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THE USEFULNESS OF SIMILARITY COEFFICIENTS IN THE COMPARISON OF BIOCENOSIS STRUCTURAL UNITS

OCENA PRZYDATNOŚCI MIAR PODOBIENSTWA DLA PORÓWNIANIA JEDNOSTEK STRUKTURALNYCH BIOCENÓZ

Summary. A study of flora and fauna that concerned the groupings of parasitoids from the subfamily Pimplinae (Hymenoptera, Ichneumonidae) in the agricultural landscape with three levels of mosaic structure (low, medium and high) was used. The obtained data were analysed in terms of quality and quantity using 12 similarity measures and the results were presented in dendrograms. Later on, Mantel test was applied to verify the hypothesis on the similarity of the measures. Based on the dendrograms the similarity measure groups were specified. One of them contains Bray, Jaccard and Kulczyński measures, while the others include Horn and Morisita, Binomial and Gower, Euclidean and Manhattan, Chao and Mountford measures. The Canberr measure did not show any similarity to any of the analysed measures. The measures could be interchanged within a group during the study. The most suitable measures for comparing structural units of biocenoses turned out to be Bray, Jaccard and Kulczyński coefficients.

Key words: biocenoses structure, cluster analysis, dendrogram, fauna, Pimplinae, flora, multivariate analysis, similarity measures

Introduction

In biocenotic research similarity measures are used for qualitative, quantitative and qualitative-quantitative comparison of the structures of units or groups of animals that form the studied biocenosis (TROJAN 1992, 1998). A full range of information about the similarity of these structures is rendered by a qualitative-quantitative comparison. Many similarity measures can be applied in the analysis. Some frequently used ones include

Jaccard, Kulczyński, Manhattan or Morisita (MARDIA et AL. 1979, JONGMAN et AL. 1987, MAILAFIYA et AL. 2009). This was the reason for a higher number of similarity measures as well as the evaluation as to which of the considered measures should be introduced the same or similar structure of biocenosis and which ones significantly differ from the others. Taking into consideration the fact that the structure of animal units is closely related to the structure of floral biocenosis (COLLIER et AL. 1978), the effectiveness of the similarity measures was verified with respect to the flora forming these biocenoses.

The aim of the study was to evaluate 12 similarity measures with respect to qualitative-quantitative analysis of agricultural landscape structural units based on the flora and the parasitoids of the Pimplinae (Hymenoptera, Ichneumonidae). This group was selected due to its numerous populations in agricultural landscape refugiums such as shrubberies, field borders or road sides.

Material and methods

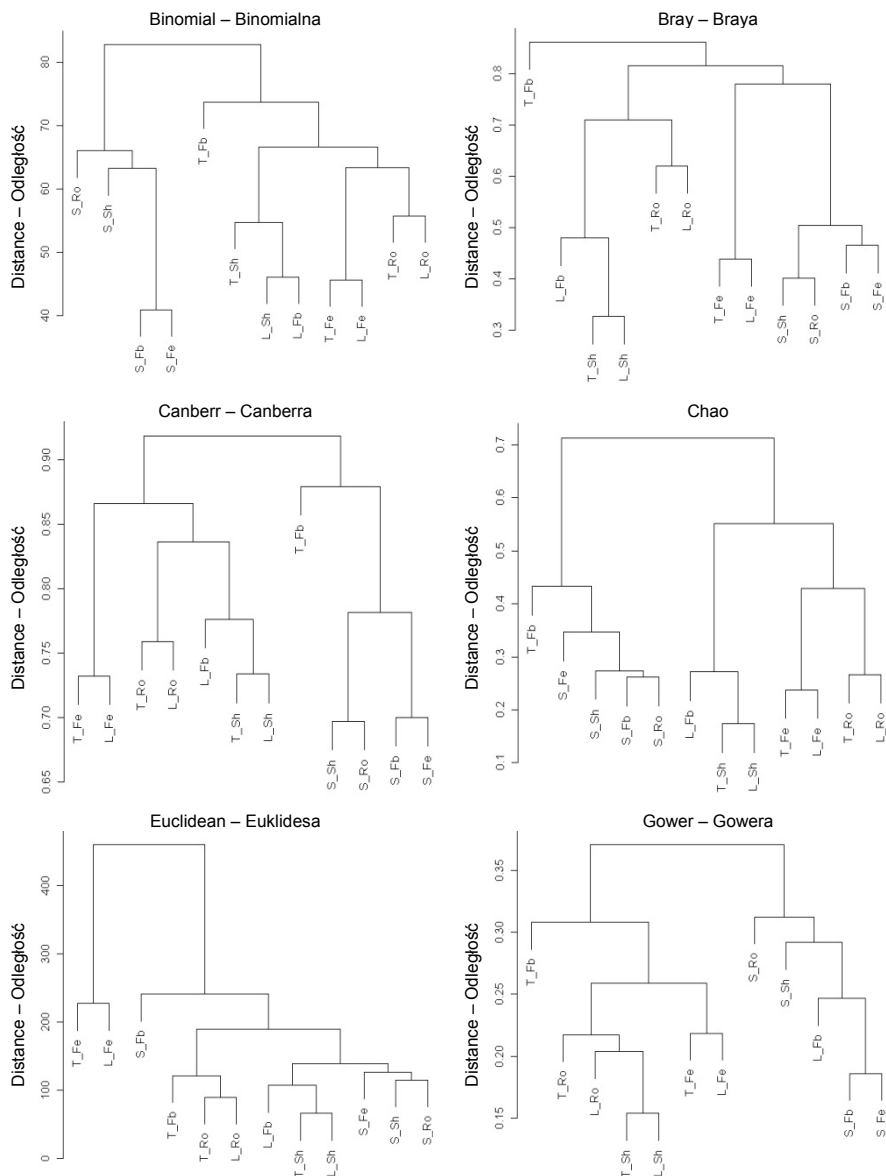
The research was performed in the landscape of Wielkopolska (Poland) in the years 1996-1998. The three-level mosaic landscape included: low mosaic – the area of Trzebaw (UTM: XT29), medium – the area of Łęczyca (UTM: XT29) and high – the area of Strzeszyn (UTM: XU21). The share of agricultural brownfield in the total acreage of the landscape types was 3.3%, 7.6% and 33.4%, respectively. The research was based on a similarity analysis between four structural groups: forest edges, shrubberies, field borders and roadsides. They were situated in three types of landscape classified on the basis of the flora and the parasitoids from the subfamily Pimplinae (Hymenoptera, Ichneumonidae).

The study material consisted of 189 vascular plant species and 4,387 Pimplinae, classified into 57 species, caught into yellow Moericke traps (MOERICKE 1953). In total 3,037 samples were taken, out of which 981 came from the landscape of low mosaic structure, 1,007 samples from the landscape of middle mosaic structure and 1,049 from high mosaic structure area. Moericke traps had been first used by SAWONIEWICZ (1979) to catch those parasitoids in Poland. Pimplinae subfamily species in question are ecto- and endoparasitoids of larvae and ectoparasitoids of pupae of phytophagous species feeding in agrocenoses. 134 Pimplinae species have been recorded in Poland.

In the study the following similarity measures were taken into consideration: Binomial, Bray, Canberr, Chao, Euclidean, Gower, Horn, Jaccard, Kulczyński, Manhattan, Morisita and Mountford (MOUNTFORD 1962, WOLDA 1981, FAITH et AL. 1987, KREBS 1999, ANDERSON and MILLAR 2004). For every similarity measure a grouping of structural units in the landscape types was performed. For each grouping result, dendrograms were created. As the next step of analysis the Mantel test was applied in order to compare similarity measures. It was executed for 1,000 permutations. Finally the measures were grouped and the obtained dendrograms were presented. Calculations were made with the R software, version 2.10.0 (R DEVELOPMENT CORE TEAM 2009).

Results

As a result of the study structural units of agricultural landscape were classified into groups. Figure 1 presents the dendrograms for every similarity measure.



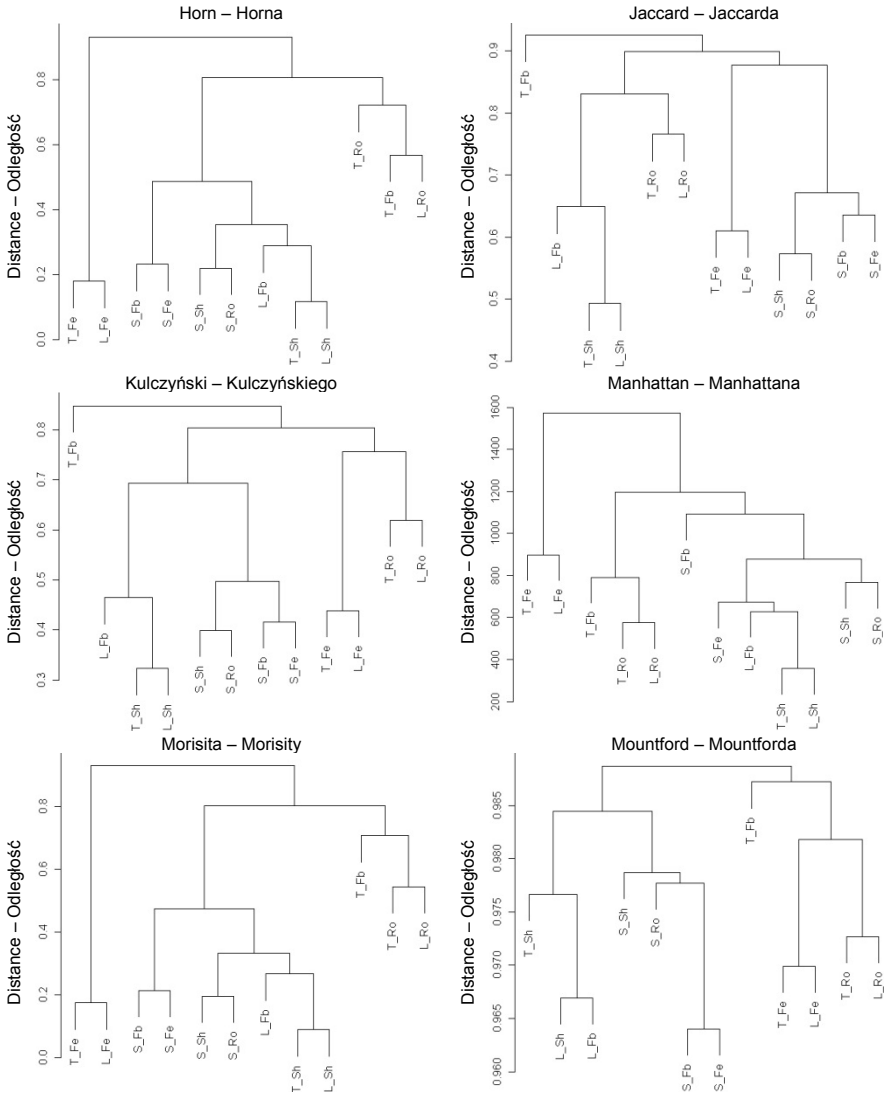


Fig. 1. Dendrograms of the similarity measures of biocenoses structural units (T_Fe – forest edge in Trzebow, T_Sh – shrubberies in Trzebow, T_Fb – field border in Trzebow, T_Ro – roadside in Trzebow, L_Fe – forest edge in Łęczycy, L_Sh – shrubberies in Łęczycy, L_Fb – field border in Łęczycy, L_Ro – roadside in Łęczycy, S_Fe – forest edge in Strzeszyn, S_Sh – shrubberies in Strzeszyn, S_Fb – field border in Strzeszyn, S_Ro – roadside in Strzeszyn)

Rys. 1. Dendrogramy miar podobieństwa jednostek strukturalnych biocenoz (T_Fe – skraj lasu w Trzebawiu, T_Sh – zakrzewienia w Trzebawiu, T_Fb – miedza w Trzebawiu, T_Ro – przydroże w Trzebawiu, L_Fe – skraj lasu w Łęczycy, L_Sh – zakrzewienia w Łęczycy, L_Fb – miedza w Łęczycy, L_Ro – przydroże w Łęczycy, S_Fe – skraj lasu w Strzeszynie, S_Sh – zakrzewienia w Strzeszynie, S_Fb – miedza w Strzeszynie, S_Ro – przydroże w Strzeszynie)

Next step of the study was the comparison of the dendrograms with Mantel test (MANTEL and VALAND 1970). The results are presented in Table 1. If the level of significance is lower than 0.001, than the two measures are similar.

The results of the similarity measures grouping are shown in Figure 2.

Table 1. Mantel statistics for 12 similarity measures
Tabela 1. Wartości testu Mantela dla 12 miar podobieństwa

Similarity measure Miara podobieństwa	Bra	Can	Cha	Euc	Gow	Hor	Jac	Kul	Man	Mor	Mountford
Binomial Binomialna	0.46 0.01	0.59 < 0.001	0.42 0.001	0.16 0.273	0.88 < 0.001	0.39 0.022	0.46 0.011	0.45 0.012	0.51 0.009	0.38 0.029	0.80 < 0.001
Bray Braya		0.90 < 0.001	0.67 < 0.001	0.47 0.045	0.33 0.065	0.92 < 0.001	0.99 < 0.001	0.99 < 0.001	0.59 0.001	0.92 < 0.001	0.74 < 0.001
Canberr Canberra			0.63 < 0.001	0.39 0.06	0.44 0.008	0.78 < 0.001	0.89 < 0.001	0.90 < 0.001	0.59 0.001	0.78 < 0.001	0.83 < 0.001
Chao					0.27 0.037	0.53 < 0.001	0.67 < 0.001	0.67 < 0.001	0.35 0.01	0.53 < 0.001	0.71 < 0.001
Euclidean Euklidesa					0.21 0.213	0.66 < 0.001	0.47 0.022	0.45 0.048	0.84 < 0.001	0.68 < 0.001	0.33 0.042
Gower Gowera						0.26 0.091	0.33 0.059	0.32 0.072	0.62 0.004	0.26 0.107	0.62 < 0.001
Horn Horna							0.92 < 0.001	0.92 < 0.001	0.65 0.001	0.99 < 0.001	0.67 < 0.001
Jaccard Jaccarda								0.98 < 0.001	0.60 0.001	0.92 < 0.001	0.73 < 0.001
Kulczyński Kulczyńskiego									0.58 < 0.001	0.92 < 0.001	0.75 < 0.001
Manhattan Manhattana										0.66 < 0.001	0.57 < 0.001
Morisita Morisity											0.67 < 0.001

In the upper row of each measure – value of the Mantel statistics, in the lower row of each measure – significance level.

W górnym wierszu każdej miary – wartość testu Mantela, w dolnym wierszu każdej miary – poziom istotności.

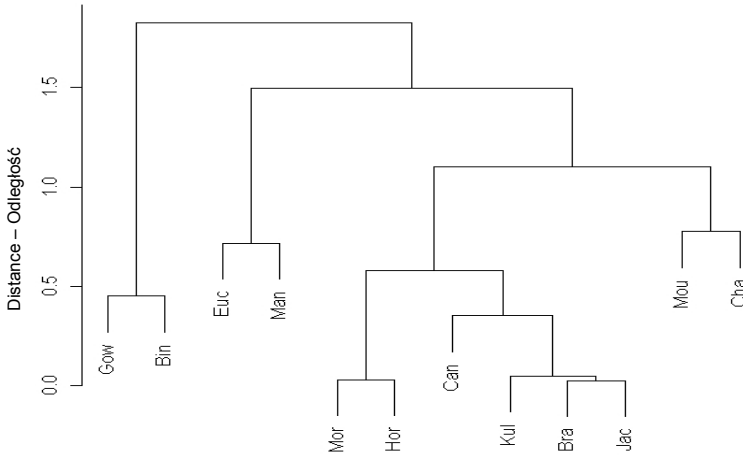


Fig. 2. Dendrogram of the 12 similarity measures (Bin – Binomial, Bra – Bray, Can – Canberr, Cha – Chao, Euc – Euclidean, Gow – Gower, Hor – Horn, Jac – Jaccard, Kul – Kulczyński, Man – Manhattan, Mor – Morisita, Mou – Mountford)

Rys. 2. Dendrogram 12 miar podobieństwa (Bin – binomialna, Bra – Braya, Can – Canberra, Cha – Chao, Euc – Euklidesa, Gow – Gowera, Hor – Horna, Jac – Jaccarda, Kul – Kulczyńskiego, Man – Manhattana, Mor – Morisity, Mou – Mountforda)

Conclusions

The dendrogram of the similarity measures in Figure 2 helps to verify which similarity measures are most similar to each other. The fact that two measures belong to the same group means that they yield similar results. It also means that they can be interchanged. The outcome proves that Bray, Jaccard and Kulczyński measures are a part of the same group. In addition, Horn and Morisita, Binomial and Gower, Euclidean and Manhattan as well as Chao and Mountford measures constitute other groups. Furthermore, Chao and Mountford measures are the most distant from the other similarity coefficients. In particular, the distances to Bray and Jaccard measures are the largest. As a result, these measures should be used for the comparison of the structural units of biocenosis consisting of the considered flora and the parasitic fauna.

In conclusion, the study helped to establish that the most suitable measures to compare structural units of biocenoses are Bray, Jaccard and Kulczyński coefficients.

Acknowledgments

The authors are grateful to the editor and referee for detailed and careful comments that enhanced the completeness and clarity of the paper.

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OCENA PRZYDATNOŚCI MIAR PODOBIENSTWA DLA PORÓWNIANIA JEDNOSTEK STRUKTURALNYCH BIOCENÓZ

Streszczenie. Wykorzystano badania florystyczne i faunistyczne dotyczące zgrupowań parazytoiidów z podrodziny Pimplinae (Hymenoptera, Ichneumonidae) w krajobrazie rolniczym o trzech stopniach mozaikowatości – niskim, średnim i wysokim. Otrzymane dane poddano analizie jakościowo-ilościowej z wykorzystaniem 12 miar podobieństwa, a wyniki przedstawiono w postaci dendrogramów. Ponadto zastosowano test Mantela weryfikujący hipotezy o miarach podobnych. Dendrogram wykreślony dla analizowanych miar podobieństwa pozwolił wskazać miary podobieństwa należące do tej samej grupy. Stwierdzono, że miary Braya, Jaccarda i Kulczyńskiego stanowiły jedną grupę, miary Horna i Morisity, miary binomialna i Gowera, miary Euklidesa i Manhattana oraz miary Chao i Mountforda stanowiły kolejne grupy miar podobnych, natomiast miara Canberra nie wykazywała podobieństwa do żadnej z analizowanych miar. W ramach każdej z grup miary podobieństwa można stosować zamiennie. Ponadto stwierdzono, że miarami najbardziej odpowiednimi dla porównań jednostek strukturalnych biocenoz są miary Braya, Jaccarda i Kulczyńskiego.

Słowa kluczowe: struktura biocenozy, analiza skupień, dendrogram, fauna, Pimplinae, flora, analiza wielowymiarowa, miary podobieństwa

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Accepted for print – Zaakceptowano do druku:

13.05.2011

For citation – Do cytowania:

*Piekarska-Boniecka H., Siatkowski I., Szabelska A., 2011. The usefulness of similarity coefficients in the comparison of biocenosis structural units. *Nauka Przyr. Technol.* 5, 6, #111.*