Chapter 20

Development of earthworm populations in abandoned arable fields under grazing management.

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20.1 INTRODUCTION

An experiment was begun in 1972 on a nature reserve in the southern Netherlands with the object of incorporating adjacent abandoned arable land into the reserve. Icelandic horses were introduced as herbivores additional to the native rabbit population to graze the developing vegetation and so maintain the open character of the landscape and merge the boundaries between the reserve and the fields. This experiment created an opportunity to investigate the development of the earthworm population in relation to the vegetation succession.

The low density of earthworm populations in arable land has been attributed partially to mechanical damage during cultivation but Evans and Guild (1948) considered the main limiting factor to be the low input of suitable plant residues. This study investigated the effect of plant residues from the developing vegetation on the earthworm population and the influence of earthworm activity on the soil conditions and vegetation.

20.2 STUDY AREA AND SAMPLING METHODS

The nature reserve Cranendonck occupies 100 hectares of sandy soil comprising approximately equal areas of coniferous forest, heath and blowing sand, and abandoned arable fields (Fig. 20.1). Ten sampling sites were selected in abandoned fields and four in adjacent fields still under arable cultivation. Earthworms were sampled from 1975 by handsorting duplicate samples (30 × 30 × 30 cm) 3–5 times each year. Soil properties

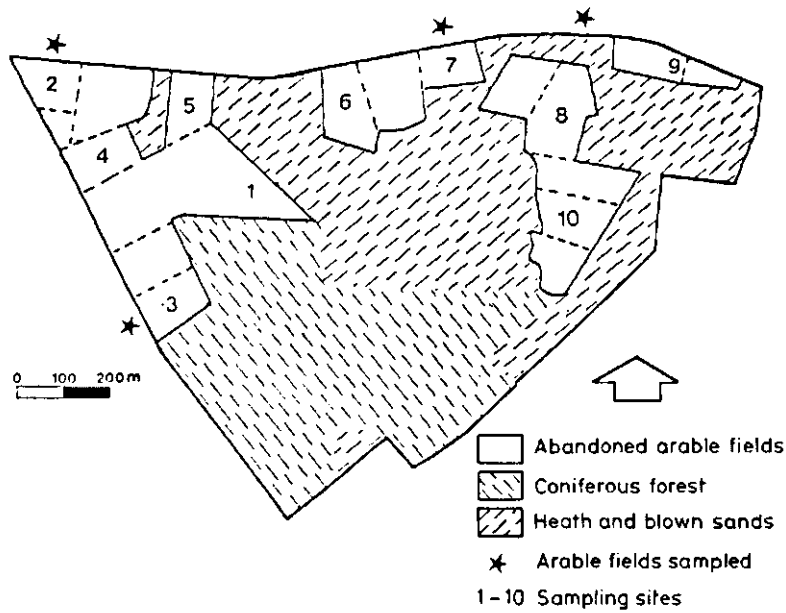

Fig. 20.1 Plan of Cranendonck nature reserve.

were determined in 1973 as follows: pH in KCl; organic matter as loss on ignition; total N by destruction with phenol-H_2SO_4 + Se and distillation of NH_3; total P by extraction with Fleischmann acid; total K, total Fe and Cu by extraction in 0.1 N HCl + 0.4 N oxalic acid (1:10). Other workers monitored activities of horses and rabbits, and the development of the vegetation.

20.3 FLUCTUATIONS IN EARTHWORM NUMBERS

Lumbricus rubellus comprised 95 % of all the worms sampled. In four sites (1–4) in the west of the reserve, numbers showed a distinct decline in 1976 followed by an increase up to 1979 and a decrease in 1980. In four sites (6, 7, 8, 10) in the east of the reserve, numbers increased steadily from 1975 to 1979 and fell in 1980 (Fig. 20.2). Two other sites (5, 9) showed irregular fluctuations and were not analysed further.

The decrease in 1976 coincided with a period of very dry hot weather in spring and summer which reduced the populations on the sites with the lowest water tables (Table 20.1). The decrease in 1980 coincided with cold, wet weather conditions in 1979 and 1980. Of the sites in the east of the reserve, the two with the lower initial population densities (8 and 10) had caught up with the remainder. Throughout the whole period

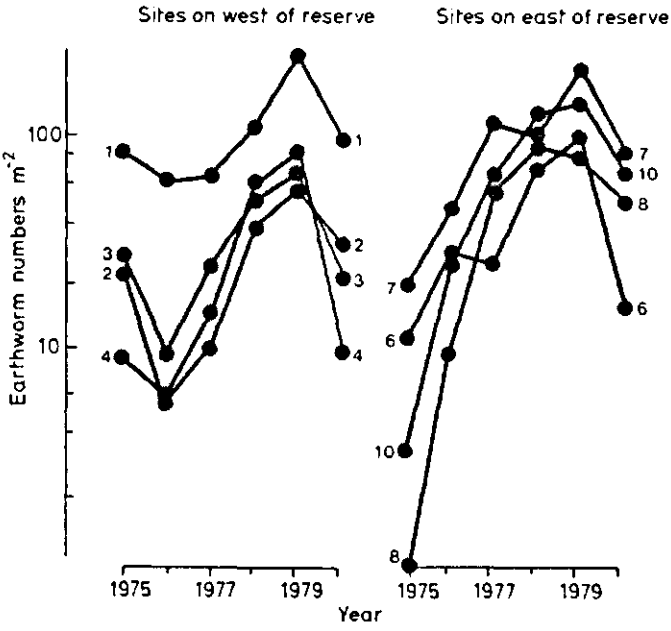

Fig. 20.2 Population densities (log $n + 1$) of *L. rubellus*.

Table 20.1 Physical and chemical properties of the sites.

Site	Highest ground water level (cm below surface)	pH	Organic matter ($g\,kg^{-1}$)	Total N ($g\,kg^{-1}$)	Total P ($g\,kg^{-1}$)	Total Fe ($g\,kg^{-1}$)	K ($mg\,kg^{-1}$)	Cu ($mg\,kg^{-1}$)
1	< 40/40–80	4.6	33	1.0	0.8	1.1	5	4.2
2	> 80	4.8	33	0.8	0.9	1.2	24	2.6
3	> 80	4.6	36	0.9	0.8	1.4	5	2.4
4	> 80	4.6	34	0.8	0.9	1.4	5	4.0
6	40–80/ > 80	4.6	32	0.8	0.9	2.1	7	1.8
7	40–80/ > 80	4.9	35	0.9	0.9	1.7	6	2.3
8	40–80/ > 80	5.0	25	0.8	1.0	2.1	6	2.5
10	40–80/ > 80	4.8	19	0.6	0.9	3.1	0.6	4.1

1975–80, the population densities in the adjacent fields under arable management remained low. A total of only 22 worms was found in 120 samples.

The proportion of juveniles in the population declined when total numbers fell (Fig. 20.3). *L. rubellus* has only a limited ability to retreat to deeper soil and under adverse weather conditions mortality was greatest amongst the smaller worms.

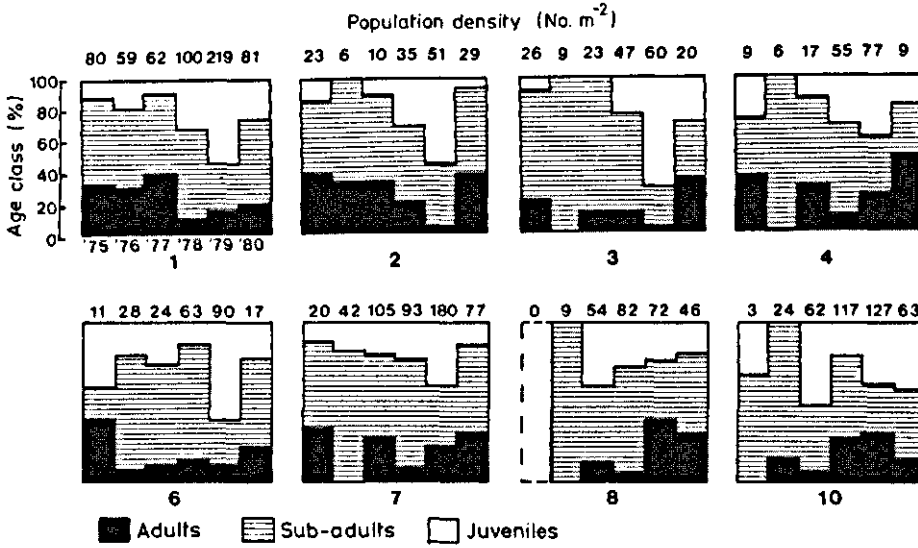

Fig. 20.3 Age class distribution (%) of *L. rubellus*, 1975–80.

20.4 SUCCESSION

During the period of observation, although the vegetation of the abandoned arable fields varied considerably from site to site, arable plants decreased and grasses, typically *Agrostis stolonifera* and *A. tenuis*, increased. This is part of a succession in which arable species are

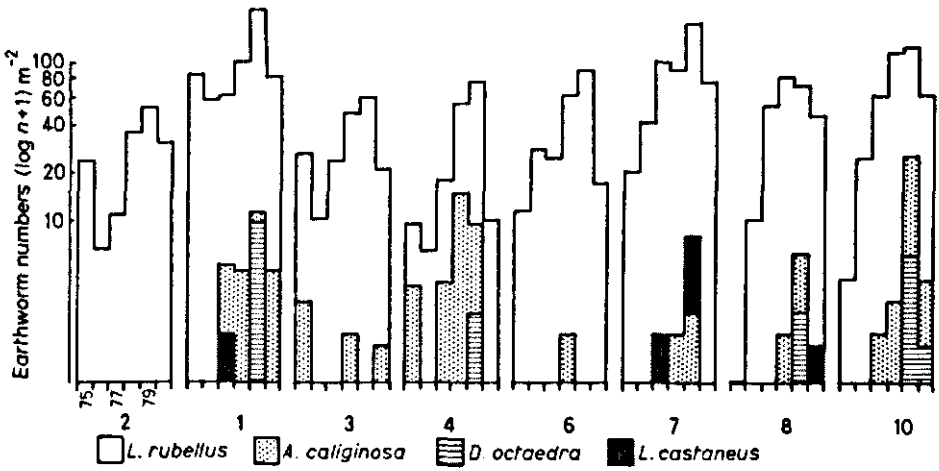

Fig. 20.4 Species composition of sites in supposed order of vegetation succession.

gradually replaced by species typical of dry sandy grasslands (*Koelerio-corynephoreta*) or very poor grasslands tending to heath (*Nardo-calluneta*).

In the first two years of observations, the earthworm populations of all but two of the sites consisted exclusively of *L. rubellus* (Fig. 20.4). By the fourth year *A. caliginosa* had colonized all but one of the sites and between the third and sixth years *Lumbricus castaneus* was recorded in three sites and *Dendrobaena octaedra* in four. Though typically a coprophage, *L. castaneus* showed no relation between the year of colonization and the incidence of horse dung. Invasion by *D. octaedra* also showed no specific relationship with particular plant species but it is typically a species of heath and impoverished sites. The site with only *L. rubellus* was subject to high trampling pressure.

20.5 CONCLUSIONS

Observations have been made over a period of six years in a succession which can be expected to continue developing for several decades. Although the results are therefore preliminary, they nevertheless confirm the results of other studies on colonization. The four earthworm species so far recorded: *L. rubellus, A. caliginosa, L. castaneus* and *D. octaedra* have been reported as pioneer colonists, although not always in the same combination, in pulverized fuel ash (Satchell and Stone, 1977), municipal refuse (Brockmann *et al.*, 1980), restored opencast coal mines (Dunger, 1969) and pastures (Martin, 1977). These species seem to have little in common, – *L. rubellus* and *L. castaneus* are active surface migrants, *A. caliginosa* is not; *D. octaedra* tolerates sites with very acid organic horizons, *A. caliginosa* does not (Satchell, 1955); *L. rubellus* and *L. castaneus* have high reproductive rates, *A. caliginosa* does not (Evans and Guild, 1948). The success of these species as colonists is clearly not explainable in simple terms of mobility, fecundity or ecological category. Though convergent as pioneers their biology is individual to each species.

20.6 ACKNOWLEDGEMENTS

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20.7 REFERENCES

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