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Studies on the effects of some physico-chemical parameters on the distribution of Collembola: A case study from Hooghly District, West Bengal

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Abstract

The study reflects the distribution pattern of collembolan fauna in four study sites of Hooghly district on fluctuation of soil parameters such as moisture, temperature, and pH. Seasonal impact on species number and composition has also been observed here. The ecological study of the Collembola about some physico-chemical parameters has not been studied so far in the district of Hooghly, West Bengal. The seasonal abundance of the Collembolan population depends on soil moisture, neutral pH and humic soil. We have encountered a total of 25 species under 17 genera from 13 subfamilies of 9 families under 3 orders. The analysis represents that the family Entomobryidae is the most dominant one (32%) followed by Paronellidae (20%) and Isotomidae (12%). The members of the genus *Lepidocyrtus* Bourlet, 1839 are abundant (46.69%) and species-rich. There is a spike in the number of individuals during the spring and Monsoon season, although few species show evenness throughout the seasons.

Keywords: Abundance, Seasonality, Soil Moisture, Springtails

Introduction

Collembola is among the most abundant and major mesofauna along with acari, found in the soil, and performs a crucial role in litter decomposition, mineral cycling, fungal spore transfer and soil structure formation. Springtails are predominant under leaf litter; however express selectivity over a few minor habitats such as termite nests, marine littoral zones, lentic neuston, caves and snow fields (Christiansen, 1964). Some edaphic collembolan species also act as bio-indicators and thus help to predict the dynamic of some crop production (Lavelle *et al.*, 2006). Springtails are quite abundant though they are very sensitive to the physical and chemical composition change of the soil and their microhabitat which indicates the pollution level in that environment (Eaton *et al.*, 2004). They are widespread and can easily reach a density of 10 to 100 thousand per meter square (Hopkin, 1997). Collembola represents 50% and 60% of total arthropod fauna found in the soil and leaf litter respectively (Strok, 1988).

Temperature and humidity have a significant role in the molting number which leads to species-specific sexual maturity (Butcher *et al.* 1971). The relative decrease in the humidity causes lower reproduction, mortality and even migration from its usual niche (Vannier & Thibaud, 1968). It has been shown that seasonal occurrence regularity is rare among them and is masked by environmental factors (Gisin, 1995). Previously, Choudhury and Roy (1966, 1972), Mitra *et al.* (1977), Hazra and Choudhuri (1983), Hazra and Sanyal (1996), and Mandal *et. al.* (2011) in their studies revealed the effect of some ecological and soil factors on the springtail fauna of West Bengal, an extension of their works had been done here, particularly at the Singur–Polba block of Hooghly district.

Materials and Methods

Location

Hooghly district is situated at the west bank of Hooghly River and 47 km north of Kolkata conquering 3,149 km square area, latitude and longitude 22.9012° N,

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88.3899° E. The soil is mainly of alluvial type with a pH of around 6–7. Landscapes are usually flat, not exceeding an elevation above 200 m. The district observes an average annual rainfall of 82.25 mm and a temperature of 30.44°C. *Artocarpus heterophyllus, Mangifera indica, Musa paradisiaca, Ficus religiosa, Azadirachta excels, etc. are some of the commonly noticed trees and Sporobolus diander, Euphorbia hirta, Clerodendrum indicum,* Bambusa *tulda* are mostly occurred herbs or shrubs of Hooghly district.

Study Sites

The study was conducted from February 2022 to January 2023 in four distinct sites of Hooghly district. The sites were about 8-20 km away from Singur railway station, Hooghly district. All four sites have collembola specific habitats such as leaf litter, vegetable litter, agro-ecosystem, water bodies (pond, canal), etc. and all the sites are undisturbed. Details data of these stations are as follows:

- Station I (Stn1) – Village Rajarbathan, Singur, Hooghly. Latitude and longitude - 22.869°N, 88279°E.
- Station II (Stn 2) – Near Agricultural field, village Boichipota, Singur, Hooghly. Latitude and longitude - 22.856°N, 88.274°E.
- Station III (Stn 3) – Near Agricultural field, village Mathurkur, Polba- Dadpur, Hooghly. Latitude and longitude - 22.889°N, 88.219°E.
- Station IV (Stn 4) – Near Ghiya river, village Karicha, Singur, Hooghly. Latitude and longitude - 22.872°N, 88.277°E.

Analysis of Environmental Parameters

- **Moisture –** Moisture was measured digitally using 'Soil Moisture Meter' (Model: PMS- 714) by inserting its moisture sensing head into the 10 cm depth of soil. After a few minutes when the reading stabilized, data was taken.
- **Temperature –** Soil temperature was taken using a manual thermometer putting its head inside the soil.
- **pH –** Soil pH was tested using 'SOIL PH METER' (Model: PH- 220S). Calibration was done with standard buffer solutions pH 4.0/pH 7.0 before measuring the pH of any site.

Sample Collection

Specimens were collected following two types of methods, direct method and indirect method. In the direct method, specimens were caught using an entomological aspirator. In the indirect method, soil samples were collected from the collection site and collembola specimens were extracted using the 'Brussels Tullgren funnel' at the lab. Specimens were stored in 70% alcohol until further study.

Laboratory work

Specimens are sorted up to family level under Leica M205A stereo microscope and photographed by Leica DMC6200. For taxonomic identification, slides were prepared using Hoyer's media as a mounting media and mounted slides were placed in a Hot plate at 45°C for 3 days until they were completely dried. Then the specimens were identified to species level under the Leica DM 2500 binocular. All the specimens were deposited at the Zoological Survey of India.

Discussion

Soil particles, components and composition play a crucial role in the accommodation of soil arthropods, especially in the case of collembola. The factors of soil such as nitrogen content, adequate oxygen level, quite

Table 1. Taxonomic status of Collembola species from Hooghly district in the year 2022–2023 with their total no. of examples and specific habitat

Sl. No.	Collected species	Total no. of examples	Station no.	Habitat
	Family: Hypogastruridae			
1.	*Xenylla welchi* Folsom, 1916	45	Stn. 1	Vegetable litter
	Family: Neanuridae Subfamily Neanurinae			
2.	*Lobella (Lobella) maxillaris* Yosii, 1966	21	Stn. 1 and Stn 3	Leaf and vegetable litter
	Family: Onychiuridae Subfamily Onychiurinae			

3.	*Allonychiurus* sp.	42	Stn. 1	Vegetable litter of jute plant
4.	*Bionychurus* sp.	3	Stn. 1	Mango leaf litter
	Family: Isotomidae Subfamily Anurophorinae			
5.	*Cryptopygus indicus* Brown, 1932	5	Stn. 1	Leaf litter
6.	*Cryptopygus tridentatus* (Handschin, 1929)	3	Stn. 1	Leaf litter
	Subfamily Isotominae			
7.	*Isotomurus balteatus* (Reuter, 1876) Handschin, 1929	5	Stn 1 and Stn 3	Agricultural field side
	Family: Paronellidae Subfamily Salininae			
8.	*Dicranocentroides flavescens* Yosii, 1966	2	Stn 1, Stn 2, Stn 3	Grasses near water body
9.	*Yosiia dehradunia* Mitra, 1967	11	All stations	Grasses near water body
10	*Salina (Salina) bengalensis* Mitra, 1966	16	Stn 1 and Stn 2	Near water body
	Subfamily Paronellinae			
11	*Cyphoderus albinus* Nicolet, 1842	35	All stations	Leaf litter and rotten banana bark
12	*Cyphoderus assimilis* Borner, 1906	2	Stn 1	Rotten banana bark
	Family: Entomobryidae Subfamily Lepidocyrtinae			
13	*Lepidocyrtus (Acrocyrtus) heterolepis* Yosii, 1959	148	All stations	Leaf litter
14	*Lepidocyrtus (Acrocyrtus) scaber* Ritter, 1911	14	Stn 2	Leaf litter
15	*Lepidocyrtus (Cinctocyrtus) medius* Schaeffer, 1898	51	Stn 1 and Stn 3	Leaf litter
16	*Lepidocyrtus (Allocyrtus) lepidornatus* (Handschin, 1930) Yoshii, 1982	98	Stn1, Stn3	Leaf litter
17	*Lepidocyrtus* (*Lanocyrtus) caeruleicornis* Bonet, 1930	7	Stn3	Leaf litter
	Subfamily Entomobryinae			
18	*Homidia cingula* (Borner, 1906) Yosii, 1959	91	All stations	Leaf litter and rotten banana bark
	Subfamily Seirinae			
19	*Seira (Seira) arunachala* Mitra, 1976	15	Stn 1	Leaf litter and rotten banana bark
20	*Seira* sp.	1	Stn1	Rotten banana bark
	Family: Orchesellidae Subfamily Heteromurinae			
21	*Alloscopus tetracanthus* (Borner, 1906) Handschin, 1928	38	All stations	Leaf litter and rotten banana bark
	Subfamily Orchesellinae			
22	*Orchesellides* sp.	8	Stn 1	Rotten banana bark
	Family: Sminthuridae Subfamily Sphyrothecinae			
23	*Sphyrotheca (Sphyrotheca) gangetica* Yosii, 1966	3	Stn 1	Leaf litter
	Family: Dicyrtomidae Subfamily Dicyrtominae			
24	*Calvatomina trivandrana* Prabhoo, 1971	17	Stn 4	Leaf litter
25	*Calvatomina pagoda* Yosii, 1966	1	Stn1	Rice straw litter

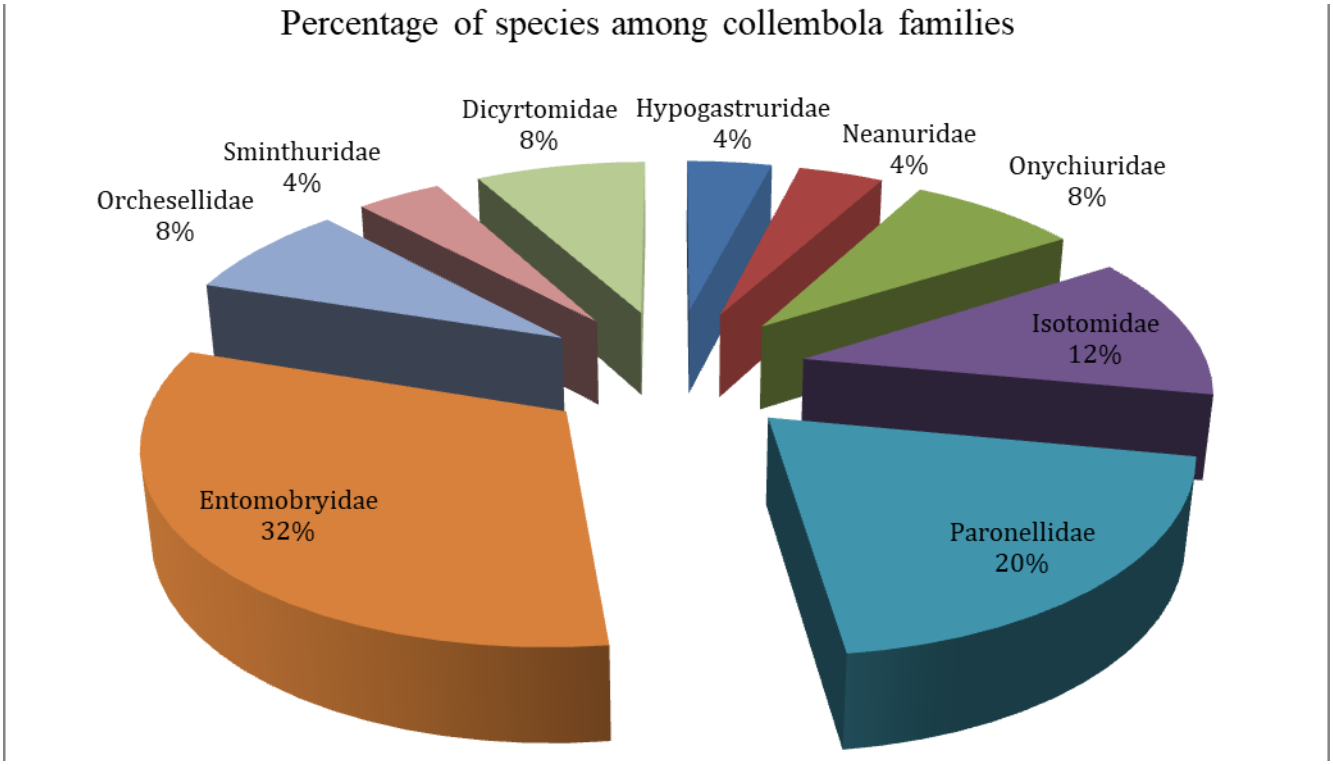

Figure 1. The family-wise abundance of Collembolan species of Hooghly district (Singur and Dadpur block).

Table 2. Presenting seasonal data of species encountered and average of the three environmental factors

Season Month	Study site	Reported species	Total no. of examples.	Temperature (°C) (Average)	pH (Average)	Soil moisture (Average)
Spring February-March	Stn 1 and Stn 2	*Homidia cingula*	22	22.5- 27.7	7.02	26.84%
		Xenylla welchi	45			
		Yosiia dehradunia	3			
		Dicranocentroids flavescens	3			
		Salina bengalensis	1			
		Alloscopus tetracanthus	28			
		Cyphoderus albinus	3			
		Lepidocyrtus (Acrocyrtus) heterolepis	40			
		Lepidocyrtus (Acrocyrtus) scaber	14			
		Lobella (L.) maxillaris	21			
		Total	**180**			

Summer April - June	Stn 1 and Stn 3	*Yosiia dehradunia*	7	28.7- 30.1	7.18	28.35%
		Cyphoderus albinus	28			
		Cyphoderus sp.	14			
		Homidia cingula	10			
		Lepidocyrtus (Cinctocyrtus) medius	28			
		Lepidocyrtus (Acrocyrtus) heterolepis	22			
		Lepidocyrtus (Allocyrtus) lepidornatus	10			
		Cryptopygus indicus	3			
		Seira (Seira) arunachala	12			
		Calvatomina pagoda	1			
		Sminthurus sp.	6			
		Lobella (L.) maxillaris	10			
		Allonychiurus sp.	42			
		Bionychurus sp.	5			
		Total	**198**			
Monsoon July - August	Stn 1 and Stn 4	*Cyphoderus albinus*	1	28.9– 29.1	6.50	30.13%
		Lepidocyrtus (Acrocyrtus) heterolepis	98			
		Lepidocyrtus (Allocyrtus) lepidornatus	40			
		Homidia cingula	49			
		Alloscopus tetracanthus	38			
		Cryptopygus tridentatus	5			
		Sphyrotheca gangetica	3			
		Calvatomina trivandrana	18			
		Lobella (L.) *maxillaris*	1			
		Total	**253**			
Winter Decem- ber - January	Stn 1 and Stn 3	*Yosiia dehradunia*	1	14– 26	6.74	17.26%
		Salina bengalensis	13			
		Salina sp.	2			
		Cyphoderus albinus	2			
		Cyphoderus assimilis	2			
		Isotomurus balteatus	3			
		Lepidocyrtus (Acrocyrtus) heterolepis	16			
		Lepidocyrtus (Cinctocyrtus) medius	28			
		Lepidocyrtus (Allocyrtus) lepidornatus	48			
		Lepidocyrtus (*Lanocyrtus) caeruleicornis*	6			
		Homidia cingula	10			
		Alloscopus tetracanthus	1			
		Seira (Seira) arunachala	2			
		Seira sp.	3			
		Orchesellides sp.	8			
		Total	**144**			

neutral pH level, temperature (29-30°C) and moisture (50-60 %) are needed for the maximum activity of soil living organisms and also work as a limiting factor for their abundance (Directorate of Forests Government of West Bengal, 2016). In the context of this, the soil type of Hooghly district is of new alluvial type which has high humus content, is less acidic as well as with high water holding capacity.

The soil of Hooghly district is of neutral type, pH usually resides between 6.2 and 7.9. There is a slight increase in pH shown during summer and spring and decreases gradually during Autumn and Winter. The soil temperature showed a significant role in the population

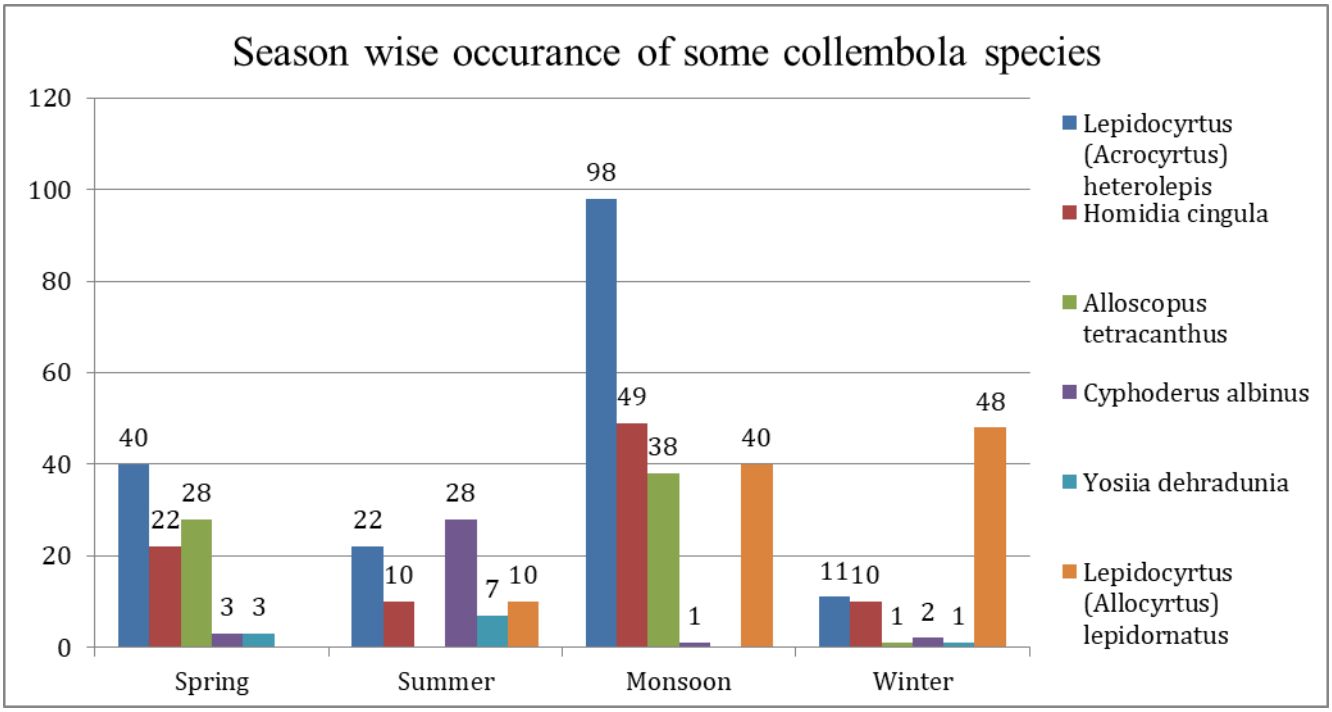

Figure 2. Some of the most prevalent Springtail species and their dominance throughout the year.

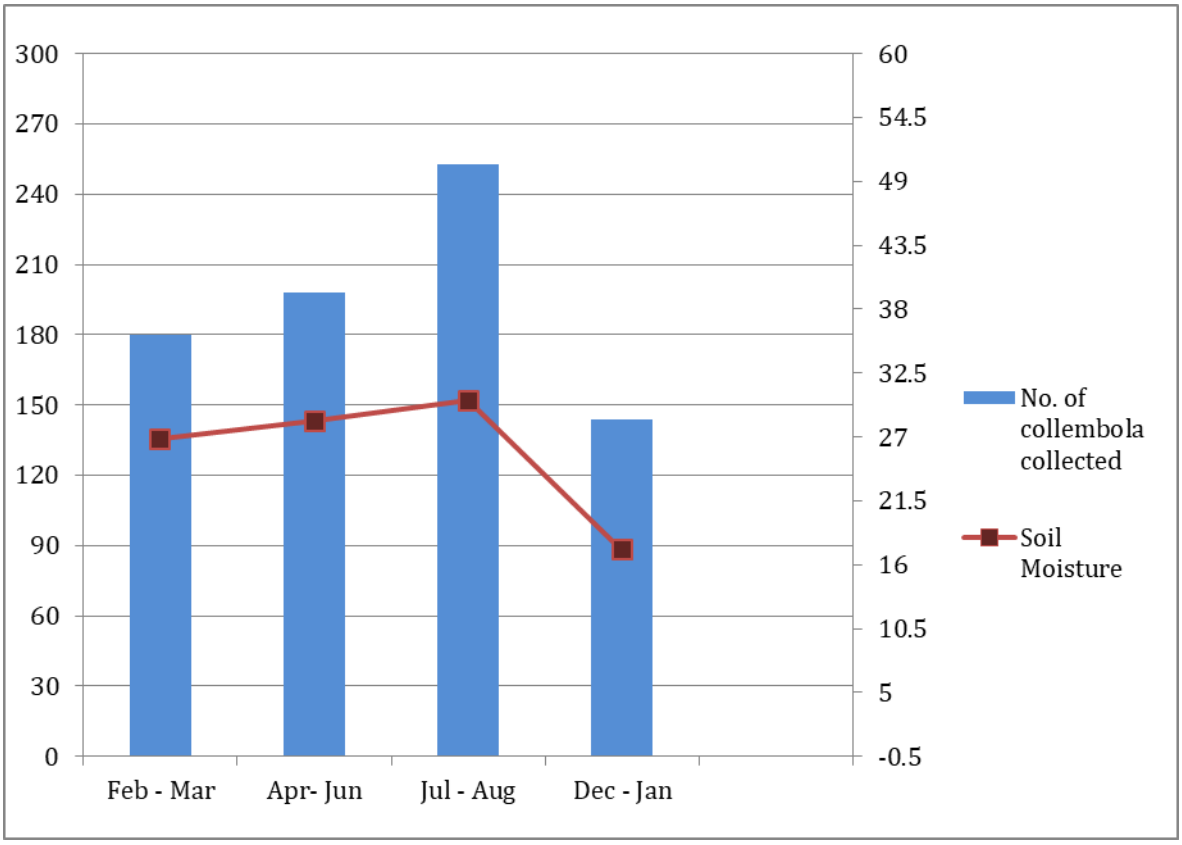

Figure 3. Correlation between total Collembolan population density and soil moisture of four main seasons observed in Hooghly district.

fluctuation of Collembola in the studied locality. Maximum temperature in the month of April-May showed minimum population. When the temperature was 33-37°C with a moisture level moderate in July-August, showed a high population of Collembola (Table 2). Another small peak was observed in November and December.

In the study, the number of species encountered 25 species under 17 genera under 3 orders (Table 1). The most dominant family was Entomobryidae consisting of 32% of the total population (Figure 1). Most of which are edaphic and hemiedaphic ones. Species from the family Entomobryidae under the order Entomobryomorpha are prevalent, among which genus *Lepidocyrtus* (46.69%) possesses the maximum number of individuals as well as species. *Lepidocyrtus (A.) heterolepis* (21.73%), *Homidia cingula* (13.37%), *Alloscopus tetracanthus* (5.58%), *Cyphoderus albinus* (5.13%), *Lepidocyrtus (Allocyrtus) lepidornatus* (14.39%) – were the most prevalent and ubiquitous species which were found in every season and so that their seasonal occurrence has been evaluated graphically. A gradual rise in the number in the case of *Lepidocyrtus (A) heterolepis* is seen during the rainy and spring seasons, whereas *Homidia* shows a quite undisturbed curve throughout the year with a slight increase during winter (Figure-2). It has been seen that species such as *Cyphoderus albinus* and *Alloscopus tetracanthus*, which have multiple habitat preferences, are not affected much by the seasonality as they can be found both in soil and water-rich dense dark places (e.g. rotten Banana bark). Two species *Xenylla welchi* and *Allonychiurus* sp. were collected from their colonies under the vegetable litter. A greater number of larval instars are being observed during the cold season. *Xenylla welchi, Cryptopygus indicus, Cryptopygus tridentatus, Lepidocyrtus (Allocyrtus) lepidornatus, Seira (Seira) arunachala, Calvatomina trivandrana* are the species newly recorded from Hooghly District. Mandal *et al.* (2018) in their checklist of West Bengal mentioned only two species from Hooghly; the study includes additional 20 species new to the district. *Calvatomina pagoda, Sphyrotheca gangetica, Cryptopygus tridentatus, Cyphoderus assimilis, Lepidocyrtus* (*Lanocyrtus) caeruleicornis* are some of the least encountered species. Hazra (1978a, 1978b), and Mandal *et. al.* (2011) observed the lowest peak of the collembola population during May, unlike that Figure 3 shows December is the month with the lowest number of individuals. Nevertheless, study duration along with different parameters and collection numbers should be increased for strong and valid interpretation.

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