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ANALYSIS OF SIMILARITIES BETWEEN AGRICULTURAL LANDSCAPE STRUCTURAL UNITS ON THE BASIS OF FLORA AND PARASITE ENTOMOFAUNA

ANALIZA PODOBIEŃSTWA JEDNOSTEK STRUKTURALNYCH KRAJOBRAZU ROLNICZEGO NA PRZYKŁADZIE FLORY I PASOŻYTNICZEJ ENTOMOFAUNY

Summary. The study presents the relationships between the plants flora and the fauna of parasitic *Hymenoptera* of the Pimplinae subfamily (*Hymenoptera*, Ichneumonidae) in agricultural landscapes of low, medium and high mosaic structure. The basis for the study was a similarity analysis of landscape structural units, such as forest edges, shrubberies, field borders and roadsides. In order to indicate similar and dissimilar structural elements of landscape a hierarchical cluster analysis was applied. A similarity was found between the flora and parasitic entomofauna of most structural units of landscape regardless of its mosaic structure. Midfield shrubberies were the only elements that showed similarity of entomofauna in all the landscape types. Only the field border in the low-mosaic landscape was the most dissimilar in terms of flora and entomofauna when compared to other structural units in all the landscape types.

Key words: agricultural landscape structure, cluster analysis, dendrogram, fauna, flora, multivariate analysis, Pimplinae

Introduction

As in all Europe, in Poland cultivated land predominates, so both for scientific and practical reasons, it has been subject to many studies that focused on geobotany and various animal groups.

Traditional farming creates many types of spatial units (RINGLER and HEINZELMANN 1986), and its intensification results in vast, monotonous fields.

Structural differentiation is vital for a proper functioning of agricultural landscape. Particular significance is attributed to marginal habitats such as mid-field greenery, field borders and roadsides. Their presence helps maintain habitat diversity in time and space, which in turn stimulates self-controlling mechanisms in agrocenoses (DENNIS 2000, EKBOM 2000, MARINO and LANDRIS 2000, RYSZKOWSKI et AL. 2001, BOLLER et AL. 2004, VOLLHARDT et AL. 2008, MACFADYEN et AL. 2009, CHEN et AL. 2010, HOLZSCHUH et AL. 2010).

The study attempts to present the relationships between vascular plant flora and the fauna of parasite *Hymenoptera* of the Pimplinae subfamily (*Hymenoptera*, Ichneumonidae) in agricultural landscape of various mosaic structure. Similar and dissimilar elements of landscape structure are presented and their relationships are evaluated.

Material and methods

The study was carried out in the agricultural landscape of central Wielkopolska (Poland). It covered agricultural landscapes of low, medium and high mosaic structure. The share of uncultivated land in the landscape of low structural diversity (L) was 3.3%, in the landscape of medium structural diversity (M) – 7.6% and of high structural diversity (H) – 33.4%. The basis for this study was an analysis of similarity between structural units such as forest edges (Fe), shrubberies (Sh), field borders (Fb) and roadsides (Ro) on the basis of flora and the parasitoids of the Pimplinae subfamily (*Hymenoptera*, Ichneumonidae).

In the studied structural units the identified vascular plant flora included 189 species in total. Structural units of the landscape were grouped on the basis of 4387 parasitoid specimens, belonging to 57 species and caught in 3037 samples with the method of Moericke yellow traps (MOERICKE 1953).

In search of similar and dissimilar landscape structure elements a hierarchical cluster analysis was applied with the use of agglomerating average linkage method (EVERITT 1974, MARDIA et AL. 1979). The results obtained were presented in the form of dendrograms, which they were analysed. All statistical analyses were performed using R 2.10.0 (R DEVELOPMENT CORE TEAM 2009).

Results

A statistical analysis of the flora (Fig. 1) shows that in the landscape of low diversity the shrubberies and roadsides were most similar (Fig. 1 a). On the other hand, the highest

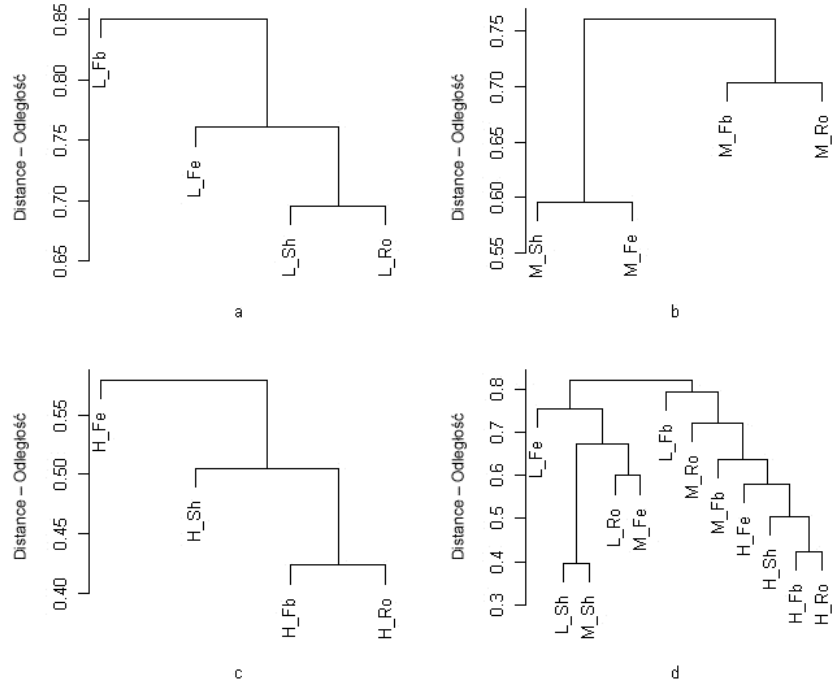

Fig. 1. Dendrogram for the flora in agricultural landscape of: a – low (L), b – medium (M), c – high (H) structural diversity and d – all types together; in four habitats: forest edge (Fe), shrubberies (Sh), field border (Fb), roadside (Ro)
Rys. 1. Dendrogram dla flory w krajobrazie rolniczym o: a – małym (L), b – średnim (M), c – dużym (H) zróżnicowaniu strukturalnym i d – łącznie we wszystkich typach; w czterech środowiskach: skraj lasu (Fe), zakrzewienia (Sh), miedza (Fb), przydroże (Ro)

dissimilarity was shown by the field border. In the landscape of medium mosaic structure two groups of structural units could be clearly defined: the shrubberies and forest edge on the one hand versus field borders and roadsides on the other (Fig. 1 b). An analysis of the most varied landscape proved the highest similarity for the field borders and roadsides, and the highest dissimilarity for the forest edge (Fig. 1 c).

When clustered all the structural units of the three landscape types (Fig. 1 d) indicated a clear dissimilarity of the flora in all the units within the most diverse landscape. A similar group was made up by shrubberies, roadsides and forest edge within the landscape of low diversity. On the other hand, the field border and roadsides in the landscape of medium mosaic structure were similar to the structural units of the most diverse landscape. It is worth noting that the shrubberies in low and medium diversity landscapes were similar. In the landscape of medium diversity the shrubberies and forest edge were the most similar to all the studied habitats of the simple-structure landscape. A group of similarities was also made up by the forest edge in the medium diversity landscape and roadside in the simple structure landscape.

While clustering the Pimplinae fauna (Fig. 2) of low mosaic landscape structural units in quality-quantity categories two groups of habitats were defined in which parasitoids showed the highest similarity. One group included the shrubbery and forest edge, while the other one – the field border and roadside (Fig. 2 a). In the landscape of middle mosaic structure level the Pimplinae communities on the field border and in shrubberies were similar (Fig. 2 b), and the forest edge stood out most significantly. On the other hand, in the landscape of high mosaic structure the grouping inhabiting the shrubberies and roadside was the smallest similar group, while the roadside formed the most dissimilar group (Fig. 2 c).

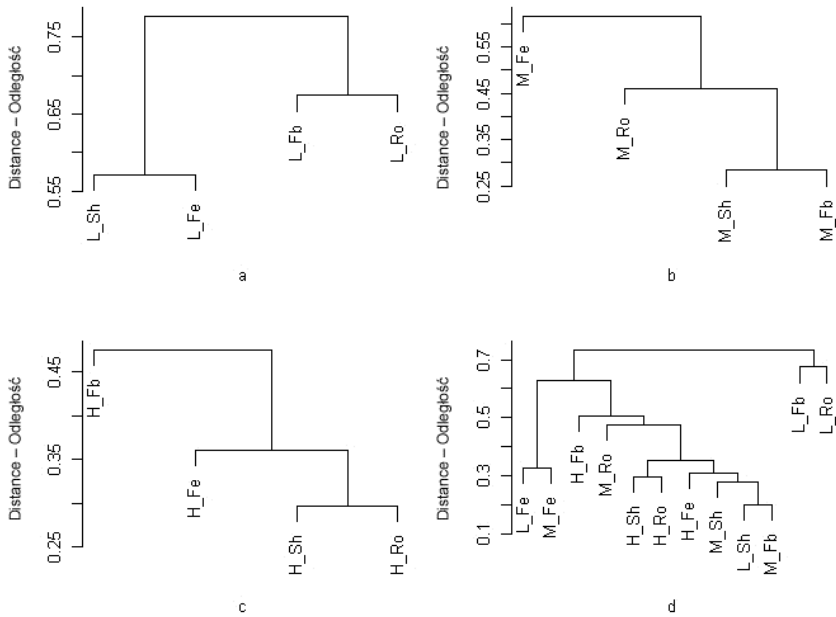

Fig. 2. Dendrogram for the parasitoids in agricultural landscape of: a – low (L), b – medium (M), c – high (H) structural diversity and d – all types together; in four habitats: forest edge (Fe), shrubberies (Sh), field border (Fb), roadside (Ro)
Rys. 2. Dendrogram dla parazytoidów w krajobrazie rolniczym o: a – małym (L), b – średnim (M), c – dużym (H) zróżnicowaniu strukturalnym i d – łącznie we wszystkich typach; w czterech środowiskach: skraj lasu (Fe), zakrzewienia (Sh), miedza (Fb), przydroże (Ro)

By analysing the similarity of the Pimplinae fauna on the basis of communities inhabiting all the structural units of the three landscape types (Fig. 2 d) it was found that only the Pimplinae of shrubberies showed similarity and at the same time were similar to the communities of most habitats found in the landscape of high mosaic structure and to the communities on the field border in the medium mosaic landscape. The communities of forest edge of the low- and medium-mosaic landscape and the field border and roadside in the low mosaic structure landscape differed greatly.

An overall comparison of all the vascular plant flora and the Pimplinae fauna in all the structural units of the three landscape types (Fig. 3) proved that the field border in the landscape of low mosaic structure was the most dissimilar habitat. Moreover, the roadsides in the landscapes of low and medium mosaic structures formed one group while forest edges, occurring also in the landscape of low and medium mosaic structure, formed another one. Both habitats differed from other structural units, but the rest of the habitats were similar.

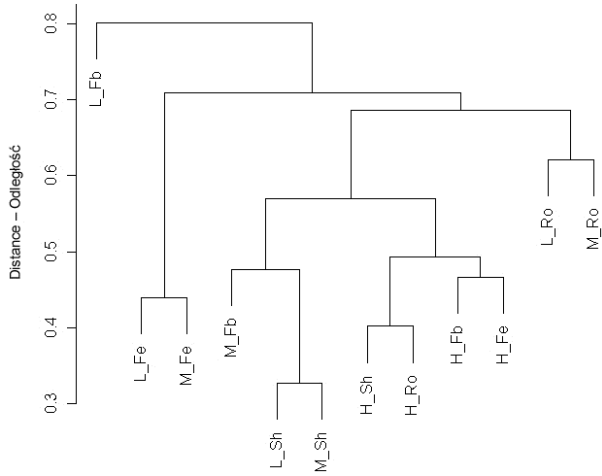

Fig. 3. Dendrogram for the flora and parasitoids in agricultural landscape of low (L), medium (M) and high (H) structural diversity in four habitats: forest edge (Fe), shrubberies (Sh), field border (Fb), roadside (Ro)
Rys. 3. Dendrogram dla flory i parazytoidów w krajobrazie rolniczym o małym (L), średnim (M) i dużym (H) zróżnicowaniu strukturalnym w czterech środowiskach: skraj lasu (Fe), zakrzewienia (Sh), miedza (Fb), przydroże (Ro)

Discussion

Within the three analysed agricultural landscape types (low, medium or high diversity) the same structural units were analysed, namely forest edges, shrubberies, field borders and roadsides. Their surface share was different, which resulted from the manner of farming and the area history. The richest flora was found in the most diverse landscape type, which was also subject to the strongest and most diverse anthropopressure. In statistical analyses this landscape type differed most from the others.

On the basis of the obtained results it should be stated that the suggested cluster analysis with the use of dendrograms is a proper tool that helps to characterize structural units of agricultural landscape. The method grouped parasitic entomofauna of various habitats of agricultural landscape in a similar manner to the method using e.g. Shannon index, applied to compare insect communities in the landscape (PIEKARSKA-BONIECKA

2005). The advantage of cluster analysis is a possibility to conduct a thorough analysis of units through indicating groups of similar objects and a measure describing this similarity.

The obtained results confirmed the role of midfield shrubberies, which attracted entomofauna showing similarity regardless of the level of landscape diversity (PIEKARSKA-BONIECKA 2005).

It was also proved that on the forest edges in the landscape of low and medium mosaic structure the Pimplinae communities differed from others (PIEKARSKA-BONIECKA 2005).

The other structural units of agricultural landscape showed similarity both in terms of flora and parasitic entomofauna. Those habitats attract parasitic entomofauna, which adds to increasing their buffer capacity and creates elements of environmental natural resistance.

Conclusions

A similarity was found between the flora and parasitic entomofauna of most structural units of landscape regardless of its mosaic structure.

Midfield shrubberies were the only elements that showed similarity of entomofauna in all the landscape types.

Only the field border in the low-mosaic landscape was the most dissimilar in terms of flora and entomofauna when compared to other structural units in all the landscape types.

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Streszczenie. W pracy przedstawiono relacje zachodzące pomiędzy florą roślin naczyniowych a fauną pasożytniczych błonkówek z podrodziny Pimplinae (*Hymenoptera*, Ichneumonidae) w krajobrazie rolniczym o małym, średnim i wysokim stopniu mozaikowatości. Podstawą niniejszych badań była analiza podobieństwa jednostek strukturalnych krajobrazu, takich jak skraje lasów, zakrzewienia, miedze oraz przydroża. W celu wskazania podobnych i niepodobnych elementów strukturalnych krajobrazu zastosowano hierarchiczną analizę skupień, wykorzystując aglomeracyjną metodę średnich połączeń. Stwierdzono, na podstawie analizowanej flory i pasożytniczej entomofauny, podobieństwo większości jednostek strukturalnych krajobrazu bez względu na stopień jego mozaikowatości. Ponadto, zakrzewienia śródpolne wykazały podobieństwo we wszystkich typach krajobrazu, natomiast skraj lasu w krajobrazie o niskim stopniu mozaikowatości był elementem najbardziej różniącym się od pozostałych struktur badanych typów krajobrazu.

Słowa kluczowe: struktura krajobrazu rolniczego, analiza skupień, dendrogram, fauna, flora, statystyczna analiza wielowymiarowa, Pimplinae

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