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SPATIAL DISTRIBUTION PATTERNS AND CONSERVATION STATUS OF LARGE BRANCHIOPODS IN THE CIUC–BASIN, ROMANIA

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LEVÉLLÁBÚ RÁKOK (BRANCHIOPODA: ANOSTRACA, NOTOSTRACA, SPINICAUDATA, LAEVICAUDATA) ELTERJEDÉSE ÉS TERMÉSZET-VÉDELMI HELYZETE A CSÍKI-MEDENCÉBEN

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KIVONAT: Romániában a levéllábú rákok (Anostraca, Notostraca, Spinicaudata, Laevicaudata) elterjedésére vonatkozó részletes vizsgálatokat az 1950-es években végeztek utoljára. Az általános módszer alapján a fajok lelőhelyeit helység szinten adták meg. Így hiányzanak a gyakorisági adatok, ami nagyon megnehezíti a fajok természetvédelmi helyzetének értékelését. Ebben a cikkben részletes, kisléptékű adatokat közlök a levéllábú rákok elterjedéséről a Csíki–medencében. Hat fajt találtam meg összesen 48 tócsában (a felmért élőhelyek 18%-ában). A fajok gyakorisága az élőhelyek száma alapján egytől negyvenig változik. Az élőhelyek többsége természetes eredetű ártéri vagy teraszon elhelyezkedő időszakos tócsa. Nem találtam levéllábú rák fajokat mocsaras területeken, tőzeges talajon és pionír élőhelyeken (útmenti árkok, kőbányák). Statisztikailag szignifikáns különbséget találtam az ártéri és teraszon fekvő tócsák között a vizes időszak hosszában és a vízmélységben: az ártéri tócsák sekélyebbek és gyorsabban kiszáradnak, mint a teraszon lévők. Nincs szignifikáns különbség a fajszám és felület tekintetében. A teraszon fekvő tócsák körül a domináns területhasználat a szántóföld és a beépített terület, az ártéri tócsák esetében a kaszálórétek. Ennek következtében a teraszon fekvő tócsákat a fizikai megszűnés veszélye fenyegeti inkább (feltöltés, mezőgazdasági és háztartási hulladék lerakása), az ártéri tócsákat hosszú távon a folyószabályozás következtében a csökkenő talajvízszint.

ABSTRACT: Systematic investigations on the distribution of large branchiopods in Romania were made for the last time in the 1950's. Based on the locality–based approach of distribution data it is very difficult to assess the conservation status of the species. This paper provides small–scale spatial distribution data of large branchiopods in the Ciuc–basin in the Eastern Carpathians. Six species were found in a total of 48 habitats (18% of the total surveyed habitats). Species frequency as expressed by the number of occupied

habitats varies from 1 to 40. Existing large branchiopod habitats are terrace or floodplain ponds of a natural origin. No large branchiopods were found in permanently wet areas (eutrophic marshes), on peat soil, or in pioneer habitats (roadside ditches, quarries). There are statistically significant differences in the duration and depth of terrace and floodplain ponds: floodplain ponds are shallower and dry out faster. There are no differences in surface size and species number between terrace and floodplain ponds. The land use composition surrounding the ponds differs largely: In the case of floodplain ponds hay meadows dominate, and in the case of terrace ponds arable land and urban areas are dominant. Therefore, terrace ponds are threatened more by physical destruction while floodplain ponds may be affected in the long term by the lowering of groundwater level due to the river regulation.

Key words: Anostraca, Notostraca, Spinicaudata, Laevicaudata, Ciuc–basin, terrace ponds, floodplain ponds

Introduction

Large branchiopods are a worldwide threatened group of crustaceans (BELK 1998). The main habitat type of this group is temporary ponds. The small size of these habitats explains why habitat destruction is considered the main threat for this group (BELK 1998, KING 1998, MURA 1999, CVETKOVIC–MILICIC and PETROV 2001, EDER and HÖDL 2002). Large branchiopod species richness is especially high in dry and semiarid areas. In Europe, the Pannonian lowland and the South-Romanian lowlands are among the most species-rich areas for large branchiopods (BOTNARIUC 1948, LÖFFLER 1993). Interestingly, current research on large branchiopods is lacking from the central part of the Pannonian lowland (FORRÓ 2000) and from the South-Romanian plains.

A problem of the study of large branchiopods and their conservation in these little researched areas is that historic species records were published on the locality level, so very little is known on the abundance of species relative to habitat availability in the respective areas. This general conceptual problem limits the value of historic zoogeographical data for conservation in many animal groups.

Literature data on the habitat types of large branchiopods vary widely. They were often found in roadside ditches, vehicle tracks and other pioneer habitats, fact which would suggest that at least some species disperse readily and are tolerant to environmental factors. This, however, is in contrast with the fact that many large branchiopod species have a restricted distribution (KING et al. 1996). Recent studies on the dispersal of aquatic invertebrates disprove the old concept that zooplankton disperses readily by wind, rain or waterfowl (JENKINS and UNDERWOOD 1998), fact which is coherent also with the large number endemisms found in large branchiopods (King et al. 1996). All these would justify a more increased attention on the conservation of this group and implicitly, their habitats. The conservation value of temporary ponds was discussed in Romania by BĂNĂRESCU (1970, 1995, 1996).

The Ciuc–basin is a well defined landscape unit of the Eastern Carpathians, with a rich wetland matrix. No data have been published previously on the large branchiopods of the area. As mentioned, locality–based distribution data provide little information on species abundance, frequency or rarity. For this reason, this paper presents detailed information on the local distribution of large branchiopods in

the Ciuc-basin. I address the following specific questions: What is the spatial and altitudinal range occupied by the group in the research area? What is the relative frequency of species expressed by the number of occupied habitats? What standing water habitat types are occupied by the group and what habitat types are lacking the group? What are the main threats to the habitats in a spatial context?

Research area

The Ciuc–basin (46°39'N, 25°29'E and 46°11'N, 25°59'E) is a roughly 1500 km^2 tectonic mountain basin of the Eastern Carpathians, constituting the upper catchment area of the Olt river (KRISTÓ 1994) (Fig. 1). Its altitude varies from 630 to 1800 m above sea level. Geomorphologically, it consists of a mountain region covered mainly by spruce forests, clearings and mountain pastures, and the river floodplain, terraces and sediment cones of the creeks, occupied mainly by agricultural areas and settlements. The spatial arrangement of agricultural land use is determined by topography, soil wetness and traditions. The general picture is that low altitude wet areas as the floodplain of the river are used as hay meadows for cattle, while dryer areas like the terraces are used as arable land, and areas with steeper slope on the hill foots are used as cattle pastures. Mountain pastures are mainly grazed by sheep.

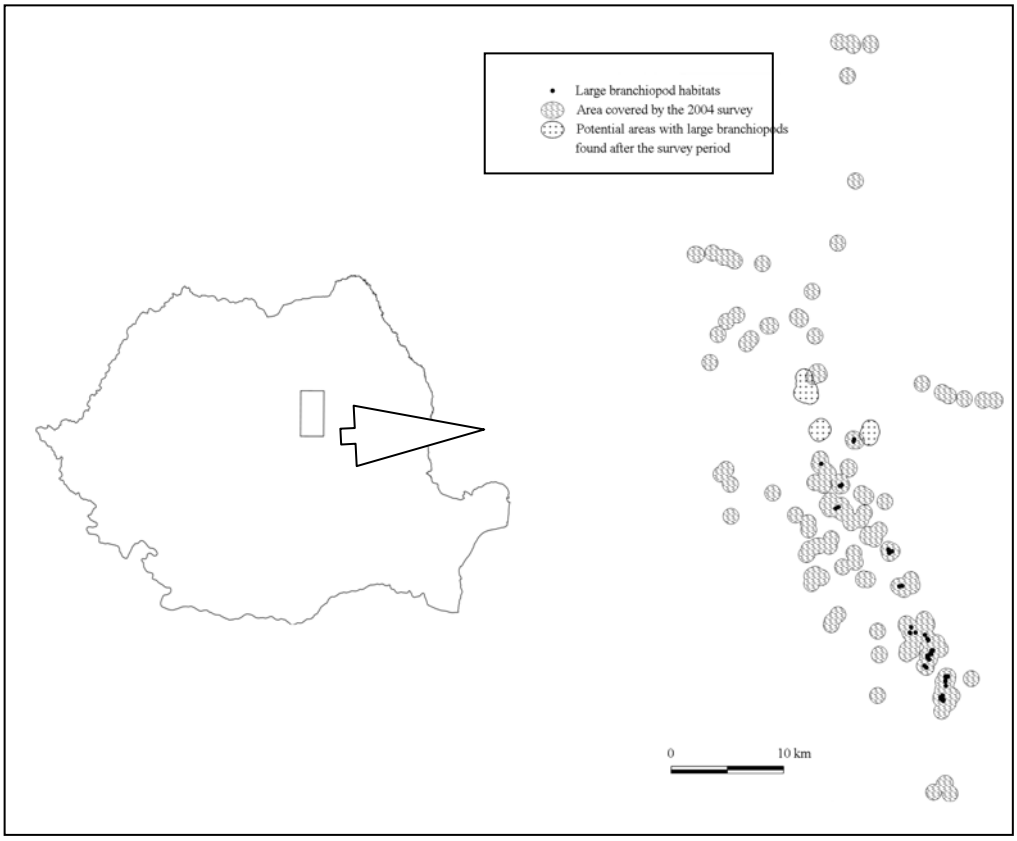

Figure 1. The location of the study area in Romania (on the left side), and the areas covered by the survey in 2004, identified large branchiopod habitats and potential areas with large branchiopod habitats identified after the survey period (on the right side).

The lower part of the basin is characterized by a relatively wide floodplain and flat terraces, and the river shows middle section characteristics. All these contribute to the formation of large wetland areas. The course of the river and the floodplain was dramatically changed during the river regulation of the 1970's and 1980's. The old bed of the river was filled up in most places and the river now flows in a deep channel. Floods are now rare compared to before regulation times when spring and summer floods were regular. However, because of a high density of springs on the floodplain and because of the conservative nature of local agriculture, there was no dramatic land use change in the area, fact which may have also contributed to the preservation of some wetland areas and grasslands (DEMETER 2001).

Methods

I surveyed 273 standing water habitats in the Ciuc–basin in 2004 from March to May and in smaller areas of the basin in previous years for the presence of large branchiopods. The total area covered by surveyed habitats is 1084 km^2 (minimal convex area that contains all habitats), and the altitudinal range from 634 m to 1505 m. Although the typical habitats of large branchiopods are temporary ponds on open areas, there are some records from permanent waters and from forested areas as well (BRTEK and THIÉRY 1995, DUMONT and NEGREA 2002, pers. obs). Therefore all kind of standing waters were sampled (temporary, permanent, forest pond habitats). I collected plankton samples with a 150 µm mesh size, 15 cm diameter net or visually inspected the ponds. Samples were preserved in 4% formol. Species were later determined using BOTNARIUC and ORGHIDAN (1953) and BRTEK and MURA (2000). The geographic position was recorded by a handheld GPS Garmin 72. I used the Manifold software for spatial analysis. The area covered by the survey is shown in Fig. 1, together with three sites with high pond density (potential large branchiopod habitats) that were identified after the survey period.

Results

Six species of large branchiopods were found in a total of 48 ponds (17.58% of the surveyed habitats). Three of the species are Anostraca (*Chirocephalus shadini*, *Drepanosurus hankoi*, *Tanymastix stagnalis*), one Notostraca (*Lepidurus apus*), one Spinicaudata (*Eoleptestheria ticinensis*) and one Laevicaudata (*Lynceus brachyurus*). The occupancy of species varies from 1 habitat to 40 (Fig. 2).

All records of large branchiopods are new for Romania. The three Anostraca species are new for the Romanian fauna (Demeter 2004). Previously, *E. ticinensis* was described from 5 localities from the southern and eastern part of the country and in a continuous belt along the lower section of the Danube. *L. brachyurus* was described from one locality from southern Romania. *L. apus* was found in three localities from the western, southern and eastern parts of Romania (Fig. 3). All historic data are from BOTNARIUC and ORGHIDAN (1953), because no significant additions were made to this work.

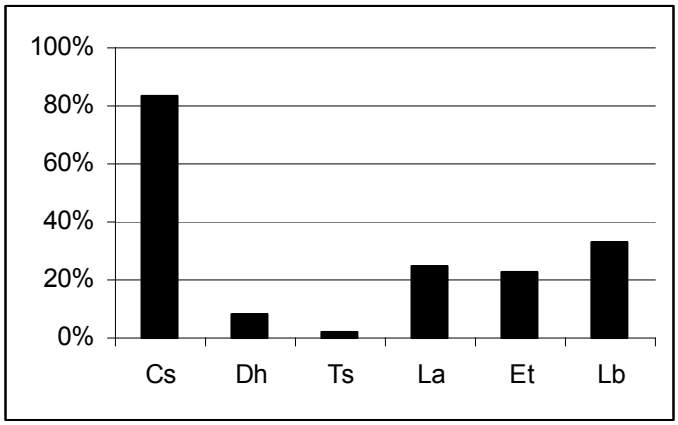

Figure 2. Relative frequency (number of occupied habitats) of large branchiopod species in the Ciuc–basin. Cs–*Chirocephalus shadini*, Dh–*Drepanosurus hankoi*, Ts–*Tanymastix stagnalis*, La–*Lepidurus apus*, Et–*Eoleptestheria ticinensis*, Lb–*Lynceus brachyurus*

The altitudinal range of habitats with large branchiopods is between 635 m and 678 m (the lower 5% of the total surveyed range). The area covered by large branchiopod habitats is 64.65 km^2, 6% of the total surveyed area (see Fig. 1 for the position of large branchiopod habitats within the survey area). The density of ponds with large branchiopods is 0.74 pond/km^2, while the total habitat density for the whole area is 0.25 pond/km^2.

Relative to the floodplain of the Olt river, which represents a main wetland area, the large branchiopod habitats can be grouped into two classes: ponds situated on the floodplain, and ponds situated on the terraces, mainly on the first terrace. 26 of the large branchiopod habitats are situated on the floodplain and 22 on the terraces.

The ponds situated on the floodplain have a significantly shorter duration than those on the terraces (the general mean for large branchiopod habitats is 10.4 weeks). Terrace ponds are significantly deeper (Table 1), and as expected, their altitude above sea level is higher. There is no significant difference regarding the size and species number (for floodplain ponds the mean is 1.6 species/pond, while for terrace ponds 1.8 species/pond) (Table 1). The land use composition in the surroundings of the ponds also differs largely between ponds on the floodplain and the terrace: hay meadows are the main land-use form around 69% of the floodplain ponds, while urban and arable land covers 45% of the surroundings of terrace ponds (Fig. 4)

No large branchiopods have been found in roadside ditches, forest pools, permanent waters, peat bogs and permanently wet areas (marshes).

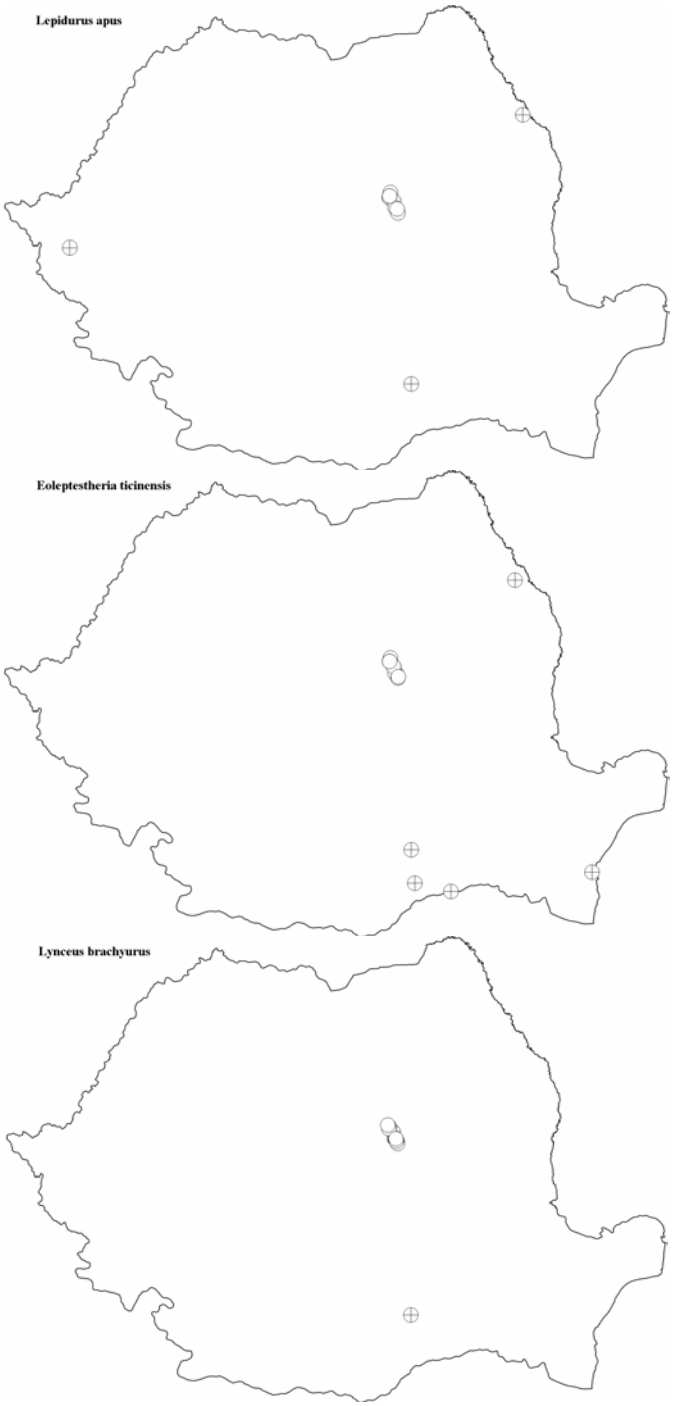

Figure 3. The distribution of species found in the Ciuc-basin that were previously recorded in Romania. Circles with a cross: data from BOTNARIUC and ORGHIDAN (1953), empty circles: data from this survey.

Table 1. Statistics summary of Mann-Whitney U-test regarding differences between ponds with large branchiopods situated on the floodplain (group 1, n=26), and on terraces (group 2, n=22). Significant results are highlighted.

	Rank Sum, Group 1	Rank Sum, Group 2	U	Z	p-level
ALTITUDE (m)	**462**	**714**	**111**	**-3.62103**	**0.000294**
LENGTH (m)	712	464	211	-1.55187	0.120703
WIDTH (m)	618	558	267	-0.39314	0.694218
DEPTH (cm)	**516**	**660**	**165**	**-2.50369**	**0.012296**
DURATION (weeks)	**450**	**726**	**99**	**-3.86933**	**0.000109**
SPECIES NUMBER	605	571	254	-0.66213	0.507891

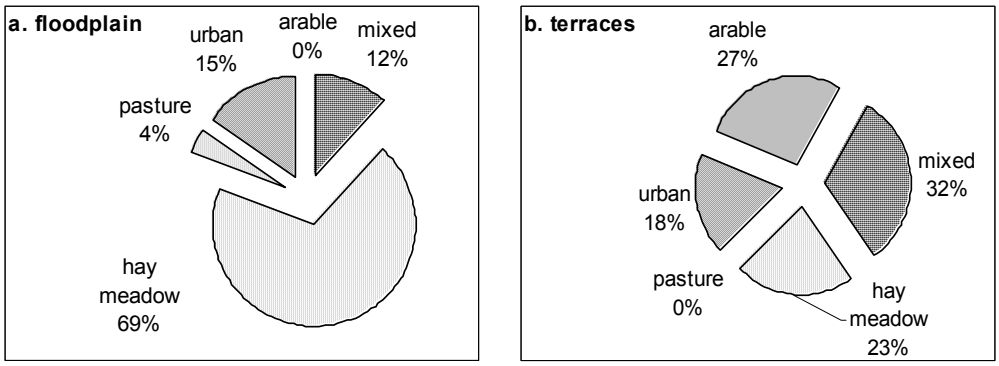

Figure 4. The main land use forms in the surrounding areas of ponds with large branchiopods: a. on the floodplain, b. on the terraces. Mixed land use means a mixture of arable land, hay meadow and urban facilities (railway, buildings, main road)

Discussion

All records of large branchiopods are new for Romania. Three Anostraca species are new for the Romanian fauna. Two other large branchiopod species have very few records (*L. apus* three localities, *L. brachyurus* one locality). One species, *E. ticinensis* was recorded from the eastern and southern part of the country. Historic records on large branchiopods (Botnariuc and Orghidan 1953) cover a large part of the eastern, southern and western part of the country, and some parts of Transylvania too. The large proportion (five out of six) of new and relatively rarely recorded species may be due to the lack of studies, but also may show that the Ciuc–basin has special faunal characteristics at least regarding this group. Further small–scale studies are needed to confirm this.

In a European biogeographical context, *D. hankoi* was considered Pannonic endemism (Löffler 1993, Brtek and Thiéry 1995), but found later in Belorussia near Minsk (Nagorskaja et al. 1998), and now during this survey (see also Demeter 2004). *C. shadini* is considered a Western Palearctic species by Löffler (1993), with its westernmost known habitat in Austria (EDER et al. 1996). *T. stagnalis* is a Western Palearctic species, *L. apus* is a cold water Holarctic species. *E. ticinensis* is

a Palearctic species with a disjunct area, it occurs in southern Europe. *L. brachyurus* is a Holarctic species, it is absent from most of southern Europe (LÖFFLER 1993, BRTEK and TIÉRY 1995). This picture shows that the large branchiopod fauna of the Ciuc-basin is a mixture of species distributed in the western, eastern, northern and southern parts of Europe.

Large differences between species occupancy (frequency) are one of the surprising findings of this study. Two of the Anostraca species are found in very few habitats (one for *T. stagnalis* and four for *D. hankoi*). The reasons for this are not clear. Differences in dispersal capacities and environmental tolerance spectrum may be potential limiting factors. The low frequency of *T. stagnalis* is strange, as this species is considered as one of the tolerant and widely distributed species in Europe (BRTEK and THIÉRY 1995). Our findings are limited by detection probability, as species may be hidden in the resting egg bank (EDER and HÖDL 2002) and also there are potential habitats that were not covered during this study. So longer term studies may modify the picture presented here.

Also surprising is that large branchiopod habitats are confined to a very narrow altitudinal and spatial range. Altitude and corresponding microclimatic factors can not fully explain this. An important factor could be habitat density that increases the chance of effective dispersal. Habitat density is three times larger in the area with large branchiopod habitats (0.75 pond/km^2) than on the whole area covered by all the surveyed ponds (0.25 pond/km^2).

Large branchiopods are generally associated with open lowlands or alpine regions, but there are records from forest habitats too (*Chirocephalus diaphanus* in an oak forest near Sighişoara, HARTEL pers. com.). No large branchiopod habitats were found in forests and in the mountain area during this study.

A classification of large branchiopod habitats in the study area is planned based on vegetation. An obvious and intuitively ecologically significant classification is one based on the position of the habitat relative to the floodplain. The statistical analysis shows that there are significant differences between the two types of habitat regarding duration and depth, but not in species number and surface area. Ponds on the floodplain have a shorter duration and smaller depth than those on the terrace. This is connected most probably with substrate structure: probably ponds on the floodplain are more closely connected with the groundwater, and follow its fluctuations, while ponds on the terraces have a better bottom isolation.

The regulation of the river in the 1970-s and 1980-s could have amplified the fluctuations of the floodplain water table, more exactly the speed of drying of the floodplain after the spring maximum water level. On the contrary, ponds situated on the terraces are independent of floodplain water level fluctuations. It is necessary to mention also that no large branchiopods were found on peat substrate or permanently wet areas on the floodplain, but only on areas that dry up completely.

A large proportion (69%) of the large branchiopod habitats situated on the floodplain are surrounded by hay meadows, while 45% of terrace habitats are surrounded by urban areas and arable land. Mixed land use that encompasses urban facilities, arable land and hay meadows are also larger for terrace ponds. This could be important regarding the threats that these two types of habitats face. Terrace habitats are much more exposed to habitat destruction by digging or filling, while floodplain habitats are affected more by the consequences of the river regulation on water level fluctuations.

Another conservation implication of the differences between terrace habitats and floodplain habitats is that, maybe as a consequence of a faster drying, floodplain ponds usually can be used in the local agriculture (as part of the hay

meadows), while terrace ponds gain a specific trait due to a longer water cover: the development of tussocks of sedge (*Carex* spp.). Tussocks of sedge make virtually impossible the mowing of the ponds, and the high water level in spring is a nuisance for plowing. As a large proportion of terrace ponds are situated in a matrix of arable land, these ponds are more likely to be filled up with agricultural waste, household waste or drained by ditches in order to increase arable land size. Also, while floodplain ponds may profit from vertebrate umbrella species such as the white stork, the corncrake and amphibians, isolated terrace ponds have little chance for this (DEMETER and HARTEL in press).

This study did not focus specifically on the conservation threats of large branchiopod habitats. It only provides a somewhat theoretical background for the main threats that two types of large branchiopod habitats face. However, it has to be mentioned that the two rare species found in the area are threatened by local extinction. The only known habitat of *T. stagnalis* has been built in to a hotel in 2004. One of the four *D. hankoi* habitats is drained by a deep ditch and part of it was ploughed up. All this indicate the great need for conservation measures specially designed for large branchiopod habitats, as suggested by several authors (BĂNĂRESCU 1970, 1995, 1996, KING et al. 1996, Belk 1998, EDER and HÖDL 2002).

Conclusions

The spatial and altitudinal distribution of large branchiopods is limited in the Ciuc–basin, though the area is an ideal matrix of potential habitats for large branchiopods. However, further research may increase the known ranges of species in the area.

The frequency (habitat occupancy) of species varies from 1 to 40 habitats. Two Anostraca species have very few habitats, these I consider locally endangered.

Large branchiopods are confined to natural temporary ponds in the area. No large branchiopods have been found in permanent waters, marshes, roadside ditches and peat bogs.

Floodplain ponds and terrace ponds face different threats at present. Terrace ponds are more threatened by habitat destruction caused by urban expansion and intensive agricultural land use. Floodplain ponds are less threatened by immediate habitat destruction, but face the consequences of river regulation and a lowering of the water table.

Special conservation measures are needed that focus on large branchiopod habitats, especially the halt of filling up of ponds with agricultural and household waste.

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