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STUDY ON THE BIOMASS AND PRODUCTIVITY OF LUMBRICIDAE POPULATIONS IN THE DECIDUOUS ECOSYSTEM

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Abstract. The present study analyses the earthworms in the deciduous ecosystem (Ruginoasa Station) of Cândeşti Platform, in the south-east of Argeş County, in terms of biomass and monthly productivity during March-October 2007. Besides numerical dominance, the biomass of Lumbricidae species highlights the role of each species in the activity of matter and energy transfer within an ecosystem. The special dynamics of the two parameters showed different values, given the structure of the vegetation, soil and soil layers, and especially the differences between the individual weights of the species. *Octolasion lacteum* species was dominant in terms of biomass density and recorded high values at the soil levels analysed, except in the litter. Of the total calculated biomass (27.598 mg d.s./square meter), this species dominates in a ratio of 74.69%. Biological productivity was increased at 0-10 cm, with the highest value for *Octolasion lacteum* species (4.03 mg d.s./m^2), followed by *Eisenia lucens* species (0.9 mg d.s./m^2) and *Aporrectodea rosea rosea* species (0.641 mg d.s./m^2). Also, the highest values of the biomass were recorded in spring and autumn months. The species with a lower numerical density recorded low values of the biomass, leading to low biological productivity and vice versa.

Keywords: deciduous forest, lumbricidae, biomass, productivity.

Rezumat. Studiu privind biomasa şi productivitatea populaţiilor de Lumbricidae într-un ecosistem de foioase. În acest studiu sunt analizate comunitaţile de râme dintr-un ecosistem de pădure de foioase (Staţia Ruginoasa) situat în Platforma Cândeşti în partea sud-estică a Judeţului Argeş, din punct de vedere al biomasei şi productivităţii lunare în perioada martie-octombrie 2007. Alături de dominanţa numerică, biomasa speciilor de lumbricide evidenţiază rolul fiecărei specii în activitatea de transfer de materie şi energie din cadrul unui ecosistem. Dinamica spaţială a celor doi parametri a evidenţiat valori diferite, având în vedere structura covorului vegetal, a solului şi nivelurile de sol şi mai ales a diferenţelor dintre greutăţile individuale ale speciilor. Specia *Octolasion lacteum*, fiind dominantă din punct de vedere a densităţii în biomasă, a înregistrat valori ridicate la nivelurile de sol analizate, mai puţin în litieră. Din totalul biomasei calculate (27.598 mg.s.u./m^2), această specie domină în proporţie de 74.69%. Productivitatea biologică a fost ridicată la nivelul 0–10 cm, cea mai mare valoare deţinând-o specia *Octolasion lacteum* (4.03 mg.s.u./m^2), urmată de specia *Eisenia lucens* (0.9 mg.s.u./m^2) şi *Aporrectodea rosea rosea* (0.641 mg.s.u./m^2). De asemenea, cele mai mari valori ale biomasei s-au observat în lunile de primăvară şi de toamnă. Speciile care au avut o densitate numerică scăzută, au înregistrat şi valori scăzute ale cantităţii de biomasă, ceea ce a condus la o productivitate biologică scăzută şi invers.

Cuvinte cheie: pădure de foioase, lumbricide, biomasă, productivitate.

INTRODUCTION

The term **earthworms** includes a diverse group of Oligochaeta (Annelida), consisting of over 3,500 species (COLEMAN *et al*., 2004), found in soil, trees, wet areas of tropical forests; others are important benthonic organisms of freshwater and marine water (BRINKHURST & JAMIESON, 1971; JAMIESON, 1988). Most European earthworms belong to the Lumbricidae Family, containing about 600 species. The scientific literature began with the taxonomic description of LINNAEUS (1758) on *Lumbricus terrestris* species. Later, DARWIN (1881), made observations and experiments on Lumbricidae behaviour and made the first assumptions about their role in soil formation.

Darwin also highlighted the beneficial effects of earthworms in his book "Formation of agricultural soil by earthworms action", stating that "it is doubtful whether there are many animals that played such an important role in the history of the world, as did these creatures so little organized". Since then, many studies have investigated the role of earthworms in soil formation, decomposition of organic matter, circulation of nutrients and plant growth (LEE, 1985; LEE & FOSTER, 1991; EDWARD & BOHLEN, 1996; SCHEU, 2003; BROWN *et al*., 2004; COLEMAN *et al*., 2004).

Earthworm populations exhibit an irregular and aggregated distribution that may be related to vegetation, soil characteristics and biotic interactions. However, the spatial distribution of earthworms is an important parameter of their populations depending on both internal (community structure, abundance and individual parameters) and external factors (biotic and abiotic). Their contribution to processes such as decomposition, soil aggregation and plant production is presumably limited to patches where earthworms are active. Despite of the vast increase in scientific literature on earthworms in recent years, much remains to be known in their basic biology and ecology (NACHTERGALE *et al*., 2002; KOOCH & JALILVAND, 2008). Among the latter, single tree influence plays a major role. In some forests, earthworm populations are associated with plant species that provide a favourable microhabitat through their architecture and degree of ground cover, or because of the amount and quality of above - or below - ground litter they produce (ZALLER & ARNONE, 1999; CAMPANA *et al*., 2002; NACHTERGALE *et al*., 2002). Earthworm-free forest soils that have not been previously ploughed by humans tend to have very low bulk densities, due to the presence of a thick litter layer and the burrowing action of many species of native invertebrates (MCLEAN & PARKINSON, 1997a; BOHLEN *et al*., 2004). The quantitative retrieval of earthworms is affected by the size and shape of the collection area, which may also influence the accuracy of earthworm population estimates (DICKEY & KLADIVKO, 1989).

The ecosystem studied is located in the upper third of a slope, at the point called "Ruginoasa". The average slope inclination is 20 degrees, altitude varies between 380 – 400 m, and the exhibition is sunny south-east. Litter is still thin, due to rapid decomposition of the layer of leaves, branches, fruit, etc., in humus. The type of flora is *Asarum stellaria.* The stand is fundamentally natural of average productivity, relatively homogenous in terms of age, with the actual composition 4 Common Oak (*Quercus petraea*), 4 Beech (*Fagus sylvatica)*, 2 Various Hardwood (*Carpinus betulus, Tilia platyphyllos, Ulmus glabra, Prunus avium, Acer pseudoplatanus*), aged 65, being managed in forest regime (natural regeneration from the seed).

The consistency of 0.7- 0.8 stand is the third class of production, age of exploitability 120 years. The forest type is common oak – beech. The station type is hilly common oak. Due to the consistency of 0.7 – 0.8, indicating a reduction in the stand density, there were formed several levels of vegetation. The trees holding and filtering the light, heat and rain, leave less favourable conditions to the grasses and shrubs, thus providing each level with a certain regime, light, heat, moisture, wind, etc.

The purpose of this study was to evaluate the monthly dynamics of biomass and productivity of Lumbricidae communities in a mixed deciduous forest. The basis for this is that the impact of various trees on earthworm abundances is not only through their effects on litter and microclimate (FRAGOSO *et al*., 1997; NEHER, 1999), but also through altering the chemical and physical properties of the soil (ZOU & GONZALEZ, 2002). Hypothesis was that different seasons may affect biomass of earthworms at various stands and there will be relationships between seasonal variation of earthworm abundance with some of the site and species characteristics (VALCKX *et al*., 2006; NAGUMANOVA, 2007). Recognition of parameters affecting earthworm population under natural and planted forests would be useful for cultural interventions.

MATERIAL AND METHODS

The Lumbricidae samples were taken randomly, from March to October 2007, by making ten holes in the station, using a metal frame with sides of 25/25 cm. The sample units were built on depth levels, namely: L = litter; S_1 = 10 cm; S_2 = 20 cm; S_3 = 30 cm; S_4 = 40 cm. The earthworms were manually extracted from the samples, immediately after making the holes and put in tightly closed containers of 90^o alcohol. The containers had labels containing: sampling place, date (day, month and year), depth of the soil, sample number.

The fauna material was taken to the laboratory in order to test each species, using a determinator (EASTON, 1983; POP, 1949).

The biomass of Lumbricidae species was calculated by the ratio between individual weight and dry weight of each individual (mg.d.s./m^2). Individual live weight and individual weight after drying was determined by weighing on analytical balance. To remove water from the body, the fauna material was dried in a drying cabinet, at a temperature of 105^0C. By successive weighings, after 48 hours, the weight of the individuals remained constant and drying was complete. Estimation of gravimetric abundance in the form of dry weight, per square meter, facilitated the calculation of biological productivity of Lumbricidae during one year, expressed as gravimetric increases on a time unit. Data on biological productivity were obtained by adding gravimetric differences between collection time within a month.

RESULTS AND DISCUSSIONS

Lumbricidae specific composition in the ecosystem of mixed deciduous forest presented 17 species: *Allolobophora* sp., *All. dacica, All. calliginosa, All. leoni, Aporrectodea r. rosea, Dendrobaena biblica, D. octaedra, Dendrodrilus r. rubidus, Eisenia lucens, Lumbricus rubellus, L. castaneus, L. terrestris, L. t. linnaeus, Octodrilus complanatus, O. lissaensis, Octolasion lacteu.*

The biomass calculated for Lumbricidae species in the deciduous ecosystem (Ruginoasa Station) in 2007, at the five levels of soil (Fig. 1), based on numerical density, emphasizes *Octolasion lacteum* species as dominant in terms of biomass, accounting for high values at the levels of soil analysed, except in the litter. Of the total biomass (27.598 mg.d.s./m^2) calculated from March to October 2007, this species dominates in a ratio of 74.69%, with a key role in the transfer of matter and energy. *Aporrectodea rosea rosea* species, also dominant in this ecosystem, shares only 4.64% of the total biomass. The biomass stratifies vertically, from level S1 (0 – 10 cm), with a very low biomass in the litter. The largest biomass was observed at the levels S1 (0 – 10 cm), S2 (10 – 20 cm) and S3 (20 – 30 cm). Higher values of the biomass were recorded in spring and autumn. It was also found that the species with a high numerical density in this habitat, recorded a higher biomass and vice versa.

The analysis of monthly dynamics of total biomass of Lumbricidae during March-October 2007 (Fig. 2) revealed a faster increase in spring months, with a maximum value of 11.948 mg.d.s./m^2 recorded in April, followed by a decrease in May. The increase of the biomass in August was not significant, while the curve fell again in September and October. The monthly values of total biomass in 2007 ranged from 1.411 – 11.948 mg.d.s./m^2.

Estimation of the biomass of lumbricidae species, in the form of dry weight per square metre, allowed the calculation of their biological productivity during March - October 2007, expressed as the increase of the biomass per time unit. The data on biological productivity were obtained by summing the biomass differences between the times of collection, within a month. The analysis of biological productivity of Lumbricidae in the soil layers, illustrated in figure 3, revealed an increase of biological productivity in *Octolasion lacteum, Aporrectodea rosea rosea, Eisenia lucens*, *Dendrobaena* and *Lumbricus* species.

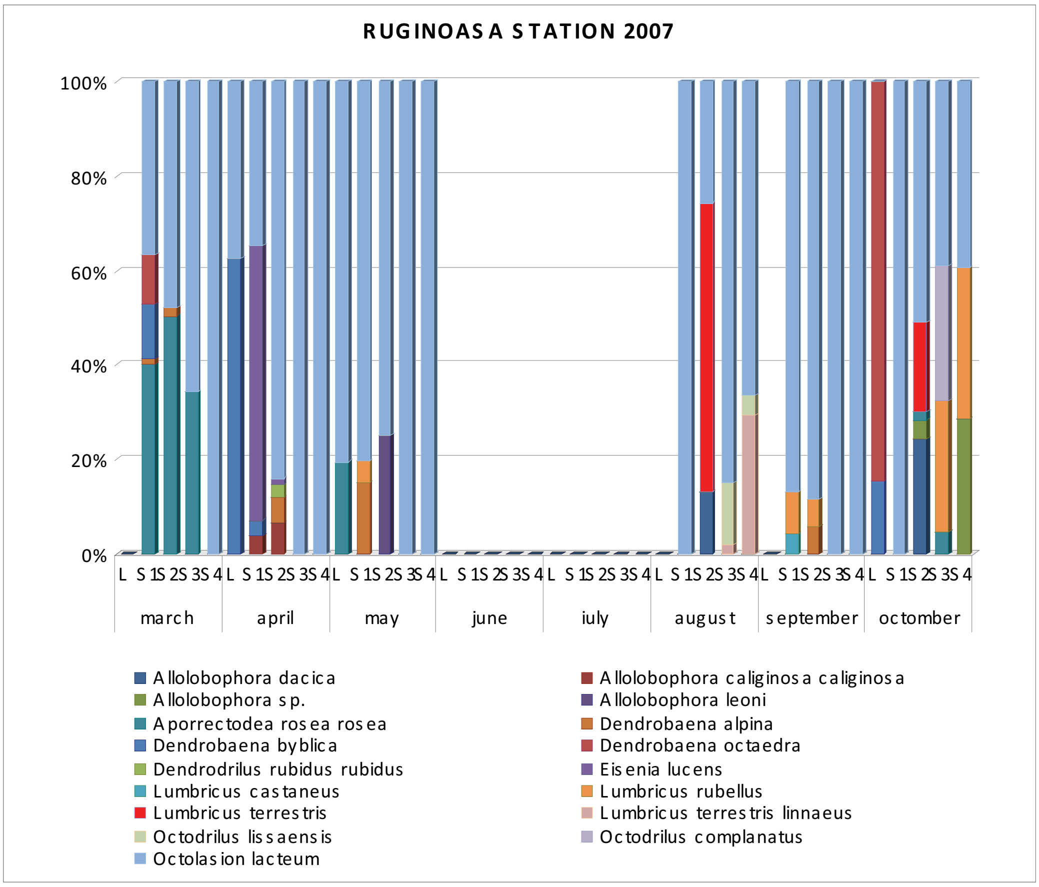

Figure 1. Biomass of Lumbricidae in the soil layers (mg.d.s./mp) in the deciduous forest (Ruginoasa Station) March-October 2007.
Figura 1. Biomasa lumbricidelor în straturile de sol (mg.s.u/mp) din pădurea de foioase (Staţia Ruginoasa) martie-octombrie 2007.

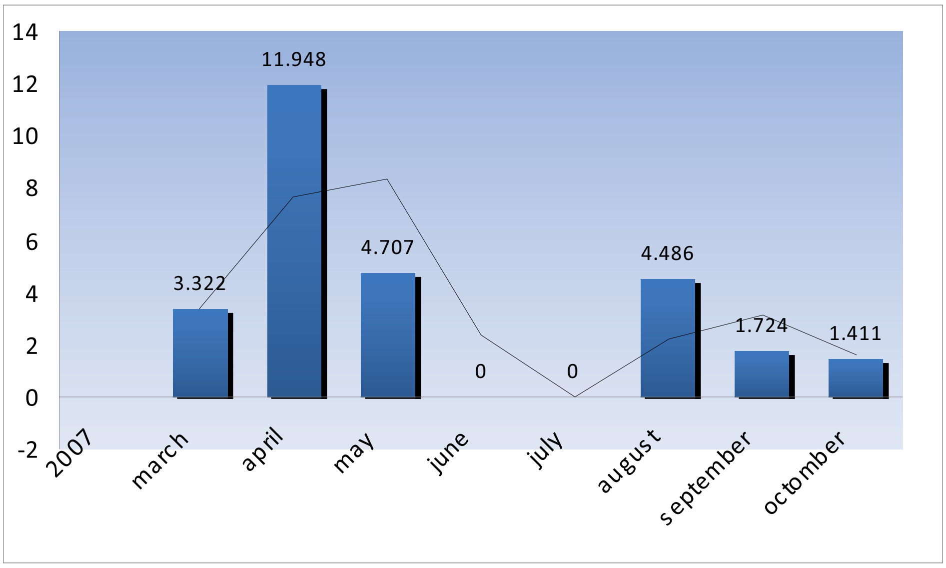

Figure 2. Monthly dynamics of total biomass of Lumbricidae (mg.d. s./mp) during March-October 2007.
Figura 2. Dinamica lunară a biomasei de lumbricide (mg.s.u/mp) în perioada martie-octombrie 2007.

Biological productivity of the soil layers in 2007 was high at the level 0– 10 cm, with a maximum value of (4.03 mg.d.s./m^2) for *Octolasion lacteum* species, followed by *Eisenia lucens* (0.9 mg.d.s./m^2) and *Aporrectodea rosea rosea* (0.641 mg.d.s./m^2). A high biological productivity was recorded at levels 10-20 cm and 30-40 cm in *Octolasion lacteum* species. The lowest biological productivity was recorded in the litter, where the biomass was also low.

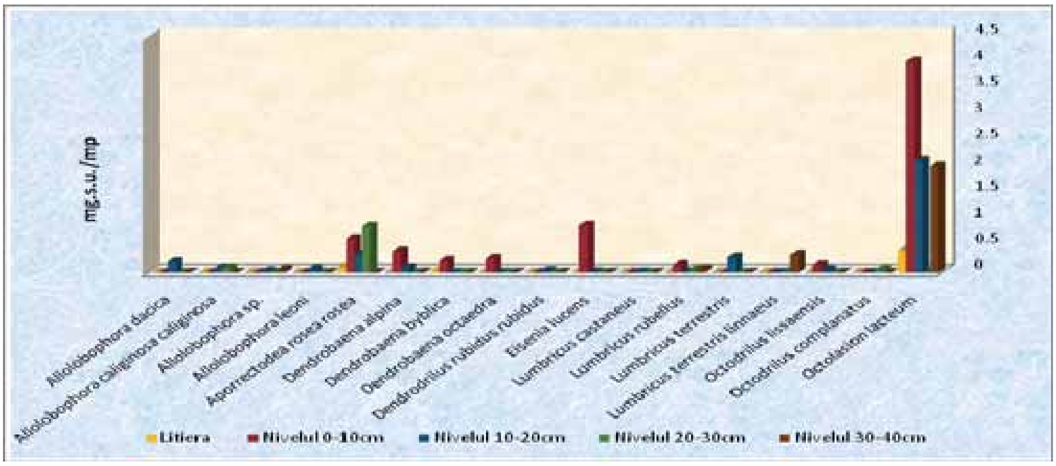

Figure 3. Biological productivity of Lumbricidae in the soil layers during March-October 2007.
Figura 3. Productivitatea biologică a lumbricidelor în stratele de sol în perioada martie-octombrie 2007.

Total productivity of *Lumbricidae* in 2007, illustrated in figure 4, results from the analysis of the lumbricidae biomass and biological productivity at the soil levels and highlights *Octolasion lacteum* species with the highest total productivity, followed by *Aporrectodea rosea rosea* and *Eisenia lucens* species. The remaining species had low productivity.

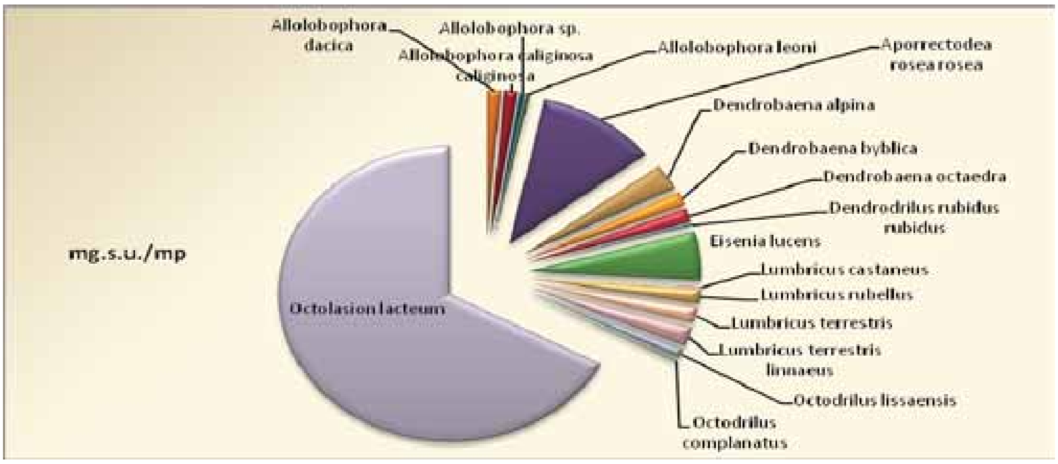

Figure 4. Total productivity of Lumbricidae in the deciduous forest (Ruginoasa Station) 2007.
Figura 4. Productivitatea totală a lumbricidelor în pădurea de foioase (Staţia Ruginoasa) 2007.

The results of this study confirmed the information according to which the biotope, vegetation, seasonal, micro-habitat and individual differences have a significant influence on the dynamics of the analysed parameters.

Direct effect of tree species on soil and litter biota are caused by the plant inputs of organic matter above and below ground, while indirect effect of trees on biota include shading, soil protection and uptake of water and nutrients by roots (NEHER, 1999). Soil properties may constrain earthworm populations only at the extremes of each variable (EDWARDS & BOHLEN, 1996), and the factors that determine earthworm population aggregations may operate at different scales from those that determine soil physical–chemical properties (WHALEN & COSTA, 2003; ROSSI, 2003).

The analysis of the biomass density of Lumbricidae at the soil levels in the ecosystem of deciduous forest (Ruginoasa Station) revealed certain differences, thus highlighting the ecological valences of *Octolasion lacteum*, *Allolobophora caliginosa caliginosa* and *Aporrectodea rosea rosea* species, with important functions in the activity of Lumbricidae populations in this ecosystem. Low, even absent biomass in June and July 2007 was mainly due to prolonged drought at that time of the year and lack of moisture in the soil layers during the sampling period, which caused the animal withdrawal in the deeper layers of the soil or formed aggregations where there was an optimal minimum for survival, moisture accounting for a limiting factor of Lumbricidae.

This might indicate that the aggregation of earthworms is more probable under shady conditions, presumably because of the better microclimate created by the tree shade. Different tree species influence the composition and the abundance of soil fauna differently, particularly the litter fauna (DEHARVENG, 1996). The composition of the over story has an impact on soil structure (READ & WALKER, 1950). Earthworm population density at a specific site is the result of the interaction of a number of factors such as soil texture moisture, pH and organic matter content (BLANCHART & JULKA, 1997; LAVELLE, 1993; SATCHELL, 1983). Other studies have shown the earthworm biomass is significantly influenced by type of tree species (NEIRYNCK *et al*., 2000; SARLO, 2006). Also in another research, conversion of pure Scots pine treatments to mixed treatments with broad-leaved species, caused an increase in abundance and biomass of earthworms (AMMER *et al*., 2006). Earthworm activity and populations are determined essentially by the moisture content of the soil (LAVELLE, 1988).

Species with a lower numerical density recorded low values of the biomass, thus leading to a low biological productivity. There were also situations in which certain species had a low density, but a higher biomass, due to the larger body waist, which led to an increase of the individual weight, especially for *Lumbricus* species.

CONCLUSIONS

The obtained biomass depended to a great extent on the density of each species and equally on the individual biomass of individuals of different species. Also, increasing the number of species caused an increase of total biomass. In the summer months, metabolism and activity of Lumbricidae were lower, causing a decrease in the biomass and productivity. The highest biomass, especially at higher levels of the soil was achieved mainly due to the dominant species *Octolasion lacteum* and *Aporrectodea rosea rosea*. Dynamics in time and space of the biomass of Lumbricidae species was closely related with and directly proportional to the micro-habitat conditions and the depth from which the soil samples were taken. From this viewpoint, spatial and temporal patterns of fauna changes induced by modifications in vegetation, especially at the transition from one successional stage to another, should give us valuable information. Hence, experimental studies should focus on the evolution of the micro-habitat diversity and its relationships with the population dynamics of Lumbricidae.

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