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TERRACE PONDS IN THE CIUC BASIN: A PRELIMINARY CHARACTERIZATION

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INTRODUCTION

Ponds and pools are among the most vulnerable and less studied habitat types worldwide (Williams 1987, King 1998, Wood et al. 2003), but awareness of their biodiversity-conservation, scientific, cultural and educational value increases (Boothby 1999, Nicolet et al. 2004, De Meester et al. 2005 and references within). In Romania there are virtually no studies on their ecology except the papers of Bănărescu (1970, 1995) who suggested their protection. Although some ponds, especially alpine ponds are situated on protected areas (Demeter and Mori 2004), there are no areas in Romania protected specifically for ponds.

The Ciuc Basin is one of the large tectonic mountain basins of the Eastern Carpathians (60x20 km) (Kristó 1957, 2002) characterized by a cold and humid climate, low amount of precipitation (600 mm yearly average) and low evapotranspiration values. It consists of three sub-units, the Upper, Middle and Lower Ciuc Basin (from North to South). The low altitude areas of basin, with a mean altitude of 650 m, are very rich in wetland habitats. More than 150 small water bodies have been surveyed in a recent study, and the total number may be several times larger (Demeter et al. 2006). Low altitude ponds of natural origin in this area can be divided into floodplain ponds and higher altitude ponds, situated mainly on the second terraces (Demeter 2005) but also on the alluvial fans. For convenience, we name these as "terrace ponds" in the following. Here we (1) present preliminary data on the morphology and distribution of terrace ponds, (2) give a list of some characteristic floral and faunal elements, and (3) put forward hypotheses on the origin of terrace ponds.

MATERIAL AND METHOD

Sites with ponds were identified in the field as part of a research project on small wetland habitats from 2003, and in some cases from topographic maps. In 2003 and 2004 we recorded the position of ponds as points, later we recorded the contour of ponds with a Garmin GPS 72. For measurements, ponds were treated as ellipses. Maximum length (large axis) was measured and width was defined as the longest line perpendicular to the large axis. We calculated length-width ratio and the angle of the main axis in degrees relative to north (North=0^o). 1:5000 topographic maps were digitized to have a better overview of the surrounding topography. For spatial analyses and presentation we used the Manifold GIS software (Manifold 6.00 Professional Edition. Manifold Ltd.). Five algal samples were collected in May 2005 and identified where possible to species level by Cărăuş I. based on Starmach (1974), Nagy-Tóth and Barna (1998), Godeanu (2002) and other literature. Biomass and density for the dominant species was calculated. The most common plant species were recorded during each field trip and a more detailed floristic and vegetation survey was made on one site (Torda valley) in October 2005. The assignment to different associations was based on the presence of characteristic species, according to the Central European School, using Coldea (1991). Observations on amphibian and large branchiopod species presence were made from 2004 (Demeter 2004, 2005, Demeter et al. 2006, Demeter and Mara 2006).

RESULTS

Pond distribution, density and morphology

We registered 154 terrace ponds and mapped the contour of 119 ponds. Most ponds are situated on the western second terrace of the Olt river. Fig. 1 shows 5 sites with terrace ponds in the Middle Ciuc basin. Ponds have a clustered distribution: 135 ponds (88%) form 12 clusters of at least 5 ponds in which the maximum distance between neighbors is 500 m. Maximum pond densities are between 24 and 47 ponds/km^2 (on three sites with an area of 0.3-0.5 km^2). 90% of the measured ponds (n=119) have a surface less than 2500 m^2, and 60% are smaller than 1000 m^2 area (mean surface area=1116 m^2, SD=1072.7 m^2, mean length-width ratio=2.18, SD=1.15). The long axis of 85% of the ponds is oriented in a North-South $\pm 45^o$ direction (Fig. 2). The mean angle of ponds relative to north is 183.1^o (e.g. they are elongated in a North-South direction), SD=34.6^o. Maximum depth is usually below 150 cm, and in years with average precipitation most ponds dry out.

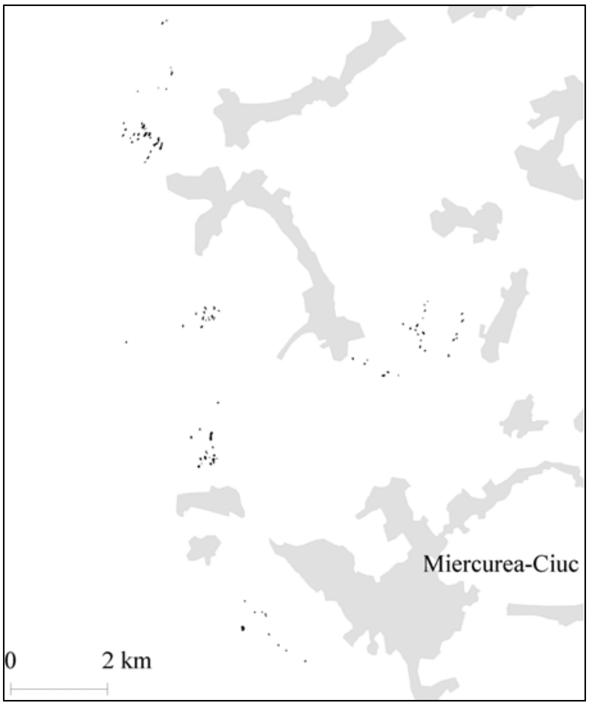

Fig. 1. Distribution of ponds (small black areas) in the Middle Ciuc basin. Grey areas represent settlements.

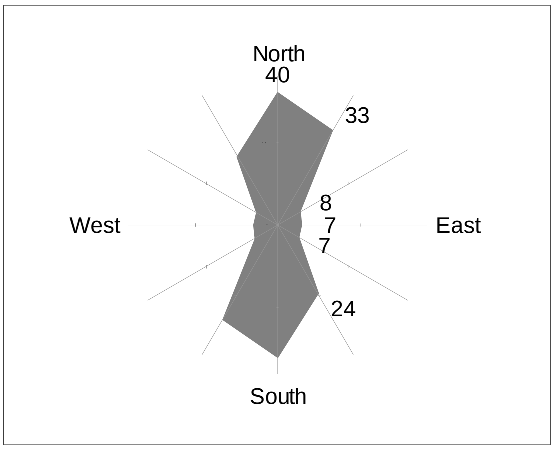

Fig. 2. The orientation of the long axis of ponds (North=0°)
Values were grouped in classes of 30° (345-15°, 15-30° etc.)

Density and biomass of algae

Seven algal samples indicate a relatively small number of species, low biomass and the dominance of small-sized species (Table 1). However, in some cases heavy blooms of *Volvox globator* have been observed.

Flora and vegetation

The vegetation of ponds is generally dominated by tussock-forming *Carex* species. So far, the following plant communities have been identified: *Caricetum gracilis* Almquiest 1929, Gräbner f. et Hueck 1931, *Caricetum vesicariae* Chouard 1924, *Typhetum latifoliae* Soó 1927 and *Phragmitetum communis* Soó 1927 em. Schmale 1939.

A preliminary list of observed species in ponds of Torda Valley is given as follows: **Equisetaceae**: *Equisetum palustre* L., **Salviniaceae**: *Salvinia natans* (L.) All., **Salicaceae**: *Salix cinerea* L., *Salix fragilis* L., **Polygonaceae**: *Polygonum bistorta* L., *Rumex acetosa* L., **Caryophyllaceae**: *Stellaria palustris* Retz., **Ranunculaceae**: *Caltha palustris* L., *Ranunculus acris* L., *Ranunculus cassubicus* L., *Ranunculus repens* L., *Ranunculus sceleratus* L., **Brassicaceae**: *Cardamine amara* L., *Nasturtium officinale* R. Br., **Rosaceae**: *Alchemilla micans* Buser, *Filipendula ulmaria* (L.), *Geum aleppicum* (L.) Maxim., *Potentilla erecta* (L.)Hampe, **Fabaceae**: *Lathyrus pratensis* L., **Geraniaceae**: *Geranium pratense* L., **Onagraceae**: *Epilobium palustre* L., **Apiaceae**: *Heracleum sphondyllium* L., **Primulaceae**: *Lysimachia nummularia* L., *Lysimachia vulgaris* L., **Rubiaceae**: *Cruciata glabra* (L.) Ehrend., *Galium palustre* L., *Galium uliginosum* L., **Boraginaceae**: *Myosotis scorpioides* L., *Symphytum tuberosum* L., **Lamiaceae**: *Clinopodium vulgare* L., *Lycopus europaeus* L., *Mentha longifolia* (L.)Hudson, *Scutellaria galericulata* L., *Stachys palustris* L., **Callitrichaceae**: *Callitriche* *palustris* L., **Scrophulariaceae**: *Veronica scutellata* L., **Valerianaceae**: *Valeriana officinalis* L., **Asteraceae**: *Cirsium rivulare* (Jacq) All., **Alismataceae**: *Alisma plantago-aquatica* L., **Menyanthaceae**: *Menyanthes trifoiata* L., **Juncaceae**: *Juncus atratus* Krocker, *Juncus effusus* L., **Cyperaceae**: *Carex acuta* L., *Carex nigra* (L.) Reichard, *Carex riparia* Curtis, *Carex rostrata* Stokes, *Carex vesicaria* L., *Carex vulpina* L., *Scirpus sylvaticus* L., **Poaceae**: *Agrostis gigantea* Roth, *Alopecurus pratensis* L., *Calamagrostis canescens* (Weber) Roth, *Deschampsia caespitosa* (L.) Beauv., *Glyceria arundinacea* Kunth, *Phalaris arundinacea* L., *Phragmites australis* (Cav.) Steudel, *Poa palustris* L., **Sparganiaceae**: *Sparganium erectum* L., Fam. **Typhaceae**: *Typha latifolia* L.

Fauna

One of the special faunal elements of terrace ponds are large branchiopods, though this group is present in the Ciuc Basin in floodplain ponds as well. *Chirocephalus shadini*, *Drepanosurus hankoi*, *Lynceus brachyurus*, *Eoleptestheria ticinensis*, *Lepidurus apus* have been found in terrace ponds (Demeter 2005). Other aquatic invertebrate fauna was not investigated until now. Terrace ponds are also important amphibian habitats. *Rana temporaria*, *R. arvalis*, *Triturus cristatus* and *T. vulgaris* frequently reproduce here (Demeter et al. in press). One of the largest known populations of *R. arvalis* in the Ciuc Basin was identified at a terrace pond site (Torda valley) (Demeter and Mara in press). *Hyla arborea,* a locally rare species was recorded in some ponds but in very low density (up to 3-4 calling males) (Demeter et al. in press).

Table 1. A list of dominant algae and other species. Density and biomass values refer to the dominant species.

Habitat	Sampling date	Density (cells/ml)	Biomass (mg/l)	Dominant species	Other species
Tor 1	05.04.6.	179	0.16	*Glenodiniopsis steinii*	*Peridinium cinctum; Trachelomonas hispida; Elakatothrix gelatinosa; Bicoeca cylindrica; Pinnularia viridis; Cyclotella comta*
Hon 1	05.04.21	39	0.05	*Cryptomonas erosa*	*Cryptomonas marssonii; Ophiocytium parvulum; Chrysococcus rufescens*
Tof 5	05.05.5	3695	1.12	*Chroomonas caudata*	*Cryptomonas marssonii; Chroomonas nordstedtii; Chrysococcus rufescens; Chromulina sp.*
Tof 1	05.05.4	2107	2333.58	*Volvox globator*	*Cryptomonas ovata, C. reflexa, Chroomonas nordstedtii, Schroederia setigera, Elakatothrix acuta, Closterium venus, Trachelomonas intermedia*
Tof 2	05.05.5	1725	1.14	*Cryptomonas reflexa, C. erosa, C. marssonii*	*Chroomonas caudata, Chroomonas sp., Cryptomonas ovata, Chrysococcus rufescens, Chromulina sp., Schroederia setigera, Mougeotia sp.*
Tof 3	05.05.5	5203	2.99	*Cryptomonas erosa, C. reflexa*	*Cryptomonas marssonii, Chroomonas caudata, C. nordstedtii, Chrysococcus sp., Diatoma vulgare, Nitzschia linearis, Trachelomonas sp.*
Tof 4	05.05.5	1626	0.43	*Chroomonas nordstedtii*	*Chroomonas caudata, Chroomonas sp., Cryptomonas erosa, Rhodomonas sp., Chlorogonium elongatum, Elakatothrix acuta, Sphaerellopsis sp., Chromulina sp.*

DISCUSSIONS

The origin of these ponds is not known, but their special morphology indicates that similar factors lead to their development. One possibility is an anthropogenic origin (hypothesis 1). Artificial fish ponds of historic age have been observed in the Ciuc Basin (Pásztohy, unpublished observations). However, existing second terrace ponds are too small and shallow, and often far from flowing water courses to be used as fisheries. Ponds were used until the first part of the 20th century by local traditional agriculture for hemp processing (collected hemp was soaked for weeks in pond water to eliminate soft tissues). Also, many of the ponds are too far from settlements to be used in the hemp agriculture – although this possibility cannot be excluded at this moment. So we have to consider this hypothesis as less probable. The highly structured and the peculiar North-South orientation of ponds also suggest a natural origin. Kristó (2002) made the only published observation on the presence of sinuous basins on the first and second terrace that „often contain temporary ponds”, and he considered these basins fossil riverbeds (hypothesis 2). This is also suggested by the collinearity of some terrace ponds, their parallel orientation relative to the main watercourse (the Olt), and their perpendicular orientation relative to the small tributaries of the Olt.

However, in our opinion ponds of the first and second terrace should be treated separately. One of the reasons is that the first terrace has 1.5 m maximum relative height while the second terrace has 8-10 m relative height (Kristó 1957), so geomorphological formations of the second terrace should be much older than the formations of the first terrace. Moreover, the shape of pond basins on the first terrace is often meander-like, but on the second terrace it is generally linear. In many cases the ponds form chains in small U shaped valleys and/or are associated with a waving surface. This formation is known in the literature as *derasion valley* that forms in conditions of permafrost by solifluction and areal erosion processes, indicating a periglacial origin of these ponds (hypothesis 3). It is possible that ice wedges or ice lenses also helped creating pond basins. These processes are active at present at high latitudes, in the tundra climate. The fact that the ponds are markedly elongated in a North-South (+-30^{o}) direction and there are very few ponds that elongated in a West-East direction suggests that permanent snow patches could have also played a role in the development of pond depressions through processes known as nival erosion.

Hypothesis 3 predicts that terrace ponds in the Ciuc Basin are roughly 10000 years old, since the periglacial climate and processes ended then at this latitude and altitude. Seemingly it is paradoxal how ponds can persist for such a long time without naturally filling in. One possible explanation for a slow succession is the cold climate of the basin (shown also by the low algal biomass). Tussocky sedge vegetation slows the warming-up of ponds during spring by shading them, and ponds with intact vegetation are much colder than those that are burnt (Demeter pers. obs.). For example in 2004 and 2005 deeper ponds had solid ice on their bottom until the beginning of April. Also, periodical dry-out allows a rapid decomposition of organic matter and slows down sediment accumulation (Biggs et al. 1994). Another prediction of hypothesis 3 is that terrace ponds could have been refuges for some elements of the periglacial flora and fauna. It is long known that due to their cold microclimate, mineral water fens in the Ciuc Basin host more than 30 relict plant species and also relictary plant communities (Rațiu 1980). From the plant species found until now in these ponds, *Spiraea salicifolia* is considered glacial relic. We expect that future surveys will show more relic plant species and communities from these habitats. One could argue that the presence of glacial relic species is an evidence for the age of teh habitats where they were found, but this could not be the case as these organisms may be later colonists from other relic habitats and populations.

The presence of two cold-stenothermal *Anostraca* species (*Chirocephalus shadini* and *Drepanosurus hankoi*) in terrace ponds is interesting from a biogeographic point of view. These two species were described for the first time in Romania from the Ciuc Basin (Demeter 2004), and later found in two other mountain basins of the Eastern Carpathians (Demeter unpublished). *Drepanosurus hankoi*, a species considered Pannonic endemism by Löffler (1993) was known previously from one locality in Hungary (where it has no recent records), several habitats in Southern Slovakia (Brtek 1976) and one site in Belorussia (Nagorskaja et al. 2000). *Chirocephalus shadini* is a Western Palearctic cold-stenothermal fairy shrimp (Löffler 1993) that reaches its westernmost limit in Austria (Eder et al. 1997), and has a very fragmented distribution in Central Europe (Brtek and Thiéry 1995). We suggest that these two species could also be relics of colder climates, given that were not recorded from other regions in Romania and dispersal in many fairy shrimps is very slow.

All these observations indicate a high scientific and a potential educational value of terrace ponds. Unfortunately their destruction has been accelerated during communist times especially through dessiccation and filling up using heavy machinery, and then continued in the post-communist period at a small but equally destructive scale. Currently, pond sites (not only individual ponds) that are situated close to settlements are threatened with fill-up with agricultural, construction or household waste (or all three) and sawdust. The vegetation of ponds often indicates recent or older impact. *Filipendula ulmaria, Calamagrosis epigeios, Geranium pratense* indicate drying while the dominance of *Phragmites australis* may be connected with fire: there is one known case where peat set light in the 1960's in a pond that is now dominated by reed.

CONCLUSIONS

Terrace ponds are a distinct habitat type that should be further investigated as a special geomorphological formation and for their role in hosting a special biota. We propose a study of pond sediments as a means to understand their formation and evolution. Until more detailed studies and more information will be available on their origin, biota and ecology, we propose that ponds and pond sites should be accorded a status of preliminary protection.

REZUMAT

Lucrarea prezintă o caracterizare preliminară din punct de vedere morfologic, floristic şi faunistic a unui tip de baltă temporară cu caracteristici distincte în Depresiunea-Ciucului, cu un interes ştiințific ridicat. Majoritatea acestor bălți se află pe terasa a doua a Oltului şi pe conurile de dejecție în partea vestică a râului. Forma lor este circulară sau eliptică, majoritatea lor având o suprafață mai mică de 2500 km^2 şi o adâncime maximă mai mică de 150 cm. În condiții de precipitații medii majoritatea bălților se usucă. Cele mai multe bălți sunt alungite într-o direcție aproape de nord-sud. Numărul bălților cunoscute este peste 150, de obicei acestea se găsesc în grupuri 2-20. Numărul de specii şi biomasa de alge sunt scăzute în timpul primăverii (aprilie-mai), indicând oligotrofie, dar au fost observate ocazional explozii de *Volvox globator*, indicând hipertrofie. Vegetația caracteristică a bălților este reprezentată de rogozuri cespitoase. Au fost identificate relicte glaciare (*Spiraea salicifolia*) şi elemente boreale (*Comarum palustre*). Din faună a fost studiată până în prezent distribuția filopodelor (Branchiopoda: Anostraca, Notostraca, Conchostraca) şi amfibienilor. Au fost identificate specii rare ca *Drepanosurus hankoi* (Anostraca) şi *Rana arvalis*. Prezentăm ipoteze despre originea bălților dintre care originea periglaciară pare a fi cea mai probabilă. Propunem instietuirea unui regim de protecție pentru a opri distrugerea acestor habitate până ce sunt efectuate studii mai detaliate.

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