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Role of various diets on fecundity and longevity of an ecologically important soil Microarthropod-*cyphoderus javanus*

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Abstract
The purpose of this present study was to determine the influence of different diets on survival and reproductive outputs of soil collembolan *Cyphoderus javanus*. These experimental organisms were given four types of foods on the basis of their nutritional quality- Baker's yeast, rotten wood and bark, decaying plant litter and fresh leaves of *Artocarpus heterophyllus* (Jack tree). Feeding preference is very critical for collembolans survival and adaptation. The results indicated that under laboratory conditions maximum lifespan and fecundity were obtained in organisms fed with food having extreme nutritional quality (Baker's yeast). Absence of egg deposition and least longevity was observed in females fed with very low nutritional value containing diet (Fresh leaves of Jack tree). Poor food quality leads to lower individual life span and short reproductive period which helps to conclude that the population of *Cyphoderus javanus* are one of the highly sensitive collembolan species.

Keywords: longevity, fecundity, soil microarthropod, plant litter

Introduction
Soil is a complex living body that breaths, assimilates organic and in organic elements, breakdowns and mineralizes organic matters of biological origin and stores reserves as organic matter (Sharma and Pawez, 2017) [16]. Soil microorganisms are involved in major processes such as humification, recycling and mineralization of organic residues leading to the plant availability of nutrients (Emmerling *et al.*, 2002) [5]. Collembolans are the most abundant ubiquitous soil organisms in terrestrial ecosystems and considered as ideal biological indicators of soil fertility and ecosystem health may be due to their contribution towards soil genesis, dynamics and evolution (Bhagawati *et al*.,2020) [1]. They have very wide global distribution from sea shore to high altitude of the top mountain of Himalaya (Yoshii, 1966) [23]. According to Sharma and Pawez (2018) [17], natural stochasticity in insect abundance over short time scales is linked to their high reproductive rate and environmental factors (Schowalter,2011) [15] such as soil temperature, moisture, food availability and soil texture (King,1939) [9].In natural habitats, collembola feed on a great variety of resources such as fungi, bacteria, mosses, pollen grains, spores, decaying and debris (Mc Millan and Healey, 1971) [11]. *Cyphoderus javanus* is a common soil microarthropod species found in tropical lateritic soil of India and is characterized by large population in unpolluted fertile soils, short life cycle, high fecundity, frequent moulting and year-round reproduction in laboratory culture (Sahana *et al*., 2016; Das and Joy, 2009) [13, 4]. Some researchers (Watson, 1970; Booth and Anderson, 1979; Saur and Ponge 1988; Peternel1989; Kurup and Prabhoo, 1982) [22, 2, 14, 12, 10] have studied the gut contents of collembolan to know their food preferences, nevertheless we have very limited awareness about effect of food quality on life span, fecundity and moulting of collembolans. No data is available on the reproduction and life-history parameters of *Cyphoderus javanus* in relation to diet. Therefore, the present study investigates the effects of various food feeds on the longevity and fecundity of this species *Cyphoderus javanus* under laboratory conditions.

Materials and Methods
Collection and acclimatization of *Cyphoderus javanus*
The experimental organism for the present investigation *Cyphoderus javanus* were collected from three different sites of Thiruvananthapuram District- Neyyar, Vithura and Agastyavanam Biological Park. Sufficient soil samples of 25 cm^2 were randomly collected from different altitudinal places of study sites using a soil augar.100 samples were collected from study sites and brought to the laboratory and cultured in a small polythene vessel containing 2 cm thick layer of moist soil. The organisms in each culture jar were given with various foods- 1. Baker's Yeast (extreme nutritional value) 2. Decaying leaf litter (high nutritional value) 3) Rotten tree barks and wood (moderate nutritional value) and 4) Fresh leaves of *Artocarpus heterophyllus* (Jack tree) without visible damage (low nutritional value) and maintained at room temperature 28.9±0.5^{0}C. The medium was daily moistened with distilled water from time to time. The egg laying usually started within 3 days and newly

emerged juveniles and young ones were reared in separate vessel to obtain specimens of same age groups by transferring adults into new vessels at regular intervals.

Fecundity and Longevity Studies

For fecundity studies, live specimens of *Cyphoderus javanus* were randomly collected from different study sites during 12 months from July 2019 to June 2020. Specimens were separated by hand collection followed by light extraction methods (Haarlov, 1947) [7] and were cultured in polythene vessels of 6cm diameter and 7m height for further identifications. From the collected samples, seven sub adult male and female individuals were introduced into each culture vessel. The adults were removed after laying eggs and transfer 15 juveniles in each fresh culture jar with different foods. Fecundity was recorded in each oviposition by carefully separating eggs from culture chamber using a fine brush. Total number of eggs hatched in each oviposition, longevity, breeding cycle, egg development time, development period of juveniles, sub-adults and adults were recorded carefully.

Data Analysis

The experiments were carried out in five replicates and their mean values were considered for interpretation. Microsoft Excel and SPSS (2015) software were used for working out the statistical part.

Result and Discussions

Fecundity Studies: Eggs are laid in clusters. Freshly laid eggs of *Cyphoderus javanus* were small, spherical, soft, smooth and whitish in colour and about .0001 mm in size. The incubation period of *Cyphoderus javanus* were found to be 3-6 days with a mean of 3.2 days depending on the environmental temperature. Six ovipositions were observed for the entire five replica studied in female *C.javanus* fed with yeast pellets. The number of eggs laid were between 70 and 80 in first oviposition, between 81 and 87 in second oviposition, between 83 and 90 in third oviposition, between 68 and 81 in fourth oviposition, between 52 and 66 in fifth oviposition and between 45 to 50 in sixth oviposition. A mean number of 71.83 eggs were laid in each oviposition in replica one, 72.33 in replica two,71.16 in replica three, 70.67 in replica four and 70 in replica five (Table1). In case of *Cyphoderus javanus* fed with rotten wood and bark and five ovipositions were noticed, number of eggs of laid were between 47 and 54 in first oviposition, between 51 and 62 in second oviposition, between 64 and 68 in third oviposition, between 21 and 38 in fourth oviposition and between 4 to 12 in fifth oviposition. A mean number of 41.4 eggs were laid in each oviposition in replica one, 40.4 in replica two,44 in replica three, 40 in replica four and 41.6 in replica five (Table 2). The fecundity was observed between 75 (minimum) and 97 (maximum) numbers of eggs in five ovipositions in *Cyphoderus javanus* fed with decaying plant litter (Table 3). No eggs laid by female *Cyphoderus javanus* when fed with fresh leaves of Jack tree (with no visible damage) at 28.9±0.5^{0}C (Table 4).

Table 1: Fecundity of *Cyphoderus javanus* fed with Baker's yeast at 28.9±0.5^{0}C

Replicates	Oviposition						Total number of eggs laid	Mean number of eggs laid
	1	2	3	4	5	6		
1	70	87	88	74	66	46	431	71.83
2	80	85	90	68	64	47	434	72.33
3	76	82	83	76	61	49	427	71.16
4	73	81	87	81	52	50	424	70.67
5	71	83	89	72	60	45	420	70.00

Table 2: Fecundity of *Cyphoderus javanus* fed with rotten wood and bark at 28.9±0.5^{0}C

Replicates	Oviposition					Total number of eggs laid	Mean number of eggs laid
	1	2	3	4	5		
1	54	56	64	21	12	207	41.4
2	47	51	66	38	0	202	40.4
3	50	62	68	31	9	220	44.0
4	49	53	65	29	4	200	40.0
5	52	55	67	24	10	208	41.6

Table 3: Fecundity of *Cyphoderus javanus* fed with decaying leaf litter at 28.9±0.5^{0}C

Replicates	Oviposition					Total number of eggs laid	Mean number of eggs laid
	1	2	3	4	5		
1	30	40	18	8	1	97	19.4
2	28	37	12	0	0	77	15.4
3	32	31	15	5	2	85	17
4	23	42	10	0	0	75	15
5	21	45	9	1	0	76	15.2

Two-way ANOVA results revealed that there is no significant difference in the number of eggs in each replicate during different oviposition and showed significant variation in the number of eggs laid during different oviposition (Table 4). One-way ANOVA showed significant difference in fecundity of *Cyphoderus javanus* between different foods provided for culturing this experimental organism (F= 1679.415, F crit= 3.885294, P<0.05).

Table 4: Two-way ANOVA showing fecundity of *Cyphoderus javanus* with various diets

Food Quality	Between groups			Between Oviposition
	F	P-value*	F	P-value*
Baker's yeast	0.3167	0.8634	68.8161	6.57E-12
Rotten wood & bark	0.5914	0.6737	135.5379	4E-12
Decayed leaf litter	1.1429	0.3719	88.5781	1.05E-10

* P<0.05, significant

Longevity Studies: The maximum life span of *Cyphoderus javanus* is obtained in Baker's yeast fed organisms ranged between 110 (minimum) and 120(maximum) days. The maximum longevity observed in individuals fed with rotten wood and bark was 102 days and minimum of 92 days. The maximum longevity of 73 days and minimum of 62 days recorded in animals fed with decayed leaf litter and lowest life span noticed in organisms fed with fresh leaves (maximum: 39 and minimum: 29 days) (Table 5 &Figure 1)

Table 5: Effects of various diets on Longevity of *C. javanus*

Diet	Replicates					Mean ±SE
	1	2	3	4	5	
Baker's Yeast	120	115	110	117	112	114.8±0.16
Rotten wood and bark	102	100	99	97	92	98±0.17
Decayed leaf litter	69	62	66	73	66	67.2±0.21
Fresh Jack leaves	39	32	33	31	29	32.8±0.30

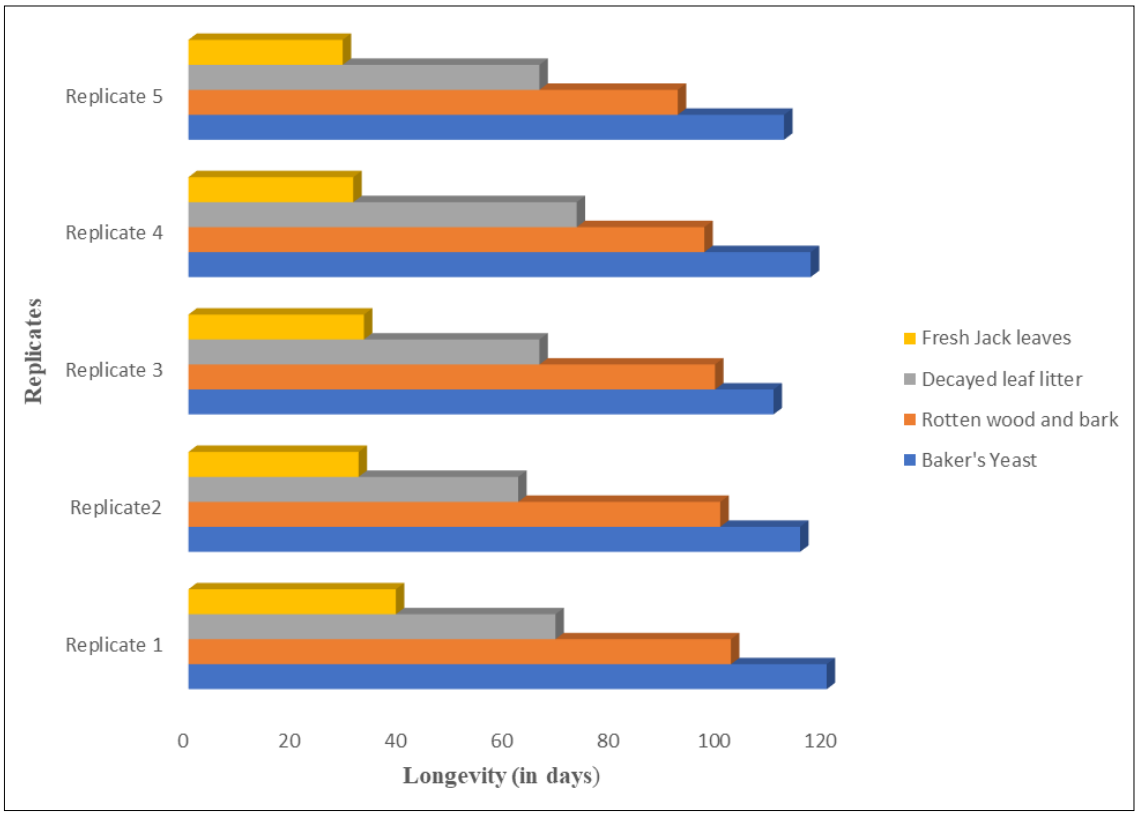

Fig 1: Dietery Effects on Longevity of *C. Javanus*

The present study confirming the results of Thomas and kumar (2020) [20], studied the effect of feed on the life history of a tropical soil collembolan *Bilobella branuera* and arrived at a conclusion fecundity, oviposition and longevity were affected by different types of feed provided, recorded maximum values in baker's yeast pellet feeding collembolans. The longevity in collembola is obviously dependent on environmental factors and probably species specific, greatest at lower temperatures and decreasing with increasing temperature (Ireson,

1990) [8].Pieternel *et al.* (1989) [12] reported that poor food quality leads to a longer individual life span, a longer reproductive period, helping to ensure that the *Folosomia candida* species can survive periods of adverse environmental conditions.

Size at breeding is an important life history parameter for terrestrial isopods as it influences female fecundity (Bouaziz *et al*., 2015) [3]. Brood development take place in a limited space on the female body, the larger females can bear more numerous broods (Sokolowicz and Araujo, 2013) [19]. Brood size increased as a function of length, independent of season whereas only large sized females produced more eggs in *Idotea baltica* in the period May to December (Guarino *et al*.,1993) [6]. According to Snider and Butcher (2017) [18], hatching success increases concurrently with the increase in egg production and decreases with progressing age and decreasing fecundity. Waller and Verdi (2016) [21] suggested that the variation in isopod fecundity explained by a combination of factors influencing individual growth and ecophysiology, genetic determinant of growth rate, ability of individuals to utilize resources, the given environmental conditions, the birth rate in seasonal environment and the timing of allocation of resources to reproduction.

Conclusion

Nutritional value of different foods significantly affected fecundity and survival *of Cyphoderus javanus*. Food with extreme nutritional quality increased longevity and reproduction while low nutritional quality of diet inversely affects organism's reproductive capacity and life span. High fecundity and longevity recorded in organism fed with baker's yeast, followed by rotten wood & bark and decayed plant litter. Very lowest rate of fecundity and lifespan are noticed in animals fed with fresh leaves of *Artocarpus heterophyllus* (having very low nutritional value). Diet with poor nutritional quality directly influences the biochemical and physiological body functions of the collembola and in turn alter the growth and survival capacities of the organism. The results of the above finding revealed that life history parameters growth, reproduction, onset of sexual maturity, egg production was closely related with nutritional quality of diet.

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