Seasonal dynamics and vertical distribution of enchytraeids in Luojiashan, Wuhan, China

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Abstract

An annual survey of the enchytraeid community was conducted in Luojiashan in Wuhan from October 1993 to September 1994. The densities reached a maximum of 56000 ind·m^{-2} in June, and dropped to a minimum of 1600 ind·m^{-2} in August. The biomass varied between 0.022 and 1.8 g·m^{-2}, with one maximum in June and the other in November, and a minimum in August. It is shown that the enchytraeid numbers are positively correlated with soil moisture and temperature. Vertically, the worms had a more superficial distribution in October and July than in January and April.

Key words: Enchytraeid community, Seasonal dynamics, Vertical distribution, Central China

Introduction

Recent studies (e.g. Wang et al., 1999; Xie et al., 1999) has shown that enchytraeid species are abundant in a number of terrestrial habitats of China. However, no ecological work has been reported in the country. An annual investigation was carried out in Luojiashan, Wuhan in 1993-1994 in order to examine the standing crop and distribution of enchytraeids.

Material and methods

The sampling site is a uniform area in the north of the Luojiashan Hill (30°33'N□114°23'E, <100 m ASL), Wuhan, which is covered by deciduous broad-leaved forest. The climate is sub-tropical with mean annual air temperature 16.7°C; mean annual precipitation 1160 mm, (75% of which falls in spring and summer); mean annual evaporation is 1148 mm (Liu, 1984). The soil is yellow-brown with a pH of 6.3-6.5. During the sampling period, the surface soil temperature was between 6-26°C, and soil moisture (105°C, 3h) was 11-26% (Fig. 1).

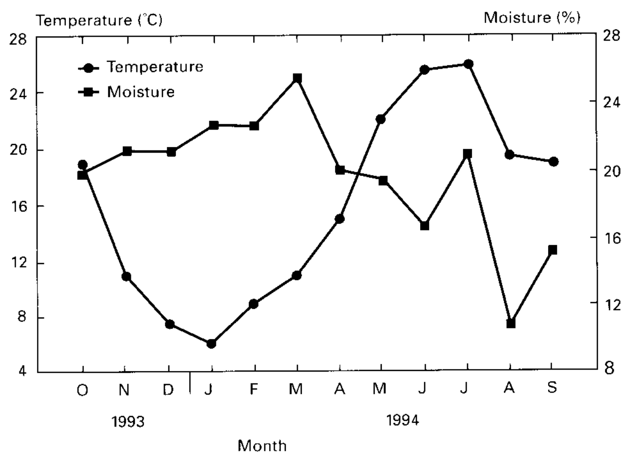
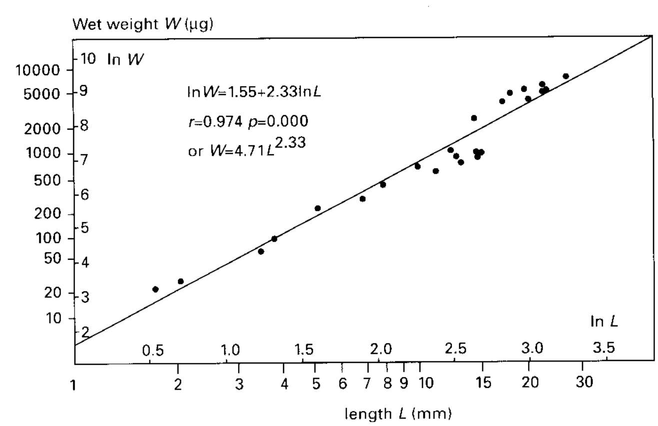


Fig. 1: Soil temperature and moisture (% of fresh weight) during the study period (October 1993 to September 1994).

Fig. 2: Length-weight relationships of enchytraeids.



Ten soil cores of 13 cm² surface area and 9 cm depth were taken in the middle of every month from October 1993 to September 1994 to assess the temporal variation in density. In October, January, April and July, three replicate units of 100 cm³ were taken from the layers 0-2 cm, 2-7 cm, 7-12 cm and 12-17 cm, respectively, to determine the vertical distribution at different seasons. At the same time, some qualitative samples were taken for taxonomic identification based upon live material or stained whole-mounts.

For extraction, wet-funnels modified after O'Connor (1962) were used. Each sample was placed in a glass cylinder 9 cm diameter and 2 cm height, with a 1-mm sieve underneath. The light bulb (60 W) was held in a tinned truncated-cone. Generally the extraction lasted for 3 h, and when air temperature was less than 20°C, 3 h 18 min. To increase the heating, the bulbs were moved towards the samples every 18 minutes until the surface temperature became 45-50°C. The specimens were preserved in 10% formalin.

A length-weight relationship was calculated to overcome the difficulty in weighing a small number of worms (Fig. 2). The material was from Wuhan City and Hunan Province. After being blotted, wet weight (about 4.5 times dry weight) of a big individual, or a batch of small worms, was measured using an electronic balance (Sartorius). The length was measured under a binocular microscope.

To track the change of mean body size in the field, the length of complete specimens from Luojiashan was measured every month. If the number was too great, 20 individuals were randomly picked for measurement. The body weight was then calculated by the above-mentioned length-weight equation. Biomass was the product of density multiplied by mean weight. Data were processed using STATISTICA 6.0 and EXCEL 97.

Results

Seasonal dynamics

The enchytraeid community in Luojiashan consisted chiefly of *Hemienchytraeus bifurcatus* Nielsen & Christensen, 1959, *Achaeta brevivasa* Graefe, 1980, and Marionina spp.. Seasonal variation in size and standing crop are described as follows.

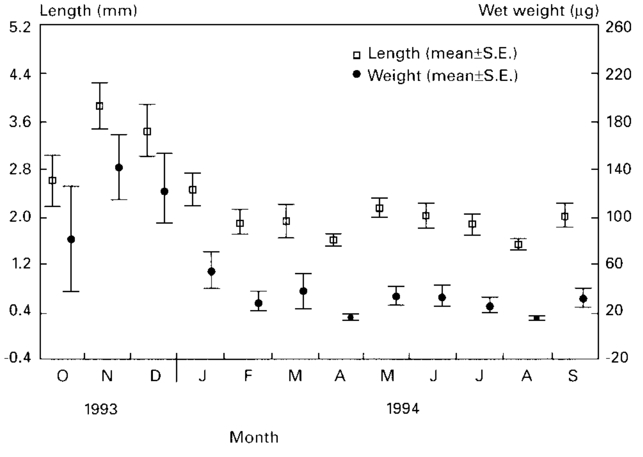


Fig. 3: Seasonal changes of mean length and wet weight of enchytraeids during the study period (October 1993 to September 1994).

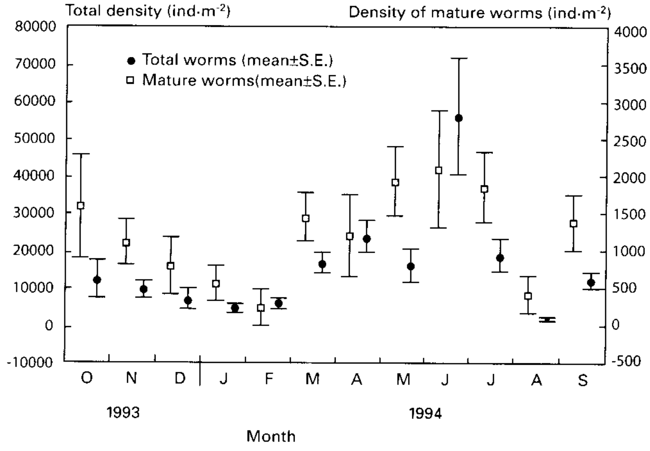


Fig. 4: Seasonal fluctuations of enchytraeid densities during the study period (October 1993 to September 1994).

Body size

Fig. 3 shows that the enchytraeids in Luojiahshan were bigger between October and December, with mean length of 2.6-3.8 mm, and mean weight of 82-142 μg, and smaller between January to September, with mean length of 1.5-2.5 mm, and mean weight of 14-55 μg.

Densities

Enchytraeid densities varied between 1600 and 56000 ind·m^{-2} (mean±S.E. =150006±4100) (Fig. 4). The densities reached a maximum in June, and dropped to a minimum in August which was a period of drought. In winter (December to February), the numbers of total worms were also low.

The densities of mature worms varied between 400 and 2100 ind·m^{-2} (mean±S.E. =1200±175), being about 10% of the total in general. The seasonal trend was similar to that of the total, with a high abundance from May to July, and a low abundance in August and February (Fig. 4).

Biomass

Enchytraeid biomass varied between 0.022 and 1.8 g·m^{-2} (mean±S.E.=0.66±0.15) in wet weight. Unlike density, it had two maxima in the year (Fig. 5). The summer maximum in June coincided with the large number of small worms (Fig. 4), whereas the peak in November can be explained by a small number of large worms. The minimum occurred also in August.

Correlation with environmental factors

The fluctuations in density seemed to correlate with air temperature and soil moisture (Fig. 1). The relationship is described by the following equations:

$$D=0.015M^{3.4}T^{1.5} \quad R^2=0.51 \quad n=12 \quad p=0.04$$

$$D_M=1200M+90T-2500 \quad R^2=0.56 \quad n=12 \quad p=0.02$$

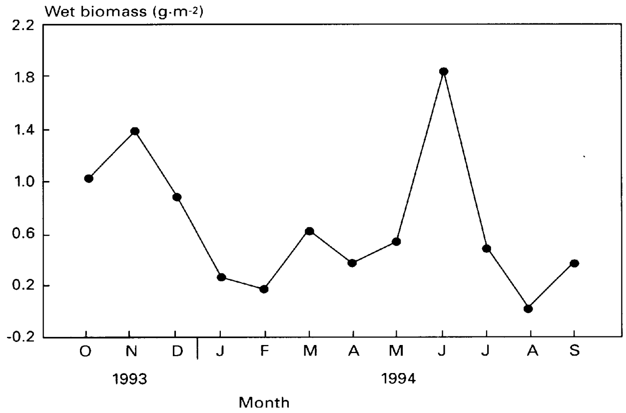
where D-density in total (ind·m^{-2}) (0-9cm),

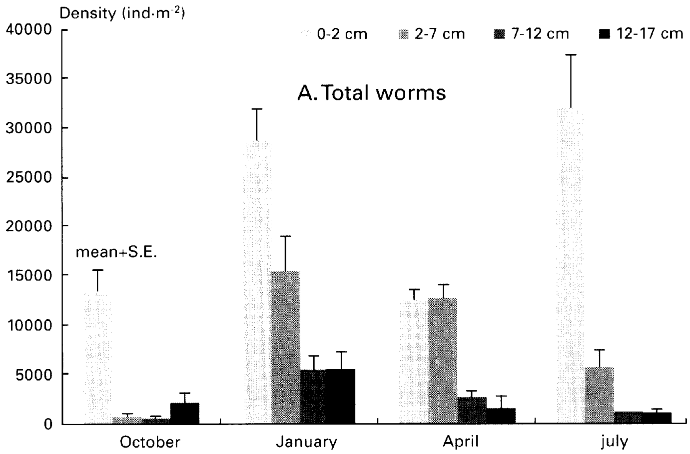
D_M-density of mature worms (ind·m^{-2}) (0-9cm), *M*-soil moisture (% of fresh weight),

T-temperature at soil surface (°C).

Thus, the total enchytraeid densities and the densities of mature worms relate positively to soil temperature and moisture within certain ranges.

Fig. 5: Seasonal fluctuations of enchytraeid biomass during the study period (October 1993 to September 1994).





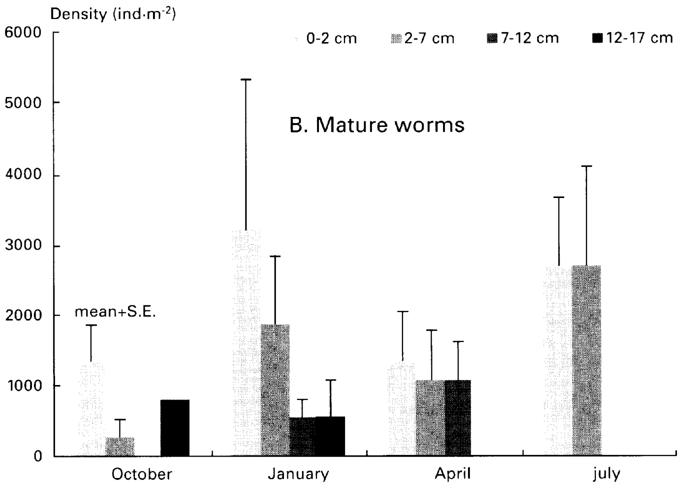


Fig. 6: Distribution of enchytraeids in different layers of soil profile. A. total worms, B. mature worms.

Vertical distribution

Enchytraeids were distributed superficially in October and July (63%, 65% in the 0-2 cm layer, respectively) but less so in January and April (31% and 23% in the same layer, respectively) (Fig. 6A). The mature worms tended to be distributed more evenly at different depths of soil (30%, 20%, 29%, 33% at 0-2 cm in January, April, July and October, respectively) (Fig. 6B).

Discussion

The standing crops of enchytraeids in Luojiashan are similar to those found in Europe and North America, for example, 1000-100000 (200000) ind·m^{-2} and 1-10 (25) g·m^{-2} in Denmark (Nielsen, 1955a), 500-22000 ind·m^{-2} and 0.5-3.0 g·m^{-2} in Canada (Dash & Cragg, 1972). Probably, even higher abundances are to be expected in China, particularly in the north and in mountainous forests. Hence, the enchytraeid community could also be an important feature in the Chinese terrestrial ecosystem.

This study as well as previous studies (e.g. Nielsen, 1955b; Nurminen, 1967; O'Connor, 1957) demonstrates that the enchytraeids fluctuate in number as a response to temperature and/or moisture. The temperature optimum varies for different species. It has been estimated to be 25-28°C in Enchytraeus buchholzi, 17-25°C in *Enchytraeus albidus* and *Lumbricillus lineatus*, and ca. 18°C in *Cognettia sphagnetorum* (Abrahamsen, 1971; O'Connor, 1957). During the present study, the greatest density was recorded at 25°C in June. Some species were reported to prefer very low temperature, such as *Stercutus niveus*, which peaked in winter (Dózsa-Farkas, 1973). As a rule, however, the total densities are positively correlated with temperatures up to ca. 30°C (O'Connor, 1957). In terms of moisture, Nielsen (1955b) and O'Connor (1957) pointed out that enchytraeids are immediately killed when soil moisture is lower than that corresponding to a pF of ca. 4, and numbers are related positively at least up to about pF 2. The present study also indicated that moisture is crucial for survival, clearly demonstrated by the low number in the August sampling during drought.

O'Connor (1958) reported that the number of mature enchytraeids showed a winter maximum and a summer minimum in North Wales, whereas the total number had an inverse tendency. Except for the August minimum induced by drought, the dynamics of total worms in Wuhan is similar to that in Wales. However, there is a clear difference between the seasonal changes of mature worms in two sites. In Wales, which experiences mild winters and cool summers, worms bred through the winter but cocoons hatched in spring. In Wuhan which experiences higher summer and winter temperatures than Wales, mature worms were found in every month but peaked in June.

A number of authors (e.g. Nielsen, 1955a; O'Connor, 1957; Dash & Cragg, 1972) have found that enchytraeids tend to be distributed in the upper part of the soil profile and this study agrees well with the earlier conclusion. With respect to seasonal changes in vertical distribution, Nurminen (1967) and Lundkvist (1982) reported that enchytraeids are more deeply distributed in winter in northern Europe, and this is probably due to vertical migration and/or to differential mortality rate caused by frost. In Wuhan, the soil temperature was not less than 6°C during the survey. Thus, the main reason for the more even distribution in winter and early spring could be the active movements of worms.

This preliminary study, revealed some ecological features of an enchytraeid community in a habitat of the subtropical area along Changjiang River. To increase the knowledge of these important worms in China, studies should be carried out more intensively and extensively in future.

Acknowledgements

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