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Feeding and casting activities of the earthworm (*Octolasion tyrtaeum*) and their effects on crop growth under laboratory conditions

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The biochemical breakdown of plant residues caused by soil animals and micro-organisms is the main process of humus development (Haider 1996). Earthworms are one of the most important groups of soil animals involved in decomposing litter and incorporating plant residues in the upper soil horizons. The activity of earthworms has been shown to enhance plant yield (Curry & Boyle 1987) because of their beneficial effects on soil properties (Edwards & Bohlen 1996; Lee 1985). The objectives of the present study on endogeic earthworm *Octolasion tyrtaeum* were to analyse: (1) the effects of litter types on feeding and casting activities of earthworms in a surplus of three diets; (2) changes in properties of the soil in earthworm casts; and (3) evaluate effects of earthworm casts on crop growth. *Octolasion tyrtaeum* was selected for the present study, because this species is abundant in the study site (Kaushal *et al*. 1999).

The soil collected from agricultural field at Shamkhet (29^0 23´ N 79^0 31´ E; altitude 1700 m) is alfisol of laterite origin and contains 44% sand, 29% silt and 27% clay. The soil contained: organic C 3.61% and N 0.27% (C:N = 13.4). The soil was air dried, crushed and sieved through 2 mm sieve to remove earthworms, other soil fauna and fragments of grasses. Air-dried soil (2 kg) was packed into each glass column (15 cm diameter and 10 cm deep). The soil was maintained at 25% gravimetric moisture content and the columns were placed in a glasshouse at 20-25°C for 60 days.

Litter diets consisted of grass (*Cynodan dactylon* L.), maize (*Zea mays* L) and wheat (*Triticum aestivum* Spear). Plant leaves were collected at the approach of vegetal senescence assuming that this material represents the composition of food normally available to worms during their period of activity. Maize leaves were cut into pieces about 1-2 cm^2, and grasses and wheat leaves into 1-2 cm long pieces. Leaves were moistened and stored at room temperature in loosely sealed nylon bags and allowed to decompose slightly till they became visible brown with fungal colonization. Decomposition improves food acceptability (Edwards & Lofty 1977) and several studies have suggested that micro-organisms are essential for earthworm nutrition (Shipitalo *et al*. 1988).

Adults of *O. tyrtaeum* were collected from the agricultural field and cultured in the laboratory in the same soil. Five worms from the stock culture were added to each of the glass column, treated with three litter types. The worms were fed with freshly decomposing leaves and surface casts collected at weekly intervals, dried and weighed. The weight of the moist food added to each column was recorded and a sample of each food type was retained in order to determine equivalent dry weight. After the completion of the experiment, the

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columns were emptied; the worms were removed, rinsed and weighed. Unconsumed plant materials were separated from the soil aggregates. For each treatment the food consumption and the cast production were estimated.

Cast and non-ingested soil without litter were analysed to determine pH by a digital pH meter, organic C by wet oxidation method and P by the wet ashing method of Jackson (1958). Organic matter content was estimated from the percentage loss-on-ignition in a muffle furnace at 600°C (Mariño & Morgan 1999). N was determined by Kjel auto Vs-KTP Nitrogen Analyser based on micro Kjeldahl technique. K was determined by flame photometry.

For analysing the effects of *O. tyrtaeum* on plant growth, two treatments were applied; “control treatment” without earthworms, and a plus “earthworm treatment” with five clitellate individuals 60-70 day old having an average fresh weight (with gut contents) in the range of 3.4 to 4.4 g per pot. Earthen pots (26 cm diameter, 25 cm height) were filled with sieved soil brought from the site. All pots were maintained in the glasshouse at 20-25°C and 25-30% soil moisture. Five seeds of maize, barley and wheat were sown per pot; after three weeks, two plants were maintained per pot. The plants were harvested after 3 months and shoot and root weight was determined.

Food consumption rate by earthworms was 8.8 to 15.9 mg dry weight day^{-1}, and weight-specific food consumption 21.7 to 41.7 mg g^{-1} live worm day^{-1} on three food substrates (Table 1). No correlations were observed between initial worm biomass and weight-specific food consumption for all food substrates. According to Satchell (1983) food palatability is the most important factor influencing food consumption of earthworms. The food consumption is also influenced by the durability of the food particles (Bostrom & Lofs-Holmin 1986). Higher food consumption of *O. tyrataeum* with wheat leaves than grass and maize leaves in the present study indicates greater palatability and preference for wheat leaves. The consumption rates obtained in the present study probably overestimated actual earthworm consumption, as other sources of weight loss, e.g. decomposition due to micro-organisms, were not taken into account.

Although earthworms ingested lower amounts of maize leaves, they showed a better growth rate in comparison to other diets i.e. grass and wheat leaves (Table 1). Weight changes were positively correlated with food consumption for grass only ($r = 0.847$; $P < 0.1$), not for maize and wheat. The average relative growth rates of *O. tyrtaeum* (5.8 to 7.4 mg day^{-1}) were lower than the rates for *Lumbicus terrestris* and *L. rubellus* (10 mg day^{-1}) (Devliegher & Verstraete 1997; Shipitalo *et al.* 1988).

Under all diets, granular surface casts occurring as coherent masses were produced. Mean weight specific cast production rate when all food substrates were taken together was 16.7 mg live $worm^{-1}$ day^{-1} (Table 1). The cast production rates of *O. tyrtaeum* (12.6 - 24.1 mg g^{-1}) were low compared to 250 mg to 3.01g g^{-1} live worm day^{-1} reported for other species i.e. *Lumbicus terrestris* and *L. rubellus* (Shipitalo *et al.* 1988).

Mean pH of casts was slightly higher in laboratory samples than non-ingested soil (Table 2). Organic matter showed an increase of 11.5%, organic carbon 1.94%, nitrogen 63.0%, phosphorus

Table 1. Food consumption, worm weight change, cast production of *Octolasion tyrtaeum* under laboratory conditions for 60 days (± 1 SE).

Parameters	Maize	Grass	Wheat
Initial weight (g live $worm^{-1}$)	0.406 ± 0.019	0.4 ± 0.016	0.381 ± 0.017
Final weight (g live $worm^{-1}$)	0.629 ± 0.008	0.581 ± 0.05	0.556 ± 0.04
Change in weight (%)	+54.9	+45.3	+45.9
Mean growth rate (mg live $worm^{-1}$)	7.4 ± 0.7	6.0 ± 1.9	5.8 ± 1.4
Weight-specific growth rate (mg live $worm^{-1}$)	18.3 ± 1.1	15.1 ± 4.3	15.3 ± 3.6
Consumption (mg day^{-1})	8.8 ± 0.8	11.7 ± 1.7	15.9 ± 0.5
Weight-specific consumption (mg g^{-1} live $worm^{-1}$)	12.7 ± 1.4	29.3 ± 3.1	41.7 ± 2.2
Cast production (mg g^{-1} live $worm^{-1}$)	5.1 ± 0.2	5.3 ± 0.9	9.2 ± 0.4
Weight-specific cast production (mg g^{-1} live $worm^{-1}$)	12.6 ± 0.6	13.3 ± 2.4	24.1 ± 0.9

116% and potassium 176% in laboratory produced casts compared to non-ingested soil. C:N ratios of casts produced under laboratory conditions were lower than that of non-ingested soil. Several studies have reported that earthworm casts contain more C and N and have a higher C:N ratio than non-ingested soil (Lavelle *et al.*1992; Lee 1985*)*. Casts produced by *O. tyrtaeum* also contained more C and N but had lower C:N ratio than non-ingested soil which was probably more likely due to preferential selection of soil particles and higher N content of casts as has been recorded for *Lumbricus rubellus* by Syers *et al.* (1979). Higher concentration of available P occurred in earthworm casts compared with non-ingested soil observed for casts produced by *O. tyrtaeum* (Table 2), as also reported by several workers (Sharpley & Syers 1977), which could be contributed to enhanced earthworm activity, and partly to the physical breakdown of plant material.

The results of the crop growth experiment showed that compared to the "control" dry weight yield were higher in the "earthworm treatment" (Table 3). Compared to control, total plant dry weight in earthworm treatment increased 65% in maize, 58.1% in wheat and 61.7% in barley (Table 3). Marked effects of earthworms on plant growth have been demonstrated in pot and small-scale field enclosure experiments with dry matter increases ranging from 20-100% (Curry & Boyle 1987; Stephens & Davoren 1995). Similar results obtained for *O. tyrtaeum* indicate that manipulation of earthworms experiments are needed, using a range of earthworm densities, soil types and environmental conditions, in order to establish the conditions under which enrichment of soil with *O. tyrtaeum* can increase the crop yield.

Table 2. Changes in soil properties of non-ingested soil and casts produced by *O. tyrtaeum* under laboratory experiments (± 1 SE).

Soil characteristics	Non-ingested soil	Earthworm casts
pH	6.7 ± 0.07	6.9 ± 0.25
Organic matter (%)	6.08 ± 0.36	6.78 ± 0.01
Organic C (%)	3.61 ± 0.12	3.68 ± 0.01
N (%)	0.27 ± 0.015	0.44 ± 0.027
P (%)	0.012 ± 0.002	0.026 ± 0.002
K (%)	0.23 ± 0.03	0.64 ± 0.06
C:N ratio	13.4	8.4

Table 3. Dry weight (g dry wt.) of maize, barley and wheat plants after 90 days of growth in earthworm treatment under laboratory experiments (n = 5; ± 1 SE).

Treatment/ Crop component	Crops		
	Maize	Barley	Wheat
Control			
Shoot	3.2 ± 0.6	0.3 ± 0.07	0.5 ± 0.05
Root	2.3 ± 0.4	0.02 ± 0.01	0.04 ± 0.02
Earthworm treatment			
Shoot	6.02 ± 1.5	0.5 ± 0.2	0.82 ± 0.04
Root	3.15 ± 0.24	0.02 ± 0.06	0.1 ± 0.02

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References

Boström, U. & A. Lofs-Holmin. 1986. Growth of earthworms (*Allolobophora caliginosa*) fed shoots and roots of barley, meadow fescue and lucerne. Studies in relation to particle size, protein, crude fibre content and toxicity. *Pedobiologia* **29**: 1-13.

Curry, J.P. & K.E. Boyle. 1987. Growth rates, establishment and effects on herbage yield of introduced earthworms in grassland on reclaimed cutover peat. *Biology and Fertility of Soils* **3**: 95-98.

Devliegher, W & W. Verstraete. 1997. The effects of *Lumbricus terrestris* on soil in relation to plant growth: Effects of nutrient enrichment processes (NEP) and gut-associated processes (GAP). *Soil Biology & Biochemistry* **29**: 341-346.

Edwards, C.A. & P.J. Bohlen. 1996. *Biology of Earthworms*. 3rd edn. Chapman and Hall, London.

Edwards, C.A. & J.R. Lofty. 1977. *Biology of Earthworms*. Chapman and Hall, London.

Haider, K. 1996. *Biochemie des Bodens*. Ferdinand Enke, Stuttgart.

Jackson, M.L. 1958. *Soil Chemical Analysis*. Prentice Hall, Englewood Cliffs, N.J., U.S.A.

Kaushal, B.R., B. Kandpal, S.P.S. Bisht, S. Bora & R. Dhapola. 1999. Abundance and seasonal activity of earthworms in croplands of Kumaon Himalaya. *European Journal of Soil Biology* **35**: 171-176.

Lavelle, P., G. Melendez, B. Pashanasi & R. Schaefer. 1992. Nitrogen mineralization and reorganization in casts of the geophagous tropical earthworm *Pontoscolex corethrurus* (Glossoscolecidae). *Biology and Fertility of Soils* **14:** 49-53.

Lee, K.E. 1985. *Earthworms: Their Ecology and Relationships with Soils and Land Use*. Academic Press, Sydney.

Mariño, F. & A.J. Morgan. 1999. The time-course of metal (Ca, Cd, Cu, Pb, Zn) accumulation from a contaminated soil by three populations of the earthworm, *Lumbricus rubellus*. *Applied Soil Ecology* **12**: 169-177.

Satchell, J.E. 1983. Earthworm microbiology. pp. 351-364. *In*: J.E. Satchell (ed.) *Earthworm Ecology – From Darwin to Vermiculture*. Chapman and Hall, London.

Sharpley, A.N. & J.K. Syers. 1977. Seasonal variation in casting activity and in the amounts and release to the solution of phosphorus form earthworm casts. *Soil Biology & Biochemistry* **9**: 227-231.

Shipitalo, M.J., R. Protz & A.D. Tomlin. 1988. Effect of diet on the feeding and casting activity of *Lumbricus terrestris* and *L. rubellus* in laboratory culture. *Soil Biology & Biochemistry* **20**: 233-237.

Stephens, P.M. & C.W. Davoren. 1995. Effect of the lumbricid earthworm *Aporrectodea trapezoid* on wheat grain yield in the field, in the presence or absence of *Rhizotonia solani* and *Gaeumannomyces graminis* var. *tritici*. *Soil Biology & Biochemistry* **28**: 561-567.

Syers, J.K., A.N. Sharpley & D.R. Keeney. 1979. Cycling of nitrogen by surface casting earthworms in a pasture ecosystem. *Soil Biology & Biochemistry* **11**: 181-185.