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Seasonal distribution of *Isotomina thermophilan* in a secondary succession and a homegarden in Cachar, Assam

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Abstract

Present investigation was carried out in Cachar district of Assam over a period of two years (May 2007 - April 2009) to understand the seasonal ecology of *Isotomina thermophila* (Axelson, 1900) in secondary succession and homegarden ecosystems. Population was found to be maximum during July 2008 (7949.05 No. m^{-2}) and September 2008 (7949.05 No. m^{-2}) in homegarden whereas the peak was recorded in secondary succession during September 2008 (13656.05 No. m^{-2}). Least population was encountered during March 2008 (1222.93 No. m^{-2}) and April 2008 (1630.57 No. m^{-2}) in homegarden and secondary succession, respectively. It may be due to the fact that, vital activity of this species effected in the dry period or migrate towards lower soil profile in search of food and moisture. Linear regression analysis established the hypothesis that all the environmental variables showed positive and significant influence on the population dynamics whereas in homegarden, rainfall ($r = 0.36$, $p > 0.05$) did not show any influence. In multiple regression analysis positive and significant influences ($p < 0.05$) were recorded for both the investigated sites. Rainfall, relative humidity and temperature facilitated the soil moisture, microbial activity, litter decomposition may favour the reproduction and growth rate of the species. Among microclimatic conditions except soil pH all other parameters exhibited significant correlations ($p < 0.05$) with population. Based on the present investigation, it can be concluded that *I. thermophilia* does not differ much with the general ecology of collembolans in this sub humid climate.

Key words

Climatic variables, Total nitrogen, Multiple regression, *Isotomina thermophila, Seasonal ecology*

Introduction

Population dynamics is the study of marginal and long-term changes in the numbers, individual weights and age composition of individuals in one or several populations, and biological and environmental processes influencing those changes. Natural populations live in changing environments; indeed, animal numbers may be intricately linked to environmental periodicity (Caswell and Trevisan, 1991). Every organism of the earth showed their monthly or seasonal dynamics based on their phenology, microhabitat, environmental conditions *etc*. Like other animal in the earth, soil collembola population also responded to its changing environment promptly as it influenced their vital activity, reproduction, fecundity and mortality. The dynamics of this arthropod group varied throughout the year with a remarkable manner depending upon wide range of factors such as climatic and edaphic variables, vegetational types, landuse patterns, food availability and their phenology (Hazra, 1991, Naurala *et al*., 2003, Gope *et al*., 2007).

Workers from different parts of India and abroad reported their peak abundance in various time of the year. Numerous papers comes world wide to explain the dynamics of collembola and on those papers no uniform peak abundance was noticed in general. The importance of different edaphic properties on the life history, vital activity and dynamics of soil collembola has been studied throughout the globe. Some progress has been made towards the understanding of the effects of different edaphic factors on the ecology of soil microarthropods in the country (Hazra and Choudhuri, 1990; Hazra, 1991; Gope and Ray, 2006; Ray and Gope, 2006; Gope *et al*., 2007).

Seasonal dynamics of collembolan fauna was reported from various land use types of India and abroad and in maximum cases attention was paid on the total collembolan community (Hazra, 1991; Chagnon, *et.al*., 2000; Gope *et al*., 2007). In this present investigation, a care was taken on a particular species of collembola, *Isotomina thermophila* a true soil dwelling species in two landuse types' *viz.* secondary succession and homegarden to know the seasonal ecology. *Isotomina thermophila* belongs to Isotomidae family under the order collembola feed on fungal hypae and decaying leaf litter. Both the sites are ecologically important as former vegetation is made up of herb and shrubs created after destruction of mature forest (Finegan, 1984). Moreover, it is a creator of better environment for the climax community. The second landuse type is important because it's a man made ecosystem, characterized by mixture of woody and non-woody plant species used for substantial need of the household. Present investigation was carried out to study the population dynamics of *Isotomina thermophila* and its correlation with the environmental as well as edaphic factors in two land use types.

Materials and Methods

Study sites: Present investigation was carried out in Cachar district situated at the valley of River Barak, Assam in Northeastern region of India, comes under a recognized biodiversity hotspot namely Indo-Burma. The Cachar district lies between longitude 92°45′ E and latitude 24°41' N. The sites selected for the study were a homegarden and a secondary succession. The secondary succession selected (10 yr old) for the present investigation was situated near Assam University campus, Dargakona whereas home garden (25 yr old) situated in Irongmara village of Cachar district, Assam 1 km away from University campus. The climate of the study site was subtropical warm and humid with average rainfall 2660 mm and most of which is received during the southwest monsoon season (May to September). The mean maximum temperature ranged from 25.1 (January) to 32.6°C (August) whereas, the mean minimum temperature ranged from 11 (January) to 25°C (August). Average humidity of the area was 87%.

Soil sampling and extraction of *I. thermophilia*: Soil samples have been regularly collected at a monthly interval for a period of two years (May 2007 to April 2009) from both the study sites between 08.00 to 09.00 hrs. On each sampling, 10 sample units were taken at random with stainless steel soil augur (2.5 cm diameter) at a depth of 10 cm. These samples were immediately transferred to polythene bags then sealed and brought to laboratory. The extraction was done using Tullgren funnel type extractor (as modified by Murphy (1962) under 25W electric bulb. The extracted microarthropods were collected in specimen tube containing 70% ethanol. After identification of major taxonomic unit all the specimens were preserved in 70% ethanol separately. Prior to identification of collembola, specimens were mounted in DPX mounting media and identified by using face contrast microscope with an enlarged view of 10x X 100x. Soil analyses were done by standard methods followed by Allen *et al.,* (1989) and, Anderson and Ingram, (1993).

Table - 1: Relation between environmental variables and population dynamics

Environmental variables	Linear regression analysis					
	Homegarden			Secondary succession		
	Regression equation	'r' value	'p' value	Regression equation	'r' value	'p' value
Rainfall	2.6765x + 3127.5	0.36	>0.05	5.3328x + 4222.2	0.40	<0.05
Relative humidity	181.31x - 10608	0.68	<0.001	314.31x - 19404	0.67	<0.001
Air temperature	243.4x - 2366.7	0.45	<0.05	644.29x - 10786	0.64	<0.001
	Multiple regression analysis					
	Regression equation				'F' value	Multiple 'R'
Homegarden	- 10931 - 0.10 Rainfall + 168 Relative humidity + 56 Air temperature				5.86**	0.47
Secondary succession	- 23616 - 2.13 Rainfall + 213 Relative humidity + 503 Air temperature				9.46***	0.59

** = Means significant at 0.01 level and *** = Significant at 0.001 level

Table - 2: Physical properties of two investigated sites

Soil parameters	Homegarden	Secondary succession	ANOVA
Bulk density (gm cm^{-3})	1.27 ± 0.13	1.12 ± 0.09	'F' = 8.58, 'p' = 0.008
Water holding capacity (%)	41.30 ± 2.12	37.56 ± 1.10	'F' = 13.03, 'p' = 0.002
Soil texture			
Sand	54.90 ± 0.05	84.70 ± 0.52	
Silt	22.1 ± 0.53	09.50 ±0.45	
Clay	23.10 ± 0.75	05.80 ± 0.36	
Textural class	Sandy clay loam	Loamy sand	

Population density was calculated for the encountered soil collembola followed by Singh *et al*., (1978) in MS Office Excel - 2003.

$$P = 10000X / 0.785\ d^2$$

Where, P = Population density m^{-2}, X = Population/Sample, d = Diameter of the augur.

Statistical analysis: Linear regression, multiple regression and analysis of variance (ANOVA) were performed by statistical software Statistica version 5.

Results and Discussion

Proper knowledge on the bionomics of collembola till now remains incomplete and for this reason seasonal ecology of this group is till unpredictable. Recently, large scale studies are conducted either at the community or species level which also revealed marked, unpredictable seasonal changes in collembola population (Chagnon, *et al*., 2000). The dynamics of *I. thermophilia* in both the investigated sites are depicted in Fig. 1. In 2 year of study, peak population were recorded during July 2008 (7949.05 No. m^{-2}) and September 2008 (7949.05 No. m^{-2}) in home garden and least was observed in the month of March 2008 (1222.93 No. m^{-2}). Similar patterns of seasonal distribution also noticed in secondary succession where maximum population was observed during the month of September, 2008 (13656.05 No. m^{-2}) and lowest in April 2008 (1630.57 No. m^{-2}). In consistent with the present findings, the monsoon maxima of total collembola was also reported by Reddy and Venkataiah (1990); Alfred *et al*. (1991), Roy *et al.* (2003), Gope *et al.* (2007). *I. thermophilia* is truly a soil dwelling collembola may not persuing its vital activity in the dry period or migrate towards lower soil strata in search of food and moisture. Here both linear and multiple regression model were employed to established the hypothesis that environmental variables having influence on the population dynamics of *I. thermophilia* (Table 1). Results revealed that rainfall

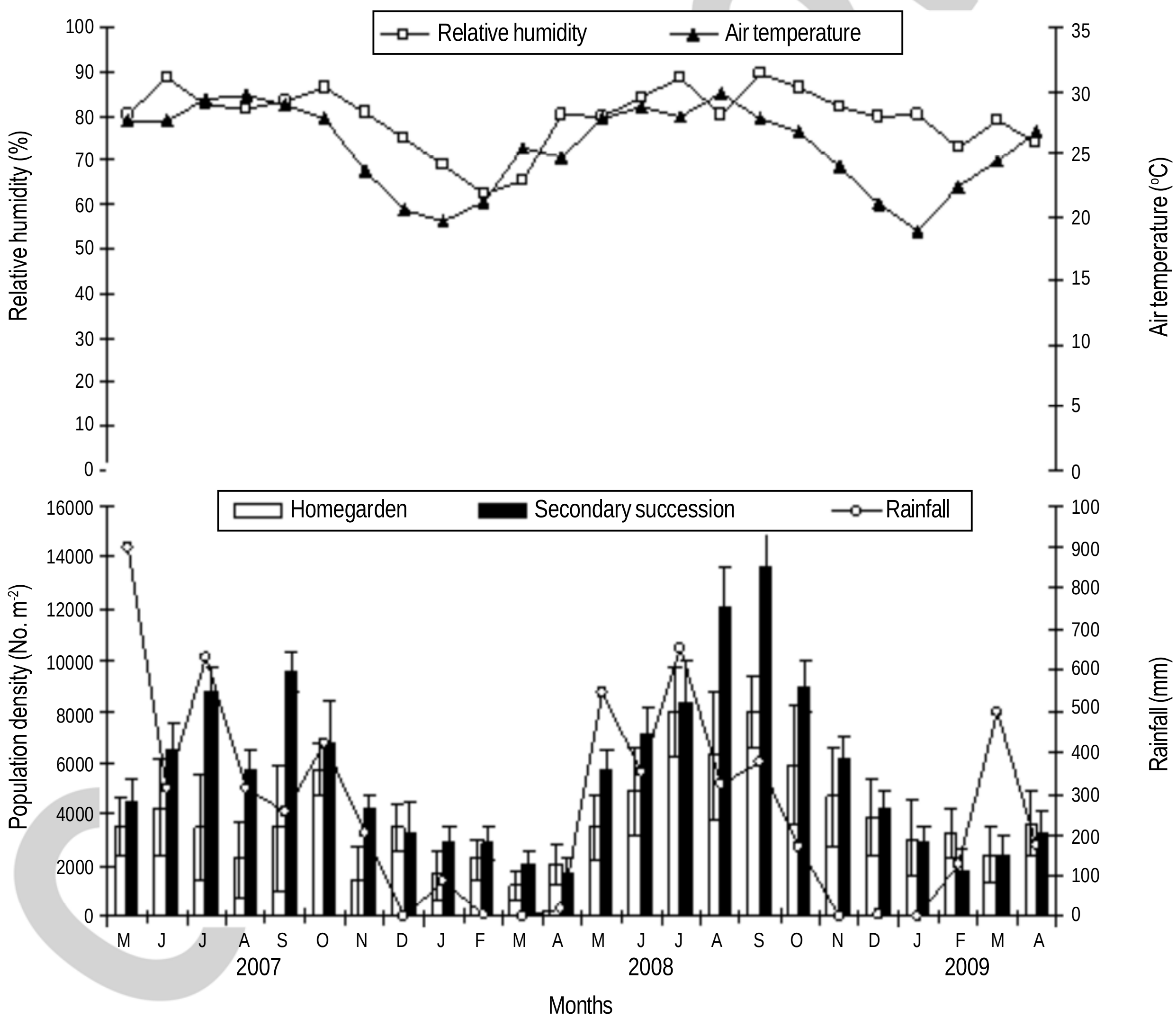

Fig. 1: Population dynamics of *I. thermophilis* in relation to environmental parameters

Table - 3: Relation between edaphic factors and population dynamics

Edaphic factors	Homegarden			Secondary succession		
	Regression equation	'r' value	'p' value	Regression equation	'r' value	'p' value
Moisture content	93.87x + 1971.80	0.38	>0.05	335.02x - 5.684	0.59	<0.01
pH	-1197.20x + 11481	-0.26	>0.05	565.67x + 1925.9	0.03	>0.05
Carbon content	298.50x - 486.08	0.59	<0.01	14014x - 10112	0.82	<0.001
Total nitrogen	52383x - 1195.90	0.56	<0.01	136786x - 8856.5	0.87	<0.001
Available phosphorous	24016x - 20765	0.66	<0.0001	48378x - 44641	0.85	<0.001
Exchangeable potassium	26084x - 758.75	0.51	<0.01	55333x - 3967.3	0.83	<0.001

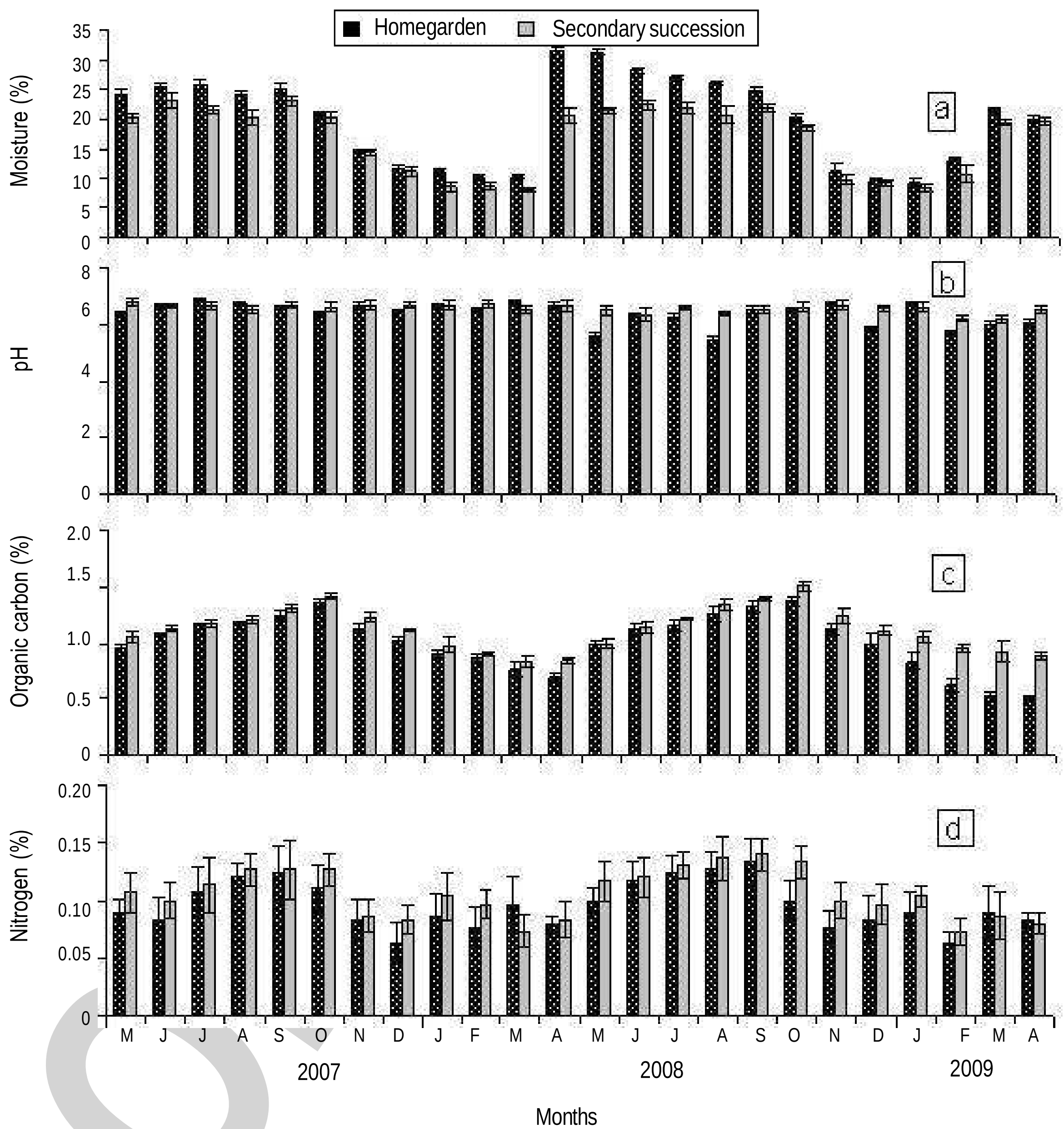

Fig. 2: Dynamics of (a) soil moisture, (b) soil pH, (c) organic carbon content and (d) total nitrogen over the study period (May 2007 to April 2009)

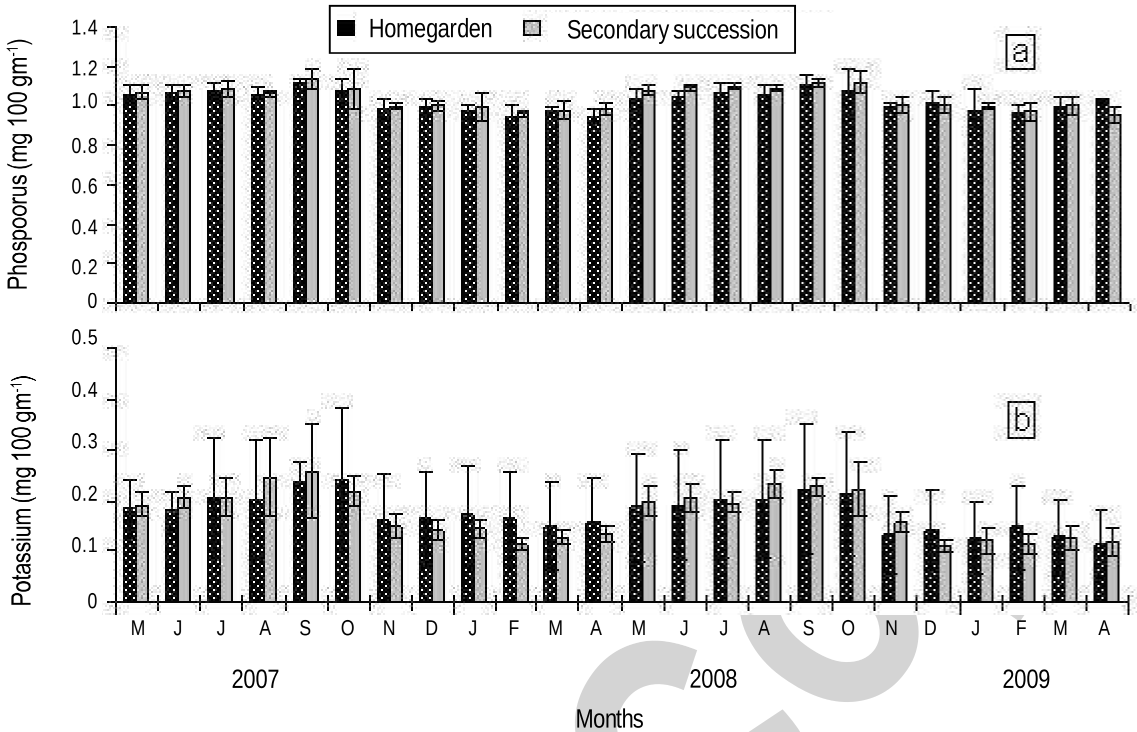

Fig. 3: Dynamics of (a) available phosphorous and (b) extractable potassium over the study period (May 2007 to April 2009)

(r= 0.40, p<0.05), relative humidity (r= 0.67, p<0.001) and air temperature (r= 0.64, p<0.001) all had individually positive and significant effect on population dynamics in secondary succession whereas in homegarden except rainfall (r= 0.36, p>0.05) other two parameters showed similar trend of effects as in secondary succession. Combined effect of all environmental parameters on the population density was assessed by multiple regression analysis where positive and significant influences were reported for both the sites (p<0.05). The combined effect of climatic factors showed strong influence on this group of population supported by (Reddy and Ao, 1995) where they indicated that these factors are regulating their different vital activities. Least population of *I. thermophilia* in dry period may be attributed to their mortality due to less food abundance because fungus needs high relative humidity and soil moisture for their reproduction and growth which were low in this period.

Physical characteristics of the described soil types are presented in Table 2. Bulk density differed significantly within the homegarden site ('F' = 8.58, 'p' = 0.008) and maximum of it was recorded in this system (1.27). Employed ANOVA revealed that the water holding capacity among the investigated soil types differed significantly ('F' = 13.03 'p' = 0.002). Like bulk density, homegarden (41.30) also showed higher water holding capacity as compared to secondary succession. Textural class of homegarden was recorded sandy clay loam while in secondary succession it was loamy sand. The values of moisture content were found to be higher in the wet months (June to October) in both the investigated sites (Fig. 2 a). The pH values of both the investigated sites did not show much fluctuation but found a significant difference between the two sites (Fig. 2 b). The overall soil organic carbon content was higher in secondary succession throughout the study period (Fig. 2 c). Total nitrogen, available phosphorous and exchangeable potassium, all the three parameters were also higher in secondary succession ranging 0.07% - 0.13%, 0.95 mg 100 gm^{-1} - 1.14 mg 100 gm^{-1} and 0.11 me100 gm^{-1} - 0.26 me 100 gm^{-1}, respectively (Fig. 2d, 3 a,b). The moisture content dynamics in any soil solely depends on the precipitation. In the present study, the moisture content of soil found to be higher during July to October (Fig. 2a). Soil physical characteristics revealed that in both the sites, bulk density and water holding capacity were lowest for secondary succession as this site having higher sand values than that of homegarden soil. The low bulk density in the secondary succession might be due to the thick vegetational coverage, thick canopy coverage to prevent the sunlight and temperature which in turn increase litter decomposition and carbon content. Organic carbon content is an important constituent of the soil organic matter and determines the availability of other soil macronutrients. Soil organic carbon compounds hold basic cations and are a source of energy for decomposers, contributing to the increase supply of nutrients, such as N and K in soil. The highest nutrient concentration of soil during July to October may be attributed to nutrient release during decomposition process because in this period high temperature, heavy rainfall and high relative humidity influence the high rate of decomposition.

The soil moisture content exhibited significant correlations with population of both homegarden ($r=0.38$, $p<0.05$) and secondary succession ($r=0.58$, $p<0.01$) corroborates the works of Hazra and Choudhuri (1990), Hazra (1991), Gope and Ray (2006). The level of moisture content declined in the dry months (November to February) due to low rainfall and excessive evaporation of soil water as a result the species may tend to migrate to higher depths. Since the present investigated areas are habituated with high precipitation therefore, population may not withstand the dry period which may leads to the morality of *I. thermophilia*. The soil pH in the present study did not exhibit wide range of variation among the investigated sites and no significant influence of it was recorded on population dynamics. The pH may have inhibitory role on the increase of microarthropod population. Positive but insignificant correlation with the soil pH reports supporting the investigation of Gope and Ray (2006). Among the chemical parameters nitrogen, phosphorous and potassium all the parameters showed positive and significant relationship with the population (Table 3). The soil organic carbon content having a significant correlation with collembola was established by many workers throughout the globe. Here significant positive correlation between population and soil organic matter corroborates the findings of Hazra and Choudhuri (1990); Hazra (1991); Gope and Ray (2006). The total nitrogen content of soil showed positive and significant relationship with the population. The observation in the present study favored the fact that, available phosphorous was having strong influence on the *I. thermophilia* dynamics. The work of Reddy and Ao (1995) also supports the present investigated results in this context. Like available phosphorous the study on the influence of exchangeable potassium over dynamics of different groups of soil microarthropod were scanty in Indian sub continent. In the present investigation attempts were taken to establish the effect on the ecology of soil microarthropod population.

Homegarden and secondary succession are the two different land use types where ecology of *I. thermophilia* is studied for the first time in this northeast hot spot area. Moreover, homegarden is a typical land use type which is managed by household and provides a platform of *in-situ* conservation of plant genetic resources. Study revealed more abundance of *I. thermophilia* in secondary succession may be less disturbed compared to homegarden.

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