Collembola Communities in Different Compost Types as Bioindicator of Substrate Quality

Lilyana KOLEVA*, Milena YORDANOVA, Georgi DIMITROV

University of Forestry, Sofia, Bulgaria
*Corresponding author: liljanamarkova@abv.bg

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Collembolans are a good indicator of the degree of mineralization and humification of the soil. Their ecological characteristics, habitat and feeding type can help the analysis of composting processes and determining the quality of the resulting substrate. A particular interest is the potential antagonistic effect of compost on soil plant euedaphic life forms pathogens and phytophagous arthropods.The aim of this study was to establish the quality differences between the four types of mature compost by studying the structure of Collembola communities in them. The investigations were carried out with two substrates composed of forest wastes and two substrates composed of agricultural wastes. The difference between the compost types was the origin and size of the substrate particles. The results were obtained by field and laboratory studies. In the studied composts, the identified species were hemiedaphic, euedaphic and atmobiont. Hemiedaphic life forms dominated in the compost of agricultural wastes. The have the highest density into the compost of forest wastes. With regard to food sources the collembolans established species were divided into three ecological functional groups: herbivores, predators and detritivores. The groups of predators and herbivores were the smallest, and the most numerous were the detritivores. The detritivores population was established in high population density in the compost of forest wastes. The studies allow evaluating the found differences in the collembolans species composition and their number in the studied compost types. The results could be used as an estimate of the composting process and the quality of the compost.

Keywords: Collemlola, agricultural and wastes, compost

Introduction

Artificial fertilization and intensive soil tillage have a negative impact on the soil in the long term. Therefore, measures to revitalize soils are becoming increasingly important. The soil is home to an enormous number and variety of organisms. In the maintenance of a healthy soil with sustainable soil fertility, they take over a number of important tasks. An alternative to it is an intake of low-pollution compost in the soil, the safest and cheapest. The prominent role of soil fauna in the process of humus formation has been proved, (Coleman & Wall 2015, Bagyaraj et al. 2016, Chertov et al. 2017).

The soil mesofauna is also positively influenced by the supply of organic fertilizer. The results of Idinger & Kromp (1997) establish that the saprophagous groups like certain collembolans as well as the nematoceran families of sciarids, cecydomiids and chironomids occurred more abundantly in the compost-fertilized fields than in nonfertilized and inorganic fertilized field.

Collembola are common inhabitants of soil, ground vegetation and tree trunks. Water surfaces are also colonized, especially when vegetation is present. Collembola communities have been analysed by numerous authors (Gisin 1943, Zmudczyńska-Skarbek 2015, da Silva et al. 2016, Rendoš et al. 2016), but our knowledge of the effect of environmental changes on collembolan communities is very poor. Results of these studies give evidence of strong relationships of species composition with soil conditions. The aim of this study was to establish the quality differences between the four types of mature compost by studying the structure of Collembola communities in them.

Materials and Methods

The characteristics of the compost

Various types of compost (forest and agricultural) were used for the purposes of the study. The composts in this work will be called conditional: forest compost, types A and B and agricultural compost, types C and D. The wood waste materials from deciduous trees (branches and bark) were used for compost A and B as "brown" material (carbon source). The sorted waste materials from the household and freshly mown grass were used as a "green" material (source of nitrogen), and as activator of composting process- forest litter. The difference between the compost types A and B was the size of the substrate particles. The waste materials from agricultural production were used for C and D, as "green" material was stems of tomatoes and peppers, but as "brown" material shoots of vines, and as activator -soil. The difference between the compost types C and D was the size of the substrate particles. The duration of the composting process was terminated after 145 days, with a temperature peak of 68°C.

Sampling for investigation of compost

Samples were taken from the piles of mature compost. For the representative sample, an amount of about 100 cm^3 has been repeatedly taken from all sides of each compost heap to give average sample of 1L. After mixing of composting materials, the samples were placed in plastic bags, sealed and stored in a refrigerator at 4-5 °C to carry out laboratory analysis.

Extraction of the collembolans from the compost

The extraction of collembolans followed the concept of Macfayden (1961). All adult specimens were bleached in lactic acid for 24 hours and then determined to species level by Gisin (1960) and Palissa (1964). Collembola were identified according to Fjellberg (1998, 2007).

Results and Discussion

Species composition and abundance of individuals

When processing of the soil samples during the whole period of the studies were extracted a total number of 2106 (Σ collembolans/100 cm3), of which 1575 adults belonging to 14 species belonging to 10 genera and 6 families

The identified species were arranged systematically:

Kingdom: Animalia
- Subkingdom: Eumetazoa
  - Phylum: Arthropoda
    - Subphylum: Hexapoda
      - Class: Entognatha
        - Order: Collembola
          - Suborder: Entomobryomorpha
            - Family: Tomoceridae
              - *Tomocerus minor* (Lubbock 1862)
          - Family: Entomobryidae
            - *Lepidocyrtus curvicollis* Bourlet, 1839
            - *Lepidocyrtus cyaneus* Tullberg, 1871
            - *Heteromurus nitidus* (Templeton, 1835)
            - *Orchesella flavescens* (BOURLET, 1839)
            - *Orchesella villosa* (Geoffroy 1762)
          - Family: Isotomidae
            - *Folsomia candida* Willem, 1902
            - *Folsomia fimetaria* (Linnaeus, 1758)
            - *Folsomia quadrioculata* (Tullberg, 1871)
            - Isotoma viridis Bourlet, 1839
            - *Proisotoma minima* (Absolon, 1901)
      - Suborder: Poduromorpha
        - Family: Onychiuridae
            - *Onychiurus* Gisin, 1952
            - *Onychiurus* spp. (armatus-group) ∗
      - Suborder: Symphypleona
        - Family: Katiannidae
          - *Sminthurinus aureus* (Lubbock, 1862)
        - Family: Sminthuridae
          - *Sminthurus viridis* (Linnaeus, 1758)

The classification and nomenclature of species of Collembola in the various compost types is based primarily on Gisin 1960, Hopkin (1997), Potapov (2001) and others.

Ecological characteristic. Life-forms of collembolans

According to Gisin (1943), the insects from the order of Collembola are divided into three life forms: atmobiont, hemiedaphic and euedaphic. The life forms of the species composition of collembola communities in the compost types are listed in Table 1. The hemiedaphic and euedaphic forms were dominated. The atmobiont collembolans were underrepresented.

Table 1: Life forms of established species of the order Collembola

Life forms	Species	Compost type
atmobiont		
	Orchesella flavescens	A; B; C
	Orchesella villosa	A; B; C
	Sminthurus viridis	C
	Lepidocyrtus curvicollis	B;C
hygrophilic hemiedaphon		
	Tomocerus minor	B; C
mesophilic hemiedaphon		
	Sminthurinus aureus	A; C
	Folsomia quadrioculata	A;B; C;D
	Lepidocyrtus cyaneus	A; B;C; D
	Isotoma viridis	C; B; D
	Proisotoma minima	A; B; C
euedaphon		
	Onychiurus spp. (*Onychiurus armatus* - group Gisin, 1952)	A; B; C; D
	Folsomia candida	A; B; C; D
	Folsomia fimetaria	A; B; C; D
	Heteromurus nitidus	C; B; D

Food specialization of collembolans

With regard to food sources the established Collembola species were divided into three ecological functional groups: herbivores, predators and detritivores according to (Hopkin 1997).The group of predators was smallest and the most numerous was the group of saprofagige. Depending on conditions, some phytophage species can be saprophages, especially as mycophages (Ulber 1982). The species identified by us were assigned to different groups according to feeding type only available literature data, which relate mainly to Western and Central Europe and part of North America and Australia (Table. 2).

Table 2: Feeding specialization (first trophic level) of identified species of the order Collembola

Feeding specialization	Species	Compost type
herbivores		
	Lepidocyrtus curvicollis	B; C
	Lepidocyrtus cyaneus	A; B; C; D
	Heteromurus nitidus	B; C; D
	Isotoma viridis	B; C; D
	Proisotoma minima	A; B; C
	Sminthurus viridis	C
detritivores		
	Orchesella flavescens	A; B; C
	Folsomia candida	A; B; C; D
	Folsomia fimetaria	A; B; C; D
	Folsomia quadrioculata	A; B; C; D
	Sminthurinus aureus	A; C
herbivore/detritivore		
	Onychiurus spp. (*Onychiurus armatus* - group Gisin, 1952)	A; B; C; D
detritivores/fungivore		
	Tomocerus minor	C; B
predator		
	Orchesella villosa	A; B; C

The taxonomic characterization showed that the representatives of the Collembola fauna in the compost types belong to the following families: Entomobryidae, Isotomidae, Neanuridae, Onychiuridae, Katiannidae, Sminthuridae. Species richness was highest /12 species/ in the forest compost (B) and lowest /7 species/ in the agricultural compost (D).

The data on abundance of the species demonstrated that the number of the dominant species was from 3 to 5 species; 39.2 % of the identified species were detritivores, 46.4 % herbivores and 7.1 % predators. The herbivore species of genus *Onychiurus* were in high abundance in agricultural compost (D) and the herbivores of family Isotomidae: *Isoloma viridis* in the agricultural compost (C).

The present study has analysed the structure of collembola communities in the four types of mature compost. The results has shown that compost type have an influence on Collembola species. According to Beare et al. (1992, 2014) functionally similar organisms often have different tolerance ranges with regard to certain environmental parameters as well as their physiological requirements microhabitat preferences. It can also be inferred that different species in the same habitat may fulfill different functions in the ecosystem. Mebes and Filser (1998) found differences in the influence of various Collembola species on the nitrate leaching and also assumed this for the organic matter decomposition. Cragg and Bardgett (2001) also found that the number of species or the species diversity is not decisive for the organic matter decomposition, promoting of microbial activity and release of organic carbon and nitrate, but only the species composition of the Collembola communities. In the open field, the hemiedaphic species are more exposed to microclimatic changes than the euedaphic species living in deeper soil layers (Heimann-Detlefsen et al. 1994).

According to Dunger et al. (2004), the euedaphone reacts more slowly to environmental changes than the hemiedaphone.In the present experiments, the animals were exposed to largely constant environmental conditions. An exception is the compost humidity. The drying out of the substrates during the experimental periods may have different effects on the species. According to

Fountain and Hopkin (2005), however, *F. candida* is also exceptionally resistant to dehydration.

It is possible that differences in the species composition of Collembola can occur due to processes arising from the physical and chemical composition of the different compost types and biological activity in the various substrate types. But these differences could be explained by established life forms of collembolans that are bioindicators of changes in soil and substrate quality. The vegetation structure plays an important role in the life cycle of atmobionts, and the soil substrate – in euedaphic species. Of undoubted interest is the further development of study, including the establishment of interactions between Collembola fauna and various properties of compost.

Conclusions

The most common were species of *Folsomia, Onychiurus, Lepidocyrtus* and *Heteromurus;*

The biodiversity was greater in the compost B and lowest in the compost D;

The hemiedaphic life forms were dominated in compost type, and the euedaphic life forms in in compost type. The atmobiont collembolans were underrepresented;

The established life forms of the Collembola communities can be used as bioindicators for the maturity status of the compost.

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