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DRAGONFLY ASSEMBLAGES OF A SHALLOW LAKE TYPE RESERVOIR (TISZA-TÓ, HUNGARY) AND ITS SURROUNDINGS

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The dragonfly fauna of the typical water bodies of the Reservoir Tisza-tó was characterised based on a two-year study. We collected 728 imagoes, 384 larvae and 194 exuviae during the study, and there were 101 observations of imagos. We confirmed the presence of 39 species (13 Zygoptera and 26 Anisoptera).
We distinguished 5 types of water bodies inside and around the Reservoir Tisza-tó: leaking canals, a new inundated area of the reservoir, native water bodies inside the reservoir, in- and outflows, and River Tisza inside the reservoir. Both traditional diversity statistics and scalable diversity characterisation suggested that the most species-rich were the native water bodies, with a species-pool of 34 species; there were 30 species in the in- and outflows, while the leaking canals and the reservoir were moderately species-rich with 25 species each. The River Tisza was relatively species-poor compared to the other water bodies (12 species). Cluster analysis of the species composition revealed that the fauna of the River Tisza is clearly separated from the other water bodies. The fauna of the new inundated area, the native water bodies, and the in- and outflows were similar; these water bodies had direct connection to the reservoir. The fauna of the leaking canals was slightly different from them.

Key words: dragonflies (Odonata), lowland reservoir, Tisza, biodiversity, typical water bodies

INTRODUCTION

Dragonflies are key organisms of the food web as predators both as larvae and as imagoes (BENKE 1976). They usually have definite habitat preference and territorial behaviour (CORBET 1999). The taxon has relatively few species which can be identified in the field. They are usually abundant and sensitive indicators of the structural changes of their habitats, and the changes of the water quality caused by biotic and/or abiotic factors (BULÁNKOVÁ 1997, CHWALA & WARINGER 1996, LENZ 1991, MÜLLER *et al.* 2002, SCHMIDT 1985). There are standard techniques to estimate their composition and abundance (DÉVAI 1997*a*). Therefore, they are especially useful for habitat assessment, producing comparable results even in local, regional or larger scale. All of these features make the dragonflies a very useful group of animals for habitat assessment and biodiversity monitoring, especially in the case of shallow lakes or the running water of the Great Hungarian Plain (DÉVAI 1997*b*).

The study period lasted for two years, because we wanted to provide a complete collection of the species of the Reservoir Tisza-tó. Besides the extensive faunistic survey of the Reservoir Tisza-tó we wanted to explore the major differences between the characteristic types of water bodies based on the dragonfly fauna.

There are a few publications about the fauna of this area before the establishment of the Reservoir Tisza-tó (BENEDEK *et al.* 1973, STEINMANN 1959*a*, *b*, 1962, TÓTH 1974, 1998). KÁTAI and DÉVAI (1978) published data about the dragonfly fauna of the Reservoir Tisza-tó after the establishment.

MATERIALS AND METHODS

Study area

The Reservoir Tisza-tó (or sometimes it is mentioned as Kiskörei-tározó) is the second largest water body in Hungary, which was created in 1973 on the River Tisza. It is located in the Middle-Tisza-Region, between the 404 and 440 river km; its length is 33 km and the average depth is approximately 1.3 m. The total area is 127 km^2. Its largest width is 6.58 km and the smallest is 0.6 km. The water level varies strongly depending on damming. Only a small part of the reservoir is covered by water during the whole year; it gets dry partly after the water drainage in winter. There are several oxbows close to the main water body of the reservoir; these were caused by the regulation of the River Tisza. A leaking canal system surrounding the reservoir, returns the accumulated groundwater into the lake. Three creeks [Laskó, Rima (Eger-patak) and Nyárád-ér] also carry water into the main reservoir. Three large canals (Nagykunság, Jászság and Tiszafüred canals) provide the irrigation-water supply to the surrounding areas. A considerable part of the area belongs to the nature conservation area of the Hortobágy National Park.

Sampling methods

Samples were collected during 1998 and 1999. Altogether, we spent 52 days field tracking and collecting samples. Imagoes of dragonflies were collected by a steel framed net with the bag made from curtain-textile or soft plastic net-textile. Exuviae were collected individually. Larvae were collected by sweep sampling using a standard hand net usually used in limnology. The following keys were used for identifying the imagoes: ASKEW (1988), BENEDEK (1965), DREYER (1986), and STEINMANN (1984). Exuviae and larvae were identified by the keys of ASKEW (1988), GERKEN and STERNBERG (1999), HEIDEMANN and SEIDENBUSCH (1993). The collected specimens were stored in ethyl-alcohol.

Data were collected from five types of water bodies inside and around of the Reservoir Tisza-tó, altogether from 55 localities. These characteristic water bodies are as follows:

(1) Leaking canals around the Reservoir Tisza-tó: This is a drainage canal system which makes possible to return the collected groundwater to the reservoir by pumping stations. There were 18 sampling locations of this kind.

(2) The new inundated area of the reservoir: Samples were collected along the shore of the basins (at Abádszalók, at Poroszló, at Tiszavalk) of the Reservoir Tisza-tó. There were 19 sampling locations. These locations run dry during the winter.

(3) Native water bodies inside the reservoir: These are topographically well confined water bodies located inside the reservoir, which are recognizable on the field, because they were cut off oxbows or streams within the area of reservoir before the establishment of it. There were 8 sampling locations. These are covered by water during the whole year.

(4) In- and outflows: These are watercourses that flow into the reservoir (the Creek Rima, Laskó, Nyárád-ér) and the two canals that rise from the reservoir (Jászsági-főcsatorna and Nagykunsági-főcsatorna). Each of the sampling locations was within 2 km of the reservoir. There were 5 sampling locations

(5) The River Tisza: This is a narrow riverside margin of the river. The whole studied bed of the River Tisza was inside the reservoir, although it was connected to the reservoir only in the case of extremely high water level. There were 5 sampling locations.

Data analyses

Scalable diversity characterization was used to display the species richness of the dragonfly fauna of the water bodies. The calculation was based on the relative frequency occurrence data. Rényi's diversity profile was used (TÓTHMÉRÉSZ 1998). As a special case it includes the logarithm of the species number, the Shannon diversity index, the quadratic or Simpson diversity index, and the logarithm of Berger–Parker diversity (TÓTHMÉRÉSZ 1995). Therefore, it is a family of diversity indices. It is proposed to use for diversity comparisons (SOUTHWOOD & HENDERSON 2000). It has a so-called scale parameter. When the value of the scale parameter is low the method is extremely sensitive to the presence of rare species. When the value of the scale parameter increases the diversity is less sensitive to the rare species than earlier. For a large scale parameter value the method is sensitive only to the frequent species. The result of this scale-dependent characterization of diversity can be used in a graphical form to visualize the diversity relations of communities. When we are using a one-parameter family $D(a)$ of diversity indices, then the family may be portrayed graphically by plotting $D(a)$ against the (scale) parameter a. This curve, the graph of the $D(a)$ diversity index family, frequently mentioned as the diversity profile of the community. Basically, a serves as a scale parameter, and members of the $D(a)$ diversity index family have different sensitivity to the rare and frequent species depending on a, which may be regarded as a scale parameter. It is important to stress that the curves of two diversity profiles may intersect. For two communities, the intersection of the diversity profiles means that one of the communities is more diverse for the rare species, while the other one is more diverse for the frequent species.

Rogers–Tanimoto index was used to measure the similarity of the species composition of the dragonfly fauna of the compared water bodies, and the single average method was used during the cluster analysis (LEGENDRE & LEGENDRE 1998).

BioBev program package was used for data management (HORVÁTH *et al.* 1997). Diversity analyses and cluster analysis were performed by the NuCoSA package (TÓTHMÉRÉSZ 1993).

Table 1. Country-wide occurrence categories, and local relative occurrence frequencies of the dragonfly species for the suborder Zygoptera in the studied water bodies. Notations: V – very frequent, IV – frequent, III – less frequent, II – rare, I – sporadic.

Taxon	Country-wide	Local
Ischnura elegans pontica SCHMIDT, 1938	IV	0.211
Coenagrion puella puella (LINNÉ, 1758)	IV	0.130
Erythromma viridulum viridulum CHARPENTIER, 1840	III	0.126
Platycnemis pennipes pennipes (PALLAS, 1771)	IV	0.126
Coenagrion pulchellum interruptum (CHARPENTIER, 1825)	IV	0.114
Lestes sponsa sponsa (HANSEMANN, 1823)	IV	0.114
Agrion splendens splendens (HARRIS, 1782)	IV	0.057
Erythromma najas najas (HANSEMANN, 1823)	III	0.053
Sympecma fusca (VAN DER LINDEN, 1820)	V	0.028
Ischnura pumilio (CHARPENTIER, 1825)	IV	0.016
Lestes barbarus (FABRICIUS, 1798)	IV	0.016
Lestes virens vestalis RAMBUR, 1842	IV	0.004
Chalcolestes viridis viridis (VAN DER LINDEN, 1825)	II	0.004

RESULTS

There were 728 imagoes, 384 larvae and 194 exuviae collected during the study, which correspond to 780 data items (543 imagoes, 154 larvae and 83 exuviae). Additionally there were 101 imago data items resulting from observations. All of these data items were recorded as presence/absence data irrespective of the number of individuals actually collected or observed. Altogether, the total number of data items was 881. As the result of the research we confirmed the presence of 39 species (13 Zygoptera and 26 Anisoptera) altogether. The collected and/or observed dragonfly fauna of the Reservoir Tisza-tó is shown in Table 1 for the Zygoptera and in Table 2 for the Anisoptera, as well as the country-wide occurrence frequency (DÉVAI *et al.* 1994) and the local occurrence frequency.

The most species-rich were the native water bodies, with 34 species; there were 30 species in the in- and outflows, while the leaking canals and the reservoir were moderately species rich with 25 species. The River Tisza was relatively species-poor compared to the other water bodies; 12 species were identified. The total number of collected species for the studied water bodies, separately for the two suborders, are shown in Figure 1.

Scalable diversity characterization, provided by the diversity profiles of the water bodies, is displayed by Figure 2; it is evident that the native water bodies

Table 2. Country-wide occurrence categories, and local relative occurrence frequencies of the dragonfly species for the suborder Anisoptera in the studied water bodies. Notations as in Table 1.

Taxon	Country-wide	Local
Crocothemis servilia servilia (DRURY, 1770)	III	0.103
Sympetrum depressiusculum (SÉLYS-LONGCHAMPS, 1841)	III	0.099
Sympetrum sanguineum sanguineum (MÜLLER, 1764)	IV	0.099
Orthetrum albistylum albistylum (SÉLYS-LONGCHAMPS, 1848)	III	0.088
Sympetrum vulgatum vulgatum (LINNÉ, 1758)	IV	0.088
Orthetrum cancellatum cancellatum (LINNÉ, 1758)	III	0.076
Aeshna mixta LATREILLE, 1805	IV	0.065
Anax imperator imperator LEACH, 1815	III	0.065
Anaciaeschna isosceles isosceles (MÜLLER, 1767)	III	0.053
Sympetrum meridionale (SÉLYS-LONGCHAMPS, 1841)	IV	0.042
Gomphus flavipes flavipes (CHARPENTIER, 1825)	II	0.031
Anax parthenope parthenope (SÉLYS-LONGCHAMPS, 1839)	I	0.027
Aeshna affinis VAN DER LINDEN, 1820	IV	0.023
Brachytron pratense (MÜLLER, 1764)	III	0.023
Cordulia aeneaturfosa aeneaturfosa FÖRSTER, 1902	II	0.023
Sympetrum flaveolum flaveolum (LINNÉ, 1758)	IV	0.019
Sympetrum striolatum striolatum (CHARPENTIER, 1840)	IV	0.015
Leucorrhinia caudalis (CHARPENTIER, 1840)	I	0.011
Libellula quadrimaculata quadrimaculata LINNÉ, 1758	III	0.011
Libellula fulva fulva MÜLLER, 1764	II	0.008
Epitheca bimaculata bimaculata (CHARPENTIER, 1825)	I	0.008
Sympetrum pedemontanum pedemontanum (ALLIONI, 1766)	I	0.008
Gomphus vulgatissimus vulgatissimus (LINNÉ, 1758)	III	0.004
Aeshna viridis EVERSMANN, 1836	I	0.004
Orthetrum coerulescens anceps (SCHNEIDER, 1845)	III	0.004
Sympetrum fonscolombii (SÉLYS-LONGCHAMPS, 1840)	II	0.004

were the most diverse; the in- and outflows were the second most diverse. The leaking canals were more diverse than the reservoir, and the River Tisza was the less diverse.

The cluster analysis of the species composition of the dragonfly fauna showed that the species composition of the River Tisza was very different from the others, while the fauna of the other water bodies were similar to one another (Fig. 3). The most similar was the species composition of the native water bodies, and the in- and outflows. The fauna of the reservoir was also similar to them.

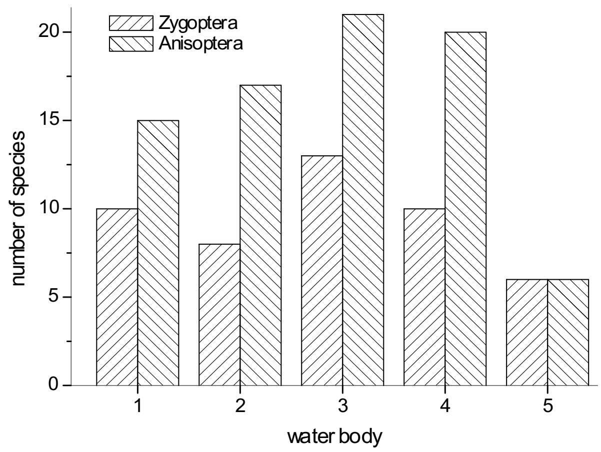

Fig. 1. Species richness of the dragonfly fauna of the water bodies, separately for the two suborders. Notations: 1 = leaking canals, 2 = new inundated area, 3 = native water bodies, 4 = in- and outflows, 5 = River Tisza

DISCUSSION

We identified 39 species: 13 Zygoptera and 26 Anisoptera. This was 60 per cent of the whole Hungarian Odonata fauna. We compared the species richness of the studied water bodies (Fig. 1). Species richness of the Reservoir Tisza-tó was the smallest. Majority of the dragonfly species of the Hungarian fauna preferred standing waters and there were only a few species living in larger streams as were

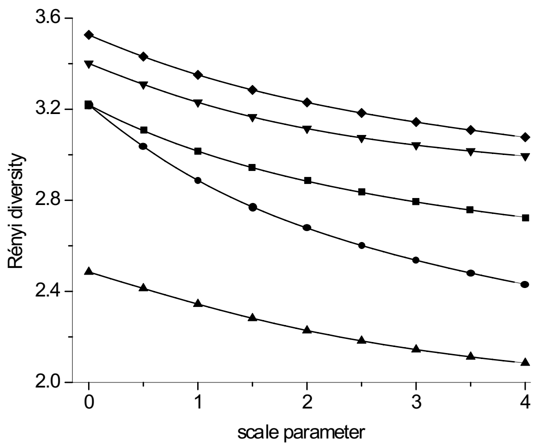

Fig. 2. Diversity profiles of the studied water bodies. Notations: ■ = leaking canals, ● = new inundated area, ♦ = native water bodies, ▼ = in- and outflows, ▲ = River Tisza

reported by DÉVAI and MISKOLCZI (1987). This was also the case for the studied water bodies. Even nowadays, three decades after the establishment, the most species-rich were the native water bodies inside the reservoir.

In- and outflows were very important from the point of view of colonizing of the reservoir. It resulted in large species richness because both the dragonflies of the creeks and standing water habitats were represented. In these water bodies we demonstrated the presence of many species with sporadic, rare and moderately frequent occurrence according to the country-wide occurrence frequency (DÉVAI *et al*. 1994). Among these there was a species, which was found only here [*Orthetrum coerulescens anceps* (SCHNEIDER, 1845)].

The native water bodies contained water during the whole year, and they were under the control of the nature conservation auspices of Hortobágy National Park. Because they were permanent, the number of species was the highest here. It was remarkable that some nationally sporadic species [*Anax parthenope* (SÉLYS-LONGCHAMPS, 1839); *Aeshna viridis* EVERSMANN, 1836; *Leucorrhinia caudalis* (CHARPENTIER, 1840) and *Epitheca bimaculata* (CHARPENTIER, 1825)] appeared here. There were two highly protected species of the Bern Convention: *Leucorrhinia caudalis* (CHARPENTIER, 1840) and *Aeshna viridis* EVERSMANN, 1836. There were four species [*Lestes virens vestalis* RAMBUR, 1842, *Chalcolestes viridis* (VAN DER LINDEN, 1825), *Leucorrhinia caudalis* (CHARPENTIER, 1840) and *Aeshna viridis* EVERSMANN, 1836] which were found only in these water bodies.

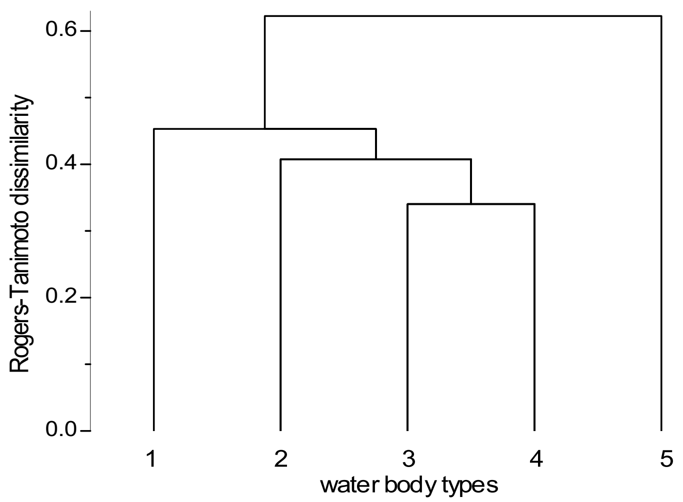

Fig. 3. Hierarchical cluster analysis of the water bodies. Rogers–Tanimoto dissimilarity and single average fusion algorithm were used. Notations: 1 = leaking canals, 2 = new inundated area, 3 = native water bodies, 4 = in- and outflows, 5 = River Tisza

Despite the relatively high number of species of the reservoir at the individual sampling locations numbers were low. This means that the reservoir was not homogeneous. In comparison with the other water bodies the high species richness of the reservoir reflected the effect of some especially rich habitats (e.g. 14 or 18 species). At the same moment only a few species were collected in the basin at Abádszalók (e.g. 1, 3 or 5 species). The composition of the dragonfly fauna of the basin at Abádszalók reflected the negative consequences of a profound human influence. Bathing and other aquatic sports (motor-boat and jet ski) resulted in the impoverishment of the local fauna through destruction of the submerged macrovegetation and marshy vegetation. Mole stones deposited along the beach also increased the disturbance. The stones also hindered the settlement of marshy vegetation. Under these conditions only a few dragonfly species [*Platycnemis pennipes* (PALLAS, 1771), *Ischnura elegans pontica* SCHMIDT, 1938, *Orthetrum cancellatum* (LINNÉ, 1758), *Orthetrum albistylum* (SÉLYS-LONGCHAMPS, 1848)] can survive; these tolerated the disturbance better than the other species (MÜLLER *et al.* 2003).

The average number of species was also low in the leaking canals. There was a strong human influence in this type of water body. The high fluctuation of the water level and the excavation of the channel had strong influence on the dragonfly fauna, limiting the diversity. There was just one species [*Sympetrum fonscolombii* (SÉLYS-LONGCHAMPS, 1840)] which was detected only in this water body type.

The river Tisza was species-poor. There were three species characteristic to the river: *Gomphus flavipes* (CHARPENTIER, 1825) *Gomphus vulgatissimus* (LINNÉ, 1758); *Agrion splendens* (HARRIS, 1782). There was a generalist species, *Platycnemis pennipes* (PALLAS, 1771), which was also frequent.

Using the scalable diversity characterization (Fig. 2) the following order of the diversity of dragonfly fauna of the studied water bodies has been formed. The River Tisza was the least diverse both for the frequent and the rare species, as was expected in the case of rivers. It is followed by the reservoir; then the leaking canals, followed by the in- and outflows. Finally, the native water body was the most diverse type of the water bodies. The diversity profiles of the dragonfly fauna of the water bodies did not cross each other, which means that the orders according to the diversity were the same for the rare, moderately frequent, and the frequently occurring species. This may be interpreted in the following way: the basic structure of the fauna was similar for the whole set of studied water bodies. Each water body was characterized by a stable or relatively stable, typical dragonfly assemblage. In the case of dramatic changes of the fauna and/or strong degradation, or in the case of unstable faunistic composition the shape of the diversity profiles are usually different and they cross each other. This was not the case for the studied water bodies.

Based on the cluster analysis of the faunistic composition of the studied water bodies the reservoir, the native water bodies, and the in- and outflows were similar (Fig. 3.). These water bodies had direct connection to the reservoir. By the clusteranalysis they constitute essentially a group of closely similar water bodies based on the similarity of their dragonfly fauna. In the case of the leaking canal system there was no direct connection to the reservoir; these were connected to the reservoir by pumping stations. The dragonfly fauna of this water body type was slightly separated from the previous group of water bodies. The River Tisza separated with the highest level from the others by the cluster analysis. It was lower in every species richness measure compared to the other four water body types.

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