Growth and survival of *Eisenia fetida* (Sav.) (Oligochaeta: Lumbricidae) in relation to temperature, moisture and presence of *Enchytraeus albidus* (Henle) (Enchytraeidae)*

J.K. Haukka

Department of Pest Investigations, Agricultural Research Centre, SF–31 600 Jokioinen, Finland

**Summary.** The aim of this study was to investigate the environmental requirements of *Eisenia fetida* (Lumbricidae) and its relation to *Enchytraeus albidus* (Enchytraeidae). Specimens of *Eisenia fetida* were cultured at two different temperatures (15°C and 25°C) and moisture conditions (50% and 80%) in presence or absence of *Enchytraeus albidus*. *Eisenia fetida* grew best at the higher temperature and amount of moisture. *Enchytraeus albidus* impaired the growth of *Eisenia fetida* at the higher temperature. When *Enchytraeus albidus* was present, the mortality of *Eisenia fetida* increased.

Interaction between *Eisenia fetida* and *Enchytraeus albidus* was shown, although the mechanisms remain unclear. These species, coexisting in the same habitat (compost), appear to have slightly different niches: *Eisenia fetida* favours warmer, moister conditions than *Enchytraeus albidus*.

**Key words:** *Eisenia fetida* – *Enchytraeus albidus* – Competition experiment – Temperature – Moisture

According to some observations *Eisenia fetida* (Sav.), an earthworm typical of composts, is abundant when the compost is rather moist and warm. On the other hand, the enchytraeid worm *Enchytraeus albidus* (Henle) seems to become more abundant when the compost gets drier and cooler. Is the shift of population numbers determined by temperature and moisture only, or do interspecific relationships contribute to the shift in species abundance? Very few studies have included experimental work on the interspecific relations among soil animals (Anderson 1978) although Hagvar (1984) recently pointed to interspecific competition as an important factor in determining population densities of coexisting soil animals.

In this study relationships between *Eisenia fetida* and *Enchytraeus albidus* were tested in a laboratory experiment under different conditions of temperature and moisture. Most attention was paid to *Eisenia fetida* because of its potential importance in waste management. The environmental requirements for *Eisenia fetida* are quite well known; the most important factors are suitable moisture and temperature (Tsukamoto and Watanabe 1977; Kaplan et al. 1980a,b). Apparently the most important environmental factors for *Enchytraeus albidus* are the same as for *Eisenia fetida* (Reynoldson 1943; Ivleva 1960). *Eisenia fetida* is thought to have originated as a corticolous species of mountain forests south of the Caspian Sea and it also occurs in many forests in the southern region, but now it is typically a species of dung heaps and composts (Satchell 1983). *Enchytraeus albidus* is frequently found in decomposing algal heaps on sea shores (Nurminen 1967; O’Connor 1967), but also occurs regularly in composts.

**Materials and methods**

**Experimental design.** The experiments were carried out using a 2^3^-factorial design (Montgomery 1979). Growth and mortality of *Eisenia fetida* were used as dependent variables. The variables were moisture, temperature and presence or absence of *Enchytraeus albidus*. The temperatures used were 15º and 25ºC, which is approximately the optimal temperature for growth of *Eisenia fetida* (Tsukamoto and Watanabe 1977; Kaplan et al. 1980a; Satchell 1983). The growth medium contained 50% or 80% water by weight (optimal moisture

* Dedicated to the late Prof. Dr. M.S. Ghilarov
for Eisenia fetida is about 80% (Kaplan et al. 1980a; Satchell 1981). The 60 replicates were divided into eight treatment combinations. Only five replicates were included in the experiments where Enchytraeus albidus was absent, because it was known that variance would then be relatively small (Haimi and Huhta, in press). The experiments were carried out during the spring and autumn of 1984. Cultures were established in plastic boxes (95 × 95 × 65 mm). The lids of the boxes had four 1-cm² holes. The food was a mixture of 31% (fresh weight) cooked potatoes, 31% barley porridge, 16% white bread, 16% meat and 6% orange peels. This composition was designed to simulate food wastes, and was found by Haimi and Huhta (in press) to support optimum growth of Eisenia fetida. To kill soil animals and toxic fungi the bark was maintained at 105°C for 2 h (Haimi and Huhta, in press). Portions of food (25 g) were embedded in sieved (4-mm) pine bark, and the water content of pine bark was adjusted to 50% or 80% by adding tap water. The boxes were filled to two-thirds of their volume. To keep the moisture stable, water was added every 2nd or 3rd day so that the original weight of the boxes remained unchanged.

At the beginning of experiments, 20 individuals of Eisenia fetida were weighed to the nearest 0.1 mg and put into each box. Only newly hatched specimens were used for the experiments. According to the experimental design, 30 individuals of Enchytraeus albidus were added to 40 boxes. The lengths of these worms were measured to the nearest 1 mm. All individuals for experiments were taken from the same compost. Experimental boxes were kept at 15° or 25°C for 23 days.

Extraction of animals and determination of biomasses. After the experiment ended, individuals of Eisenia fetida were picked out of the boxes by hand and were counted and weighed. Enchytraeus albidus was taken out of the boxes using the wet funnel method of O'Connor (1962). Individuals of Enchytraeus albidus were put into 70% ethanol and measured later. Their weights were determined according to a regression method (Abrahamsen 1973).

Statistical methods. Analysis of variance with one covariate (initial weight of an individual) was used for the analyses. The dependent variables were growth and mortality. For Eisenia fetida the model was a 2³-factor design, and for Enchytraeus albidus it was a 2²-factor design. Transformations needed to satisfy the assumptions of the analysis of variance are described with the results. Calculations were made with the Statistical Packet for Social Sciences program.

Results

Growth and survival of Eisenia fetida

The dependent variable (growth) was calculated by subtracting the mean weight of an individual at the beginning of the experiment from that at the end of the experiment. To satisfy the assumptions of ANOVA, the original data were transformed using square root transformation (Sokal and Rohlf 1969). Before transformation, the negative value found in one case was recorded as zero.

The effect of moisture on growth was significant at the 5% level (Table 1). The interaction between temperature and presence of Enchytraeus albidus was highly significant (P = 0.0000). Owing to this interaction, the presence of Enchytraeus albidus impaired the growth of Eisenia fetida at the higher (25°C) temperature. In contrast, at the lower temperature (15°C) growth improved (Fig. 1). The covariate (initial weight of an individual) was only slightly significant (P = 0.084).