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WESTERN GHATS: A BIODIVERSITY HOTSPOT FOR CILIATED PROTISTS

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EXTENDED ABSTRACT

TheWestern Ghats, World Heritage Site, Nilgiri Sub-Cluster (10°09'N 77°03'E), India, includes biosphere reserves, national parks, and several wildlife sanctuaries which conserve a plethora of species of animals, plants, and microbes (UNESCO 2007). Among these the Silent Valley National Park (Fig. 1), a part of the Western Ghats, is known for its high alpha biodiversity index of 4.8 (one of the highest in the world) as calculated by the Zoological Survey of India based on the diversity of flora. Climate of the region remains moderate with temperatures varying from 8°C to 27°C and precipitation between 3200mm to 7500mm.Vegetation of the Silent Valley includes tropical rain forests, montane sub-tropical forests, and montane temperate forests. Very low penetration of light through the tropical rain forest increases the humidity level, which supports a lot of climbers, ferns and fungi on the thick trunks of the trees. The park being a cliff plateau is naturally guarded on all sides by high mountains or faults of the Western Ghats and has remained inaccessible to all types of extraneous factors including human agencies.

Figure 1. Diagrammatic depiction of salient features of the Silent Valley National Park. The three largest peaks (arrowheads) are located on the north eastern boundary, the river Kunthipuzha originates from various peaks of the Nilgiri hills and traverses the entire length of the Valley. Sairandri is the entry point of the National Park.

The fauna of Silent Valley National Park is less documented as compared to flora; only some faunal groups including vertebrates and insects have been worked out by some groups (Mathew and Rahamathulla 1993; Mathew, Rugmini and Binoy 2003; Bird Life International 2005).Micro-organisms have been largely ignored but their importance in supporting biota cannot be over-estimated. One such understudied group is that of ciliated protists, despite the fact that they play an important role in the food web as a trophic link between bacteria and primary consumers. Thus far, only two reports exist reflecting the diversity of ciliates from the national park (Kumar et al. 2010, 2015); these studies described three newand fouralready known (though first records from India) of hypotrich ciliates. In the present study, we report the community structure of ciliates from four different ecozones of the Silent Valley Nation Park, i.e., tropical rain forest, grassland, reed swamp forest, and riverine forest. A total of 45 ciliate species (belonging to 6 class, 12 order, 16 families, and 31 genera: more than 50% of which arefirst reports from India,and their distribution from the ecozoneswere recorded (Tables 1, 2). Out of 45 ciliates identified, 34 were from the tropical rain forest tracts and eighteen were from the riverine forest soil giving them an aquatic connection (Table 2).

Table 1. List of 45 free living soil ciliate species from the Silent Valley National Park.

S. No.	CLASS	ORDER	FAMILY	GENUS/SPECIES
1, 2	Litostomatea	Haptorida	Spathidiidae	*Spathidium*sp. 1, 2
3-5	Colpodea	Colpodida	Colpodidae	*Colpodacucullus*, *C. inflata, C. steinii*
6	Oligohymenophorea	Tetrahymenida	Tetrahymenidae	*Tetrahymena* sp.
7	Colpodea	Bursarimorphida	Bursariidae	*Bursaria* sp.
8-9	Heterotrichea	Heterotrichida	Blepharismidae	*Blepharismahyalinum*, *Blepharisma*sp.
10	Oligohymenophorea	Peniculida	Frontoniidae	*Frontonia*sp.
11	Oligohymenophorea	Sessilida	Vorticellidae	*Vorticella* sp.
12	Litostomatea	Haptorida	Tracheliidae	*Dileptus*sp.
13	Armophorea	Armophorida	Metopidae	*Metopus*sp.
14	Spirotrichea	Stichotrichida	Amphisiellidae	Stichotrichine sp.
15	Spirotrichea	Urostylida	Holostichidae	*Anteholostichaangida*
16	Spirotrichea	Urostylida	Holostichidae	*Caudiholostichasylvatica*
17	Spirotrichea	Urostylida	Bakuellidae	*Bakuellanilgiri*
18	Spirotrichea	Urostylida	Bakuellidae	*Holostichideschardezi*
19	Spirotrichea	Urostylida	Urostylidae	*Pseudourostylafranzi*
20	Spirotrichea	Urostylida	Urostylidae	*Pseudourostyla levis*
21-22	Spirotrichea	Uroleptida	Uroleptidae	***Uroleptuscaudatus, U. lepisma***
23, 24	Spirotrichea	Sporadotrichida	Oxytrichidae	*Cyrtohymenacitrina, C. primicirrata*
25	Spirotrichea	Sporadotrichida	Oxytrichidae	*Notohymena*sp.
26-27	Spirotrichea	Sporadotrichida	Trachelostylidae	*Gonostomum affine, G. singhii*
28-31	Spirotrichea	Sporadotrichida	Oxytrichidae	*Oxytrichasetigera, Oxytricha*sp. 1,2,3
32	Spirotrichea	Sporadotrichida	Oxytrichidae	*Urosomoidadorsiincisure*
33	Spirotrichea	Sporadotrichida	Oxytrichidae	*Rigidocortex octonucleatus*
34	Spirotrichea	Sporadotrichida	Oxytrichidae	*Apoamphisiella*sp.

S. No.	CLASS	ORDER	FAMILY	GENUS/SPECIES
35	Spirotrichea	Sporadotrichida	Oxytrichidae	*Australocirrus oscitans*
36	Spirotrichea	Sporadotrichida	Oxytrichidae	*Gastrostyla* sp.
37	Spirotrichea	Sporadotrichida	Oxytrichidae	*Hemigastrostyla*sp.
38	Spirotrichea	Sporadotrichida	Oxytrichidae	*Steiniasphagnicola*
39-41	Spirotrichea	Sporadotrichida	Oxytrichidae	*Sterkiellahistriomuscorum, S. tricirrata, S. tetracirrata*
42	Spirotrichea	Sporadotrichida	Oxytrichidae	*Stylonychianotophora*
43-44	Spirotrichea	Sporadotrichida	Oxytrichidae	*Pleurotricha*sp.1, 2
45	Spirotrichea	Euplotida	Euplotidae	*Euplotes*sp.

The ciliated protists were collected, cultured and identified using standard internationally acceptable procedures which included live cell imaging and protargol staining to obtain biometry and morphogenetic data (Kumar et al. 2010, 2015). Classification and nomenclature used in the text and tables is according to Lynn (2008) and Berger (1999, 2006, 2008) while the terminology is as given by Wallengren (1900), Borror (1972, 1979), and Martin (1982).

Table 2. Distribution of species in different ecozones of Silent Valley National Park.TRF – Tropical Rain Forest, GL- Grassland, RSF- Reed Swamp Forest, RVF- Riverine Forest.

S. No.	Genus/species	TRF	GL	RSF	RVF
1	*Anteholostichaangida*	√			
2	*Apoamphisiella*sp.	√			
3	*Australocirrusoscitans*	√			
4	*Bakuellanilgiri*		√		
5	*Blepharismahyalinum*	√			
6	*Blepharisma*sp.	√			√
7	*Bursaria* sp.				√
8	*Caudiholostichasylvatica*	√			
9	*Colpodacucullus*	√			
10	*Colpodainflata*	√			
11	*Colpodasteinii*	√	√	√	√
12	*Cyrtohymenacitrina*	√			
13	*Cyrtohymenaprimicirrata*				√
14	*Dileptus*sp.	√			
15	*Euplotus*sp.	√			
16	*Frontonia*sp.	√			√
17	*Gastrostyla*sp.	√			
18	*Gonostomum affine*	√			
19	*Gonostomumsinghii*	√			
20	*Hemigastrostyla*sp.	√			
21	*Holostichideschardezi*	√			

S. No.	Genus/species	TRF	GL	RSF	RVF
22	*Metopus*sp.				√
23	*Notohymena*sp.				√
24	*Oxytrichasetigera*	√	√	√	
25	*Oxytricha*sp. 1	√		√	
26	*Oxytricha*sp. 2			√	
27	*Oxytricha*sp. 3				√
28	*Uroleptuslepisma*	√			
29	*Uroleptuscaudatus*				√
30	*Pleurotricha*sp. 1	√			
31	*Pleurotricha*sp. 2				√
32	*Pseudourostylafranzi*				√
33	*Pseudourostyla levis*	√			
34	*Rigidocortexoctanucleatus*	√			
35	*Spathidium*sp. 1	√			√
36	*Spathidium*sp. 2	√	√	√	√
37	*Steiniasphagnicola*	√			√
38	*Sterkiellahistriomuscorum*				√
39	*Sterkiellatricirrata*	√			
40	*Sterkiellatetracirrata*	√			√
41	Stichotrichine (unidentified)	√			
42	*Stylonychianotophora*	√			√
43	*Tetrahymena*sp.	√			
44	*Urosomoidadorsiincisura*	√			
45	*Vorticella* sp.	√		√	√

The detailed morphology and morphogenesis of two *Uroleptus* species, viz., *Uroleptuslepisma* and *U. caudatus*, first recorded from India have been described in the present report; further a note on the distribution of the hypotrichs, especially,urostylid ciliates have been presented.

Uroleptuslepisma has been previously reported from Portugal, while *Uroleptuscaudatus* has been found from Austria. *Uroleptuslepisma* from the Silent Valley inhabits the sandy soils of riverine forests. Earlier descriptions of its presence are from soils with high salinity (Berger and Foissner 1989). However, *Uroleptuscaudatus* was isolated from the soil of tropical rain forest and it shows many differences from the earlier described population from Austria (Eigner 2001).Of the six urostyloid species (for details refer Kumar et al. 2010), three species viz., *Anteholostichaangida*, *Caudiholostichasylvatica* and *Holostichideschardezi* were isolated from tropical rain forests. *Bakuellanilgiri* was found in a stretch of grasslands while *Pseudourostylafranzi* and *Pseudourostyla levis* were isolated from the sandy soils of riverine forests. All populations of *P. levis* thus far described have been isolated from fresh water bodies; *P levis*, Silent Valley population, was found in a soil sample and is thus an exception.*Caudiholostichasylvatica*, *Holostichideschardezi*, *Pseudourostylafranzi,* and *Pseudourostyla levis* have also been reported to occur elsewhere and appear to be widely distributed. According to Foissner (1998) *Caudiholostichasylvatica* has been isolated from several sites in Austria, USA, Japan, S. Korea, China, and Australia.*Holostichideschardezi* is a soil ciliate and occurs in the Holarctis, the Palaeotropis, and Australis, having

been reported thus far from Senegal (type locality) and various sites in South Korea, Kenya, Germany, Italy, and Austria. *Pseudourostylafranzi* appears to be distributed worldwide; it has been reported from several sites in Europe, South America, Australia, Asia (China), and Africa. *Pseudourostyla levis* was found from various sites in Japan (Takahashi 1973, 1988, 1991); it has also been isolated from the river Yamuna near Delhi, India (Gupta 1990).

Sterkiellahistriomuscorum is the type species of the genus; it occurs in a wide variety of habitats worldwide having been reported from fresh water ponds, lakes, and soils (Berger 1999). *Sterkiellatetracirrata* showed unique combination of characters within the genus in having invariably four transverse cirri (Kumar et al. 2015). *Sterkiellatricirrata* has been previously reported from the soil of burnt savannah in the Ivory Coast; the Silent Valley population is rather similar in ciliature with the previous report except for some minor differences.

Overall, the ciliated protozoa of the Silent Valley National Park showed a mix of endemic (or erstwhile undescribed) and worldwide species.Some of these species are cosmopolitan,while others are endemic, showing that microevolution and dispersal of the group has occurred over a long period of time in this protected region. Furthermore, the high ciliate diversity from the Silent Valley National Park is primarily due to the fact that it is evolutionarily an archaic zone and secondarily the area is full of tropical rain forest tracts, an ideal environment for the growth of microorganisms.

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