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Distribution and Demographics of the Tropical Soil Pill Bug, *Cylisticus convexus*

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Abstract: The demographic structure and vertical distribution pattern of the tropical isopod *Cylisticus convexus* were investigated in three localities (Mekkarai, Kottavasal, and Achenkovil) during different seasons, as well as soil conditions. The density of isopods was found to be high during the post-monsoon season (38.24±2.83), moderate during the monsoon season (31.04±3.63), and low during the pre-monsoon season (17.87±2.69). When compared to Mekkarai and Kottavasal, the population density of isopods in Achenkovil was higher in all seasons except pre-monsoon season, when the density was nearly the same in all three habitats. Achenkovil's soil is rich in organic carbon (2.45%), calcium (1754 ppm), and magnesium (79 ppm). Mekkarai's soil is rich in nitrogen (2511 ppm) and phosphorus (3.9 ppm). *Cylisticus convexus* has a very poor vertical dispersion power in soil, going only to a depth of 30 cm from the surface. Even in pre-monsoon, the density of this organism is much higher in the top soil than in the middle layer (10-20 cm). The distribution of isopods is mostly determined by the availability of high organic carbon content and low nitrogen and phosphorus content in the soil, which could explain why Achenkovil has a higher density than Mekkarai and Kottavasal.

Keywords: Isopod, *Cylisticus convexus* ,Organic carbon content, Ecosystem

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Introduction

Soil is an unconsolidated mineral mass on the earth's surface that is influenced by parent material's genetic and environmental elements, climate, micro- and macro-organisms, terrain, and time. Organic matter decomposition is dependent on the combined activities of soil microorganisms and tiny organisms. Small organisms that feed on litter have specialised feeding sites; some feed primarily on parenchymatous tissue, others on the veins of leaf tissues, and so on. Mites and collembola predominate in soils, fully destroying litter and promoting the production of soil aggregates. The organic fraction of the soil, humus, is a product of soil organism activity and is comparatively deficient in the tropics where breakdown rates are significantly rapid. *Cylisticus convexus* is a common microarthropod found in dirt. This is an isopod found just beneath the earth surface, at a depth of 1-5 cm. These micro-arthropods like moist environments (Yoshi.1966). The distribution patterns of these isopods vary in number depending on the soil layer. Many of them can be found on the surface of the soil. In lower levels, the population dropped. Collembola's vertical spread is governed by changes in soil temperature and moisture content, which cause downward migration. Gisin (1943), Nielsen (1949), Kuhnelt (1955), and Delamare Deboutteville (1951) have shown that higher population densities exist in the top layers of soil. Exceptions arise only when sufficient food is provided at greater depths. The current study was carried out to investigate the demographic structure of *Cylisticus convexus* during various seasons as well as the vertical distribution pattern of this micro arthropod in the soil.

Materials and Methods

Study area:

The study areas were chosen in Tamil Nadu's Tenkasi District and Kerala's Kollam District on the leeward side of the Southern Western Ghats. Mekkarai was chosen because it is located between 9^0 03′ N latitude and 77^0 13′ E longitude; Kottavasal is located between 11^0 08′ N latitude and 79^0 35′ E longitude; and Achenkovil is located between 9^0 05′ N latitude and 77^0 07′ E longitude.

Collection and transportation of sample:

Three locations on the leeward side of the South Western Ghats were chosen: Mekkarai, Kottavasal, and Achenkovil. 15 sampling locations were chosen from each site. Soil samples of 55 cm^2 area were obtained at random from different altitudes in Tenkasi and Kollam Districts using a soil auger from these sites. The monthly data were pooled to create seasonal data, with the monsoon season being June-September, the post-monsoon season being October-January, and the pre-monsoon season being February-May 2019. Soil samples were obtained from the soil profile at depths of 0-10 cm, 10-20 cm, and 20-30 cm. Soil samples were collected and transported to the laboratory in polythene bags. The soil samples were then transported to the Berlese funnel device, where the organisms were extracted in picric acid-containing beakers. The population density of these organisms was estimated after they were separated.

Soil edaphic factors analysis:

Soil edaphic variables such as soil temperature, pH, exchangeable acid and base, organic carbon content, moisture content, sand, silt, and clay content were discovered in soil samples. A soil thermometer was used to measure the temperature of the soil at the site. The pH of the soil was determined using a soil pH meter. Trivedy and Goel (1987) technique was used to estimate edaphic factors. The organic carbon content of the soil was determined using the Walkley and Black (1934) method. Gravimetry was used to determine the moisture content of the soil.

Soil chemical factors analysis:

Soil samples were air dried and sieved before being examined for chemical components such as nitrogen, phosphorus, potassium, calcium, and magnesium. The nitrogen content was determined using the Kjeldahl distillation method, while the phosphorus concentration was determined using the Molybdate stannous chloride method. The potassium concentration was determined using the flame photometry method (APHA, 2012). Calcium and Magnesium were determined using the Jackson(1958) methods.

Statistical analysis:

Microsoft Excel was used to create descriptive statistics. ANOVA was used in one way to determine the difference in soil parameters between sites. To calculate population density, the mean and standard deviation of the samples were calculated. A two-way ANOVA was used to determine the difference in the density of species between seasons and depths.

Table 1: Soil characteristics of Mekkarai, Kottavasal and Achenkovil at different collection sites

Sample	pH	OC (%)	EA (%)	EB (%)	Sand (%)	Silt (%)	Clay (%)	N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
Mekkarai I	4.1	2.01	3.1	9.1	54	14.12	4.21	2014	3.8	147	145	65
Mekkarai II	4.2	2.0	3.2	9.21	52	15.21	4.63	2511	3.9	152	125	69
Mekkarai III	4.0	2.06	2.8	9.58	55	15.32	5.21	2024	3.21	148	258	62
Mekkarai IV	41	2.04	2.98	8.94	52	14.32	5.12	2014	3.21	136	245	68
Mekkarai V	4.02	2.03	2.8	8.69	54	15.2	5.63	2031	3.54	195	254	63.21
Kottavasal I	4.2	2.41	3.21	9.23	54	11.2	4.52	2412	3.2	187	214	65
Kottavasal II	4.0	2.62	3.25	9.32	54	14.21	5.36	2147	3.54	145	254	52
Kottavasal III	4.3	2.15	3.65	9.23	58	11.62	5.63	2541	3.45	125	258	54
Kottavasal IV	4.2	2.32	3.52	9.12	56	14.23	6.32	2145	3.9	149	224	58
Kottavasal V	4.1	2.41	3.12	9.54	52	14.23	6.23	2415	3.56	158	254	56
Achenkovil I	5.9	2.12	83	10	8	0.48	15	2411	2.4	114	1320	74
Achenkovil II	5.8	2.12	78	11	8.5	0.58	14	2147	2.6	154	1450	48
Achenkovil III	5.3	2.32	86	9	8.7	0.68	18	2158	3.21	142	1245	79
Achenkovil IV	5.7	2.45	82	9.8	7.9	0.69	19	2312	2.15	114	1451	76
Achenkovil V	5.6	2.41	88	9.7	7.5	0.78	17	2415	2.14	124	1754	79

Results

SOIL EDAPHIC FACTORS:

pH:

The pH of Mekkarai fluctuates from 4.0 to 4.2 at different locations. Kottavasal soil pH ranges from 4.0 to 4.3, while Achenkovil pH ranges from 5.3 to 5.9 (Table 1). One-way ANOVA revealed a significant difference in the pH of Mekkarai, Kottavasal, and Achenkovil ($F=4.6237$ $P<0.05$).

Organic Carbon content (OC%):

The OC% fluctuates between 2.0 and 2.06 in Mekkarai and 2.15-2.62 in Kottavasal. Achenkovil has an organic carbon percentage ranging from 2.12-2.45. (Table 1). ANOVA revealed a significant difference in the OC% at three study locations.

Exchangeable acid (EA) and Exchangeable base (EB):

In Achenkovil, the EA% and EB% were significantly higher than in Kottavasal and Mekkarai. The EA in Mekkarai is 2.8-3.2, 3.12-3.65 in Kottavasal, and 78-88 in Achenkovil. The EB in Mekkarai is 8.69-9.58, 9.12-9.54 in Kottavasal, and 9-11 in Achenkovil (Table 1). The one-way ANOVA revealed a significant difference in the EA% of the three research locations but no difference in the EB%.

Sand, Silt and Clay %:

When compared to Achenkovil, the sand content in Mekkarai and Kottavasal was nearly identical. In comparison to Mekkarai and Kottavasal, Achenkovil had a low silt level. Achenkovil also had a significant clay content. Sand content ranges from 52-55% in Mekkarai, 52-58% in Kottavasal, and 7.9-8.7% in Achenkovil. The silt percentage in Mekkarai ranges from 14.12-15.32%, 11.2-14.23% in Kottavasal, and 0.048-0.078% in Achenkovil. Clay concentration in Mekkarai ranges from 4.21-5.63%, 4.52-6.32% in Kottavasal, and 14-19% in Achenkovil (Table 1). The sand composition of three study locations differed significantly according to one-way ANOVA.($F=1.62\times10-5$ $P<0.05$). At three study sites, one-way ANOVA of silt and clay revealed no significant difference (Silt% $F=0.5483$ $P>0.05$; Clay% $F=0.3223$ $P>0.05$).

Nitrogen, Phosphorus and Potassium content:

The nitrogen level in Kottavasal and Achenkovil was high, but the phosphorus and potassium content in Kottavasal and Mekkarai were higher

than in Achenkovil (Table 1). The one-way

ANOVA used to determine if there was a significant difference in the NPK content of Mekkarai, Kottavasal, and Achenkovil revealed a very high positive significant difference in these three features of all ecosystems. (N-F= 2045.23, P< 0.05; F=17.0673,P<0.05; and K-F=518.70,P<0.05).

Calcium and Magnesium content:

When compared to Mekkarai and Kottavasal, the amount of calcium and magnesium in Achenkovil was relatively high. Calcium levels in Kottavasal range from 214-258 ppm, 125-258 ppm in Mekkarai and 1245-1451 ppm in Achenkovil. Magnesium levels range from 52 to 65 ppm in Kottavasal, 62 to 69 ppm in Mekkarai, and 48 to 79 ppm in Achenkovil. The Ca and Mg concentration of three study sites differed significantly in one way ANOVA (Ca-F= 15.8047, P<0.05; Mg-F=415.2393, P<0.05).

POPULATION DENSITY:

Mekkarai:

Cylisticus convexus population density was highest in Mekkarai during the post-monsoon season, with a mean population density of 30.24±1.94, followed by the monsoon season (22.34±3.27) and the pre-monsoon season (12.51±1.82).(Table 2). There was no variation in population density between sites (F=1.1396, F critical=1.7382; P>0.05), but there was a substantial difference between seasons (F=3.2E+05, F critical=4.232; P<0.05).

Kottavasal:

The highest density was found in Kottavasal during the post-monsoon season (32.54±1.71), followed by the monsoon season (23.59±2.62) and the pre-monsoon season (14.78±2.36) (Table 2). There was no variation in population density between sites (F=0.7431, F critical=1.7382; P>0.05), although there was a substantial difference between seasons (F=8.7E+07, F critical=4.232; P<0.05).

Achankovil:

In Achankovil the highest density was found during the post-monsoon season (38.24±2.83), followed by the monsoon season (31.04±3.63) and the pre-monsoon season (17.87±2.69).(Table 2). There was no variation in population density between sites (F=1.3084, F critical=1.7382; P>0.05), although there was a substantial difference between seasons (F=1.7E+06, F critical=4.232; P<0.05).

VERTICAL DISTRIBUTION PATTERN:

Mekkarai: Cylisticus population density showed a definite pattern of vertical distribution in Mekkarai. The density is highest in the top layer (0-10 cm depth), and it diminishes with depth. The density variation is also seen in different seasons (Table 3). A two-way ANOVA revealed a significant variation in the density of *Cylisticus* between soil layers (F=12.6716 P<0.05) and seasons (F=7.029 P<0.05).

Kottavasal: In the Monsoon, Post-Monsoon, and Pre-monsoon seasons, the top layer (0-10 cm) had the highest density, followed by the intermediate layer (10-20 cm), and the bottom layer (20-30 cm) had the lowest density. This implies that there is a vertical distribution of *Cylisticus* population density in different soil strata, with the distribution pattern heading upward (Table 4). A two-way ANOVA was used to determine whether there was a significant variation in the density of *Cylisticus* at different depths (F=9.5808 P<0.05).

Achankovil: During the monsoon season, a greater number of *Cylisticus* were recorded in the top layer of soil (0-10 cm depth). In June, it was 18/m^2, 14/m^2 in July, and August. In the middle layer (10-20 cm depth), the density was lower. In June and July, it was just 12/m^2, 13/m^2 in August and 9/m^2 in September. The bottom layer (20-30 cm depth) has the lowest density. In June, it was 9/m^2, 8/m^2 in July and 4/m^2 in August and September. During the post-monsoon and pre-monsoon seasons, higher density was observed in the top layer (0-10 cm), followed by the intermediate layer (10-20 cm), and the bottom

Table 2: Mean Population density of *C. convexus* in Mekkarai, Kottavasal and Achenkovil during three seasons

Season	Mekkarai	Kottavasal	Achenkovil
Pre- monsoon	12.51 ± 1.82	14.78 ± 2.36	17.87 ± 2.69
Monsoon	22.34 ± 3.27	23.59 ± 2.62	31.04 ± 3.63
Post-monsoon	30.24 ± 1.94	32.54 ± 1.71	38.24 ± 2.83

Table 3: Seasonal vertical distribution pattern of *Cylisticus convexus* in Mekkarai

Depth	Pre-monsoon	Monsoon	Post-monsoon
	February	June	October
0-10 cm	11	14	18
10-20 cm	6	10	14
20-30 cm	3	5	6
	March	July	November
0-10 cm	7	11	15
10-20 cm	6	9	13
20-30 cm	2	2	4
	April	August	December
0-10 cm	5	12	14
10-20 cm	4	10	15
20-30 cm	2	2	3
	May	September	January
0-10 cm	2	10	10
10-20 cm	2	7	12
20-30 cm	1	1	2

Table 4: Seasonal vertical distribution pattern of *Cylisticus convexus* in Kottavasal

Depth	Pre Monsoon	Monsoon	Post-monsoon
	February	June	October
0-10 cm	8	18	20
10-20 cm	6	9	13
20-30 cm	3	3	4
	March	July	November
0-10 cm	8	13	16
10-20 cm	7	9	12
20-30 cm	4	3	3
	April	August	December
0-10 cm	5	12	19
10-20 cm	6	10	15
20-30 cm	2	2	2
	May	September	January
0-10 cm	5	10	18
10-20 cm	5	7	11
20-30 cm	0	2	1

Table 5: Seasonal vertical distribution pattern of *Cylisticus convexus* in Achenkovil

Depth	**Pre Monsoon**	**Monsoon**	**Post-monsoon**
	February	June	October
0-10 cm	13	18	23
10-20 cm	11	12	13
20-30 cm	3	9	7
	March	July	November
0-10 cm	11	14	20
10-20 cm	10	12	11
20-30 cm	3	8	7
	April	August	December
0-10 cm	6	14	23
10-20 cm	5	13	10
20-30 cm	2	4	6
	May	September	January
0-10 cm	3	13	21
10-20 cm	3	9	11
20-30 cm	2	4	5

layer (20-30 cm). This implies that the population density of *Cylisticus* is vertically distributed in different soil strata, with the distribution pattern trending upward (Table 5). A two-way ANOVA was used to determine if there is a significant difference in the density of *Cylisticus* at different depths ($F=8.8545$ $P<0.05$), and there is also a significant difference in the density of different soil layers at different seasons ($F=6.7177$ $P<0.05$).

Discussion

Achenkovil's soil is highly acidic in response and high in organic carbon content. The texture of the soil is sandy loam. The exchangeable acidity is relatively low, while the exchangeable base is considerable. This soil has high in nitrogen and phosphorus content, as well as potassium, calcium, and magnesium. Mekkarai's soil is mildly acidic and sandy loam in texture. The even values of soil characteristics indicated reduced mineral leaching from this ecosystem (Balagopal, 1980). Isopod population density is always high during the monsoon season. This is followed by the post-monsoon season and pre-monsoon. The high density of *Cylisticus* in the Achenkovil during and after the monsoon indicated that they prefer slightly acidic soil with high organic carbon content. This species' vertical distribution pattern revealed a preference for top soil habitant throughout monsoon, post-monsoon, and pre-monsoon season. The low density of *Cylisticus* in the bottom layer (20-30 cm depth) indicated that this species prefers aestivation in the cracks of rocks and barks. Isopods are less capable of vertical movement than collembolans (Yoshi, 1966). This study shows that this organism's vertical dispersion power is modest, with a maximum depth of 30 cm from the surface during any season of the year. This species' population density is highest during the monsoon season, followed by the post-monsoon and pre-monsoon seasons.

This study focused on the soil isopod *Cylisticus convexus*. The density of isopods was assessed in three habitats (Mekkarai, Kottavasal, and Achenkovil) at different seasons. Soil qualities at Mekkarai, Kottavasal, and Achenkovil were investigated. The vertical distribution pattern of isopods was investigated in three ecosystems during three seasons. In comparison to Mekkarai and Kottavasal, the population density of isopods was found to be higher in Achenkovil during all seasons. In the pre-monsoon season, the population density of isopods was nearly same in all three environments. Mekkarai, Kottavasal, and Achenkovil have sand loam soil that is acidic in response. The soil in Achenkovil has a high OC% and magnesium content. This isopod has a relatively limited vertical dispersal power in soil. It may reach a maximum depth of 30 cm below the surface. This organism's density is much higher at the top soil than in the middle layer (10-20 cm). The distribution of isopods is heavily influenced by the availability of organic carbon and the lack of phosphorus in the soil.

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