# ECOLOGICAL STRUCTURE AND FUNCTIONS IN ANTHROPOGENIC COENOSES

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**Abstract.** The aim of this paper is to identify the general characteristics of structure and functioning of coenoses from a few anthropogenic habitats: sterile dumps, sterile ponds, afforestations. Ten sites were studied; four of them are natural habitats and their analysis is necessary for comparisons. The analysis of data is directed to epigeic invertebrate fauna but it is also commented the vegetation status, for a better reflection of the structure and functions of these coenoses. In anthropogenic habitats both vegetation and invertebrate fauna differ as structure and functioning in comparison with the adjacent natural areas and the slow evolution of vegetation influences the other coenotic components. The determining factor of this situation is human pressure: either the substrata are radically modified or the level of primary producers is drastically controlled by humans, or both.

**Keywords:** sterile dumps, sterile ponds, afforestation, structure and functions of coenoses.

**Rezumat. Structură şi funcţii ecologice în cenoze antropogene.** Această lucrare are ca scop identificarea trăsăturilor structurale şi funcţionale generale a cenozelor din câteva categorii de habitate antropogene: halde de steril, iazuri de decantare şi păduri plantate. Au fost studiate zece habitate dintre care patru naturale, pentru comparaţii. În analiza datelor am pus accentul pe fauna de nevertebrate epigee dar comentăm şi statusul vegetaţiei, pentru o mai bună ilustrare a structurii şi funcţiilor cenozelor. Atât vegetaţia cât şi fauna de nevertebrate din habitatele antropogene diferă mult structural şi funcţional în comparaţie cu zonele naturale adiacente, iar evoluţia lentă a vegetaţiei influenţează celelalte componente biotice. Factorul determinant în zonele antropogene studiate este amprenta umană: fie substratul este radical modificat, fie nivelul producătorilor primari este drastic controlat de om, sau ambele situaţii.

**Cuvinte cheie:** halde de steril, iazuri de decantare, împăduriri, structura şi funcţiile cenozelor.

## INTRODUCTION

With the development of human society, both needs and human activities have multiplied and diversified, most of them with negative effects on our living environment. Speaking of ecological systems, we see lately a growing rate of degradation of the natural ecosystems and consequently, the emergence of ecological structures with strong anthropogenic footprint.

We refer to those ecological structures that are radically modified by man through its activities, especially at the level of two components: soil / substrate and vegetation. In light of these changes, we consider anthropogenic systems:

- Crops, vineyards and orchards – these have controlled vegetation and much reduced as diversity (up to the monospecific level) and the soil is altered due to agricultural practices (e.g. ploughing, fertilizing, applying herbicides, pesticides, etc.);
- Industrial landfill (waste material derived from mining activities, mining and mineral extraction, etc.); it comes to the dumps and tailing dams. These areas have usually a radically modified substrate which is not ground, but a substrate exclusively mineral, sometimes loaded with pollutants (such as heavy metals), which causes drastic changes in the structure of the primary producers compartment and hence, other biotic elements and the function of the ecological structure as a whole.

It is natural to ask ourselves how far - structurally and functionally - are these areas compared to the adjacent natural ecological structures and, if possible, on this basis, to conclude whether it is more efficient to restore these areas or let renaturation working on our behalf to remedy the environmental damages.

For this, we studied only anthropogenic areas (waste dumps and tailings ponds) which are either in the process of revegetation or environmentally restored.

We analysed the structure of epigeic invertebrate fauna (structure of numerical dominance, constancy classes, diversity, the degree of similarity) and as part of functions, aspects of vegetation cover and trophic relationships between invertebrate groups, as an expression of the flow of matter and energy at the local level.

## MATERIAL AND METHODS

For purposes of this paper there were selected sets of data from previous studies carried out in the above mentioned areas, comparable as the period of the year in which they were made and working method.

The epigeic invertebrate fauna was collected using pitfall traps (10 sample units each site) located at about 5 m distance each other and filled with a mixture of 4% formaldehyde and liquid detergent solution (1: 1 vol.).

The epigeic invertebrates were identified at the over-specific (Order rank or superior). As BIAGGINI et al. (2007), we consider useful and fair this approach.

Beyond the empirical processing (structural indicators), to highlight the differences between datasets we used tests and statistical programs (one-way anos, NMDS) based on the decision that the distribution of non-normal data requires the use of non-parametric tests. Also, for setting the existence (or not) of correlations (in case of trophic relationships), we used Excel function for the r coefficient of linear correlation.

**The analysed sites**

**Site 1 –** Bârlii sterile dump (Retezat National Park).
*Geographical position*: W Romania;
*Type*: sterile material resulting from the construction of a tunnel (adduction) in the perimeter of Râul Mare-Retezat hydropower plant and stored on a meadow;
*Status*: Technogenic area which is four years after experimental revegetation process with a mixture of perennial herbaceous plant seeds (grasses) (PAUCĂ-COMĂNESCU et al., 1999; PUIA et al., 2001).
**Site 2 –** natural mixed forest, adjacent to site 1.
**Site 3 –** Ciurila sterile dump (Retezat National Park);
*Type*: sterile material resulting from the construction of a tunnel (adduction) in the perimeter of Râul Mare-Retezat hydropower plant and stored on the right side of Ciurila spring;
*Status*: technogenic area which is 45 years after the last deposit of sterile material; under renaturation.
**Site 4 –** natural mixed forest, adjacent to site 3.
**Site 5** – Valea Mică flotation pond;
*Geographical position*: W. Romania, close to Zlatna town (Alba County);
*Type*: sterile material (stored on a meadow), resulted from the technological process of extracting metals (Cu, Zn, Fe, etc.) nearby the Factory S.C. Ampellum – Zlatna S. A.;
*Status*: flotation pond; non-active technogenic area (abandoned) for about twelve years; under renaturation.
**Site 6** – Valea Mică natural meadow adjacent to site 5.
*Geographical position*: W. Romania, close to Zlatna town (Alba County);
*Type*: natural habitat, adjacent to site 5.
**Site 7 –** Boşneag flotation pond.
*Geographical position*: W. Romania, close to Moldova Nouă town (Caraş-Severin County);
*Type*: sterile material (stored on a meadow), resulted from the technological process of extracting metals (Cu, Zn, Fe, etc.) at the nearby factory (Moldomin S. A.);
*Status*: flotation pond; four years after the ecological restoration process ended.
**Site 8** - Lunca Dunării flotation pond.
*Geographical position*: W. Romania, close to Moldova Nouă town (Caraş-Severin County);
*Type*: sterile material (stored on a meadow), resulted from the technological process of extracting metals (Cu, Zn, Fe, etc.) at the nearby factory (Moldomin S. A.), adjacent to site 7;
*Status*: flotation pond; ten years after the ecological restoration process ended.
**Site 9 –** Adea deciduous forest plantation.
*Geographical position*: (W. Romania, Arad County);
*Type*: forest plantation;
*Status*: four years old forest plantation.
**Site 10 –** Adea natural forest.
*Geographical position*: (W. Romania, Arad County), adjacent to site 9.
*Type*: natural habitat;
*Status*: natural deciduous forest of 110 years old.

***Processes of restoration and reforestation***

***In site 1*** it was used a mixture of perennial herbaceous plants seeds (PAUCĂ-COMĂNESCU et al., 1999) to stabilize, at least superficially, the mineral substrate and to induce at the substrate level the accumulation of organic matter.

***In sites 7 and 8*** the sterile material has undergone to a restoration process consisting in covering the sterile with a layer of soil allochthonous (15-20 cm thick) from an adjacent meadow and then planting seedlings of willow, seabuckthorn, acacia, etc.; these species were elected after previous tests (as growing and adaptation).

## RESULTS AND DISCUSSIONS

***The structure of numerical dominance, constancy classes, diversity, similarity***

Starting from the numerical abundances, we found that most of the analysed sites (grouped in categories of the same type, e.g. sterile dams, tailings ponds or plantation vs. adjacent natural forest) show significant differences (Table 1).

Table 1. Structural characteristics of the coenoses in the studied sites.

| | Nr. of superior taxa | N/u.p. | % eudominant + dominant | % subrecedent + recedent | % euconstant + constant | % accessory + accidental |
|---|---|---|---|---|---|---|
| **Site 1** | 17 | 93.4 | 29.41 | 52.94 | 58.82 | 23.53 |
| **Site 2** | 14 | 46.5 | 14.28 | 71.43 | 50 | 14.28 |
| **Site 3** | 13 | 22 | 23.07 | 69.23 | 38.46 | 46.15 |
| **Site 4** | 15 | 60.37 | 20 | 80 | 33.3 | 33.3 |
| **Site 5** | 13 | 161.75 | 23.08 | 53.85 | 61.53 | 30.77 |
| **Site 6** | 12 | 218.37 | 41.67 | 41.66 | 75 | 16.67 |
| **Site 7** | 19 | 112.9 | 31.58 | 52.63 | 57.9 | 15.79 |
| **Site 8** | 18 | 103 | 33.3 | 50 | 55.55 | 16.67 |
| **Site 9** | 18 | 34.2 | 22.2 | 38.89 | 33.34 | 16.67 |
| **Site 10** | 15 | 49 | 40 | 60 | 46.66 | 46.66 |

In sites 1-2 (Bârlii), the epigeic invertebrate fauna inhabiting the sterile dam and from the adjacent natural forest is similar as number of over-specific taxa. The structure of epigeic invertebrate populations exhibits close values (and similar taxonomical composition associated to these values) for the eudominant and dominant groups. The structural ecological superiority of the adjacent natural forest is due to the high percentage of euconstant taxa plus the percentage also high of the relative constant taxa (Table 2).

Table 2. Structural characteristics of the coenoses from sites 1 and 2.

| | D | % D Coleoptera | %D ACS+ACD | Similarity (%) |
|---|---|---|---|---|
| **Site 1** | 1.9945 | 7.51 | 1.36 | 80 |
| **Site 2** | 1.7232 | 18.34 | 2.55 | |

D = Shannon-Weaver index of diversity
%D = proportion of Coleoptera from D
%D ACS+ACD = proportion of accessory and accidental groups.

The differences in structure (p= 0.0001) and degree of similarity between the two conenoses are shown in Figure 1.

At Ciurila (sites 3-4), both on the sterile dump and in the adjacent natural forest, there was registered a similar number of invertebrate taxa but their numerical abundances is higher in the forest. The epigeic invertebrates on the sterile dam are present in a lower percentage as constant and euconstant groups, while in the natural adjacent forest, the balance between the (eu)constant groups on one side and the accessory and accidental groups on the other side (as proportions) ensures the plasticity and dynamic balance of the natural ecosystem (Table 3).

The differences in structure (p = 0.0005) and degree of similarity between the two coenoses are shown in Figure 2.

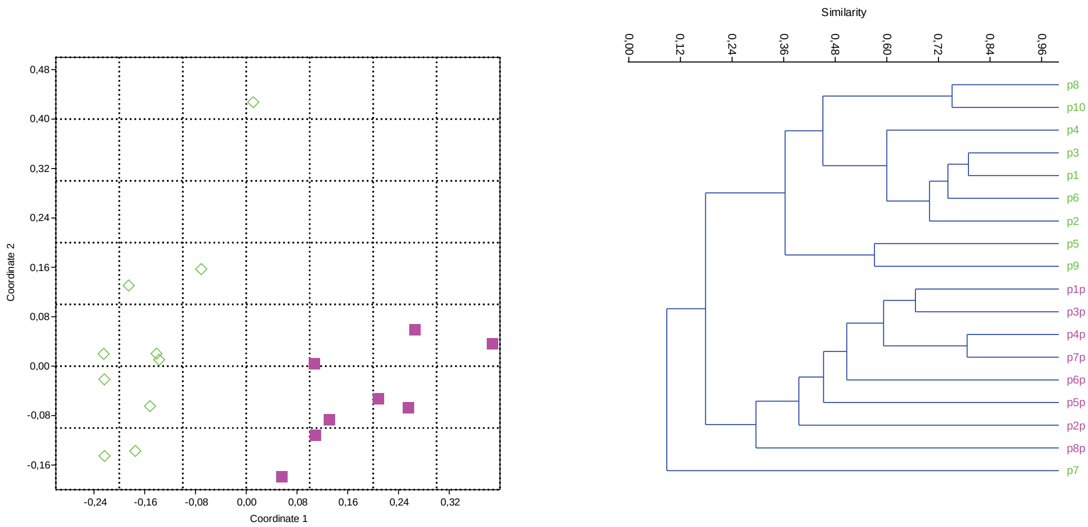


Figure 1. The differences (left) and degree of similarity (right) between the epigeic invertebrate communities of sites 1 and 2 (diamond = sterile dam coenoses; square = natural forest coenoses).

Table 3. Structural characteristics of the coenoses from sites 3 and 4.

| | D | % D Coleoptera | %D ACS+ACD | Similarity (%) |
|---|---|---|---|---|
| **Site 3** | 1.8366 | 5.96 | 8.93 | 78.57 |
| **Site 4** | 1.7524 | 19.54 | 13.96 | |

D = Shannon-Weaver index of diversity; %D = proportion of Coleoptera from D; %D ACS+ACD = proportion of accessory and accidental groups.

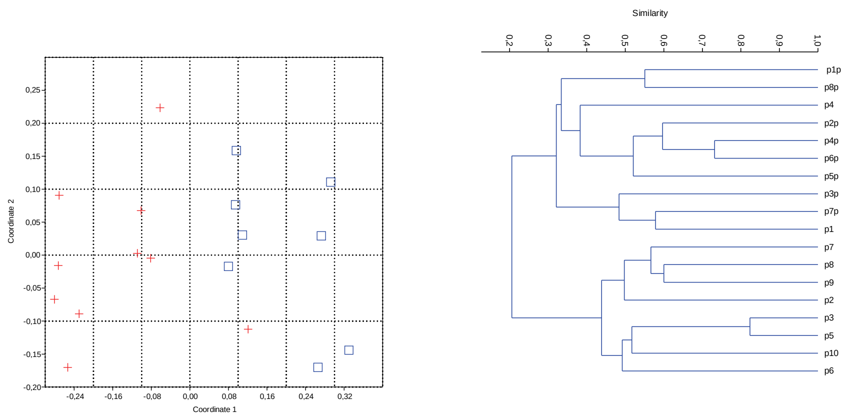


Figure 2. The differences (left) and degree of similarity (right) between the epigeic invertebrate communities of sites 3 and 4 (cross = sterile dam; square = natural forest).

As in previous cases, in sites 5-6 (Valea Mică), there was found a similar number of over-specific invertebrate taxa and higher numerical abundances of the invertebrate community inhabiting the natural meadow. On the flotation pond, the proportion of euconstant and constant invertebrate groups is similar to those of the meadow. Also, on the flotation pond it was noticed a smaller difference between the proportion of euconstant and constant invertebrate groups and of accessory and accidental ones in comparison with the situation existing on meadow, where, to the (eu)constant taxa is added the percentage of relative constant ones (Table 4).

Table 4. Structural characteristics of the coenoses from sites 5 and 6.

| | D | % D Coleoptera | %D ACS+ACD | Similarity (%) |
|---|---|---|---|---|
| **Site 5** | 1.0681 | 20.02 | 9.29 | 80 |
| **Site 6** | 1.7159 | 8.23 | 0.69 | |

D = Shannon-Weaver index of diversity
%D = proportion of Coleoptera from D
%D ACS+ACD = proportion of accessory and accidental groups of invertebrates.

The differences (p = 0.0002) and the degree of similarity of the coenotic elements from sites 5 and 6 are shown in Figure 3.

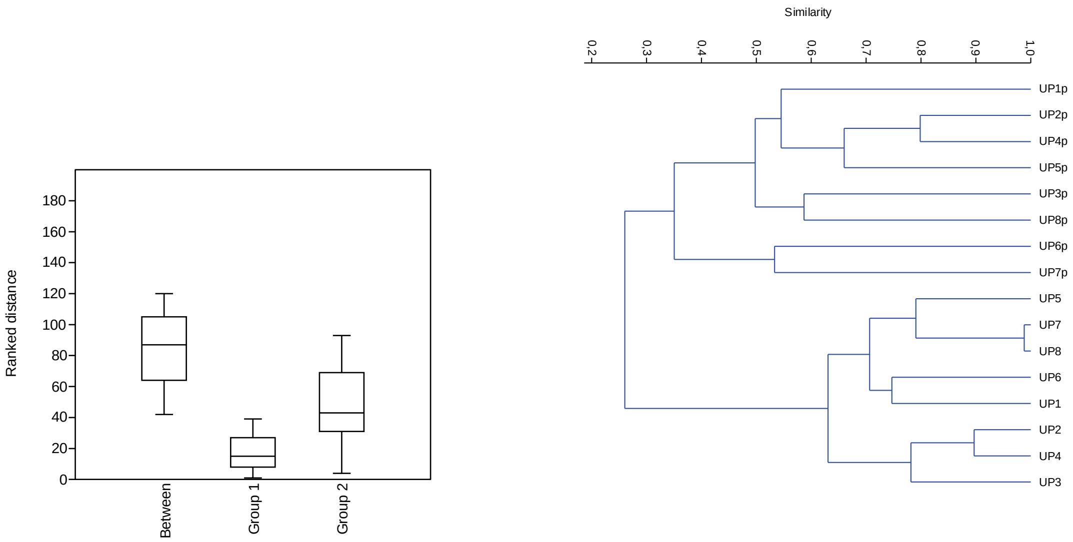


Figure 3. The differences (p = 0.0002) (Bray-Curtis, left) and degree of similarity (right) between the epigeic invertebrate communities of sites 5 and 6 (Valea Mică).

On the flotation ponds from Boşneag and Lunca Dunării (sites 7-8) the epigeic invertebrate communities are almost identical in taxa number and their proportions in the structure of numerical dominance and as classes of constancy.

According to the analysis of data (Fig. 4), there is not a certain distribution of taxa and of the structural elements depending on ecological gradients existing in sites 7 and 8. Also, no significant differences between the structure of the two invertebrate communities were noticed (Table 5).

Table 5. Structural characteristics of the coenoses from sites 7 and 8.

| | D | % D Coleoptera | %D ACS+ACD | Similarity (%) |
|---|---|---|---|---|
| **Site 7** | 2.1773 | 16.12 | 0.58 | 91.9 |
| **Site 8** | 2.1766 | 16.28 | 0.95 | |

D = Shannon-Weaver index of diversity
%D = proportion of Coleoptera from D
%D ACS+ACD = proportion of accessory and accidental groups.

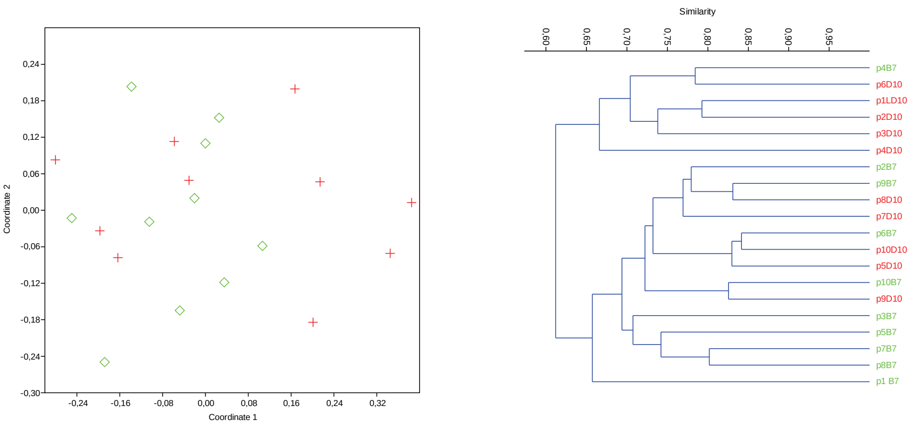


Figure 4. The differences (p = 0.2127) (left) and degree of similarity (right) between the epigeic invertebrate communities of sites 7 and 8 (Boşneag and Lunca Dunării) (diamond = Boşneag; cross = Lunca Dunării).

Between the forest plantation and the adjacent natural forest (sites 9-10) there is a great similarity as number of over-specific invertebrate taxa and structure of numerical dominance; the differences are given by the higher proportions of the euconstant taxa present in the natural forest (Annex 1).

Table 6. Structural characteristics of the coenoses from sites 9 and 10.

| | **D** | **% D Coleoptera** | **%D ACS+ACD** | **Similarity (%)** |
|---|---|---|---|---|
| **Site 9** | 1.8896 | 1.04 | 3.57 | 84.85% |
| **Site 10** | 1.3024 | 19.73 | 5.743 | |

D = Shannon-Weaver index of diversity
%D = proportion of Coleoptera from D
%D ACS+ACD = proportion of accessory and accidental groups

Because in terms of efficiency the analysis of epigeic invertebrate fauna was made only in part at the species level (Coleoptera: Carabidae), the diversity will be discussed at the over-specific level (Fig. 5).

In many papers, including COLEMAN's (2004), it is demonstrated (based on studies) that ground beetle fauna exhibits a higher diversity on the forested sterile dumps in comparison with the barren ones and also this diversity is higher on older forested dumps. It seems that the degree of cover of the vegetation layer does not influence directly the ground beetle fauna (except the phytophagous species) and the influence of canopy layer is due to the microclimatic characteristics it determines and to the formation of litter layer.

SCHWERK et al. (2006) found that on the sterile dumps forested with birch, the changes in ground beetle communities are rather stochastic and not a result of the ecological succession.

SCHWERK & ABS (2001) mention that the slow ecological succession on the sterile dumps is due to the low rate of soil formation and hence, the slow evolution of the conenoses as a whole.

PRACH & PISEK (2001) stated that the succession may be relied on spontaneous restoration projects, except in extreme cases, when it comes to toxic substrate. "Letting a site to allow spontaneous processes to revegetated is quite advantageous if the site in question is small and surrounded by natural vegetation. Spontaneous succession is cheap and revegetated sites typically exhibit greater natural value" they said.

HODAOVÁ & PRACH (2003) also stated that the vegetation on the restored sterile dumps develops in a different way than that colonizing naturally the sterile dumps. In the last case is about a higher specific diversity in more advanced successional stages in comparison with the restored sites.

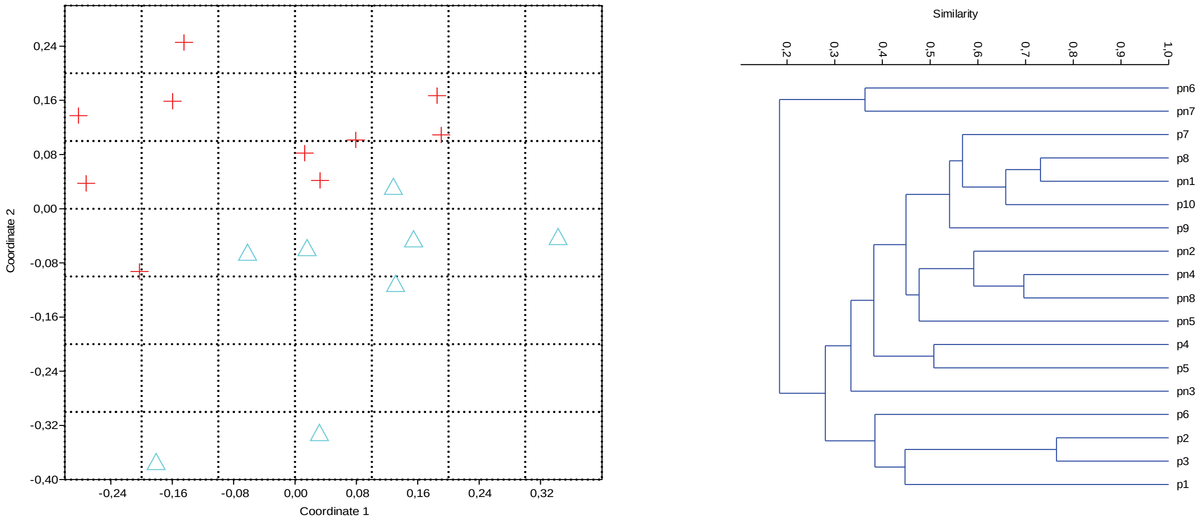


Figure 5. The differences (p = 0.0034) (left) and degree of similarity (right) between the epigeic invertebrate communities of sites 9 and 10 (cross = Adea plantation; triangle = natural forest).

***Functional characteristics***

In this paper, the functional characterization of the studied conenoses will be not performed by numerical estimates of vegetation and invertebrates biomass, but indirectly by the estimation of the degree of the vegetation cover (herbaceous layer and canopy layer) and by the numerical densities of epigeic invertebrates and also, by the trophic relationships between some predator groups (spiders, chilopoda, opiliones, predator ground beetle species) and the potential prey, as a reflection of the flux of matter and energy through the local coenoses.

About vegetation, it appears (Table 7) that both the woody and herbaceous vegetation is less represented in sites where processes of revegetation take place (sites 1, 3 and 5) compared with the restored ones (sites 7 and 8). Among dumps, that one at Bârlii (site 1) has a unique status of the herbaceous layer, at least reported to the age of the heap (four years old) thanks to the impulse of the initial experiments (seeding of the substrate), followed by the spontaneous processes of revegetation.

Also, on the flotation ponds (sites 5, 7, 8), at the vegetation level, it is noticed the difference in favour of those ecologically restored (sites 7, 8).

About the forest plantation we could say that it is different both in comparison with the plantations made on the flotation ponds and in comparison with the natural adjacent forest (Table 7). For details about the vegetation of Boşneag and Lunca Dunării, see DIHORU (2001).

At the epigeic invertebrate communities level, the trend is similar to the vegetation, since phytophagous invertebrate groups depend on vegetation and hence the higher trophic levels. This state of fact is reflected by the existence of trophic relationships between few invertebrate groups and their local trophic offer.

Because most of over-specific taxa are heterogeneous as trophic status, we chose to quantify / verify the existence of trophic relations between several groups of invertebrates (spiders, predatory ground beetles, centipedes, opiliones) and their food supply.

From the analysis undertaken is noticed that on the sterile dumps (sites 1, 3) there exist differences in the existent trophic relationships between predators and prey, but in comparison with the adjacent natural habitats (sites 2, 4). To be more specific, on Bârlii sterile dump (site 1), among invertebrate predator we analysed, only the predator ground beetle species established trophic relationships with mites and dipterans. The other groups (spiders, centipedes, opiliones) use in a smaller proportion the local source of food and thus, their relation with the predator ground beetles is not a competitive one.

In the natural forests adjacent to the sterile dumps (sites 2 and 4), all the groups of predators we studied established 3-5 trophic relationships with their food source and among them, no competitive relations were noticed (positive values of r).

Among the flotation ponds, on the site 5, where revegetation processes take place, the predators have trophic relations with different groups of food and thus they are not in competition for food.

Table 7. Some functional characteristics of the investigated conenoses.

| | **Age (years)** | **Status** | **% cover of herbaceous layer** | **% coverage of canopy** | **Nr. of predator groups** | **Nr. of predator -prey relationships** |
|---|---|---|---|---|---|---|
| **Site 1** | 4 | renaturation | ± 40 | < 10 | 4 | 3 |
| **Site 2** | > 100 | natural | 100 | 100 | 3 | 12 |
| **Site 3** | 45 | renaturation | ± 50 | 70 | 3 | 3 |
| **Site 4** | > 100 | natural | 80 | 100 | 4 | 12 |
| **Site 5** | ± 15 | renaturation | ± 20 | 0 | 2 | 2 |
| **Site 6** | n.a. | natural | 100 | 0 | 2 | 0 |
| **Site 7** | 4 | restoration | 100 | 70-75 | 4 | 4 |
| **Site 8** | 10 | restoration | 100 | 80-85 | 4 | 11 |
| **Site 9** | 4 | plantation | 40 | 50 | 2 | 2 |
| **Site 10** | 110 | natural | 80 | 100 | 3 | 5 |

On the flotation ponds ecologically restored (sites 7 and 8), on the "younger one" (site 7), only the predator ground beetles and spiders have real trophic relations with the local source of food and among these predators there are no trophic interactions because they consume different categories of food.

In the forest plantation (site 9), only spiders and opiliones have obvious trophic relations with the local source of food, but they consume different groups of prey and thus, as in previous similar situations, they do not compete for food (Annex 2).

Talking about plantations, the NMDS analysis show (Fig. 6) the obvious difference between the forest plantation from site 9 and plantations made on sterile substrate (sites 7 and 8).

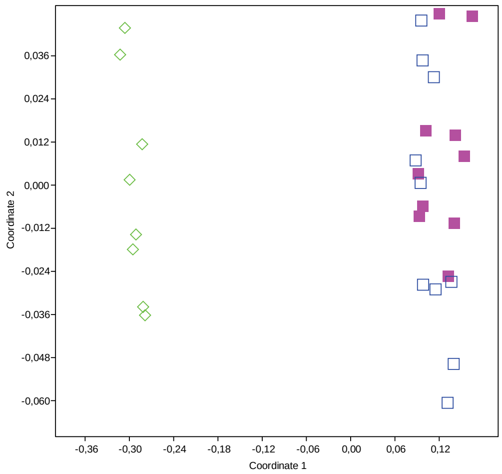


Figure 6. The differences (p = 0.0001) between the epigeic invertebrate communities of sites 5, 7 and 8 diamond = site 5, squares = sites 7 and 8).

## CONCLUSIONS

Data analysis reflects obvious structural differences both between sites with anthropogenic conenoses and in comparison with the natural ones.

Although the similarity of taxonomical composition is very high among the sites studied, differences are given by their numerical abundances, which determine on the one hand the structure of dominance and persistence of taxa in local coenoses local (classes of constancy) and secondly, trophic relations (partially analysed).

From the structure point of view, each category of anthropogenic conenoses, no matter their age, is far from the status of natural one, and by comparison, the conenoses where the renaturation takes place, have a slower development in comparison with those ecologically restored, but in favour of diversity and stability (in time, of course), because nature choose the ways and makes things working, not humans (as in case of the restored sites).

About taxonomical biodiversity, like BREMER & FARLEY (2010) and BROCKERHOFF et al. (2008), we concluded that forest plantations (woody species) have a high potential to support the development of herbaceous layer and zoofauna, but with the help of three factors: the substrate type, reforestation formula, the right management post-reforestation.

As functions, it is clear that all the conenoses inhabiting sterile areas, renaturated or restored ecologically, bear, as a dimension of their functionality, the footprint of 3 essential elements: the type of substrate (soil or sterile), vegetation type (natural colonization or plantation) and their age.

Like other specialists before us, we conclude that if there are no economic emergencies to make productive the sterile dumps or flotation ponds by reforestation, it is more desirable the renaturation, both as costs and ecological significance, and thus, in time, the anthropogenic areas become similar to natural ones, both as structure and functioning.

In both situations – restoration and renaturation – the success of the development of the local coenoses depends on the close vicinity of the natural habitats and the lack of the anthropogenic stress (PRACH & HOBBS, 2008).

We mention again that these conclusions are partial, due to the limited approach of the theme. Further studies are necessary, at larger scale and more parameters investigated, to obtain a more complex image of the structure and functioning of these conenoses.

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**Annex 1.**

| TAXA | Site 1 | | Site 2 | | Site 3 | | Site 4 | | Site 5 | | Site 6 | | Site 7 | | Site 8 | | Site 9 | | Site 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | D% | F% | D% | F% | D% | F% | D% | F% | D% | F% | D% | F% | D% | F% | D% | F% | Site | F% | D% | F% |
| GASTROPODA | 0.11 | 10 | 4.03 | 100 | 0 | 0 | 0.62 | 37.5 | 0 | 0 | 0 | 0 | 0.17 | 20 | 0 | 0 | 1.16 | 40 | 0 | 0 |
| OLIGOCHAETA | 0 | 0 | 0.54 | 12.5 | 0 | 0 | 0.62 | 12.5 | 0 | 0 | 0 | 0 | 0.09 | 10 | 0.1 | 10 | 0 | 0 | 0.25 | 12.5 |
| ACARINA | 1.17 | 40 | 49.2 | 100 | 22.7 | 70 | 33.77 | 100 | 0.31 | 13 | 1.26 | 50 | 3.1 | 100 | 4.37 | 100 | 38.21 | 100 | 33.9 | 75 |
| OPILIONES | 10.92 | 100 | 0 | 0 | 23.2 | 70 | 23.81 | 87.5 | 0 | 0 | 0 | 0 | 0.44 | 40 | 0.58 | 30 | 0.29 | 10 | 1.02 | 50 |
| ARANEAE | 4.28 | 80 | 3.5 | 75 | 2.73 | 30 | 2.69 | 62.5 | 5.64 | 100 | 6.7 | 100 | 12.04 | 100 | 21.9 | 100 | 3.5 | 50 | 5.36 | 87.5 |
| CRUSTACEA Isopoda | 0 | 0 | 1.34 | 62.5 | 3.18 | 10 | 0.83 | 50 | 0 | 0 | 0 | 0 | 3.19 | 70 | 3.49 | 60 | 8.16 | 80 | 0.25 | 12.5 |
| COLLEMBOLA | 18.95 | 90 | 6.18 | 62.5 | 0 | 0 | 4.55 | 12.5 | 5.02 | 100 | 38.1 | 100 | 17.71 | 100 | 12.1 | 100 | 11.95 | 80 | 9.7 | 87.5 |
| THYSANOPTERA | 0.21 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0.08 | 13 | 0.06 | 12.5 | 0 | 0 | 0 | 0 | 0.29 | 10 | 0 | 0 |
| MYRIAPODA-Chilopoda | 4.71 | 60 | 2.42 | 50 | 0.45 | 10 | 0.62 | 25 | 0 | 0 | 0.11 | 12.5 | 0.53 | 30 | 0.58 | 40 | 0 | 0 | 0.25 | 12.5 |
| MYRIAPODA-Diplopoda | 1.5 | 40 | 2.42 | 50 | 0 | 0 | 3.72 | 62.5 | 0 | 0 | 0 | 0 | 1.15 | 70 | 1.16 | 40 | 1.46 | 50 | 0.51 | 25 |
| HETEROPTERA | 0.11 | 10 | 0.27 | 12.5 | 0.45 | 10 | 0 | 0 | 0.15 | 25 | 0 | 0 | 0.62 | 50 | 0.68 | 30 | 1.75 | 50 | 0.25 | 12.5 |
| HOMOPTERA -Aphididae | 0.85 | 60 | 0.8 | 37.5 | 1.36 | 10 | 1.86 | 37.5 | 0.31 | 38 | 0 | 0 | 2.65 | 90 | 3.2 | 80 | 2.62 | 50 | 0 | 0 |
| HOMOPTERA - Cicadoidea | 0.43 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 1.47 | 100 | 7.44 | 75 | 1.5 | 80 | 1.16 | 70 | 10.2 | 70 | 1.27 | 25 |
| HYMENOPTERA var. | 7.38 | 80 | 0.8 | 25 | 5.91 | 60 | 0.21 | 12.5 | 0 | 0 | 0 | 0 | 9.83 | 100 | 7.86 | 100 | 3.79 | 50 | 2.04 | 62.5 |
| HYMENOPTERA - Formicidae | 8.35 | 90 | 2.95 | 62.5 | 4.5 | 60 | 0.83 | 25 | 2.78 | 75 | 11.2 | 100 | 11.07 | 100 | 15.1 | 100 | 3.5 | 50 | 17.3 | 87.5 |
| BLATTODEA | 0 | 0 | 0 | 0 | 0.45 | 20 | 0 | 0 | 0 | 0 | 0.63 | 62.5 | 0 | 0 | 0 | 0 | 4.08 | 60 | 0 | 0 |
| ORTHOPTERA var. | 2.35 | 80 | 0 | 0 | 0 | 0 | 0 | 0 | 1.08 | 63 | 4.64 | 100 | 0.62 | 40 | 0.68 | 50 | 0.29 | 10 | 0 | 0 |
| ORTHOPTERA - Gryllidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.21 | 50 | 0 | 0 |
| DERMAPTERA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 66.6 | 100 | 0 | 0 | 0.26 | 30 | 0.1 | 10 | 2.04 | 40 | 15.6 | 100 |
| DIPTERA | 33.12 | 90 | 6.45 | 100 | 31 | 100 | 1.65 | 37.5 | 12.6 | 100 | 24.9 | 100 | 8.68 | 100 | 8.54 | 100 | 0 | 0 | 0 | 0 |
| LEPIDOPTERA | 0.21 | 10 | 0 | 0 | 0.91 | 10 | 0.21 | 12.5 | 0.15 | 13 | 0.34 | 25 | 0.09 | 10 | 0.1 | 10 | 0 | 0 | 0.25 | 12.5 |
| ZYGENTOMA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| COLEOPTERA | 5.35 | 80 | 19.1 | 100 | 3.18 | 40 | 24.01 | 100 | 3.78 | 100 | 4.58 | 100 | 26.26 | 100 | 27.3 | 100 | 3.5 | 60 | 12.2 | 100 |

**Annex 2.**

| LINEAR CORRELATIONS | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 7 | Site 8 | Site 9 | Site 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Carabus* sp.-Gastropoda | - | 0.339 | - | -0.238 | - | - | 0.976 | - | - | -0.218 |
| *Carabus* sp.-Oligochaeta | - | 0.801 | - | 0.504 | - | - | -0.162 | - | - | - |
| Carabidae-Gastropoda | - | - | - | | - | - | 0.863 | - | - | - |
| Carabidae-Oligochaeta | - | - | - | 0.629 | - | - | 0.248 | - | - | - |
| Carabidae-Acarina | 0.814 | 0.881 | - | 0.236 | - | -0.333 | 0.083 | 0.387 | - | - |
| Carabidae-Isopoda | - | -0.609 | - | 0.862 | - | - | -0.308 | 0.171 | - | - |
| Carabidae-Collembola | 0.168 | 0.144 | - | 0.282 | 0.212 | -0.218 | -0.143 | 0.105 | - | - |
| Carabidae-Aphididae | - | -0.132 | - | 0.734 | - | - | -0.078 | 0.085 | - | - |
| Carabidae-Diptera | 0.593 | 0.702 | - | 0.356 | -0.522 | -0.343 | -0.589 | 0.224 | - | - |
| Araneae-Gastropoda | - | 0.562 | - | -0.269 | - | - | 0.198 | - | 0.153 | - |
| Araneae-Oligochaeta | - | 0.681 | - | 0.709 | - | - | -0.347 | - | - | -0.218 |
| Araneae-Acarina | -0.125 | 0.809 | -0.235 | -0.054 | - | 0.18 | 0.255 | 0.7645 | 0.367 | 0.092 |
| Araneae-Isopoda | - | 0.808 | -0.196 | 0.625 | - | - | 0.579 | 0.864 | 0.49 | 0.278 |
| Araneae-Collembola | 0.299 | 0.139 | - | 0.078 | 0.842 | -0.148 | 0.024 | 0.674 | 0.831 | 0.224 |
| Araneae-Aphididae | - | 0.024 | -0.196 | 0.714 | - | - | 0.079 | 0.585 | -0.374 | - |
| Araneae-Diptera | 0.023 | 0.71 | 0.531 | -0.251 | 0.024 | -0.332 | 0.422 | 0.857 | 0.037 | 0.143 |
| Chilopoda-Gastropoda | - | 0.484 | - | -0.046 | - | - | -0.049 | - | - | - |
| Chilopoda-Oligochaeta | - | 0.796 | - | 0.0882 | - | - | -0.196 | - | - | -0.143 |
| Chilopoda-Acarina | - | 0.683 | -0.109 | 0.221 | - | - | 0.133 | 0.611 | - | 0.827 |
| Chilopoda-Isopoda | - | 0.686 | -0.111 | 0.538 | - | - | 0.128 | 0.669 | \ | -0.143 |
| Chilopoda-Collembola | 0.147 | -0.068 | - | 0.339 | - | - | -0.18 | 0.331 | - | 0.644 |
| Chilopoda-Aphididae | - | -0.26 | -0.111 | 0.916 | - | - | 0.106 | 0.358 | - | - |
| Chilopoda-Diptera | 0.019 | 0.378 | 0.841 | -0.185 | - | - | 0.255 | 0.686 | - | 0.834 |
| Opiliones-Gasteropoda | - | | - | 0.074 | - | - | 0.373 | - | -0.272 | - |
| Opiliones-Acarina | -0.193 | - | | 0.504 | - | - | 0.169 | 0.706 | 0.302 | -0.519 |
| Opiliones-Isopoda | - | - | -0.146 | 0.582 | - | - | -0.361 | 0.601 | 0.723 | -0.378 |
| Opiliones-Collembola | -0.116 | - | - | 0.744 | - | - | -0.466 | 0.804 | -0.045 | -0.682 |
| Opiliones-Aphididae | - | \ | -0.146 | 0.506 | - | - | -0.108 | 0.034 | 0.029 | - |
| Opiliones-Diptera | 0.724 | - | -0.246 | 0.105 | - | - | -0.254 | 0.351 | 0.099 | -0.161 |
| Carabidae-Araneae | -0.198 | 0.788 | - | 0.643 | -0.131 | 0.299 | 0.035 | 0.155 | - | - |
| Carabidae-Chilopoda | 0.588 | 0.7801 | - | 0.732 | - | - | -0.084 | -0.185 | - | - |
| Carabidae-Opiliones | 0.843 | - | - | 0.233 | - | - | 0.466 | 0.466 | - | - |
| Araneae-Chilopoda | 0.179 | 0.683 | 0.784 | 0.711 | - | - | -0.183 | 0.738 | - | -0.126 |
| Araneae-Opiliones | -0.193 | - | -0.329 | 0.35 | - | - | -0.163 | 0.432 | -0.041 | -0.335 |
| Chilopoda-Opiliones | 0.677 | - | -0.241 | 0.157 | - | - | 0.146 | -0.064 | | -0.378 |