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Habitat spectra of the Lumbricidae (Oligochaeta) in Finland

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A study of the Lumbricidae in nine types of habitat in different parts of Finland shows that both the habitat spectra and the constancies of the species decrease gradually from south to north, the more eurytopic species (*Dendrobaena octaedra* (Sav.), *Dendrobaena rubida* (Sav.) s.l. and *Lumbricus rubellus* Hoffm.) extending farther north than the less eurytopic and stenotopic ones. At the northern periphery of their ranges the species occupy those types of habitat in which they are most constant in southern Finland, and the more eurytopic a species is in the south, the less rapidly its habitat spectrum diminishes towards the north. Similarities in habitat spectrum were found between some of the species, but these did not apply over the whole range of the species in Finland.

The number of species decreases gradually along the climatic gradient from the south of Finland to the north. Within each climatic zone it also decreases along a soil gradient from fertile mull to raw humus or peat. The effect of climatic and edaphic factors upon the geographical distribution and habitat spectra of the species in Finland is discussed.

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In Finland most of the Lumbricids reach the northern limit of their ranges (KARPPINEN & NURMINEN 1964, TERHIVUO & VALOVIRTA 1974). Their occurrence in Finnish coniferous and deciduous forest soils has been studied by SIIVONEN (1941), KARPPINEN (1958), HUHTA *et al.* (1967) and NURMINEN (1967). The present paper concerns the habitat spectra of eleven Lumbricid species in different parts of Finland. It is based on sampling from nine types of habitat between 60° N and 70° N, along a S-N climatic gradient of about 1 100 km.

1. Material, methods and habitats

Altogether 421 localities representing nine types of habitat and distributed all over Finland were sampled on 1—11 August 1970, 8—20 June 1971, 1—10 August 1972, 13 September — 4 October 1973 and 26 June — 3 July and 28 September — 19 October 1974 (Fig. 1, Table 1). In each locality 2—5 persons performed the qualitative sampling (digging, searching under stones, in stumps, in compost, in dung heaps, etc.). The specimens were preserved in 70 % ethanol or in a solution of 2 parts of 80 % ethanol and 1 part of 40 % formalin.

At each sampling site the dominant plant species were recorded. On the basis of the uniform grid 27°E system (HEIKINHEIMO & RAATIKAINEN 1971) the localities were grouped into four zones, which roughly correspond to the climatic zones of JOHANSSON (1936) (Fig. 1; the climatic zones were redrawn from KALLIOLA 1973).

The nine habitat types. The forests (i.e. all habitats with trees) are arranged according to increasing moisture and luxuriance of vegetation from CIT to forests with rich soils. In central and northern Finland the forest types of southern Finland are replaced by parallel types of plant communities. In this paper the abbreviations for southern forest types are used to symbolize the forests in all zones.

1. *Cladina (CIT) and Calluna (CT) types.* Dry, podsolic soils with acid raw humus, pH about 4. Dominant tree *Pinus* and dominant dwarf shrub *Calluna*; few, if any, bushes, grasses or herbs. The ground layer is dense with *Cladina* and *Pleurozium.*

2. *Vaccinium type (VT).* Less dry, podsolic soils with acid raw humus. *Pinus, Juniperus,* more dwarf shrubs, grasses and herbs, but fewer lichens than in CIT and CT.

3. *Myrtillus type (MT).* Moist heath forest, podsolic soils with acid raw humus. *Picea, Pinus, Betula,* many grasses and herbs; the dominant dwarf shrub is *Vaccinium*; dense moss layer with many species, including *Hylocomium* and *Pleurozium.*

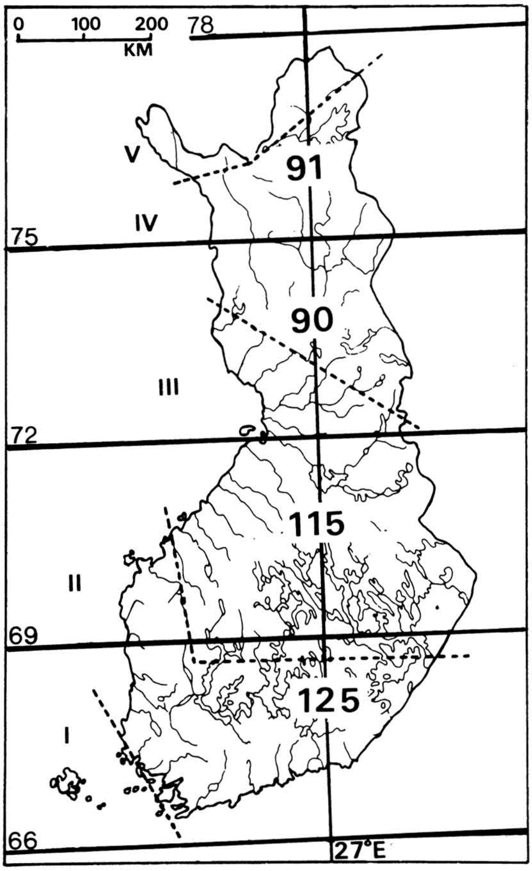


Fig. 1. Numbers of Lumbricid samples from the four zones (66–68, 69–71, 72–74 and 75–77) and the climatic zones of Finland (I–V, dashed lines) according to Johansson (1936, redrawn from (Kalliola 1973)

4. *Oxalis-Myrtillus type (OMT)*. Moist heath forest, soils with less acid humus than in MT. Dominant trees often conifers, but many deciduous trees, bushes, herbs and grasses, and fewer dwarf shrubs and mosses than in MT.

5. *Forests with rich soils (OMaT, FT etc.)*. Mull-like, weakly acid or neutral soils. Deciduous trees and conifers; vegetation luxuriant with many bushes, herbs and grasses; dwarf shrubs almost absent, moss layer sparse but rich in species.

Open habitats (without trees) comprise both 'man-made' and 'natural' habitats.

6. *Backyards*. Soils with dung heaps, compost, etc., near human settlements and inhabited by anthropochorous species. The soil is rich in organic matter and ruderal plants. Sampled only in 1972—74.

7. *Meadows*. Both dry and moist types, rich in grasses and herbs; soils mull-like or clayey. Many were earlier tilled.

8. *Shores*. Plant communities of various kinds by the sea or lakes or rivers. Wet or moist soils with mud, organic matter or clay.

9. *Bogs*. Usually very acid with *Sphagnum* peat, some with small *Pinus* and dwarf shrubs (*räme* bogs), a few ditched.

Since many of the individuals of *Dendrobaena rubida* (Sav.) (*s.l.*) were immature, they were not identified to subspecies but treated collectively.

2. Results and discussion

A. Habitat spectra

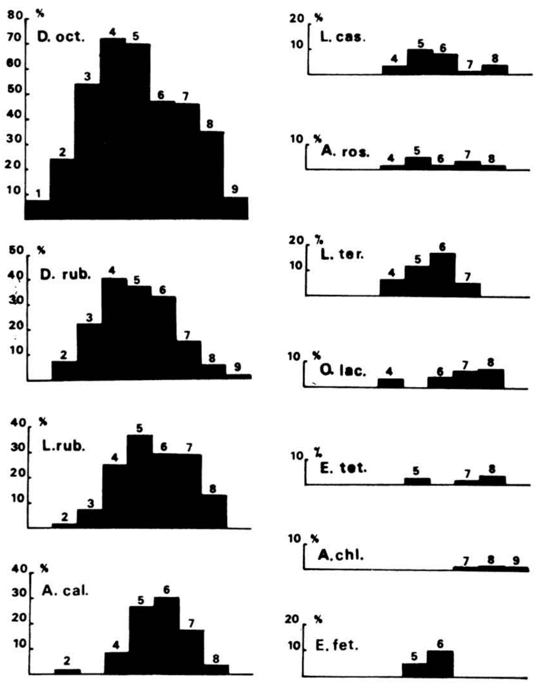
Table 1 lists the frequencies of the 11 species recorded in the various habitats. The most constant was *Dendrobaena octaedra* (170 records in 421 localities sampled, i.e. 40.4 %), and this species has the widest habitat spectrum. The less eurytopic *D. rubida* (*s. l.*) and *Lumbricus rubellus* were recorded in 18.3 % and 17.1 % of the samples, respectively, whilst for all the other species the values were ≤ 10 %. As most species do not occur throughout Finland, the mean constancies are low. In calculating the constancies (Fig. 2) account was taken of the differences in the numbers of samples from habitats of different types within each of the four zones (see Table 1). Thus every record of the species was multiplied by the term $\frac{13}{n}$, 13 being the approximate mean number of samples taken in a habitat, and n the number of that type of habitat sampled within the zone in question.

Fig. 2 may also give some idea of the habitat preferences of the species. *D. octaedra* was found most often in OMT, forests with rich soils and MT. It was also found in the most extreme habitats, viz. CT forests and bogs, but was not very constant there. *D. octaedra* was the only species found more than once in bogs, mostly in decaying logs buried in *Sphagnum* near the forest edge. Thus in Finland this species is not restricted to forests, as suggested by Siivonen (1941:14).

Dendrobaena rubida (*s. l.*) was mostly recorded in OMT, forests with rich soils and backyards (Fig. 2). *Allolobophora caliginosa* was most often found in backyards, forests with rich soils and meadows; once recorded in VT near a meadow

Table 1. The numbers of samples from different habitats in 1970–74 within the four zones and the frequencies of the species.

Habitats	Zones 66–68 n	with Lumbricids	69–71 n	with Lumbricids	72–74 n	with Lumbricids	75–77 n	with Lumbricids	*Eiseniella tetraedra*	*Allolobophora rosea*	*A. caliginosa*	*A. chlorotica*	*Octolasion lacteum*	*Eisenia fetida*	*Dendrobaena octaedra*	*D. rubida* (s.l.)	*Lumbricus rubellus*	*L. castaneus*	*L. terrestris*	Number of species
Cladina (CIT) and Calluna (CT) types	13	3	15	1	10	—	11	—	—	—	—	—	—	—	4	—	—	—	—	1
Vaccinium type (VT)	14	10	14	2	11	1	11	1	—	—	1	—	—	—	13	4	1	—	—	4
Myrtillus type (MT)	14	14	14	8	10	4	12	5	—	—	—	—	—	—	28	12	4	—	—	3
Oxalis-Myrtillus type (OMT)	15	14	14	10	9	8	10	4	—	1	5	—	2	—	31	17	12	2	4	8
Forests with rich soils (OMaT, FT etc.)	15	15	13	13	10	9	11	6	1	3	15	—	—	3	35	20	20	6	7	9
Backyards (soils near human settlements)	12	12	4	3	5	4	6	2	—	1	10	—	2	5	12	12	11	4	5	9
Meadows	15	15	13	10	11	5	10	2	1	2	10	1	4	—	24	8	17	1	3	10
Shores	13	9	14	7	13	5	9	2	2	1	2	1	4	—	18	3	7	2	—	9
Bogs	14	4	14	2	11	—	11	—	—	—	—	1	—	—	5	1	—	—	—	3
Total	125	96	115	56	90	36	91	22	4	8	43	3	12	8	170	77	72	15	19	—
%		76.8		48.7		40.0		24.2												



in Maarianhamina (668:10), Åland. In *Lumbricus rubellus* the constancy was highest in forests with rich soils.

Lumbricus castaneus and *Allolobophora rosea* were most constant in forests with rich soils but occur only in southern Finland. *L. terrestris* was most often recorded in backyards and forests with rich soils. In northern Finland *L. terrestris* and *A. caliginosa* were found only in backyards, their presence perhaps being due to human influence.

Octolasion lacteum was mostly found in shore and meadow soils, *Eiseniella tetraedra* in shore

←

Fig. 2. Constancies and habitat spectra of the species. The smoothed constancy values refer to Finland as a whole (see text). Forests: 1 = CIT and CT, 2 = VT, 3 = MT, 4 = OMT and 5 = forests with rich soils (OMaT, FT etc.); open habitats: 6 = backyards (soils near human settlements), 7 = meadows, 8 = shores and 9 = bogs.

soils and *Eisenia fetida* in backyards. *E. tetraedra* was once recorded in a wet *Betula* stand on the slope of Saana fell in Kilpisjärvi (767:27), Finnish Lapland (TERHIVUO & VALOVIRTA 1974).

According to JULIN (1949), *Eisenia fetida* is entirely dependent on human activity. In southern Finland it seems able to survive in forests with rich soils and great annual accumulation of organic matter, but evidently these individuals have spread from places under permanent human influence.

Two individuals of *Allolobophora chlorotica* were found submerged in a pool in a peat bog near Överby (670:09), Åland, SW Finland. Since this species was also found in the nearby shore at Marsund (670:09), it may survive in moist and even submerged habitats in Åland, at least.

D. octaedra, *D. rubida* and *L. castaneus* live mostly in the upper layers of the soil, *A. caliginosa*, *A. rosea* and *L. terrestris* are deep-burrowing species which require soils rich in organic matter, and *L. rubellus* is intermediary between these two groups (JULIN 1949, ABRAHAMSEN 1972, RUNDGREN 1975). Fig. 2 shows that the deep-burrowing species tend to have narrower habitat spectra than the species of the upper layers. *L. rubellus* is intermediary in this respect as well.

Among the Lumbricids, *D. octaedra*, *D. rubida* (*s. l.*) and *L. rubellus* are the most eurytopic species in Finland. They also have the widest habitat spectra in Iceland (BENGTSON *et al.* 1975), Sweden (JULIN 1949, NORDSTRÖM 1974) and Norway (STÖP-BOWITZ 1969, ABRAHAMSEN 1972).

B. Regional differences in habitat spectra

Fig. 3 shows the cumulative frequencies of each species within the four zones. About 50 % of all the records were made in zone 66—68, about 25 % in 69—71, 15 % in 72—74 and 10 % in 75—77. Four species, *A. rosea*, *A. chlorotica*, *L. castaneus* and *E. fetida*, were found only in zone 66—68. *D. octaedra* was the only species recorded in all four zones.

Fig. 4 shows the regional differences in the habitat spectra of the six species recorded in at least two of the four zones. In view of the few records of *E. tetraedra* this species was excluded. The more eurytopic the species is in southern Finland, the farther north it occurs, and the wider is its habitat spectrum even at the periphery of its range. At the periphery of their ranges the species were mostly recorded in those habitats where they were most constant in southern Finland.

Two qualitative indices based on the presence or absence of the species in each of the nine types of habitat were used to study the similarities in the habitat spectra of the species in

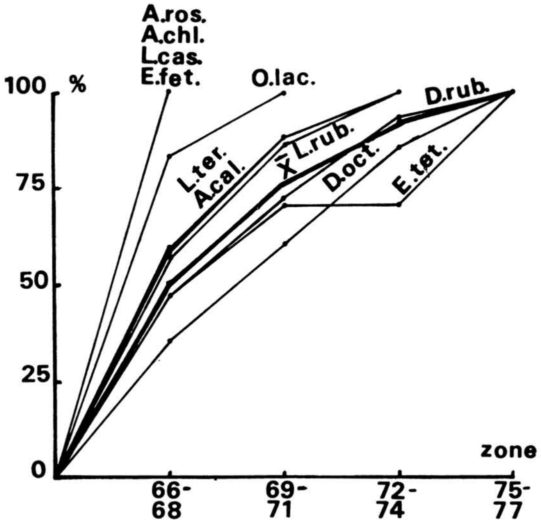


Fig. 3. Cumulative frequencies of the records of each species within the four zones. X̄ refers to all the records.

Table 2. Similarities in the habitat spectra of the species in different zones. Index values of ≥ 75 % are given (see also the text). Symbols: / = the index of Jaccard (1902), × = the indices of Sørensen (1948). and Jaccard (1902).

	Zone 66–68								Zone 69–71			Zone 72–74	
	A. rosea	*A. chlorotica*	*O. lacteum*	*D. octaedra*	*D. rubida* (s.l.)	*L. rubellus*	*L. castaneus*	*L. terrestris*	*D. rubida* (s.l.)	*L. rubellus*	*L. terrestris*	*D. rubida* (s.l.)	*L. terrestris*
E. tetraedra	—	/	—	—	—	—	—	—	—	—	—	—	—
A. caliginosa	×	—	/	/	×	×	×	/	×	×	×	—	×
O. lacteum	×	—	—	—	—	—	×	/	—	—	—	—	—
D. octaedra	—	—	—	—	×	×	—	—	—	—	—	/	—
D. rubida (s.l.)	/	—	—	—	—	×	/	—	—	/	/	—	—
L. rubellus	/	—	—	—	—	—	/	—	—	—	—	—	—
L. castaneus	×	—	—	—	—	—	—	×	—	—	—	—	—
L. terrestris	×	—	—	—	—	—	—	—	—	/	—	—	—

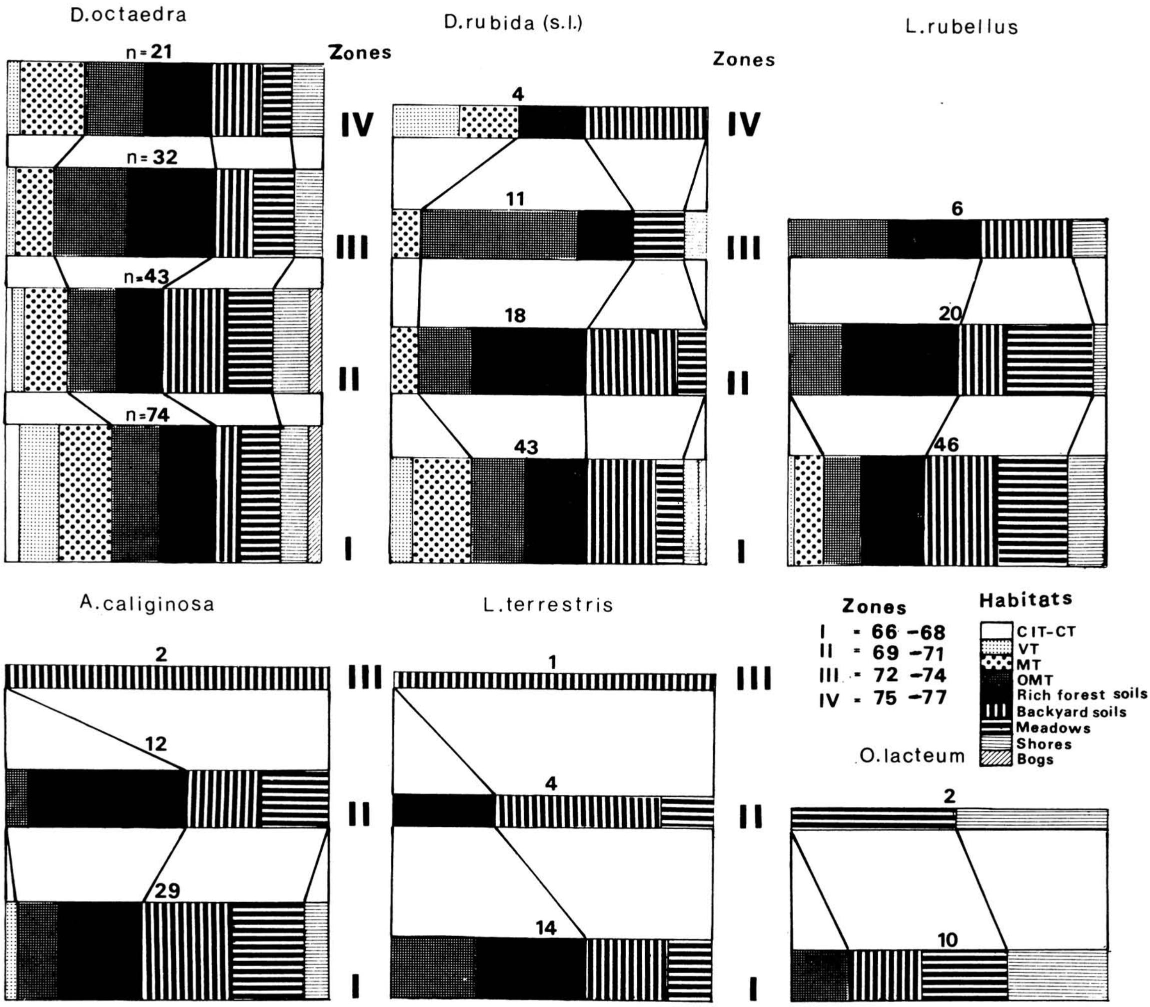


Fig. 4. Differences in the habitat spectra of six species in different zones. The habitat spectra of the other species are seen in Fig. 2.

each zone. The indices are: JACCARD (1902), $CC = \frac{c}{a+b-c} \cdot 100$, where a is the number of those types of habitat where species 1 was recorded, b is the number of those where species 2 was recorded, and c is the number of those where both species were found; SØRENSEN (1948), $QS = \frac{2c}{a+b} \cdot 100$, symbols as before. Table 2 gives the index values of ≥ 75 % for every two species compared.

Most of the values in Table 2 refer to zone 66—68. The habitat spectra of the various species do not all decrease according to the same pattern, and for the species with highly similar index values in Table 2 the constancy peaks (Fig. 2) mostly do not occur in the same habitat, either. This suggests that the species compared have different habitat preferences.

C. Occurrence of Lumbricidae in relation to climatic and edaphic factors

The constancies of the Lumbricid species in the nine types of habitat within the four zones are given in Fig. 5. In southern Finnish forests the number of species increases from 1 to 8 along a gradient from dry to moist forest types.

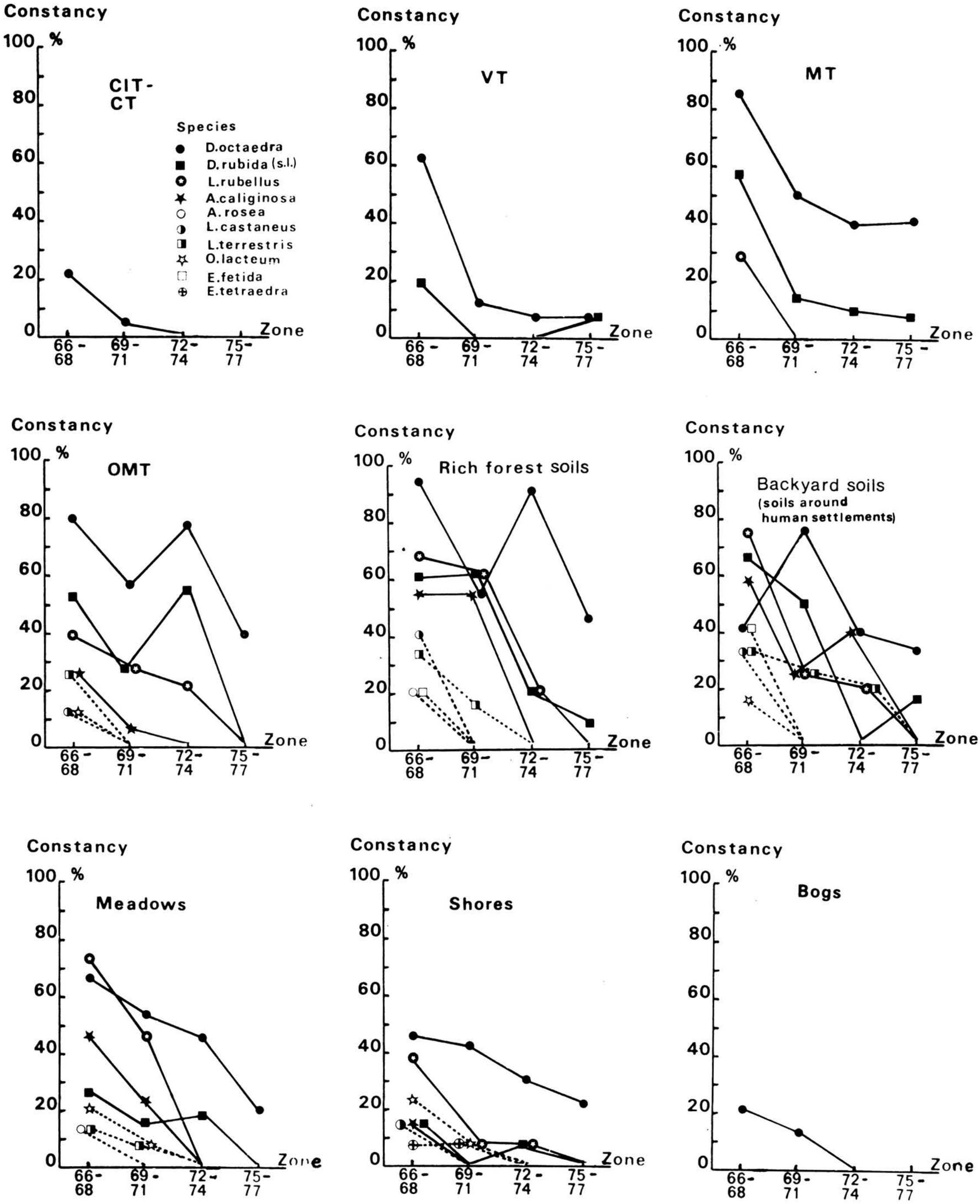


Fig. 5. The constancies of Lumbricid species in the nine types of habitat and in the four zones. In each habitat only the species recorded at least twice are included.

Table 3. Climatic data of the zones seen in Fig. 1, according to JOHANSSON (1936, taken from KALLIOLA 1973).

Temperature and rain (annual means)	Climatic zones I	II	III	IV	V
Number of days with mean temperature of ≥ +5°	~180	180—160	160—140	140—120	<70
Number of months with mean temperature of > 0°	> 8	8—7	7—6	6—5	5—3
Mean temperature of July (°C)	+16	+16 — 17	+16	+14 — 15	+12 — 14
Mean temperature of February (°C)	—4 — 5	—6 — 9	—9 — 11	—12 — 14	—14 — 12
Annual rainfall (mm)	500—600	600—700	500—600	400—550	400—450
Mean depth of snow cover (cm)	<20	20—50	30—70	60—70	50—60

In northern Finland the corresponding increase is from 0 to 2, the other two zones being intermediary.

In southern Finland the numbers of individuals vary much even within the same forest type. In VT there may be 4—36 ind./m², in OMaT forests 52—346 ind./m² (KARPPINEN 1958:138, see also SIIVONEN 1941, HUHTA *et al.* 1967) and in a luxuriant *Corylus* stand in Åland 816 ind./m² (Terhivuo, unpubl.). Undoubtedly, not only the number of species (Fig. 5) but also the number of individuals is highest in forests with rich soils and lowest in dry heath forests. Fig. 2 shows that the species occurring in dry heath forests have higher constancies in forests with good soils. Evidently, they are able to tolerate the extreme edaphic conditions prevailing in dry heath forests, but these habitats are suboptimal for them. It seems that a high content of soil moisture improves the environmental conditions for Lumbricids both directly and indirectly.

The decrease in the constancies of the species towards the north is found for each forest type (Fig. 5). The peaks in *D. octaedra* and *D. rubida* (*s.l.*) in zones 72—74 and 69—71 (OMT, rich forest soils and backyards) do not differ significantly from the corresponding values in zone 66—68. The climatic data for the four zones (Table 3) show downward trends both in the annual temperature conditions and in the annual amount of rain towards the north.

The same downward trends in numbers and constancies are also seen in the open habitats. Those with most species in common are the backyards and the meadows, but the constancies tend to be lower in the latter. The shores are rich in species but the constancies are low. Bogs are poor in both respects.

The downward trends in the constancies and numbers of the species in both forests and open habitats in successive zones are probably due chiefly to climatic factors. The climatic conditions become gradually more severe from south to north in Finland (Table 3) and so determine the northernmost limit of distribution for each species. But none of the species are distributed equally far north in every kind of habitat they occupy, which shows that their occurrence is strongly influenced by edaphic factors. Probably, the narrowing of the habitat spectra of the species towards the north mostly indicates the joint influence of climatic and edaphic factors upon the different species. Since the species differ from each other physiologically and genetically and seemingly prefer different types of habitat, their habitat spectra do not diminish equally in all the zones. Our data were not quantitative and so do not warrant any conclusions about the possible role of intra- and/or interspecific interactions of the species in the different habitats. For this further studies are needed.

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