 C, D, G).

Ecology: Frequent in soils, mosses and forest litter, rare in *Sphagnum*.

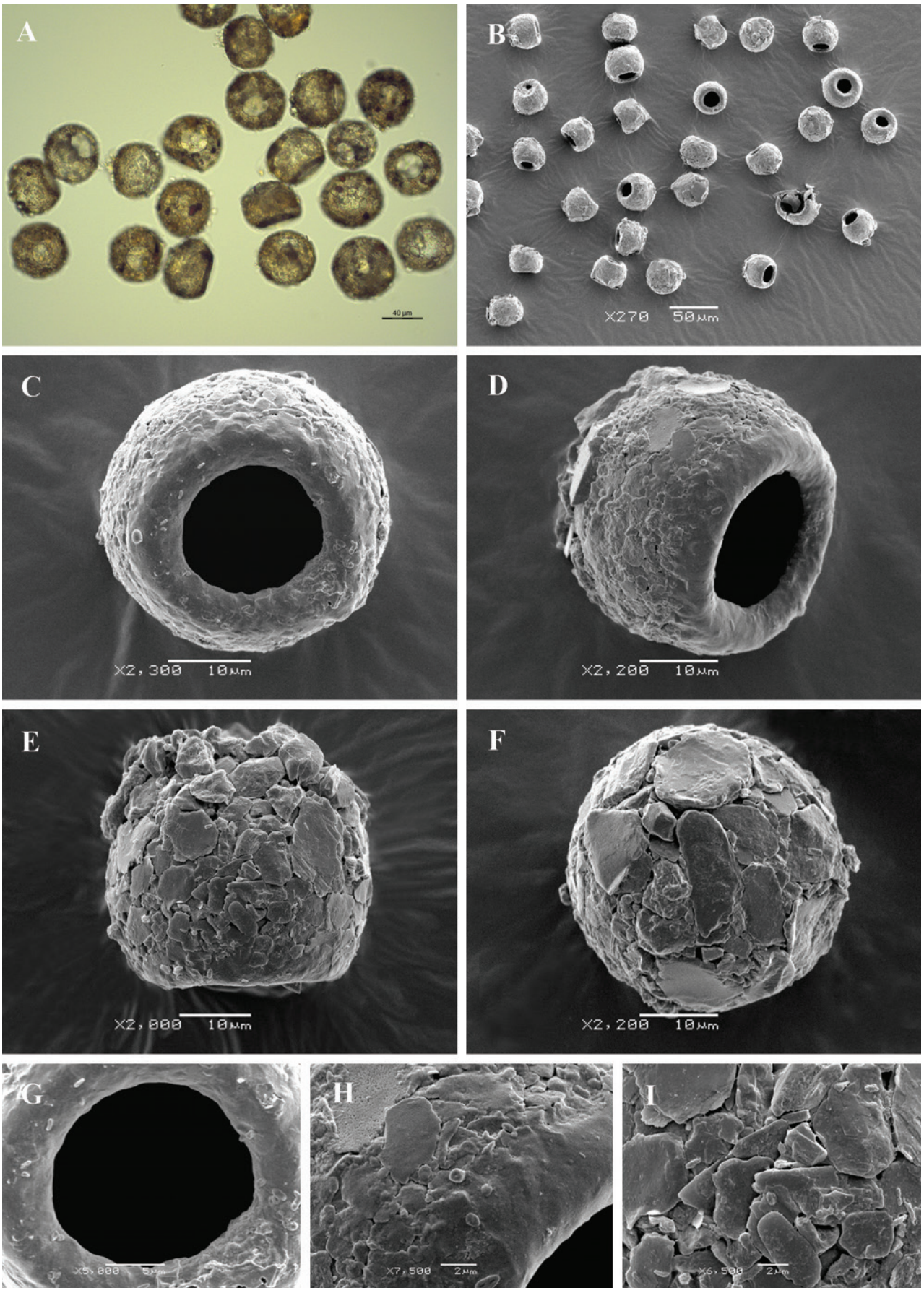
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 77. *Phryganella acropodia*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	37,7	37,5	2,15	0,37	5,70	34	43	33
Diameter of aperture	16,4	16,7	1,78	0,33	10,85	14	20	29
Depth	33,4	33,0	2,58	0,47	7,72	29	38	30
Depth/Diameter ratio	0,44	0,45	0,05	0,009	11,36	0,35	0,52	29
Aperture/Diameter ratio	0,88	0,89	0,06	0,012	6,82	0,73	0,99	30

Fig. 87. Light (A) and scanning electron (B-I) micrographs of *Phryganella acropodia*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C-D) Apertural view of two specimens showing general shape. (E) Lateral view. (F) Dorsal view. (G) Close up view of aperture to illustrate its smooth rim and circular outline. (H, I) Details of lateral and dorsal side of the shell to illustrate its rough surface, covered with large pieces of quartz.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D
X2,200 10µm
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X2,000 10µm
F
X2,200 10µm
G
H
X7,500 2µm
I
X6,500 2µm

Phryganella hemisphaerica (Penard, 1890) Penard, 1902

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 169, Pl. VII, fig. 108 à 114; **Last revision:** Penard 1902, Faune Rhizopodique du Bassin du Léman, p. 421, fig. 1 à 5.

Synonyms: *Pseudodifflugia hemisphaerica* Penard, 1890; *Difflugia globulosa* Leidy, 1879 (in part).

Description: Shell yellowish or brownish, circular in apertural and aboral views, hemispherical in lateral view (Fig. 88 A-F); composed mainly of small to medium pieces of quartz, mixed with diatom frustules, with rough surface (Fig. 88 C-I). Shell components usually in close contact with each other, organic cement rarely visible between particles (Fig. 88 D-I). Aperture large, circular, central, non invaginated, with thin collar of organic cement (Fig. 88 C-E, H, I).

Ecology: Common in standing freshwater basins, among aquatic vegetation and in *Sphagnum*.

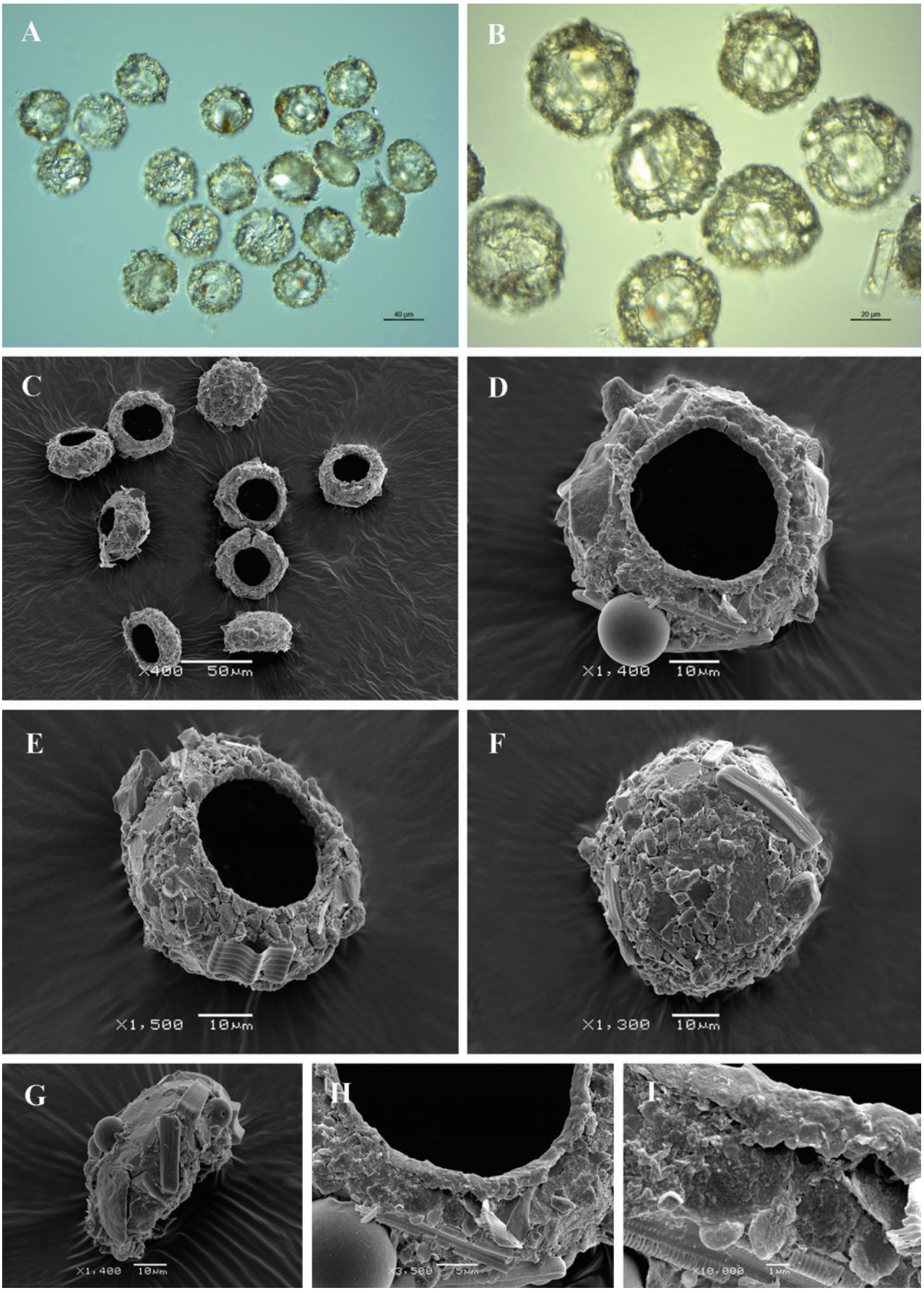
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 78. *Phryganella hemisphaerica*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	52,2	52,0	5,11	0,93	9,79	42	60	30
Diameter of aperture	31,8	31,6	3,70	0,68	11,64	24	42	30
Depth	31,5	31,1	4,89	0,89	15,52	21	41	30
Aperture/Diameter ratio	0,61	0,61	0,06	0,01	9,84	0,50	0,79	30
Depth/Diameter ratio	0,61	0,60	0,09	0,02	14,75	0,41	0,85	30

Fig. 88. Light (A, B) and scanning electron (C-I) micrographs of *Phryganella hemisphaerica*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D, E) Apertural view of two specimens showing general shape. (F) Dorsal view. (G) Lateral view. (H) Close up view of aperture to illustrate its thin collar and circular outline. (I) Details of lateral side of the shell to illustrate its rough surface, covered with large pieces of quartz and diatom frustules.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F
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G
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H
X3,500 5µm
I
X10,000 1µm

Phryganella nidulus Penard, 1902

Original description: Penard 1902, Faune Rhizopodique du Bassin du Léman, p. 419, fig. 1 à 4 (p. 420).

Synonyms: *Difflugia globulosa* Leidy, 1879 (in part).

Description: Shell yellowish or brownish, opaque, large, circular in apertural and aboral views, hemispherical in lateral view (Fig. 89 A-E); composed mainly of small to medium pieces of quartz, mixed with diatom frustules, with rough surface (Fig. 89 B-I). Shell components usually in close contact with each other, organic cement rarely visible between particles (Fig. 89 F-I). Aperture large, about two-thirds of the shell-diameter, circular, central, slightly invaginated, surrounded by quartz particles, with irregular outline (Fig. 89 B, C, F, G).

Ecology: Frequent in benthos of lakes and reservoirs, less frequent in *Sphagnum*.

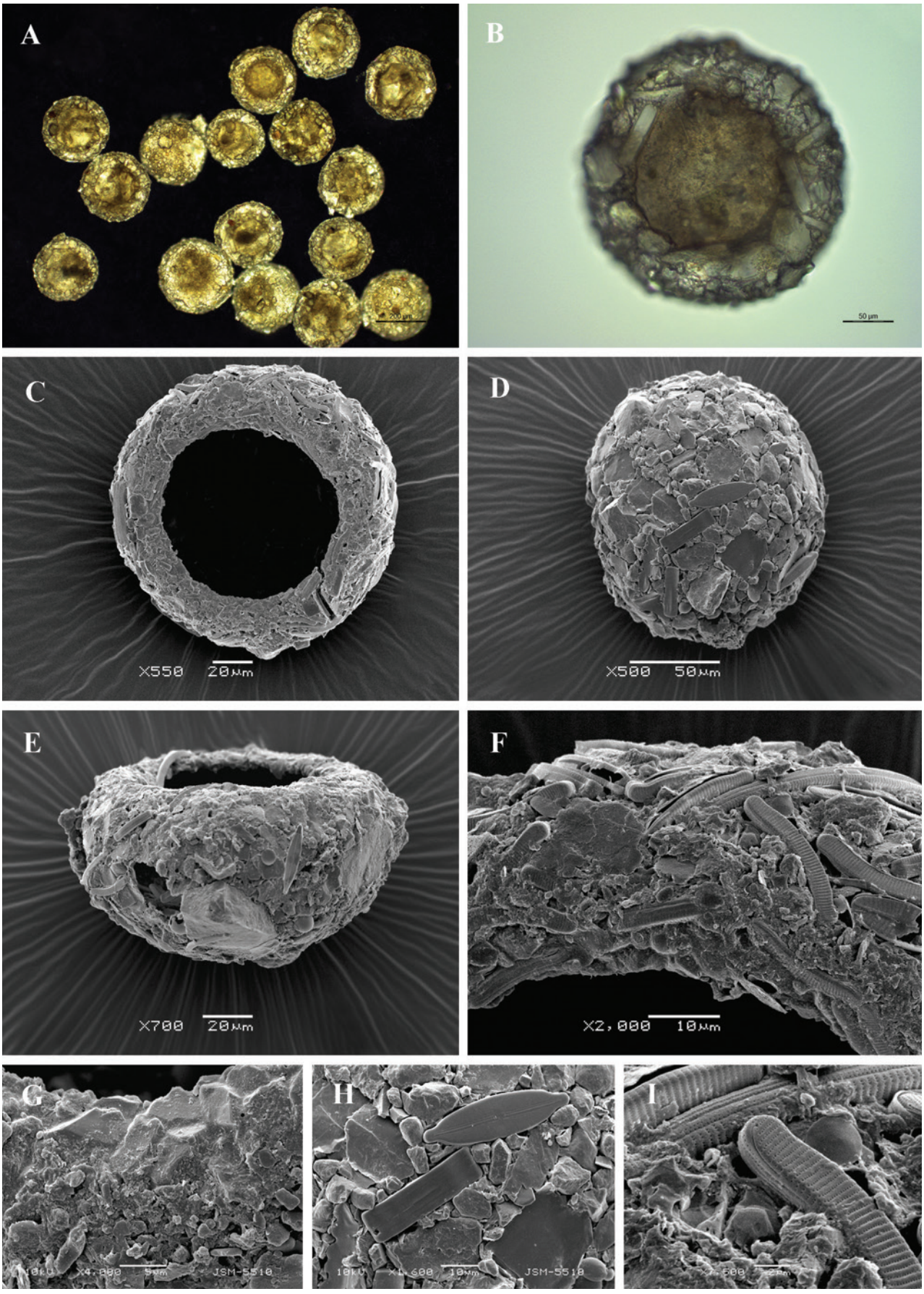
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky et al. 2006); **Rila Mts.** (Todorov 2004, 2005, Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924).

Table 79. *Phryganella nidulus*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Diameter	153,5	151,3	9,75	2,08	6,35	140	174	22
Diameter of aperture	88,3	88,3	7,46	1,59	8,45	72	99	22
Depth	85,7	87,4	7,17	1,65	8,37	71	95	19
Aperture/Diameter ratio	0,58	0,57	0,031	0,007	5,34	0,49	0,63	22
Depth/Diameter ratio	0,56	0,56	0,027	0,006	4,82	0,49	0,59	19

Fig. 89. Light (A, B) and scanning electron (C-I) micrographs of *Phryganella nidulus*. (A) View of several specimens to illustrate variability in shape and size of the shell. (B, C) Apertural view of two specimens showing general shape and large aperture. (D) Dorsal view. (E) Lateral view. (F, G) Close up view of apertural rim to illustrate its denticulate outline. (H, I) Details of dorsal side of the shell to illustrate its rough surface, covered with large pieces of quartz and diatome frustules.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Argynnia dentistoma (Penard, 1890)

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 162, Pl. VI, fig. 98 à 100, Pl. VII, fig. 1 à 5.

Synonyms: *Nebela dentistoma* Penard, 1890; *Nebela crenulata* Penard, 1893; *Nebela collaris* Leidy, 1879 (in part).

Description: Shell colourless, transparent, ovoid or pyriforme, with sides tapering evenly and gradually from rounded aboral region towards to aperture, sometimes forming short neck (Fig. 90 A-D); laterally compressed, with oval transverse section; without lateral margins and lateral pores (Fig. 90 E-F); composed of thickened, oval, circular or irregular polygonal, do not overlapping shell-plates, embedded by porous organic cement (Fig. 90 D- I). Aperture oval, denticulated, surrounded by shell-plates, without collar of organic cement (Fig. 90 C-H). Cytoplasm granular, does not fills whole shell; one large ovular nucleus with numerous small nucleoli; pseudopodia usually few, large, not very long, fast moving.

Notes: The species has been recorded as nominal species, as synonyms *N. dentistoma* and *N. crenulata*, as well as infrasubspecific taxa *Nebela dentistoma* var. *oblonga.*

Ecology: Common in *Sphagnum,* as well as in soil mosses and litter in deciduous forests.

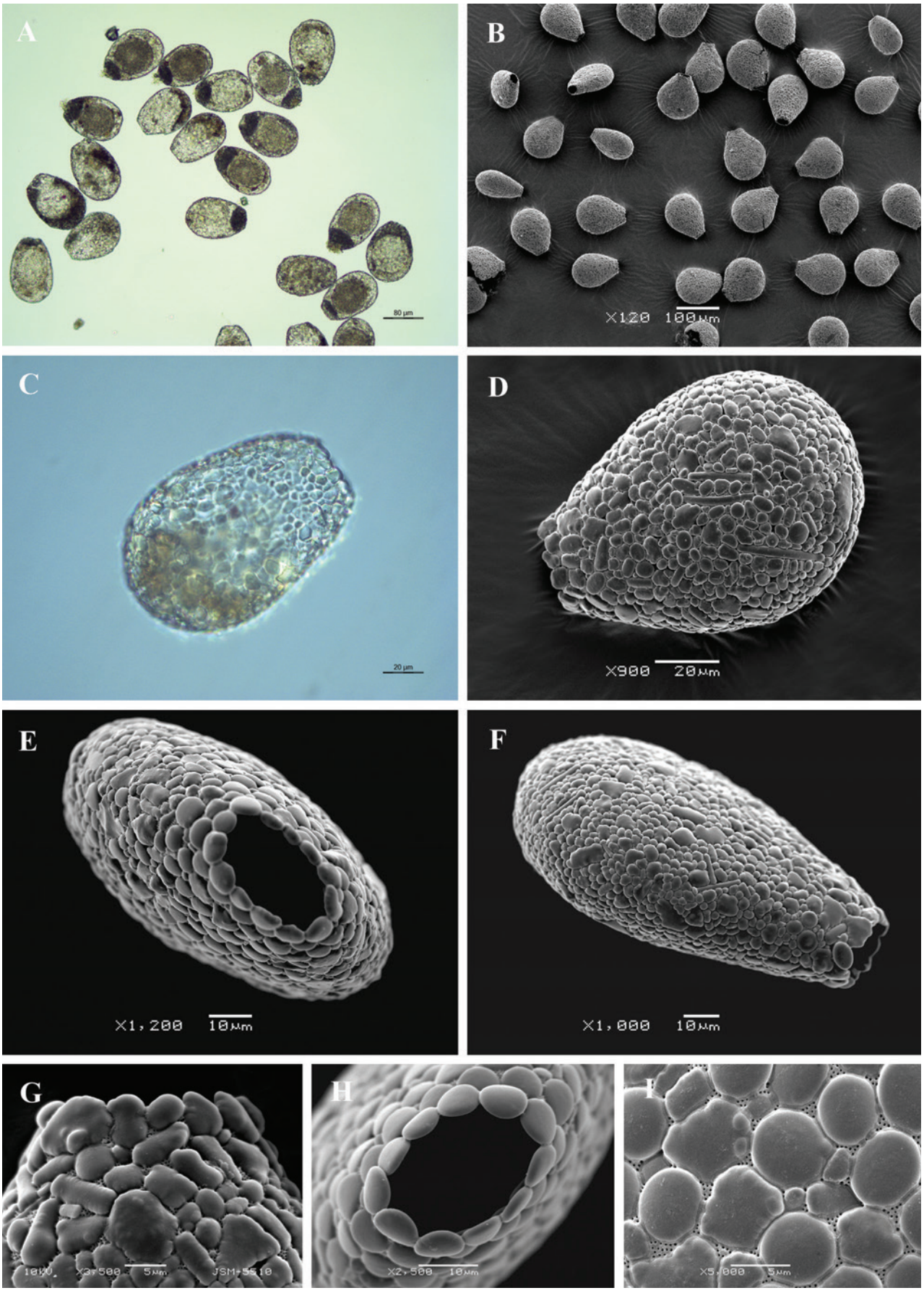
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: **Pirin Mts.** (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 80. *Argynnia dentistoma.* Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	108.4	111.3	15.84	2.80	14.61	82	137	32
Breadth	78.6	78.9	9.25	1.63	11.77	60	97	32
Large axis of aperture	26.4	26.4	4.59	0.81	17.38	19	37	32
Depth	49.6	50.9	8.75	1.86	17.65	32	66	22
Breadth/Length ratio	0.73	0.72	0.06	0.011	8.26	0.6	0.9	32
Aperture/Breadth ratio	0.34	0.33	0.04	0.007	12.32	0.3	0.4	32

Fig. 90. Light (A, C) and scanning electron (B, D-I) micrographs of *Argynnia dentistoma*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Broad lateral view. (E) Apertural view. (F) Narrow lateral view. (G) Broad lateral view of apertural region. (H) Close up view of aperture showing its oval outline. (I) Detail of shell surface showing shape and arrangement of shell-plates, and porous structure of the organic cement.


A
80 µm
B
×120 100µm
C
20 µm
D
×900 20µm
E
×1,200 10µm
F
×1,000 10µm
G
H
×2,500 10µm
I
×5,000 5µm

Argynnia vitraea (Penard, 1899)

Original description: Penard 1899, *Revue Suisse de Zoologie*, 7, p. 43, Pl. 4, fig. 5 à 16.

Synonyms: *Nebela vitraea* Penard, 1899.

Description: Shell colourless, transparent, ovoid or pyriforme, with sides tapering evenly and gradually from rounded aboral region towards to aperture (Fig. 91 A-D); laterally compressed, with oval transverse section; without lateral margins and lateral pores (Fig. 91 E-F); composed of thickened, oval, circular or angular shell-plates, adhering at their edges, rarely overlapping, embedded by porous organic cement (Fig. 91 D- I). Aperture oval, denticulated, surrounded by ring of small irregularly-shaped sand-grains (Fig. 91 D-G). Cytoplasm granular, does not fills the whole shell; one large ovular nucleus with numerous small nucleoli; pseudopodia usually few, in stage of active movement only one, large, long and fast moving.

Notes: *Argynnia vitraea* is too close to *A. dentistoma* and differs difficultly from it mainly by the larger size and by the arrangement of shell-plates, which are usually touching tightly and sometimes have small particles on their borders. The species has been recorded in both as nominal species and as synonym *N. vitraea.*

Ecology: Frequent in wet *Sphagnum*.

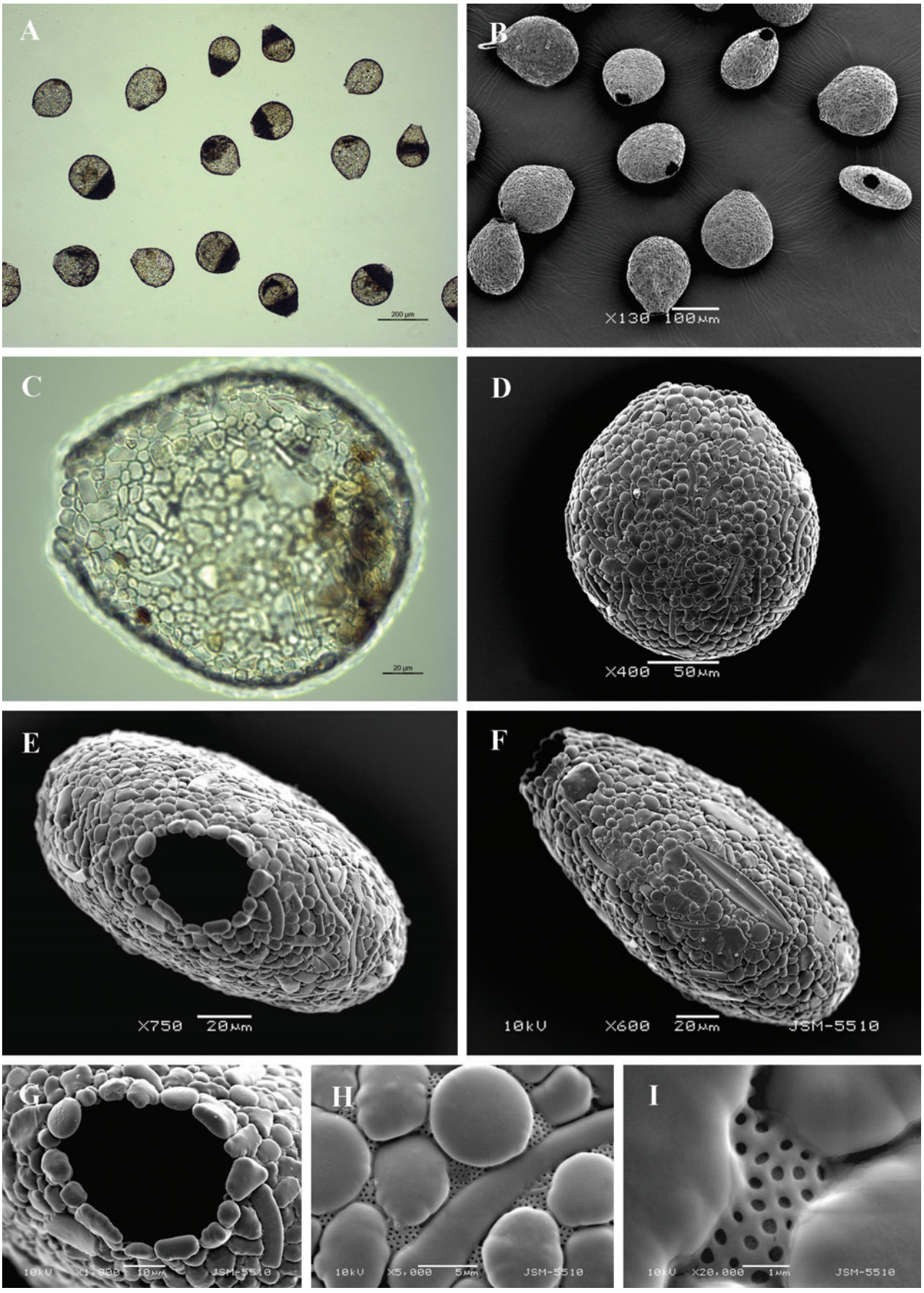
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2004, 2005); **Vitosha Mts.** (Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995).

Table 81. *Argynnia vitraea*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	177.3	175.4	9.84	1.54	5.55	148	198	41
Breadth	158.5	162.8	15.01	2.34	9.47	107	186	41
Large axis of aperture	46.4	44.8	6.18	0.97	13.31	37	60	41
Depth	93.7	94.2	9.79	2.45	10.44	76	108	16
Breadth/Length ratio	0.89	0.90	0.06	0.01	7.26	0.62	0.98	41
Aperture/Breadth ratio	0.30	0.29	0.05	0.007	16.20	0.2	0.4	41

Fig. 91. Light (A, C) and scanning electron (B, D-I) micrographs of *Argynnia vitraea*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Broad lateral view. (E) Apertural view. (F) Narrow lateral view. (G) Close up view of aperture showing its oval and irregularly dentate outline. (H) Detail of shell surface showing shape and arrangement of shell-plates, and porous structure of the organic cement. (I) Close up view of porous organic cement.


A
200 µm
B
X130 100µm
C
20 µm
D
X400 50µm
E
X750 20µm
F
10kV X600 20µm JSM-5510
G
10kV X1,000 10µm JSM-5510
H
10kV X5,000 5µm JSM-5510
I
10kV X20,000 1µm JSM-5510

Awerintzewia cyclostoma (Penard, 1902) Schouteden, 1906

Original description: Penard 1902, Faune Rhizopodique du Bassin du Léman, p. 390, fig. 1 à 6 (p. 391); **Last revision:** Schouteden 1906, *Annales de Biologie Lacustre***,** 1 (3), p. 357.

Synonyms: *Heleopera cyclostoma* Penard, 1902.

Description: Shell brownish or purple, opaque, ovoid, with sides tapering evenly and gradually from rounded aboral region towards to aperture, laterally compressed, oval in transverse section (Fig. 92 A-G); anterior half of the shell smooth, composed of flattish, siliceous shell-plates; posterior part rough, covered mainly of larger pieces of quartz (Fig. 92 D-F). Aperture terminal, small, oval, truncate, without lateral commissures, bordered by thin collar of organic cement, with characteristic double margins in the apertural region (Fig. 92 A-H).

Notes: The species has been recorded in both as nominal species and as synonym *H. cyclostoma* (Rhodopes Mts.).

Ecology: Frequent in calcareous soils and mosses, rare in *Sphagnum*.

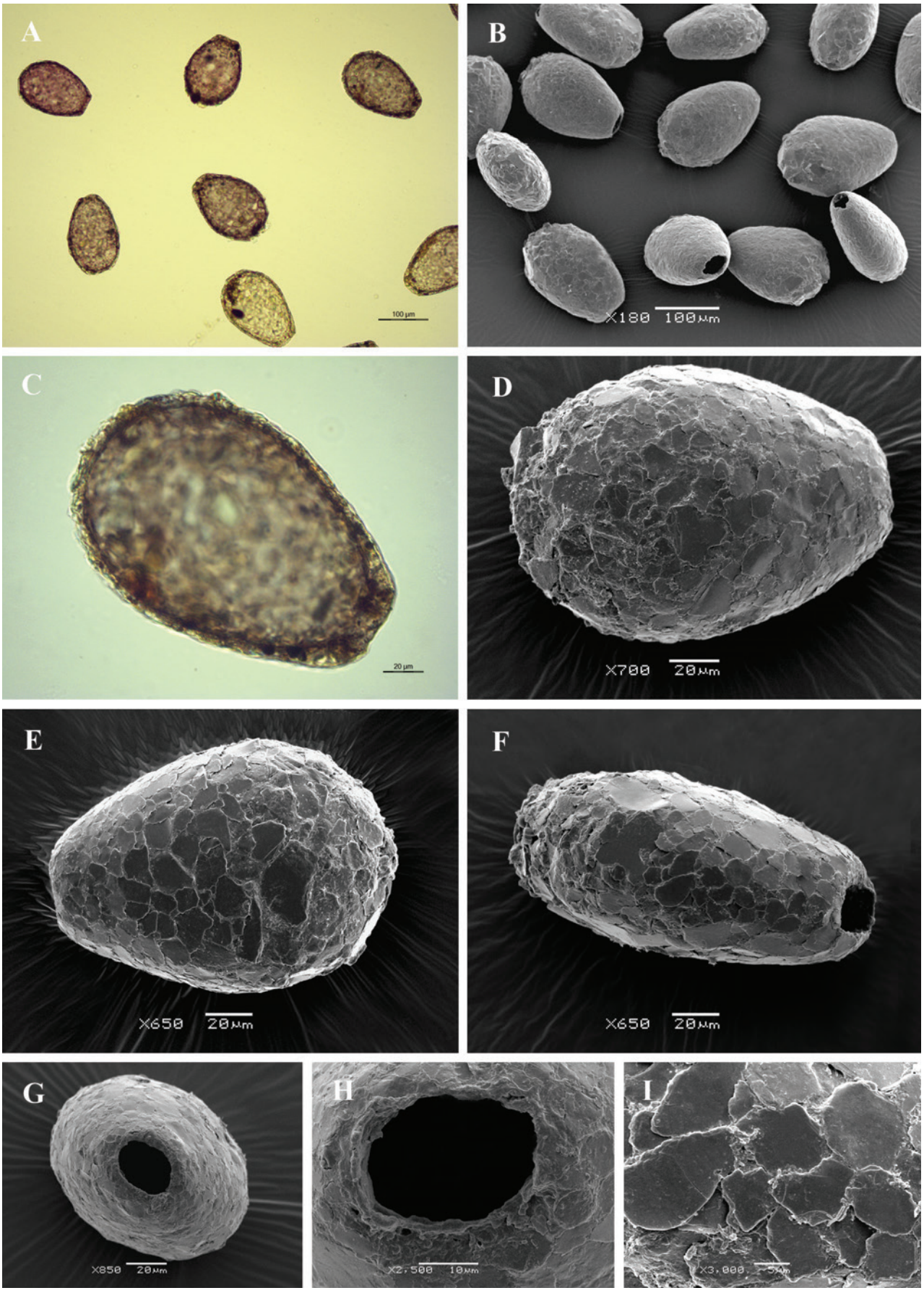
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Pateff 1924, Golemansky et al. 2006); **Rila Mts.** (new data).

Table 82. *Awerintzewia cyclostoma*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	162.0	161.7	8.07	1.33	4.98	146	178	37
Breadth	111.4	110.7	5.56	0.91	4.99	98	121	37
Large axis of aperture	41.8	41.2	5.21	0.86	12.46	31	54	37
Depth	81.5	81.9	5.73	1.81	7.03	73	90	10
Breadth/Length ratio	0.69	0.69	0.04	0.006	5.11	0.6	0.8	35
Aperture/Breadth ratio	0.38	0.38	0.05	0.008	12.83	0.3	0.5	36

Fig. 92. Light (A, C) and scanning electron (B, D-I) micrographs of *Awerintzewia cyclostoma*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C-E) Broad lateral view of three specimens to show general shape. (F) Narrow lateral view. (G) Apertural view showing oval sross section of the shell and small oval aperture. (H) Close up view of aperture showing its oval outline and bordering rim of organic cement. (I) Portion of shell to show arrangement of flattish particles in the anterior part of the shell.


A
100 µm
B
X180 100µm
C
20 µm
D
X700 20µm
E
X650 20µm
F
X650 20µm
G
X850 20µm
H
X2,500 10µm
I
X3,000 5µm

Lagenodifflugia bryophila (Penard, 1902) Ogden, 1987

Original description: Penard 1902, Faune Rhizopodique du Bassin du Léman, p. 324, figs. 1-4; **Last revision:** Ogden 1987, *Bulletin of the British Museum (Natural History),* Zoology series, 52 (1), p. 15.

Synonyms: *Pontigulasia bryophila* Penard, 1902; *Pontigulasia bryophila* var. *elachys* Jung, 1942; *Pontigulasia varadi* Godeanu, 1972; *Zivkovicia bryophila* (Penard, 1902) Ogden, 1983.

Description: Shell yellowish-brownish, opaque, elongated-pyriform, with pronounced constriction at place of internal diaphragm, forming distinct neck about one-third of the body length and ovoid main body with circular transverse section (Fig. 93 A-D); covered mainly of small to medium quartz particles and occasionally with larger particles, with rough surface (Fig. 93 C-H). Shell components usually in close contact with each other, only small areas of organic cement are seen as network of rings with perforated centre; each ring of about 500-750 nm in diameter has an internal network with ten to fourteen irregular pores of about 40-70 nm in diameter (Fig. 93 I). External aperture roughly circular, with notched or tooth-like appearance, surrounded by regularly arranged small quartz particles; internal diaphragm constructed of small particles as part of shell wall, with single central opening of about 12-14 μm (Fig. 93 E-G). Cytoplasm granular, fills almost whole shell, without symbiotic zoochlorellae; one large ovular nucleus with numerous small nucleoli; pseudopodia usually two to four, long and fast moving (Fig. 93 A-B).

Notes: The species has been recorded in both as nominal species and as synonym *P. bryophila* (Rhodopes Mts., Rila Mts., Vitosha Mts.).

Ecology: Frequent in *Sphagnum* and freshwater habitats.

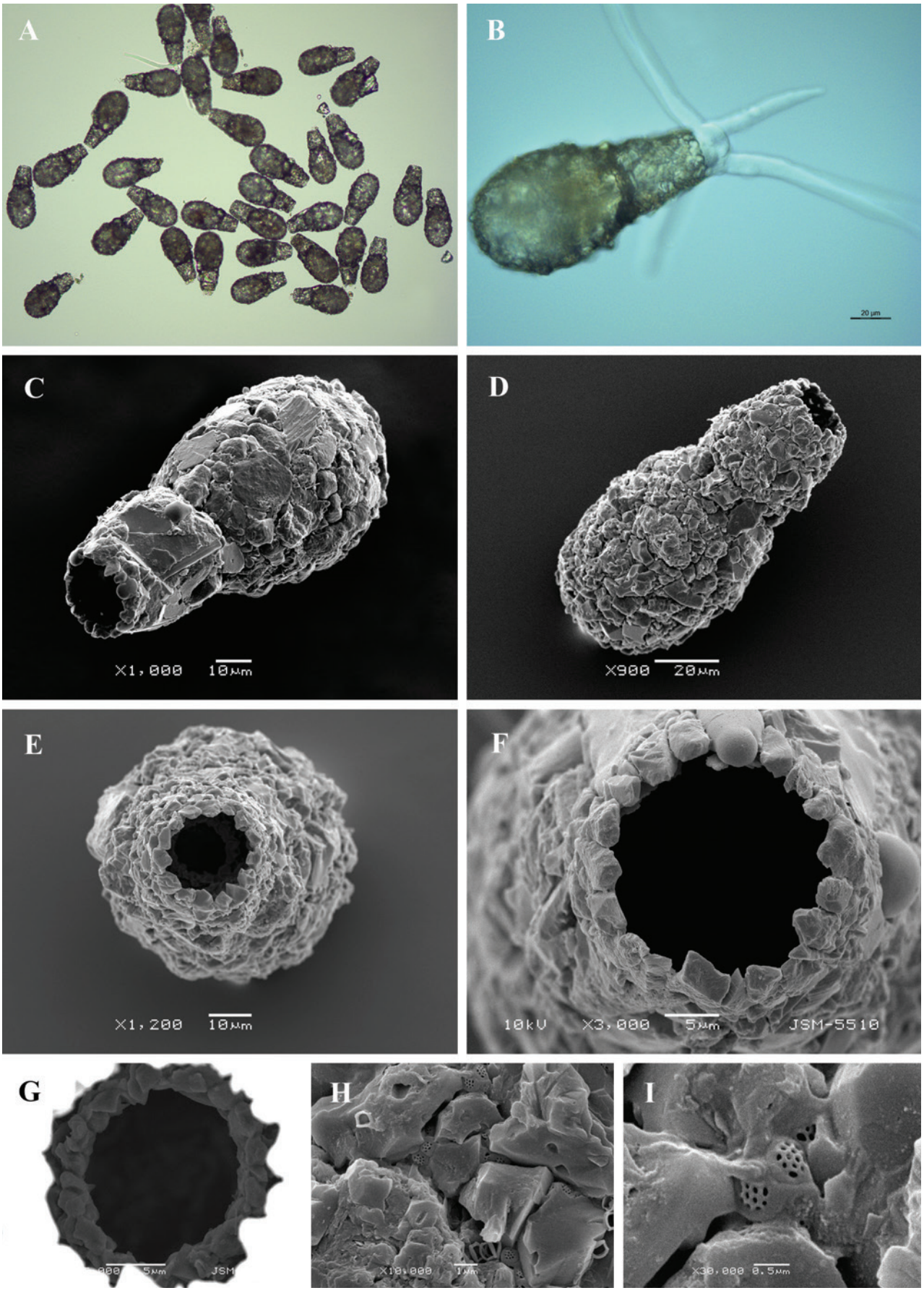
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1990, Todorv 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 83. *Lagenodifflugia bryophila*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	115.6	116.0	6.36	0.96	5.50	101	132	44
Breadth	56.8	57.0	2.56	0.39	4.52	53	63	44
Diameter of aperture	23.4	23.7	2.65	0.40	11.33	18	29	44
Breadth/Length ratio	0.49	0.49	0.03	0.004	5.38	0.5	0.6	44
Aperture/Breadth ratio	0.41	0.41	0.05	0.007	11.14	0.3	0.5	44

Fig. 93. Light (A, B) and scanning electron (C-I) micrographs of *Lagenodifflugia bryophila*. (A) View of many specimens to illustrate variability in shape and size of the shell. (B) View of live specimen showing long endolobopodia and granular cytoplasm (C, D) Lateral view of two individuals to show a general shape. (E) Apertural view. (F) Close up view of aperture. (G) Close up view of internal opening. (H) Portion of shell to show arrangement of particles and rough surface of the shell. (I) Detail of organic cement network.


A
B
20 µm
C
X1,000 10µm
D
X900 20µm
E
X1,200 10µm
F
10kV X3,000 5µm JSM-5510
G
H
X10,000 1µm
I
X30,000 0.5µm

Lagenodifflugia vas (Leidy, 1874) Medioli and Scott, 1983

Original description: Leidy 1874a, *Proceedings of the Academy of Natural Sciences of Philadelphia*, 26, p. 155; **Last revision:** Medioli and Scott 1983, *Cushman Foundation for Foraminiferal Research*, Special Publication, 21, 33, Pl. 2, Figs. 18-23, 27, 28.

Synonyms: *Difflugia vas* Leidy, 1874; *Difflugia pyriformis* var. *vas* Leidy, 1879; *Pontigulasia vas* (Leidy) Schouteden, 1906; *Zivkovicia vas* (Leidy, 1874) Ogden, 1983 (in part).

Description: Shell yellowish-brownish, opaque, pyriform, with not always conspicuous constriction at place of internal diaphragm, dividing shell of two unequal parts, smaller wedge-shaped neck, about one-third of the body length, and larger rounded main body, with circular transverse section (Fig. 94 A-F); covered mainly of small to medium quartz particles, often with constriction more or less hidden by larger particles (Fig. 94 B, D-F). Shell components usually in close contact with each other, only small areas of organic cement are seen infrequently as network with mesh of about 450-600 nm in diameter and walls 150-200 nm thick; each mesh perforated with smaller openings of different size (Fig. 94 H, I). External aperture roughly circular, with notched or tooth-like appearance, surrounded by regularly arranged small quartz particles; internal diaphragm constructed of small particles as part of shell wall, with single central opening of about 25-30 μm (Fig. 94 E-G). Cytoplasm granular, fills almost whole shell, without symbiotic zoochlorellae; one large ovular nucleus, few nucleoli Pseudopodia usually two to four, long and fast moving (Fig. 94 A, C).

Ecology: Frequent in *Sphagnum* and freshwater habitats.

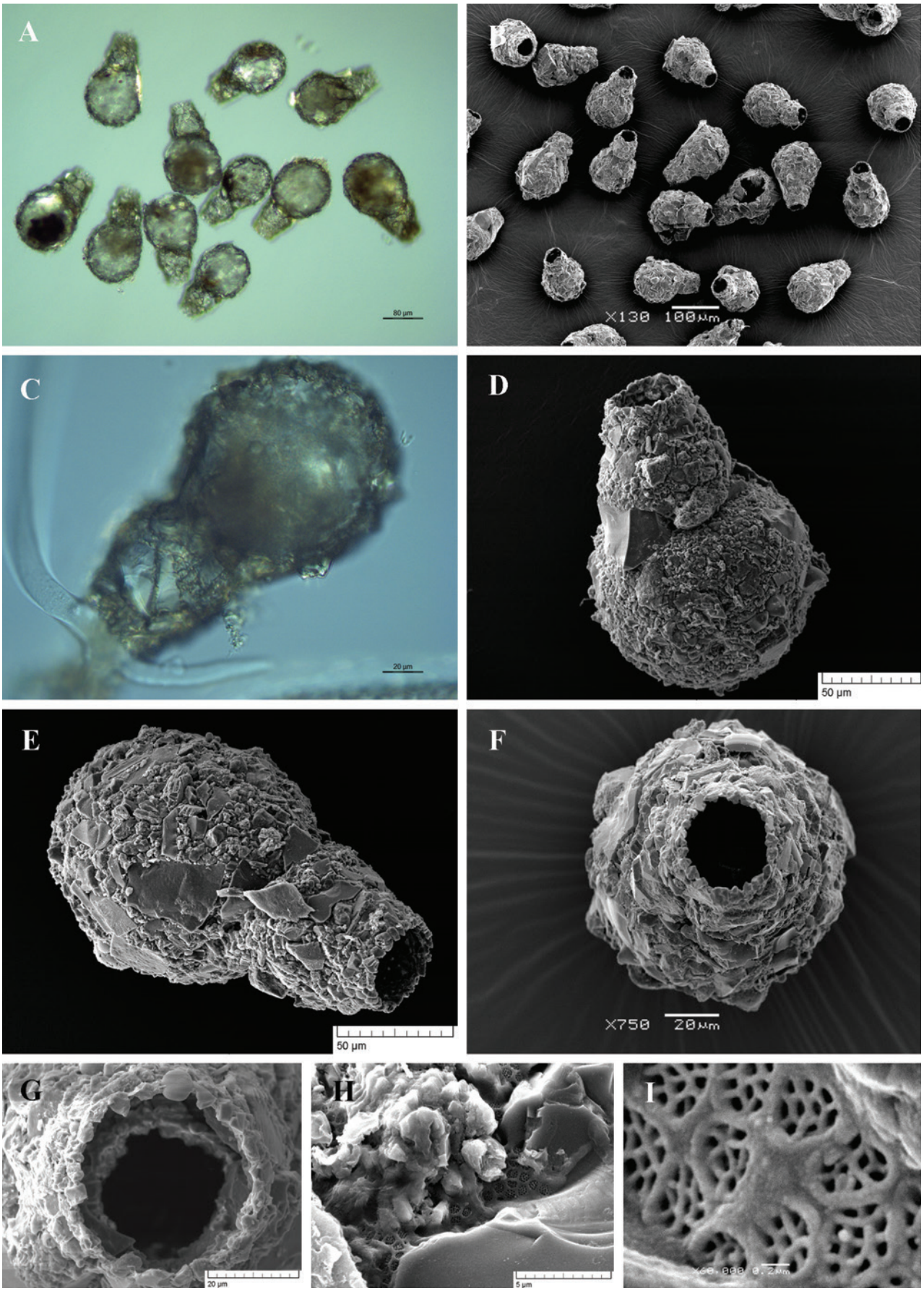
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Bankov et al. 2018).

Table 84. *Lagenodifflugia vas*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	176.4	175.0	9.20	1.60	5.21	157	196	33
Breadth	111.1	113.0	7.30	1.27	6.57	96	127	33
Diameter of aperture	37.1	36.0	3.64	0.63	9.80	32	46	33
Breadth/Length ratio	0.63	0.62	0.05	0.008	7.30	0.6	0.8	33
Aperture/Breadth ratio	0.33	0.34	0.03	0.006	9.57	0.3	0.4	33

Fig. 94. Light (A, C) and scanning electron (B, D-I) micrographs of *Lagenodifflugia vas*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen showing long endolobopodia and granular cytoplasm. (D, E) Lateral view of two individuals to show a general shape. (F) Apertural view. (G) Close up view of internal opening. (H) Portion of shell to show arrangement of particles and rough surface of the shell. (I) Detail of organic cement network.


A
80 µm
B
X130 100µm
C
20 µm
D
50 µm
E
50 µm
F
X750 20µm
G
20 µm
H
5 µm
I

Pontigulasia rhumbleri Hopkinson, 1919

Original description: Cash, Wailes and Hopkinson 1919, *The British Freshwater Rhizopoda and Heliozoa*. Vol. IV, p. 49, Pl. LXIII, figs. 1, 2.

Synonims: *Pontigulasia compressa* Rhumbler, 1896; (non *Pontigulasia compressa* (Carter, 1864).

Description: Shell colorless or yellowish, transparent, pyriform, rounded aborally and tapering evenly towards to the aperture, without forming distinct neck (Fig. 95 A-C); laterally compressed, with oval transverse section (Fig. 95 D); composed mainly of flattish pieces of quartz and diatom frustules, with relatively smooth appearance (Fig. 95 A-C). Shell components usually in close contact with each other; only small areas of organic cement are seen as either individual rings or as network with mesh of about 500 nm in diameter and walls 250-300 nm thick; each mesh enclosure covered by inner strands of cement which form smaller mesh with different size (Fig. 95 H, I). External aperture roughly circular, surrounded by small quartz particles and diatom frustules (Fig. 95 D, E). Internal dividing bridge ribbon-shaped, placed centrally at short distance from aperture, evenly widening towards to its connects with broader sides of the shell, leaving large openings on either side (Fig. 95 F). Cytoplasm granular, does not fills the whole shell; cell attached to the shell wall with clearly visible short epipodes; one large ovular nucleus; pseudopodia usually one or two, sometimes numerous, large, long, fast moving (Fig. 95 A, B).

Notes: The species has been recorded in both as nominal species and as synonym *P. compressa* (Rhodopes Mts., Rila Mts., Vitosha Mts.).

Ecology: Frequent in *Sphagnum* and standing freshwater bodies, among submerged aquatic vegetation.

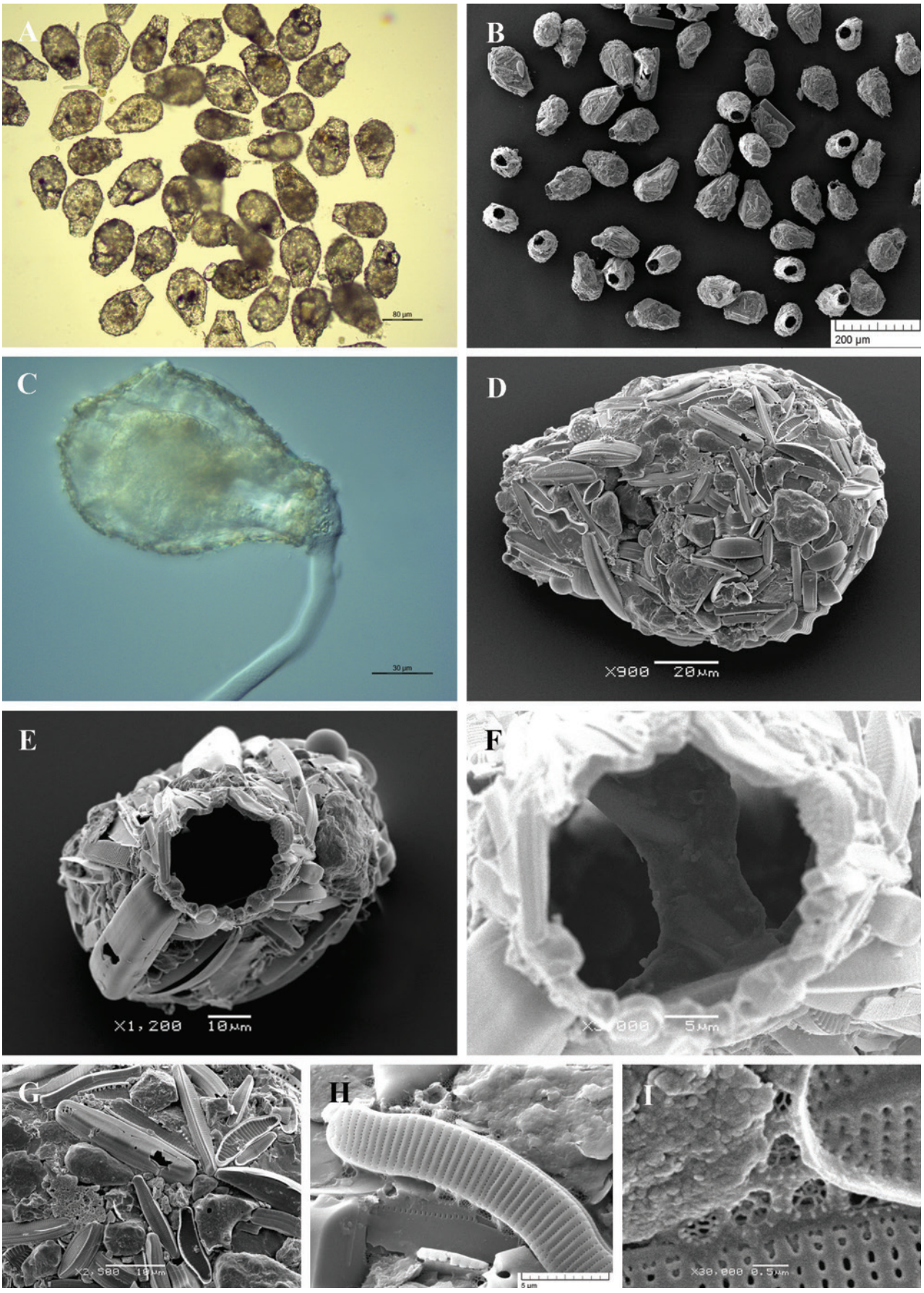
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Todorov 2004, 2005); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924).

Table 85. *Pontigulasia rhumbleri*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	116.3	116.9	8.86	1.52	7.62	101	139	34
Breadth	79.5	80.7	6.42	0.94	8.08	62	92	47
Diameter of aperture	29.3	29.4	3.03	0.44	10.35	23	37	47
Depth	65.7	64.7	5.40	1.44	8.22	60	76	14
Breadth/Length ratio	0.67	0.68	0.05	0.009	8.02	0.6	0.8	34
Aperture/Breadth ratio	0.37	0.36	0.04	0.006	10.42	0.3	0.5	47

Fig. 95. Light (A, B) and scanning electron (C-I) micrographs of *Pontigulasia rhumbleri*. (A) View of many specimens to illustrate variability in shape and size of the shell. (B) View of live specimen to show a single long endolobopodia. (C) Broad lateral view showing general shape. (D) Apertural view (E) View of aperture showing its irregular outline and surrounding angular particles of quartz. (F) Close up view of internal opening. (G) Portion of shell surface. (H, I) Details of organic cement network.


A
80 µm
B
200 µm
C
30 µm
D
X900 20µm
E
X1,200 10µm
F
5µm
G
H
I
X30,000 0.5µm

Zivkovicia compressa (Carter, 1864) Ogden, 1983

Original description: Carter 1864, *Annals and Magazine of Natural History*, 13, p. 22, Pl. I, figs. 5, 6; **Last revision:** Ogden 1983, *Protistologica*, 19, p. 226, Figs. 18-29.

Synonims: *Difflugia compressa* Carter, 1864; *Difflugia pyriformis* var. *vas* sub-var. *bigibbosa* Penard, 1899; *Pontigulasia bigibbosa* Penard, 1902

Description: Shell yellowish-brownish, opaque, pyriform, with characteristic V-shaped notch on the shell, indicating place of internal diaphragm; divided into two unequal parts, smaller wedge-shaped neck, and larger rounded main body; laterally compressed, with oval transverse section (Fig. 96 A-F); covered mainly of small to medium quartz particles, mixed with several angular large particles, with rough surface (Fig. 96 B, D-F). Shell components usually in close contact with each other, small areas of organic cement are seen as network with mesh of about 500-650 nm in diameter and walls 150-250 nm thick; each mesh perforated by about 12-14 smaller openings of different size (Fig. 96 H, I). External aperture broadly-oval, surrounded by regularly arranged small quartz particles; internal diaphragm constructed of small particles as part of shell wall, with two internal openings on either narrow sides of the shell, placed close to the shell wall; internal openings are not visible through the external aperture when viewed directly and are seen clearly when shell is tilted to either side (Fig. 96 G). Cytoplasm granular, fills almost whole shell, without symbiotic zoochlorellae; pseudopodia usually two to four, long, fast moving (Fig. 96 A, C).

Ecology: Frequent in *Sphagnum*.

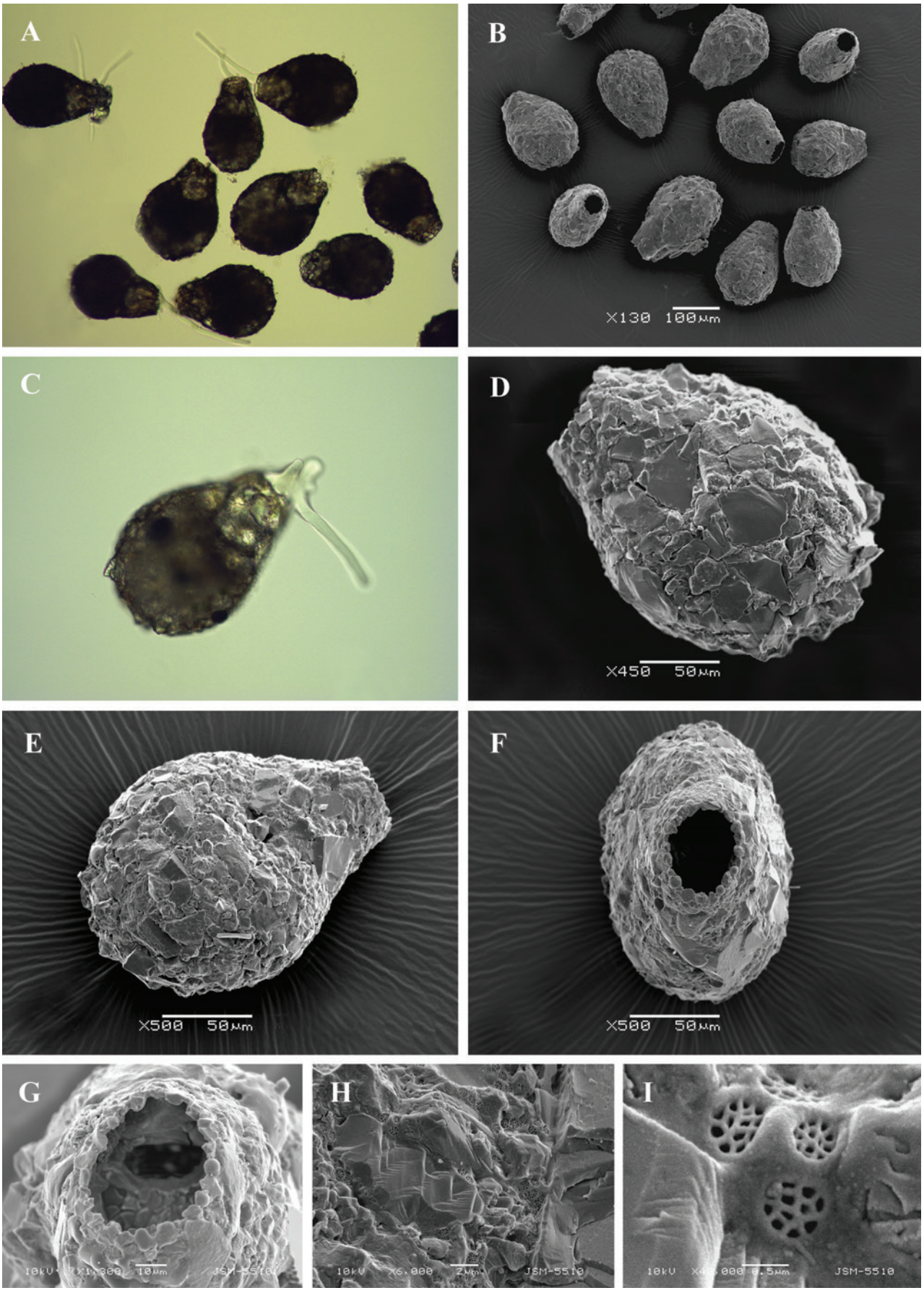
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 86. *Zivkovicia compressa*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	199.6	195.0	16.01	2.24	8.02	173	248	51
Breadth	140.5	141.0	11.99	1.68	8.53	99	166	51
Large axis of aperture	45.6	44.8	4.96	0.69	10.89	35	59	51
Depth	106.8	105.3	7.25	1.07	6.79	86	123	46
Breadth/Length ratio	0.71	0.71	0.05	0.007	7.51	0.5	0.8	51
Aperture/Breadth ratio	0.33	0.32	0.04	0.005	10.99	0.3	0.4	51

Fig. 96. Light (A, C) and scanning electron (B, D-I) micrographs of *Zivkovicia compressa*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen showing endolobopodia. (D, E) Broad lateral views. (F) Apertural view (G) Apertural view of tilted specimen to show one of the internal openings. (H) Portion of shell showing its rough surface. (I) Detail of organic cement network.


A
B
X130 100µm
C
D
X450 50µm
E
X500 50µm
F
X500 50µm
G
H
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Zivkovicia spectabilis (Penard, 1902) Ogden, 1987

Original description: Penard 1902, Faune Rhizopodique du Bassin du Léman, p. 318, fig. 1-9 (p. 319); **Last revision**: Ogden 1987, *Bulletin of the British Museum (Natural History),* Zoology series, 52 (1), p. 15.

Synonyms: *Pontigulasia spectabilis* Penard, 1902; *Zivkovicia vas* (Leidy, 1874) Ogden, 1983 (in part).

Description: Shell yellowish-brownish, opaque, pyriform, with pronounced constriction at place of internal diaphragm, dividing shell of two parts, almost equal in length - tubular or wedge-shaped neck, slightly convex in middle, and spherical main body; uncompressed, with circular transverse section (Fig. 97 A-F); covered mainly of small to medium quartz particles and occasionally with fragment of diatom frustules, with rough surface (Fig. 97 D-F). Shell components usually in close contact with each other, only small areas of organic cement are seen infrequently as network with mesh of about 600-950 nm in diameter, without well pronounced walls; each mesh is covered by inner strands of cement forming fine network of about 15-25 openings with different size (Fig. 97 H, I). External aperture roughly circular, surrounded by irregularly arranged small to medium quartz particles; internal diaphragm constructed of small particles as part of shell wall, with two internal openings, placed close to the shell wall and partly visible through the external aperture when viewed directly (Fig. 97 D-G). Cytoplasm granular, completely fills rounded body, without symbiotic zoochlorellae; one large ovular nucleus, few nucleoli; pseudopodia usually one to three, long, fast moving (Fig. 97 A, C).

Notes: The species has been recorded in both as nominal species and as synonym *P. spectabilis* (Rhodopes Mts.).

Ecology: Frequent in freshwater habitats and in *Sphagnum*.

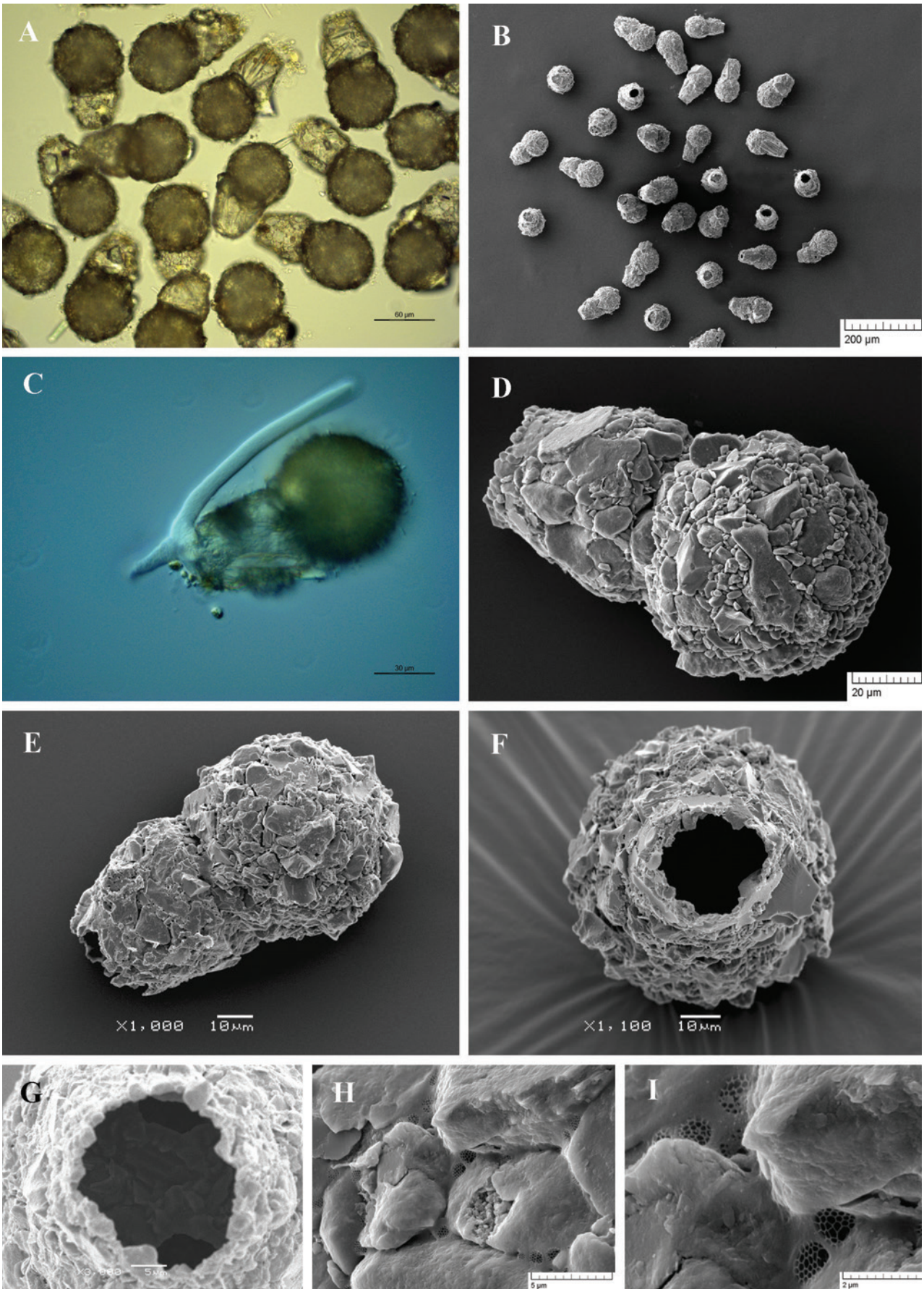
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Golemansky 1968); **Rila Mts.** (Todorov 2004).

Table 87. *Zivkovicia spectabilis*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	114.5	115.5	6.45	1.02	5.63	102	131	40
Breadth	70.3	70.5	4.67	0.74	6.64	56	78	40
Diameter of aperture	26.1	26.0	2.60	0.41	9.96	20	32	40
Breadth/Length ratio	0.61	0.61	0.04	0.006	5.99	0.5	0.7	40
Aperture/Breadth ratio	0.37	0.36	0.03	0.005	9.17	0.3	0.4	40

Fig. 97. Light (A, C) and scanning electron (B, D-I) micrographs of *Zivkovicia spectabilis*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen showing long endolobopodia. (D, E) Lateral view of two individuals to show a general shape. (F) Apertural view. (G) Close up view of internal openings. (H) Portion of shell to show arrangement of quartz particles and rough surface. (I) Detail of organic cement network.


A
60 µm
B
200 µm
C
30 µm
D
20 µm
E
×1,000 10µm
F
×1,100 10µm
G
H
5 µm
I
2 µm

Archerella flavum (Archer, 1877) Loeblich and Tappan, 1961

Original description: Archer 1877, *Quarterly Journal of Microscopical Science*, new series, 17, p. 336, Pl. XXI, Fig. 9; **Last revision:** Loeblich and Tappan 1961, *Proceedings of the Biological Society of Washington*, 74, p. 217.

Synonyms: *Ditrema flavum* Archer, 1877; *Amphitrema flavum* Archer, 1877.

Description: Shell yellowish-brownish, transparent, elliptical, with broadly rounded edges; laterally compressed, with oval to elliptical transverse section; on each of the narrow edges is located one small oval aperturte (Fig. 98 A-F); entirely composed of organic matter, smooth. Apertures two, small, oval, bordered by thin collar (Fig. 98 H, I). Cytoplasm granular, fills whole shell, always fullfiled with numerous symbiotic zoochlorellae; one large vesicular nucleus placed centraly in the cell, with one small nucleolus; pseudopodia rarely visible, usually two or three, thin, long, fast moving (Fig. 98 A, B).

Notes: The species has been recorded as synonym *Amphitrema flavum* (Rhodopes Mts., Vitosha Mts.).

Ecology: Common in *Sphagnum*.

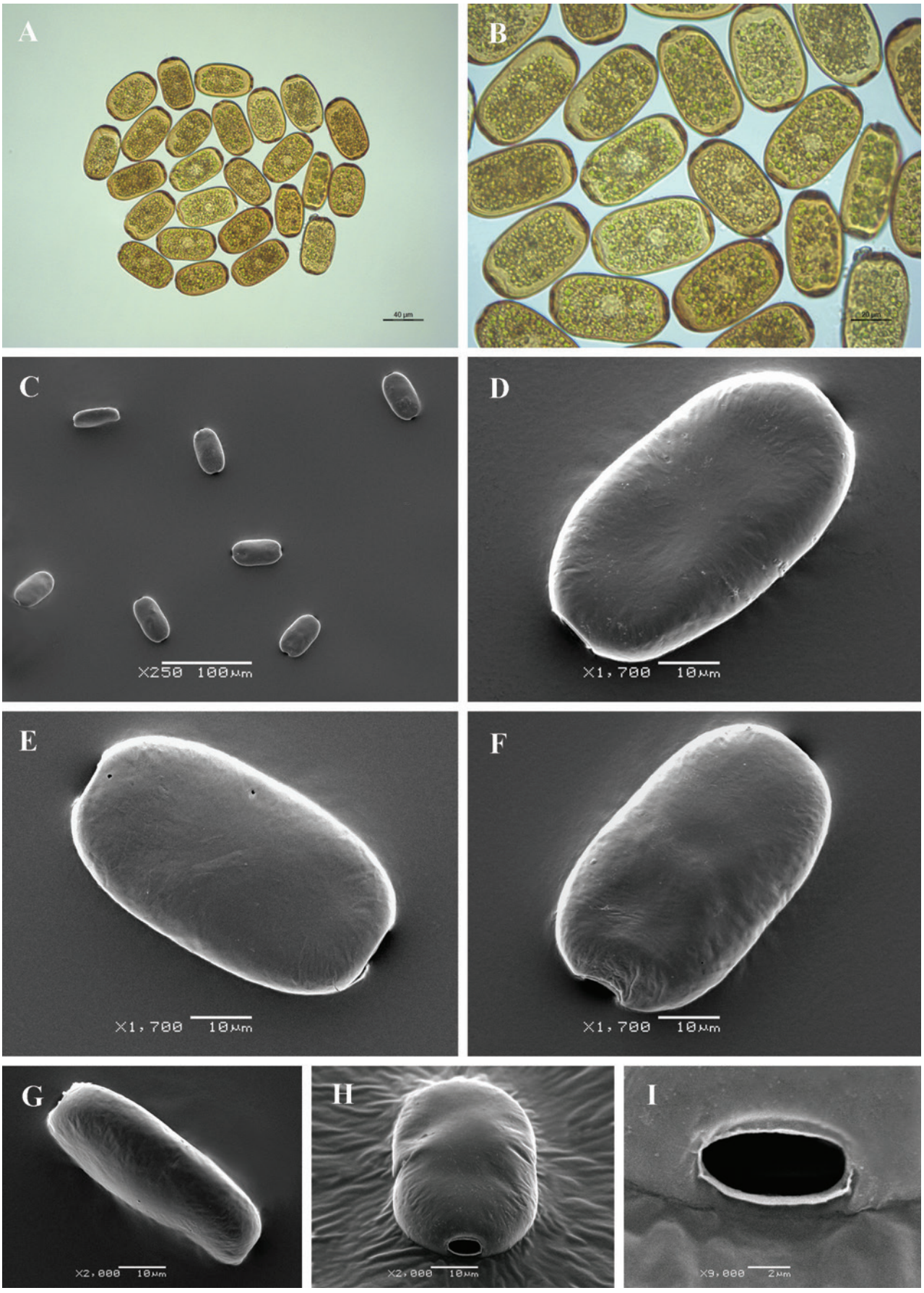
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 88. *Archerella flavum*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	55.9	56.3	4.55	0.82	8.13	46	64	31
Breadth	32.2	31.9	2.7	0.50	8.47	26	39	31
Large axis of aperture	9.1	9.3	1.40	0.25	15.43	6	12	31
Depth	19.9	18.8	3.69	0.87	18.55	14	28	18
Aperture/Breadth ratio	0.58	0.57	0.06	0.010	9.82	0.5	0.7	31

Fig. 98. Light (A, B) and scanning electron (C-I) micrographs of *Archerella flavum*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D-F) Broad lateral view of three individuals to show the general shape and smooth shell surface. (G) Narrow lateral view. (H) Apertural view to show small aperture. (I) Close up view of aperture showing its oval outline and thin apertural collar.


A
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X250 100µm
D
X1,700 10µm
E
X1,700 10µm
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X1,700 10µm
G
X2,000 10µm
H
X2,000 10µm
I
X9,000 2µm

Assulina muscorum Greeff, 1888

Original description: Greeff 1888, *Sitzungsberichte der Gesellschaft zur Beförderung der gesammten Naturwissenschaften zu Marburg,* 3, pp. 117-118.

Synonyms: *Assulina seminulum* Leidy, 1879 (in part); *Assulina minor* Penard, 1890.

Description: Shell yellowish-brownish, in young individuals colourless; ovoid, laterally compressed, with elliptical transverse section (Fig. 99 A-G); composed of small, oval, overlapping shell-plates of about 4,7-5,2 x 2,1-2,3 µm, regularly arranged in 12-15 alternating diagonal rows, rarely irregularly arranged (Fig. 99 D-G, I). Aperture oval or lenticular, surrounded by haphazardly arranged shell-plates, bordered by thin membrane of organic cement, with irregularly-dentate margin (Fig. 99 F-H). Cytoplasm hyaline, with many granules concentrated in the central region, fills almost whole shell; one vesicular nucleus containing single small nucleolus, placed posteriorly in the cell (Fig. 99 B). Pseudopodia few, fine, long, straight, rarely observed.

Notes: *Assulina muscorum* differs from *A. seminulum* by the shape and size of the shell and by twice smaller shell-plates.

Ecology: Common in *Sphagnum* and aerophilic mosses, less frequent in soils.

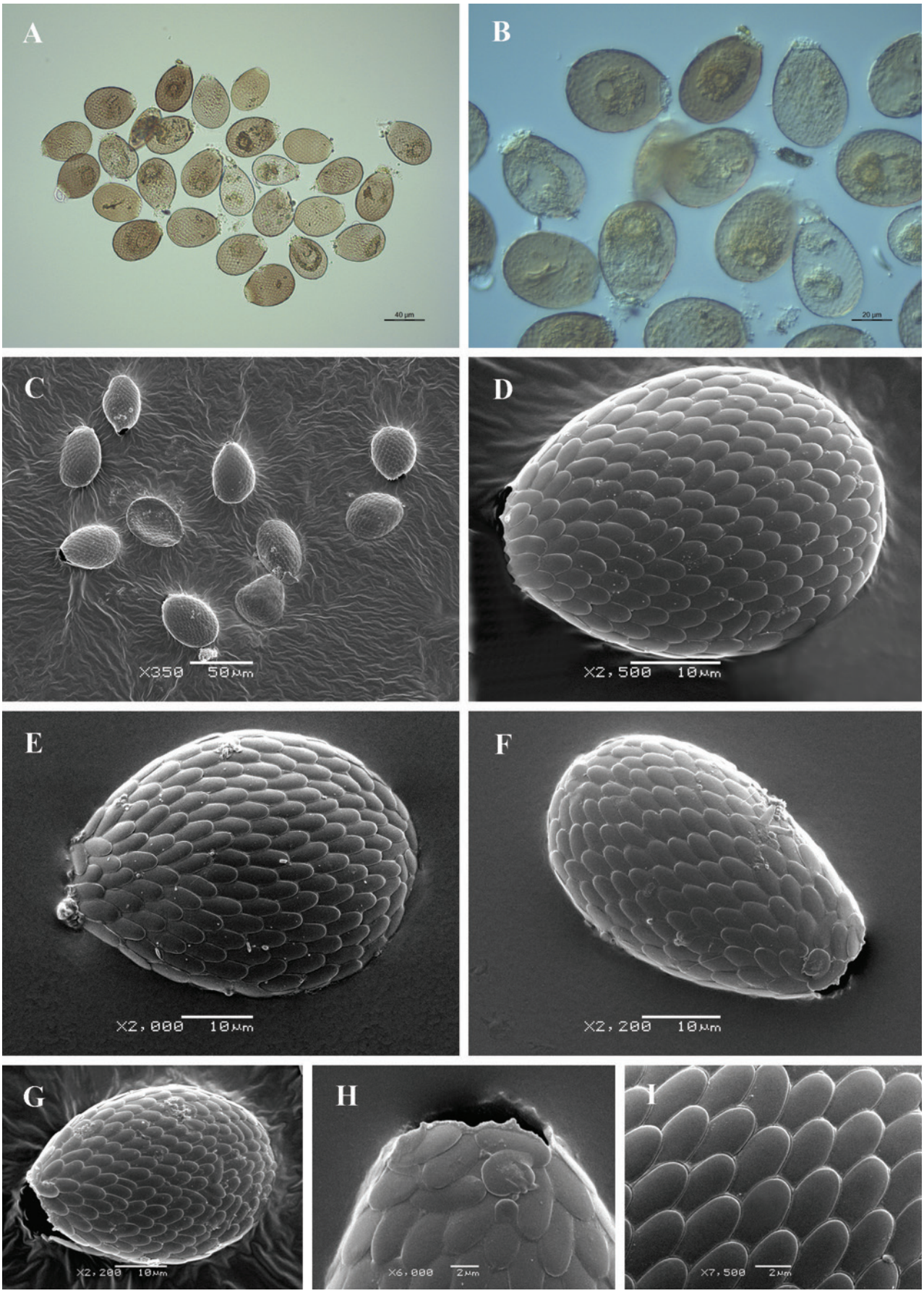
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 89. *Assulina muscorum*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	45.7	46.1	4.32	0.78	9.46	37	55	31
Breadth	34.4	33.7	2.99	0.54	8.71	29	42	31
Large axis of aperture	11.2	11.1	1.69	0.30	15.08	8	15	31
Depth	18.7	18.5	1.46	0.32	7.80	16	22	20
Breadth/Length ratio	0.76	0.75	0.07	0.012	8.74	0.6	0.9	31
Aperture/Breadth ratio	0.33	0.32	0.04	0.008	13.51	0.3	0.5	31

Fig. 99. Light (A, B) and scanning electron (C-I) micrographs of *Assulina muscorum*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D-F) Broad lateral view of three individuals to show general shape and regular arrangement of shell-plates. (G) Latero-apertural view of aperture to illustrate its lenticular-oval shape. (H) Close up view of apertural region showing arrangement of apertural-plates and thin border of organic cement. (I) Detail of shell surface to show overlapping, oval shell-plates.


A
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X2,200 10µm
G
X2,200 10µm
H
X6,000 2µm
I
X7,500 2µm

Assulina seminulum (Ehrenberg, 1848) Leidy, 1879

Original description: Ehrenberg 1848b, *Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königliche Preussischen Akademie der Wissenschaften zu Berlin*, 13, p. 379; **Last revision:** Leidy 1879, *Report of the United States Geological Survey of the Territories*, 12, p. 225, Pl. XXXVII, figs. 18-25.

Synonyms: *Difflugia seminulum* Ehrenberg, 1848; *Difflugia Assulina seminulum* Ehrenberg, 1871; *Difflugia semen* Ehrenberg, 1871; *Euglypha brunnea* Leidy, 1874; *Euglypha seminulum* Leidy, 1878.

Description: Shell yellowish-brownish, in very young individuals colourless; ovoid or sub-spherical, laterally compressed, with elliptical transverse section (Fig. 100 A-F); composed of oval, overlapping shell-plates of about 9-10 x 4-5 µm, regularly arranged in 16-18 alternating diagonal rows, rarely irregularly arranged (Fig. 100 B-F, I). Shell-plates usually overlapped from aperture to the aboral region, but in some individuals are imbricated inversely, from aboral region to the aperture (Fig. 100 C). Aperture oval or lenticular, surrounded by evenly spaced or haphazardly arranged shell-plates, bordered by a thin membrane of organic cement, with irregularly-dentate margin (Fig. 100 D-G). Cytoplasm granular, does not fills entirely shell; one large nucleus placed posteriorly in the cell. Pseudopodia few, fine, long, straight, rarely observed.

Ecology: Common in *Sphagnum*, less frequent in aerophilic mosses and soils.

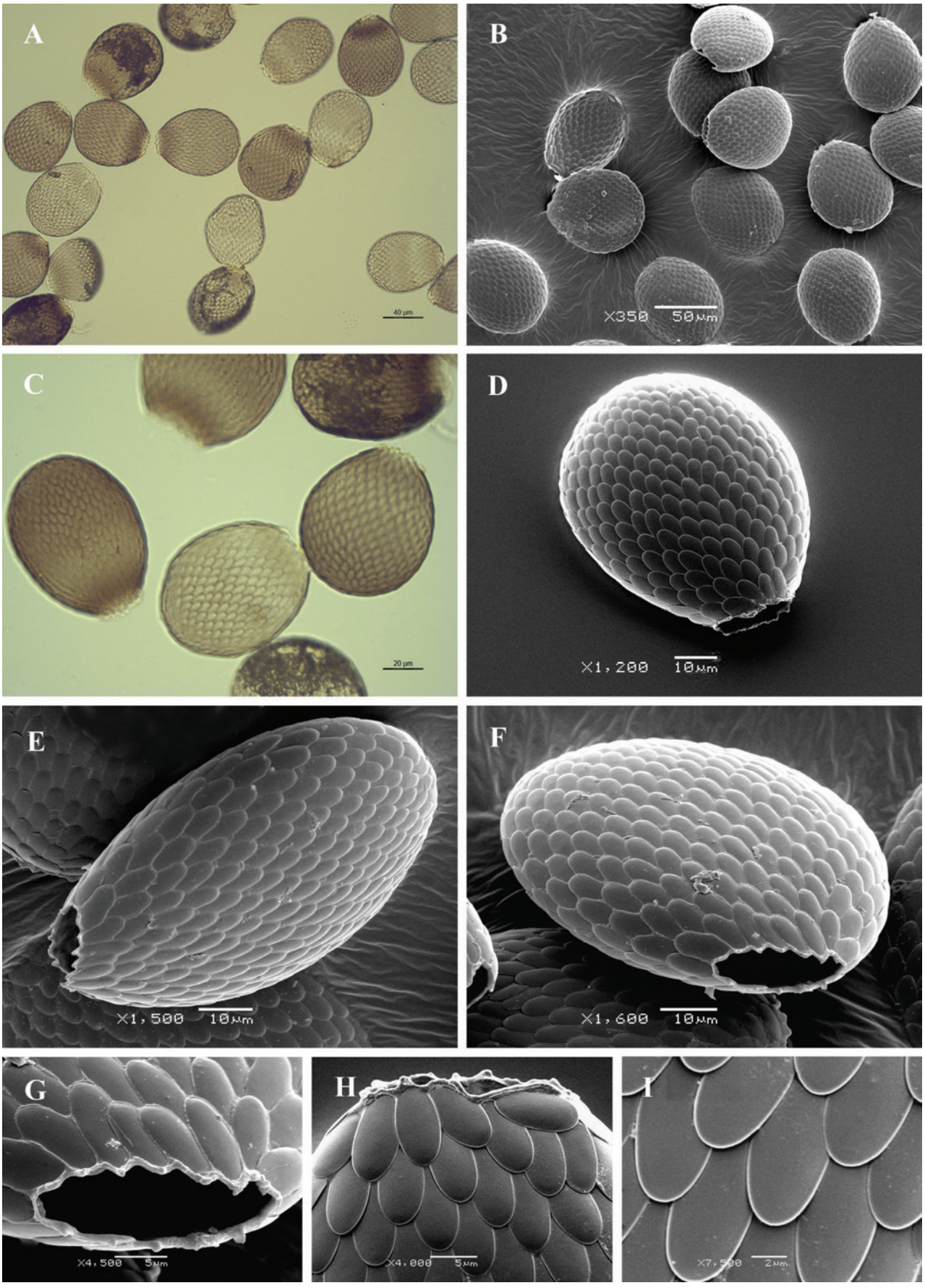
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Golemansky and Todorov 1993, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1990, Bankov et al. 2018).

Table 90. *Assulina seminulum*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	79.4	80.2	5.45	0.99	6.83	65	91	30
Breadth	63.1	63.1	6.08	1.11	9.63	44	77	30
Large axis of aperture	21.2	20.3	4.05	0.74	19.10	15	35	30
Depth	32.4	32.8	1.90	0.41	5.86	28	36	21
Breadth/Length ratio	0.79	0.80	0.05	0.010	6.56	0.7	0.9	30
Aperture/Breadth ratio	0.34	0.34	0.06	0.010	16.68	0.2	0.5	30

Fig. 100. Light (A, C) and scanning electron (B, D-I) micrographs of *Assulina seminulum*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D) Broad lateral view showing general shape and regular arrangement of shell-plates. (E) Narrow lateral view. (F) Apertural view. (G) Close up view of aperture to illustrate shape of aperture, arrangement of apertural-plates and thin border of organic cement. (H) Lateral view of apertural region (I) Detail of shell surface to show overlapping, oval shell-plates.


A
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D
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F
X1,600 10µm
G
X4,500 5µm
H
X4,000 5µm
I
X7,500 2µm

Euglypha bryophila Brown, 1911

Original description: Brown 1911, *Journal of the Linnean Society of London, Zoology*, 32, no 212, p. 82, Pl. 9, figs. 14-15.

Synonyms: *Euglypha α* Vejdovsky, 1882; *Euglypha cristata* Penard, 1890 (in part).

Description: Shell colorless, transparent, elongate-oviform, slightly compressed and oval in transverse section; apex of the aboral region bears a tuft of long, thin and tapering siliceous spines, three to nine in number (Fig. 101 A-E, H); composed of oval, slightly overlapping shell-plates of about 8 x 4 μm, arranged in eight to nine longitudinal and eleven to thirteen transverse alternating rows (Fig. 101 B-E, I). Aperture circular, surrounded by seven to nine oval and denticulate apertural plates with pronounced three-lobed thickening at the denticulate margin and elongated lobe at the posterior margin; each apertural plate with large median tooth and two smaller lateral teeth on each side (Fig. 101 G-H). Cytoplasm fills about two-thirds of the shell; one small vesicular nucleus with central nucleolus. Pseudopodia one or a few, thin, long, directed straight ahead, fast moving.

Ecology: Frequent in mosses, rarely in forest litter, soils and *Sphagnum*.

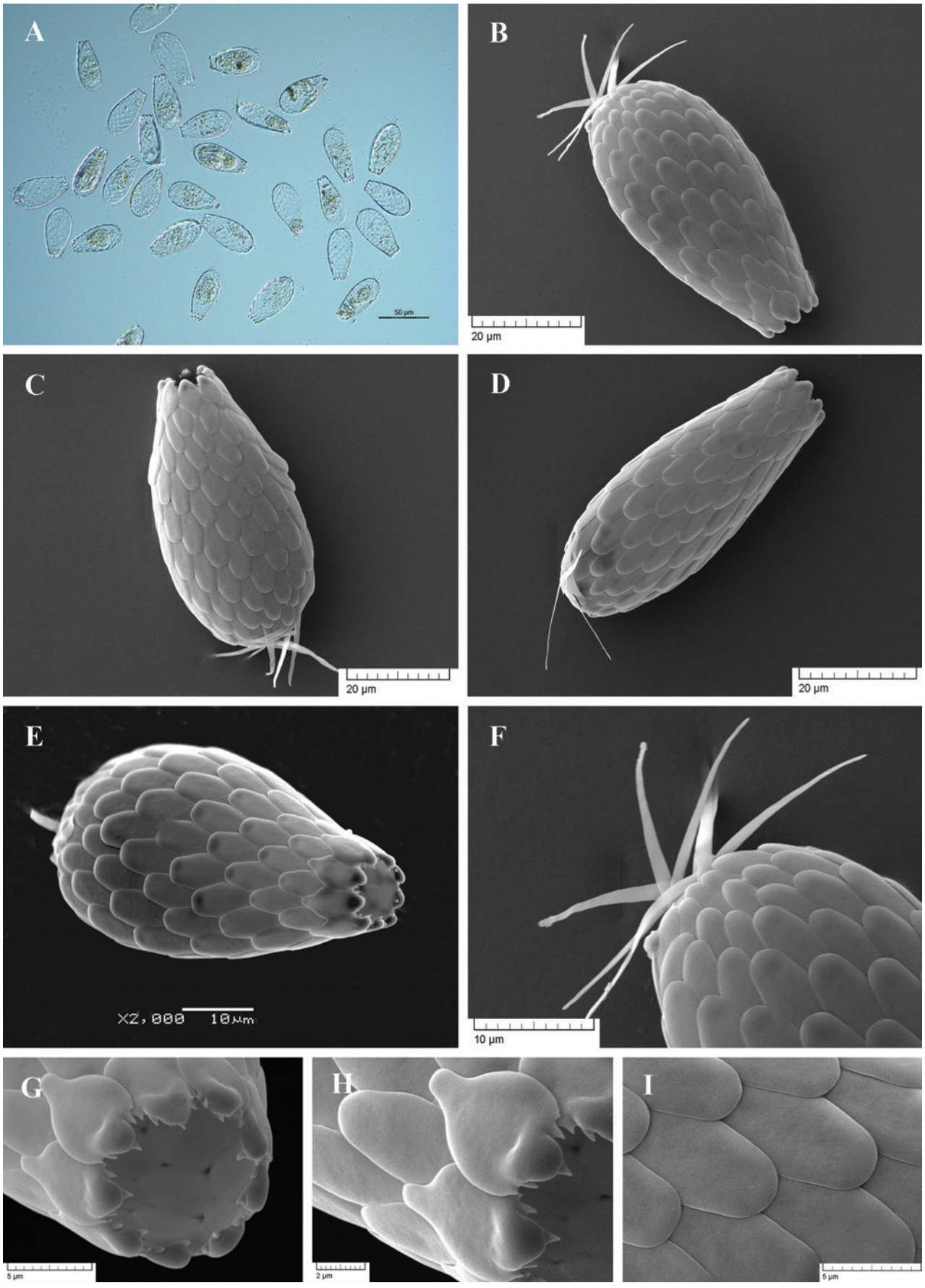
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1990, Bankov et al. 2018).

Table 91. *Euglypha bryophila*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	49.1	50.0	4.94	0.9	10.07	34	56	30
Breadth	21.3	21.7	2.24	0.41	10.52	14	24	30
Diameter of aperture	8.8	8.7	1.28	0.23	14.49	6	11	30
Depth	16.4	16.7	1.79	0.43	10.96	11	18	17
Length of spines	11.4	10.7	2.69	0.52	23.69	7	19	27
Breadth/Length ratio	0.44	0.43	0.04	0.007	8.72	0.4	0.5	30
Aperture/Breadth ratio	0.42	0.40	0.05	0.01	13.08	0.3	0.5	30

Fig. 101. Light (A) and scanning electron (B-I) micrographs of *Euglypha bryophila*. (A) View of many specimens to illustrate variability in shape and size of the shell. (B, C) Broad lateral view of two specimens to show symmetrical arrangement of shell plates and disposition of spines in the centre of the aboral region. (D) Narrow lateral view. (E) Apertural view. (F) View of aboral region showing spines and their attachment to the shell. (G) Close up view of aperture. (H) View of apertural plates illustrating pronounced three-lobed thickening at the anterior margin and elongated lobe at the posterior margin (I) Detail of shell surface to show overlapping shell plates.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I
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Euglypha ciliata (Ehrenberg, 1848), Leidy, 1878

Original description: Ehrenberg 1848b, *Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königliche Preussischen Akademie der Wissenschaften zu Berlin*, 13, p. 379; **Last revision:** Leidy 1878, *Proceedings of the Academy of Natural Sciences of Philadelphia,* 30, p. 172.

Synonyms: *Difflugia ciliata* Ehrenberg, 1848; *Euglypha setigera* Perty, 1852 (in part); *Difflugia pilosa* Ehrenberg, 1871; *Difflugia Setigerella ciliata* Ehrenberg, 1871; *Difflugia Setigerella pilosa* Ehrenberg, 1871.

Description: Shell colorless, transparent, oviform, compressed, elliptical in transverse section, with short siliceous spines slightly varying in size and distributed on lateral margin only (Fig. 102 A-E); spines attached to surface with small hemispherical nodules of organic cement, easily broken (Fig. 102 E, H); shell composed of oval overlapping shell-plates of about 4,5-6 x 3-4 µm, arranged in eleven to twelve longitudinal and eighteen to twenty transverse alternating rows (Fig. 102 A-D). Aperture oval, surrounded by ten to twelve roughly oval, denticulate apertural-plates, which are thickened at denticulate margin; each apertural plate with large median tooth, which does not exceed its outer margin, and two smaller lateral teeth on each side (Fig. 102 C, D, F, G). Cytoplasm does not fills entirely shell; one large ovular nucleus, with few nucleoli. Pseudopodia numerous, thin, long, fast moving.

Notes: The species has been recorded in both as nominal species and as infrasubspecific taxon *E. ciliata* f. *glabra* Wailes, 1915 (Rhodopes Mts., Rila Mts.).

Ecology: Frequent in mosses, freshwater habitats and *Sphagnum*.

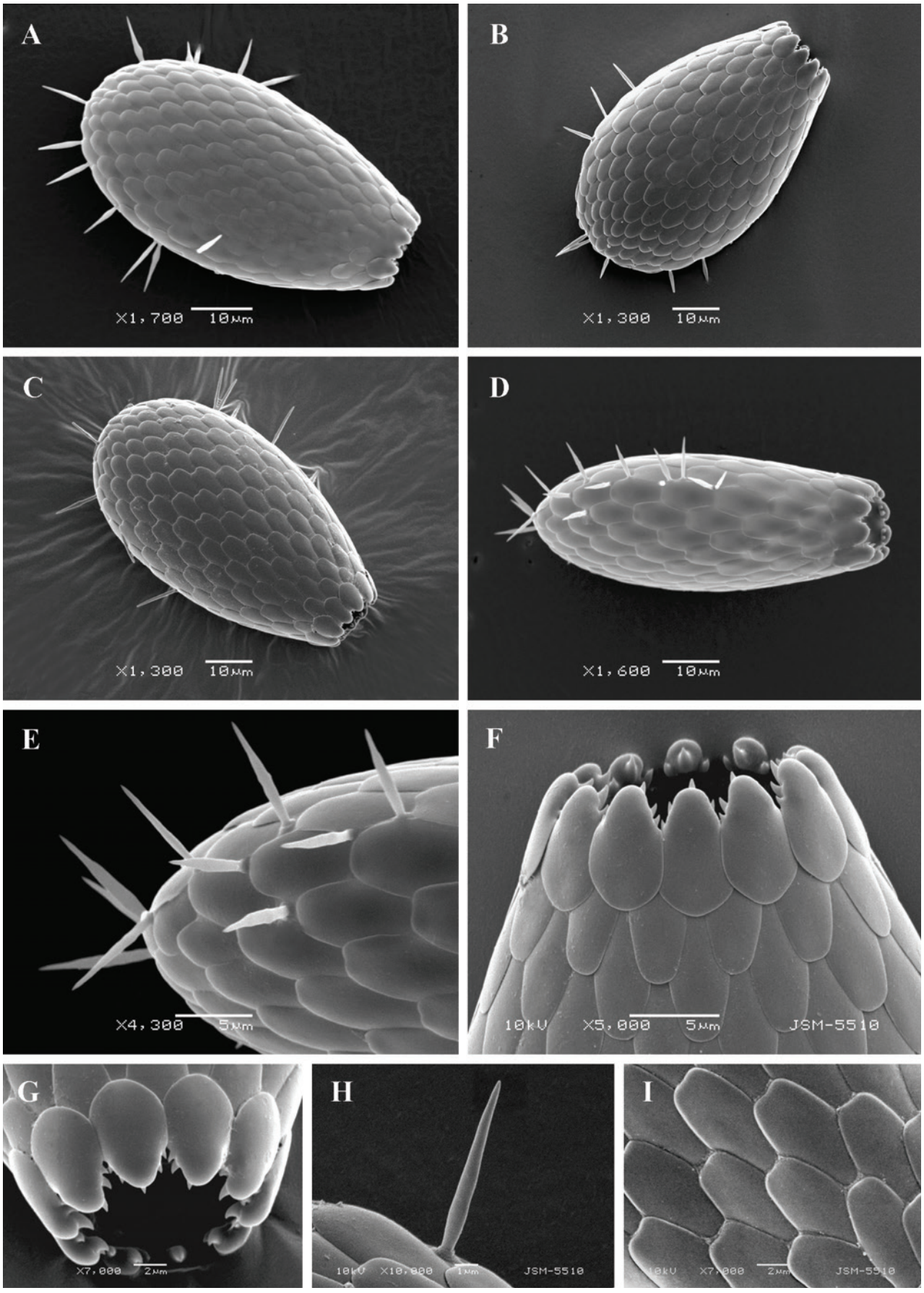
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 92. *Euglypha ciliata*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	64.8	64.8	4.40	0.80	6.79	56	74	30
Breadth	40.4	40.3	4.39	0.80	10.88	31	49	30
Diameter of aperture	14.1	14.1	2.27	0.41	16.14	10	18	30
Depth	25.1	25.5	1.87	0.56	7.45	22	28	11
Length of spines	8.7	9.0	1.91	0.36	21.95	5	12	28
Breadth/Length ratio	0.62	0.61	0.05	0.009	8.34	0.5	0.8	30
Aperture/Breadth ratio	0.35	0.35	0.04	0.007	11.37	0.3	0.4	30

Fig. 102. Scanning electron micrographs of *Euglypha ciliata*. (A-C) Broad lateral view of three specimens to show general shape, arrangement of shell plates and disposition of spines. (D) Narrow lateral view. (E) View of aboral region illustrating spines and their attachment to the shell surface. (F) Lateral view of apertural region. (G) Close up view of aperture. (H) Close up view of a single spine. (I) Detail of shell surface to show overlapping shell-plates.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E
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F
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G
X7,000 2µm
H
10kV X10,000 1µm JSM-5510
I
10kV X7,000 2µm JSM-5510

Euglypha compressa Carter, 1864

Original description: Carter 1864, *Annals and Magazine of Natural History***,** 13, no 73, p. 32, Pl. I, fig. 13.

Synonyms: *Euglypha ampullacea* Hertwig and Lesser, 1874; *Euglypha ciliata* Leidy, 1879 (in part); *Euglypha α* Vedovsky, 1882 (in part); ? *Euglypha zonata* Maggi, 1888.

Description: Shell large, colorless, transparent, broadly oviform, considerably compressed, elliptical in transverse section; with short siliceous spines slightly varying in size and distributed on lateral margin only (Fig. 103 A-F); spines attached to the surface with small hemispherical nodules of organic cement, easily broken (Fig. 103 F, H); shell composed of oval overlapping shell-plates of about 5-6 x 3,5-5 µm, arranged in fifteen to seventeen longitudinal and eighteen to twenty transverse alternating rows (Fig. 103 D-F). Aperture oval, surrounded by ten to fourteen roughly oval to triangular denticulate apertural-plates, which are thickened at denticulate margin; each apertural plate with large median tooth and three or four smaller lateral teeth on each side (Fig. 103 E-G). Cytoplasm fills about two-thirds of the shell; one large ovular nucleus, with few nucleoli (Fig. 103 A-B). Pseudopodia numerous, thin, radiating, sometimes branched, fast moving.

Notes: The species has been recorded in both as nominal species and as infrasubspecific taxon *E. compressa* f. *glabra* Wailes, 1915 (Rhodopes Mts.).

Ecology: Frequent in mosses, freshwater habitats and *Sphagnum*.

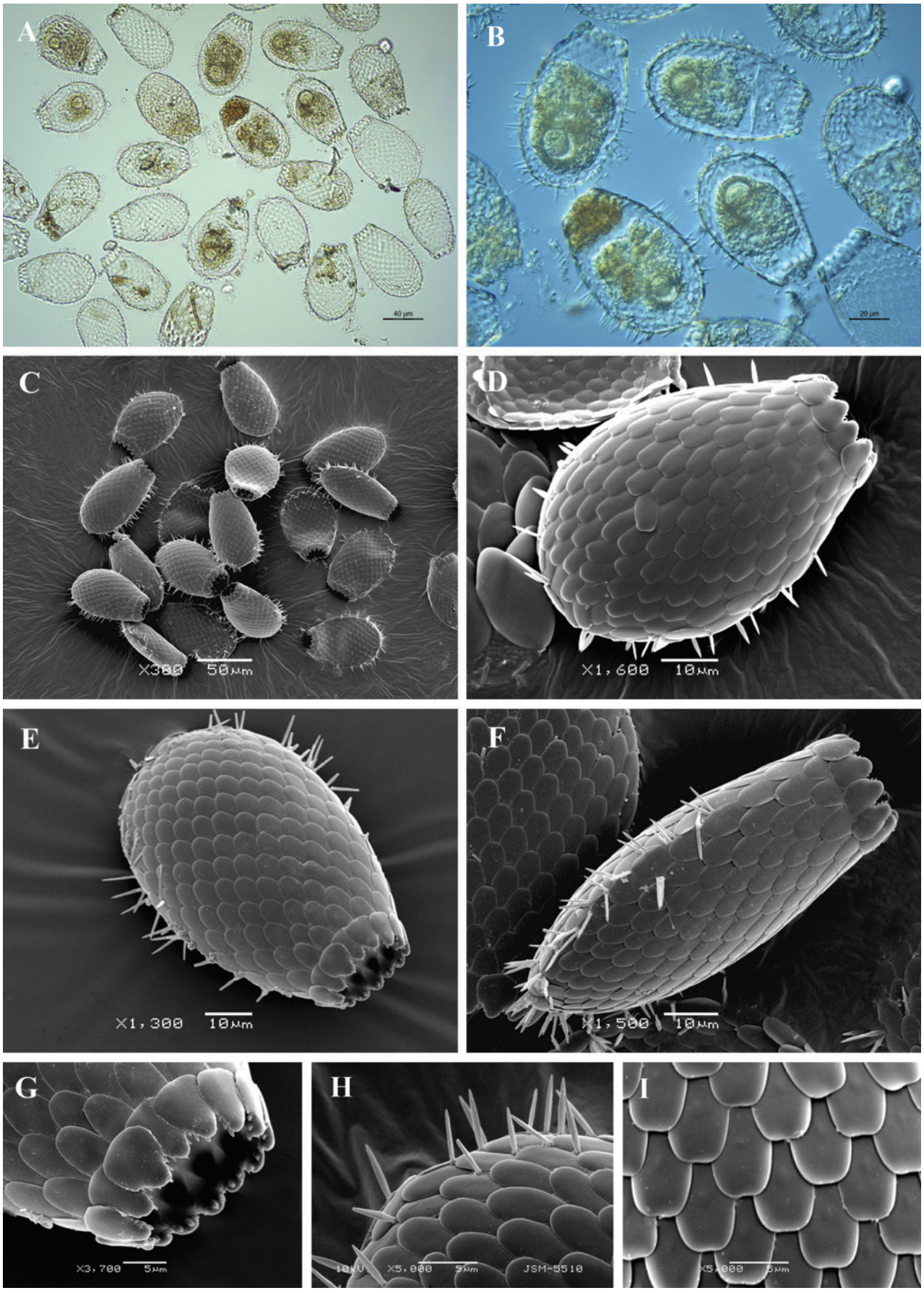
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 93. *Euglypha compressa*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	72,6	73,5	5,15	0,96	7,09	63	83	29
Breadth	46,5	46,5	3,83	0,72	8,24	39	57	28
Diameter of aperture	16,6	16,8	2,21	0,41	13,31	12	20	29
Depth	24,6	25,5	3,40	1,13	13,82	17	29	9
Length of spines	7,7	6,0	4,05	0,84	52,59	4	18	23
Breadth/Length ratio	0,64	0,64	0,05	0,01	7,81	0,55	0,74	28
Aperture/Breadth ratio	0,36	0,36	0,04	0,01	11,11	0,29	0,43	28

Fig. 103. Light (A, B) and scanning electron (C-I) micrographs of *Euglypha compressa*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D, E) Broad lateral view of two specimens to show general shape, arrangement of shell plates and disposition of spines. (F) Narrow lateral view. (G) Close up view of apertural region. (H) View of aboral region illustrating spines and their attachment to the shell surface. (I) Detail of shell surface to show overlapping shell-plates.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F
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H
X5,000 5µm JSM-5510
I
X5,000 5µm

Euglypha cristata Leidy, 1874

Original description: Leidy 1874c, *Proceedings of the Academy of Natural Sciences of Philadelphia*, 26, p. 226.

Description: Shell colorless, transparent, elongated, with long, slightly-constricted neck, uncompressed and circular in transverse section; apex of the aboral region with a tuft of three to nine long, thin, flattened and tapering siliceous spines (Fig. 104 A-E, G, H); shell composed of oval to hexagonal, slightly overlapping shell-plates of about 8-9 x 5-6 μm, arranged in five to six longitudinal and eleven to thirteen transverse alternating rows (Fig. 104 C-E, I). Aperture circular, surrounded by five to six oval or hexagonal denticulate apertural plates, which are thickened at the denticulate margin; each apertural plate with large median tooth and three smaller lateral teeth on each side (Fig. 104 E, F). Cytoplasm fills almost whole shell; one small vesicular nucleus with central nucleolus. Pseudopodia usually one, rarely few, thin, long, directed straight ahead, fast moving (Fig. 104 A, B).

Notes: The species has been recorded in both as nominal species and as infrasubspecific taxon *E. cristata* var. *major* Wailes, 1911 (Vitosha Mts.).

Ecology: Common in *Sphagnum*.

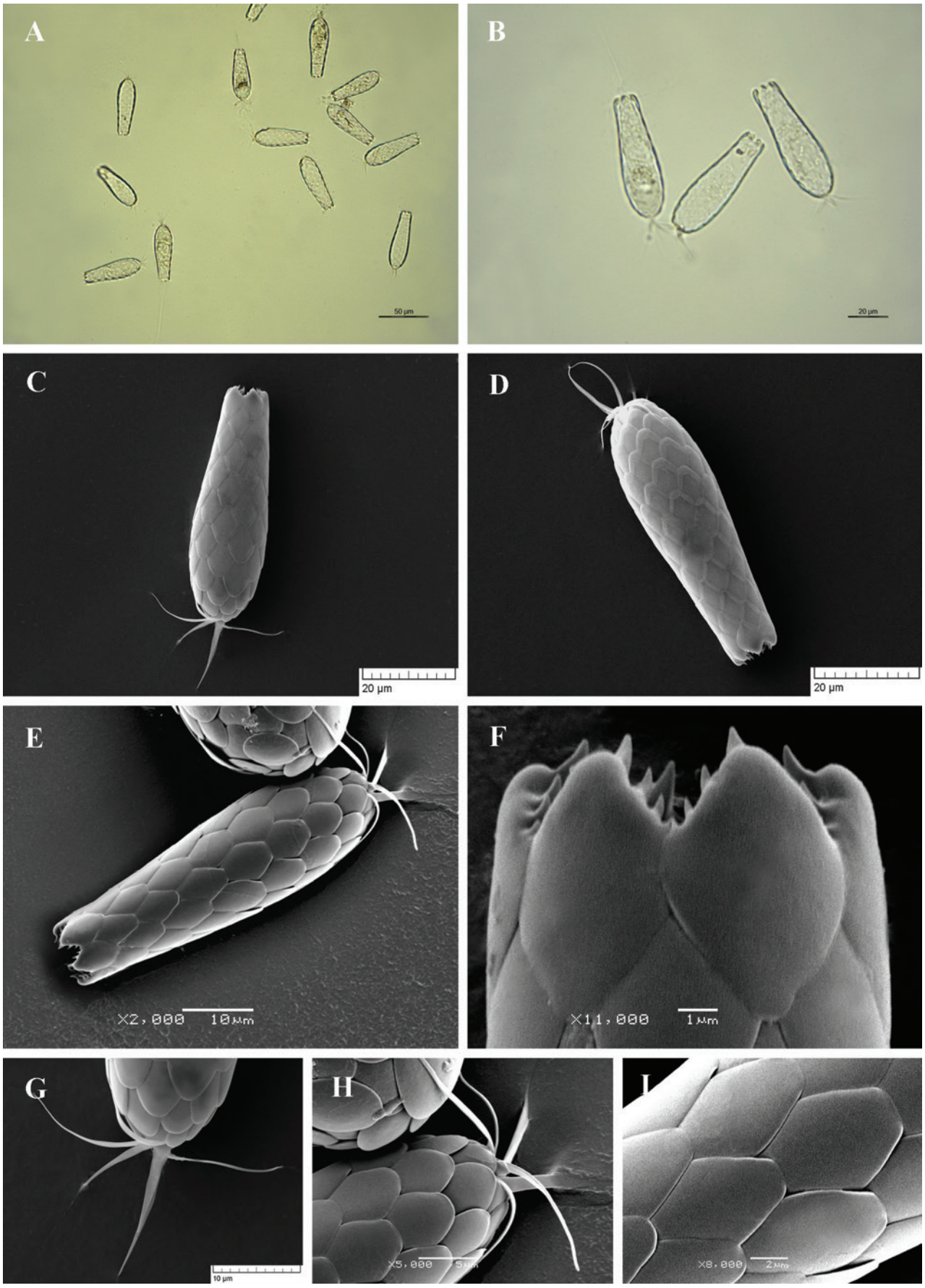
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995).

Table 94. *Euglypha cristata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	50.1	52.2	6.84	1.17	13.65	31	59	34
Breadth	16.3	16.7	2.00	0.34	12.22	11	19	34
Diameter of aperture	8.3	8.6	1.39	0.24	16.77	5	11	34
Length of spines	9.8	9.7	3.05	0.65	31.20	5	16	22
Breadth/Length ratio	0.33	0.32	0.03	0.005	9.75	0.3	0.4	34
Aperture/Breadth ratio	0.51	0.51	0.07	0.01	14.40	0.4	0.7	34

Fig. 104. Light (A, B) and scanning electron (C-I) micrographs of *Euglypha cristata*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C-E) Lateral view of three specimens to show symmetrical arrangement of shell plates and disposition of spines in centre of the aboral region. (F) View of apertural plates. (G-H) View of aboral region showing spines and their attachment to the shell (I) Detail of shell surface to show overlapping shell plates.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Euglypha filifera Penard, 1890

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 179, Pl. IX, fig. 69 à 73.

Synonyms: *Euglypha setigera* Perty, 1852 (in part); *Euglypha ciliata* Leidy, 1879 (in part); *Euglypha longispina* Taránek, 1881.

Description: Shell colorless, transparent, elongate-oviform, slightly compressed, oval in transverse section; with long spines on the lateral margins of aboral part of the shell, attached to surface with small hemispherical nodules (Fig. 105 A-E, H); shell composed of oval overlapping shell-plates of about 10 x 5 μm, arranged in seven to eight longitudinal and ten to twelve transverse alternating rows (Fig. 105 D-E, I). Aperture circular, usually surrounded by eight, rarely nine or ten oval and finely-denticulate apertural plates, thickened at the denticulate margin; each apertural plate with large median tooth and two or three smaller lateral teeth on each side (Fig. 105 F-G). Cytoplasm fills about two-thirds of the shell; one large ovular nucleus with many nucleoli. Pseudopodia numerous, thin, radiating, straight, fast moving.

Ecology: Frequent in mosses, freshwater habitats and *Sphagnum*.

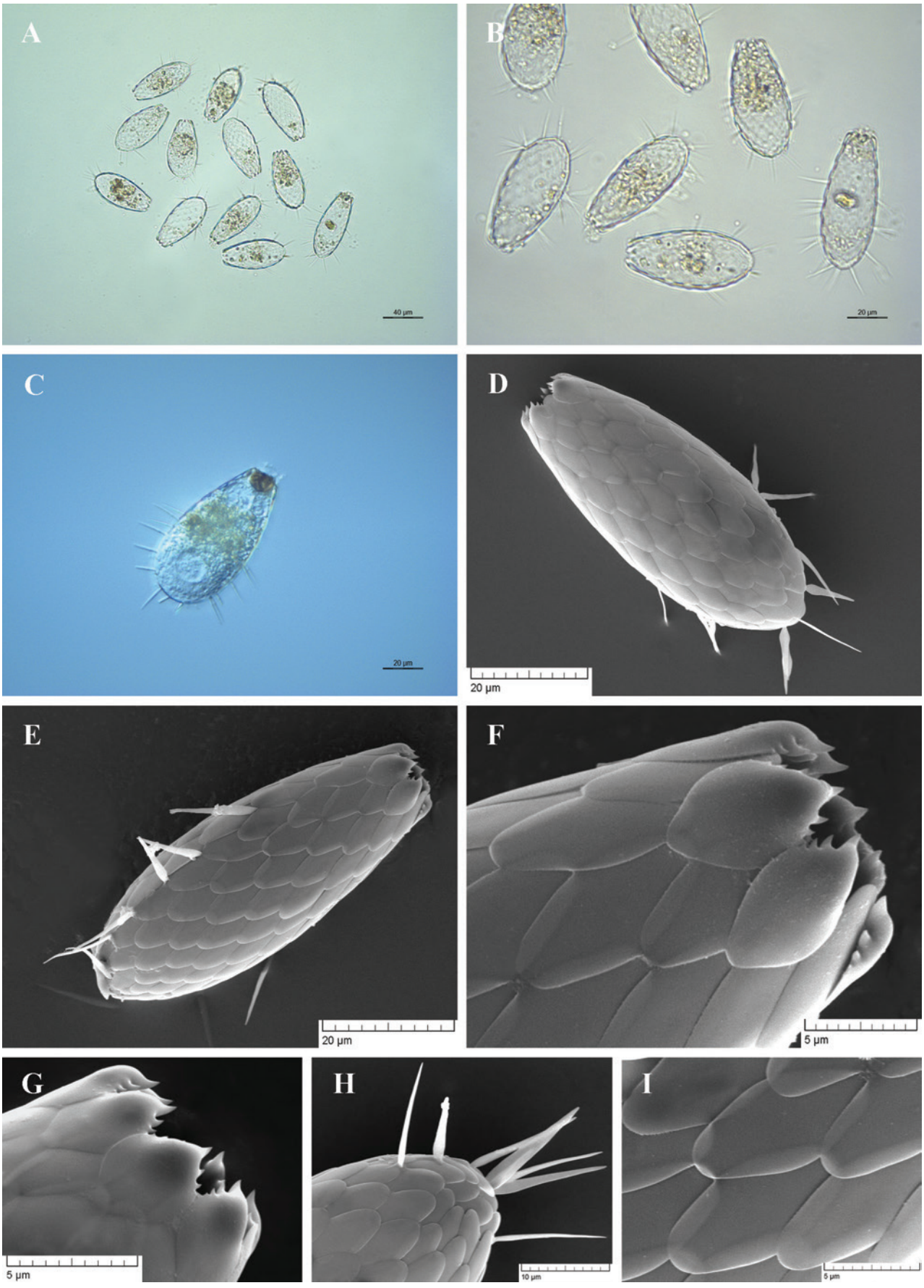
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 95. *Euglypha filifera*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	65,0	64,4	3,34	0,60	5,14	60	74	31
Breadth	33,2	31,5	4,40	0,79	13,2	27	40	31
Diameter of aperture	12,3	12,0	1,97	0,35	16,0	9	18	31
Depth	24,3	24,6	1,28	0,32	5,27	22	26	16
Length of spines	15,2	15,0	3,61	0,65	23,8	9	23	31
Breadth/Length ratio	0,5	0,5	0,06	0,01	12,0	0,4	0,6	31
Aperture/Breadth ratio	0,4	0,4	0,06	0,01	15,0	0,3	0,5	31

Fig. 105. Light (A-C) and scanning electron (D-I) micrographs of *Euglypha filifera*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C) View of live specimen. (D) Broad lateral view to show symmetrical arrangement of shell plates and disposition of spines on the lateral margins. (E) Narrow lateral view. (F, G) Lateral view of apertural region to show shape of apertural plates. (H) View of aboral region illustrating spines and their attachment to the shell. (I) Detail of shell surface to show overlapping shell plates.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Euglypha laevis (Ehrenberg, 1845) Perty, 1849

Original description: Ehrenberg 1845, *Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königliche Preussischen Akademie der Wissenschaften zu Berlin*, 10, p. 307; **Last revision:** Perty 1849, *Mittheilungen der Naturforschenden Gesellschaft in Bern*, no 146-149, pp. 163, 164, 168.

Synonyms: *Difflugia laevis* Ehrenberg, 1845; *Euglypha alveolata* Leidy, 1879 (in part); *Euglypha γ* Vejdovsky, 1882.

Description: Shell colorless, transparent, ovoid, glabrous, compressed, in transverse section varies from sub-circular in apertural region to elliptical from the mid-bory to the aboral region (Fig. 106 A-E); composed of elongated-oval, slightly overlapping shell-plates of about 5-6 x 2-3 μm, arranged in nine to ten longitudinal and eleven to thirteen transverse alternating rows (Fig. 106 C-E). Aperture oval to sub-circular, surrounded by eight to ten oval or hexagonal denticulate apertural plates, slightly thickened at the denticulate margin; each apertural plate with large median tooth and two smaller lateral teeth on each side (Fig. 106 F-H). Cytoplasm does not fills the whole shell; one small vesicular nucleus with central nucleolus, placed posteriorly in the cell. Pseudopodia numerous, thin, long, fast moving.

Ecology: Ubiquitous.

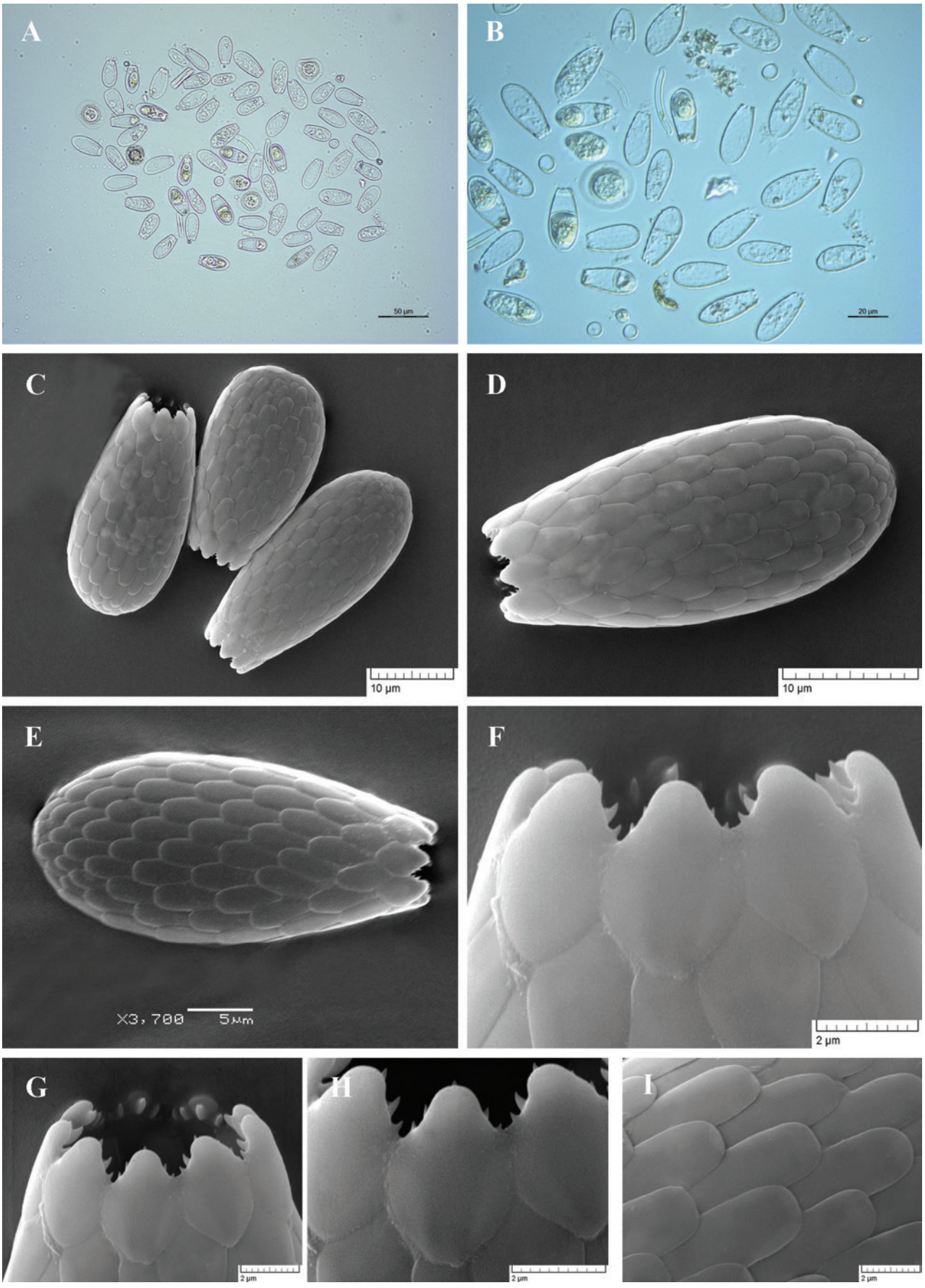
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 96. *Euglypha laevis*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	30.1	30.0	4.20	0.70	13.95	25	40	36
Breadth	15.0	14.5	3.33	0.56	22.12	10	23	36
Diameter of aperture	6.7	6.8	1.23	0.21	18.34	5	10	36
Depth	11.8	11.5	1.57	0.45	13.35	10	15	12
Breadth/Length ratio	0.50	0.52	0.08	0.01	15.78	0.32	0.64	36
Aperture/Breadth ratio	0.46	0.45	0.08	0.01	17.46	0.29	0.69	36

Fig. 106. Light (A, B) and scanning electron (C-I) micrographs of *Euglypha laevis*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C-E) Broad lateral views to show general shell shape and symmetrical arrangement of shell plates. (F-G) Apertural views to illustrate shape and arrangement of apertural plates. (H) Close up view of apertural plates. (I) Detail of shell surface to show overlapping shell plates.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Euglypha rotunda Wailes, 1911

Original description: Wailes and Penard 1911, *Proceedings of the Royal Irish Academy*, 31, Part 65, pp. 17, 41, 60, 61, 62, Pl. IV, fig. 19.

Description: Shell colorless, transparent, ovoid, glabrous, compressed, transverse section varies from circular in apertural region to oval from the mid-bory to the aboral region (Fig. 107 A-E); composed of oval, slightly overlapping shell-plates of about 7-8 x 4-5 μm, arranged in nine to ten longitudinal and eleven to thirteen transverse alternating rows (Fig. 107 B-E). Aperture circular, surrounded by eight to twelve oval or hexagonal denticulate apertural plates, slightly thickened at the denticulate margin; each apertural plate with large median tooth and two or three smaller lateral teeth on each side (Fig. 107 F-H). Cytoplasm fills almost whole shell; one small vesicular nucleus with central nucleolus, placed posteriorly in the cell. Pseudopodia numerous, thin, long, fast moving (Fig. 107 A, B).

Ecology: Ubiquitous.

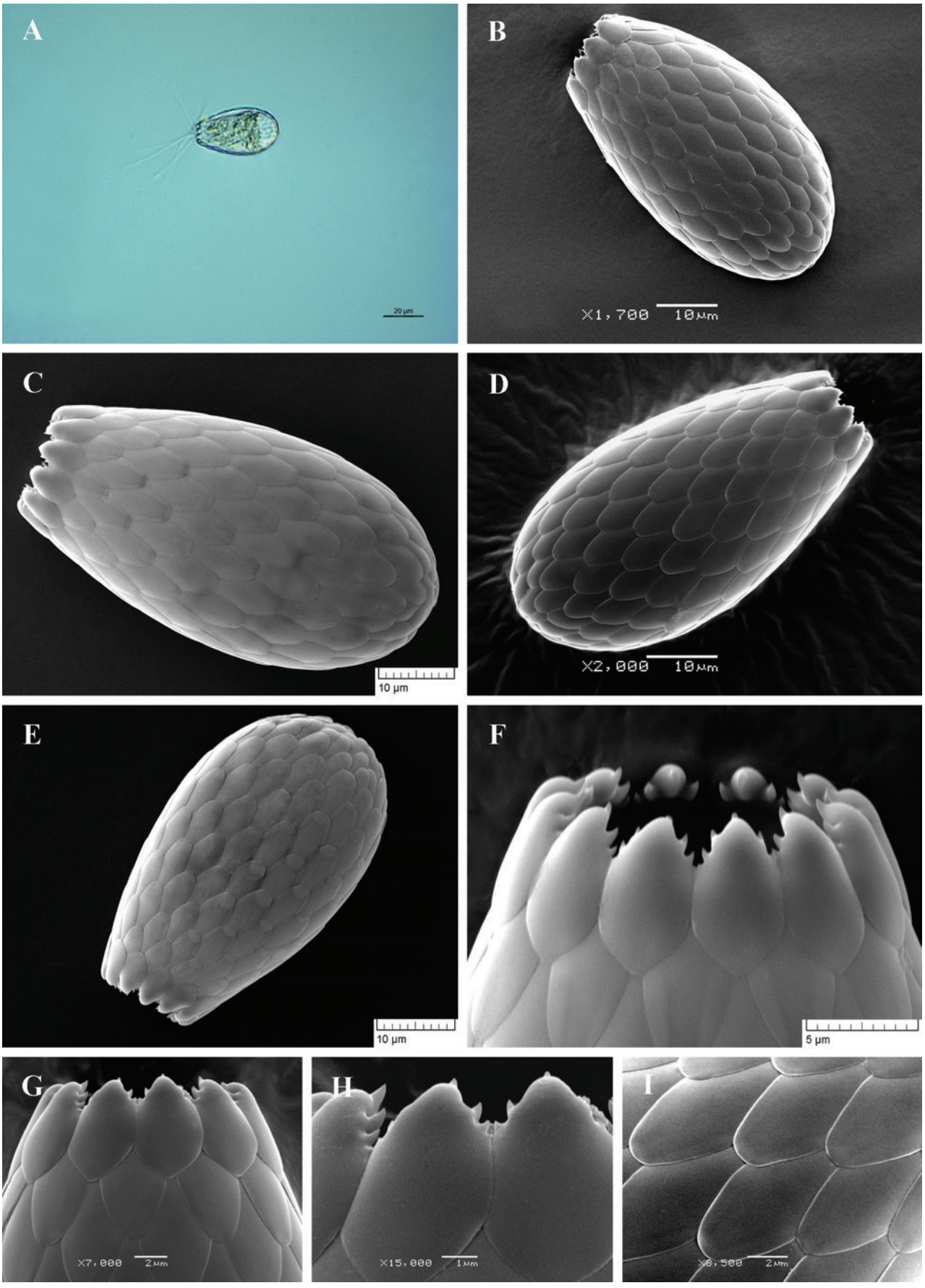
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 97. *Euglypha rotunda*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	50.5	50.6	7.25	1.30	14.36	41	68	31
Breadth	25.9	24.1	4.89	0.88	18.86	19	37	31
Diameter of aperture	11.6	11.3	2.69	0.48	23.21	8	18	31
Depth	20.7	19.6	4.17	1.01	20.11	16	29	17
Breadth/Length ratio	0.51	0.51	0.05	0.01	10.41	0.38	0.60	31
Aperture/Breadth ratio	0.45	0.44	0.08	0.01	16.73	0.32	0.69	31

Fig. 107. Light (A) and scanning electron (B-I) micrographs of *Euglypha rotunda*. (A) View of live specimen showing numerous thin and long filopodia. (B-E) Broad lateral view of four specimens to show uniformity of shell shape and symmetrical arrangement of shell plates. (F-G) Apertural views to illustrate shape and arrangement of apertural plates. (H) Close up view of apertural plates. (I) Detail of shell surface to show overlapping shell plates.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I
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Euglypha strigosa (Ehrenberg, 1871) Leidy, 1878

Original description: Ehrenberg 1871, *Abhandlungen der Königliche Akademie der Wissenshaften zu Berlin (1871)*, p. 257, Taf. II B, fig. 31; **Last revision:** Leidy 1878, *Proceedings of the Academy of Natural Sciences of Philadelphia,* 30, p. 172.

Synonyms: *Difflugia strigosa* Ehrenberg, 1871; *Difflugia Setigerella strigosa* Ehrenberg, 1871; *Euglypha ciliata* var. *strigosa* Leidy, 1879 (in part); *Euglypha heterospina* Penard, 1890.

Description: Shell colorless, transparent, oviform or pyriform, compressed, oval in transverse section, with siliceous spines varying in size and distributed over the whole shell surface (Fig. 108 A-D); spines attached to surface with small hemispherical nodules of organic cement, easily broken (Fig. 108 F); shell composed of oval overlapping shell-plates of about 7-8 x 4-5 µm, arranged in twelve to fourteen longitudinal and sixteen to seventeen transverse alternating rows (Fig. 108 C, D). Aperture circular, surrounded by ten to fourteen roughly oval to triangular denticulate apertural-plates, thickened at denticulate margin; each apertural plate with large median tooth and three or four smaller lateral teeth on each side (Fig. 108 F-G). Cytoplasm fills almost whole shell; one large ovular nucleus, with few nucleoli. Pseudopodia numerous, thin, radiating, fast moving (Fig. 108 A-B).

Ecology: Frequent in mosses, freshwater habitats and *Sphagnum*.

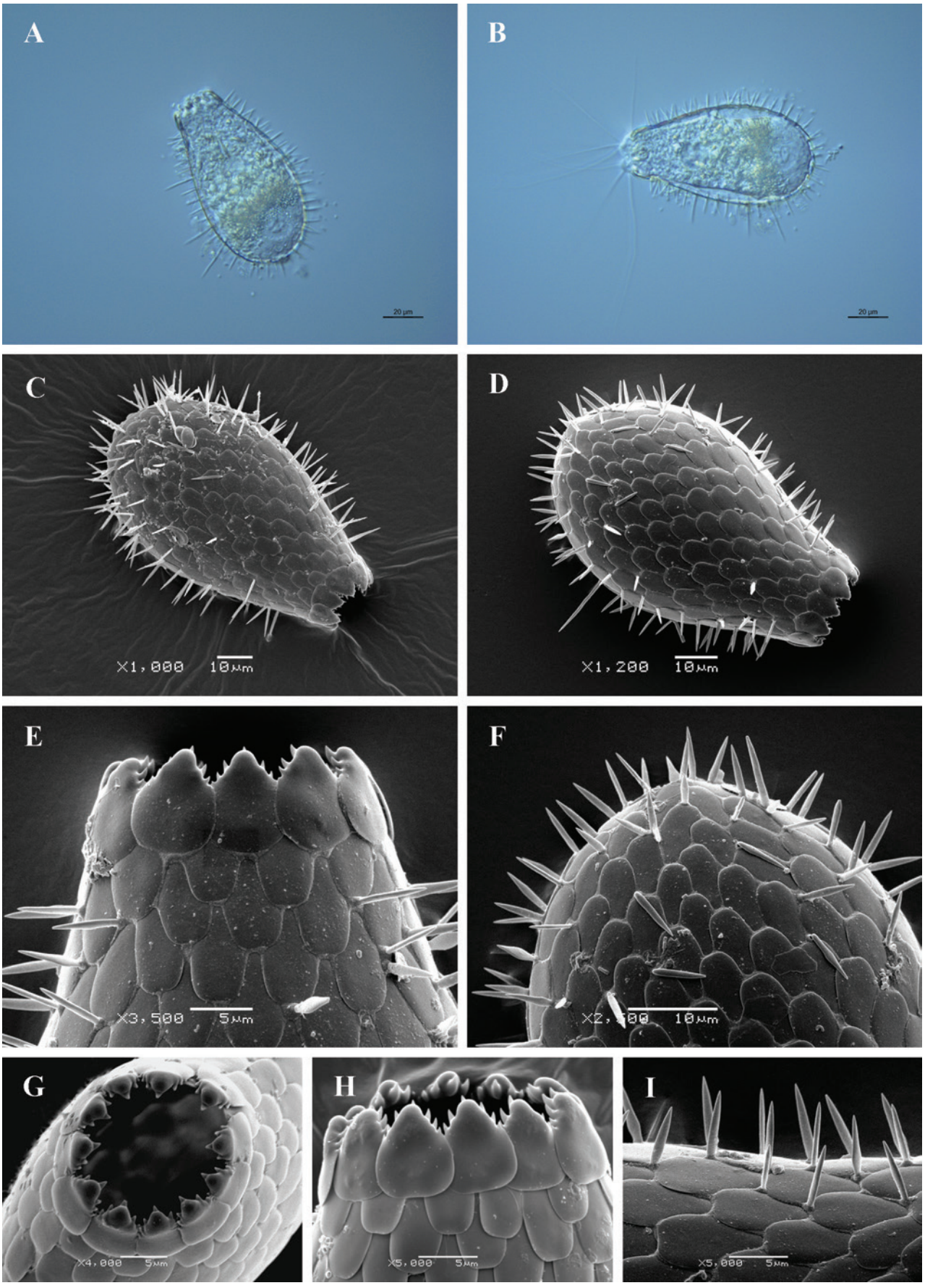
Geographical distribution: Cosmopolitan

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff, 1928, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 98. *Euglypha strigosa*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	77.0	78.8	7.49	1.25	9.72	60	91	36
Breadth	46.0	47.0	5.35	0.89	11.64	32	57	36
Diameter of aperture	17.2	17.5	2.48	0.41	14.43	11	25	36
Depth	26.5	26.6	1.78	0.41	6.72	24	31	19
Length of spines	9.6	9.3	4.78	0.83	49.74	4	21	33
Breadth/Length ratio	0.60	0.61	0.05	0.008	7.76	0.5	0.7	36
Aperture/Breadth ratio	0.37	0.36	0.04	0.006	9.62	0.3	0.5	36

Fig. 108. Light (A, B) and scanning electron (C-I) micrographs of *Euglypha strigosa*. (A, B) View of live specimens showing cytoplasm and numerous thin, long filopodia. (C, D) Broad lateral view of two specimens to show arrangement of shell plates and disposition of spines. (E) Lateral view of apertural region. (F) View of aboral region illustrating spines and their attachment to the shell surface. (G) Apertural view to illustrate arrangement of apertural-plates and pronounced tickness at the denticulate margin. (H) Close up view of apertural-plates. (I) Detail of shell surface to show overlapping shell-plates and shape of spines.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Euglypha tuberculata Dujardin, 1841

Original description: Dujardin 1841, *Histoire naturelle des Zoophytes. Infusoires*, pp. 251-252, Pl. 2, fig. 7-8.

Synonyms: *Difflugia areolata* Ehrenberg, 1841; *Euglypha alveolata* Dujardin, 1841 (in part); *Euglypha tuberculosa* Dujardin, 1841; *Difflugia alveolata* Pritchard, 1861; *Euglypha pusilla* Entz, 1877; *Euglypha β* Vejdovsky, 1882.

Description: Shell colorless, transparent, elongate-oviform, glabrous, uncompressed, circular in transverse section (Fig. 109 A-E); composed of circular to broadly oval overlapping shell plates, arranged in seven to eight longitudinal and ten to twelve transverse alternating rows (Fig. 109 D-E, I). Aperture circular, surrounded by eight to twelve oval and finely-serrated apertural-plates, which are barely thickened at the denticulate margin, with small triangular median tooth and four to five smaller lateral teeth on each side (Fig. 109 F-H). Cytoplasm fills about two-thirds of the shell; one large vesicular nucleus with one central nucleolus. Pseudopodia numerous, thin, radiating, generally straight, fast moving.

Notes: The species has been recorded in both as nominal species and as synonym *E. alveolata* (Rhodopes Mts., Vitosha Mts.).

Ecology: Frequent in mosses, freshwater habitats and *Sphagnum*.

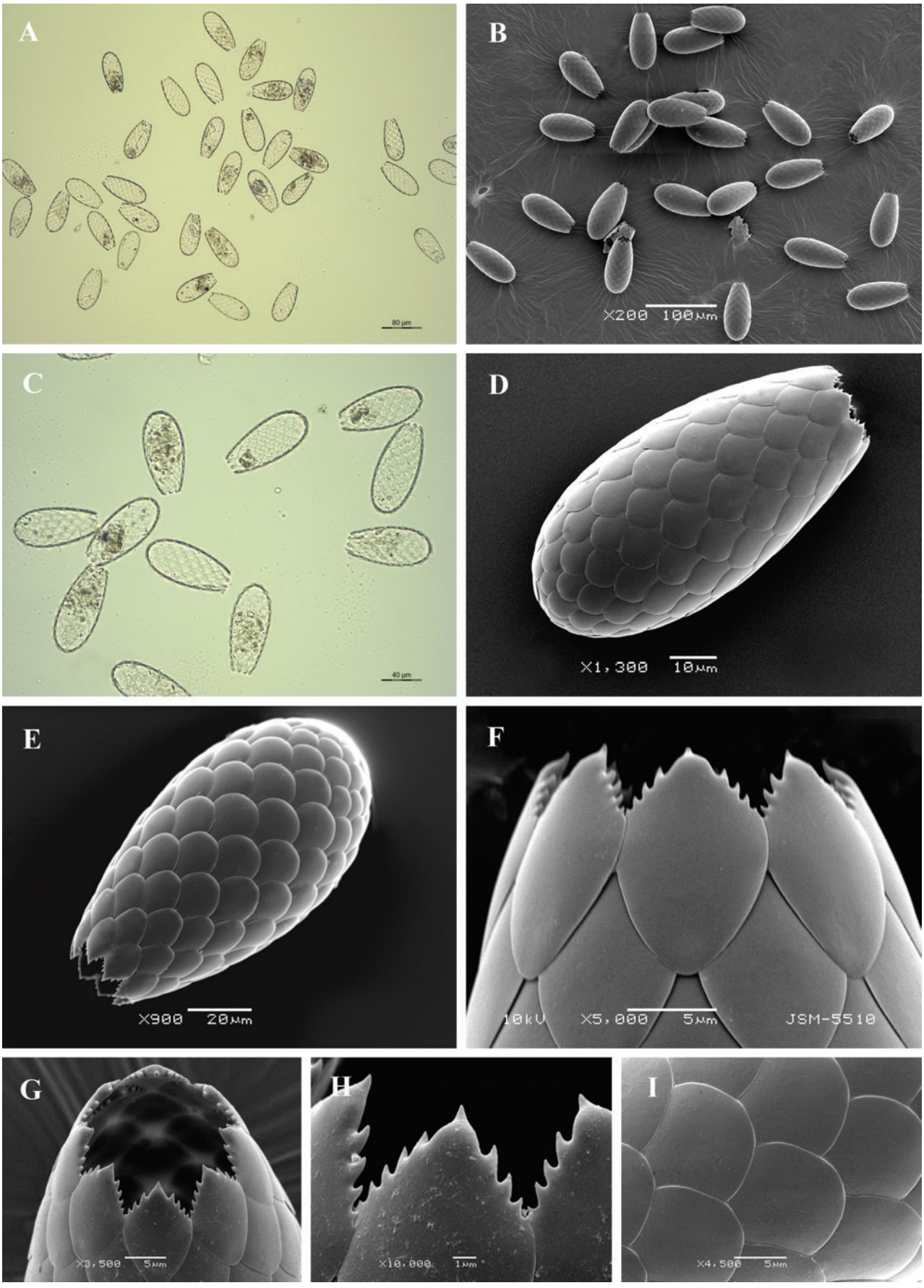
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 99. *Euglypha tuberculata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	89.3	87.4	8.94	1.43	10	74	111	39
Breadth	42.3	40.5	5.90	0.90	13.22	36	57	39
Diameter of aperture	16.6	16.7	2.33	0.37	14.04	10	23	39
Breadth/Length ratio	0.47	0.47	0.03	0.005	6.74	0.4	0.5	39
Aperture/Breadth ratio	0.39	0.40	0.05	0.008	12.19	0.3	0.5	39

Fig. 109. Light (A, C) and scanning electron (B, D-I) micrographs of *Euglypha tuberculata*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D, E) Broad lateral view of two specimens to show symmetrical arrangement of shell plates. (F) Lateral view of apertural region to show shape of apertural plates. (G) Apertural view. (H) View of apertural plates. (I) Detail of shell surface to show overlapping shell plates.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I
X4,500 5µm

Scutiglypha crenulata (Wailes, 1912) Foissner and Schiller, 2001

Original description: Wailes 1912, *Journal of the Linnean Society of London, Zoology*, 32, no 214, p. 147, Pl. 12, figs. 34-37; **Last revision:** Foissner and Schiller 2001, *European Journal of Protistology*, 37, p. 168, Figs. 1, 2, 6-13.

Synonyms: *Euglypha alveolata* Leidy, 1879 (in part); *Euglypha crenulata* Wailes, 1912.

Description: Shell colorless, transparent, ovoid or with sides tapering from the rounded fundus in nearly straight lines to the aperture; uncompressed, circular in transverse section, with two to six stout scale-spines which arises at the middle of the shell at nearly equal distance from the apex (Fig. 110 A-D, I); composed of characteristic scutiform shell-plates, with crenulated lower margins, of about 10-12 x 9-10 μm, arranged in seven to eight longitudinal and eleven to thirteen transverse alternating rows (Fig. 110 C, D, H). Aperture circular, surrounded by nine to twelve oval, finely denticulate apertural plates, not thickened at denticulate margin; each apertural plate with large triangular median tooth and four to five smaller lateral teeth on each side (Fig. 110 F, G). Cytoplasm fills about two-thirds of the shell; one large nucleus placed posteriorly in the cell. Pseudopodia numerous, thin, long, generally straight, fast moving.

Notes: The species has been recorded as infrasubspecific taxon *E. crenulata* var. *minor* Wailes, 1912.

Ecology: Freshwater habitats and *Sphagnum*, very rare.

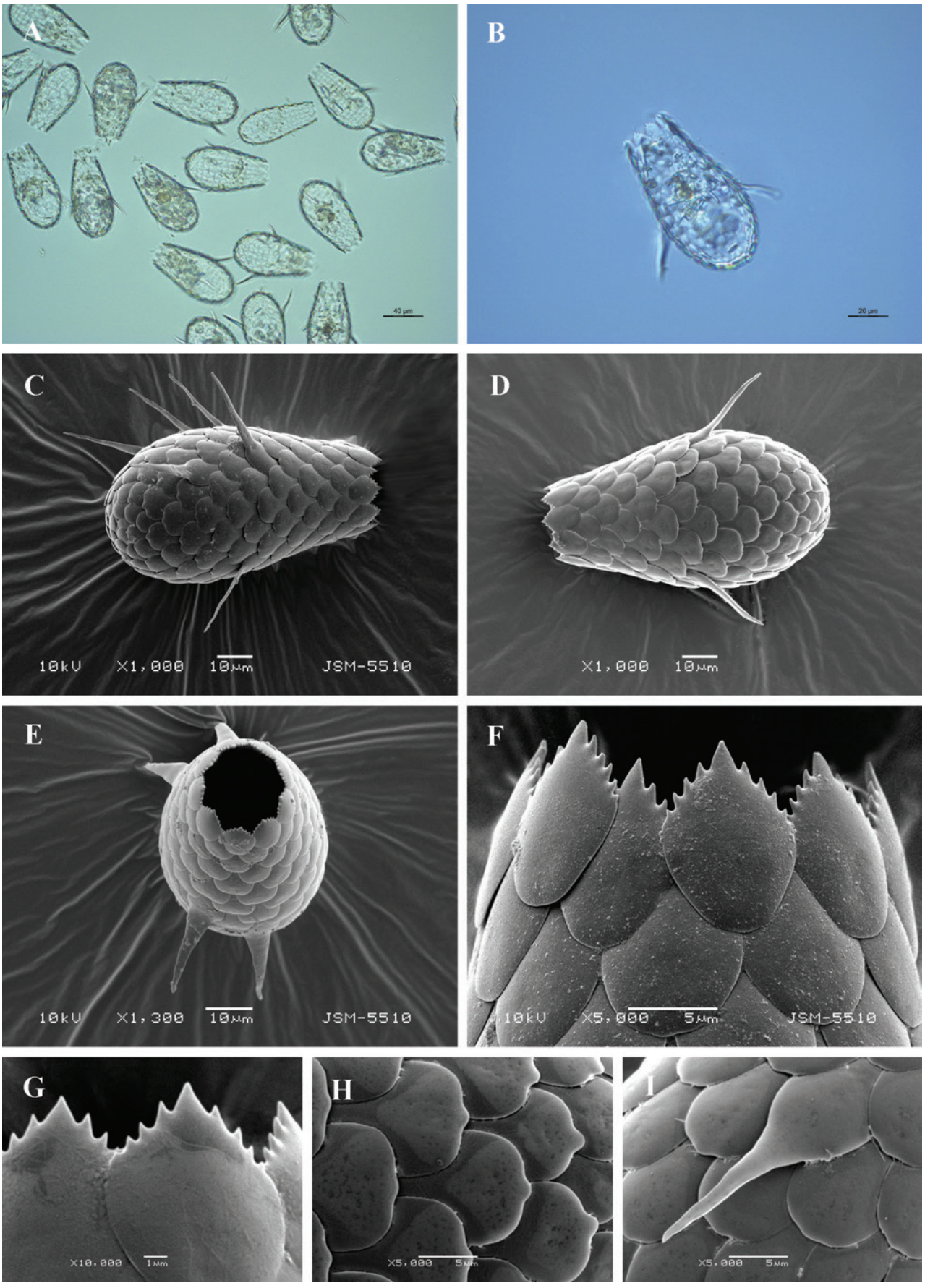
Geographical distribution: Probably cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Vitosha Mts. (Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995); **Pirin Mts.** (new data).

Table 100. *Scutiglypha crenulata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	81.3	82.0	3.75	0.67	4.61	73	86	31
Breadth	41.6	42.0	3.05	0.54	7.33	33	46	32
Diameter of aperture	18.6	18.9	1.46	0.26	7.83	16	21	32
Length of spines	20.1	20.8	4.02	1.07	19.95	11	26	14
Breadth/Length ratio	0.52	0.52	0.03	0.006	6.73	0.4	0.6	31
Aperture/Breadth ratio	0.45	0.45	0.04	0.006	7.96	0.4	0.5	32

Fig. 110. Light (A, B) and scanning electron (C-I) micrographs of *Scutiglypha crenulata*. (A) View of many specimens to illustrate variability in shape and size of the shell. (B-D) Lateral view of three specimens to illustrate general shape, symmetrical arrangement of shell plates and disposition of spines. (E) Apertural view. (F) Lateral view of apertural region to illustrate shape and arrangement of apertural-plates. (G) Close up view of apertural-plates. (H) Detail of shell surface to show characteristic scutiform and crenulated shell-plates. (I) View of modified shell-plate with spine.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Sphenoderia fissirostris Penard, 1890

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 184, Pl. X, fig. 30 à 40.

Description: Shell colorless, transparent, ovoid, compressed in apertural region, with transverse section varied from circular in the main body to oval or lenticular in the apertural region (Fig. 111 A-E); composed of oval, overlapping siliceous shell-plates arranged in four transverse rows; in the first three rows they are large of about 16-18 x 10-12 μm, in the fourth row and on the apex they are twice smaller (Fig. 111 C-E, H, I). Aperture small, terminal, linear, surrounde by conical collar with thin organic lip; collar is covered with very small oval siliceous plates of about 0,8-1 x 0,6-0,7 μm (Fig. 111 D-H). Cytoplasm hyaline, fills almost whole shell; one nucleus with few nucleoli, placed posteriorly in the cell (Fig. 111 A, B). Pseudopodia numerous, thin, long, radiating, sometimes branched, fast moving.

Ecology: Common in *Sphagnum*.

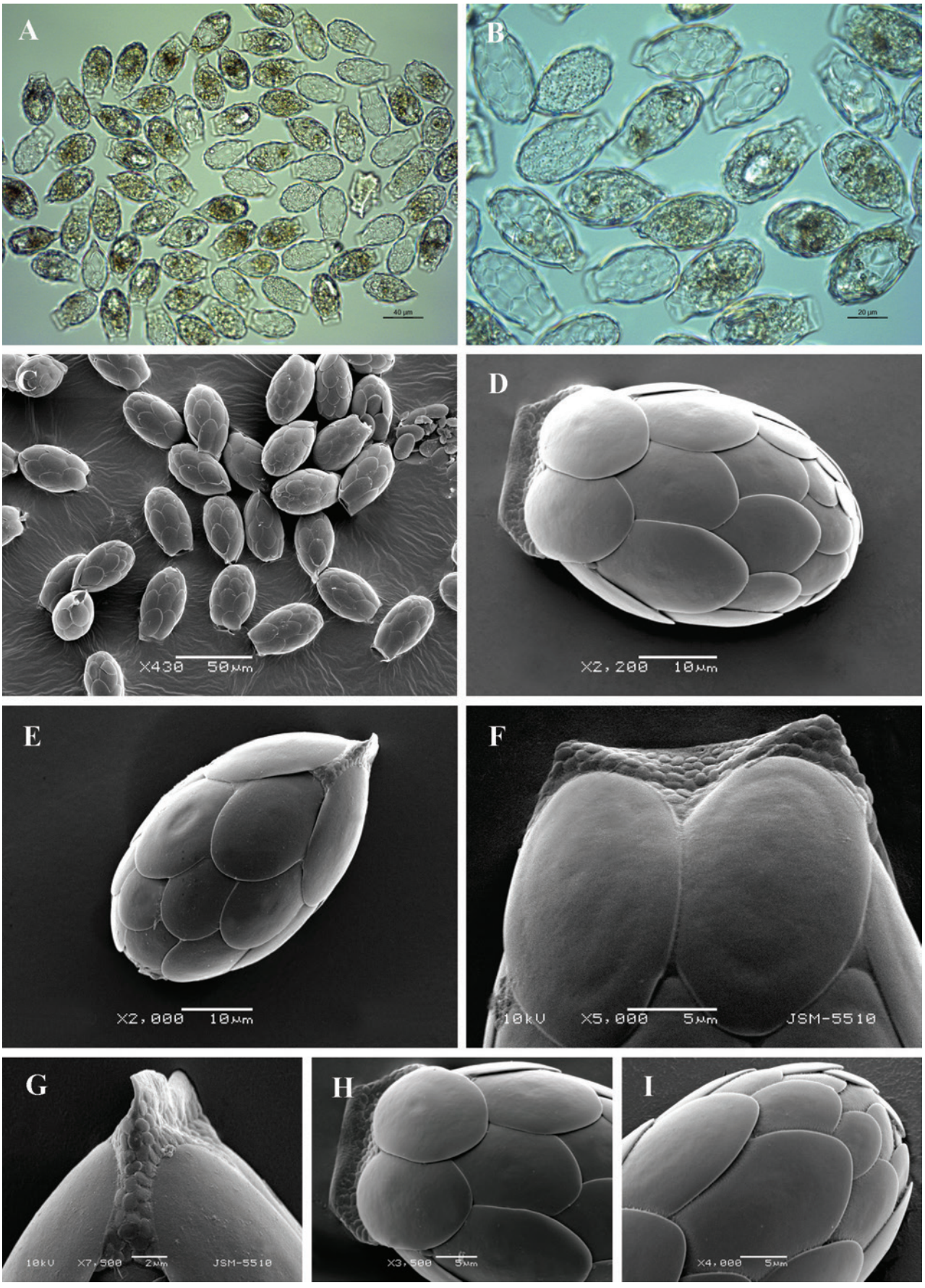
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 101. *Sphenoderia fissirostris*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	50.0	49.8	3.44	0.63	6.89	41	57	30
Breadth	27.9	27.6	1.42	0.26	5.11	26	31	30
Aperture width	15.4	15.4	1.55	0.28	10.03	11	18	30
Depth	26.7	26.5	1.80	0.33	6.75	23	30	30
Breadth/Length ratio	0.56	0.56	0.04	0.006	6.36	0.5	0.7	30
Aperture/Breadth ratio	0.55	0.57	0.06	0.01	10.45	0.4	0.6	30

Fig. 111. Light (A, B) and scanning electron (C-I) micrographs of *Sphenoderia fissirostris*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D) Broad lateral view. (E) Narrow lateral view. (F) Apertural view to illustrate shape and arrangement of apertural-plates and structure of the collar. (G) Close up lateral view of aperture showing linear aperture and conical collar. (H) Detail of apertural part of the shell to show large, oval shell-plates in the first two rows. (H) Detail of aboral region to show smaller, oval or circular shell-plates on the shell apex.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I
X4,000 5µm

Sphenoderia labiata Thomas et Gauthier-Lièvre, 1959

Original description: Thomas et Gauthier-Lièvre 1959, *Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord*, 50, p. 213, Fig. 3 E, F.

Description: Shell colorless or yellowish, transparent, ovoid, strongly compressed, with elliptical transverse section (Fig. 112 A-F); composed of elongated-oval, slightly overlapping shell-plates of about 8-10 x 4-5 µm, regularly arranged in eight to nine longitudinal and ten to twelve transverse alternating rows (Fig. 112 C-F, I). Aperture small, terminal, linear, surrounded by thin organic collar of about 4-5 µm; collar covered with small oval or circular siliceous plates of about 1-2 µm (Fig. 112 D-G). Cytoplasm hyaline, fills almost the whole shell; one nucleus placed posteriorly in the cell. Pseudopodia few, thin, long, fast moving.

Notes: *Sphenoderia labiata* differs from other species of the genus *Sphenoderia* by its strongly compressed shell, by the shape, size and arrangement of shell-plates and by its very fine and thin organic collar.

Ecology: In *Sphagnum*, rare.

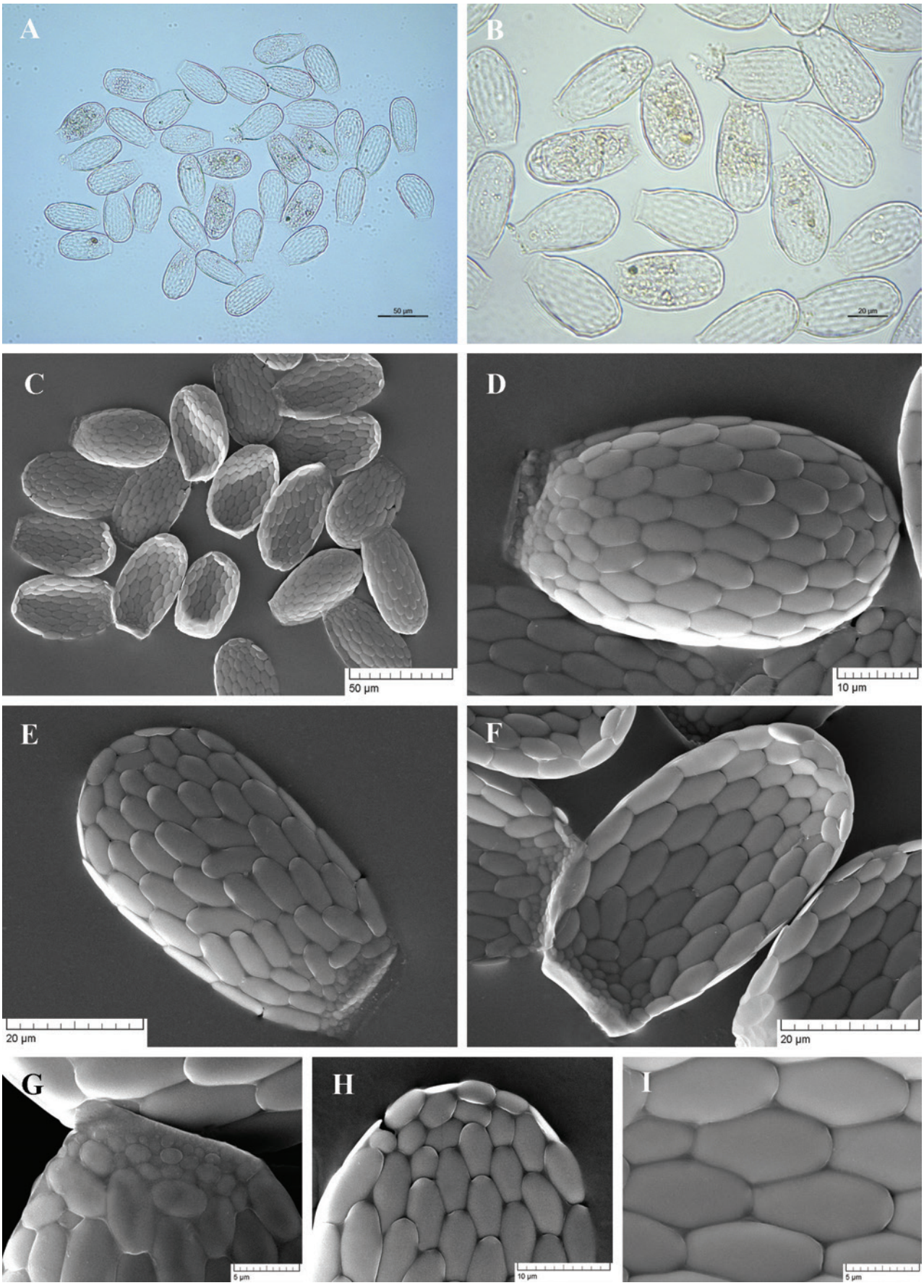
Geographical distribution: Probably cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (new data); **Rila Mts.** (new data).

Table 102. *Sphenoderia labiata*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	53.3	51.3	6.86	1.23	12.86	43	67	31
Breadth	31.8	30.8	4.34	0.78	13.65	25	41	31
Aperture width	16.1	15.8	2.22	0.40	13.77	13	21	31
Depth	20.6	20.0	2.98	0.94	14.51	16	26	10
Breadth/Length ratio	0.60	0.59	0.06	0.01	9.90	0.5	0.7	31
Aperture/Breadth ratio	0.51	0.50	0.04	0.007	7.99	0.4	0.6	31

Fig. 112. Light (A, B) and scanning electron (C-I) micrographs of *Sphenoderia labiata*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D-F) Broad lateral view of three individuals to illustrate general shape and regular arrangement of shell-plates. (G) Close up view of aperture to illustrate shape and arrangement of apertural-plates and structure of the collar. (H) Detail of aboral region to show smaller, oval or circular shell-plates on the shell apex. (I) Detail of shell surface to show overlapping, oval shell-plates.


A
50 µm
B
20 µm
C
50 µm
D
10 µm
E
20 µm
F
20 µm
G
5 µm
H
10 µm
I
5 µm

Sphenoderia lenta Schlumberger, 1845

Original description: Schlumberger 1845, *Annales des Sciences Naturelles (Zoologie)*, ser. 3, v. 3, p. 256.

Description: Shell colorless, transparent, ovoid or globular, uncompressed, with circular transverse section (Fig. 113 A-E); composed of almost equal in size oval, overlapping siliceous shell-plates of about 12-13 x 8-9 μm, so arranged that they do not form regular longitudinal and transverse rows (Fig. 113C-F). Aperture small, terminal, linear, surrounded by conical organic collar; one lip of the collar is concave whilst the other lip is inclined inwards; collar covered with small oval siliceous plates of about 3-4,5 x 1,2-1,8 μm (Fig. 113 E-H). Cytoplasm hyaline, fulfilled with small brilliant, colorless granules, fills about two-thirds of the shell; one nucleus placed posteriorly in the cell. Pseudopodia numerous, thin, long, radiating, sometimes branched, fast moving.

Ecology: Common in *Sphagnum*.

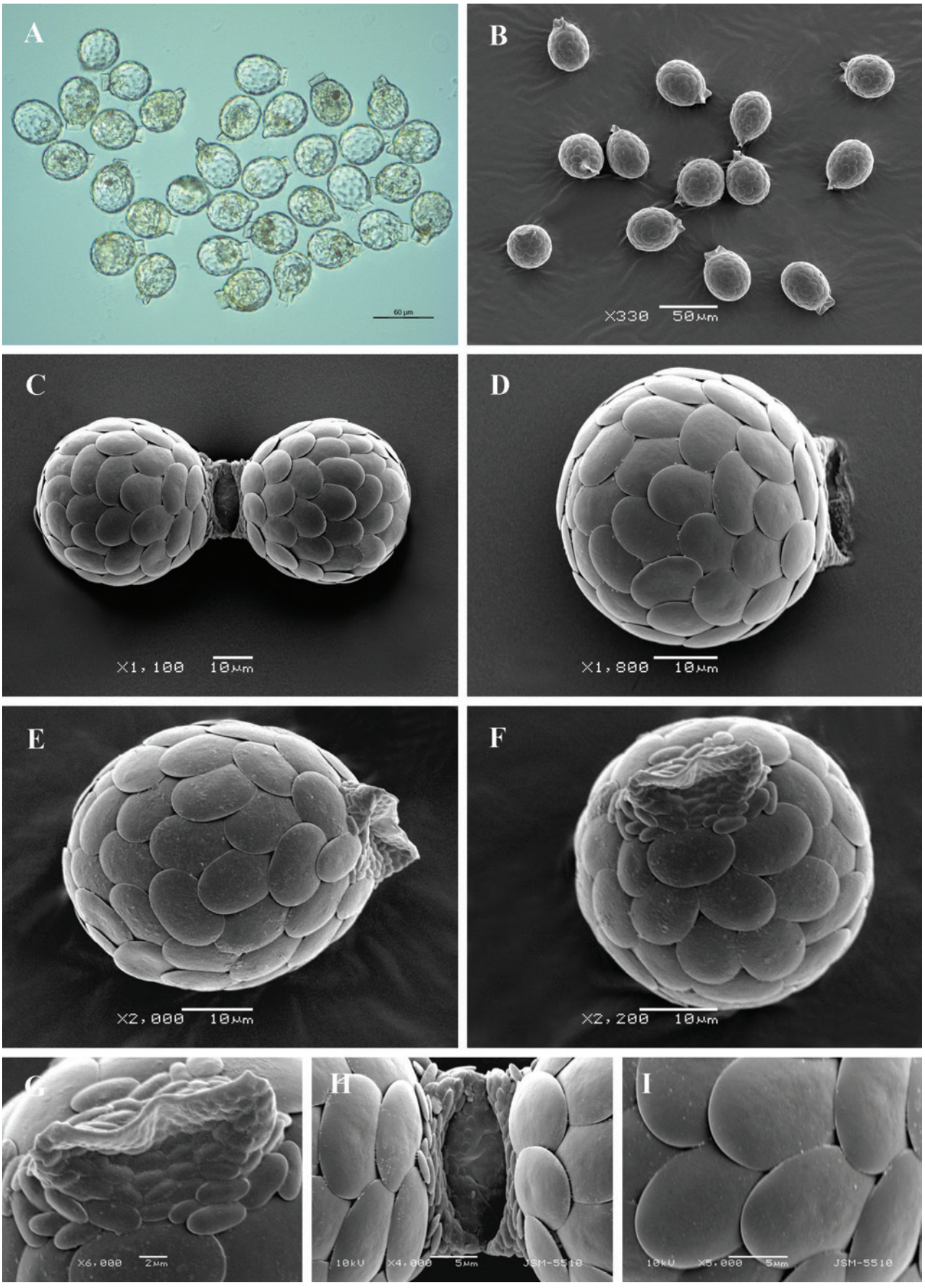
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 103. *Sphenoderia lenta*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	50.9	51.5	4.57	0.83	8.98	38	59	30
Breadth	39.7	39.8	3.61	0.66	9.09	23	45	30
Diameter of aperture	17.1	17.6	1.78	0.32	10.40	12	20	30
Breadth/Length ratio	0.78	0.78	0.07	0.01	8.27	0.6	0.9	30
Aperture/Breadth ratio	0.43	0.43	0.04	0.008	10.14	0.4	0.5	30

Fig. 113. Light (A) and scanning electron (B-I) micrographs of *Sphenoderia lenta*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) Two individuals at final stage of division. (D) Broad lateral view to illustrate arrangement of shell-plates on the shell surface. (E) Narrow lateral view. (F) Apertural view. (G-H) Close up view of aperture to illustrate shape and arrangement of apertural-plates and structure of the collar. (I) Detail of shell surface to show overlapping shell-plates.


A
60 µm
B
X330 50µm
C
X1,100 10µm
D
X1,800 10µm
E
X2,000 10µm
F
X2,200 10µm
G
X6,000 2µm
H
10kV X4,000 5µm JSM-5510
I
10kV X5,000 5µm JSM-5510

Sphenoderia minuta Deflandre, 1931

Original description: Deflandre 1931, *Annales de Protistologie*, 3, p. 91, Pl. XV, fig. 10-13.

Description: Shell small, colorless, transparent, ovoid, uncompressed, with circular transverse section (Fig. 114 A-F); composed of oval, almost equal in size, overlapping siliceous shell-plates of about 8-9 x 5-6 μm, not quite properly arranged in five to six longitudinal and five to six transverse rows (Fig. 114 C-F). Aperture small, terminal, linear, surrounded by organic collar; one lip of the collar is concave whilst the other lip is inclined inwards; collar is covered with small oval siliceous plates of 1,2-1,4 x 0,6-0,8 μm (Fig. 114 E-H). Cytoplasm hyaline, fulfilled with small colorless granules, fills about two-thirds of the shell; one nucleus placed posteriorly in the cell. Pseudopodia numerous, fine, long, fast moving.

Ecology: Common in *Sphagnum*.

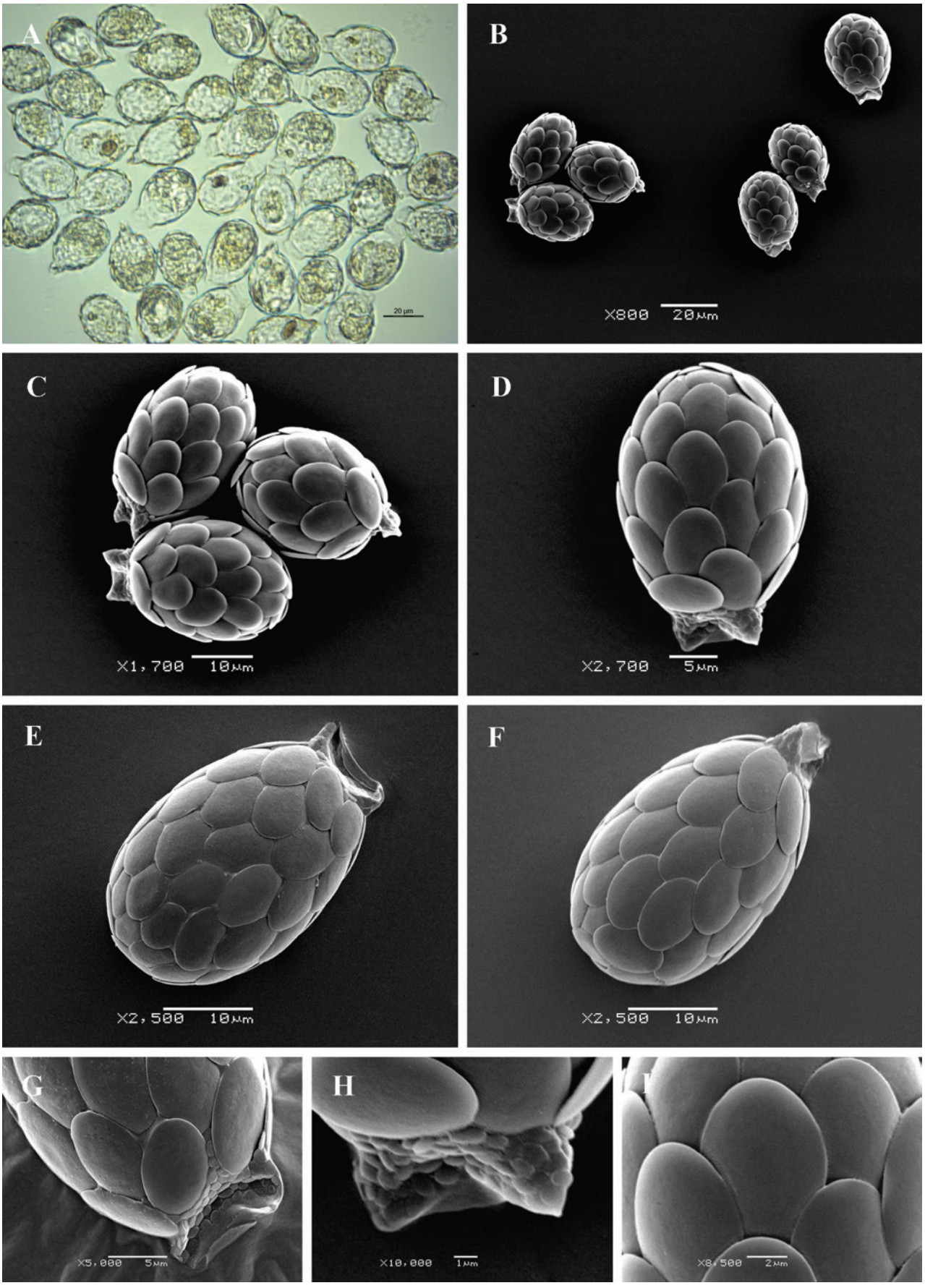
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 104. *Sphenoderia minuta*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	34.8	34.8	1.90	0.35	5.4	31	38	30
Breadth	22.5	22.4	1.52	0.28	6.74	21	28	30
Diameter of aperture	10.1	10.2	1.21	0.22	11.97	8	13	30
Depth	22.1	22.0	1.41	0.28	6.40	18	25	26
Breadth/Length ratio	0.65	0.65	0.05	0.009	7.38	0.6	0.8	30
Aperture/Breadth ratio	0.45	0.43	0.06	0.01	14.25	0.3	0.6	30

Fig. 114. Light (A) and scanning electron (B-I) micrographs of *Sphenoderia minuta*. (A-C) View of several specimens to illustrate variability in shape and size of the shell. (D, E) Broad lateral view of two induviduals to illustrate arrangement of shell-plates on the shell surface. (F) Narrow lateral view. (G) View of apertural region. (H) Close up view of aperture to illustrate shape and arrangement of apertural-plates and structure of the collar. (I) Detail of shell surface to show overlapping shell-plates.


A
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C
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D
X2,700 5µm
E
X2,500 10µm
F
X2,500 10µm
G
X5,000 5µm
H
X10,000 1µm
I
X8,500 2µm

Sphenoderia ovoidea Jung, 1942

Original description: Jung 1942, *Archiv für Protistenkunde*, 95, p. 329, Abb. 75.

Description: Shell colorless or yellowish, transparent, ovoid, slightly compressed, with roughly circular to oval transverse section (Fig. 115 A-E); composed of two types of shell-plates: large, oval and slightly overlapping plates of about 13-14 x 8-9 μm, and small elongated-ovoid of about 3-5 x 1,6-2,5 μm, filling the interstices between large plates; shell-plates are so arranged that do not form regular longitudinal and transverse rows (Fig. 115 B-E). Aperture small, terminal, linear, surrounded by a thin organic collar of about 3-5 μm; collar is covered with small oval siliceous plates of about 1-1,5 x 0,7-0,9 μm (Fig. 115 C-G). Cytoplasm hyaline, fills almost the whole shell; one nucleus placed posteriorly in the cell. Pseudopodia numerous, fine, long, radiating, fast moving.

Notes: *Sphenoderia ovoidea* differs from *S. fissirostris* by the presence of two types of shell-plates, their arrangement and size, by thin organic collar, and by its slythly compressed shell.

Ecology: In *Sphagnum*, rare.

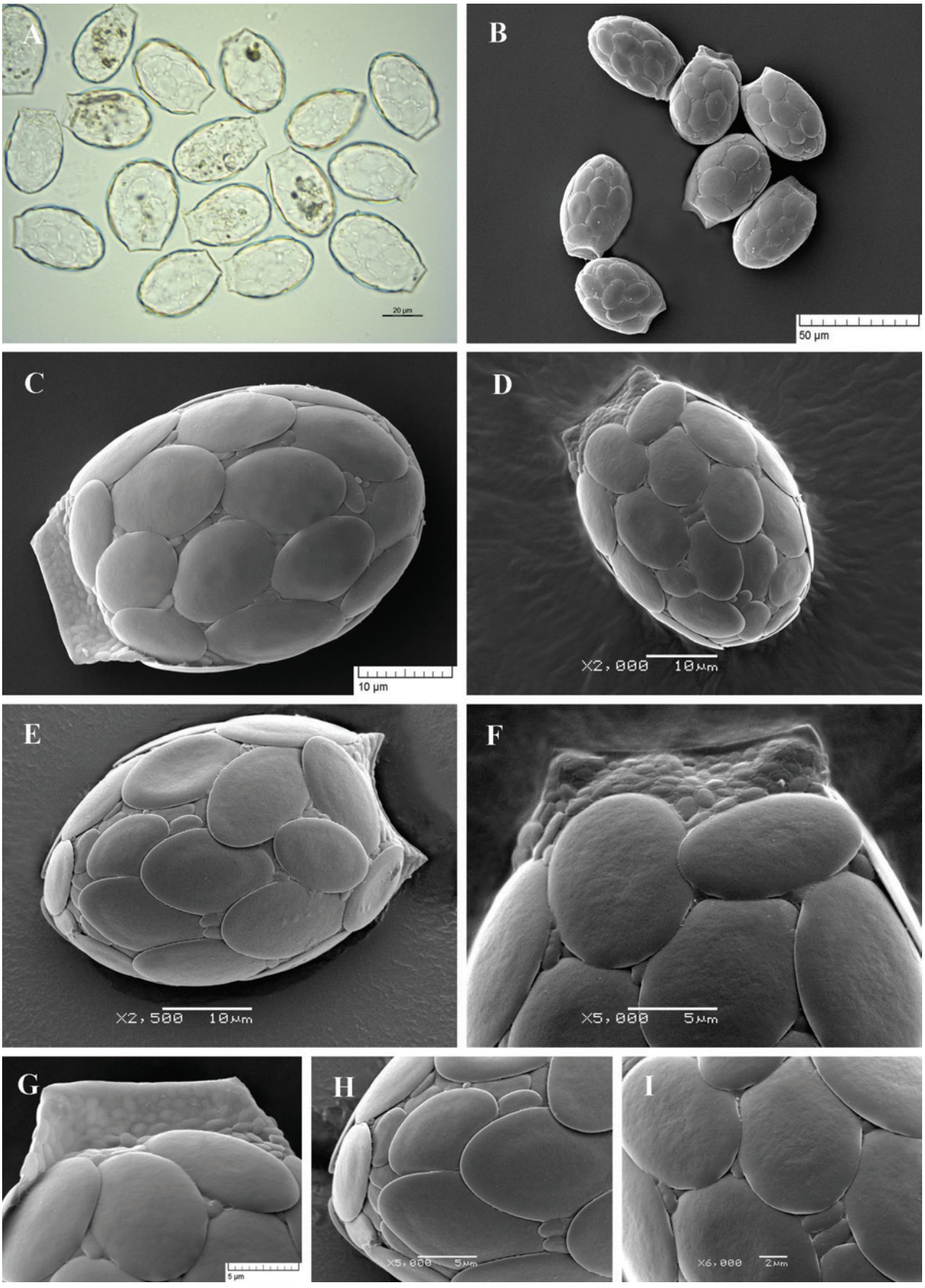
Geographical distribution: Probably cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Stara Planina Mts. (Bankov et al. 2018); **Vitosha Mts.** (Bankov et al. 2018).

Table 105. *Sphenoderia ovoidea*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	44.5	43.6	4.44	0.81	9.99	38	52	30
Breadth	28.4	28.6	1.52	0.28	5.35	25	31	30
Diameter of aperture	14.4	14.0	1.40	0.26	9.73	12	18	30
Depth	25.4	25.3	1.91	0.46	7.50	21	29	17
Breadth/Length ratio	0.65	0.66	0.07	0.01	11.44	0.5	0.8	30
Aperture/Breadth ratio	0.51	0.51	0.05	0.01	10.29	0.4	0.6	30

Fig. 115. Light (A) and scanning electron (B-I) micrographs of *Sphenoderia ovoidea*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C-E) Broad lateral view of three individuals to illustrate general shape and arrangement of large and small shell-plates. (F, G) Close up view of aperture to illustrate shape and arrangement of apertural-plates and structure of the collar. (H) Detail of aboral region to show smaller oval or circular shell-plates on the shell apex. (I) Detail of shell surface to show overlapping, large shell-plates and small, oval plates in the interstices between them.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X2,500 10µm
F
X5,000 5µm
G
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H
X5,000 5µm
I
X6,000 2µm

Trachelocorythion pulchellum (Penard, 1890) Bonnet, 1979

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 189, Pl. XI, fig. 27 à 36; **Last revision:** Bonnet 1979, *Bulletin de la Société d'Histoire Naturelle de Toulouse*, 115, p. 110, fig. 28-29, Pl. I, fig. 10-11.

Description: Shell small, colorless, transparent, elongated-ovoid, strongly compressed, with elliptical transverse section (Fig. 116 A-F); composed of elongated-oval or hexagonal, slightly overlapping shell-plates of about 4,5-6 x 2,5-3 µm, regularly arranged in eight to nine longitudinal and ten to twelve transverse alternating rows (Fig. 116 C-F, H, I). Aperture small, sub-terminal, linear, surrounded by thin organic collar of about 3-4 µm; collar is covered with small oval or circular siliceous plates of about 1-3 µm (Fig. 116 F, G). Cytoplasm hyaline, fills almost the whole shell; one nucleus placed posteriorly in the cell.

Notes: Due to its very small size and transparent shell *Trachelocorythion pulchellum* can often be overlooked. By the shape and structure of the shell it is very similar to *Sphenoderia labiata* and differs from the last species mostly by its doubly smaller size. The similarity between these species raises the question whether they really are different species of different genera, or this is a matter of an intraspecific variability of the same species. But this question can only be resolved through molecular research.

Ecology: Frequent in *Sphagnum,* as well as in brown mosses, forest litter and soils.

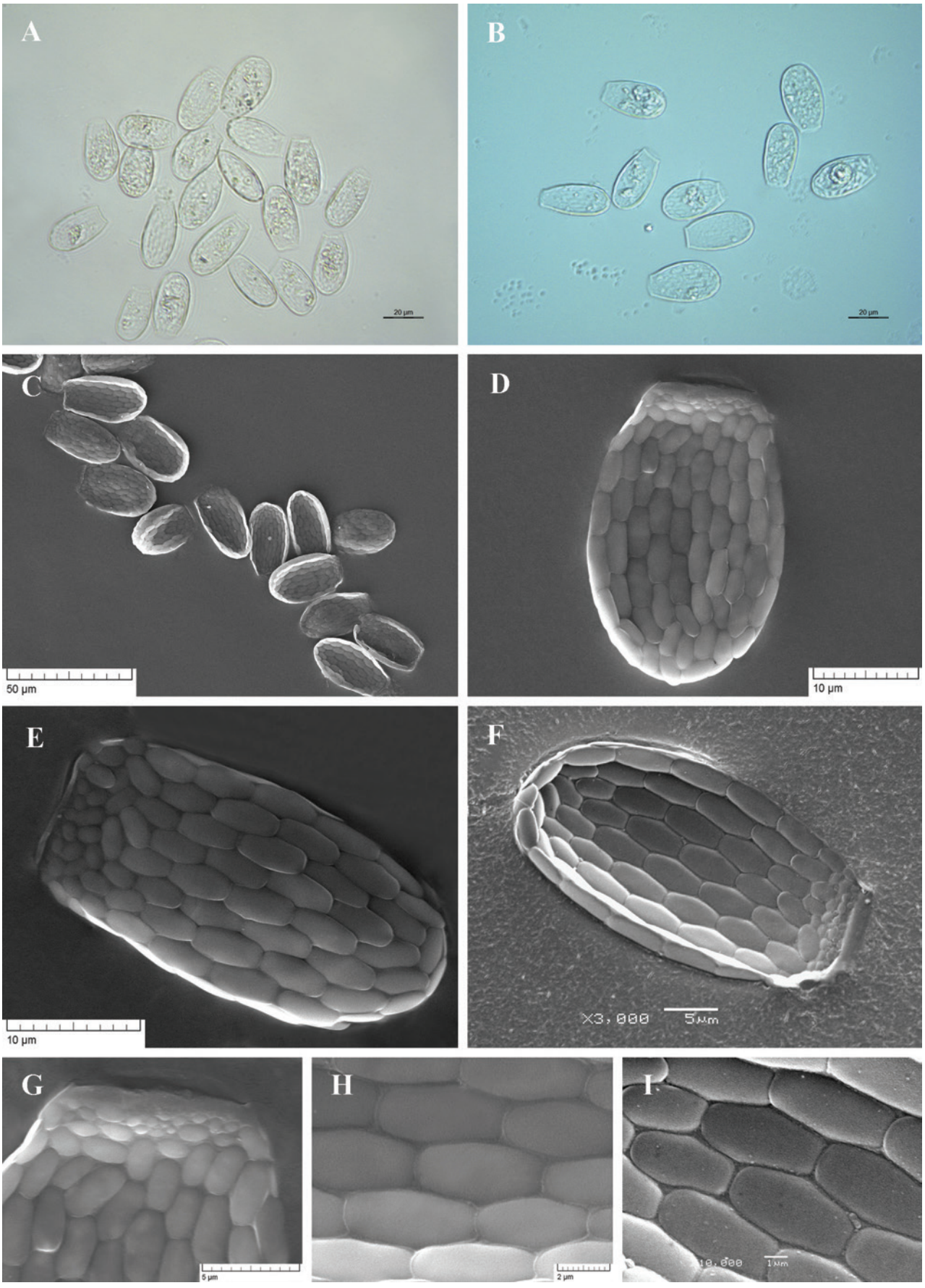
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Bankov et al. 2018).

Table 106. *Trachelocorythion pulchellum*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	30.2	30.7	3.42	0.61	11.35	22	35	31
Breadth	17.7	17.9	2.55	0.46	14.49	12	24	31
Aperture width	9.4	9.3	1.23	0.22	13.02	7	13	31
Depth	11.0	10.9	2.03	0.45	18.46	8	17	20
Breadth/Length ratio	0.59	0.59	0.06	0.01	11.02	0.5	0.7	31
Aperture/Breadth ratio	0.54	0.54	0.07	0.01	13.10	0.4	0.7	31

Fig. 116. Light (A, B) and scanning electron (C-I) micrographs of *Trachelocorythion pulchellum*. (A-C) View of several specimens to illustrate variability in shape and size of the shell. (D-F) Broad lateral view of three specimens showing general shape and regular arrangement of shell-plates. (G) Close up view of aperture to illustrate shape and arrangement of apertural-plates and structure of the collar. (H, I) Details of shell surface to show elongated-oval or hexagonal shell-plates.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G
5 µm
H
2 µm
I

Corythion constricta (Certes, 1889) Jung, 1942

Original description: Certes 1889, Mission scientifique du Cap Horn, 1882-1883, v. VI, p. 18, Fig. 2; **Last revision:** Jung 1942, *Archv f*ür *Protistenkdunde,* 95, p. 325, Abb. 68.

Synonyms: *Trinema constricta* Certes, 1889.

Description: Shell colourless, transparent, ovoid, compressed, with elliptical transverse section (Fig. 117 A-F); composed of small, oval shell-plates of about 3,5-5,1 x 2,2-2,7 µm, overlapping and haphazardly arranged (Fig. 117 C-F, I). Aperture oval, sub-terminal, oblique, invaginated, surrounded by one row of about 50 small, apertural-plates, each of them with median dorsal tooth (Fig. 117 C, D, G); bordered with pronounced pre-apertural rim, consisting by two or three rows elongated-oval plates (Fig. 117 C-H).Cytoplasm hyaline, fills about half of the shell; one nucleus, placed posteriorly in the cell.

Notes: *Corythion constricta* differs from *C. dubium* by its larger size and by pronounced pre-apertural rim, consisting of two or three rows elongated-oval plates.

Ecology: Brown mosses and *Sphagnum*, rare.

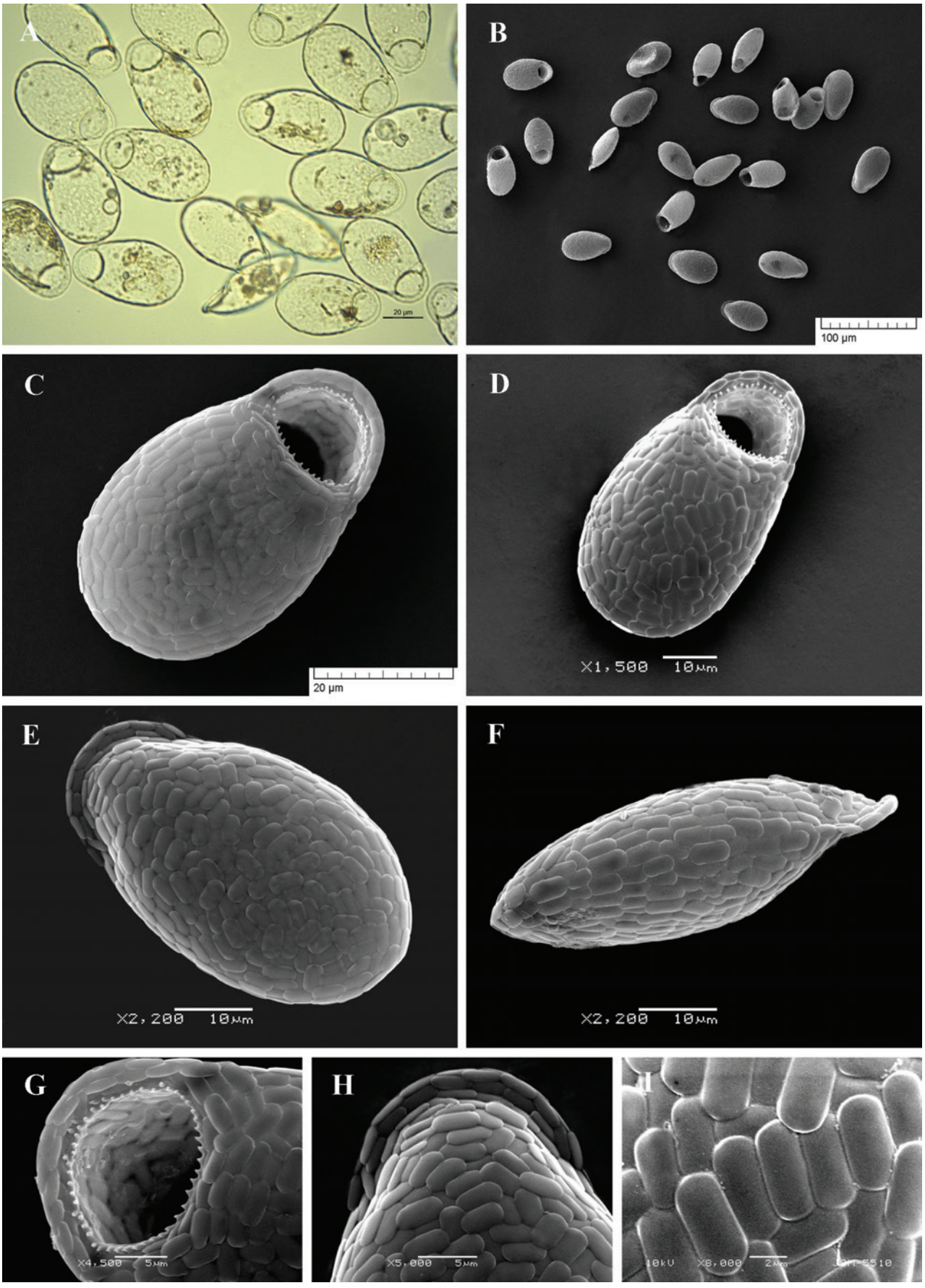
Geographical distribution: Previously *C. constricta* has been considered as endemic to southern part of South America, but in the last two decades it was found in other continents, including Europe, suggesting that this species have a broader distribution.

Distribution in *Sphagnum* mosses in Bulgaria: Rhodopes Mts. (new data); **Rila Mts.** (new data); **Vitosha Mts.** (new data).

Table 107. *Corythion constricta*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	54.1	54.4	3.02	0.55	5.60	48	60	30
Breadth	32.8	32.6	1.95	0.36	5.96	29	37	30
Large axis of aperture	15.3	15.4	1.30	0.24	8.45	13	19	30
Small axis of aperture	11.7	11.6	1.61	0.29	13.84	8	15	30
Depth	21.3	21.1	1.88	0.47	8.80	19	24	16
Breadth/Length ratio	0.61	0.61	0.04	0.007	6.25	0.5	0.7	30
Aperture/Breadth ratio	0.47	0.47	0.04	0.007	7.76	0.4	0.5	30

Fig. 117. Light (A) and scanning electron (B-I) micrographs of *Corythion constricta*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Apertural view of two individuals showing general shape and haphazardly arranged shell-plates. (E) Dorsal view. (F) Lateral view showing shell compression and oblique aperture. (G) Close up view of aperture to show its oval shape and surrounding apertural-plates, each of them with median dorsal tooth. (H) Dorsal view of apertural region showing pronounced pre-apertural rim, consisting by two or three rows elongated-oval plates. (I) Detail of shell surface to show arrangement of shell-plates.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X2,200 10µm
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X2,200 10µm
G
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H
X5,000 5µm
I
10kU X8,000 2µm

Corythion dubium Taránek, 1881

Original description: Taranek 1881, *Sitzungsberichte der Königlichen Böhmischen Gesellschaft der Wissenschaften,* p. 232, fig. 3.

Synonyms: *Arcella constricta* Ehrenberg, 1841 (in part); *Arcella disphaera* Ehrenberg, 1841 (in part); *Trinema acinus* Leidy, 1879 (in part).

Description: Shell small, colourless, transparent, ovoid, compressed, with elliptical transverse section (Fig. 118 A-F); composed of small, oval shell-plates of about 3,5-5,2 x 1,8-2,5 µm, overlapping and haphazardly arranged (Fig. 118 C-F, I). Aperture oval, sub-terminal, oblique, invaginated, surrounded by one row of about 30-40 small, apertural-plates, each of them with sharp, median tooth. (Fig. 118 C, D, G, H). Cytoplasm hyaline, with small granules anteriorly, fills about half of the shell; one nucleus, placed posteriorly in the cell, with few nucleoli. Pseudopodia very fine, thin, straight, usually numerous, slow moving.

Ecology: Ubiquitous, abundant in aerophilic mosses and *Sphagnum*.

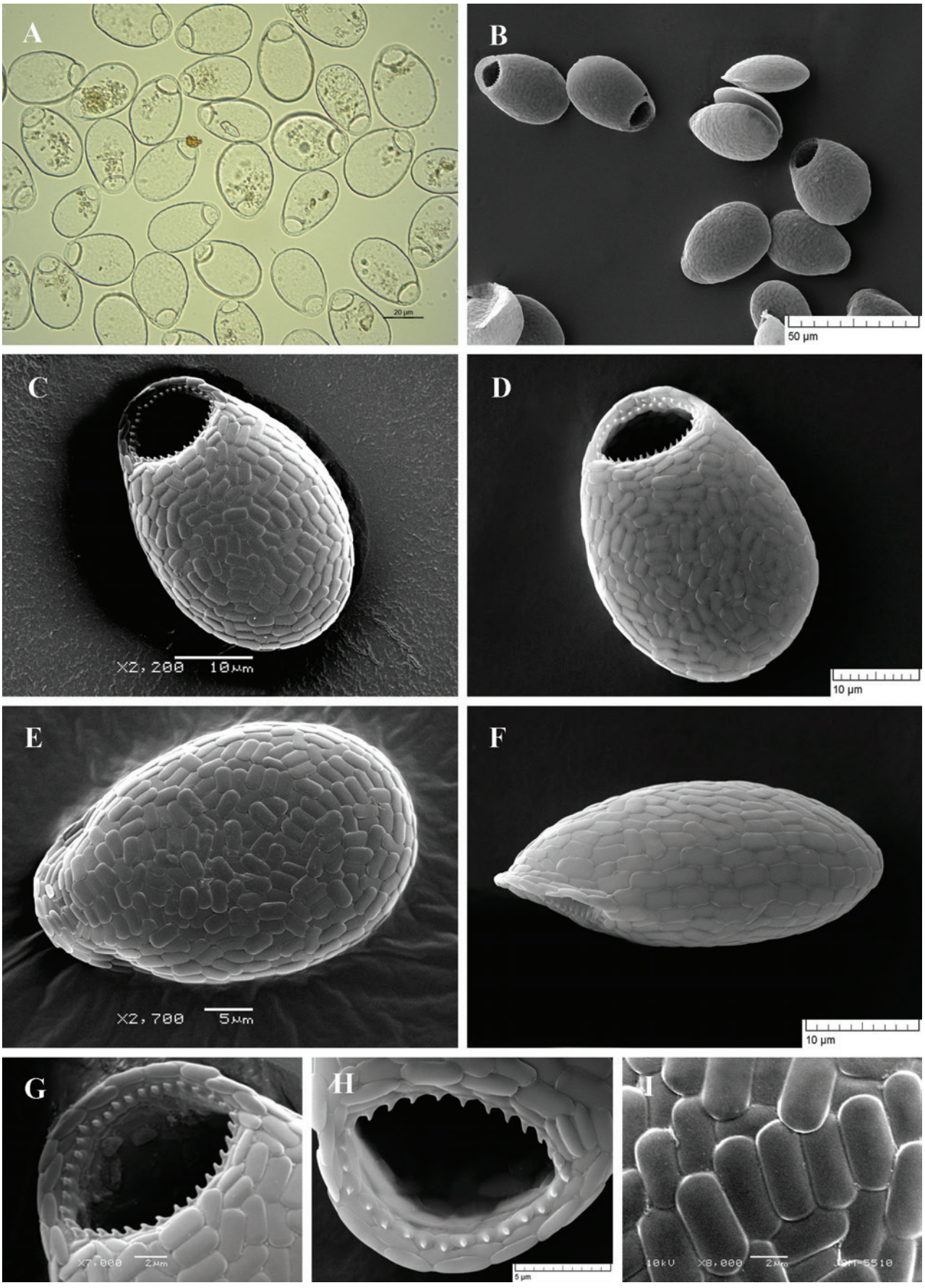
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 108. *Corythion dubium*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	39.2	40.0	3.23	0.59	8.23	31	44	30
Breadth	27.3	27.2	3.28	0.60	12.01	21	33	30
Large axis of aperture	11.4	11.5	1.61	0.29	14.11	9	15	30
Small axis of aperture	7.7	7.9	1.12	0.20	14.46	6	10	30
Depth	18.1	18.1	2.49	0.62	13.70	15	23	16
Breadth/Length ratio	0.70	0.70	0.05	0.01	7.62	0.6	0.8	30
Aperture/Breadth ratio	0.42	0.41	0.05	0.008	10.88	0.3	0.5	30

Fig. 118. Light (A) and scanning electron (B-I) micrographs of *Corythion dubium*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Apertural view of two individuals showing general shape and haphazardly arranged shell-plates. (E) Dorsal view. (F) Lateral view showing shell compression and oblique aperture. (G, H) Close up view of aperture to show its oval shape and surrounding apertural-plates, each of them with sharp, median tooth. (I) Detail of shell surface showing arrangement of shell-plates.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G
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H
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I
10kV X8,000 2µm

Playfairina valkanovi Golemansky, 1966

Original description: Golemansky 1966, *Comptes rendus de l'Académie bulgare des Sciences*, 19 (1), p. 59, Figs. 5-10.

Description: Shell colorless, transparent, ovoid-prolonged, retort shaped, with flat ventral wall, bulged out dorsal wall and rounded aboral region (Fig. 119 A-E); laterally compressed, with oval transverse section, usually lies on its lateral side; composed of large, circular, incompletely overlapping shell-plates and small oval plates which haphazardly fill interstices between large plates (Fig. 119 D-F). Apertural region with brief evaginated collar, composed of one or two rows small elliptic or prolonged plates (Figs. 119 C-E, I). Aperture oval, bordered by 12-18 denticulate apertural-plates, each of them with sharp median tooth (Figs. 119 F, G). Pseudopodia thin, long, straight, usually numerous, slow moving.

Notes: Due to its small size *Playfairina valkanovi* can often be overlooked or be confused with *Trinema lineare*, but when it is looked carefully is clearly distinguishable from the last by its compressed shell, oval transversal section, evaginated collar and oval aperture, smaller number of denticulate apertural plates (12-18) compared to *T. lineare* (18-28).

Ecology: Widely spread moss- and humus-dwelling testate amoeba, with preferences to the high-mountain *Sphagnum*-habitats.

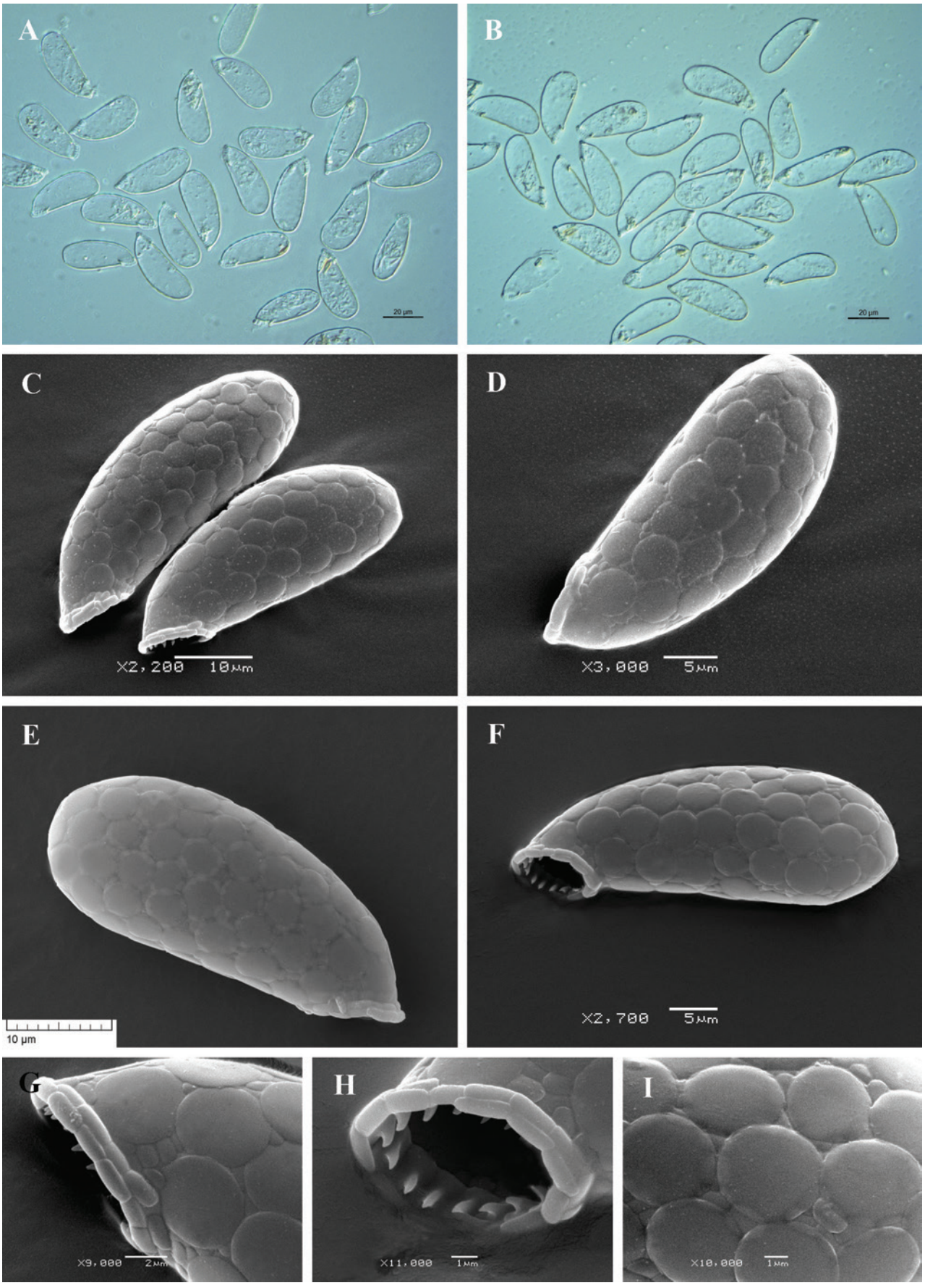
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1966, Golemansky and Todorov 1990, 2006; Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 109. *Playfairina valkanovi*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	40	40	2.04	0.25	5.1	36	45	67
Breadth	12	12	1.18	0.14	9.83	10	15	67
Depth	15	15	1.05	0.13	7.0	13	18	67
Large axis of aperture	8	8	0.75	0.09	9.38	6	11	67
Small axis of aperture	5	5	0.48	0.06	9.6	5	6	59
Depth/Length ratio	0.38	0.38	0.02	0.002	5.26	0.35	0.42	67

Fig. 119. Light (A, B) and scanning electron (C-I) micrographs of *Playfairina valkanovi*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C-E) Broad lateral view of four specimens showing general shape. (F) Latero-apertural view(G) Broad lateral view of apertural region to show evaginated collar, composed of two rows small and prolonged plates. (H) Close up view of aperture illustrating its oval shape and surrounding denticulate apertural-plates, each of them with sharp median tooth. (I) Detail of shell surface showing arrangement of shell-plates.


A
20 µm
B
20 µm
C
X2,200 10µm
D
X3,000 5µm
E
10 µm
F
X2,700 5µm
G
X9,000 2µm
H
X11,000 1µm
I
X10,000 1µm

Trinema complanatum Penard, 1890

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 187, Pl. XI, fig. 1 à 4.

Synonyms: ? *Arcella nidus-pendulus* Ehrenberg, 1841; *Trinema acinus* Leidy, 1879 (in part).

Description: Shell small, colourless, transparent, ovoid, compressed, with oval transverse section (Fig. 120 A-F); composed of two types of shell-plates: large, circular, slightly overlapping, of about 5-6 µm in diameter, and small, oval, of about 2,8-3,2 x 1,8-2,2 µm, which haphazardly fill interstices between large plates. (Fig. 120 C-F, I). Aperture circular, sub-terminal, oblique, invaginated, surrounded by two or three rows small, circular, denticulate apertural-plates and three to four rows of small shell-plates (Fig. 120 G, H). Cytoplasm hyaline, with numerous bright granules, fills about half of the shell; one small nucleus, placed posteriorly in the cell (Fig. 120 A, B). Pseudopodia very fine, thin, long, usually not well visible.

Ecology: Ubiquitous.

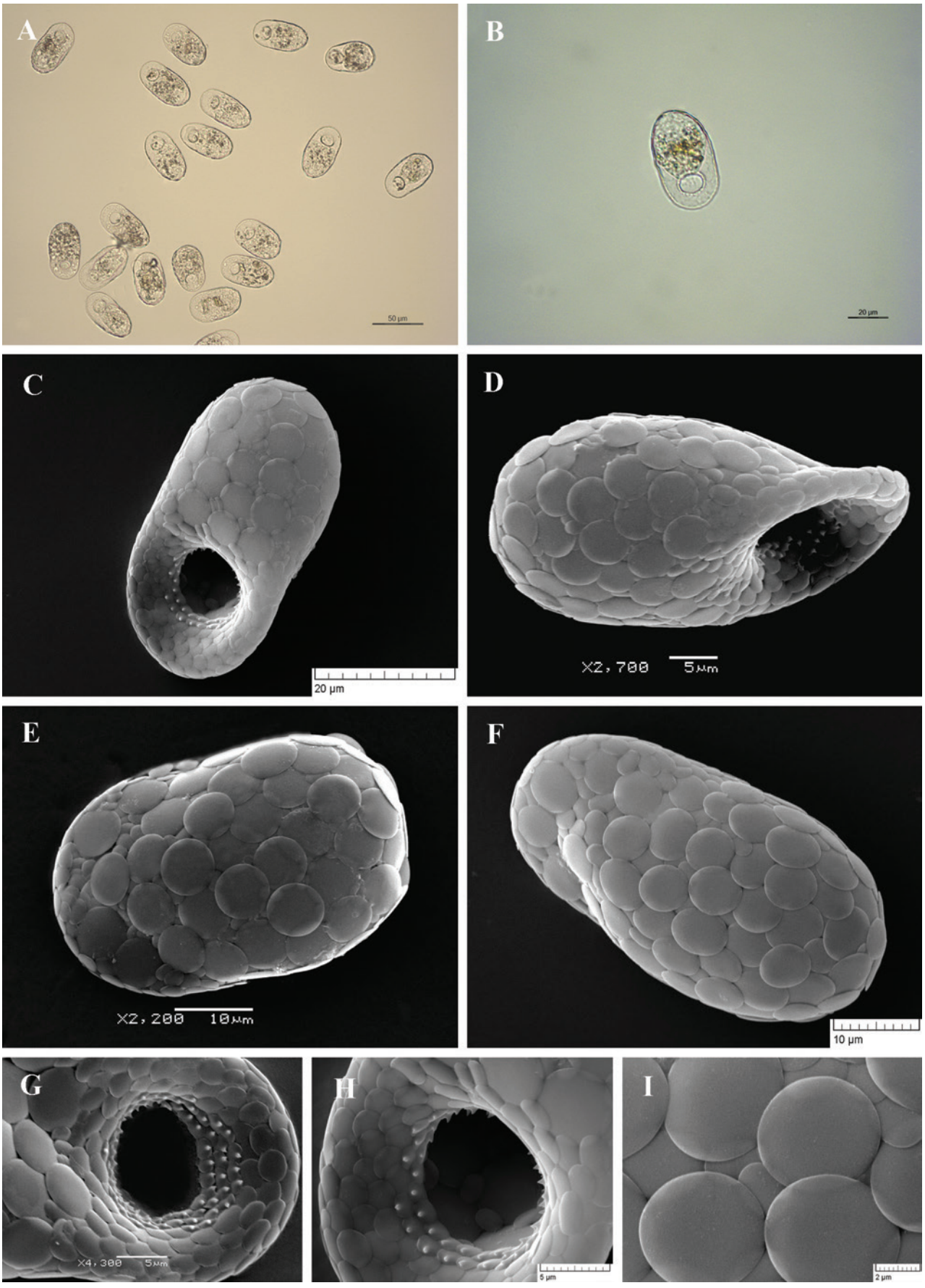
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 110. *Trinema complanatum*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	47.7	47.8	6.22	1.10	13.03	33	59	32
Breadth	28.3	28.7	3.13	0.55	11.04	20	36	32
Diameter of aperture	11.6	11.6	1.66	0.29	14.34	8	17	32
Depth	22.6	22.9	3.04	0.66	13.46	18	28	21
Breadth/Length ratio	0.60	0.60	0.05	0.009	8.67	0.5	0.7	32
Aperture/Breadth ratio	0.41	0.40	0.05	0.008	11.28	0.4	0.6	32

Fig. 120. Light (A, B) and scanning electron (C-I) micrographs of *Trinema complanatum*. (A) View of many specimens to illustrate variability in shape and size of the shell. (B) View of live specimen showing numerous bright granules filling the cytoplasm. (C) Apertural view to show general shape and regular arrangement of shell-plates. (D) Lateral view to illustrate apertural invagination and compression of the shell in the apertural region. (E, F) Dorsal view showing structure of the shell and its compression in apertural region. (G, H) Close up view of aperture to illustrate its circular shape, arrangement of numerous denticulate apertural-plates in two or three rows, and three to four rows of small shell-plates, surrounding aperture. (I) Detail of shell surface to show large, circular shell-plates and small, oval shell-plates, which haphazardly fill the interstices between them.


A
50 µm
B
20 µm
C
20 µm
D
X2,700 5µm
E
X2,200 10µm
F
10 µm
G
X4,300 5µm
H
5 µm
I
2 µm

Trinema enchelys (Ehrenberg, 1838) Leidy, 1878

Original description: Ehrenberg 1838, Die Infusionthierchen als vollkommene Organismen, p. 132, Taf. IX, Fig. IV; **Last revision:** Leidy 1878, *Proceedings of the Academy of Natural Sciences of Philadelphia,* 30, p. 172.

Synonyms: *Difflugia enchelys* Ehrenberg, 1838 (in part); *Trinema acinus* Dujardin, 1841; *Arcella enchelys* Ehrenberg, 1844; *Euglypha pleurostoma* Carter, 1857; *Euglypha enchelys* Wallich, 1864; *Trinema (Difflugia) encheli* Crevier, 1870.

Description: Shell colourless, transparent, elongate-ovoid, slightly compressed in apertural region, main body with circular transverse section (Fig. 121 A-F); composed of two types of shell-plates: large, circular, slightly overlapping, of about 10-11μm in diameter, and smaller oval, of about 4-4,5 x 2,5-2,8 μm, which haphazardly fill interstices between large plates. (Fig. 121C-F, I). Aperture circular, sub-terminal, oblique, invaginated, surrounded by one or two circle of about 40 to 60 small, circular, denticulate apertural-plates and two rows of small oval shell-plates (Fig. 121 C, D, G). Cytoplasm granular, does not fills the whole shell; one small nucleus, placed posteriorly in the cell, with one or a few nucleoli. Pseudopodia thin, long, straight, usually three to five, sometimes numerous.

Ecology: Ubiquitous.

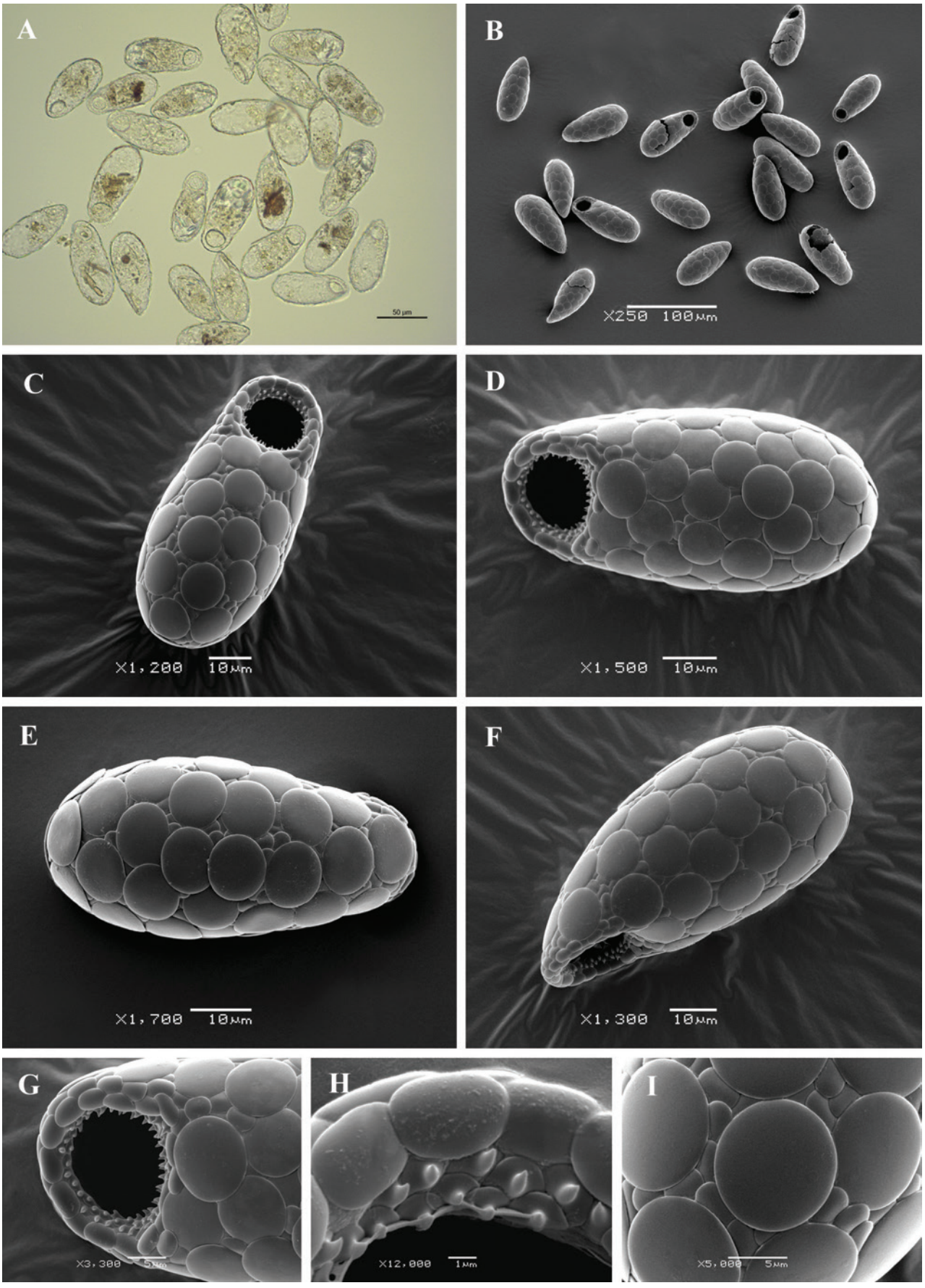
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Pateff 1924, Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 111. *Trinema enchelys*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	77.9	77.6	7.91	1.40	10.16	53	92	32
Breadth	34.9	34.7	4.32	0.76	12.38	21	44	32
Diameter of aperture	16.4	16.4	2.19	0.39	13.33	10	20	32
Depth	34.9	35.0	4.64	0.82	13.28	21	42	32
Breadth/Length ratio	0.45	0.44	0.04	0.007	8.98	0.4	0.6	32
Aperture/Breadth ratio	0.47	0.47	0.03	0.006	6.72	0.4	0.5	32

Fig. 121. Light (A) and scanning electron (B-I) micrographs of *Trinema enchelys*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C, D) Apertural view of two specimens showing general shape and regular arrangement of shell-plates. (E) Dorsal view. (F) Lateral view. (G) Close up view of apertural region. (H) Close up view of denticulate apertural-plates. (I) Detail of shell surface to show large, circular shell-plates and small, oval shell-plates which haphazardly fill the interstices between them.


A
50 µm
B
X250 100µm
C
X1,200 10µm
D
X1,500 10µm
E
X1,700 10µm
F
X1,300 10µm
G
X3,300 5µm
H
X12,000 1µm
I
X5,000 5µm

Trinema galeata (Penard, 1890) Jung, 1942

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 186, Pl. X, fig. 61 à 66; **Last revision:** Jung 1942, *Archv f*ür *Protistenkdunde,* 95, p. 325, Abb. 70.

Synonyms: *Trinema enchelys* var. *galeata* Penard, 1890.

Description: Shell small, colourless, transparent, ovoid, compressed, with oval transverse section (Fig. 122 A-F); composed of two types of shell-plates: large, circular, slightly overlapping, of about 10 µm in diameter, and small, oval, of about 3,1-3,4 x 2,4-2,7 µm, which haphazardly fill interstices between large plates. (Fig. 122 E, F, I). Aperture oval, sub-terminal, oblique, invaginated, surrounded by two or three rows small, circular, denticulate apertural-plates and three to four rows of small shell-plates, which clearly indicate place of joingtion of wide apertural visor with main body (Fig. 122 F, G, H). Cytoplasm granular, fills almost whole shell; one large nucleus, placed posteriorly in the cell, with single central nucleolus (Fig. 122 D). Pseudopodia numerous, thin, long, sometimes branching, usually well visible (122 A-C).

Notes: *Trinema galeata* differs from *T. complanatum* by the well visible line indicating the place of joingtion of wide apertural visor with the main body.

Ecology: Mosses and soils, rare in *Sphagnum*.

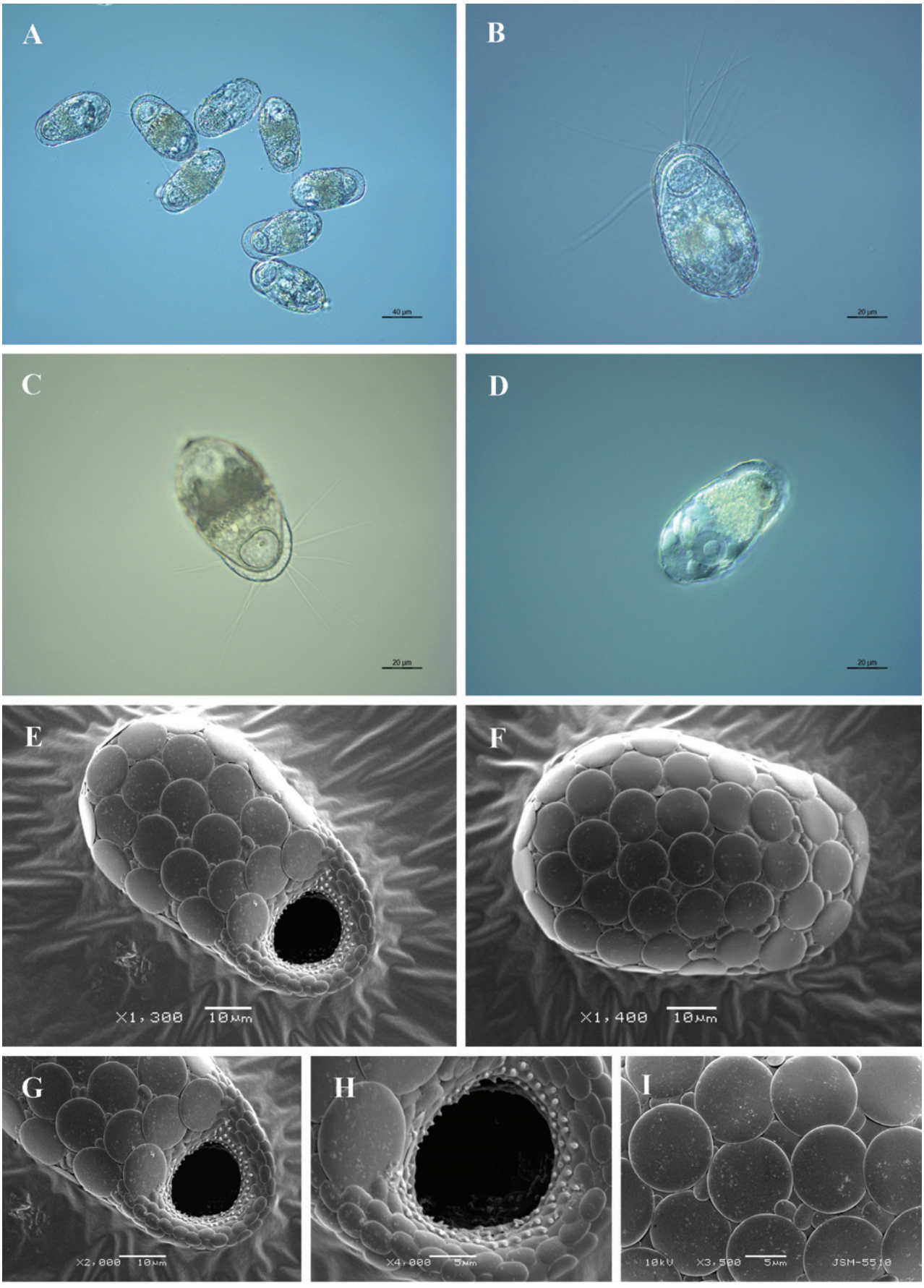
Geographical distribution: Probably cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rila Mts. (Golemansky and Todorov 1993).

Table 112. *Trinema galeata*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	57.9	46.0	16.46	2.60	28.44	41	84	40
Breadth	32.2	25.8	8.99	1.56	27.93	22	49	33
Diameter of aperture	17.4	17.8	3.64	0.78	20.91	11	24	22
Depth	26.6	24.7	5.40	1.50	20.34	20	35	13
Breadth/Length ratio	0.55	0.56	0.04	0.007	6.84	0.4	0.6	33
Aperture/Breadth ratio	0.49	0.50	0.05	0.01	10.33	0.4	0.6	22

Fig. 122. Light (A-D) and scanning electron (E-I) micrographs of *Trinema galeata*. (A) View of several specimens to illustrate variability in shape and size of the shell. (B, C) View of live specimens showing numerous thin filopodia, granular cytoplasm forming a central band and well-defined lines, indicating the place of joingtion of wide apertural visor with the main body. (D) View of live specimen to illustrate posteriorly placed nucleus with a single nucleolus. (E) Apertural view to show general shape and regular arrangement of shell-plates. (E) Dorsal view. (G) View of shell structure in the apertural region. (H). Close up view of aperture and denticulate apertural-plates. (I) Detail of shell surface to show large, circular and small, oval shell-plates.


A
40 µm
B
20 µm
C
20 µm
D
20 µm
E
X1,300 10µm
F
X1,400 10µm
G
X2,000 10µm
H
X4,000 5µm
I
10kV X3,500 5µm JSM-5510

Trinema lineare Penard, 1890

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 187, Pl. XI, fig. 5 à 17.

Synonyms: *Difflugia enchelys* Ehrenberg, 1838 (in part); *Arcella hyalina* Ehrenberg, 1841; *Arcella enchelys* Ehrenberg, 1854; *Trinema acinus* Leidy, 1879 (in part); *Trinema enchelys* forma β Awerintzew, 1906.

Description: Shell small, colourless, transparent, elongate-ovoid, uncompressed, with circular transverse section (Fig. 123 A-G); composed of two types of shell-plates: large, circular, slightly overlapping, of about 5-6 µm in diameter, and small, oval, of about 1,3-1,5 x 2-2,2 µm, which haphazardly fill interstices between large plates. (Fig. 123 B-F, I). Aperture circular, sub-terminal, oblique, invaginated, surrounded by a circle of about 20 to 40 small, circular, denticulate apertural-plates and usually two rows of small oval shell-plates (Fig. 123 D, E, H). Cytoplasm hyaline, does not fills the whole shell; one small nucleus, placed posteriorly in the cell, with one nucleolus. Pseudopodia very fine, long and straight, usually one to three.

Ecology: Ubiquitous, frequently very abundant.

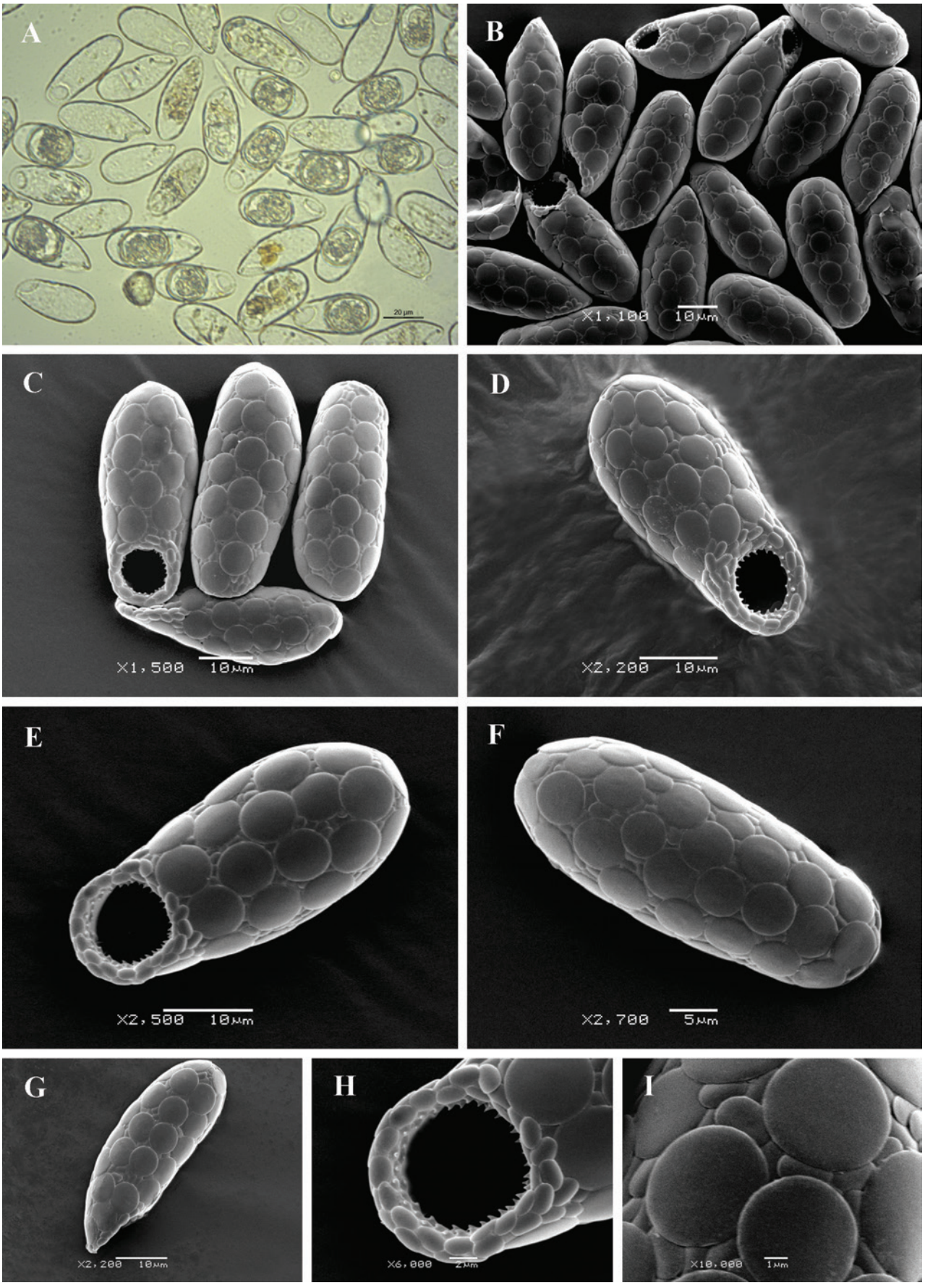
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2004, 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 113. *Trinema lineare*. Morphometric characterisation (measurements in µm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	30.2	30.5	4.83	0.88	16.0	21	40	30
Breadth	13.2	13.2	2.65	0.48	20.0	9	18	30
Diameter of aperture	6.3	6.2	1.42	0.26	22.79	3	9	30
Depth	12.7	12.4	2.56	0.47	20.18	9	18	30
Breadth/Length ratio	0.44	0.42	0.06	0.01	13.87	0.4	0.7	30
Aperture/Breadth ratio	0.48	0.48	0.08	0.01	16.39	0.3	0.7	30

Fig. 123. Light (A) and scanning electron (B-I) micrographs of *Trinema lineare*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) Apertural, dorsal and lateral views in one place. (D-E) Apertural view of two individuals to illustrate general shape and regular arrangement of shell-plates. (F) Dorsal view. (G) Lateral view. (H) Close up view of aperture to illustrate its shape, arrangement of denticulate apertural-plates and two rows of small shell-plates. (I) Detail of shell surface to show large, circular shell-plates and small, oval shell-plates which haphazardly fill the interstices between large plates.


A
20 µm
B
X1,100 10µm
C
X1,500 10µm
D
X2,200 10µm
E
X2,500 10µm
F
X2,700 5µm
G
X2,200 10µm
H
X6,000 2µm
I
X10,000 1µm

Campascus triqueter Penard, 1891

Original description: Penard 1891a, *Archives des Sciences physique et naturelles*, 26, p. 147, Pl.2.

Description: Shell colourless or yellowish, transparent, retort-shaped, trigonal, with broadly-rounded angles in transverse section (Fig. 124 A-E); in lateral view elongated, pointed posteriorly and curved towards to aperture, forming well-expressed neck; composed of small circular, oval or irregular amorphous, non-overlapping shell-plates (Fig. 124 C-I). Aperture circular, oblique, with thin collar of organic cement (Fig. 124 F, H). Cytoplasm hyaline, containing many granules and food-particles, does not fills the whole shell; one small nucleus with numerous small nucleoli, placed posteriorly in the cell; pseudopodia usually one or two, very fine, thin and long.

Ecology: In *Sphagnum* and submerged aquatic vegetation, rare.

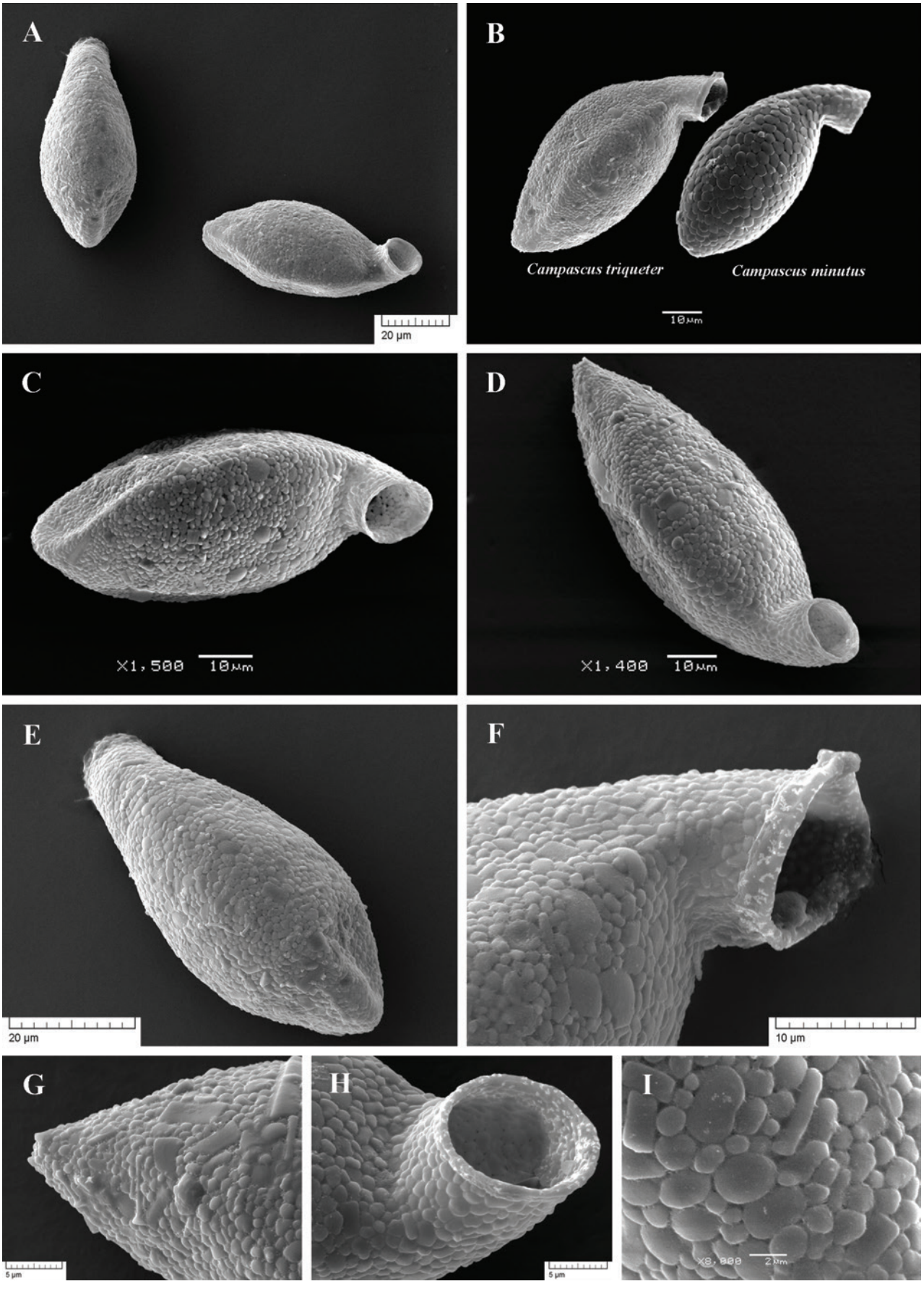
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Rila Mts. (Golemansky and Todorov 1993, Todorov and Golemansky 2000); **Vitosha Mts.** (Golemansky 1965, Golemansky and Todorov 1990, Todorov 1993, Todorov and Golemansky 1995).

Table 114. *Campascus triqueter*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	70,6	70,5	5,61	1,17	7,94	62	83	23
Breadth	28,0	28,2	1,17	0,24	4,18	26	30	23
Diameter of aperture	11,4	11,2	0,80	0,17	7,02	10	13	23
Depth	27,5	27,9	1,12	0,23	4,07	26	29	23
Breadth/Length ratio	0,4	0,4	0,03	0,01	7,5	0,35	0,46	23
Aperture/Breadth ratio	0,4	0,4	0,03	0,01	7,5	0,35	0,46	23

Fig. 124. Scanning electron micrographs of *Campascus triqueter*. (A) Two specimens showing shell shape in dorsal and apertural views. (B) Comparison between *C. triqueter* and *C. minutus* to illustrate differences in shell shape and structure. (C, D) Latero-apertural views of two specimens to show general shape and shell structure. (E) Dorsal view. (F) Close up view of apertural region to show short neck. (G) Close up view of aboral, pointed region. (H) Close up view of aperture. (I) Detail of shell surface to show arrangement of shell-plates.


A
20 µm
B
Campascus triqueter
Campascus minutus
10µm
C
X1,500 10µm
D
X1,400 10µm
E
20 µm
F
10 µm
G
5 µm
H
5 µm
I
X8,800 2µm

Cyphoderia amphoralis (Wailes and Penard, 1911)

Original description: Wailes and Penard 1911, *Proceedings of the Royal Irish Academy*, 31, Part 65, p. 31, Pl. II, figs. 13-14; **Last revision:** Todorov et al. 2009, *Journal of Eukaryotic Microbiology*, 56, p. 281, Figs. 2-7, 36.

Synonyms: *Cyphoderia trochus* var. *amphoralis* Wailes and Penard, 1911

Description: Shell yellowish–brownish, transparent, retort-shaped laterally; in ventral and dorsal views elongated-elliptical, with rounded posterior end and tapered anterior end (Fig. 125 A-F); main body with circular transverse section; shell reaches its maximum diameter at about 1/3 from its posterior end; in lateral view shell curved towards the aperture, forming well-expressed and slightly compressed laterally neck (Fig. 125 C-F); shell composed of circular, biconvex, overlapping shell-plates, which differ in size depending on their position on the shell: in largest part plates are two or three times larger than those located in apertural and aboral regions (5–6 μm and 2.5–3 μm, respectively); arrangement of shell-plates is characteristic: they insert obliquely relative to shell surface and are clearly imbricated, which gives characteristic indented and rougher outline of *C. amphoralis* (Fig. 125 C-F, G, I). Aperture oval, oblique, surrounded by about 16–18 apertural scales; aperture with thin collar of organic cement (Fig. 125 G, H). Cytoplasm hyaline, containing many granules and food-particles, does not fills the whole shell; one large nucleus with many nucleoli, placed posteriorly in the cell; pseudopodia very fine, thin and long. (Fig. 125 A, B).

Ecology: Frequent in *Sphagnum* and among submerged aquatic vegetation.

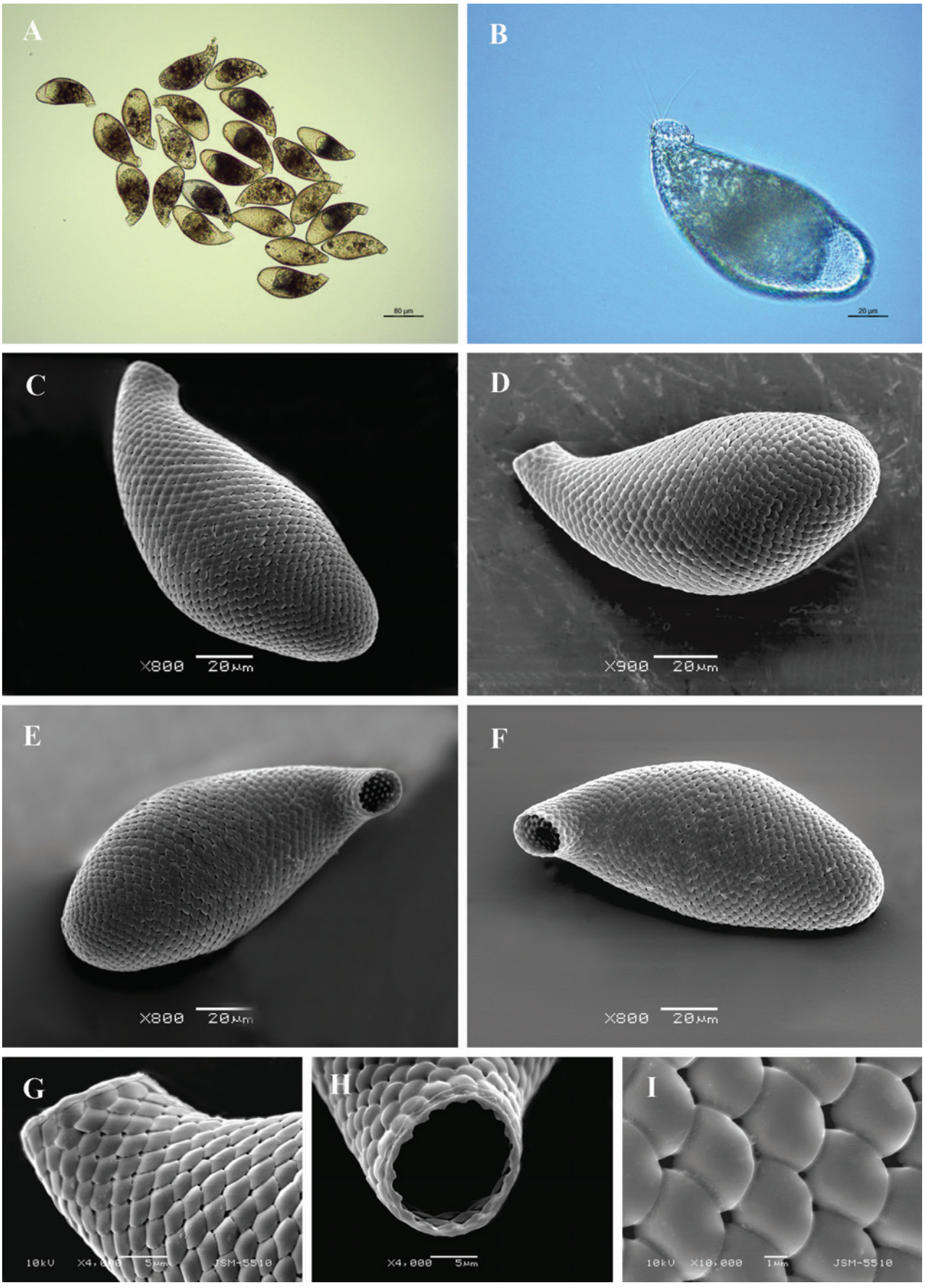
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Todorov et al. 2009); **Rila Mts.** (Heger et al. 2010, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Bankov et al. 2018).

Table 115. *Cyphoderia amphoralis*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	147.1	146.0	5.67	0.76	3.85	139	166	55
Breadth	61.5	61.0	2.32	0.31	3.78	55	66	55
Diameter of aperture	17.9	18.0	0.65	0.09	3.64	17	19	55
Breadth/Length ratio	0.42	0.42	0.02	0.003	5.07	0.3	0.5	55
Aperture/Breadth ratio	0.29	0.30	0.01	0.002	4.38	0.27	0.33	55

Fig. 125. Light (A, B) and scanning electron (C-I) micrographs of *Cyphoderia amphoralis*. (A) View of many specimens to illustrate variability in shape and size of the shell. (B) View of live specimen showing numerous granules, filling the cytoplasm and thin filopodia. (C, D) Lateral view of two specimens to show general shape and regular arrangement of shell-plates. (E, F) Latero-apertural views. (G) Lateral view of apertural region showing characteristic imbricated shell-plates and thin collar of organic cement around aperture. (H) Close up view of aperture to illustrate its broadly oval shape and arrangement of apertural-plates. (I) Detail of shell surface to show regular arrangement of overlapping shell-plates.


A
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B
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C
X800 20µm
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X900 20µm
E
X800 20µm
F
X800 20µm
G
10kU X4,000 5µm JSM-5510
H
X4,000 5µm
I
10kU X10,000 1µm JSM-5510

Cyphoderia ampulla (Ehrenberg, 1840) Leidy, 1878

Original description: Ehrenberg 1840, *Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königliche Preussischen Akademie der Wissenschaften zu Berlin*, 5, p. 199; **Last revision:** Leidy 1878, *Proceedings of the Academy of Natural Sciences of Philadelphia***,** 30, p. 173.

Synonyms: *Difflugia ampulla* Ehrenberg, 1840; *Difflugia lagena* Ehrenberg, 1841; *Cyphoderia margaritacea* Schlumberger, 1845; *Euglypha curvata* Perty, 1852; *Lagynis baltica* Schultze, 1854; *Euglypha ampulla* Claparède and Lachmann, 1859; *Euglypha baltica* Wallich, 1864; *Euglypha margaritacea* Wallich, 1864; *Difflugia Seelandica* Ehrenberg, 1869; *Difflugia adunca* Ehrenberg, 1871; *Difflugia alabamensis* Ehrenberg, 1871; *Difflugia uncinnata* Ehrenberg, 1871; *Difflugia margaritacea* Ehrenberg, 1871.

Description: Shell colourless or yellowish, transparent, retort-shaped, circular in transverse section (Fig. 126 A-F); in lateral view elongated, rounded posteriorly and curved towards the pseudostome, forming well-expressed neck; shell composed of numerous circular, feebly biconvex, comparatively small (2.0–3.5 μm) siliceous shell-plates, which are slightly overlapped and almost equal in size, regularly arranged in diagonal rows, about 16–18 in the mid-region of the shell (Fig. 126 D-F, H, I). Aperture circular or slightly oval, oblique, surrounded by about 18–22 apertural-plates; apertural rim with thin covering of organic cement (Fig. 126 G). Cytoplasm hyaline, containing many granules and food-particles, does not fills the whole shell; one large nucleus with many nucleoli, placed posteriorly in the cell; pseudopodia numerous, very fine, thin and long. (Fig. 126 A, C).

Ecology: Common in *Sphagnum* and among submerged aquatic vegetation.

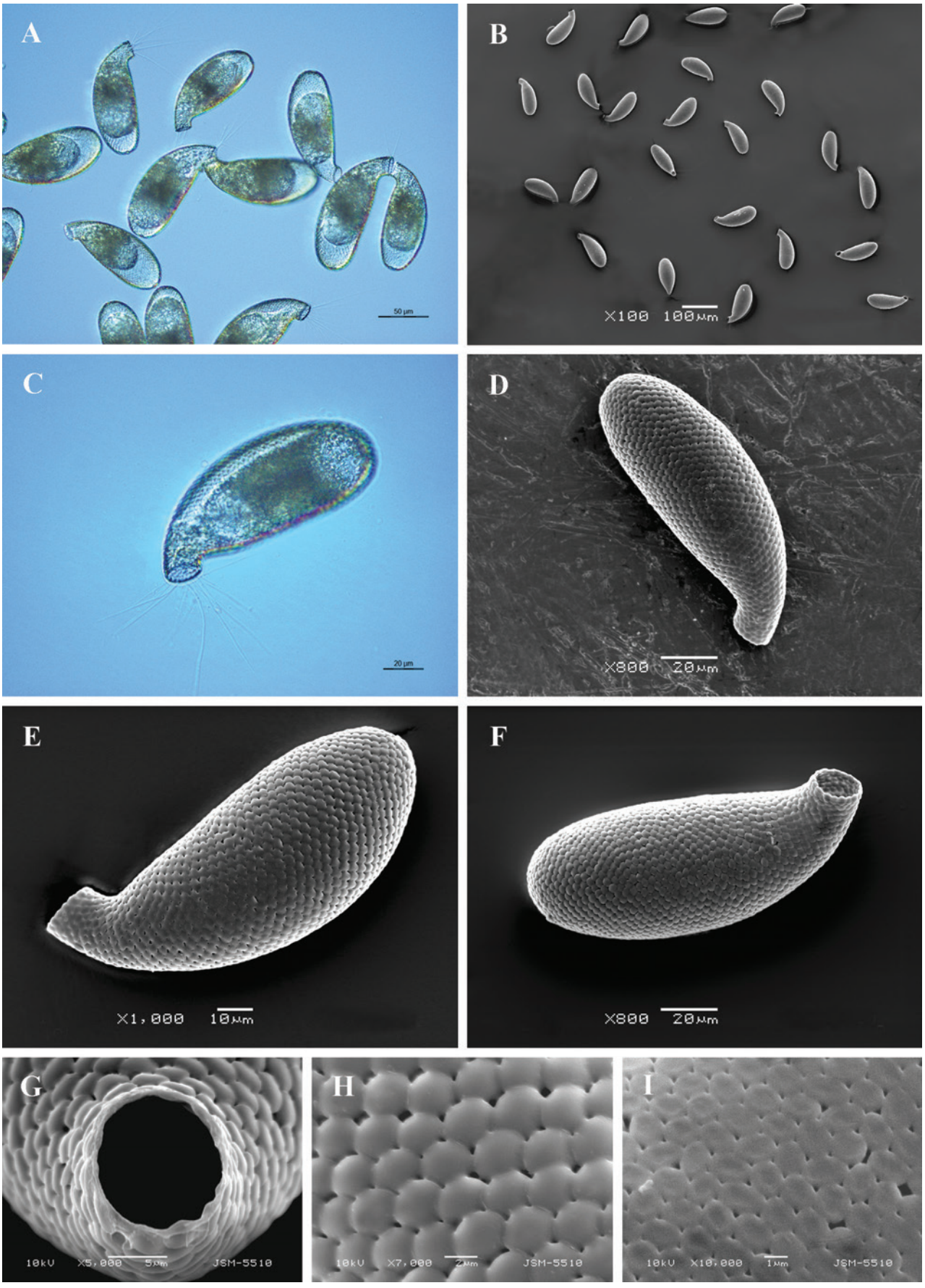
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Pateff 1924, Golemansky et al. 2006; Todorov et al. 2009, Heger et al. 2010); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2004, 2005, Todorov et al. 2009, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Todorov et al. 2009, Heger et al. 2010, Bankov et al. 2018).

Table 116. *Cyphoderia ampulla*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	127.0	125.0	9.01	0.69	7.09	107	150	170
Breadth	48.6	48.0	4.10	0.31	8.44	40	60	170
Diameter of aperture	16.0	16.0	0.97	0.07	6.04	14	18	170
Breadth/Length ratio	0.38	0.38	0.02	0.001	4.67	0.3	0.4	170
Aperture/Breadth ratio	0.33	0.33	0.02	0.002	5.97	0.3	0.4	170

Fig. 126. Light (A, C) and scanning electron (B, D-I) micrographs of *Cyphoderia ampulla*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen showing numerous thin filopodia and cytoplasm, fulfilled with many food-particles. (D, E) Lateral view of two individuals to show general shape and regular arrangement of shell-plates. (F) Latero-apertural view. (G) Close up view of aperture. (H, I) Detail of shell surface to show regular arrangement and two types of shell-plates.


A
50 µm
B
X100 100µm
C
20 µm
D
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E
X1,000 10µm
F
X800 20µm
G
10kV X5,000 5µm JSM-5510
H
10kV X7,000 2µm JSM-5510
I
10kV X10,000 1µm JSM-5510

Cyphoderia major (Penard, 1890)

Original description: Penard 1890, *Mémoires de la Société de Physique et d'Histoire Naturelle de Genève*, 31, p. 175, Pl. VIII, fig. 65 à 67; **Last revision:** Todorov et al. 2009, *Journal of Eukaryotic Microbiology*, 56, p. 283, Figs. 20-25, 36.

Synonyms: *Cyphoderia margaritacea* var. *major* Penard, 1890.

Description: Shell large, colourless or yellowish, transparent, retort-shaped laterally and elongated–elliptical in ventral and dorsal views; with maximum diameter in the mid-region of the shell, circular in transverse section (Fig. 127 A-G); in lateral view broadly rounded posteriorly and curved towards the aperture, forming an elongated neck (Fig. 127 A-D, G); shell composed of numerous small (1.6–2.1 μm), circular or oval, plane, comparatively thick (1.5–2.0 μm), non-overlapping shell-plates, regularly arranged side by side in diagonal rows about 34–37 in the mid-region of the shell (Fig. 127 D-F, I). Aperture circular, oblique, surrounded by about 35–40 apertural scales with clearly visible (SEM) denticles; apertural rim covered with thin layer of organic cement (Fig. 127 E, H). Cytoplasm hyaline, containing many granules and food-particles, fills about two-thirds of the shell (Fig. 127 A, C); one large nucleus with many nucleoli, placed posteriorly in the cell; pseudopodia numerous, very fine, thin and long.

Ecology: Frequent in *Sphagnum* and among submerged aquatic vegetation.

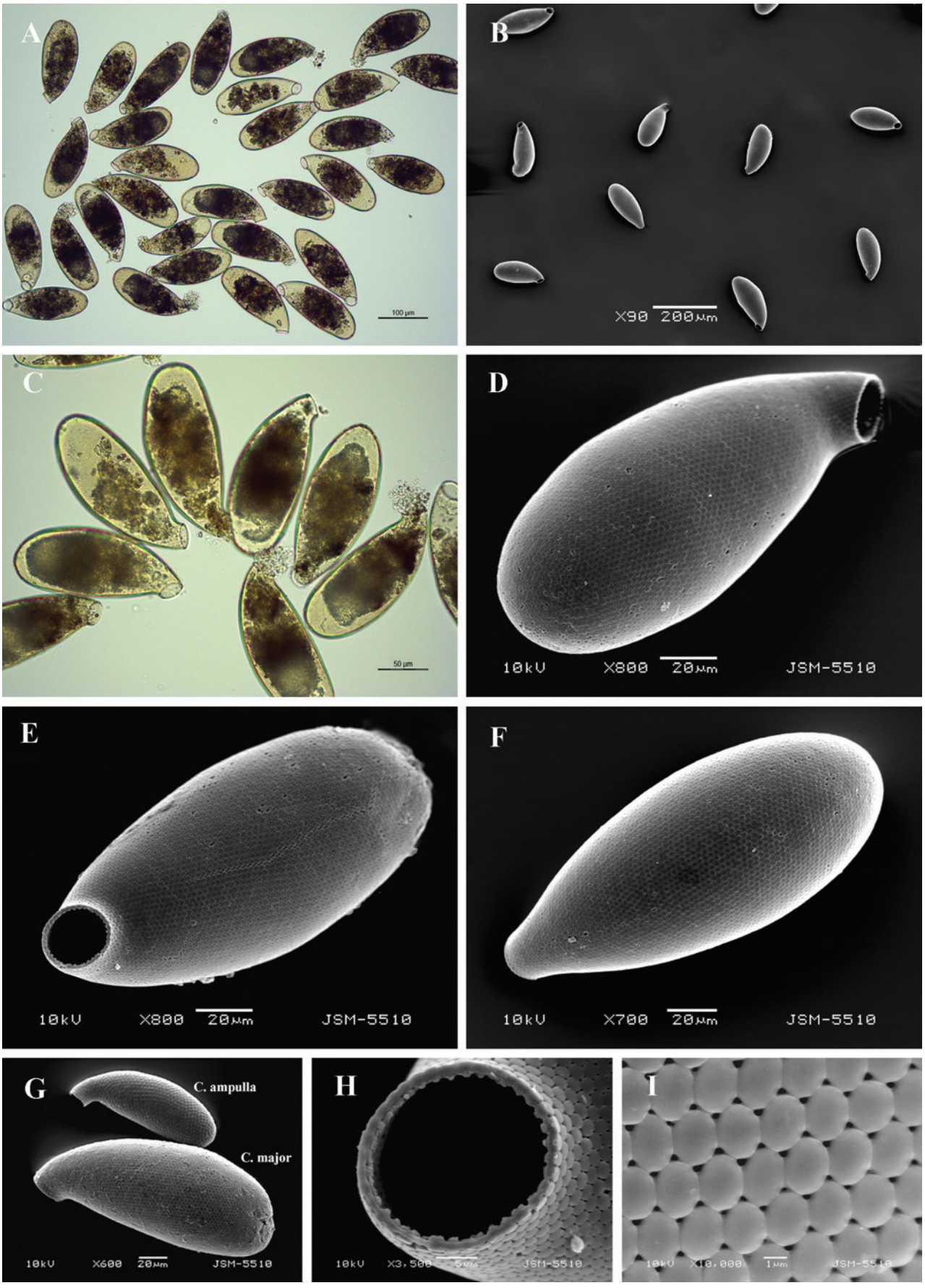
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rila Mts.** (Todorov et al. 2009, Heger et al. 2010, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Bankov et al. 2018).

Table 117. *Cyphoderia major*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	192.6	192.0	7.68	0.94	3.99	176	212	66
Breadth	78.2	78.0	0.68	0.33	3.42	72	85	66
Diameter of aperture	26.0	26.0	0.98	0.12	3.77	22	28	66
Breadth /Length ratio	0.41	0.41	0.02	0.002	4.56	0.4	0.5	66
Aperture/Diameter ratio	0.33	0.33	0.01	0.002	3.75	0.3	0.4	66

Fig. 127. Light (A, C) and scanning electron (B, D-I) micrographs of *Cyphoderia major*. (A-C) View of many specimens to illustrate variability in shape and size of the shell. (D, E) Apertural view of two individuals to show general shape and regular arrangement of shell-plates. (F) Dorsal view. (G) Lateral view of *C. ampulla* and *C. major* showing differences in their shell structure and size. (H) Close up view of aperture to illustrate its circular shape and arrangement of numerous denticulate apertural-plates. (I) Detail of shell surface to show regular arrangement of shell-plates.


A
100 µm
B
X90 200µm
C
50 µm
D
10kV X800 20µm JSM-5510
E
10kV X800 20µm JSM-5510
F
10kV X700 20µm JSM-5510
G
C. ampulla
C. major
10kV X600 20µm JSM-5510
H
10kV X3,500 5µm JSM-5510
I
10kV X10,000 1µm JSM-5510

Pareuglypha reticulata Penard, 1902

Original description: Penard 1902, Faune Rhizopodique du Bassin du Léman, p. 492, fig. 1 à 4 (p. 493).

Description: Shell colorless or yellowish, transparent, circular in transverse section, tapering evenly from the mid-body position towards the aperture and pointed aboral region; with well-expressed tubular horn of about 10-15 μm (Fig. 128 A-E); composed of small to medium, circular or oval, flattish, overlapping shell-plates, so arranged that do not form regular longitudinal and transverse rows (Fig. 128 D, E). Aperture circular, surrounded by small shell-plates, with thin collar of organic cement (Fig. 128 D-F, H). Cytoplasm hyaline, does not fills the whole shell; one large nucleus with many nucleoli, placed posteriorly in the cell; pseudopodia numerous, fine, long, generally straight and fast moving.

Ecology: In freshwater habitats and *Sphagnum,* very rare.

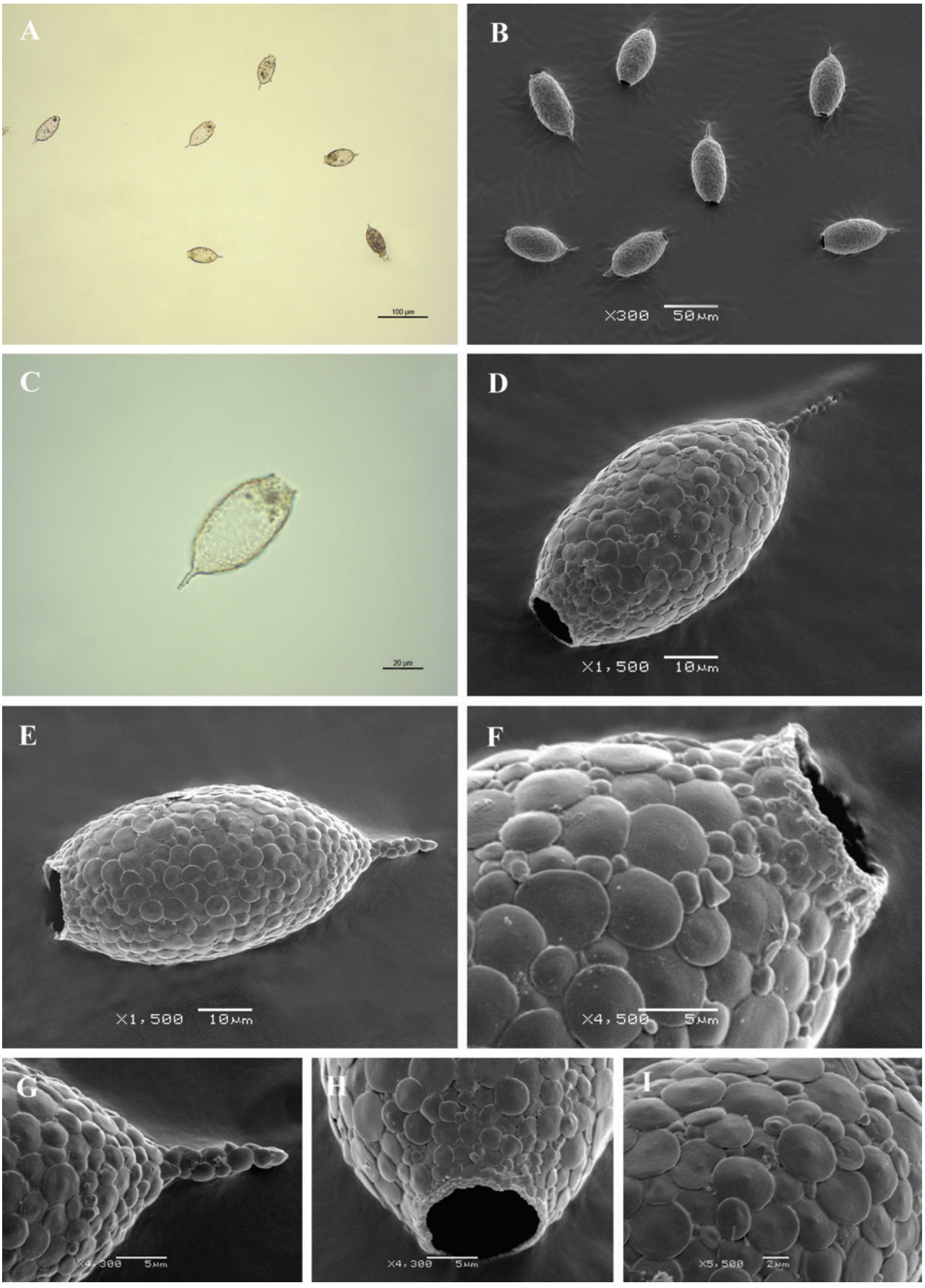
Geographical distribution: Probably cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (new data).

Table 118. *Pareuglypha reticulata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	71,9	72,5	3,28	0,91	4,56	66	77	13
Breadth	32,1	32,0	0,98	0,27	3,05	30	34	13
Diameter of aperture	11,1	11,0	1,24	0,34	1,26	9	13	13
Length of horn	11,9	12,3	2,47	0,69	20,76	7	16	13
Breadth/Length ratio	0,4	0,4	0,03	0,01	7,5	0,40	0,49	13
Aperture/Breadth ratio	0,3	0,3	0,04	0,01	13,3	0,28	0,41	13

Fig. 128. Light (A, C) and scanning electron (B, D-I) micrographs of *Pareuglypha reticulata*. (A, B) View of several specimens to illustrate variability in shape and size of the shell. (C-E) Lateral view of three specimens to show general shape and structure of the shell. (F) Lateral view of apertural region. (G) Close up view of aboral region to show well-expressed tubular horn. (H) Close up view of aperture. (I) Detail of shell surface to show overlapping shell plates.


A
100 µm
B
X300 50µm
C
20 µm
D
X1,500 10µm
E
X1,500 10µm
F
X4,500 5µm
G
X4,300 5µm
H
X4,300 5µm
I
X5,500 2µm

Tracheleuglypha acolla Bonnet et Thomas, 1955

Original description: Bonnet et Thomas 1955, *Bulletin de la Société d'Histoire Naturelle de Toulouse*, 90, p. 422, fig. 21.

Description: Shell colourless, transparent, ovoid, uncompressed, with circular transverse section (Fig. 129 A-E); composed of circular, overlapping shell-plates of about 9-10 μm in diameter, regularly arranged in eight to nine alternating diagonal rows (Fig. 129 B-E, I). Aperture circular, surrounded by nine to twelve smaller shell-plates and bordered by thin collar of organic cement, with irregularly-dentate margin (Fig. 129 E-H). Cytoplasm hyaline, with many granules concentrated in central region, does not fills the whole shell; one large nucleus with few nucleoli, placed posteriorly in the cell, bellow the granulated band. Pseudopodia not numerous, fine, long, straight, fast moving.

Ecology: Common in mosses, soils and *Sphagnum*.

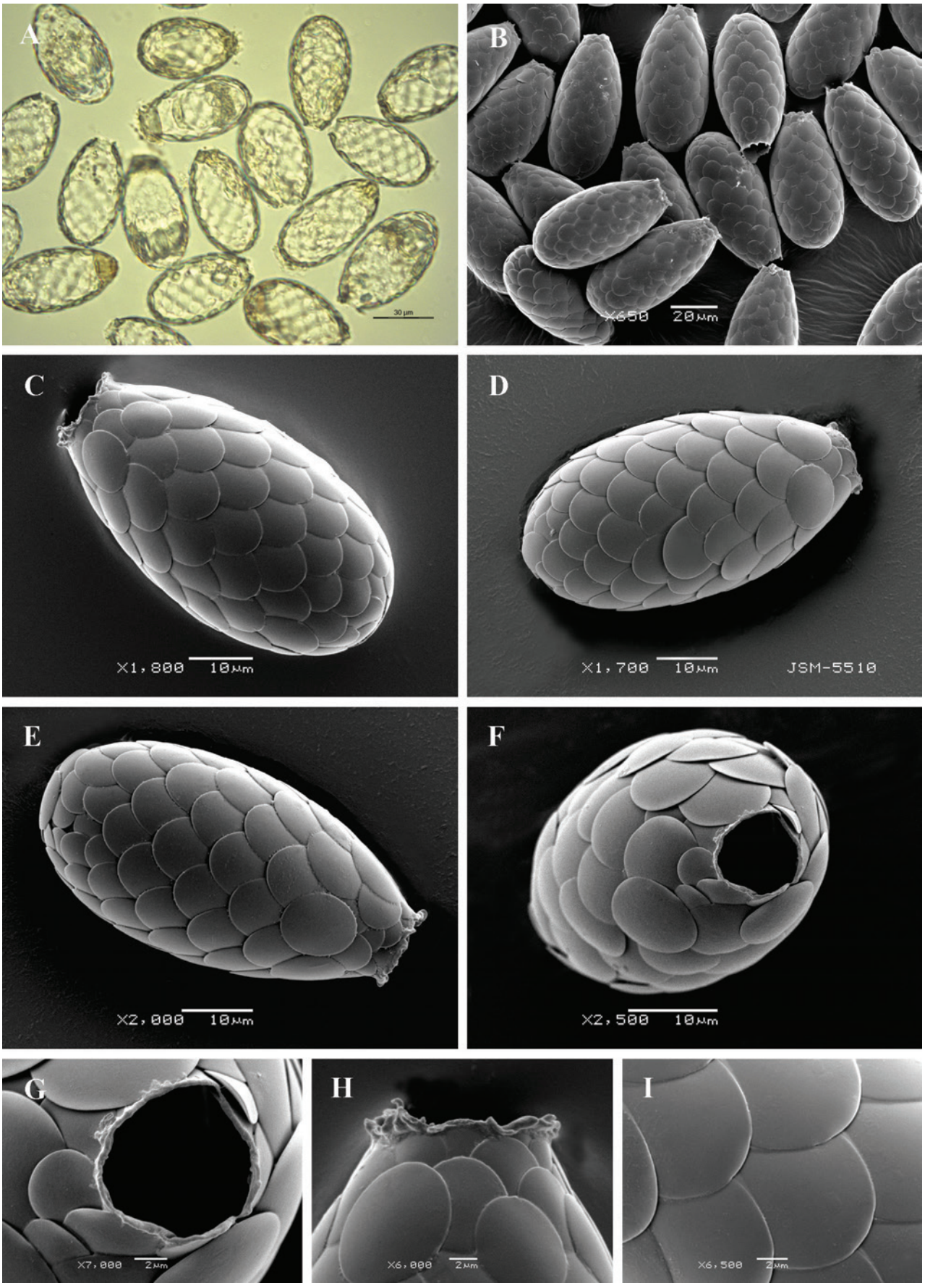
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Bankov et al. 2018); **Rhodopes Mts.** (Golemansky et al. 2006); **Rila Mts.** (Todorov and Golemansky 2000, Todorov 2005, Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 119. *Tracheleuglypha acolla*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	56.6	56.6	5.99	0.97	10.60	45	69	38
Breadth	30.4	30.6	2.31	0.37	7.58	24	36	38
Diameter of aperture	10.5	10.5	1.41	0.23	13.36	8	13	38
Breadth/Length ratio	0.54	0.54	0.05	0.008	9.11	0.4	0.6	38
Aperture/Breadth ratio	0.35	0.34	0.05	0.008	13.42	0.2	0.5	38

Fig. 129. Light (A) and scanning electron (B-I) micrographs of *Tracheleuglypha acolla*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C-E) Broad lateral view of three specimens showing general shape and regular arrangement of shell-plates. (F) Apertural view. (G) Close up view of aperture to illustrate its shape, arrangement of apertural-plates and thin border of organic cement. (H) Lateral view of apertural region (I) Detail of shell surface to show overlapping shell-plates.


A
30 µm
B
X650 20µm
C
X1,800 10µm
D
X1,700 10µm JSM-5510
E
X2,000 10µm
F
X2,500 10µm
G
X7,000 2µm
H
X6,000 2µm
I
X6,500 2µm

Tracheleuglypha dentata (Moniez, 1888) Deflandre, 1928

Original description: Moniez 1888, *Revue Biologique du Nord de la France*, 1, p. 86; **Last revision:** Deflandre 1928b. *Annales de Protistologie*, 1, pp. 40-41, fig. 8-11.

Synonyms: *Sphenoderia lenta* Leidy, 1879 (in part); *Euglypha β* Vejdovsky, 1882; *Euglypha dentata* Moniez, 1888; *Sphenoderia dentata* Penard, 1890.

Description: Shell colourless, transparent, ovoid, uncompressed, with circular transverse section (Fig. 130 A-F); composed of circular or slightly oval, overlapping shell-plates of about 9-12 μm, regularly arranged in seven to eight alternating diagonal rows (Fig. 130 D-E, I). Aperture circular, surrounded by ten to twelve shell-plates and bordered by collar of organic material with projecting tooth-like structures (Fig. 130 D-H). Cytoplasm hyaline, with many granules concentrated in the central region, does not fills the whole shell; one large nucleus with few nucleoli, placed posteriorly in the cell, bellow the granulated band (Fig. 130 C). Pseudopodia numerous, thin, long and straight, fast moving.

Notes: The species has been recorded in both as nominal species and as synonym *Sphenoderia dentata* (Vitosha Mts.).

Ecology: Common in mosses, freshwater habitats and *Sphagnum*.

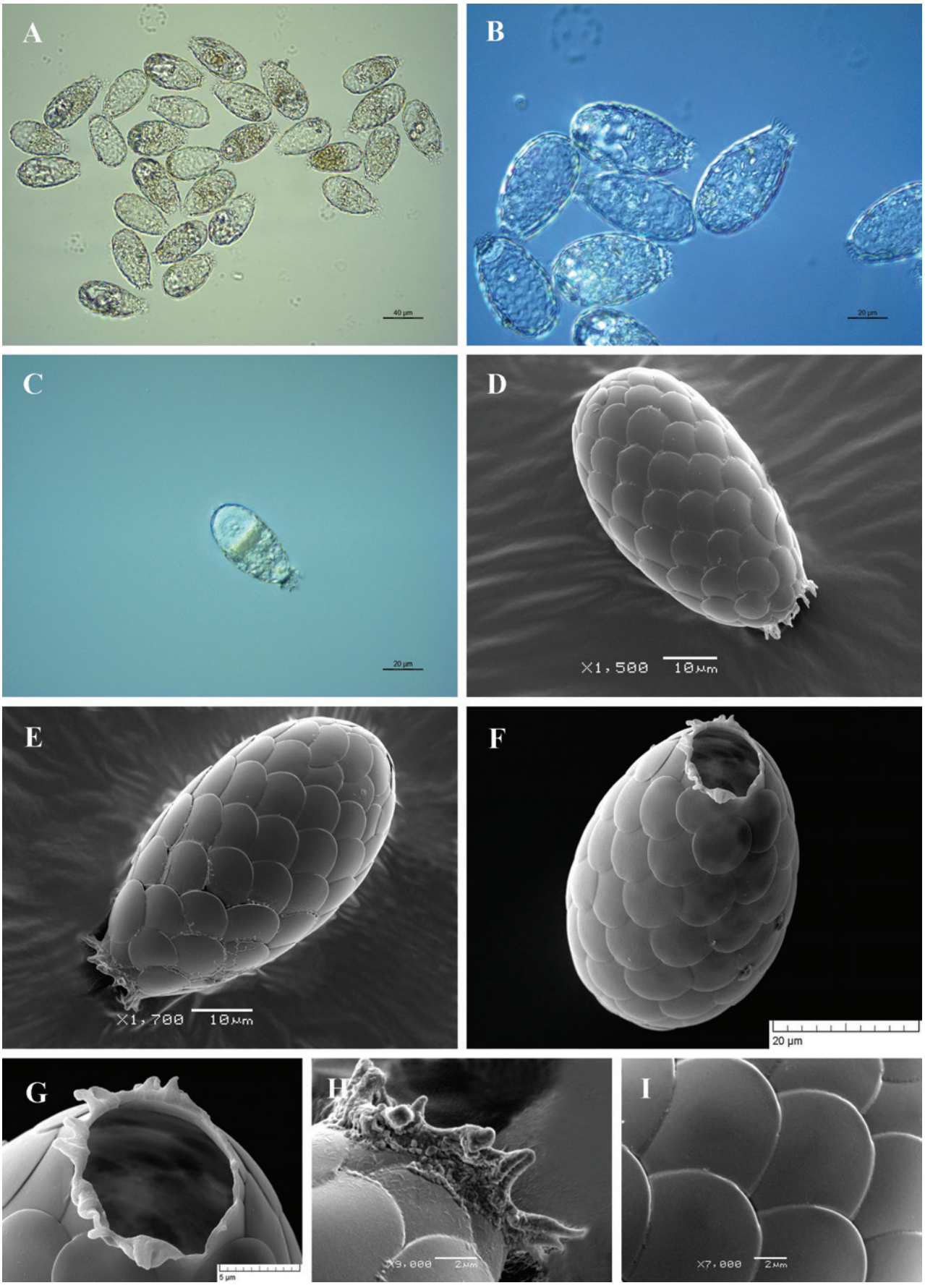
Geographical distribution: Cosmopolitan.

Distribution in *Sphagnum* mosses in Bulgaria: Pirin Mts. (Golemansky 1974, Bankov et al. 2018); **Rhodopes Mts.** (Golemansky 1968, Golemansky et al. 2006); **Rila Mts.** (Golemansky and Todorov 1993, Todorov and Golemansky 2000, Todorov 2005 Bankov et al. 2018); **Stara Planina Mts.** (Bankov et al. 2018); **Vitosha Mts.** (Pateff 1924, Golemansky 1965, Golemansky and Todorov 1985, 1990, Todorov 1993, Todorov and Golemansky 1995, Bankov et al. 2018).

Table 120. *Tracheleuglypha dentata*. Morphometric characterisation (measurements in μm)

Characters	Mean	M	SD	SE	CV	Min	Max	n
Length	58.2	60.0	7.15	1.28	12.29	45	72	31
Breadth	30.0	30.1	3.16	0.57	10.53	21	36	31
Diameter of aperture	11.0	10.8	1.58	0.28	14.38	9	17	31
Breadth/Length ratio	0.52	0.51	0.05	0.009	10.20	0.4	0.6	31
Aperture/Breadth ratio	0.37	0.37	0.05	0.009	13.82	0.3	0.5	31

Fig. 130. Light (A-C) and scanning electron (D-I) micrographs of *Tracheleuglypha dentata*. (A, B) View of many specimens to illustrate variability in shape and size of the shell. (C) View of live specimen showing granulated band in the central region of the cell and large nucleus with many nucleoli, placed posteriorly; (D, E) Broad lateral view of two individuals to show general shape and regular arrangement of shell-plates. (F) Apertural view. (G) Close up view of aperture illustrating its shape, arrangement of apertural-plates and collar of organic material. (H) Lateral view of apertural region showing tooth-like structure of the organic collar (I) Detail of shell surface to show overlapping shell-plates.


A
40 µm
B
20 µm
C
20 µm
D
X1,500 10µm
E
X1,700 10µm
F
20 µm
G
5 µm
H
X9,000 2µm
I
X7,000 2µm

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INDEX OF ILLUSTRATED SPECIES

Testate amoebae are a polyphyletic assemblage of at least three major, unrelated taxonomic groups of free-living unicellular eukaryotes (Amoebozoa, Stramenopiles and Cercozoa) which ameboid cell is covered by an extracellular shell (test). They are worldwide distributed and occur in most terrestrial and freshwater environments, as well as in brackish and marine habitats, from the tropics to polar regions. The studies on this group have significantly increased over the past two decades due to their increasing use in different applied aspects. Testate amoebae are considered as valuable bioindicators for ecological and environmental monitoring studies, in particular, as proxies for hydrological changes and for paleoclimate reconstruction in peatlands. The fact that different species have distinct ecological requirements and after death of the amoebae their shells remain well preserved in peat and sediment makes them excellent microfossils and extremely valuable in micro-paleontological studies for palaeoenvironmental reconstructions. Testate amoebae are very sensitive and quickly respond to environmental changes, such as water table depth, dryness, atmospheric pollution, deforestation and other human activities, and this makes them valuable biomonitors for current environmental health.

A total of 120 species are described in the atlas, including the majority of recorded Sphagnum-dwelling testate amoebae in Bulgaria. The following information is given for each species: description; ecology; geographical distribution; distribution in *Sphagnum* mosses in Bulgaria and relevant literature sources; morphometric characterisation; taxonomic notes; synonymous names; original publication and publication where last revision is made. Each species is illustrated by nine micrographs, primarily on scanning electron microscope (SEM), to receive information about the shell ultrastructure. Micrographs taken on light microscope (LM) are additionally given for most of them to illustrate the cytoplasm and pseudopodia of live individuals.

Since most of the described species appear to be widely distributed in Europe, as well as in many other regions of the world, the atlas may be of interest to all researchers on testate amoebae and can also be used by specialists in ecology, hydrobiology, palaeoecology, environmental monitoring, as well as by lecturers and students in biology.

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