A preliminary report of Testate Amoebae (Protozoa : Tubulinea and Cercozoa)) in Govind Wildlife sanctuary, Uttarakhand, India

ABSTRACT

Studies relating to testate amoebae in Uttarakhand have been sporadic and testates have been documented only from a few protected areas and so far there are no records from Govind Wildlife sanctuary, Uttarakhand. Therefore, as part of faunistic survey in Uttarakhand a study to document the moss inhabitant testate diversity was carried out in Govind Wildlife sanctuary in October 2019 and has filled the lacuna of TA study in the sanctuary to form the foundation for further investigation. The study revealed the occurrence of a total of 42 species belonging to 16 genera and 9 families. Of these 4 species *viz*., *Cyclopyxis tronconica* Godeanu, 1972., *Certesella martiali* Certes, 1889., *Quadrulella madibai* Kosakyan *et al*., 2016 and *Assulina discoides* Bobrov, Shimano and Mazei, 2012 are novel records to India. This report forms the baseline information for testate amoebae of Govind WLS suggesting the high diversity of testate fauna in the protected area which can be still higher if further explored.

Key words : Govind WLS, Mosses, Protozoa, Testate amoebae, Uttarakhand

INTRODUCTION

The Govind National Park, also known as Govind Pashu Vihar was established and declared as a National Park on 1st March, 1955 is in the Purola Tehsil of Uttarakashi district in Uttarakhand state and lies between latitude 31 0 02' - 31 0 20' N and longitude 770 55' - 780 40' E (Fig.1). The park is spread over an area of 953.12 sq. kms. with a varying altitude of 1300 meters to 6323 meters above sea level, of which 472.08 sq. kms. has been demarcated as National Park.

Inspite of its diverse and rich floral and faunal elements no work has been done so far on the freeliving protozoans of this renowned national park. It is very important to understand the diversity of freeliving protists because it plays a very significant role in the ecological health and make up a large part of earth's biodiversity (Nguyen *et al*., 2004; Payne, 2013). Testate amoebae (Protista) are a polyphyletic eukaryotic unicellular shelled organisms (Bobrov *et al*., 1999,2012; Lamentowicz *et al*., 2007) present in a variety of habitats like terrestrial, freshwater, estuarine and marine from the tropics to polar areas (Foissner, 1987,

1999; Kosakyan *et al*., 2016). Testate amoebae research has increased significantly over the past two decades due to their increasing use in different applied aspects as bioindicators for palaeoecological studies, in environmental monitoring, studies on their role in the cycling of elements in the terrestrial ecosystems and biogeographical and evolutionary studies (Qin *et al*., 2013). Perusal of literature reveals that 189 species of testate amoebae have been recorded from India and there is no consolidated checklist is published till date. Despite the important role in food chain and also as bioindicators for environmental monitoring the immense majority of protist diversity in many protected areas and other parts of India have not so far been seriously analysed and the perusal of literature revealed that from Govind National Park no work has been done so far. In this context this article is the first-time effort to provide information on testate amoebae fauna of Govind National Park.

This study represents the first attempt to construct a species checklist and analyze the diversity and distribution of testate amoebae in Govind WLS. Present diversity includes 43 testate amoebae taxa (16 genera and 9 families) of which 4 species are herewith reported for the first time from India.

MATERIALS AND METHODS

Moss samples (100-200grams) were collected by quadrant sampling (1m2) by scrapping from rock and tree bark from the study area during the faunistic survey to Western Himalaya in October 2019. The samples were processed with non-flooded petri dish method as described by Foissner (1992) and from each sample permanent mounts were prepared and studied under Nikon 50 i compound microscope for species level identification.

RESULTS AND DISCUSSION

The study resulted the documentation of 42 species belonging to 16 genera and 9 families (Table-1, Fig.2). Of these 4 species *viz*., *Cyclopyxis tronconica* Godeanu, 1972., *Certesella martiali* Certes, 1889., *Quadrulella madibai* Kosakyan *et al*., 2016 and *Assulina discoides* Bobrov, Shimano and Mazei, 2012 are new additions to Indian testate fauna. Testate amoebae from the family Centropyxidae proved to be the most dominant constituting 23.25% of the total species (10). Further 18.60% of the species (8) belonged to Hyalospheniidae making it the second dominant family. The families with least number of species (01) were Arcellidae and Difflugiidae.

Perusal of literature revealed that 76 species of TA have been reported from North and North East India (Chattopadhyay and Das, 2003) and of these only 21 species from Uttarakhand and 30 species span over 8 familes are herewith recorded for the first time from the state (Table-2, Fig.3). Of which the family Hyalospheniidae represented the highest number of species (27%) and the families arcellidae and Difflugiidae were represented by only one species. This documentation forms the baseline information of TA from Govind WLS suggesting the great diversity of the fauna from the protected area.

The systematic details of the species recorded from Govind National Park is provided as per the classification Adl *et al*., 2019

Phylum : Tubulinea Smirnov *et al*., 2005

Class : Elardia Kang *et al*., 2017

Order : Arcellinida Kent, 1880

Family : Arcellidae Ehrenberg, 1843

Genus *Arcella* Ehrenberg, 1830

1. *Arcella artocrea* Leidy, 1876

Family Netzeliidae Kosakyan *et al*., 2016

Genus *Cyclopyxis* Deflandre, 1929

2. *Cyclopyxis arcelloides* Penard, 1902
3. *Cyclopyxis arenata* (Cushman, 1930) Boltovskoy, 1956
4. *Cyclopyxis eurystoma* Deflandre, 1929
5. *Cyclopyxis tronconica* Godeanu, 1972 (New record from India)

***Incertae sedis Infraorder* Sphaerothecina**

Genus***Trigonopyxis* Penard, 1912**

6. *Trigonopyxis arcula* Penard, 1912

Genus ***Argynnia*** Vucetich, 1974

7. *Argynnia teres* Jung, 1942

Genus***Awerintzewia***

8. *Awerintzewia 3cyclostoma* (Penard, 1902) Schouteden, 1906

Infraorder Longithecina Lahr *et al.*, 2019

Family D**ifflugiidae** Wallich, 1864

Genus ***Difflugia*** Leclerc, 1815

9. *Difflugia globulosa* Dujardin, 1837

Family **Centropyxidae** Jung, 1942

Genus ***Centropyxis*** Stein, 1857

10. *Centropyxis aerophila* Deflandre, 1929
11. *Centropyxis cassis* (Wallich, 1864) Deflandre, 1929
12. *Centropyxis constricta* (Ehrenberg, 1841) Penard, 1890
13. *Centropyxis ecornis* Ehrenberg, 1841
14. *Centropyxis 4elongata* (Penard, 1890) Thomas, 1959
15. *Centropyxis minuta* Deflandre, 1929
16. *Centropyxis orbicularis* Deflandre, 1929
17. *Centropyxis oblonga* (Deflandre, 1929)
18. *Centropyxis platystoma* Penard, 1890
19. *Centropyxis sylvatica* (Deflandre, 1929) Bonnet et Thomas, 1955

Family **Hyalospheniidae** Schultze, 1977, emend. Kosakyan and Lara, 2012

Genus ***Certesella***Loeblich and Tappan, 1961

20. *Certesella martiali* Certes, 1889 (New record from India)

Genus ***Nebela*** Leidy, 1874

21. *Nebela longitubulata* Gautier-Lievre, 1953
22. *Longinebela penardiana* Deflandre, 1936

Genus ***Quadrulella*** Cockerell, 1909

23. *Quadrulella madibai* Kosakyan *et al*., 2016 (New record from India)
24. *Quadrulella tropica* Wailes, 1912
25. *Quadrulella quadrigera* Deflandre, 1936
26. *Quadrulella symmetrica*(Wallich, 1863) Schulze, 1875

Family : Phryganellidae Jung, 1942

Genus : ***Phryganella*** Penard, 1902

27. *Phryganella acropodia* (Hertwig and Lesser, 1874) Hopkinson, 1909

Phylum Cercozoa Cavalier-Smith, 1998, emend. Adl *et al*., 2005; emend. Cavalier-Smith, 2018

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

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

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

Genus ***Assulina*** Ehrenberg, 1872

28. *Assulina discoides* Bobrov, Shimano and Mazei, 2012 (New record from India)
29. *Assulina muscorum* Greeff, 1888
30. *Assulina quadratum* Van Oye, 1957

31. *Assulina seminulum* Ehrenberg, 1848

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

Genus ***Euglypha***Dujardin, 1841

32. *Euglypha acanthophora* (Ehrenberg, 1841) Perty, 1849
33. *Euglypha 5ciliata*(Ehrenberg, 1848) Leidy, 1878
34. *Euglypha 5denticulata* Brown, 1912
35. *Euglypha rotunda* Wailes, 1915
36. *Euglypha simplex* Decloitre, 1965
37. *Euglypha strigosa* (Ehrenberg, 1871) Leidy, 1878

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

Genus ***Corythion*** Taranek, 1881

38. *Corythion asperulum* schonborn, 1988
39. *Corythion dubium* Taranek, 1881

Genus ***Trinema*** Dujardin, 1841

40. *Trinema complanatum* Penard, 1890
41. *Trinema enchelys* (Ehrenberg, 1938) Leidy, 1878
42. *Trinema penardi* Thomas et Chardez, 1958

Table-1. Testate amoebae species recorded from Govind Wildlife Sanctuary

Sl no	Family	Scientific name	Reg. No	Image No.
1	Arcellidae	*Arcella artocrea* Leidy, 1876	Mi-943	1
2	Netzeliidae	*Cyclopyxis arcellodes* Penard, 1902	Mi-946	2
3		*Cyclopyxis arenata* (Cushman, 1930) Boltovskoy, 1956	Mi-948	3
4		*Cyclopyxis eurystoma* Deflandre, 1929	Mi-966	4
5		*Cyclopyxis tronconica* Godeanu, 1972	Mi-931	5
6		*Trigonopyxis arcula* Penard, 1912	Mi-953	6
7		*Argynnia teres* Jung, 1942	Mi-955	7
8		*Awerintzewia cyclostoma* (Penard, 1902) Schouteden, 1906	Mi-949	8

9	Difflugiidae	*Difflugia globulosa* Dujardin, 1837	Mi-969	9
10	Centropyxidae	*Centropyxis aerophila* Deflandre, 1929	Mi-929/2	10
11		*Centropyxis cassis* (Wallich, 1864) Deflandre, 1929	Mi-940	11
12		*Centropyxis constricta* (Ehrenberg, 1841) Penard, 1890	Mi-947	12
13		*Centropyxis ecornis* Ehrenberg, 1841	Mi-933	13
14		*Centropyxis elongata* (Penard, 1890) Thomas, 1959	Mi-926	14
15		*Centropyxis minuta* Deflandre, 1929	Mi-937	15
16		*Centropyxis orbicularis* Deflandre, 1929	Mi-945	16
17		*Centropyxis oblonga* (Deflandre, 1929)	Mi-959	17
18		*Centropyxis platystoma* Penard, 1890	Mi-939	18
19		*Centropyxis sylvatica* (Deflandre, 1929) Bonnet et Thomas, 1955	Mi-961	19
20	Family Hyalospheniidae	*Certesella martiali* Certes, 1889	Mi-958	20
21		*Nebela longitubulata* Gautier-Lievre, 1953	Mi-957	21
22		*Longinebela penardiana* Deflandre, 1936	Mi-954	22
23		*Quadrulella madibai* Kosakyan *et al*., 2016	Mi-941	23
24		*Quadrulella tropica* Wailes, 1912	Mi-950	24
25		*Quadrulella quadrigera* Deflandre, 1936	Mi-944	25
26		*Quadrulella symmetrica*(Wallich, 1863) Kosakyan et al., 2016	Mi-933/1	26
27		*Phryganella acropodia* (Hertwig and Lesser, 1874) Hopkinson, 1909	Mi-941/3	27

28	Family Assulinidae	*Assulina discoides* Bobrov, Shimano and Mazei, 2012	Mi-932	28
29		*Assulina muscorum* Greeff, 1888	Mi-930	29
30		*Assulina quadratum* Van Oye, 1957	Mi-929	30
31		*Assulina seminulum* Ehrenberg, 1848	Mi-929/1	31
32	Family Euglyphidae	*Euglypha acanthophora* (Ehrenberg, 1841) Perty, 1849	Mi-942	32
33		*Euglypha ciliata* (Ehrenberg, 1848) Leidy, 1878	Mi-934	33
34		*Euglypha denticulata* Brown, 1912	Mi-956	34
35		*Euglypha rotunda* Wailes, 1915	Mi-922	35
36		*Euglypha simplex* Decloitre, 1965	Mi-963	36
37		*Euglypha strigosa* (Ehrenberg, 1871) Leidy, 1878	Mi-924	37
38	Family Trinematidae	*Corythion asperulum* schonborn, 1988	Mi-951	38
39		*Corythion dubium* Taranek, 1881	Mi-952	39
40		*Trinema complanatum* Penard, 1890	Mi-923	40
41		*Trinema enchelys* (Ehrenberg, 1938) Leidy, 1878	Mi-927/1	41
42		*Trinema penardi* Thomas et Chardez, 1958	Mi-962	42

Table-2. List of species recorded for the first time from Uttarakhand, India

Sl No.	Families	Names of species
1	Arcellidae	*Arcella artocrea* Leidy, 1876
2	Netzeliidae	*Cyclopyxis arenata* (Cushman, 1930) Boltovskoy, 1956
3		*Cyclopyxis eurystoma* Deflandre, 1929
4		*Cyclopyxis tronconica* Godeanu, 1972
5		*Trigonopyxis arcula* Penard, 1912
6		*Argynnia teres* Jung, 1942
7		*Awerintzewia cyclostoma* (Penard, 1902) Schouteden, 1906
8	Difflugiidae	*Difflugia globulosa* Dujardin, 1837
9	Centropyxidae	*Centropyxis ecornis* Ehrenberg, 1841

10		*Centropyxis elongata* (Penard, 1890) Thomas, 1959
11		*Centropyxis minuta* Deflandre, 1929
12		*Centropyxis oblonga* (Deflandre, 1929)
13		*Centropyxis sylvatica* (Deflandre, 1929) Bonnet et Thomas, 1955
14	Hyalospheniidae	*Certesella martiali* Certes, 1889
15		*Nebela longitubulata* Gautier-Lievre, 1953
16		*Longinebela penardiana* Deflandre, 1936
17		*Quadrulella madibai* Kosakyan *et al*., 2016
18		*Quadrulella tropica* Wailes, 1912
19		*Quadrulella quadrigera* Deflandre, 1936
20		*Quadrulella symmetrica*(Wallich, 1863) Kosakyan *et al*., 2016
21		*Phryganella acropodia* (Hertwig and Lesser, 1874) Hopkinson, 1909
22	Assulinidae	*Assulina discoides* Bobrov, Shimano and Mazei, 2012
23		*Assulina muscorum* Greeff, 1888
24		*Assulina quadratum* Van Oye, 1957
25		*Assulina seminulum* Ehrenberg, 1848
26	Euglyphidae	*Euglypha acanthophora* (Ehrenberg, 1841) Perty, 1849
27		*Euglypha denticulata* Brown, 1912
28		*Euglypha simplex* Decloitre, 1965
29	Trinematidae	*Corythion asperulum* schonborn, 1988
30		*Corythion dubium* Taranek, 1881

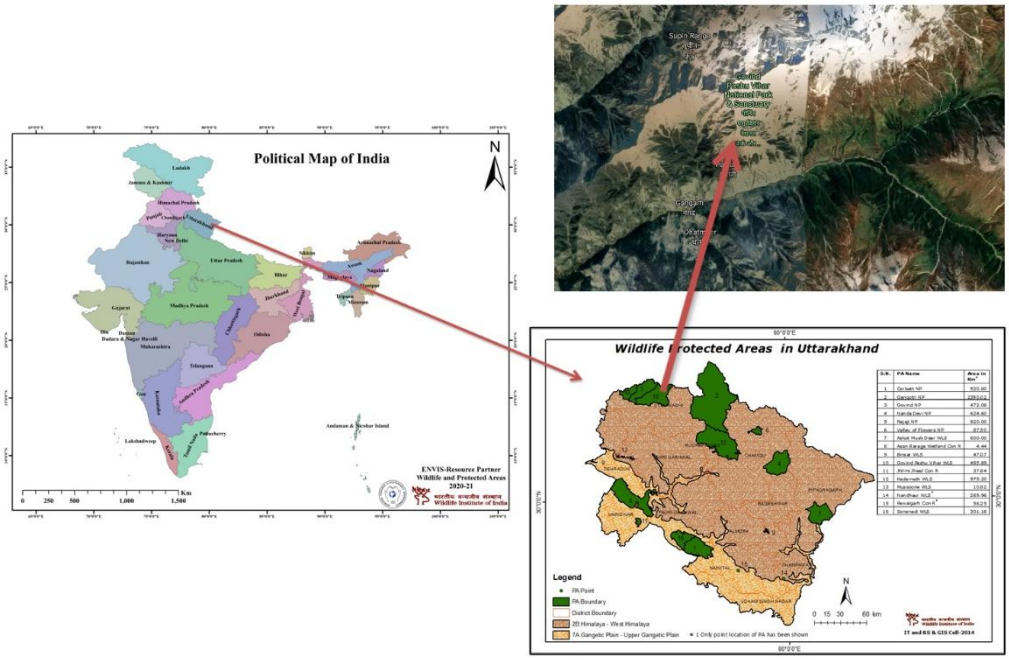

Figure .1 __Study area, Govind Wildlife sanctuary, Uttarakhand, India

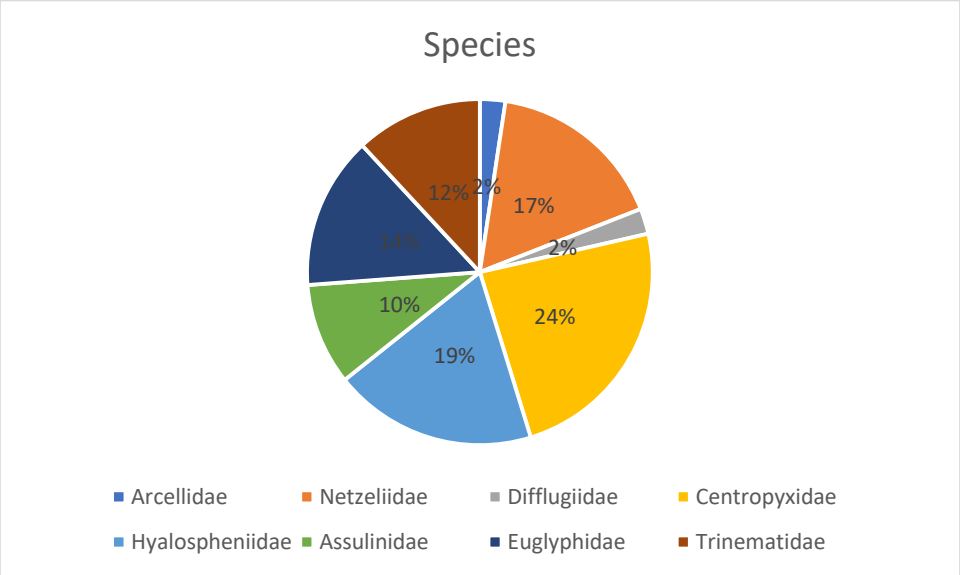

Fig.2.Testate amoebae species recorded from Govind Wildlife Sanctuary

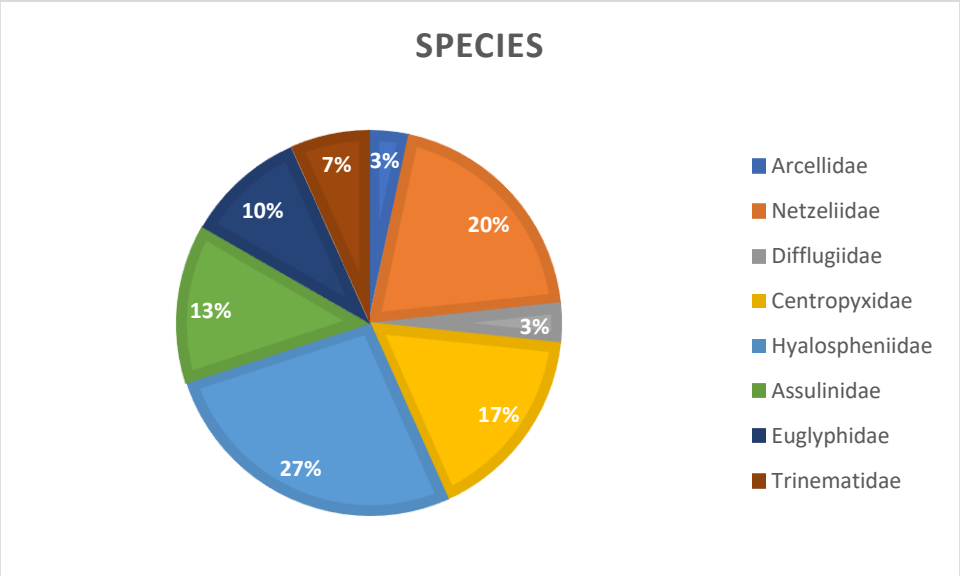

Fig.3. List of species recorded for the first time from Uttarakhand, India

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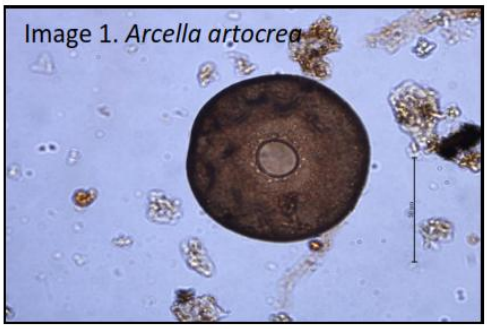
Image 1. *Arcella artocrea*

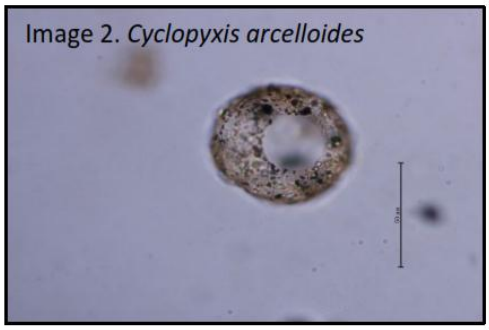
Image 2. *Cyclopyxis arcelloides*

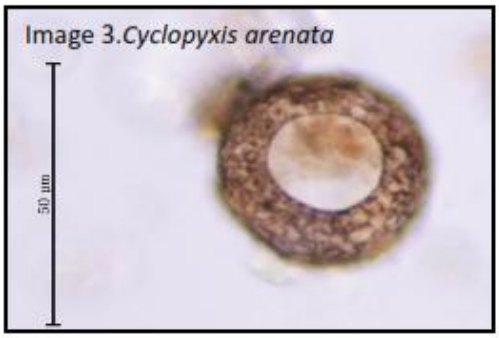

Image 3.*Cyclopyxis arenata*


Image4.*Cyclopyxis eurystoma*

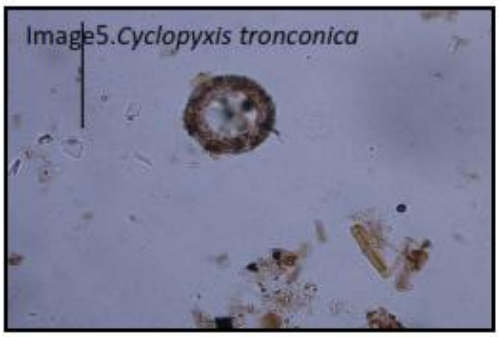
Image5.*Cyclopyxis tronconica*

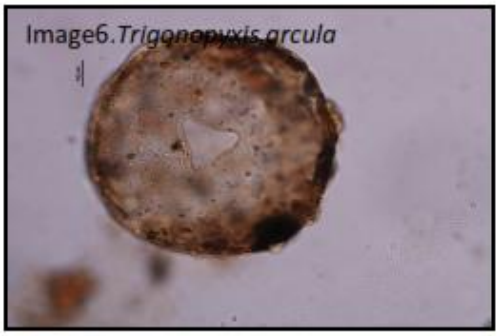
Image6.*Trigonopyxis arcula*


Image7. *Argynnia teres*


Image 8. *Awerintzewia cyclostoma*

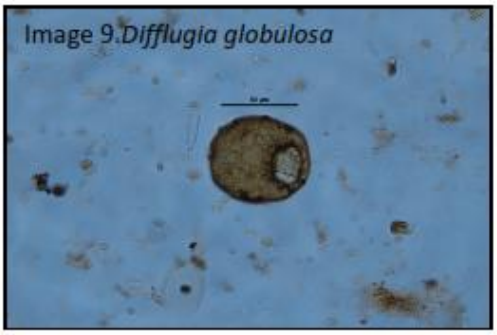
Image 9.*Difflugia globulosa*


Image 10.*Centropyxis aerophila*

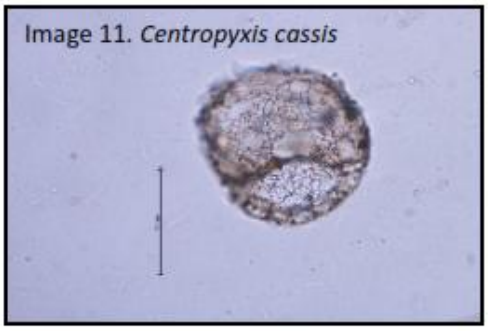
Image 11. *Centropyxis cassis*

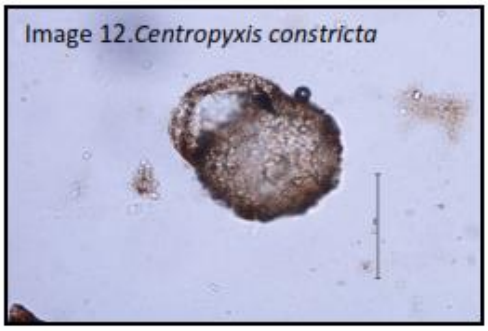
Image 12.*Centropyxis constricta*


Image 13. *Centropyxis ecornis*


Image 14. *Centropyxis elongata*

Image 15.*Centropyxis minuta*

Image 16. *Centropyxis orbicularis*

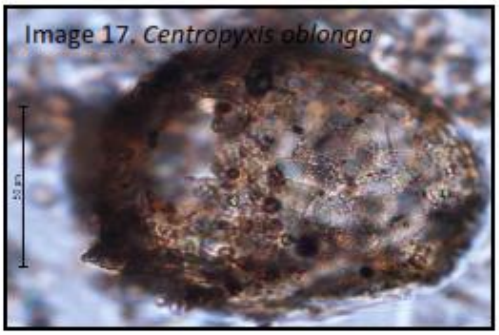

Image 17. *Centropyxis oblonga*

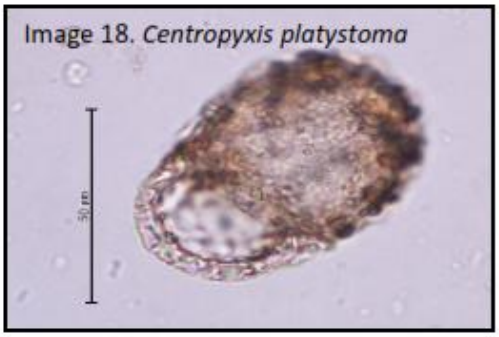

Image 18. *Centropyxis platystoma*

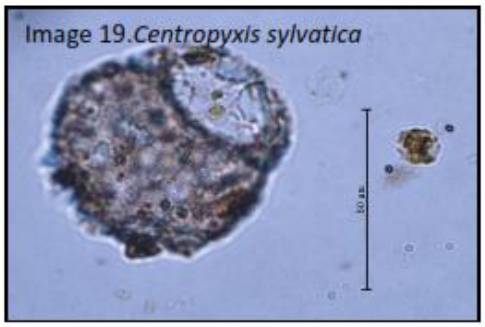

Image 19.*Centropyxis sylvatica*

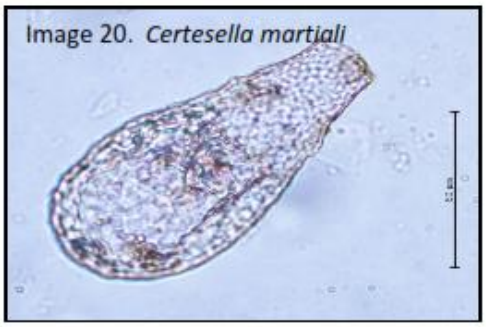

Image 20. *Certesella martiali*

Image 21. *Nebela longitubulata*

Image 22. *Longinebela penardiana*

Image 23. *Quadrulella madibai*

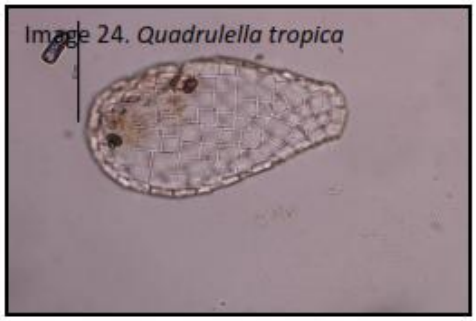

Image 24. *Quadrulella tropica*

Image 25. *Quadrulella quadrigera*

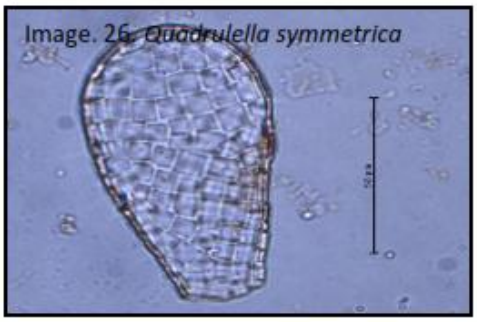

Image. 26. *Quadrulella symmetrica*

Image 27. *Phryganella acropodia*

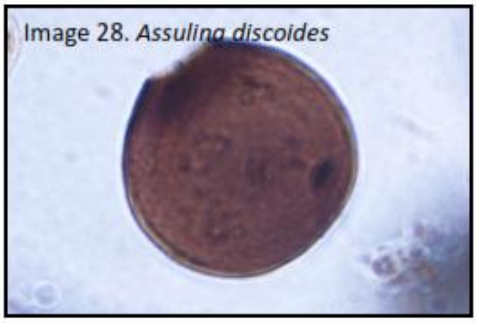

Image 28. *Assulina discoides*

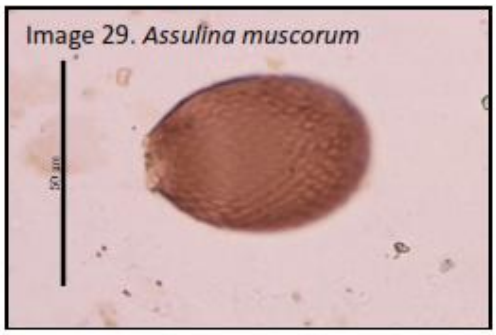
Image 29. *Assulina muscorum*

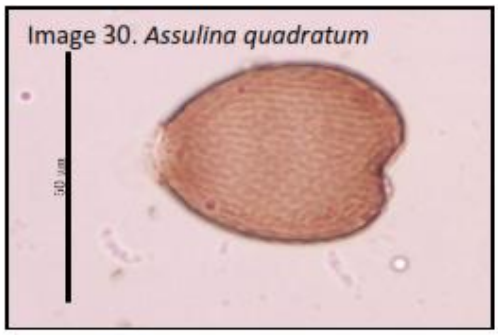
Image 30. *Assulina quadratum*


Image 31. *Assulina seminulum*

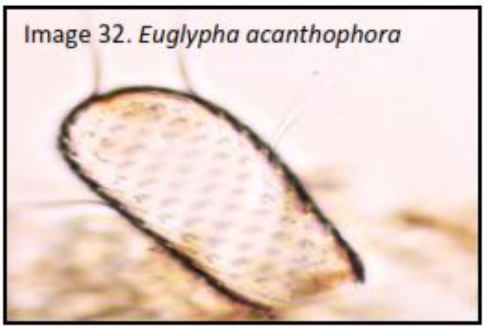
Image 32. *Euglypha acanthophora*


Image 33. *Euglypha ciliata*

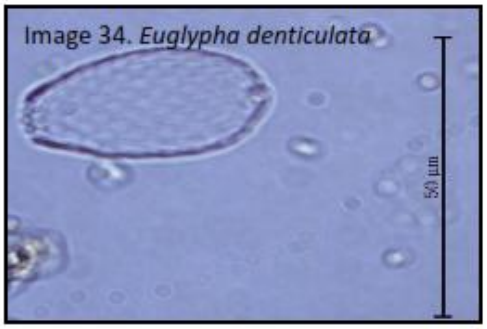
Image 34. *Euglypha denticulata*
50 µm

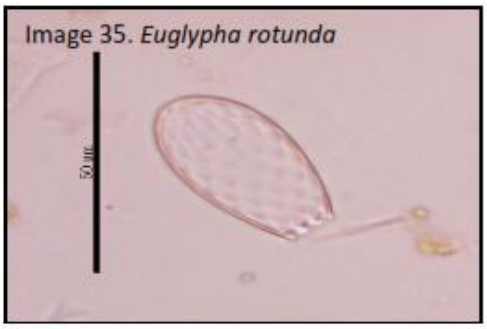
Image 35. *Euglypha rotunda*

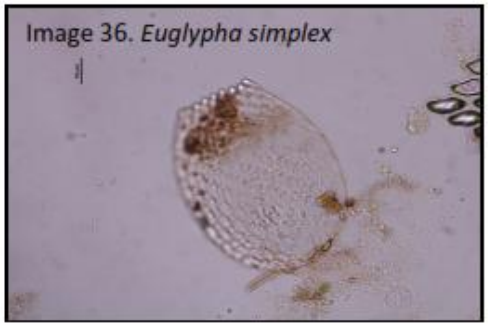
Image 36. *Euglypha simplex*

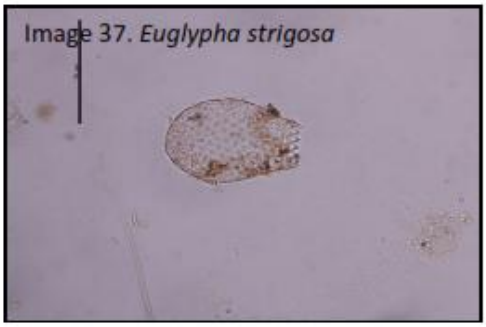
Image 37. *Euglypha strigosa*


Image. 38. *Corythion asperulum*

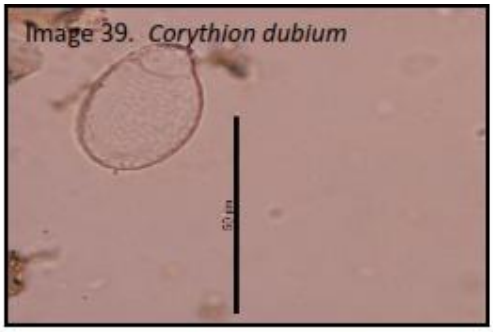
Image 39. *Corythion dubium*

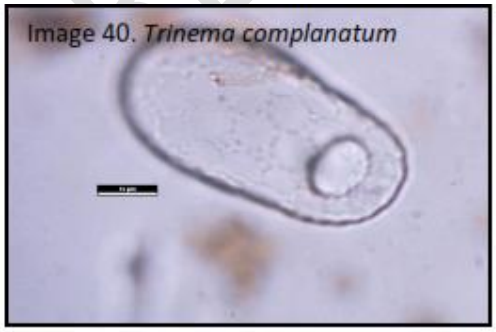
Image 40. *Trinema complanatum*


Image 41. *Trinema enchelys*

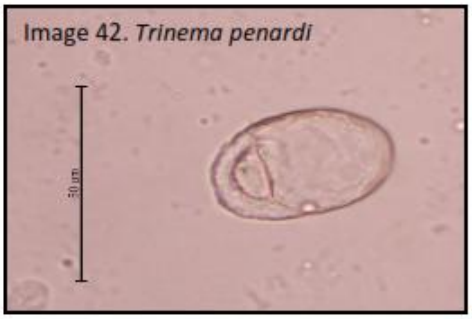
Image 42. *Trinema penardi*