Analele Ştiinţifice ale Universităţii „Al.I.Cuza" Iaşi, s. Biologie animală, Tom L, 2004

SYNECOLOGICAL ANALYSIS OF A WHEAT FIELD GROUND BEETLES COMMUNITY FROM LETEA (BACĂU DISTRICT)

BY

IRINEL E. POPESCU[1] AND ŞTEFAN R. ZAMFIRESCU[1]

Keywords: wheat field, ground beetle community, synecological analysis, boundary conditions effect

Among the 17 identified ground beetle species, *Anisodactylus signatus*, *Brachinus psophia*, *Harpalus distinguendus*, *Poecilus cupreus* and *Pseudophonus rufipes* were the most important ones. These species proved to be ecologically similar. Most species achieved maximum dominance in June. In space, some species were dominant near the edge of the wheat field while others reached their maximums toward the middle of the field. This reveals different stages of species migrations from the edge to the interior. The highest diversity was identified near the wheat field edge proving, thus, the boundary effect and, consequently, the importance of the edge non-crop habitats. Over time, the diversity seems to grow from May to the end of July and to decline afterward, most probably due to aestivation. The crop field marginal habitats are a potential source of agroecosystem diversity and a source of pest natural enemies.

Introduction

Evidence suggests that vegetative diverse plant communities support diverse and abundant insect natural enemy communities. Vegetation both in and surrounding agricultural fields may be used to enhance natural enemy populations. The effects of boundary conditions on abundance and species richness of these populations may be proved by the study of ground beetle assemblages [7].

Materials and methods

The research was carried out in a wheat field area (20 ha) which is a part of a wider wheat cultivated area (102 ha) of the Farm no. 2 of the company "S. C. Selbac", from the village "Letea Veche", Bacău district. Before 25.09.1995, the study area was planted with anion. The seeding season was between 15 – 20.10.1995. Ground beetle sampling was carried out by rain covered "Barber" pitfall traps (18 – 20 cm deep and 10 cm in diameter). Each trap was repeatedly filled with 300 ml of formalin (4%). Four groups containing 3 traps each were placed respectively at 5 m, 10 m, 15 m and 50 m from the wheat field boundary. The 3 traps within a group were placed at 10 m from each other. Pitfall trap setting was on 1.05.1996. Samples were taken every 15 days. Till

[1] „Al.I. Cuza" University of Iaşi

the 15.07.1996, 60 samples had been taken. They were grouped on 4 sampling distances and 5 sampling dates.

Species abundance values were used to compute the dominance, constancy and ecological significance indices of each species. Dominance (D) in an analytical index that gives the proportion in which one species participates to the productivity of the community (D=(nA/N) 100, nA – the number of individuals of species A, N – total number of individuals of all the recorded species). Constancy (C) is an analytical index that expresses the continuity of the presence of a population in a certain habitat (C=(nsA/Ns) 100, nsA – the number of samples that contained species A, Ns – the total number of samples). Ecological significance (W) in a synthetic index that represents the relationship between the structural index (C) and the productivity index (D) of the community (W=(CAxDA) 100, CA – the constancy of species A, DA – dominance of species A). [9].

The next step was to outline the similarity of species and sampling sites. A similarity index estimates the affinity of different populations belonging to a community and, through the species composition, the similarity of the habitats. We calculated the similarity using two different coefficients – Sorensen's similarity coefficient (Qs=2j/(a+b)) and Bray-Curtis dissimilarity (in this case similarity = 1-dissimilarity) coefficient ($BCd = \frac{\sum \left| x_{ik} - x_{jk} \right|}{\sum \left(x_{ik} + x_{jk} \right)}$). Sorensen's coefficient considers the number of samples that contained species A and B together (j), the number of samples that contained species A (a) and the number of samples that contained species B (b). Bray-Curtis coefficient considers both species presence and species abundance (i, j – two cases (two rows of the abundance matrix); k – the variable (the column); x_{ik} – number of individuals of k variable in i case; x_{jk} - number of individuals of k variable in j case). The obtained data were used for a cluster analysis that would graphically reveal the above-mentioned similarities. The linkage method was the unweighted pair groups average one [1, 3].

Then, the data were used for calculating the diversity indices – Shannon Index and Simpson Index [6].

The Shannon index formula is $H' = -\sum p_i \log p_i$ where p_i – decimal fraction of i^{th} species individuals.

Using the value of H' one can calculate the species abundance equitability which reveals how different is the studied community compared to an ideal equitable community. The equitability formula is $J' = \frac{H'}{H'_{max}}$ where H'_{max} – the value of H' calculated with the same number of species, but equal p_i values [1, 5, 6, 9].

The values of the indices, the equitability and the number of species, for every sampling site and period, were plotted against each other in order to obtain graphical images of the diversity of the ground beetle communities.

Results and discussions

During the research of the wheat field from Letea Veche we identified 17 ground beetle species: *Anisodactylus signatus* Panzer, *Amara similata* Gyllenhal, *Bembidion sp*., *Brachinus explodens* Duftschmid, *Brachinus crepitans* L., *Brachinus psophia* Serv., *Calathus ambiguous* Payk, *Calosoma auropunctatus* (Herbst), *Carabus cancellatus* Illiger, *Carabus violaceus* L., *Cicindela germanica* L., *Harpalus cupreus* L., *Harpalus distinguendus* Duftschmid, *Poecilus cupreus* L., *Pseudophonus rufipes* De Geer, *Pterostichus melas* Creutzer and *Scarites terricola* Bon.

The values of the analytical indices (Figure 1.) showed that the most constant species were *Anisodactylus signatus*, *Brachinus explodens*, *Brachinus crepitans*, *Brachinus psophia*, *Carabus cancellatus*, *Harpalus distinguendus*, *Poecilus cupreus* and *Pseudophonus rufipes*. The wheat field ground beetle community was dominated by *Anisodactylus signatus*, *Brachinus psophia*, *Harpalus distinguendus*, *Poecilus cupreus* and *Pseudophonus rufipes*. The same species had the greatest ecological significance, which means that they simultaneously contributed to the edification of the community structure and biomass. Some highly constant species (*Brachinus explodens*, *Brachinus crepitans*, *Carabus cancellatus*) with low ecological significance were represented by few individuals. Therefore, their contribution to the biomass of the ground beetle community was relatively low. Although some species were less abundant, their ecological role may be important. For instance, predators, as *Carabus cancellatus*, are normally rarer than pray species, but they are important for the continuity of the community matter circuit.

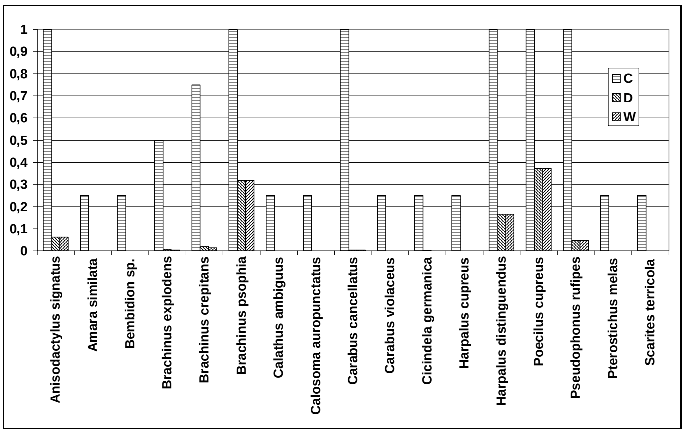

Figure 1. Ground beetle species constancy (C), dominance (D), ecological significance (W)

The temporal dominance figure (Figure 2.) shows that the highly dominant species were *Harpalus distinguendus* on 15.05.1996, *Brachinus psophia* on 30.05.1996 and on 30.06.1996, *Poecilus cupreus* on 15.07.1996 and *Pseudophonus rufipes* on 15.07.1996.

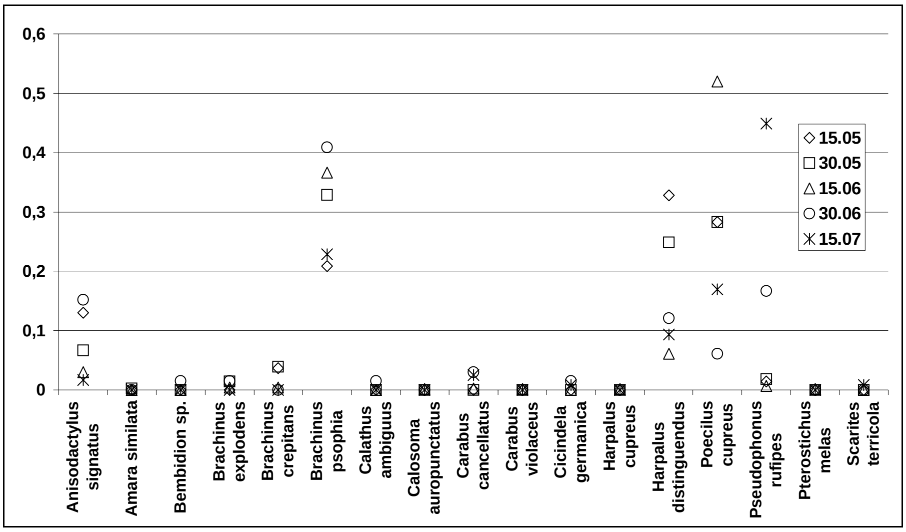

Figure 2. Ground beetle temporal dominance figure

The ecological significant species became more or less dominant from a sampling period to another: *Anisodactylus signatus* and *Brachinus psophia* dominance reached maximum at the end of June and decreased in July; *Harpalus distinguendus* dominance was maximum in the middle of May and decreased toward middle of July; *Poecilus cupreus* reached its highest dominance in the middle of June and then declined; *Pseudophonus rufipes* achieved its maximum dominance in the middle of July.

The spatial dominance figure (Figure 3.) revealed that the most dominant species were *Poecilus cupreus* at the 5 m and 15 m sampling sites, *Brachinus psophia* at the 10 m sampling site, and *Harpalus distinguendus* at the 30 m sampling site. The dominance of *Brachinus psophia* and *Poecilus cupreus* decreased toward the middle of the wheat field, while for *Anisodactylus signatus* and *Harpalus distinguendus* the dominance increased toward the wheat field interior.

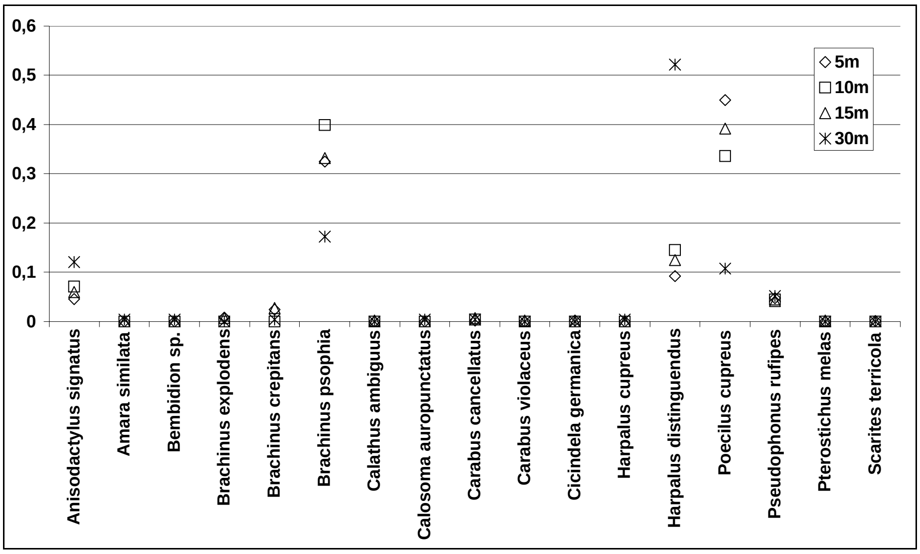

Figure 3. Ground beetle spatial dominance figure

The analysis of the similarity of the ground beetle species (Figure 4.) outlines that the important species are highly alike with respect to the ecological conditions. Thus, *Anisodactylus signatus*, *Brachinus psophia*, *Carabus cancellatus*, *Harpalus distinguendus*, *Poecilus cupreus* and *Pseudophonus rufipes* are most similar. They are also fairly similar to *Brachinus crepitans*, *Brachinus explodens*, respectively. The other 3 groups include ground beetle species that occurred in the same samples but had low abundance values.

The most similar ground beetle spatial assemblages (samples) occurred at 10 m and 15 m ones (Figure 5.). These two samples were similar to the 5 m one. The ground beetle assemblage from 30 m was the most dissimilar sample.

Additionally, the plot of the distances among samples (Figure 6.) shows that the 5m sample is more similar to the 15 m sample than to the 10 m one. Therefore, the 15 m ground beetle assemblage seems to have a key position in the similarity figure, and it may be considered as representative for both 10 m and 15 m samples in certain comparisons.

The high similarity of the boundary samples may be the result of the boundary conditions effect.

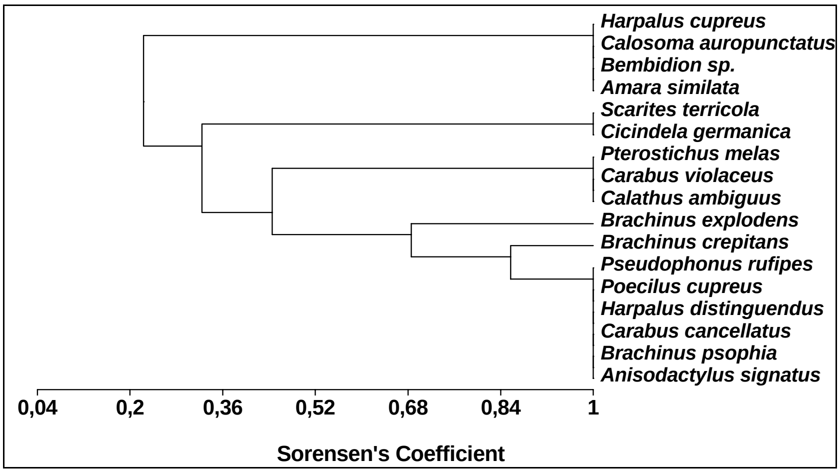

Figure 4. Ground beetle species similarity cluster.

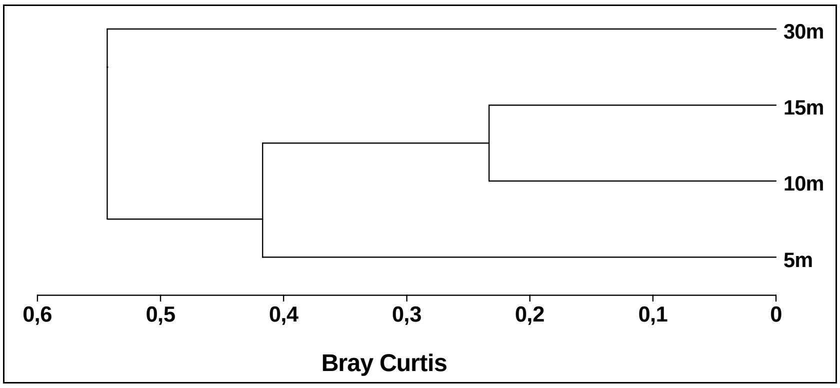

Figure 5. Ground beetle spatial assemblages similarity cluster

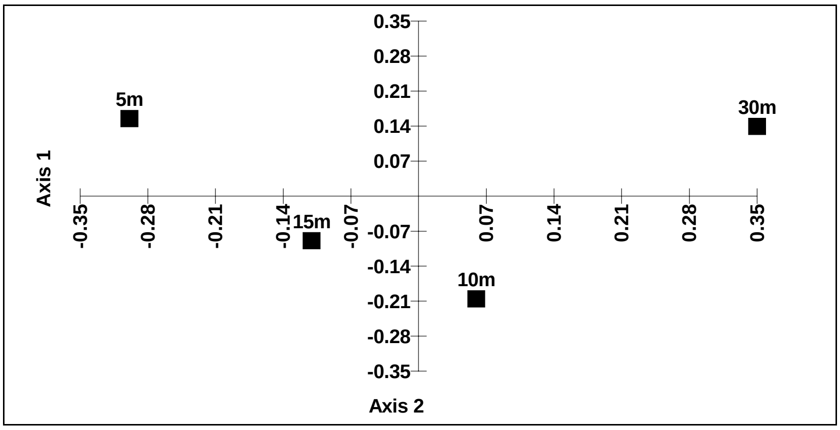

Figure 6. Plot of dissimilarity among ground beetle spatial assemblages from Principal Coordinates Analysis (Bray-Curtis coefficient)

The analysis of sample diversity (Figure 7.) emphasizes the above-mentioned hypothesis. The 5 m, 10 m and 15 m samples are more divers than the 30 m samples. The maximum diversity occurs in the 15 m ground beetle assemblage. Despite the high species richness, the lowest diversity was identified at 30 m.

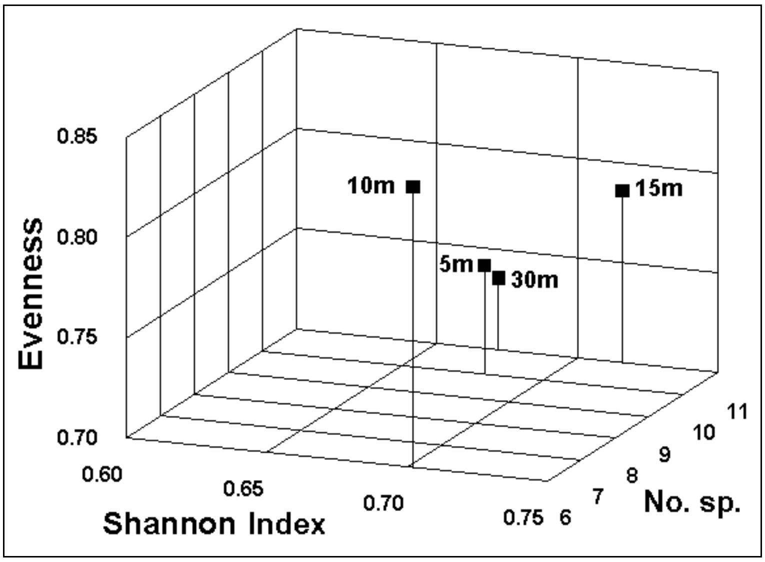

Figure 7. Diversity of the ground beetle spatial assemblages

The temporal assemblages diversity analysis (Figure 8.) reveals an obvious increase from May to June followed by a small decrease in July that most probably intensified during summer.

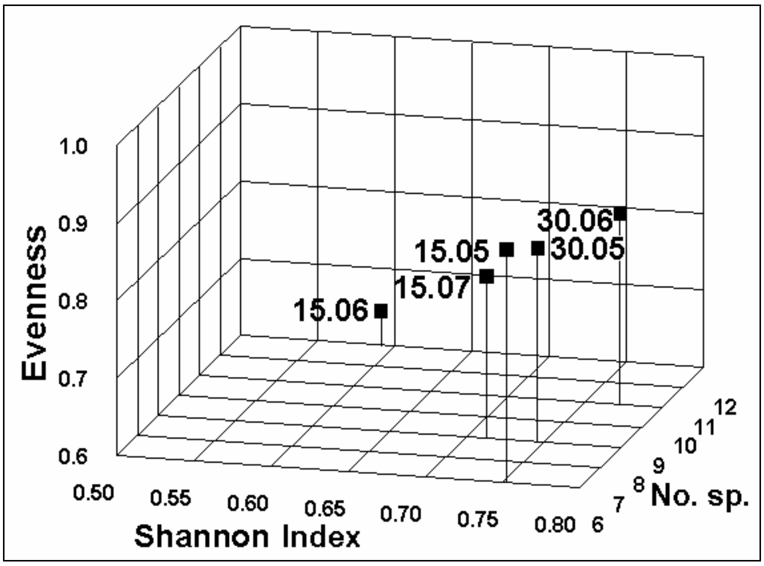

Figure 8. Diversity of the ground beetle temporal assemblages

Our results can be explained by the boundary condition effect. The boundary condition effect consists in the increment of the ground beetle assemblage diversity especially in the spring [10]. The ground beetle species emerge in non-crop habitats and spread in crop-fields. Non-crop habitats are very important to ground beetles, as many use adjacent hedges and field margins for shelter, breeding or dispersal [4]. Woody hedges may serve as very important over-wintering sites and as an early season refuge for predatory beetles in corn [8].

The diversity decrease toward midsummer results from high temperatures that trigger aestivation.

Maintenance of adjacent non-altered margins would be important for ground beetle community diversity. These communities would potentially contribute to biodiversity in agroecosystems [2]. Consequently, the diversity of pest natural enemies would increase with beneficial effects for the crops.

Conclusions

During the wheat field investigation 17 ground beetle species were identified.

In ground beetle community, the most important species were *Anisodactylus signatus*, *Brachinus psophia*, *Harpalus distinguendus*, *Poecilus cupreus* and *Pseudophonus rufipes*. These species proved to be ecologically similar.

Most species achieved maximum dominance in June

In space, some species were dominant near the edge of the wheat field while others reached their maximums toward the middle of the field. This reveals different stages of species invasions from the edge to the interior.

The highest diversity was identified near the wheat field edge proving, thus, the boundary effect and, consequently, the importance of the edge of non-crop habitats.

Over time, the diversity seems to grow from May to the end of July and to decline afterward, most probably due to aestivation.

The crop field marginal habitats are a potential source of agroecosystem diversity and, so forth, a source of pest natural enemies.

Acknowledgement

We would like to thank Prof. Dr. M. Varvara for species identification.

References

1. Cox, W. G., 1996 - Laboratory Manual of General Ecology. Ediția a VII-a. Ed. Wm. C. Brown Publishers.
2. Döring, T. F., Hiller, A., Wehkec, S., Schulte, G., Broll, G., 2003 - Agriculture, Ecosystems and Environment 98: 133–139
3. Fowler J., Cohen L., Javris P., 2000 - Practical Statistics for Field Biology, second edition. John Wiley and Sons, Chichester, New York, Weinheim, Brisbane, Singapore, Toronto, p. 1 – 259
4. Holland, J. M., Luff, M. L., 2000 - Integrated Pest Management Reviews 5: 109–129
5. Southwood, T. R. E., 1966 - *Ecological Methods with Particular Reference to the Study of Insect Populations.* London, Methuen and CO LTD
6. Stiling, P. D., 1996 - *Ecology Theories and Applications*. ed. a II-a, Prentice Hall, New Jersey.
7. Varchola, J. M., Dunn, J. P., 1999 - Agriculture, Ecosystems and Environment, 73: 41-49
8. Varchola, J. M., Dunn, J. P., 2001 - Agriculture, Ecosystems and Environment 83: 153–163
9. Varvara, M., Zamfirescu, ŞT. R., Neacşu, V., 2001 - *Lucrări practice de ecologie – manual*. Ed. Univ. “Al. I. Cuza” Iaşi.
10. Wade French, B., Elliott, N. C., Berberet, R, C., Burd, J. D., 2001 - Environ. Entomol. 30(2): 225–234