



## **A Preliminary Report of Testate Amoebae (Protozoa: Tubulinea and Cercozoa) in Govind National Park, Uttarakhand, India**

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### **Authors' contributions**

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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### **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 National Park, Uttarakhand. Therefore, as a 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 Testate Amoebae 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, *Quadrullella madibai* Kosakyan *et al.*, 2016 and *Assulina discooides* 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.

**Keywords:** Testate amoebae; protozoa; tubulinea; cercozoa; govind wildlife sanctuary; Uttarakhand; India.

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## 1. INTRODUCTION

Govind National Park (GNP) and Govind Pashu Vihar Wildlife Sanctuary (GWS) are part of high Western Himalayan highland situated in the Uttarkashi district of Uttarakhand. The protected area landscape lies between latitudes 31.1425° N and longitude 78.3387° E, covering an area of about 958 km<sup>2</sup>. Part of the Upper Tones Valley was notified as a Sanctuary in 1955 while GNP was notified in 1991, with a varying altitude of 1300 meters to 6323 meters above sea level, of which 472.08 km<sup>2</sup> has been demarcated as National Park.

In spite of its diverse and rich floral and faunal elements, no work has been done so far on the free-living protozoans of this renowned national park. It is very important to understand the diversity of free-living protists because it plays a very significant role in the ecological health and make up a large part of earth's biodiversity [1,2]. Testate amoebae (Protista) are a polyphyletic eukaryotic unicellular shelled organisms (3,4,5) present in a variety of habitats like terrestrial, freshwater, estuarine and marine from the tropics to polar areas [6,7,8]. 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 [9]. According to the present estimate 1600 species of freeliving protozoa have been recorded from India including the estuarine species. Of these 185 species are rhizopods [10] 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 review 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 42 testate amoebae species (16 genera and 9 families) of which 4 species are herewith reported for the first time from India.

## 2. MATERIALS AND METHODS

Moss samples (100-200grams) were collected by quadrant sampling (1m<sup>2</sup>) 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 [11] and from each sample permanent mounts were prepared and studied under Nikon 50 i compound microscope for species level identification.

## 3. RESULTS AND DISCUSSION

The study resulted in the documentation of 42 species belonging to 16 genera and 9 families (Table-1, Fig.2, Images 1- 42 as Annexure 1). Of these 4 species viz., *Cyclopyxis tronconica* Godeanu, 1972, *Certesella martiali* Certes, 1889., *Quadrullella 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 was found to be the most dominant constituting 23.25% of the total species (10 species). Further 18.60% of the species (8 species) belonged to Hyalospheniidae making it the second dominant family. The families with lowest number of species (01 species) were Arcellidae and Diffugiidae.

Perusal of literature revealed that 76 species of Testate Amoebae have been reported from North and North East India [12] and of these only 21 species from Uttarakhand with an addition of 30 species span over 8 families 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 Diffugiidae were represented by only one species. This documentation forms the baseline information of Testate Amoebae from Govind National Park suggesting the great diversity of the fauna from the protected area. The specimens were deposited in the National Zoological Collections repository of the Zoological Survey of India, Marine Biological Regional Centre, Chennai with specimen registration numbers. The systematic details of the species recorded from Govind National Park is provided as per the classification [13].

**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 Netzeiliidae 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 36 cyclostoma* ( Penard, 1902) Schouteden, 1906

**Infraorder Longithecina Lahr et al., 2019**

**Family Difflogiidae Wallich, 1864**

**Genus Difflogia Leclerc, 1815**

9. *Difflogia 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 elongata* (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 ciliata* (Ehrenberg, 1848) Leidy, 1878
34. *Euglypha denticulata* 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 Taraneck, 1881**

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

**Genus Trinema Dujardin, 1841**

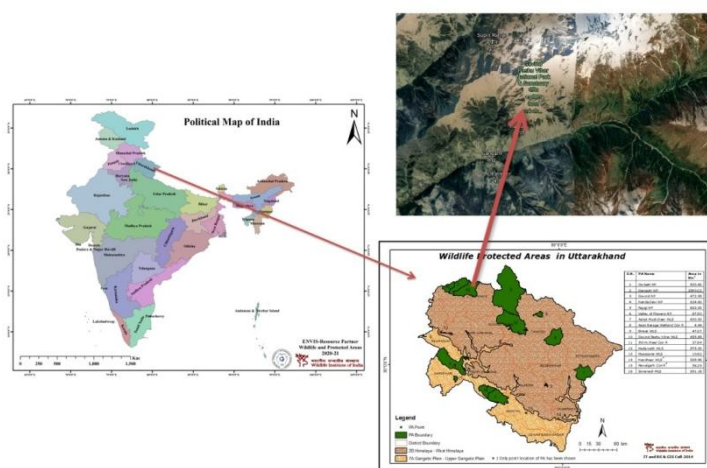
40. *Trinema complanatum* Penard, 1890
41. *Trinema enchelys* (Ehrenberg, 1938) Leidy, 1878
42. *Trinema penardi* Thomas et Chardez, 1958

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

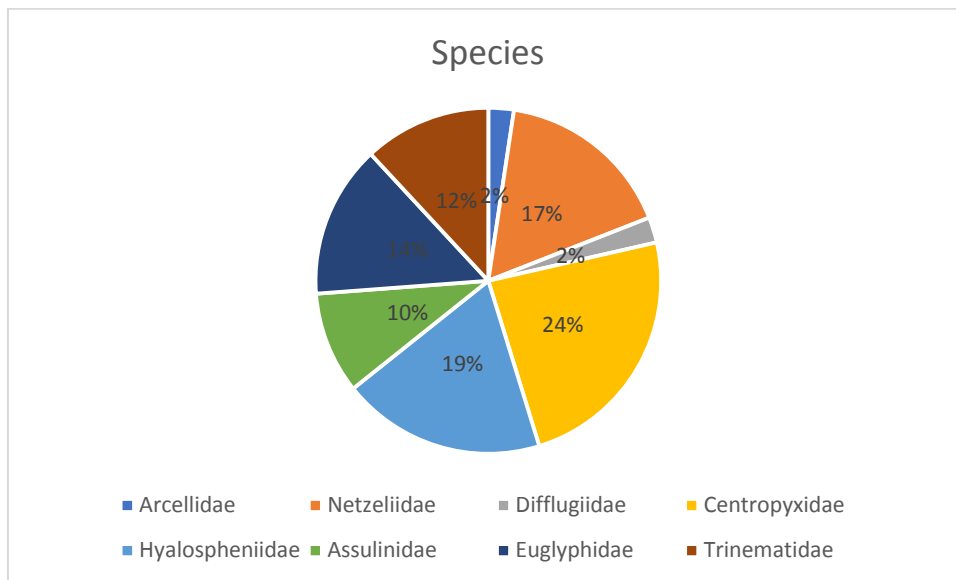
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1	Arcellidae	<i>Arcella artocrea</i> Leidy, 1876	Mi-943	1
2	Netzeiliidae	<i>Cyclopyxis arcellodes</i> Penard, 1902	Mi-946	2
3		<i>Cyclopyxis arenata</i> (Cushman, 1930) Boltovskoy, 1956	Mi-948	3
4		<i>Cyclopyxis eurytoma</i> Deflandre, 1929	Mi-966	4
5		<i>Cyclopyxis tronconica</i> Godeanu, 1972	Mi-931	5
6		<i>Trigonopyxis arcula</i> Penard, 1912	Mi-953	6
7		<i>Argynnia teres</i> Jung, 1942	Mi-955	7
8		<i>Awerintzewia cyclostoma</i> (Penard, 1902) Schouteden, 1906	Mi-949	8
9	Diffugiidae	<i>Diffugia globulosa</i> Dujardin, 1837	Mi-969	9
10	Centropyxidae	<i>Centropyxis aerophila</i> Deflandre, 1929	Mi-929/2	10
11		<i>Centropyxis cassis</i> (Wallich, 1864) Deflandre, 1929	Mi-940	11
12		<i>Centropyxis constricta</i> (Ehrenberg, 1841) Penard, 1890	Mi-947	12
13		<i>Centropyxis ecornis</i> Ehrenberg, 1841	Mi-933	13
14		<i>Centropyxis elongata</i> (Penard, 1890) Thomas, 1959	Mi-926	14
15		<i>Centropyxis minuta</i> Deflandre, 1929	Mi-937	15
16		<i>Centropyxis orbicularis</i> Deflandre, 1929	Mi-945	16
17		<i>Centropyxis oblonga</i> (Deflandre, 1929)	Mi-959	17
18		<i>Centropyxis platystoma</i> Penard, 1890	Mi-939	18
19		<i>Centropyxis sylvatica</i> (Deflandre, 1929) Bonnet et Thomas, 1955	Mi-961	19
20	Family Hyalospheniidae	<i>Certesella martiali</i> Certes, 1889	Mi-958	20
21		<i>Nebela longitubulata</i> Gautier-Lievre, 1953	Mi-957	21
22		<i>Longinebela penardiana</i> Deflandre, 1936	Mi-954	22
23		<i>Quadrulella madibai</i> Kosakyan et al., 2016	Mi-941	23
24		<i>Quadrulella tropica</i> Wailes, 1912	Mi-950	24
25		<i>Quadrulella quadrigera</i> Deflandre, 1936	Mi-944	25
26		<i>Quadrulella symmetrica</i> (Wallich, 1863) Kosakyan et al., 2016	Mi-933/1	26
27		<i>Phryganella acropodia</i> (Hertwig and Lesser, 1874) Hopkinson, 1909	Mi-941/3	27
28	Family Assulinidae	<i>Assulina discoides</i> Bobrov, Shimano and Mazei, 2012	Mi-932	28
29		<i>Assulina muscorum</i> Greeff, 1888	Mi-930	29
30		<i>Assulina quadratum</i> Van Oye, 1957	Mi-929	30
31		<i>Assulina seminulum</i> Ehrenberg, 1848	Mi-929/1	31
32	Family Euglyphidae	<i>Euglypha acanthophora</i> (Ehrenberg, 1841) Perty, 1849	Mi-942	32
33		<i>Euglypha ciliata</i> (Ehrenberg, 1848) Leidy, 1878	Mi-934	33
34		<i>Euglypha denticulata</i> Brown, 1912	Mi-956	34
35		<i>Euglypha rotunda</i> Wailes, 1915	Mi-922	35
36		<i>Euglypha simplex</i> Decloitre, 1965	Mi-963	36
37		<i>Euglypha strigosa</i> (Ehrenberg, 1871) Leidy, 1878	Mi-924	37
38	Family Trinematidae	<i>Corythion asperulum</i> schonborn, 1988	Mi-951	38
39		<i>Corythion dubium</i> Taranek, 1881	Mi-952	39
40		<i>Trinema complanatum</i> Penard, 1890	Mi-923	40
41		<i>Trinema enchelys</i> (Ehrenberg, 1938) Leidy, 1878	Mi-927/1	41
42		<i>Trinema penardi</i> Thomas et Chardez, 1958	Mi-962	42

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

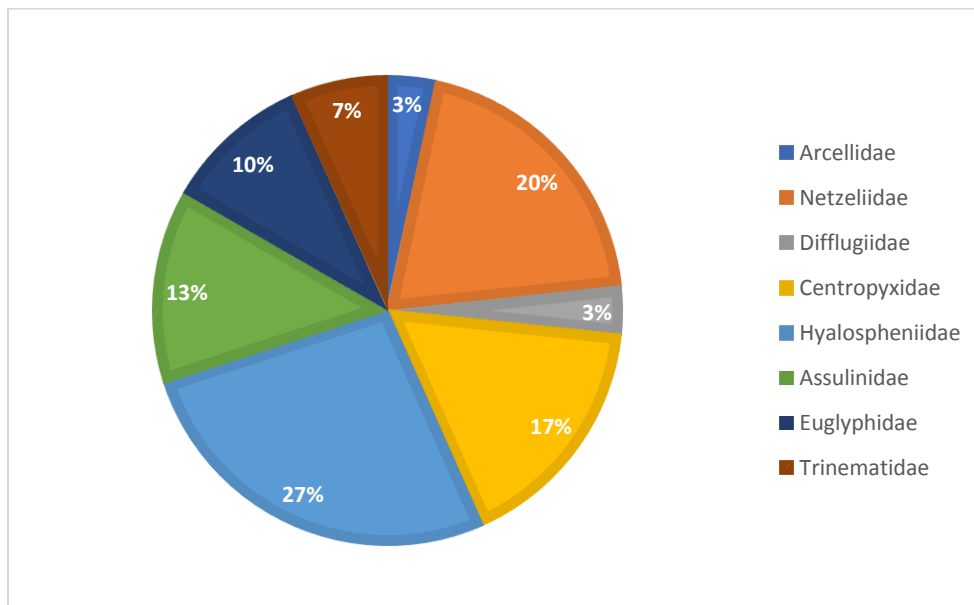
SI No.	Families	Names of species
1	Arcellidae	<i>Arcella artocrea</i> Leidy, 1876
2	Netzeiliidae	<i>Cyclopyxis arenata</i> (Cushman, 1930) Boltovskoy, 1956
3		<i>Cyclopyxis eurystoma</i> Deflandre, 1929
4		<i>Cyclopyxis tronconica</i> Godeanu, 1972
5		<i>Trigonopyxis arcula</i> Penard, 1912
6		<i>Argynnia teres</i> Jung, 1942
7		<i>Awerintzewia cyclostoma</i> (Penard, 1902) Schouteden, 1906
8		Diffugiidae
9	Centropyxidae	<i>Centropyxis ecornis</i> Ehrenberg, 1841
10		<i>Centropyxis elongata</i> (Penard, 1890) Thomas, 1959
11		<i>Centropyxis minuta</i> Deflandre, 1929
12		<i>Centropyxis oblonga</i> (Deflandre, 1929)
13		<i>Centropyxis sylvatica</i> (Deflandre, 1929) Bonnet et Thomas, 1955
14		Hyalospheniidae
15	<i>Nebela longitubulata</i> Gautier-Lievre, 1953	
16	<i>Longinebela penardiana</i> Deflandre, 1936	
17	<i>Quadrulella madibai</i> Kosakyan <i>et al.</i> , 2016	
18	<i>Quadrulella tropica</i> Wailes, 1912	
19	<i>Quadrulella quadrigera</i> Deflandre, 1936	
20	<i>Quadrulella symmetrica</i> (Wallich, 1863) Kosakyan <i>et al.</i> , 2016	
21	<i>Phryganella acropodia</i> (Hertwig and Lesser, 1874) Hopkinson, 1909	
22	Assulinidae	<i>Assulina discoides</i> Bobrov, Shimano and Mazei, 2012
23		<i>Assulina muscorum</i> Greeff, 1888
24		<i>Assulina quadratum</i> Van Oye, 1957
25		<i>Assulina seminulum</i> Ehrenberg, 1848
26	Euglyphidae	<i>Euglypha acanthophora</i> (Ehrenberg, 1841) Perty, 1849
27		<i>Euglypha denticulata</i> Brown, 1912
28		<i>Euglypha simplex</i> Decloitre, 1965
29	Trinematidae	<i>Corythion asperulum</i> schonborn, 1988
30		<i>Corythion dubium</i> Taranek, 1881



**Fig.1. Study area, Govind National Park, Uttarakhand, India**



**Fig. 2. Testate amoebae species recorded from Govind National Park**



**Fig. 3. Testate amoebae family abundance recorded for the first time from Uttarakhand, India**

#### 4. CONCLUSION

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.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

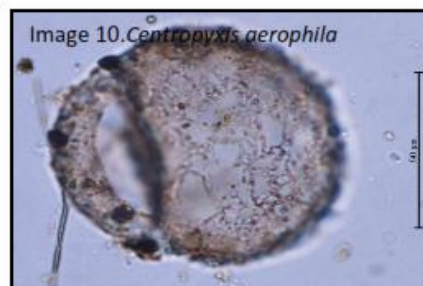
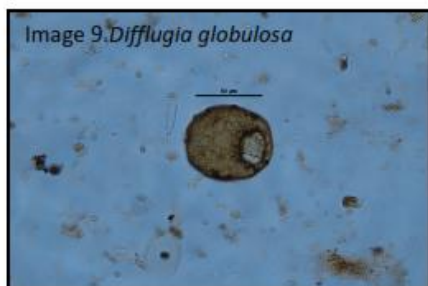
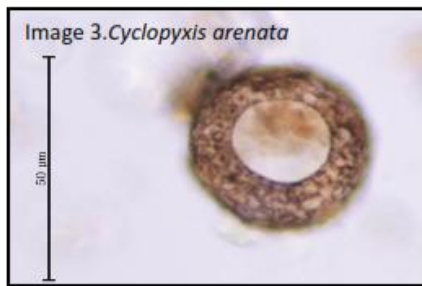
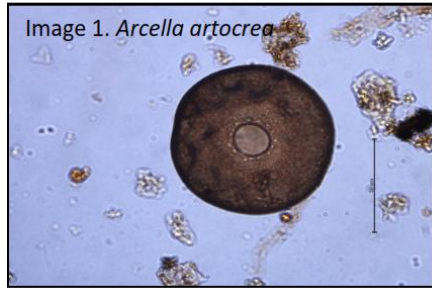
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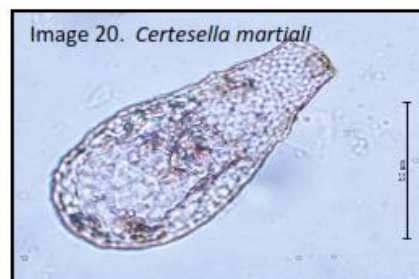
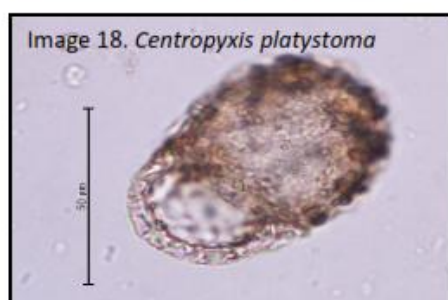
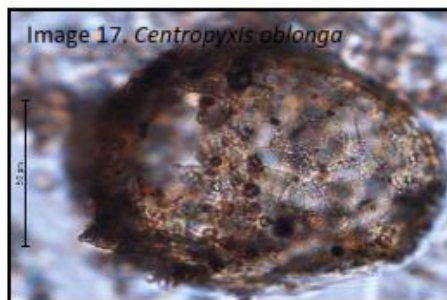
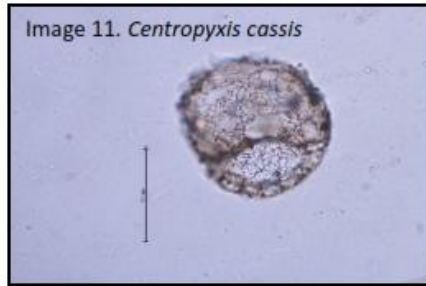
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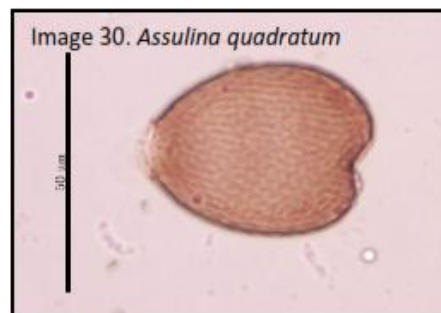
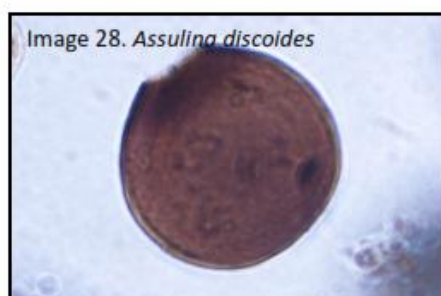
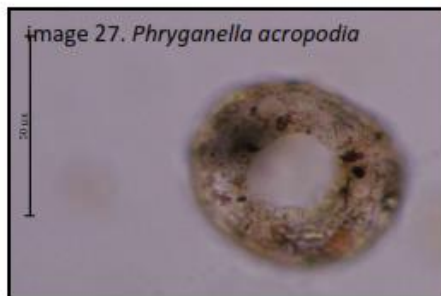
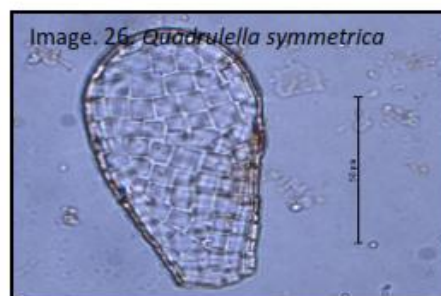
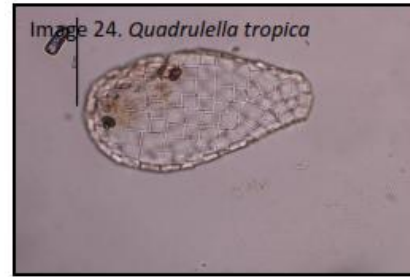


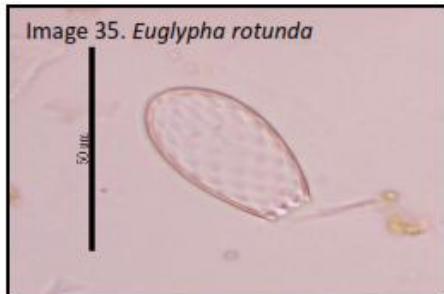
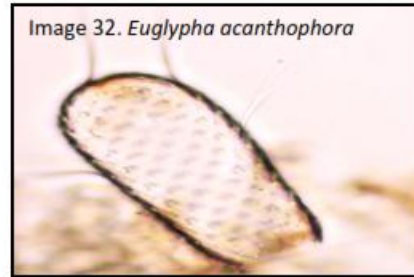
## ANNEXURE 1

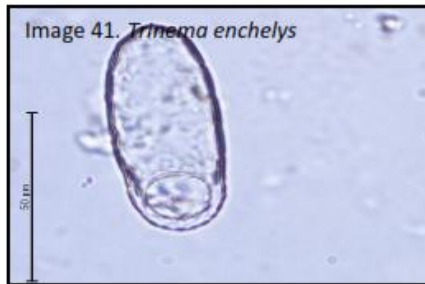












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