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The Role of the Millipede *Jonespeltis splendidus* VERHOEFF in an Ecosystem

(Diplopoda, Polydesmida, Paradoxosomatidae)

by

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Abstract: The role of *Jonespeltis splendidus*, a millipede inhabiting garden and forest floors in and around Bangalore, in the turnover of organic matter in different ecosystems was studied. The investigations revealed that these millipedes lower the C/N and H/F ratios and increase the availability of minerals in their habitats through their feeding and digestive activities, and thus serve as humifying and mineralizing agents in their ecosystems.

1. Introduction:

Soil formation is a complex process, involving the participation of soil macroinvertebrates in selective decomposition, transformation of organic material to humic compounds and formation of organomineral complexes (NYE 1955, LAVELLE 1988).

Although millipedes are one of the major regulators of this process, little is known about their role. Among millipedes, also the polydesmids are known as mull formers in forest floors (ROMELL 1935). To substantiate this a study was undertaken with the polydesmid millipede *Jonespeltis splendidus* VERHOEFF. In Bangalore these millipedes inhabit garden soils, the F and H layers of forest floors, compost heaps and the organic layers of arable land. They are geophagous, saprophagous and detritivorous. The feeding and digestive activities suggest the degradation of organic matter aided by symbiotic microflora in their gut (BANO et al. 1976). Moisture is the decisive factor for their occurrence. Their distribution is contagious and the maximum population recorded during 1975 - 1978 varied between 800 - 2400 and more per m^2 in different habitats (BANO & KRISHNAMOORTHY 1985). In the present paper their role in the increase of humic compounds in this ecosystem is discussed.

2. Sites and Methods:

2.1. Lalbagh (A Botanical Garden in South Bangalore):

Plot 1: about 1 ha, with a thick canopy of trees such as *Dalbergia sissoo, Coria myxa, Eugenia jambolana, Tamarindus indicus, Santalum album, Parkia biglandulosa* and *Plumeria acuminata.* Plot 2: 0.1 ha, with mixed tree canopy of *Pongamia glabra, Collivillea racemosa, D. sissoo, Feronia elephantum* and *Spathodea campanulata.* In both plots the soil is sandy loam with pH 6.8 - 7.0. Moisture 32 - 70 %, with a litter layer of 20 - 80 mm throughout the year.

2.2. Hebbal, Agricultural Research Station in North Bangalore:

A cultivated plot of coffee, 0.1 ha in area. The area included Banana and *Erythrina* trees along with coffee plants. Soil is sandy loam with pH 7,5 - 8,0, litter layer about 30 mm throughout the year. Moisture varied between 36 - 50 %.

2.3. Kempambudhi Tank: A Dried-up Tank in South West Bangalore:

The tank was laid dry in the land reclamation process, but a drainage channel running in the area was found to hold heavy populations of Jonespeltis. Soil, sandy loam, pH 6,5, moisture level 38 - 55 %. As there were no trees, ground litter was not present.

From these sites, fresh faeces of *J. splendidus* were carefully picked up with a forceps during the early hours of the day and brought to the laboratory. The faeces were oven dried at 105° C and used for analysis.

Apart from this, laboratory experiments were conducted, each using 200 millipedes in glass troughs of 30 cm diameter. The troughs were provided with various soils and soil litter complexes, the latter soft and partially degraded. About 1 kg of litter was added over a soil layer of 3 cm. The contents were moistened and the millipedes were introduced. After acclimation to the new habitat, the millipedes left faeces at the edges of the troughs. The faeces were carefully collected every 12 hours, oven-dried at 105° C and used for analysis.

2.4. Analysis of Faeces, Litter and Soil:

The faeces collected from the natural habitats and from experimental troughs and the soils and litter on which the animals fed were analysed independently for oxidizable carbon C, available nitrogen, carbon to nitrogen and humic to fulvic acid ratios (Tables 1, 2).

Table 1: Decomposition of organic matter by the millipede *Jonespeltis splendidus* in different habitats in India. Values are means of 3 replicates. C oxidizable Carbon, H/F humic/fulvic acid ratio.

Habitat		Samples	C %	N %	C/N	H/F
Lalbagh						
	Plot I	Soil	4,05	0,41	9,87	9,14
		Litter	31,05	4,34	7,15	14,00
		Faeces	13,20	1,36	9,71	5,88
	Plot II	Soil	2,40	0,41	5,85	6,00
		Litter	12,30	1,41	8,72	5,33
		Faeces	4,50	0,49	9,18	7,00
Hebbal		Soil	1,50	1,27	5,50	15,00
		Litter	37,05	3,79	9,77	22,00
		Faeces	9,40	1,82	5,16	6,38
Kempambudhi		Soil	0,45	0,43	1,04	28,00
		Faeces	0,75	0,61	1,22	9,87

The macronutrients present in the excrements, soils and litter (calcium, sodium, potassium and phosphorus) were determined in order to obtain the mineralization levels (Tables 3, 4). Apart from this, excrements from the different stadia were also analysed for humic substances (Tables 5).

The per cent oxidizable carbon was determined volumetrically by oxidation with potassium dichromate in conc. H_2SO_4 (WALKLEY & BLACK 1947). The humus compounds were extracted into 0,01 m NaOH and optical densities were measured spectrophotometrically (KONONOVA 1966, CAMPBELL et al. 1967). Non-protein nitrogen was determined by the micro-Kjeldahl method (HAWK et al. 1954), available calcium was determined titrimetrically by the Varsinate method (JACKSON 1967). Total potassium and sodium were determined by flame photometry (TOTH & PRINCE 1949). The composition of faeces was compared with that of the litter and soils used in the experiments. The results were statistically analysed (GOULDEN 1960).

Table 2: Decomposition of different litter types by the millipede *Jonespeltis splendidus* in sandy loam soils ($\bar{x} \pm$ SD, n = 4). C Oxidizable Carbon, H/F Humic to fulvic acid ratio.

		C %	N %	C/N	H/F
Mango litter	Soil	1,05	0,4	2,62	12
	Litter	22,05	4,34	5,08	13,66
	Faeces (4)	11,85 ± 0,653	1,08 ± 0,047	10,96 ± 0,2	7,1 ± 0,875
Cassia litter	Soil	1,05	0,81	1,3	11,5
	Litter	14,55	2,71	7,1	13,22
	Faeces (4)	7,45 ± 1,145	1,02 ± 0,094	7,28 ±0,475	6,92 ± 1,514

Table 3: Levels (µg · g^{-1} dry weight) of nitrogen, totel inorganic Ca, K^+ and Na^+ of soils and faeces of the millipede *Jonespeltis splendidus* ($\bar{x} \pm$ S.D., n = 6), * p < 0,05, ** < 0,01, *** < 0,001, n.s. not significant.

	Soil	Faeces	t	
Brown loam				
Total NPN	0,48 ± 0,09	0,47 ± 0,08	0,08	n.s.
Total Ca	88 ± 9	76 ± 11	3,08	*
Total Na^+	19 ± 2	18 ± 4	0,87	n.s.
Total K^+	3,3 ± 1,1	6,6 ± 2,2	4,40	**
Brown clay loam				
Total NPN	0,31 ± 0,07	0,33 ± 0,08	0,17	n.s.
Total Ca	80 ± 7	84 ± 6	1,33	n.s.
Total Na^+	22 ± 3	28 ± 4	4,10	**
Total K^+	3,8 ± 1,3	3,4 ± 1,1	0,60	n.s.
Black loam				
Total NPN	0,62 ± 0,09	0,42 ± 0,011	1,43	n.s.
Total Ca	211 ± 17	156 ± 11	8,82	***
Total Na^+	18 ± 4	27 ± 5	4,83	***
Total K^+	3,6 ± 1,2	4,3 ± 0,8	1,15	n.s.
Black clay				
Total NPN	0,26 ± 0,08	0,51 ± 0,06	8,75	***
Total Ca	96 ± 5	74 ± 12	8,90	***
Total Na^+	29 ± 6	30 ± 5	0,38	n.s.
Total K^+	2,6 ± 0,4	4,1 ± 0,5	4,55	**

3. Results and Discussion:

An increase in humic compounds was recorded in the faeces when compared to the soils and litter of the *J. splendidus* habitats. The faeces from the Kempambudhi tank were not as rich in humus compounds as those collected from the Lalbagh and Hebbal plots (Table 1). Similarly, the faeces collected in the laboratory from the soil-litter complex were richer in humic substances than the faeces collected from soils alone. The above results suggested that the millipedes consumed leaf litter and further degraded it in their gut; the resulting humification was evidenced by decreased C/N and H/F ratios. The stadia also acted as humifying agents in their habitat. This became espe-

Table 4: Percentage increase in mineralization levels of organic matter over control levels due to the millipede *Jonespeltis splendidus* C oxidizable carbon. $\bar{x} \pm$ S.D., n = 3.

	C	K_2O_5	Ca	P
Dung (Farm yard)	112,2 ± 1,4	96,2 ± 2,67	290 ± 5,65	226,2 ± 3,16
Mango	87,1 ± 1,4	66,1 ± 1,21	103,4 ± 3,73	131,1 ± 1,73
Guava	106,8 ± 2,3	124 ± 2,81	214,5 ± 9,85	222,5 ± 1,83
Tamarind	103,3 ± 2,47	131,2 ± 1,27	264,4 ± 4,12	46,4 ± 2,1
Hay	99,2 ± 2,71	143,3 ± 1,33	190 ± 0,97	92,1 ± 5,2

Table 5: Humification by different stadia of *Jonespeltis splendidus*: For explanation see Table 1. Values are means of 3 replicates.

	C %	N %	C/N	H/F
Sandy loam	1,35	0,869	1,55	27
Mango litter	22,05	4,34	5,08	13,66
Faeces				
Stadium III	4,5	0,966	4,65	6,76
Stadium IV	5,5	0,966	5,69	6,28
Stadium V	8,4	1,127	7,45	6,33
Stadium VI	11,55	1,67	6,9	6,8
Stadium VII	12,75	1,29	9,89	6,28
Adult	12,3	1,13	10,88	6,25

cially evident from the faeces of stages VI and VII, which were as rich in humic substances as the faeces of adults (Table 5).

An increase in macronutrients was found in the faeces collected from habitats containing litter as well as from the litter complex in the laboratory. However, there was variability in the release of minerals, perhaps depending on their concentration in the different litters or on the consumatory behaviour of the millipedes. Earlier studies on feeding behaviour suggested that these millipedes prefer partially degraded litter, as well as litter that is rich in nitrogen (BANO & KRISHNAMOORTHY 1981).

Humification in nature is achieved through the heterotrophic decomposition process, wherein myriads of organisms interact with each other and with the decomposing organic matter. In this study it is found that *Jonespeltis splendidus*, a millipede of common occurrence in Bangalore, is a selective browser, preferring moist and soft litter. This conforms with the observations of BOCOCK (1964) for soil animals. The faeces of millipedes also provide an increased surface area for microbial activity, thus facilitating further degradation.

In their habitat the millipedes feed on litter and also on farm yard manure or cattle dung, in the absence of which they prefer mineral soils. They were not found to feed on dead animals or on freshly fallen leaves. Although the contribution of these millipedes to mineral soils is negligible, they bring about soil aggregations, which improves aeration and water holding capacity. The faeces contain mucus, which promotes microbial attack. Thus these millipedes play a substantial role in nutrient cycling through decomposer organisms and in the humification process. Although their contribution does not rival those of earthworms and microbes, the levels of mineralization and humification recorded indicate their role as functional components of their ecosystem in terms of organic matter turnover and nutrient flow.

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