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Density and Diversity analysis of Aquatic Mites in Snow-Fed River Ganga near Byasi, Tehri Garhwal, Uttarakhand

Kumbhlesh Kamal Rana[1] • Rajesh Rayal[1] • Anita Chauhan[2] • Dalip Kumar Bhatia[3] • Pankaj Bahuguna[4*] • Koshal Kumar[5] • AK Dobriyal[6]

[1]*Department of Zoology, S. G. R. R. University, Dehradun-248 001, Uttarakhand, India.*
[2] *Environment Management division, Indian Council of Forestry Research and Education, Dehradun-248006, Uttarakhand, India.*
[3]*Government P.G. College Dakphater Dehradun -248125, Uttarakhand, India.*
[4]*Government Degree College Dehradun Shaher, Dehradun-248007, Uttarakhand, India.*
[5] *Department of Himalayan Aquatic Biodiversity, HNB Garhwal University Srinagar Garhwal, Uttarakhand, India*
[6] *Department of Zoology, BGR Campus HNB Garhwal University Pauri Garhwal-246001*

*Corresponding Author Email id: pankajpaurii@gmail.com

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Abstract: Hydrachnidia, more commonly known as aquatic mites, are a significant group of macroinvertebrates that play a crucial role in the aquatic food chain and contribute towards proper functioning of aquatic system.The present study was performed for two annual cycles near Byasion river Ganga to assess the density and diversity of aquatic mites. Overall, 25 species of aquatic mites belonging to 07 genus of 05 different families were recorded and identified. Family Torrenticolidae was observed to be dominant family with 11 species under two different genus. Winter season recorded maximum abundance of aquatic mites whereas monsoon recorded minimum.

Keywords: aquatic mites • Byasi • Ganga river • Torrenticolidae.

Introduction

Freshwater ecosystem is home to wide range of plants, animals and microbes.According to UNEP (2002), freshwater species networks represent approximately 9.5% of the total global animal diversity of which aquatic mites (Hydrachnidia) are significant part (Blattner *et al.*, 2019). Aquatic mites are broadly classified in class Arachnida under Phylum Arthropoda with an estimated global diversity of around 10,000 species (Di Sabatino *et al.*, 2008). Being parasites, aquatic mites possess capabilities to influence the other faunal taxa, thus, play a significant role in aquatic ecosystems (Blattner *et al.*, 2019) and are also considered to be excellent water quality indicators (Di Sabatino *et al.*, 2000). The distribution, function, quantitative and qualitative content of the freshwater biota are significantly influenced by seasonal fluctuations in several determining environmental factors viz. temperature, transparency, dissolved oxygen, water velocity and nutrient concentrations. The taxon richness of water mites is also related to the physico-chemical parameters and riparian vegetation (Zawal*et al.*, 2017). The distribution and abundance of water mite populations can be influenced by a variety of abiotic factors, including pollutants, temperature variations, dissolved oxygen, conductivity and carbonate concentrations.

Numerous studies have been carried on water mites for various aspects globally. Studies carried out by Cook (1967, 1974) are considered among the initial studies on water mites. Information of ecological distribution of water mites have been documented by Angelier (1954) and Pieczynski (1963). Researchers across the world have recorded and documented aquatic mites globally (Smith *et al.*, 2010; Gerecke, 2002; Meyer, 1994; Smith and Cook, 1991; Pesic and Saboori, 2012; William and

William, 1996; diSabatino *et al.*, 2000;Pesic *et al.*, 2006; Pesic *et al.*, 2014;Stolbov *et al.* 2019; Pesic *et al.* 2023, Smit and Pesic, 2024).

The knowledge concerning with distribution of aquatic mites from river ecosystems of India is also inadequate and extremely fragmented (Kumar and Dobriyal, 1992, 1993; Kumar *et al.*, 2007). Charles Walter (1928) was the pioneer on publishing his work on water mites from the Indian Himalayas.A detail checklist of water mites of India was published by Pesic *et al.* (2010). Aquatic mites from Himalayas are also reported from India (Kumar *et al.*, 2006; Bahuguna and Negi, 2020). Recently few important works on density and diversity of aquatic mites have also been reported from Uttarakhand (Pesic *et al.*, 2007 a-b, 2012, 2019 a-b, 2020 a-b; Bahuguna *et al.*, 2019a-b, 2020; Bahuguna and Dobriyal, 2020; Negi *et al.*, 2021; Bahuguna and Dobriyal, 2022; Pesic *et al.*, 2022a-b).

Aquatic mites are one amongst significant constituent of biotic component of freshwater ecosystems. Given the dearth of information on the aquatic mite fauna in Garhwal Himalaya coupled with the absence of regular research the present investigation on recording the occurrence of aquatic mites in upper course of the Ganges will enhance the understanding of this taxonomic group. The present finding is a contribution towards inventory of aquatic mites from Himalayan region and its habitat preference along river Ganga near Byasi, Uttarakhand.

Material and Methods

Study Area: The present study was conducted on river Ganga near Byasi. Byasi is a small town situated in Tehri Garhwal District of Uttarakhand. Sampling was carried out between latitude 30°03’25.28” N - 30°04’34.72” N and longitude 78°28’47.72” E - 78°26’30.68” E (Figure 1).

Methodology adopted: Monthly samplings for aquatic mites collection were conducted for two annual cycles *i.e.* from December 2019 to November 2021 from river Ganga near Byasi. Sampling was carried out for 5-6 hours a day along both the banks covering different microhabitat using Surber sampler (mesh size 250 µm) following standard methods (Barr, 1973; Bahuguna and Dobriyal, 2020).

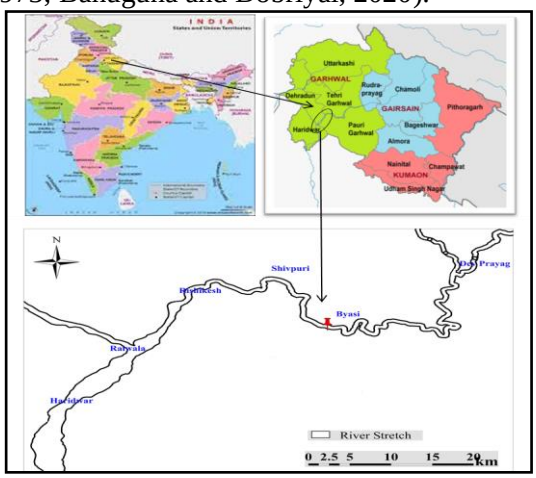

Figure 1. Location map of sampling site

Aquatic mites collected were then transferred to the vials containing 70% ethanol solution. Aquatic mite samples were then brought to the laboratory and identified using standard keys.

Statistical Analysis: MS Office Excel (ver. 2013) was used to compute the statistical mean ($\overline{X}$), standard deviation (S.D.), diversity indices and graphical presentations for the density and diversity data obtained. To calculate diversity index, cluster analysis, and multivariate analysis PAST Software (ver 4.03) is used.

Results

A total of 25 species of aquatic mites belonging to 07 genus of 05 different families*viz.* Torrenticolidae, Sperchontidae, Hygrobatidae, Aturidae and Lebertiidae were recorded from the study area (Table 1 & Figure 2). Family Torrenticolidae was observed to be dominant family with 11 species under two different genus. Only one aquatic mite species of genus *Lebertia* was reported under family Lebertiidae. Family Torrenticolidae was represented by seven species under genus *Torrenticola* and four species under genus *Monatractides*. Family Sperchontidae was represented by four species under genus *Sperchon*. Family *Hygrobatidae*

was represented by genus *Atractides* with five aquatic mites and genus *Hygrobates* with two species aquatic mites. Two species of *Kongsbergia* genus and one species of *Lebertia* represented family Aturidae and family Lebertiidae respectively.

During the entire course of study maximum individual of aquatic mites were recorded in the month of December. *Torrenticola uttarakhandensis* followed by *Sperchon indicus* and *Atractidesindicus* were the species reported with the highest number of individuals.

Average monthly variation in density of aquatic mites throughout the study period ranged from 3.67±2.34 ind.m^{-2} to 2111.33±9.97 ind.m^{-2} with highest density in December and lowest during July.Seasonal inconsistency was also observed in the aquatic mites density. Winter month recorded maximum density of aquatic mites whereas monsoon recorded lowest aquatic mite density. Seasonal variation in aquatic mite density for the study period lied between 3.83±1.70 ind.m^{-2} (monsoon) to 85.39±27.57 ind.m^{-2} (winter) (Table 2). Seasonal trend recorded for aquatic mite density was observed to be Winter> Autumn> Spring> Summer> Monsoon.

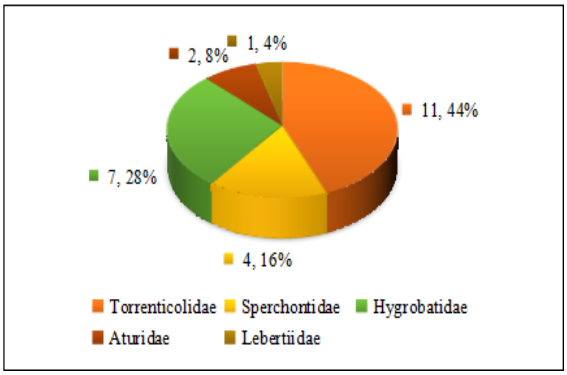

Figure 2. Percent abundance of families of aquatic mites collected from Byasi, Uttarakhand

Discussion

Aquatic mites are one of the most significant components of aquatic biodiversity of river ecosystem irrespective of availability of inadequate data on their presence and richness. Most of the species of aquatic mites recorded during present study were scrappers, collectors and gatherers.

Minimum density of aquatic mites was recorded in monsoon whereas maximum in winter. Similar finding with respect to the density of zooplankton from the Chenab River was reported by Dutta and Verma (2010). High periphytic growth in the months of winter may have positive impact on richness of aquatic mites thereby resulting in their higher density (Rana *et al.*, 2022& 2023). Bahuguna *et al.* (2019b) also reported highest density of aquatic mites during winter season collected from Randi Gad (tributary of Alaknanda River).

On the other hand, low population density of water mites during monsoon months results from high stream velocity (Negi *et al*., 2021). River water is highly turbid in monsoon months which negatively influence the presence of aquatic mites. Low turbidity results in high richness and abundance of water mites (da Silva *et al.*, 2017). During monsoon months sedimentation load increases which changes the community structure of aquatic mites (Egborgeet *al.*, 1996).

The Shannon-Wiener diversity index was found to be maximum mostly in the month of December and generally low during monsoon months. It is justified from the finding of Sharma and Chowdhary, (2011) that high diversity index resulted from presences of high number of aquatic mites in the month of December (winter). Similar results were reported by Negi*et al.* (2021) during their study on water. Aquatic mites are one amongst significant constituent of biotic component of freshwater ecosystems. They are vital part of aquatic food chain and contribute towards proper functioning of aquatic system (Bahuguna and Dobriyal, 2020). Therefore, work on the spatial and temporal distribution of aquatic mite density will helps in the better understanding of the habitat preference and adaptability of aquatic mites along with the enhancement of its global inventory.

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Table 1: Monthly average variation in density (ind.m^{-2} ±S.D.) and diversity of aquatic mites in Ganga River nearByasi during the study period

Family/Genus/Species	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov
F – TorrenticolidaePiersig, 1902; G – *Torrenticola*Piersig												
Torrenticolauttarakhandensis	11.50±6.38	10.67±6.50	8.83±2.54	4.00±1.90	3.50±2.59	3.17±2.14	1.83±1.17	0.00±0.00	0.17±0.41	1.50±1.64	4.17±1.33	5.17±3.37
Torrenticolachatterjeei	2.50±1.87	1.33±0.82	2.67±1.37	1.83±1.17	0.17±0.41	1.33±0.52	0.33±0.52	0.00±0.00	0.00±0.00	1.33±0.52	1.50±1.22	0.83±0.75
Torrenticolaturkestanica	4.50±1.64	2.50±2.17	3.50±1.71	1.33±0.52	0.67±0.82	1.50±0.55	0.17±0.41	0.17±0.41	0.00±0.00	1.17±0.75	1.83±1.17	0.67±1.03
Torrenticolawonchoeli	2.50±2.26	2.50±1.05	1.17±1.86	0.00±0.00	0.67±0.82	1.00±0.63	0.67±0.82	0.00±0.00	0.17±0.41	0.00±0.00	0.00±0.00	1.00±0.89
Torrenticolatetraporella	1.33±1.03	0.50±0.84	0.00±0.00	0.67±0.82	1.00±0.63	0.00±0.00	0.83±1.17	0.00±0.00	0.00±0.00	0.67±0.82	0.00±0.00	0.67±1.21
Torrenticolasemisuta	4.50±3.15	1.83±1.83	1.83±1.46	1.17±1.60	0.00±0.00	0.83±0.75	0.67±1.21	0.33±0.52	0.00±0.00	1.67±2.25	2.33±1.51	4.50±3.39
Torrenticolakumari	3.17±2.56	0.83±1.17	0.33±0.75	0.00±0.00	0.67±0.82	1.67±0.52	0.67±0.82	0.67±0.82	0.67±0.82	0.83±2.04	1.83±1.17	4.17±2.64
G- Monatractides												
Monatractidesgarhwaliensis	5.17±2.23	6.17±1.60	5.17±2.41	3.00±2.53	2.50±2.07	1.17±0.75	0.67±1.03	0.00±0.00	0.00±0.00	1.50±1.64	2.00±0.89	2.50±1.38
Monatractidestuzovskyi	2.83±1.17	2.00±1.55	0.67±0.75	0.50±0.84	0.83±1.17	0.50±0.55	1.00±0.89	0.17±0.41	0.00±0.00	1.33±0.82	2.17±2.14	3.50±1.76
Monatractidesoxystomus	2.50±1.97	3.00±2.83	1.33±0.47	0.00±0.00	0.50±0.84	0.00±0.00	0.17±0.41	0.00±0.00	0.67±1.21	0.00±0.00	0.67±0.82	1.67±1.03
Monatractideskontschani	7.67±1.37	4.50±2.43	2.00±0.58	2.33±1.75	0.67±0.82	0.67±0.82	0.00±0.00	0.67±1.21	1.00±0.63	1.33±1.03	4.50±1.38	5.33±2.50
Total	**48.17±6.52**	**35.83±10.83**	**27.50±6.68**	**14.83±4.26**	**11.17±4.88**	**11.83±3.19**	**7.00±2.28**	**2.00±1.79**	**2.67±1.37**	**11.33±2.88**	**21.00±5.44**	**30.00±7.24**
F – Sperchontidae Thor, 1900; G - *Sperchon* Kramer												
Sperchonindicus	7.67±3.98	11.00±7.16	3.17±1.21	4.50±3.02	2.17±2.14	2.00±1.26	1.50±0.84	0.83±0.98	0.67±0.82	3.00±2.10	4.00±1.55	4.67±1.86
Sperchongarhwalensis	7.33±2.42	7.17±3.54	5.00±2.00	4.00±1.79	2.33±2.42	1.83±0.98	1.50±1.22	0.00±0.00	0.00±0.00	2.50±1.38	2.00±0.89	4.00±1.26
Sperchonplumifer	5.83±7.33	2.00±0.89	1.00±0.58	3.00±2.61	0.00±0.00	0.33±0.82	0.00±0.00	0.00±0.00	0.00±0.00	1.33±0.52	0.33±0.52	1.17±0.98
Sperchonhirsutus	1.83±0.75	0.17±0.41	0.00±0.00	0.67±1.21	0.67±0.82	0.17±0.41	0.17±0.41	0.00±0.00	0.00±0.00	0.00±0.00	1.33±1.03	0.67±0.82
Total	**22.67±7.20**	**20.33±8.38**	**9.17±2.91**	**12.17±3.71**	**5.17±2.64**	**4.33±1.37**	**3.17±1.94**	**0.83±0.98**	**0.67±0.82**	**6.83±2.64**	**7.67±1.37**	**10.50±2.26**
F– Hygrobatidae; G – *Atractides* Koch												
Atractidesindicus	8.17±3.54	10.00±2.10	3.00±2.00	2.17±1.72	4.50±1.64	5.00±2.19	0.67±0.82	0.00±0.00	0.00±0.00	4.83±3.87	2.50±2.07	2.50±1.52
Atractidesgarhwali	8.17±3.82	5.67±2.16	5.17±3.39	2.50±1.52	2.00±1.10	0.50±0.84	1.83±1.17	0.00±0.00	0.67±1.03	2.00±0.89	2.00±1.67	3.00±1.41
Atractidesyukii	2.83±2.14	0.67±1.21	1.83±0.69	0.00±0.00	0.67±0.82	0.17±0.41	0.00±0.00	0.00±0.00	0.00±0.00	1.83±1.33	1.50±1.05	1.00±0.63
Atractidespanesari	2.50±1.22	2.83±2.32	1.33±0.47	0.33±0.52	0.00±0.00	0.67±0.82	0.83±1.60	0.67±1.21	0.00±0.00	1.00±0.63	1.50±0.84	0.33±0.52
*Atractides*sp.	2.50±1.64	0.33±0.52	0.50±0.76	0.67±0.82	0.00±0.00	0.67±0.82	0.67±0.82	0.00±0.00	0.00±0.00	0.67±0.82	0.00±0.00	0.33±0.52
G- *Hygrobates* Koch												
Hygrobatesgangeticus	1.50±0.84	0.67±0.82	1.50±1.26	0.83±1.17	0.00±0.00	0.17±0.41	0.00±0.00	0.00±0.00	0.00±0.00	1.33±0.82	1.50±1.05	0.67±1.03
Hygrobatesdobriyali	0.00±0.00	0.67±1.21	0.00±0.00	0.00±0.00	0.67±0.82	0.67±0.82	0.17±0.41	0.00±0.00	0.00±0.00	0.33±0.52	0.33±0.52	0.67±1.21
Total	**25.67±4.18**	**20.83±5.04**	**13.33±4.42**	**6.50±1.97**	**7.83±1.17**	**7.83±2.14**	**4.17±1.17**	**0.67±1.21**	**0.67±1.03**	**12.00±3.63**	**9.33±1.63**	**8.50±2.07**
F - Aturidae Thor; G - *Kongsbergia*Thor												
Kongsbergiaindica	5.17±1.17	5.83±2.79	2.17±1.57	0.83±1.17	1.50±0.84	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	1.83±1.94	2.17±0.75	2.67±2.50
Kongsbergiarucira	7.83±3.43	6.17±3.66	2.83±1.95	1.33±0.52	0.67±1.21	0.17±0.41	0.17±0.41	0.17±0.41	0.00±0.00	0.33±0.52	3.50±2.07	4.17±3.76
Total	**13.00±3.52**	**12.00±6.32**	**5.00±3.42**	**2.17±1.17**	**2.17±1.94**	**0.17±0.41**	**0.17±0.41**	**0.17±0.41**	**0.00±0.00**	**2.17±1.72**	**5.67±2.16**	**6.83±2.99**
F – Lebertiidae; G – *LebertiaNeuman*												
Lebertia sp.	1.83±1.33	0.83±1.33	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	1.00±0.89	0.00±0.00	0.67±0.82
Total	**1.83±1.33**	**0.83±1.33**	**0.00±0.00**	**0.00±0.00**	**0.00±0.00**	**0.00±0.00**	**0.00±0.00**	**0.00±0.00**	**0.00±0.00**	**1.00±0.89**	**0.00±0.00**	**0.67±0.82**
Grand Total	**111.33±9.97**	**89.83±19.42**	**55.00±11.83**	**35.67±8.24**	**26.33±4.72**	**24.17±3.92**	**14.50±3.51**	**3.67±2.34**	**4.00±0.89**	**33.33±8.24**	**43.67±6.80**	**56.50±10.01**

Table 2. Seasonal average variation in density (ind.m^{-2} ±S.D.) and diversity of aquatic mites in Ganga River nearByasi during the study period

Family/Genus/Species	Winter	Spring	Summer	Monsoon	Autumn
F – TorrenticolidaePiersig, 1902; G – *Torrenticola*Piersig					
Torrenticola uttarakhandensis	10.33±5.29	3.75±2.18	2.50±1.78	0.08±0.29	3.61±2.68
Torrenticola chatterjeei	2.17±1.50	1.00±1.21	0.83±0.72	0.00±0.00	1.22±0.88
Torrenticola turkestanica	3.50±1.98	1.00±0.74	0.83±0.83	0.08±0.29	1.22±1.06
Torrenticola wonchoeli	2.06±1.86	0.33±0.65	0.83±0.72	0.08±0.29	0.33±0.69
Torrenticola tetraporella	0.61±0.92	0.83±0.72	0.42±0.90	0.00±0.00	0.44±0.86
Torrenticola semisuta	2.72±2.52	0.58±1.24	0.75±0.97	0.17±0.39	2.83±2.66
Torrenticola kumari	1.44±2.04	0.33±0.65	1.17±0.83	0.67±0.78	2.28±2.40
G- Monatractides					
Monatractides garhwaliensis	5.50±2.12	2.75±2.22	0.92±0.90	0.00±0.00	2.00±1.33
Monatractides tuzovskyi	1.83±1.47	0.67±0.98	0.75±0.75	0.08±0.29	2.33±1.81
Monatractides oxystomus	2.28±2.02	0.25±0.62	0.08±0.29	0.33±0.89	0.78±1.00
Monatractides kontschani	4.72±2.85	1.50±1.57	0.33±0.65	0.83±0.94	3.72±2.42
Total	**37.17±11.79**	**13.00±4.77**	**9.42±3.65**	**2.33±1.56**	**20.78±9.38**
F – Sperchontidae Thor, 1900; G - *Sperchon* Kramer					
Sperchon indicus	7.28±5.58	3.33±2.77	1.75±1.06	0.75±0.87	3.89±1.88
Sperchon garhwalensis	6.50±2.83	3.17±2.21	1.67±1.07	0.00±0.00	2.83±1.42
Sperchon plumifer	2.94±4.56	1.50±2.35	0.17±0.58	0.00±0.00	0.94±0.80
Sperchon hirsutus	0.67±0.97	0.67±0.98	0.17±0.39	0.00±0.00	0.67±0.91
Total	**17.39±8.70**	**8.67±4.77**	**3.75±1.71**	**0.75±0.87**	**8.33±2.59**
F– Hygrobatidae; G – *Atractides* Koch					
Atractides indicus	7.06±3.96	3.33±2.02	2.83±2.76	0.00±0.00	3.28±2.76
Atractides garhwali	6.33±3.40	2.25±1.29	1.17±1.19	0.33±0.78	2.33±1.37
Atractides yukii	1.78±1.66	0.33±0.65	0.08±0.29	0.00±0.00	1.44±1.04
Atractides panesari	2.22±1.59	0.17±0.39	0.75±1.22	0.33±0.89	0.94±0.80
Atractides sp.	1.11±1.45	0.33±0.65	0.67±0.78	0.00±0.00	0.33±0.59
G- *Hygrobates* Koch					
Hygrobates gangeticus	1.22±1.06	0.42±0.90	0.08±0.29	0.00±0.00	1.17±0.99
Hygrobates dobriyali	0.22±0.73	0.33±0.65	0.42±0.67	0.00±0.00	0.44±0.78
Total	**19.94±6.84**	**7.17±1.70**	**6.00±2.52**	**0.67±1.07**	**9.94±2.88**
F - Aturidae Thor; G- *Kongsbergia*Thor					
Kongsbergia indica	4.39±2.50	1.17±1.03	0.00±0.00	0.00±0.00	2.22±1.80
Kongsbergia rucira	5.61±3.65	1.00±0.95	0.17±0.39	0.08±0.29	2.67±2.91
Total	**10.00±5.74**	**2.17±1.53**	**0.17±0.39**	**0.08±0.29**	**4.89±3.01**
F – Lebertiidae; G – *Lebertia Neuman*					
Lebertia sp.	0.89±1.28	0.00±0.00	0.00±0.00	0.00±0.00	0.56±0.78
Total	**0.89±1.28**	**0.00±0.00**	**0.00±0.00**	**0.00±0.00**	**0.56±0.78**
Grand Total	**85.39±27.57**	**31.00±8.05**	**19.33±6.17**	**3.83±1.70**	**44.50±12.58**

Overall, during the study period Shannon Weiner diversity index was observed to be maximum in December (3.012) and minimum in August (1.806). Dominance was found to be highest during August (0.1771) and lowest during December (0.056). Simpson diversity index was highest during December (0.944) and lowest during August (0.8229). Evenness was observed to be maximum during August (0.8694) and minimum in the month of January (0.6687). Margalef richness was observed to be highest in the month of November (4.119) and lowest (1.888) in the month of August (Table 3&Figure 3).

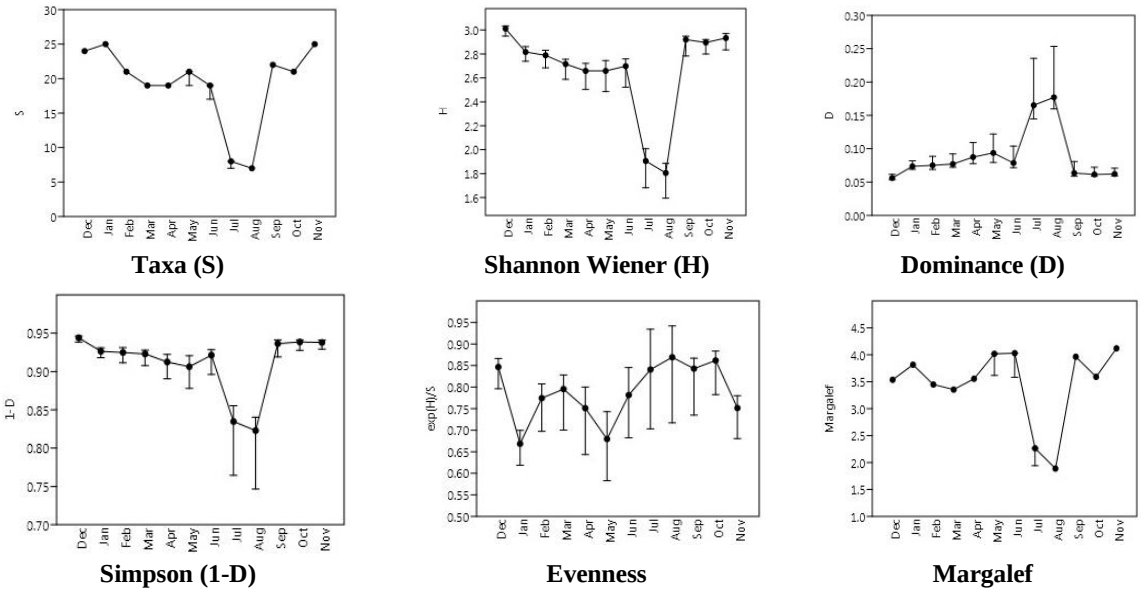

Figure 3. Plot diagrams for various indices calculated for the density of aquatic mites collected from Byasi during the study period

Table 3. Statistical analysis carried for aquatic mites density

Indices	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
Taxa_S	24	25	21	19	19	21	19	8	7	22	21	25
Individuals	668	539	330	214	158	145	87	22	24	200	262	339
Shannon_H	3.012	2.816	2.789	2.716	2.658	2.658	2.698	1.906	1.806	2.92	2.896	2.933
Dominance_D	0.05602	0.07365	0.07511	0.07704	0.08749	0.09375	0.07861	0.1653	0.1771	0.06360	0.06142	0.06217
Simpson_1-D	0.944	0.9263	0.9249	0.923	0.9125	0.9063	0.9214	0.8347	0.8229	0.9364	0.9386	0.9378
Evenness_e^H/S	0.8467	0.6687	0.7744	0.7955	0.7511	0.6795	0.7816	0.8408	0.8694	0.8428	0.8619	0.7515
Margalef	3.536	3.816	3.449	3.354	3.555	4.019	4.031	2.265	1.888	3.964	3.592	4.119

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