Population Attributes of Common Earthworm (*Lumbricus terrestris*) in Three Comparable Habitats

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ABSTRACT

The distribution pattern of common earthworm *Lumbricus terrestris* was studied in three comparable habitats viz., paddy field, vegetable garden and apple orchard enjoying similar relief in the northern agro-climate zone of Kashmir. The data regarding average density and relative abundance, revealed a higher population density in vegetable garden and lower population density in apple orchard and rice field. Highest density of earthworms (8.4 ind.m^{-2}) was recorded during May in the soil of the vegetable garden whereas the lowest density (2.0 ind.m^{-2}) was recorded in July in the same habitat. Earthworm populations registered a complete absence in the months of July and August in the rice field habitat. χ^2 test revealed an even distribution of *Lumbricus terrestris* at the vegetable garden site, whereas, an uneven distribution was observed in orchard and paddy field soils. Analysis of coefficient of correlation (r) of earthworms with the physico-chemical attributes of soil depicted a significant positive correlation with organic matter, moisture content, temperature and total nitrogen content of vegetable garden and orchard soils. However, in case of paddy field soils, coefficient of correlation (r) of earthworms with physico-chemical parameters of soil yielded insignificant results.

Keywords: *Lumbricus terrestris,* density, abundance, soil.

INTRODUCTION

Earthworms, the most indispensable component of soil macro-fauna, have rightly been named as ecosystem-engineers. By way of their burrowing habits, they weave a net of air filled ducts that accelerates the gaseous exchange and thus enhances the respiration of the roots in the soil. Their castings help soils become richer in bacteria, winning a better consistency and higher moisture and also containing a bigger part of digested organic substances that are mineralized by microbes and thus made available to the plants. The common earthworm *Lumbricus terrestris* is an anecic species, constructing burrows and pulling leaf litter down into them. Earthworms occur in habitats where conditions like moisture and temperature are favourable. They are most abundant in forests and grasslands, and least so in arid and frigid ecosystems. Earthworm densities in a variety of habitats range from less than 10 to more than 2000 ind.m^{-2}, the highest values occurring in fertilized pastures and the lowest in acid or arid soils. Within habitats, earthworms often show patchy spatial distributions corresponding with such soil factors as vegetation, soil texture or organic matter (Coleman *et al*., 2004). Since the publication of Charles Darwins' pioneering work on earthworm ecology in 1881, vast literature regarding the distribution, abundance and biomass of these beneficial creatures has been generated (Lee, 1985; Hendrix, 1995; Edwards and Bohlen, 1996 and Lavelle *et al*., 1999)

In the present study three comparable habitats lying in a close proximity were investigated for assessing the population attributes like distribution, density and abundance of earthworms under the operating influence of various physico-chemical parameters of soil.

MATERIAL AND METHODS

For the purpose of carrying out the present investigation, three sites from comparable habitats were selected on the basis of vegetation cover and cultivation practices, one each in vegetable garden, paddy field and apple orchard at Pattan (Lat. $34^0 17'$N and Long. $74^0 28'$E) in Baramulla situated at a distance of 25km towards the north of Srinagar city. In each habitat an area of $100m^2$ was demarcated as a study site where monthly sampling was performed during May to August, 2006. 10 pits of 25x25x25cm dimensions were dug out with the help of shovel. Soil blocks were carefully broken by hand and organisms collected for enumeration (Satchell, 1971; Ali *et al*., 1973; Misra and Dash 1984; Coleman *et al*., 2004). Relative abundance and average density m^{-2} were calculated following Misra (1989). χ^2 distribution and coefficient of correlation (r) were worked out following Prasad (2000).

For studying the salient physiochemical features and nutrient status of soils composite soil samples were collected, dried and sieved and stored in polyethylene bags for analysis in the laboratory. Soil chemical analysis was carried out following Walkley and Black (1934), Bear (1964), Michael (1984), Simard *et al*., (1990) and Gupta (2002).

RESULTS AND DISCUSSION

Earthworms are the most familiar and often the most important of soil fauna. Their importance arises from their influence on soil structure e.g. crumb formation, soil pore formation and on the breakdown of organic matter. The influence of varied physicochemical parameters of three comparable habitats on the population attributes of the earthworm (*Lumbricus terrestris*) revealed that the rich fertile soils of vegetable garden supported earthworms in higher densities as against the paddy field soils that favoured least. The physico-chemical features of soils from all the three sites showed a close affinity with the distribution pattern of earthworms (Table 1). In case of vegetable garden and orchard, the soils were found to be alkaline to neutral in nature depicting an

Table 1: Physico chemical attributes and coefficient of correlation (r) of soils of vegetable garden, paddy field and apple orchard.

Vegetable Garden	Miosture content (%)	Organic Carbon (%)	Organic Matter (%)	Total Nitrogen (%)	Total phosphorus (µg/l)	pH	Conductivity (ms)	Temperature (°C)	Exchangable Ca(me/100g)	Exchangable Mg(me/100g)
May	30.1	0.89	1.54	0.047	745	7.15	1.17	20.5	5.36	1.20
June	26.3	0.93	1.62	0.039	720	7.10	1.08	25.7	4.92	1.13
July	20.3	1.01	1.75	0.028	731	7.28	0.03	26.5	5.22	1.09
August	23.9	1.14	1.89	0.030	664	7.46	1.10	23.8	5.12	0.86
(r)	0.96	0.51	0.98	1.00	0.60	0.91	0.94	0.95	0.50	0.61
Paddy Field										
May	23.3	1.15	1.99	0.36	720	6.87	.050	22.7	3.0	0.38
June	34.3	1.90	3.27	0.52	812	6.93	.049	25.3	2.8	0.37
July	40.7	1.92	3.31	0.041	801	5.47	.042	19.6	2.2	0.35
August	43.9	1.97	3.40	0.038	743	5.38	.029	20.5	2.0	0.36
(r)	0.74	0.55	0.52	0.24	0.001	0.78	.062	0.69	0.12	0.38
Apple Orchard										
May	22.5	0.63	1.10	0.031	730	7.40	1.01	19.3	6.02	1.12
June	17.0	0.19	0.34	0.037	690	7.35	1.30	20.7	5.91	1.20
July	18.2	0.31	0.54	0.029	630	7.65	1.42	22.6	5.72	1.16
August	18.8	0.39	0.68	0.027	622	7.90	1.39	23.3	5.47	1.35
(r)	0.99	0.77	0.99	0.48	0.86	1.0	0.85	1.0	0.66	0.45

increasing trend in pH from 7.15 in May to 7.46 in August in vegetable garden soils while for orchid soils it showed a range of 7.4-7.9. These findings draw support from earlier works by Stevenson (1986), Brady and Weil (1996) and Miller and Gardiner (1998) who reported that the ammonia gas produced by decomposition of organic compounds gives rises to ammonium hydroxide that consequently increases pH towards the alkaline side. The earthworm population seemed least influenced by the fluctuations in pH which may be because of the fact that the earthworms are somewhat tolerant to pH changes and thrive well in alkaline and slightly acidic soils (Holmin, 1983). However, in case of rice field soils a complete reversal of the trend was observed with a decrease in pH from 6.78 in May to 5.38 in August. Fall in pH in the rice fields was accompanied by a complete absence of earthworms.

The organic matter of the soils under investigation varied between 0.52% - 3.31% in rice field soils, 0.34% - 1.10% in orchard soils and 0.98% - 1.54% in vegetable garden soils. Organic matter values depicted an increasing trend in vegetable garden soils and paddy field soils as has also been observed by Russell and Russell (1950) according to whom decomposition rates of organic matter do increase as weather warms and furnishes maximum plant growth conditions. Furthermore, the higher amounts of organic matter in paddy field soils could probably be because of continuous addition of organic manure. The total – N(%) content was found to be higher in paddy soils (0.36% - 0.52%) than in orchard soils (0.029% - 0.037%) and vegetable garden soils (0.028% - 0.047%) which is due to the fact that paddy soils are in continuous receipt of nitrogenous fertilizers and organic matter. Soil temperatures showed maximum values for vegetable garden soil (20.5^0C – 26.5^0C) and minimum values (19.3^0C – 20.7^0C) for orchard soils in accordance with the findings of Kuhnelt (1970). Moisture content of soils exhibited highest values of (32.3% - 49.9%) for paddy soils that could be a direct consequence of water – logging conditions necessary for the growth of rice plants. The lowest values of soil moisture were registered for orchard soils (17.8% – 21.3%) and can be attributed to a decline in organic matter content of the soil. A direct proportional relation between moisture retention capacity and organic matter content of soils has been reported by Tan (2000).

The total-P content of soils ranged between 664 and 745 µg/g in vegetable garden, 720-812 µg/g in paddy and 622-730 µg/g in orchard. Higher values of phosphorus in paddy could be attributed to the addition of inorganic phosphatic fertilizers during the cultivation season. The values showed a decrease during the peak growth season in accordance with the findings of Katznelson (1977). The Ca^{++} content of soils was found to vary between 4.92 me/100g and 5.36 me/100g in vegetable garden, 2.0 – 3.0 me/100g in paddy and 5.47 – 6.02 me/100g in orchard soils, whereas Mg^{++} content varied in ranges 0.8 – 1.20 me/100g,. 0.35 – 0.38 me/100g and 1.12 – 1.35 mg/100g in vegetable garden, paddy and orchard soils respectively. Ca^{++} and Mg^{++} levels depicted a decrease during the peak plant growth season owing to their uptake by growing vegetation. The alkaline and fertile soils of vegetable garden appeared to support larger earthworm populations (2.0 – 8.4 ind/m^2) than orchard and rice field soils that supported lower populations of 2.8 – 6.0 ind/m^2 and 0 – 6 m^{-2} respectively (Table 2). The highest density of earthworms in vegetable garden was observed in the month of May (8.4 ind m^{-2}) coinciding with the optimal ecological conditions like high moisture content (30.1%), organic matter (1.54%), pH (7.15), temperature (24.12^{0}C), total-N (0.036%) and total-P (682.5µg/l). Soils rich in phosphorus have been found to support rich growth of earthworms (Tian *et al*., 2000).

Table 2: Population features of earthworms in the three habitats

	Average Density / m^2			**Relative Abundance**		
	Vegetable Garden	**Paddy Field**	**Orchard**	**Vegetable Garden**	**Paddy Field**	**Orchard**
May	8.4	4.8	6.0	100%	90%	100%
June	7.2	6.0	2.8	100%	100%	70%
July	2.0	0	3.2	40%	--	70%
August	4.4	0	4.0	80%	--	80%
X^2 Distribution	20.69	6.38	8.68			

According to Kollmannsperger (1989) earthworms are excellent indicators of humus and moisture content and occur in greater densities in fertile soils with sufficient vegetation cover. Soil moisture content, available organic matter and soil pH have profound effect on the distribution of earthworms in soil profile (Satchell,1967; Bhat, 1974). However despite favourable ecological conditions in rice field ecosystem like organic matter and moisture content, a complete absence of earthworms was observed during the cultivation season. This could be attributed to a sharp decline in pH and supersaturated conditions of soil that appeared to have a detrimental effect on earthworm distribution pattern. As a direct consequence of waterlogged conditions in rice fields that develop during the cultivation season, the earthworms migrate towards the bunds and levees. They create deep burrows that form continuous macropores. These macropores are very stable and tend to diminish the water holding capacity of bunds. Earthworms are, however, relatively pH tolerant and most species can adapt to a broad spectrum of pH values. Most species in cropland are commonly found at about pH 6 – 7 (Holmin, 1983). However, a pH below 6 is not favourable for the survival of earthworms as is true for the rice field site. Moreover, the pesticides applied to the agricultural soils at the time of transplantation persist for longer periods and in turn could be detrimental to the growth and abundance (Panda and Sahu, 1996).

According to Edward and Bohlen (1996) soil moisture can influence earthworm number and biomass. The importance of soil moisture and soil temperature on earthworm activity has been stressed by many workers (Gerard, 1967; Dowdy, 1994; Dash and Patra, 1997). Cultivation in paddy field soils seems to have negative effects on earthworm population as a consequence of changes in the physicochemical status of soils (Stoneman, 1962; Churchward, 1986). Earthworms tend to avoid soils that face a greater intensity and frequency of disturbance (Haukka, 1988; Edward, 1980). The disturbance of soil by tillage, cultivation and use of pesticides along with the availability of food act as the major determinants of earthworm abundance and activity in agricultural soils (Hulugalle, 1992).

In orchard soils a sudden decrease in density from 6.0 ind m^{-2} in May to 2.8 ind. m^{-2} in June could be attributed to a decrease in moisture content and organic matter of the soils. Moreover, the persistence of pesticide residues that are applied during flowering season may also be held responsible for the fall in earthworm numbers. Surface migration could also be an additional reason behind reduced population of earthworms in orchard soils (Mather *et al*., 1992).

Analysis of coefficient of correlation (r) of earthworm distribution pattern with various soil parameters has shown significant positive correlation with moisture content (0.96), organic matter (0.98), total-N (0.95) and temperature (0.95) in case of vegetable garden soils. However, for paddy soils the overall study has indicated insignificant correlation of various soil chemical attributes with density and abundance of earthworms. This indicates that none of the physiochemical parameters alone appear to be a strong determinant for earthworm distribution pattern. As regards the orchard soils, analysis of coefficient of correlation (r) of earthworm density with soil physiochemical parameters revealed significant positive correlation with moisture content (0.99), temperature (1.0) organic matter (0.99) and pH (1.0). The χ^2 analysis of earthworm distribution in all the three habitats revealed an even distribution (χ^2 = 20.69) of earthworms in vegetable garden, whereas, an uneven distribution (χ^2=6.38) in paddy soils and (χ^2=8.68) orchard soils was registered.

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