XV Congresso della Società Italiana di Ecologia – Torino 2005
15th Meeting of the Italian Society of Ecology
Talk

Ground Beetles (Coleoptera: Carabidae) assemblages in different agroecosystems in the Po Plain (Italy)

Mauro Gobbi[*], Diego Fontaneto

[*]*University of Milan, Department of Biology, Via Celoria 26, Milan, 20133 Italy*

Abstract

Aim of this paper is to show whether local species assemblages of ground beetles are influenced by habitat typology in agricultural environment. We analysed 54 different species assemblages in the Po Plain, belonging to 4 habitats: forest, poplar stand, meadow and crop, obtaining 198 species. Data came from the literature and our unpublished researches. For each assemblage, we considered species similarity of community, species richness, and adaptive parameters of species, like flying ability, body length, and diet. Species assemblages were not more similar each other within each habitat than between habitats. Forests revealed significantly lower values of species richness than the 3 rural habitats. Predator, wingless and large species were significantly more frequent in forests and less frequent in crops. In crops small, phytophagous, and flying species were more common; intermediate values were observed in meadows and in poplar stands. Our results demonstrate that "functional groups", previously proposed to indicate coenose stability, are a better index of the impact of human activities in the landscape than species similarity: lower number of species, but higher frequency of predator, wingless and large species, found in forests, are connected to stability and, therefore, environmental quality.

Key words: bioindicators, adaptive parameters, functional groups, human activities, landscape ecology

1. Introduction

In the lowland landscape, where anthropogenic activities determine the structure and the function of the agroecosystems, the use of *taxa* as bioindicators of environmental quality, could be the first step for the building of agri-action plan (Büchs 2003; Duelli & Obrist 2003; Piorr 2003).

Duelli *et al.* (1999) explain that structural biodiversity in agricultural areas appears to be correlated with functional and organism biodiversity of the above-ground insect fauna.

Very little is known about the effect of changing landscape on soil biota (Wolter 2001) and many studies are focused on local scale only. Pesarini (1995) describes how in the Po Plain (Northern Italy), researchers have focused their attention only on local studies and on single or specific habitats.

Aims of our study are: (1) to describe the species assemblages of ground beetles (Coleoptera: Carabidae) in different landscape typology characterizing the Po lowland landscape, and (2) to examine which aspects of ground beetle morphology

[*] Corresponding author. Tel.:+39-02-50314722; e-mail: mauro.gobbi@unimi.it.

and ecology can be used to predict the attributes of communities living in natural, semi-natural, and anthropogenic habitats.

Carabid beetles (Arthropoda: Insecta) are one of the most important families of ground arthropods in agricultural ecosystems and many papers deal with their role as bioindicators (e.g., Lövei & Sunderland 1996; Cole *et al.* 2002; Holland 2002; Jeanneret *et al.* 2003; Rainio & Niemelä 2003). They are also widely distributed and biologically better known than other *taxa* of soil fauna, making them an excellent test case to describe and analyse how communities react to the anthropogenic activities in the agroecosystem of Italian lowland (Gobbi *et al.* 2004; 2005).

The study area of this contribute is the Po Plain; this lowland landscape in northern Italy is included in the biogeographic region of Middle Europe; therefore, the potential vegetation is *Quercus-Carpinetum boreoitalicum*, as for Central Europe vegetation (Andreis & Zullini 1993).

2. Material and methods

Data came from published surveys, and from our own unpublished field studies. We considered papers dealing with analyses of species assemblages of ground beetles in the Po Plain included in an altitudinal range between 0 m and 400 m a.s.l., with field sampling covering at least one complete year (Tab. 1).

Data have allowed to obtain and analyse 54 different species assemblages from the Po Plain, belonging to 4 habitats common in the Italian lowland and linked to three different levels of human interference: forests (natural habitat), poplar stands and meadows (semi-natural), and crops (completely anthropogenic habitat), obtaining 198 species.

Community assemblages were analysed considering (i) species similarity of communities (performed by ANOSIM on Jaccard similarity based on 1000 permutations) to compare differences between and within habitats; (ii) species richness and (iii) “adaptive parameters” of species like flying ability, body length and diet.

In ground beetles, flying ability depends on wing morphology; this taxon is characterized by three different types of metathoracic wing morphology, with macropterous, brachypterous and dimorphic species. Macropterous species are those with wings that can be used to fly, brachypterous species have short or no wings, in any case they are unable to fly, and dimorphic species are those for which different individuals may possess different wing morphology. Macropterous species are better dispersers than brachypterous ones that are only *per pedes* colonizers (Lövei & Sunderland 1996); therefore, wing morphology influences the pattern of species distributions in the environment (Gutiérrez & Menéndez 1997). Brandmayr (1983) has extended the concept of “power of dispersion” from the unit of species to community, quantifying this parameter as frequency of species able or unable to fly. On this bases, we have considered the frequency of the three wing morphologies in each community.

The pattern of body size distribution of ground beetles in different habitats is less studied. Blake *et al.* (1994) suggest that body size is negatively related to stresses and that larger body size can be considered an index of environmental quality (Luff 2002). In this work body size was recorded as the mean length (in centimetres), for each species.

Thiele (1977) classified carabids according to main food types into: predators (oligophagous and polyphagous) and phytophagous. Brandmayr *et al.* (2004) described how some species of the genera *Harpalus, Amara,* and perhaps *Zabrus* have opportunistic diet because they are both predators and phytophagous.

Species richness and the frequency of single adaptive parameters *per* sites were compared using ANOVA test (Gotelli & Ellison 2004).

Table 1

Papers considered for the analysis

Habitat	Consulted literature
Forest	Allegro 2001; Allegro *et al.* 2002; Bonavita & Chemini, 1996; Casale *et al.*1993; Casale & Giachino 1994; Chemini & Perini 1982; Chemini & Werth 1982; Pescarolo 1993; Pilon *et al.* 1991; Pilon 1995
Poplar stand	Casale *et al.* 1993; Pilon *et al.* 1991
Meadow	Bonavita & Chemini 1996; Casale *et al.* 1993; Fontaneto & Guidali 2001; Gobbi *et al.* 2005
Crop	Casale *et al.* 1993; Fontaneto & Guidali 2001; Pescarolo, 1990; Pescarolo 1993

3. Results

Species assemblages were not more similar each other within than between habitats (ANOSIM test: R=0.0645; p=0.163). ANOVA test shows how forests, differently to the other three rural habitats, own the lowest value of species richness ($F_{3,50}$=5.498; p=0.002) (fig. 1) and the lowest frequency of macropterous ($F_{3,50}$=6.178; p=0.001) (fig. 2) and phytophagous ($F_{3,50}$=4.418; p=0.008) species (fig. 3), but the highest frequency of large species ($F_{3,50}$=3.041; p=0.037) (fig. 4). In crops, small, phytophagous and macropterous species were more common; intermediate values were observed in meadows and in poplar stands.

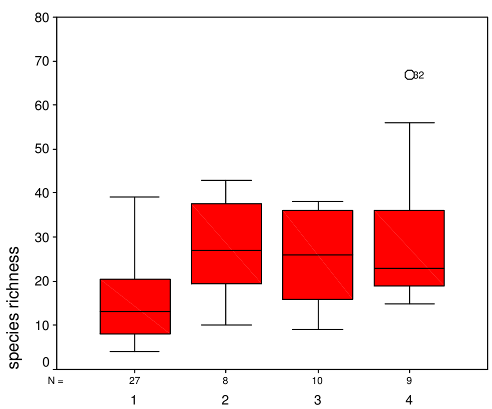

Fig. 1. Box-Whiskers diagram of species richness

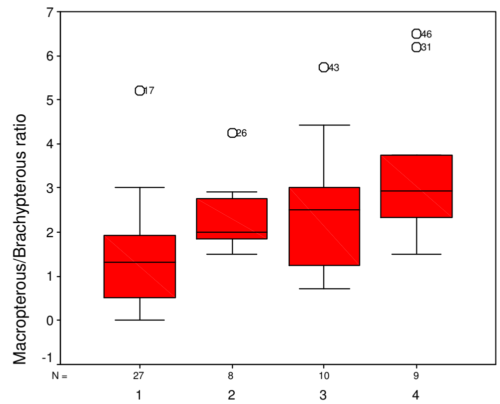

Fig. 2. Box-Whiskers diagram of macropterous and brachypterous ratio

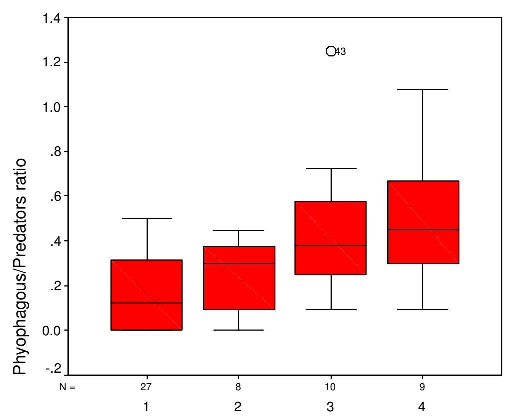

Fig. 3. Box-Whiskers diagram of phytophagous and predators ratio

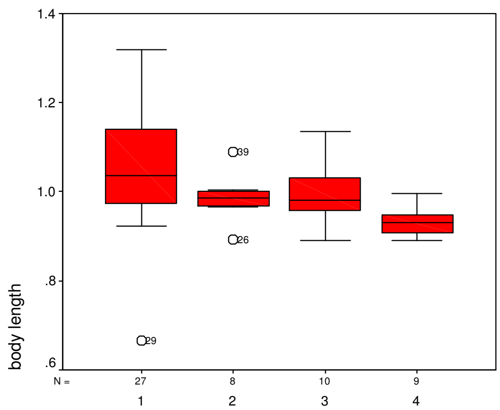

Fig. 5. Box-Whiskers diagram of body length

4. Discussion

The results of this study suggest the differential response of carabid communities to different habitat and to landscape composition.

On the basis of our data we can see that species similarity of communities it not able to evidence differences within and between habitats. Therefore, similarity of communities is not a good index to compare different habitats, at least in areas with such a high human disturbance.

Buchs (2003) reports how societies and departments of environment protection refer to biodiversity as number of species: "species richness is quality of life". Well, if we assume forests as habitats with low human interference and high natural quality, our data show that these habitats have the lowest species richness, in opposition to the three rural habitats, which are richer in species. For this reason, species richness, as similarity of species composition, may not be good descriptors of habitat quality in our study system, unless we use a low number of species as descriptor of good habitat quality.

On the contrary, adaptive parameters of species assemblages result good indicators of habitat quality. Dispersal capacity, diet and body length may be used as informative biological parameters in relation to habitat management.

Rural habitats as poplar stands, meadows and crops are characterized by communities with euritopic species, well adapted to live notwithstanding high human impact. In these habitats, driven by human activities, brachypterous species may be the first ones to disappear because they may not be able to quickly colonize nearby suitable sites. According to Gutierrez & Menendez (1997) stable and climacic habitats, as forests, favour the presence of wingless species while unstable habitats favour macropterous species.

Our analysis also shows how communities in different habitats differ for their trophic groups. Frequency of predators or phytophagous species may be sensitive to human disturbance. Phytophagous species increase with increasing human interference: frequency is higher in crops. As reported by Purtauf *et al.* (2005), frequency of phytophagous species is high in rural habitats, because of loss of potential predacious ground beetles, otherwise common in forests.

Regarding body size, ground beetles are on average larger in woodland than in rural habitats; body size, according with Burel *et al.* (2004) decreases as management intensity increases. It may be expected that habitats with low primary productivity favour species smaller in size (Blake, 1994). In forests, large species may find high trophic availability linked to soil organic matter. Moreover, larger species are more common in forests because longer life cycles are allowed in these less disturbed areas (Cole *et al.* 2002), while in rural habitats larger species, because of longer life cycle, are unable to cope with stressful conditions.

Our results suggest that the analysis of ground beetle assemblages could be of help in landscape ecology studies to determine habitat stability. This study introduces a non-taxonomic method to classify habitats with different level of stability on the basis of ground beetle ecology.

Our opinion is that "functional groups", previously proposed to indicate coenose stability, are a better index of the impact of human activities on the landscape, than species similarity. Lower number of species, but higher frequency of predator, wingless and large species, as we found in forest habitats, are connected to stability and, therefore, environmental quality. We also show that the main problem of the agroecosystems is not the loss of biodiversity as species richness, but the loss of biodiversity functions. Ecological attributes of carabid assemblages give information about their role in the agroecosystem.

Patches with predator species could be considered sink of diet specialists of pest insects, patches with lager body species may favour the presence of mammals and bird (Blake, 1994), as these vertebrates prefer to prey few specimens with high biomass than many specimens with low biomass (e.g., Larochelle 1980; Hernandez *et al.* 1991; Holland 2002).

As reported by Kotze & O'Hara (2003), during the last century, wingless, large bodied and diet specialists carabid populations quickly declined in Europe, mainly in lowlands that were rapidly changing. Therefore, our analysis is showing the response of carabid beetles to human management of rural patches. We could describe which aspects of the functional biodiversity have been lost at different level of human interference.

References

Andreis, C. & Zullini, A. (1993) – Ecosistemi terrestri. In: *Ecologia applicata*. Marchetti ed., Città Studi Edizioni, Milano: 3-41.

Blake, S. Foster, G.N. Eyre, M.D. & Luff, M.L. (1994) – Effects of habitat type and grassland management practice on the body size distribution of carabid beetles. *Pedobiologia*, 28, 502-512.

Brandmayr, P. (1983) The main axes of the coenoclinal continuum from macroptery to brachyptery in carabid communities of temperate zone. *Report 4th Symposium Carabidologic '81* (1983): 147-169 (Wageningen, dicembre 1983).

Brandmayr, P. Zetto, T. & Pizzolotto, R. (2004*) I Coleotteri Carabidi per la valutazione ambientale e la conservazione della biodiversità*. APAT manuale operativo e linee guida, Roma.

Büchs, W. (2003) Biodiversity and agri-environmental indicators—general scopes and skills with special reference to the habitat level. *Agriculture, Ecosystems and Environment*, **98**, 35-78.

Burel, F. Butet, A Delettre, YR de la Pena, N.M. (2004) Differential response of selected taxa to landscape context and agricultural intensification. *Landscape and Urban Planning,* **67**, 195-204.

Cole, L.J. McCracken, D.I. Dennis, P. Downie, I.S. Griffin, A.L. Foster, G.N. Murphy, K.J. Waterhouse, T. (2002) Relationships between agricultural management and ecological groups of ground beetles (Coleoptera: Carabidae) on Scottish farmland. *Agriculture, Ecosystems and Environment*, **93**, 323-336.

Duelli, P. Obrist, M.K. Schmatz, D.R. (1999) Biodiversity evaluation in agricultural landscapes: above-ground insects. *Agriculture, Ecosystems and Environment*, **74**, 33-64.

Duelli, P. & Obrist, M.K. (2003) Biodiversity indicators: the choice of values and measures. *Agriculture, Ecosystems and Environment*, **98**, 87-98.

Gobbi, M. Fontaneto, D. Groppali, R. & Guidali, F. (2004) I Carabidi per la valorizzazione dell'agroecosistema. *Congresso Internazionale, Il Sistema Rurale, Una sfida per la progettazione tra salvaguardia, sostenibilità e governo delle trasformazioni.* Milano, 13-14 ottobre 2004: 223-229

Gobbi, M**.** Fontaneto, D. Guidali, F. (2005) Carabid beetles (Insecta, Coleoptera) in meadows in Lombardia (Italy) lowland. *Annali del Museo Civico di Storia Naturale di Ferrara,* **6**, (2003) 3-11.

Gotelli, N.J. & Ellison, A.M. (2004) *A primer of ecological Statistics*. Sinauer Associated Inc. Publischers, Sunderland, Massachusetts, U.S.A.

Gutiérrez, D. & Menéndez, R. (1997) Patterns in the distribution, abundance and body size of carabid beetles (Coleoptera: Caraboidea) in relation to dispersal ability. *Journal of biogeography*, **24**, 903-914.

Hernandez, A. Alegre, J. Salgado, J.M. & Gutierrez, A. (1991) The role of Coleoptera in the nutrition of some vertebrates in the northeast of Spain. *Elytron,* **5**, 231-237.

Holland, J.M. (2002) *The Agroecology of Carabid Beetles*. Intercept, Andover.

Jeanneret, Ph. Schüpbach, B. Pfiffner, L. & Walter, Th. (2003) Arthropod reaction to landscape and features in agricultural landscapes. *Landscape Ecology*, **18**, 253-263.

Kotze, J. & O'Hara, R.B. (2003) Species decline-but why? Explanation of carabid beetle (Coleoptera, Carabidae) declines in Europe. *Oecologia*, **135**, 138-148.

Larochelle, A. (1980) A list of birds of Europe and Asia as predators of carabid beetles. *Cordulia,* **6**, 1-9**.**

Lövei, G.L. & Sunderland, K.D. (1996) Ecology and behaviour of ground beetles (Coleoptera: Carabidae). *Annual Reviews of Entomology*, **41**, 231-256.

Luff, M.L. (2002). *Carabid assemblage organization and species composition*. In: The Agroecology of Carabid Beetles. Holland J.M. (ed.), 65 pp.

Pesarini, F. (1995) Il popolamento animale della padania. Stato delle conoscenze e problemi irrisolti. *Quaderni della Stazione di Ecologia del Museo Civico di Storia Naturale di Ferrara,* **9**, 21-33.

Piorr, H.P. (2003) Environmental policy, agri-environmental indicators and landscape indicators. *Agriculture, Ecosystems and Environment,* **98**, 17-33.

Purtauf, T. Dauber, J. Wolters, V. (2005) The response of carabids to landscape simplification differs between trophic groups. *Oecologia,* **142**, 458-464.

Rainio, J. & Niemelä, J. (2003) Ground beetles (Coleptera: Carabidae) as bioindicators. *Biodiversity and Conservation*, **12**, 487-506.

Thiele, H.U. (1977) *Carabid beetles in their environments.* Springer Verlag, Berlin.

Wolter, V. (2001) Biodiversity of soil fauna and its function. *European Journal of Soil Biology*, **37**, 221- 227.