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Physico-chemical properties of pit soil of antlion larvae (Genus *Myrmeleon sp.*) with special reference to its population density

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Abstract
Antlion larvae made its conical pits in dry loose soil and predate small insects that fall down in to it. The Genus Myrmeleon coming under family Myrmeleontidae is a common pit building antlion larvae of Kerala, also a least studied group too. The larval stage is lengthy and may take up to two years to complete its larval stage. So the substrate should be more apt for the pit building behaviour as well as the high survival rate of the antlion larvae. Here, the antlion larvae Genus Myrmeleon inhabited substrate was collected and texture was noted by Hydrometer method. Out of the 27 soil samples collected from seven districts of Kerala, all the samples are coming under the texture class sand (six samples- fine sand, 21samples- sand). The four habitats were noted such as abandoned area, human dwelling area, forest boundaries and river banks. The habitat wise sand, silt & clay content were also examined and its chemical components were estimated. The highest number of larvae were collected from abandoned areas followed by human dwelling area and the textures in these two habitats were sand. The conclusion from this study depicts that, they prefer sand for making its pit and the population density of this medium is high. Ten chemical components of the media were correlated with population density and show a negative correlation with K and Ca.

Keywords: genus *Myrmeleon*, soil texture, hydrometer method, habitat, Kerala

Introduction

Antlion larvae Genus *Myrmeleon* is seen in loose soils and they make conical pits and wait for the prey that fall down in to it. The most common species coming under Genus *Myrmeleon* in Kerala are *Myrmeleon hyalinus* and *Myrmeleon pseudohyalinus*. In India published research works were not available in the larval behaviour studies and the special characters of their substrate wasn't analysed yet. The pit making of antlion larvae influenced by lots of parameters such as type of soil, soil illumination and vibrations. Though they are shade loving creatures it made its conical pits in abandoned areas and under the trees. The significance of the study relies on the life span of the antlion larvae. Antlion larvae took upto two years to emerge as adult from its larval stage. They are holometabolous insects and the larval stage is lengthy and they gave immense importance to lay its eggs in a safe substrate to maximise the survival rate.

Not many works were done about the soil type and preference of antlion larvae, but some works regarding soil stability and vibration were found that the larvae considered as the bioindicators of soil stability because they prefer fine grained, stable sands for pit building. According to state of environment report Kerala, the soil of the state has acidic in nature in general, low water holding capacity and high phosphate fixing capacity [2]. Soil formation is influenced by the climate, vegetation and hydrological conditions of the particular area and according to these lots of soil classification is present.

The main characteristic features of soil include soil temperature, soil moisture and soil texture. The different species of genus *Myrmeleon* was used for most of the previous studies and the pit building of *Myrmeleon pictifrons* in moisture condition and different grain size were studied by Kitching[5]. Sand preference study reveals the preference of find sand[6] for pit building in *Myrmeleon sp*. Instability of sandy soil was studied by Halloran *et al.*, [4] and the antlion larvae (*Myrmeleon crudelis)* considered as bioindicator of soil stability. The pit building strategy in different conditions like sand depth, soil type and thermal conditions were studied by Alcalay *et al.*, [1]. Maoge *et al.*, [7] analysed the chemical composition of the media and the role in the pit building of antlion larvae.

Materials and Methods

Study area: Soil sample were collected from antlion larval pits and the larvae inhabited area. 100 grams of soil samples were used for the texture analysis. The soil samples were collected from 27 study areas coming under seven districts of Kerala. Physical Properties of Soil- Hydrometer method- Procedure:- Weighed 50 g fine textured soil or 100 g coarse textured soil (>75-80% sand) which was passed through a 2mm sieve based on oven dry condition in to a beaker. Added 50 ml of 6% Hydrogen peroxide (H_2O_2) and covered the beaker with a watch glass and place it on a water bath until oxidation of organic matter is completed (indicated by the presence of effervescence), removed the beaker and cool. After cessation of frothing transferred the contents in to a dispersing cup with about 400ml of distilled water. Added to it 100 ml of calgon solution. Stirred the suspension for10 minutes by an electric stirrer. Transferred the suspension into a litre graduated cylinder and makeup the suspension up to 1 litre mark with distilled water. Stopper the mouth of the cylinder and shaked vigorously upside down and back several times for about 1 minute. Placed the cylinder on a table and noted the time

immediately. Dipped the Hydrometer in to the suspension and took the first reading after 4 minutes when particle >0.02mm have settled (Start inserting the hydrometer 10 seconds in advance of the reading time). Carefully removed the hydrometer and washed with distilled water and noted down the temperature of the suspension. Kept the suspension undisturbed and dipped the hydrometer again at the end of 2 hours after initial shaking was stopped. Now, the particles greater than 0.002mm (sand+silt) have settled. Recorded the hydrometer reading. Calculated the percentage of sand, silt and clay and determined the textural class using ISSS textural triangle [8].

Chemical properties of soil- The chemical components like Hydrogen ion concentration(PH), Electrical conductivity (EC), Organic carbon (OC), Nitrogen(N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulphur (S) , Boron (B) and Chlorine (Cl) were analysed in the labs of IRTC Mundur, Palakkad and KFRI, Peechi, Thrissur. PH and EC were determined by using PH meter and conductivity meter respectively. The principle behind the estimation procedure of OC was according to Schollenberger [9] and the methodology used for the estimation was Walkley-Black Wet Digestion Method [10]. The molybdenum blue method was used for the estimation of P and S by $CaCl_2$ extraction and the estimation of Ca, Mg, Fe, Mn, Zn and Cu by Atomic Absorption Spectrophotometry. Boron estimated by Hot-water soluble Boron method [3] and Nitrogen in the soil sample was determined by Alkaline permanganate method. Chloride determination is based on the formation of nearly insoluble silver salts. The relationship between chemical components and number of individuals were analysed in PAST software.

Population density of antlion larvae- The number of larvae were counted from the study area itself and the relationship between the population density and its chemical and physical properties of soil were done.

Results and Discussion

Table 1: Study areas in which the soil collections were made

Sl No.	Name of place	Habitat	Latitude	Longitude
1	Parli	Abandoned	10º47’36”N	76º33’52”E
2	Thiruvizhamkunnu	Forest	11º02’23”N	76º22’16”E
3	Parali Riverbank	Riparian	10º47’15”N	76º33’41”E
4	Parli Manamthody	Human dwelling	10º47’33”N	76º33’51”E
5	Edathara	Abandoned	10º47’29”N	76º33’58”E
6	Pezhumpara	Abandoned	10º34’41”N	76º36’13”E
7	Murukkumpara	Abandoned	10º49’62”N	76º32’94”E
8	Wadakkancherry	Human dwelling	10º39’52”N	16º15’05”E
9	Nedupuzha	Human dwelling	10º29’34”N	76º12’46”E
10	Kodungallur	Human dwelling	10º13’20”N	76º12’09”E
11	Poomala	Riparian	10º36’00”N	76º14’35”E
12	Ezhattumugham	Riparian	10º17’40”N	76º27’09”E
13	Vellayani	Human dwelling	8º25’53”N	76º59’09”E
14	Brennan college campus	Human dwelling	11º46’41”N	75º28’07”E
15	Kuruva	Riparian	11º50’48”N	76º04’20”E
16	Thennal resort, Kattikulam	Human dwelling	11º50’26”N	76º05’05”E
17	Bengalow kunnu	Forest	11º17’17”N	76º14’17”E
18	Nilambur Dippo	Human dwelling	11º16’44”N	76º15’11”E
19	Irrigation office	Human dwelling	11º16’18”N	76º13’43”E
20	Dhony temple	Forest	10º51’11”N	76º37’29”E
21	Idimuzhikkal	Human dwelling	11º09’48”N	75º52’39”E
22	Marthoma college, Tiruvalla	Human dwelling	9º24’02”N	76º35’02”E
23	Moyan modal school	Human dwelling	10º46’46”N	76º39’17”E
24	vettikkattiri	Human dwelling	10º43’53”N	76º16’56”E
25	Kanniyampuram	Human dwelling	10º46’14”N	76º21’26”E
26	Kinavallur	Human dwelling	10º48’32”N	76º33’56”E
27	Thumboormuzhi	Riparian	10º17’44”N	76º27’33”E

The study area in which the collection of antlion larvae was explained in Table 1 and the four different habitats of Genus Myrmeleon is described below

1. Abandoned area

The area in which no disturbance of animals, human being are considered as abandoned area.

2. Human Dwelling area

The area near to houses, schools, bus stops etc are considered as human dwelling area.

3. Forest area

The area near to forest boundaries are considered in this habitat. From the forest area up to 5 kms were considered as forest area in which abandoned areas, human dwelling area included.

4. Riparian

River banks were considered as riparian habitat.

Soil Texture Analysis

A total of 27 soil samples were collected from seven districts of Kerala namely Palakkad, Thrissur, Wayanad, Malappuram, Thiruvanathapuram, Kannur and Pathanamthitta. From this, twenty one soil samples were of the texture class sand and six soil samples were of the texture class fine sand (77.8% of soil samples were in texture class sand and 22.2% was fine sand).

Ten soil samples were collected and analysed the texture by examining the percentage of the soil components (sand, silt and clay) in Palakkad District. Seven soil samples are

coming under the texture class sand and three samples coming under fine sand (Fig. 1). The soil samples collected from the study area Parali, Thiruvizhamkunnam, Parli river bank were fine sand in texture and that of Ottappalam, Manamthody, Moyan school, Kinavallur, Edathara, Dhoni, and Pezhumpara were sand in texture. Ottappalam, Kinavallur and Edathara were the study sites in which the absence of silt component noted.

Seven soil samples were tested from Thrissur district (Fig. 2) in which three samples were coming under texture class fine sand and four samples were texture class sand. The soil samples collected from Asarikkadu, Wadakkanchery and Nedupuzha were fine sand in texture and Thumburmuzhi, Vallathol Nagar, Kodungallur, Poomala and Ezhattumugham were sand in texture. Kuruva and Kattikulam of Wayanad District (Fig. 3), Benglakunnu, Nilambur Dippo, Nilambur Irrigation office and Idimuzhikkal of Malappuram District (Fig. 3) were tested and the result shows the sand texture in that place. The samples collected from Vellayani of Thiruvanathapuram (southern district of Kerala state) (Fig. 4), Brennan college campus of Kannur District (Eastern part of state) (Fig. 4), Tiruvalla of Pathanamthitta District (Fig. 4) was sand in texture.

In the case of Palakkad District the minimum and maximum sand percentage is noted from the soil samples collected from Pezhumpara & Moyan modal school area and Thiruvizhamkunnu & Parli river bank respectively. Pezhumpara is an abandoned area and Moyan modal school is a human dwelling area. Thiruvizhzmkunnu and Parli river banks are coming under forest and riparian respectively. In the case of Thrissur, the sand percentage was minimum in the soil collected from Thumboormuzhy and the sand percentage was maximum in the soil collected from Murikkumpara and Nedupuzha.

In case of Malappuram district all the four samples were observed similar percentage of sand particle.The data regarding habitat and texture was described in Table 2 and its relationship with the population density was explained in Table 3.

Table 2: Consolidated data of soil collection districts, habitat and its texture.

Sl No	District	Habitat	Texture class
1	Palakkad	Abandoned	Fine sand
2		Abandoned	sand
3		Abandoned	sand
4		Forest area	Fine sand
5		Forest area	sand
6		Human dwelling	sand
7		Human dwelling	sand
8		Human dwelling	sand
9		Human dwelling	sand
10		Riparian	Fine sand
11	Thrissur	Abandoned	Fine sand
12		Human dwelling	Fine sand
13		Human dwelling	Fine sand
14		Human dwelling	sand
15		Human dwelling	sand
16		Riparian	sand
17		Riparian	sand
18		Riparian	sand
19	Thiruvanathapuram	Human dwelling	sand
20	Kannur	Human dwelling	sand
21	Wayanad	Riparian	sand
22		Human dwelling	sand
23	Malappuram	Forest	sand
24		Human dwelling	sand
25		Human dwelling	sand
26		Human dwelling	sand
27	Pathanamthitta	Human dwelling	sand

Table 3: Relationship between population density of antlion larvae and texture of pit soil

Sl no	Habitat	Presence of antlion larvae (%)	Texture	
			Sand (%)	Fine sand (%)
1	Abandoned	42.1	50	50
2	Forest	9.3	66.7	33.3
3	Riparian	8.1	20	80
4	Human dwelling area	40.5	86.7	13.3
	Total	100	100	

From the soil sample collection area, also noted the number of individuals for identifying the relationship between the texture of soil and number of individuals (Population density). From the data it is understood that, the highest number of larvae were collected from abandoned areas followed by human dwelling area. The textures in these two habitats were sand, the population density shows a positive correlation with the texture class sand. Below 10% of the larvae were collected from Forest and riparian habitat. The texture of soil collected from four habitats and the presence of antlion larvae were explained in the table 3 and 4.

Table 4: Relationship between the habitat and population density of antlion larvae

Sl No	District	Habitat	Population density
1	Palakkad	Riparian	8.9
2		Human dwelling	33.3
3		Abandoned	15.7
4	Thiruvananthapuram	Human dwelling	7.8
5		Human dwelling	3.3
6		Human dwelling	3.3
7	Thrissur	Abandoned	11.1
8		Human dwelling	12.2
9		Human dwelling	2.2
10		Human dwelling	2.2

The sand, silt and clay content in each district, habitat was explained in Fig 1 to Fig4. Number of individuals are significantly positively correlated with silt (Pearson's correlation, 5% significance) in sandy soil (Fig. 5). Soil samples collected from seven districts (total of 27 sites) indicated that sand was the predominant content, 80% of every soil sample was sand, and there was slight variation in the silt and clay content.

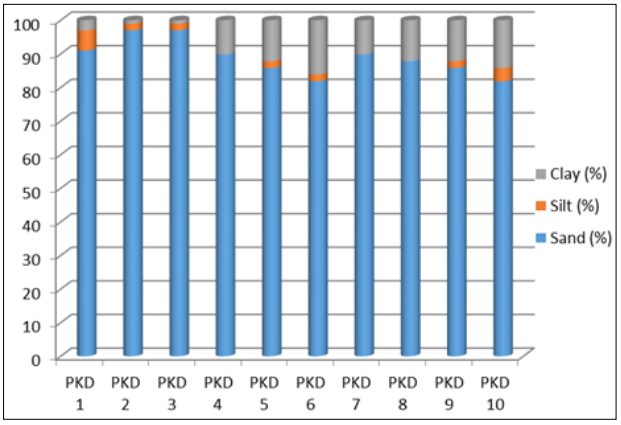

Fig 1: The sand, silt and clay percentage of soil samples in Palakkad District PKD1=AA, PKD2=FB, PKD3=RA, PKD4=RB, PKD5=HDA, PKD6=HDA, PKD7=HDA, PKD8=AA, PKD9=FB, PKD10=AA

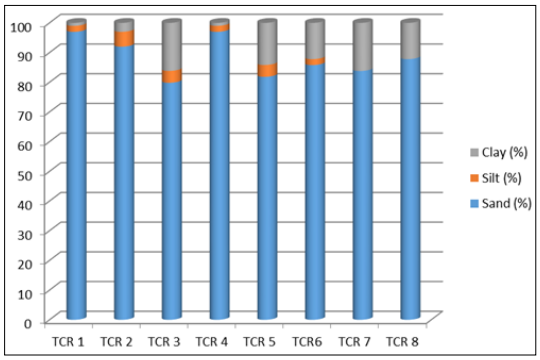

Fig 2: The sand, silt and clay percentage of soil samples in Thrissur District TCR1= HDA, TCR2=HDA, TCR3=RB, TCR4=HDA, TCR5=HDA, TCR6=HDA, TCR7=RB, TCR8=RB

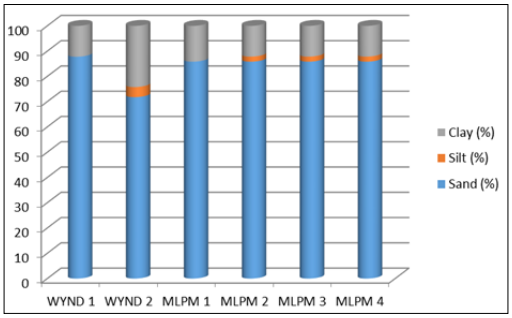

Fig 3: The sand, silt and clay percentage of soil samples in Wayanad and Malappuram Districts. WYND1=RB, WYND2=HDA, MLPM1=FB, MLPM2=HDA, MLPM3=HDA, MLPM4=HDA

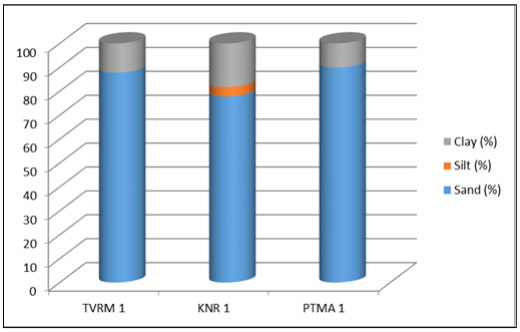

Fig 4: Sand, silt and clay percentage of soil samples in Thiruvananthapuram, Kannur and Pathanamthitta Districts TVRM1=HDA, KNR1=HDA, PTMA1=HDA

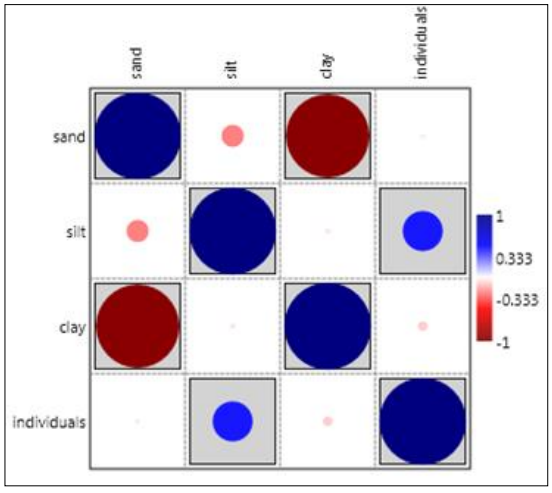

Fig 5: Correlation plot showing the relation between soil characters and Myrmeleon larvae.

Soil Chemical Analysis

Chemical composition of the media also has an important role in the pit building of antlion larvae. Higher the concentration of acidity, salinity, Calcium and magnesium are suppressive to larval development. But Potassium, Sulphate and Chlorides are good for larval development [6].

PCA for all 10 chemical parameters of soil where antlion larvae sampled and the number of individuals present were done. The soil chemical parameters are EC, OC, N, P, K, Ca, Mg, S and Cl. The Mg, OC, EC, and P^H were influenced the number of individuals in a positive manner. But, Ca and K show a negative correlation with the number of individuals. The Eigen values and map were given in Table 5 and Fig. 6 respectively.

Table 5: Eigen values

PC	Eigenvalue	% variance
1	2.26E+06	97.286
2	56452.5	2.4302
3	5133.78	0.221
4	1137.15	0.048953
5	232.276	0.009999
6	75.0003	0.003229
7	6.51953	0.000281
8	2.93664	0.000126
9	0.0668348	2.88E-06
10	0.00245453	1.06E-07

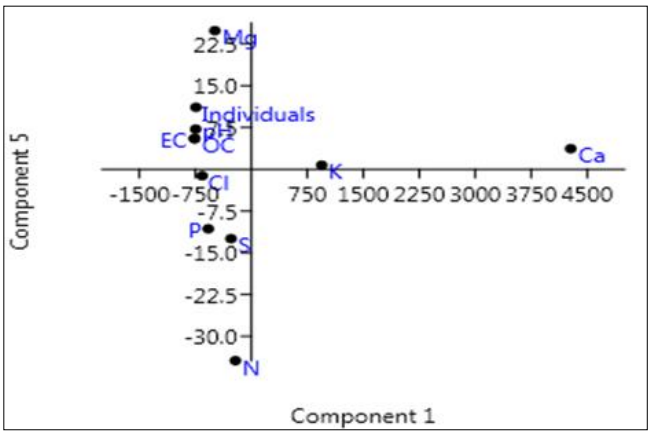

Fig 6: PCA map showing negative correlation between K & Ca and number of individuals.

The antlion larvae inhabited soil composed of sand, silt and clay particles. According to the International Union of Soil Sciences (IUSS), the soil particles were classified and this was used to interpret the soil texture in this study. Sand particles has low water and nutrient holding capacity, loose when dry and very low stickiness when wet. The silt components has low to medium water and nutrient holding capacity and shows some stickiness when wet. The clay component has high water and nutrient holding capacity, hard when dry and high degree of stickiness when wet.

From the 27 soil samples collected from study areas, 21 samples were classified under texture class sand and 6 samples were coming under fine sand. The sand texture was analyzed by evaluating the sand, silt and clay content of the soil samples. The correlation between the components of soil and number of individuals were performed and the result shows a positive correlation between the numbers of larvae with sand having highest silt content. It is assumed that, one reason behind the preference of sandy soil for pit

building substrate was the nature of sand and silt with low water holding capacity and easily dry when wet compared to clay soil.

The study of Phogat *et al*., [8] described that the larvae build its pits in sand particle with low water holding capacity and low stickiness when wet and the present study also agrees with this result. For the survival of antlion larvae they choose the sand particle for making its pit. If the rainy season or wet condition occurs, the larvae took a dormancy period by burying deep into the sand until the sand become dry. It is a survival mechanism of pit building antlion larvae. Chemical composition of the media also has an important role in the pit building and development of antlion larvae. From this study, a negative correlation between calcium and potassium with the number of individuals were identified. The relationship between the chemical component of antlion inhabiting soil and its influence on larvae are not studied earlier and it can be studied in future. In general, higher the concentration of acidity, salinity, calcium and magnesium are suppressive to larval development. But potassium, sulphate and chlorides are good for larval development. Soils those are more favorable for the development of larvae are rich in potassium, magnesium and sulphates. The element that adversely affects the development of antlion is nitrogen [7].

Conclusion

The study gives a baseline data about the different biotic and abiotic parameters of soil inhabiting antlion larvae and its habitat. This is only confined to a single genus and the larval stage is completed in soil with three instars. The lengthy larval period successfully completed by the help of its habitat and a first information regarding the soil and habitat was depicted in this study.

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