Journal of Species Research 9(4):462-466, 2020

Twelve unrecorded species of testate amoebae discovered from Korea

Jongwoo Jung*

Department of Science Education, Ewha Womans University, Seoul 03760, Republic of Korea

**Correspondent: jongwoo@ewha.ac.kr*

Testate amoebae are easily recognized as their characteristic shells from other protistan groups. They in which more than 1,900 species have been recorded are mixture of heterogeneous groups mainly composed of Amoebozoa and Cercozoa. In Korea, 74 species of testate amoebae have been recorded since late 1980s. Here I report a list of 12 unrecorded species of testate amoebae from Korea which were discovered during 2016–2018: *Arcella crenulata* Deflandre, 1928; *Centropyxis cassis* (Wallich, 1864); *C. delicatula* Penard, 1902; *C. hirsuta* Deflander, 1929; *C. orbicularis* Deflandre, 1929; *C. sylvatica* (Deflandre, 1929); *Cyclopyxis eurystoma* Deflandre, 1929; *C. intermedia* Kufferath, 1932; *C. kahli* (Deflandre, 1929); *Difflugia diafana* Vucetich, 1987; *D. manicata* Penard, 1902; *Awerintzewia cyclostoma* Schoutenden, 1906. As a result the fauna of testate amoebae in Korea is composed of 86 species. There are still much more species remained to be discovered in Korea. The faunal studies on testate amoebae will provide us valuable information about freshwater and soil environments.

Keywords: Arcellinida, *Awerintzewia*, *Cyclopyxis*, Korean indigenous species, testate amoeba

DOI:10.12651/JSR.2020.9.4.462

Introduction

Most people may not be familiar with testate amoebae. However, these protist groups are so diverse that we can find them nearly all kinds of aquatic and soil habitats (Ogden and Hedley, 1980). As testate amoebae have their characteristic tests, they can be easily recognized. Their tests are various not only in composition such as proteinaceous, agglutinate, siliceous or calcareous materials but also in their shapes. Moreover, their shells are well preserved even after they die, which makes testate amoebae indicators of past environments.

Testate amoebae are mixture of heterogeneous groups, mainly composed of phylum Amoebozoa Cavalier-Smith and phylum Cercozoa Cavalier-Smith. More than 1,900 species of testate amoebae have been recorded in the world (Qin *et al*., 2011). They are widely used in ecology and restoration (Creevy *et al*., 2018), forensic science (Szelecz *et al*., 2014), and palaeoecology (Booth, 2002; Lamentowicz *et al*., 2013).

In Korea, taxonomic and faunistic studies on these groups have begun recently. After Chung and Choi (1989), several researchers have conducted researches on testate amoebae of Korea (Chung and Cha, 1990; Chung and Kang, 1991; Chung *et al*., 1992; Chung and Choi, 1995; Jung, 2016). As a result, 74 species of testate amoebae have been recorded in this country. In this paper, I added 12 species to the Korean fauna of testate amoebae. These species had been discovered from several locations of Korea in the last three years (2016–2018).

Materials and Methods

Specimens were collected by Hanna Kim (HK) or Jongwoo Jung (JJ) from several freshwater habitats such as streams, bogs, etc. Freshwater samples were collected with water plants and bottom sediments, and testate amoebae were sorted from these samples. Sorting was performed under an inverted microscope, AE2000 (Motic, Hong Kong) using thin glass pipettes. Then selected specimens were mounted on hole slides with Canada balsam media. I observed them using a research microscope, BX53 (Olympus, Tokyo, Japan). All the specimens are deposited in NIBR, Incheon, Korea.

Results

Phylum Amoebozoa Lühe, 1913
Subphylum Lobosa Carpenter, 1861
Class Tubulinea Smirnov *et al*., 2005
Order Arcellinida Kent, 1880
Family Arcellidae Ehrenberg, 1843
Genus *Arcella* Ehrenberg, 1832

1. *Arcella crenulata* Deflandre, 1928
(돌기입대접벌레) (Fig. 1A)

Material examined. One individual (VQUMIV0000002987): Korea, Gyeonggi-do, Paju-si, Geomsan-dong, 11 Oct. 2016, 37°46′28.40″N 126°44′15.96″E, collected by JJ.
Diagnosis. Shell brown, circular with a domed aboral region, having numerous small pores in the surface. Aperture invaginated, circular with crenulated margin.

Family Centropyxidae Jung, 1942
Genus *Centropyxis* Stein, 1859

2. *Centropyxis cassis* (Wallich, 1864) Deflander, 1929
(건포도베레모벌레) (Fig. 1B)

Material examined. One individual (VQUMIV0000002985): Korea, Jeju-do, Jeju-si, Hallim-eup, Sangmyeong-ri, 13 Oct. 2016, 33°21′27.92″N 126°16′22.02″E, collected by JJ; one individual (FKRUPR0000000163): Korea, Gyeonggi-do, Goyang-si, Deokyang-gu, Eupnae-ro, 5-82, Gongreungcheon Stream, 15 May 2018, 37°41′49.42″N 126°54′01.08″E, collected by JJ; four individuals (FKRUPR0000000181-4): Korea, Gyeonggi-do, Yangju-si, Jangheung-myeon, Bugok-ri, 480-1, Gongreungcheon Stream, 15 May 2018, 37°43′28.12″N 126°58′35.44″E, collected by JJ; one individual: Korea, Incheon, Ganghwa-gun, Gilsang-myeon, Jangheung-ri, Jangheung Reservoir, 14 Apr. 2019, 37°37′22.62″N 126°30′05.50″E, collected by JJ; two individuals: Korea, Incheon, Ganghwa-gun, Yangdo-myeon, Dojang-ri, Giljeong Stream, 27 Sep. 2019, 37°38′55.58″N 126°27′57.87″E, collected by JJ; one individual: Korea, Incheon, Ganghwa-gun, Yangdo-myeon, Insan-ri, Insan Reservoir, 27 Sep. 2019, 37°41′54.20″N 126°25′52.46″E, collected by JJ.
Diagnosis. Shell medium, broadly elliptic, hemispherical in lateral view, flattened above the aperture. Aperture wide, semi-circular, encrusted with several large xenosomes in the anterior margin.

3. *Centropyxis delicatula* Penard, 1902
(가운데입베레모벌레) (Fig. 1C)

Material examined. One individual (ZIIYPR0000000763): Korea, Gyeonggi-do, Yangju-si, Majeon-dong, Gwangsacheon Stream, 11 Oct. 2016, 37°46′50.18″N 127°04′08.22″E, collected by JJ.
Diagnosis. Shell organic, yellow till brown or brown-grey, hyaline, without xenosomes, sometimes with some spines, more or less circular in dorsal view, hemispherical or flattened in lateral view. Aperture more or less centric, tubular invaginated.

4. *Centropyxis hirsuta* Deflander, 1929
(거친베레모벌레) (Fig. 1D)

Material examined. One individual (ZIIYPR0000000764): Korea, Gyeonggi-do, Paju-si, Geomsan-dong, Sapogyocheon Stream, 11 Oct. 2016, 37°46′28.40″N 126°44′15.96″E, collected by JJ; five individuals (FKRUPR0000000198-202): Korea, Gyeonggi-do, Goyang-si, Deokyang-gu, Eupnae-ro, 5-82, Gongreungcheon Stream, 15 May 2018, 37°41′49.42″N 126°54′01.08″E, collected by JJ; One individual (FKRUPR0000000225): Korea, Gyeonggi-do, Yangju-si, Jangheung-myeon, Bugok-ri, 480-1, Gongreungcheon Stream, 15 May 2018, 37°43′28.12″N 126°58′35.44″E, collected by JJ; one individual: Korea, Incheon, Ganghwa-gun, Yangdo-myeon, Insan-ri, Insan Reservoir, 27 Sep. 2019, 37°41′54.20″N 126°25′52.46″E, collected by JJ.
Diagnosis. Shell medium, almost round in dorsal view, hemispherical or flattened in lateral view, strongly flattened above the aperture. Aperture wide-elliptical, eccentric.

5. *Centropyxis orbicularis* Deflandre, 1929
(둥근베레모벌레) (Fig. 1E)

Material examined. One individual (ZIIYPR0000000211): Korea, Gyeonggi-do, Goyang-si, Deokyang-gu, Eupnae-ro, 5-82, Gongreungcheon Stream, 15 May 2018, 37°41′49.42″N 126°54′01.08″E, collected by JJ; two individuals: Korea, Incheon, Ganghwa-gun, Yangdo-myeon, Insan-ri, Insan Reservoir, 27 Sep. 2019, 37°41′54.20″N 126°25′52.46″E, collected by JJ.
Diagnosis. Shell relatively large, round in dorsal view, hemispherical in lateral view, having surface covered with mineral particles of various sizes and shapes.

6. *Centropyxis sylvatica* (Deflandre, 1929) Bonnet & Thomas, 1955 (둥근몸베레모벌레) (Fig. 1F)

Material examined. One individual (VQUMIV0000002984): Korea, Jeju-do, Jeju-si, Hallim-eup, Sangmyeong-ri, 13 Oct. 2016, 33°21′27.92″N 126°16′22.02″E, collected by JJ.
Diagnosis. Shell relatively large, broadly ovate in dorsal view, clearly divided into a visor and abdomen, more than hemispherical in lateral view.

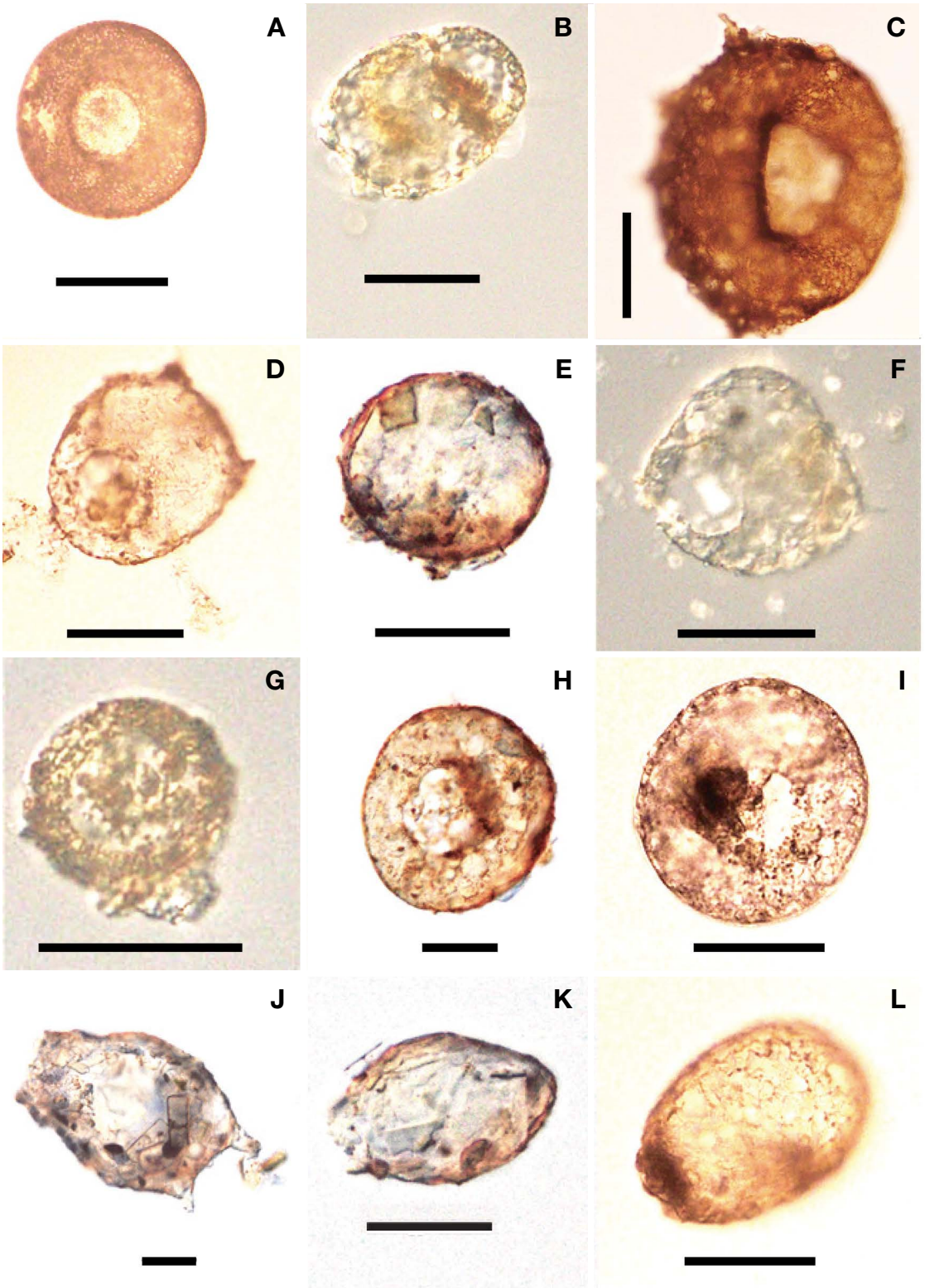

Fig. 1. Testate Amoebae. A, *Arcella crenulata* Deflandre, 1928, apertural view; B, *Centropyxis cassis* (Wallich, 1864), lateral view; C. *Centropyxis delicatula* Penard, 1902, apertural view; D, *Centropyxis hirsuta* Deflander, 1929, apertural view; E, *Centropyxis orbicularis* Deflandre, 1929, lateral view; F, *Centropyxis sylvatica* (Deflandre, 1929), apertural view; G, *Cyclopyxis eurystoma* Deflandre, 1929, apertural view; H, *Cyclopyxis intermedia* Kufferath, 1932, apertural view; I, *Cyclopyxis kahli* (Deflandre, 1929), apertural view; J, *Difflugia diafana* Vucetich, 1987, lateral view; K, *Difflugia manicata* Penard, 1902, lateral view; L, *Awerintzewia cyclostoma* Schoutenden, 1906, lateral view. Scale bars: A–L = 50 μm.

Family Trigonopyxidae Loeblich and Tappan, 1964
Genus *Cyclopyxis* (Deflandre, 1929)

7. *Cyclopyxis eurystoma* Deflandre, 1929
(넓은입둥근벌레) (Fig. 1G)

Material examined. One individual (VQUMIV0000002986): Korea, Jeju-do, Seogwipo-si, Shoesokkak, 13 Oct. 2016, 33°15′16.30″N 126°37′22.20″E, collected by HK; Six individuals (ZIIYPR0000000243-8): Korea, Gyeonggi-do, Yangju-si, Jangheung-myeon, Bugok-ri, 480-1, Gongreungcheon Stream, 15 May 2018, 37°43′28.12″N 126°58′35.44″E, collected by JJ; one individual: Korea, Incheon, Ganghwa-gun, Yangdo-myeon, Dojang-ri, Giljeong Stream, 27 Sep. 2019, 37°38′55.58″N 126°27′57.87″E, collected by JJ.
Diagnosis. Shell medium, round in dorsal view, hemispherical in lateral view; covered with mineral particles. Aperture large, up to half the shell diameter, round, slightly deepened.

8. *Cyclopyxis intermedia* Kufferath, 1932
(둥근벌레) (Fig. 1H)

Material examined. One individual (ZIIYPR0000000242): Korea, Gyeonggi-do, Paju-si, Jori-eup, Janggok-ri, 459, Gongreungcheon Stream, 19 Jun. 2018, 37°43′49.97″N 126°50′05.78″E, collected by JJ.
Diagnosis. Shell brown, usually round in dorsal view, more than hemispherical in lateral view; lateral sides evenly rounded; dorsal side usually flattened, composed of xenosomes. Aperture circular, located in the center of ventral surface, with edge covered by small xenosomes.

9. *Cyclopyxis kahli* (Deflandre, 1929) Deflandre, 1929
(깊은입둥근벌레) (Fig. 1I)

Material examined. One individual (ZIIYPR0000000767): Korea, Gyeonggi-do, Paju-si, Geomsan-dong, Sapogyocheon Stream, 11 Oct. 2016, 37°46′28.40″N 126°44′15.96″E, collected by JJ.
Diagnosis. Shell relatively large, round in dorsal view, more than hemispherical in lateral view. Aperture small, round, finely toothed.

Family Difflugiidae Wallich, 1984
Genus *Difflugia* Leclere, 1815

10. *Difflugia diafana* Vucetich, 1987
(두꼬리원통벌레) (Fig. 1J)

Material examined. Two individuals (ZIIYPR0000000223-4): Korea, Gyeonggi-do, Yangju-si, Jangheung-myeon, Bugok-ri, 480-1, Gongreungcheon Stream, 15 May 2018, 37°43′28.12″N 126°58′35.44″E, collected by JJ.
Diagnosis. Shell elongated, yellowish gray; with two long, somewhat diverging horns in the posterior region; with a short but well-defined neck in the anterior region; covered by small and thin exogenous particles and by some detritus of organic origin. Aperture oval.

11. *Difflugia manicata* Penard, 1902
(손잡이꽃병벌레) (Fig. 1K)

Material examined. One individual (ZIIYPR0000000142): Korea, Gyeonggi-do, Goyang-si, Deokyang-gu, Eupnae-ro, 5-82, Gongreungcheon Stream, 15 May 2018, 37°41′49.42″N 126°54′01.08″E, collected by JJ; four individuals (ZIIYPR0000000185-8): Korea, Gyeonggi-do, Yangju-si, Jangheung-myeon, Bugok-ri, 480-1, Gongreungcheon Stream, 15 May 2015, 37°43′28.12″N 126°58′35.44″E, collected by JJ; one individual: Korea, Incheon, Ganghwa-gun, Yangdo-myeon, Dojang-ri, Giljeong Stream, 27 Sep. 2019, 37°38′55.58″N 126°27′57.87″E, collected by JJ.
Diagnosis. Shell medium, yellow-brown, pear-shaped, tapering towards the aperture and the base of the fundus. Aperture round, surrounded by fine grains of sand.

Family Heloeperidae Jung, 1942
Genus *Awerintzewia* Schoutenden, 1906
(타원입납작벌레속)

12. *Awerintzewia cyclostoma* Schoutenden, 1906
(타원입납작벌레) (Fig. 1L)

Material examined. One individual (ZIIYPR0000000766): Korea, Gyeonggi-do, Paju-si, Geomsan-dong, Sapogyocheon Stream, 11 Oct. 2016, 37°46′28.40″N 126°44′15.96″E, collected by JJ.
Diagnosis. Shell large, planet-trapezoidal; straight at the base of the fundus. Aperture broadly oval with small lateral incisions; the edge of the aperture lined with thin small plates.

Discussion

As a result of this study, the fauna of testate amoebae in Korea is composed of 86 species. Most of previous faunal studies had focused on species of central areas of South Korea such as Chungcheongbuk-do and Chungcheongnam-do. Many unrecorded species have been found through recent studies on the species of northern areas. Therefore, considerable species diversity of testate amoebae must reside in this country. As the testate amoebae are important as indicator of environmental changes, faunal

studies on these groups will provide us valuable information to study freshwater and soil environments.

Acknowledgements

This work was supported by a grant from the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR 2016-01-201; NIBR 2017-01-201; NIBR 2018-01-102; NIBR 2018-01-202).

References

Booth, R.K. 2002. Testate amoebae as paleoindicators of surface-moisture changes on Michigan peatlands: modern ecology and hydrological calibration. Journal of Paleolimnology 28:329-348.

Chung, W.H. and H.Y. Cha. 1990. A taxonomic study on the order Gromiida (Protozoa: Sarcomastigophora: Rhizopoda) from Korea. Korean Journal of Systematic Zoology 6:209-218.

Chung, W.H. and J.B. Choi. 1989. A taxonomic study of orders Arcellinida and Gromiida (Protozoa: Sarcomastigophora: Rhizopoda) from Ch'ŏngju area, Korea. Korean Journal of Systematic Zoology 5:183-204.

Chung, W.H. and J.B. Choi. 1995. A taxonomic study of order Arcellinida (Protozoa: Sarcomastigophora: Rhizopoda) from Korea (II). Korean Journal of Systematic Zoology 11:335-341.

Chung, W.H. and S.B. Kang. 1991. Taxonomy of Thecamoebae (Rhizopodea: Protozoa) from Korea. Korean Journal of Systematic Zoology 7:55-64.

Chung, W.H., S.B. Kang and J.B. Choi. 1992. A taxonomic study of order Arcellinida (Protozoa: Sarcomastigophora: Rhizopoda) from Korea. Korean Journal of Systematic Zoology 8:11-18.

Creevy, A.L., R. Andersen, J.G. Rowson and R.J. Payne. 2018. Testate amoebae as functionally significant bioindicators in forest-to-bog restoration. Ecological Indicators 84:274-282.

Jung, J. 2016. New records of testate amoebae from Korea. Korean Journal of Environmental Biology 34:314-319.

Lamentowicz, M., M. Gałka, K. Milecka, K. Tobolski, Ł. Lamentowicz, B. Fiłkiewicz-Kozieł and M. Blaauw. 2013. A 1300 years multi-proxy, high resolution record from a rich fen in northern Poland: Reconstructing hydrology, land-use and climate change. Journal of Quaternary Science 28:582-594.

Ogden, G.G. and R.H. Hedley. 1980. An atlas of freshwater testate amoebae. British Museum (Natural History). Oxford University Press, Oxford, UK.

Qin, Y., S. Xie, H.G. Smith, G.T. Swindles and Y. Gu. 2011. Diversity, distribution and biogeography of testate amoebae in China: Implications for ecological studies in Asia. European Journal of Protistology 47:1-9.

Szelecz, I., B. Fournier, C. Seppey, J. Amendt and E. Mitchell. 2014. Can soil testate amoebae be used for estimating the time since death? A field experiment in a deciduous forest. Forensic Science International 236:90-98.

Submitted: September 25, 2019
Revised: October 21, 2020
Accepted: October 21, 2020