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Prevalence of springtail (Collembola) in the cultivated maize fields at Puthia Upazila, Rajshahi district, Bangladesh

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Abstract
In the present study we have collected 4697 individuals of collembola from the five maize fields (*Zea mays*) during April to December 2015 at Puthia Upazila. They were identified into five families and six species, viz., *Podura aquatica* (Poduridae), *Hypogastrura armata* (Hypogastruridae), *Entomobrya nivalis* & *Orchesella* sp (Entomobryidae), *Dicranocentroides gisini* (Paronellidae), and *Tomocerus minor* (Tomoceridae). From the monthly samples, the highest number of collembolan was found in the month May (983) and lowest was in November (259). Among the five unions of Puthia upazila, the highest prevalence of collembola found in Belpukuria union (21%), Silmaria (20%), Puthia (20%), Jewpara (20%) and Baneshwar union (19%) respectively. The highest prevalence of collembola was *Entomobrya nivalis* (59%), and lowest was *Tomocerus minor* (2%), and the rest was *Orchesella* sp (20%), *Dicranocentroides gisini* (8%), *Podura aquatic* (6%), *Hypogastrura armata* (5%) respectively. From the results it has been found that both month and Collembola has a significant diversity on number of collembola population in maize fields (P-value 0.002 and <0.001). *E. nivalis* was found to be most than all other type of collembolan. Finally, this works may help to find information regarding the abundance and diversity of collembolan and their role in soil formation by decomposing maize plants after harvesting.

Keywords: Collembola, diversity, maize field, Springtail, Rajshahi district

1. Introduction
Collembola are commonly known, as springtails are small and permanently wingless (Apterygote) insects. These are minor pests in agriculture but its importance as biological agent in the soil forming process is immense [1]. In comparison to the more highly evolved insects, collembola are phylogenetically older and they are more primitive in regard to their morphological and physiological properties. With some exceptions, the natural habitat of Collembola is soil. Depending on the species, they can live on soil surfaces, in litter layers, or in the deeper horizons of the mineral soil [2].

Springtails are colonizing in the soil habitats that provide enough humidity and food, such as organic matter, pH, or microorganisms. Some researcher regarded them as key indicators of soil fertility and health but sometimes agricultural intensification tends to reduce collembolan diversity [3-5]. Through their feeding activity on organic material, especially plant residues, they enhance the turnover rate of carbon in soil [6-8]. In fact, there remains much to be done in the taxonomy of the collembolans of Bangladesh. The present study was particularly intended to works on the abundance and ecology of collembolans. The English entomologist [29] in the year 1870 gave the name Collembola to this group of insects. First pioneer taxonomic work on springtails was done by Imms [9]. Thereafter, contributions of scientists are worth mentioning in India [10, 30, 31]. There are approximately 7500~8000 described collembolan species worldwide [1, 11]. In Bangladesh only 4 genera fewer than 4 families are recorded [12]. Another, two genera of collembola as *Rambutsinella* and *Entomobrya* and other three species *Podura aquatic*, *Hypogastrura armata* and *Tomocerus minor* were identified [13, 14]. Later they studied the diversity of collembola in five ecological habitats, and found highest number collembolan inhibiting in the leaf litter at Rajshahi City Corporation [15]. Therefore the main goal of this study was to investigate the prevalence of Springtail in the cultivated maize fields at Puthia Upazila, Rajshahi district, Bangladesh.

2. Materials & Methods

2.1 Study sites: Collembola was collected from Puthia upazila. Puthia upazila is located in Rajshahi division of Bangladesh. The geographical distribution of Rajshahi is 24° North and 89° East. Collembola were collected from five different maize fields each having one acre area of cultivated land at Puthia upazila; (i) Puthia union (ii) Baneshwar union (iii) Belpukuria union (iv) Silmaria union and (v) Jewpara union. The study was conducted in a predominantly agricultural area, in the Puthia upazila 24°22'30.00" N 88°50'60.00" E. Area of puthia upazila is 192.64 sq km that lies on the northern bank of the river Padma and lowland (22 m above sea level), underlain by alluvial soil which results fertile quality soils.

2.2 Climatic condition of the study area: Rajshahi has a tropical wet and dry climate. The climate of Rajshahi is generally marked with monsoons, high temperature, considerable humidity and moderate rainfall. The hot season commences early in March and continues till the middle of July. The maximum mean temperature observed is about 32°C to 36°C during the month of April to July and the minimum was January is about 7°C to 16°C. The highest rainfall is observed during the months of monsoons. The annual rainfall in the district is about 1448 millimeters. Large scale and small scale farming are also practiced with different management intensity. Sampling was conducted in three different maize cultures as well as in grassy embankments and shelterbelts.

2.3 Sampling, extraction and taxonomic identification

Samplings were carried out during April to December 2015. A total of 100 soil samples were taken from the each maize field and sometimes manually collected by a handmade aspirator. In each habitat, soil cores of 100 cm^3 were collected. Collembola were extracted from the soil cores for 10 days using a Berlese-Tullgren apparatus. Specimens were collected in 70% ethanol and separated under a binocular microscope. Springtails were identified at the species level according to Key [1, 15, 17] in this study. Taxonomic classification is based on the annotated checklist of the Indian collembolan [31] and checklist of collembolan of the world (www.collembola.org/).

2.4 Data analysis

The characteristics of collembola community structures were analyzed by using different diversity indices. Two-way analysis has been performed using IBM SPSS (version 20). Results of the two-way analysis of variance (ANOVA) that examined the effect of month and Collembola, Different species and their number in maize fields has been summarized in Tables.

3. Results

In this study, collembolan insect were collected from five different maize fields such as Baneshwar, Jewpara, Belpukuria, Puthia and Silmaria unions of Puthia Upazila. Among the 4697 individual specimens of collembolan 888 specimens were identified into six species which are *Podura aquatica*, *Hypogastrura armata*, *Entomobrya nivalis*, *Dicranocentroides gisini*, *Orchesella* sp and *Tomocerus minor* (Table-1). Identifying species belong into the four families namely Poduridae, Hypogastruridae, Entomobryidae and Tomoceridae. From the results it has been found that both month and collembolan type has a significant effect on number of collembola in maize fields with p-value 0.002 and <0.001(Table-2). It has been also found that irrespective of species type, numbers of collembola are found to be most in April and least in December. On the other hand, *E. nivalis* was found to be most than all other species (Fig.1). The highest number of collembolan was found in the Belpukuria (975) and lowest was in Baneshwar union (880). These high number of collembolan activity may have a role in soil formation after harvesting maize. The organic and inorganic compounds have directly contribution in soil formation, nutrient cycling in the maize fields. The two-way analysis of variance that examined the effect of month and Place (Union) on number of collembola in maize fields has been performed and the obtained results are summarized. The results shown that month has a significant effect on number of collembola in maize fields with p-value <0.001 (Table-3). It has been also found that irrespective of place, number of collembola is found to be highest in May and lowest in October (Fig.2). On the other hand, place has no significant effect in number of collembola in maize fields (p-value=0.872). During the study *E. nivalis* was the highest in all the time. However, in the survey, the *H. armata* was not found in the month of October, November and December. Although *T. minor* was lowest in all month but also interestingly the species was not found in the month of August, November and December (Fig. 3). Among the monthly collections, the highest percentage of collembolan was *Entomobrya nivalis* (57%), following *Orchesella* sp (20%), *Dicranocentroides gisini* (8%), *Podura aquatica* (6%), *Hypogastrura armata* (5%) and *Tomocerus minor* (2%) respectively (Fig.4). The results of this study show that a critical assessment is necessary over the choice of collembolan as a bioindicators of land use intensification or agricultural farming.

Table 1: Checklist of Collembola collected from the maize fields at Puthia Upazila from April-December 2015.

Serial #	Order	Suborder	Family	Species
1	Collembola	Arthropleona	Poduridae	*Podura aquatica*
2	,,	,,	Hypogastruridae	*Hypogastrura armata*
3	,,	,,	Entomobryidae	*Entomobrya nivalis*
4	,,	,,	,,	*Dicranocentroides gisini*
5	,,	,,	,,	*Orchesella sp*
6	,,	,,	Tomoceridae	*Tomocerus minor*

Table 2: The two-way analysis of variance (ANOVA) that examined the presence in month and number of collembola species distribution in maize fields.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Level
Corrected Model	26279.333[a]	13	2021.487	10.471	.000	***
Intercept	14602.667	1	14602.667	75.642	.000	***
Month	6080.000	8	760.000	3.937	.002	***
Pest	20199.333	5	4039.867	20.927	.000	****
Error	7722.000	40	193.050			
Total	48604.000	54				
Corrected Total	34001.333	53				

a. R Squared =.773 (Adjusted R Squared =.699), Dependent Variable: Number of collembolan, *** significant at 1% level of significant.

Table 3: Two-way analysis of variance (ANOVA) that examined the effect of month and Place on number of Collembola in maize fields summarized.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Level
Corrected Model	140392.578[a]	12	11699.381	21.415	.000	***
Intercept	490262.422	1	490262.422	897.403	.000	***
Month	139725.778	8	17465.722	31.970	.000	***
Place	666.800	4	166.700	.305	.872	
Error	17482.000	32	546.313			
Total	648137.000	45				
Corrected Total	157874.578	44				

a. R Squared =.889 (Adjusted R Squared =.848), Dependent Variable : Number of Collembolan, *** significant at 1% level of significant.

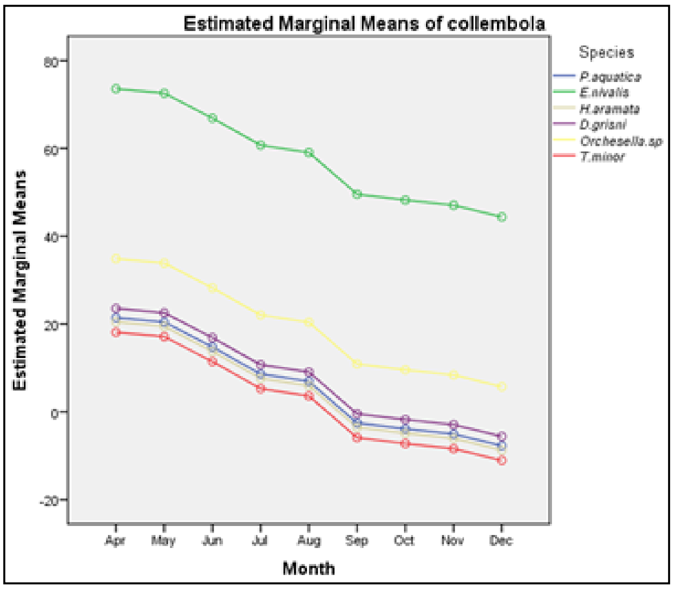

Fig 1: Estimated marginal means of number of collembola according to month and prevalence of different species in the five maize fields at Puthia Upazila**.**

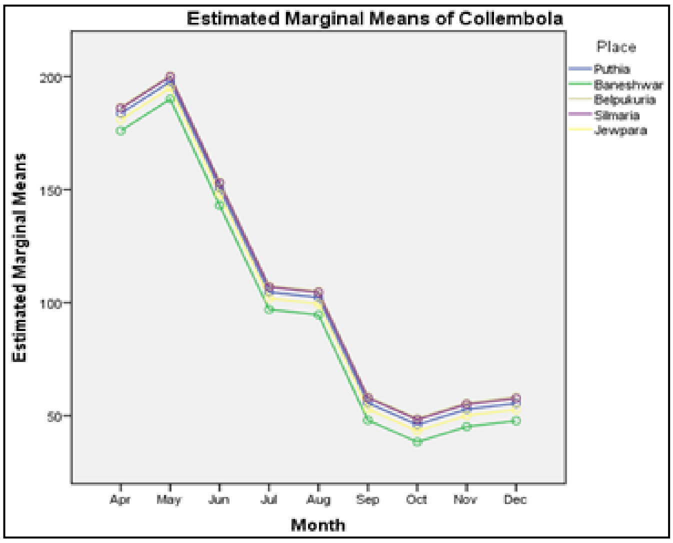

Fig 2: Showing estimated marginal means of number of collembola according to month and their effect on the distribution in the five maize fields at Puthia Upazila.

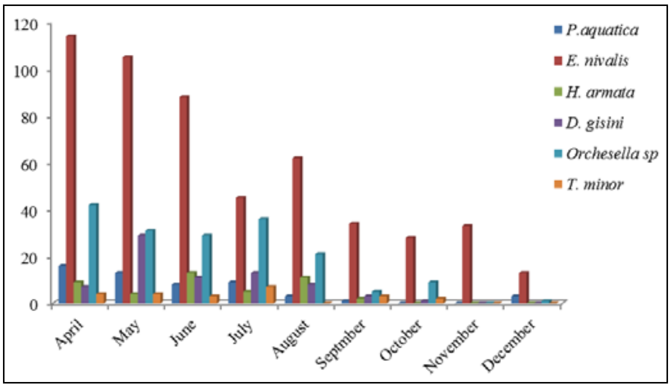

Fig 3: Monthly prevalence of identified six species of collembolan collected from the five maize fields at Puthia Upazila**.**

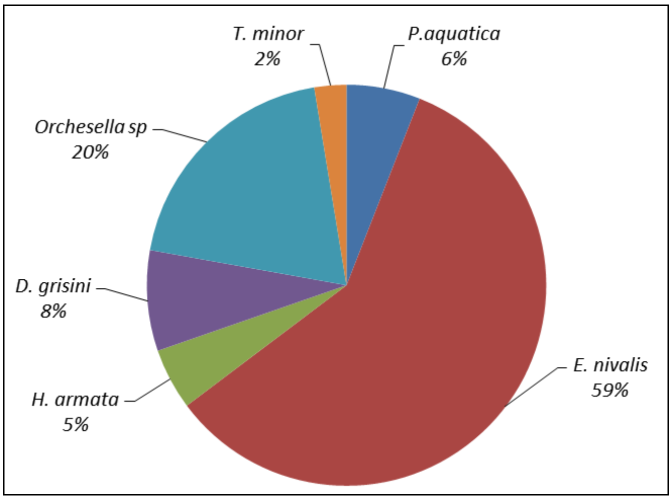

Fig 4: Distribution of identified six species of collembolan collected from the five maize fields at Puthia Upazila.

4. Discussion

During this study the populations of collembolan and the six species were not evenly distributed in the sampled five maize fields. The highest number of *E. nivalis* in all the month predicts that the species are dominant in the maize fields. Scientist found that the greater diversity loss was associated with soil P, K, pH and percentage sand, but not with soil N, or with latitude, or mean annual precipitation suggesting that variation in soil properties may influence the degree to which communities respond to changes in resource availability [17]. However, in this experiment we didn't found such change in our experiment. All the sampling soils present all most six species in each maize field didn't show significant difference. Although examination of species interactions require a different experimental design, it is difficult to explain the opposite responses of the local species other than that they most likely reflect an interaction with *E. nivalis,* which had highest abundance in all maize fields**.** The peak populations reached by the co-dominant soil and litter dwelling collembolan during annual cycle have also been observed [18]. In this study multiple peaks suggest that the different collembolan species produce many generations during annual cycle, a trait of potentially multivoltine and iteroparous species. The decline in populations in the month of October to December indicates the end of a generation and this varies between genera. The implications of this are that each genus has a peculiar life history and that the population dynamics of each genus can be influenced by variation in micro environmental attributes in the maize fields. Interestingly, only three species of collembolans (*E. nivalis*, *P. aquatic, Orchesella* sp) were found in the December and decreasing the populations at the same time. Habitat heterogeneity has been recognized as an important factor affecting both invasion and impacts on native species assemblages, although interpretations may vary, partly due to differences in scale [19-21]. On the small scale, some have argued that habitats suitable for indigenous species are likely also to be suitable for introduced species, and invasion thereby leading to the most species-rich patches becoming even more species rich, while others emphasize that indigenous diversity may improve resistance against invasion in species-rich habitats [22, 23]. Our results suggest a common scenario that six species may be so strongly favored by suitable conditions that it drastically increases species abundances. On the other hand, the fact that *E. nivalis* seems able to utilize higher quality litter to a more extent suggests that this area may provide the more species with a spatial refuge. Thus, habitat homogeneity may be playing a role in maintaining the overall species diversity in the maize fields. It might be argued that the fauna of springtails in cultivated soil, where disturbances occur regularly due to soil tillage, manure application, harvesting and pesticide applications, will be limited and low in diversity of species. Compaction by soil tillage and other mechanical operations seem to affect especially the density of springtails in cultivated land negatively, through inversion of soil layers and less diversity of pores [24, 25, 4]. The density of *Protaphorura armata* increased with increasing plant species and functional group number whereas density of Hypogastruridae decreased [26]. However, in our study *Hypogastrura armata* was consistence from April to September, but it was absent from October to December in all the maize fields meaning that the species didn't show any positive relation with the diversity of plant/habitats rather environmental temperature. Crop types, crop rotations and other changes in vegetation, may have negative or positive effects on mesofauna, while harvesting clearly decreased the density of springtails, as discussed [27]. The diversity of plant species, and the inclusion of grasses and legumes in the cropping systems, beneficially affected both the density and diversity of springtails in a grassland study [28]. Here we found that the collembola in soil habitats are not at same in abundance in all the time. Therefore, this works may contribute the abundance and diversity of collembolan and their role in soil formation in the maize cultivated fields.

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