NEWTS AND FISH IN THE REMNANTS OF FORMER WETLANDS FROM NORTH-WESTERN ROMANIA IN FRONT OF THE SAME ENEMY

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Abstract. The interaction between fish and amphibians is detrimental to amphibians. Both groups are present in the north-eastern Pannonian Plain, which was covered in the past by large wetlands. These wetlands were drained and reduced to canals and regularized watercourses in the last 150 years. In these last remnants of the former wetlands we identified two newt and 18 fish species (five non-natives) in the spring of 2015. Here, fish and newts use the same habitats; no negative relation was registered between their abundance. Fish and newts were present for a long time in this region; they survived together, and they are not excluding each other even under anthropogenic pressure. Fish are linked to small watercourses, which were mostly modified by humans in the past. Both newts and fish are affected by the proximity of the agricultural areas to the water, which negatively influences species richness. The intensive agriculture, its expansion to the water edge, and the massive use of pesticides threaten the survival of both groups. They managed to resist the desiccation of the wetlands, surviving tens of years in these small aquatic habitats, but they are unlikely to come through this last anthropogenic assault.

Keywords: coexistence, small aquatic habitats, agriculture, endemic species, relict species.

Rezumat. Tritonii și peștii din rămășițele vechilor mlaștini din nord-vestul României în fața aceluiași inamic. Interacțiunea dintre pești și amfibieni este în detrimentul amfibienilor. Ambele grupe sunt prezente în nord-estul Câmpiei Panonice, care a fost acoperit în trecut cu mlaștini întinse. Aceste zone umede au fost drenate și reduse la canale și cursuri de apă regularizate în ultimii 150 de ani. În aceste ultime rămășițe ale fostelor zone umede am identificat două specii de tritoni și 18 specii de pești (cinci non-native) în primăvara anului 2015. Peștii și tritonii utilizează același habitat; nu au fost înregistrate corelații negative între abundențele lor. Peștii și tritonii sunt prezenți de mult timp în regiune; au supraviețuit împreună și nu se exclud, nici chiar sub presiune antropică. Peștii sunt legați de ape curgătoare mici, care au fost modificate de om în trecut. Atât tritonii cât și peștii sunt afectați de proximitatea terenurilor agricole față de apă, care influențează negativ bogăția de specii. Agricultura intensă, extinsă până la marginea apei și utilizarea masivă a pesticidelor periclitează supraviețuirea ambelor grupe. Ele au rezistat la desecarea zonelor umede, supraviețuind zeci de ani în habitate acvatice mici, dar este improbabil să treacă acest ultim atac antropic.

Cuvinte cheie: coexistență, habitate acvatice mici, agricultură, specii endemice, specii relicte.

INTRODUCTION

Fish are considered one of the many dangers for amphibians (e.g. HECNAR & M'CLOSKEY, 1997; SMITH et al., 1999; RESHETNIKOV, 2003; DAVIDSON & KNAPP, 2007; MANENTI & PENNATI, 2016; CABRERA-GUZMÁN et al., 2017; MIRÓ et al., 2018). Only few amphibians, like *Bufo bufo* (Linnaeus, 1758), are not negatively affected by fish (e.g. RESHETNIKOV, 2003; MANENTI & PENNATI, 2016). The negative impact is not caused only by predators (e.g. HECNAR & M'CLOSKEY, 1997; HARTEL et al., 2007) or introduced species (e.g. RESHETNIKOV, 2003; DENOËL & LEHMANN, 2006; CABRERA-GUZMÁN et al., 2017; MIRÓ et al., 2018), but also by the non-predator, small sized fish (LEU et al., 2009). Cases are known when fish removal has contributed to an increase in amphibian populations (e.g. ARONSSON & STENSON, 1995; KNAPP et al., 2007; MORI et al., 2017). Many of the non-native fish species present in Europe (e.g. COPP et al., 2005) are a threat for amphibians (e.g. RESHETNIKOV, 2003; CABRERA-GUZMÁN et al., 2017). Invasive fish are spreading through the natural hydrographic network (e.g. COPP et al., 2005; RESHETNIKOV, 2013). They are also advantaged by the modifications and creation of artificial canals, which connect different catchment basins (e.g. ELGIN et al., 2014).

The north-eastern Pannonian Plain from north-western Romania used to be covered by large swamps and wetlands (e.g. POP, 1960; UJVÁRI, 1972; ANDÓ, 1997; ARDELEAN & KARÁCSONYI, 2002). These areas with a rich biodiversity have been desiccated for the last 150 years (e.g. POP, 1960; UJVÁRI, 1972; ANDÓ, 1997; ARDELEAN & KARÁCSONYI, 2002). The wetlands were replaced by agricultural fields crossed by canals which link the natural watercourses (e.g. UJVÁRI, 1972; FAZEKAS, 2008). Regions of high biodiversity can still be found, like remnants of the old swamps which shelter the ancient native fauna with relict and mountain species in the plain (e.g. COVACIU-MARCOV et al., 2009; FERENŢI et al., 2012). Fish and newts were frequently observed together in these habitat fragments (TELCEAN et al., 2014; COVACIU-MARCOV – personal data). Also, in the western Pannonian Plain, near Vienna, fish and amphibians coexist in structured habitats, with numerous macrophytes (SPOLWIND & PINTAR, 1997).

Previous studies regarding the impact of fish on amphibians were performed in large artificial habitats, like ponds, in human modified regions (e.g. HECNAR & M'CLOSKEY, 1997; JOLY et al., 2001; HARTEL et al., 2007), or in laboratory (e.g. WINANDY & DENOËL, 2015; WINANDY et al., 2015; 2017). In contrast, the large wetlands from the Pannonian Plain have existed for a long time (e.g. POP, 1960; UJVÁRI, 1972; ARDELEAN & KARÁCSONYI, 2002), sheltering both fish and newts. Thus, we were wondering if the past coexistence of amphibians and fish in the ancient wetlands could balance the relation between the two groups; can fish and amphibians exist in the same habitats without excluding each other? To verify this, we have investigated the remnants of north-western Romanian wetlands (artificial canals and modified streams), at the same time, in the same place, and with the same method. Although many studies regarding the impact of fish on amphibians did not directly quantify fish, using information from other sources instead (e.g. HECNAR & M'CLOSKEY, 1997; HARTEL et al., 2007; MANENTI & PENNATI, 2016), the habitats' small dimensions permitted the investigation of both groups in the same time, same place and with the same method. The study had the following objectives: **1**. to list the fish and amphibian species from the remnants of the regions wetlands, **2**. to analyse the co-occurrence of fish and amphibians, **3**. to establish the relation of both groups to water parameters, their habitats and surroundings characteristics, **4**. to emphasize the current status based on the presence of conservatively important or invasive species.

MATERIAL AND METHODS

The studied region is situated in north-western Romania (Fig. 1), near the border with Hungary, in the Romanian Western Plain (MÂNDRUŢ, 2006). It is part of the Tisa River drainage area, and is crossed by the Barcău, Ier and Crasna Rivers (UJVÁRI, 1972). In the past these rivers' floodplains formed large wetlands with a remarkable biodiversity. These were almost completely dried out starting more than 150 years ago (see in: POP, 1960; UJVÁRI, 1972; ANDÓ, 1997; ARDELEAN & KARÁCSONYI, 2002). Presently, the region is completely modified, watercourses were rectified and dammed. In addition to this, numerous drainage canals were created, which desiccated the old wetlands and connected different river systems (e.g. UJVÁRI, 1972; ARDELEAN & KARÁCSONYI, 2002). Even the small watercourses were regularized, some turning into small ponds. The region's altitude is approximately 150 m; presently it is inhabited and used almost exclusively for agriculture.

In March and at the beginning of April 2015 we performed five days of field study, one per week. We investigated 63 small-sized aquatic habitats, 54 of which were sampled (the rest were ephemeral spring habitats without aquatic fauna). We avoided the main watercourses, choosing only artificial canals or small streams which had been modified in the past. From the 54 sampled habitats, 31 were artificial canals, and 23 were small, initially natural, streams with a slow flow. Generally, the habitats were approximately 1 m wide, but many times they were narrower. We rarely encountered wider habitats, up to 2 meters. They usually had a depth of only some tens of cm, surpassing 1 meter in the deeper sectors. Because they were stagnant or slow flowing plain waters, all of them had a very dense aquatic vegetation (reed, rush, aquatic cormophytes, algae, etc). Generally, the water surface was largely covered by vegetation, with only small sectors without vegetation.

Amphibians and fish were captured with two nets, operated by the same persons. The nets, also utilized in other studies (e.g. TELCEAN et al., 2014; SAS-KOVÁCS et al., 2015), have two-meters-long metallic handles equipped with a metallic circle of 50 cm diameter, and covered with 1 mm mesh net. Each habitat was investigated for 20-30 minutes. The captured animals were identified in situ. All individuals from native species were immediately released back in their habitats. Data on the surrounding terrestrial habitats and water parameters were also registered. We investigated two habitat types: streams and canals. Because all habitats have abundant aquatic vegetation, we did not take it into account, but we noted the presence or absence of trees or shrubs on the banks (usually willows, rarely pseudo-indigo bush, or others). Twenty-five habitats had trees or shrubs on the banks. We also noted the appearance of the surrounding habitats (arable land, pasture, meadow, wet area) and the distance to the arable land (more or fewer than 10 meters between the arable land and the water; sometimes the arable land even reaching the water edge). In 30 cases the arable land was at more than 10 meters distance from the water, and in 24 habitats it was closer than 10 meters. Because the water speed was too slow, it was not considered a parameter. We have analysed several other water parameters, like redox potential, dissolved oxygen, pH value, conductivity, dissolved solids and salinity, turbidity, cyanobacteria, and the total algae content with a portable HANNA HI 98291-02 multimeter.

The data were analysed both globally and separately by amphibians and fish. For amphibians we only considered newts, which remained in the water for the duration of the entire study. Anurans were not included because some species have a short aquatic period, and because of the variation in their hibernation period – not all species were active for the entire duration of the study (FUHN, 1960). Moreover, compared with anurans, newts are much more affected by fish (LANDI et al., 2014). First, we calculated the frequency of occurrence and the percentage abundance for each species and group, considering the habitat type near water, the presence/absence of trees near water, and the distance from the agricultural fields. Based on scientific literature, fish were classified according to their distribution range into native largely distributed/endemic/non-native, and by their feeding type into predators/non-predators (e.g. BĂNĂRESCU, 1964; KOTTELAT & FREYHOF, 2007). Diversity was calculated using the Shannon-Wiever index, and similarity using the Jaccard index. The significance of the differences between streams and canals, considering the distance from the agricultural field, etc., were calculated by the Mann-Whitney index. The correlation between newts and fish abundance and abiotic parameters were calculated using the bivariate linear regression. We used correspondence analysis for estimating the relation between aquatic vertebrates and different abiotic parameters. The statistics were realized with Past 3 software (HAMMER et al., 2001).

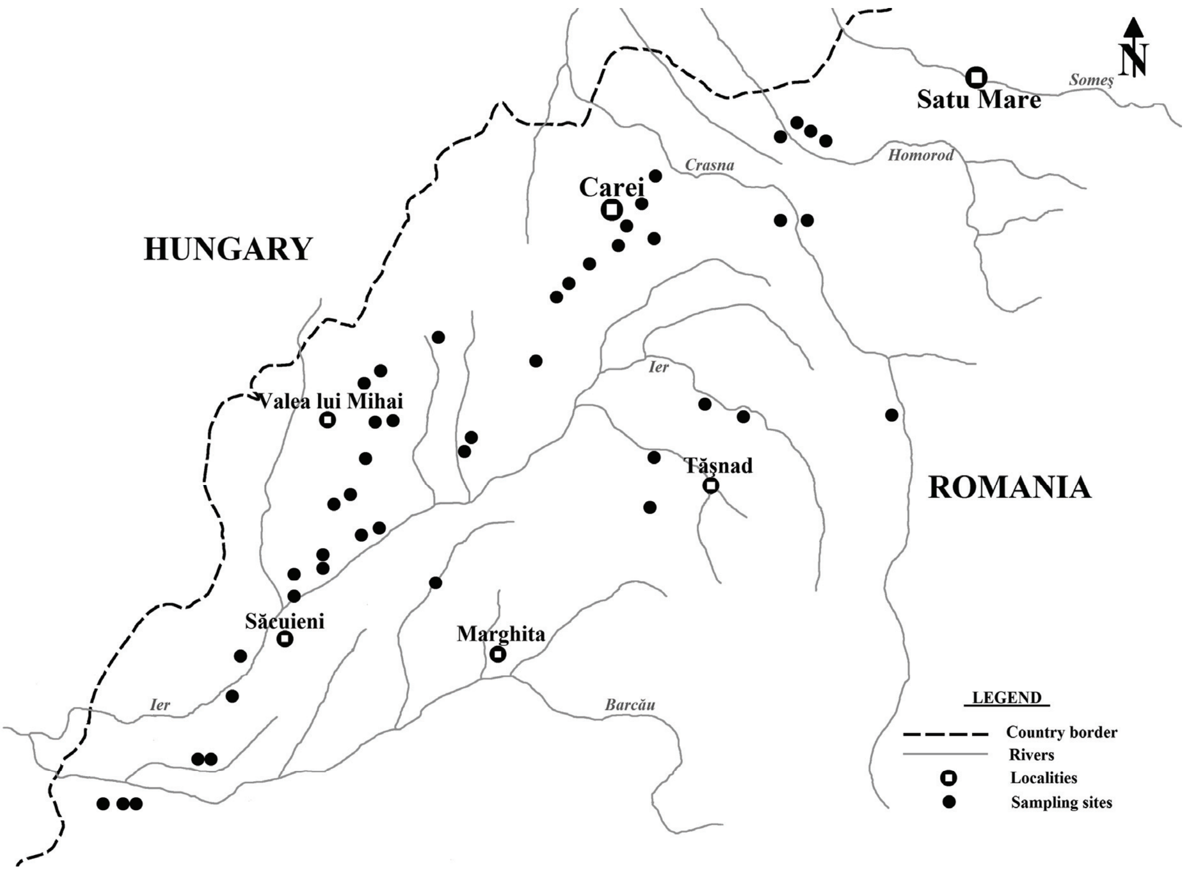

Figure 1. Sampling points in north-western Romania

RESULTS

No fish or newts were identified in 9 of the 54 studied habitats. In 21 of the habitats we found both groups. In 9 habitats we found only newts, and in 15 only fish. We found 109 individuals from two newt species: *Lissotriton vulgaris* (Linnaeus, 1758) and *Triturus dobrogicus* (Kiritzescu, 1903). In 9 of the 30 habitats with newts we found both species. In 7 habitats *T. dobrogicus* was the only newt species present and in 14 habitats *L. vulgaris*. We captured 728 individuals belonging to 18 fish species (*Umbra krameria* Walbaum, 1792; *Esox lucius* Linnaeus, 1758; *Pseudorasbora parva* Temminck & Schlegels, 1846; *Rutilus rutilus* (Linnaeus, 1758); *Scardinius eritrophthalmus* (Linnaeus, 1758); *Carassius carassius* (Linnaeus, 1758); *Carassius gibelio* (Bloch, 1782); *Rhodeus amarus* (Bloch, 1782); *Alburnus alburnus* (Linnaeus, 1758); *Ballerus sapa* (Pallas, 1814); *Gobio carpathicus* (Linnaeus, 1758); *Leucaspius delineates* Heckel, 1843; *Misgurnus fossilis* (Linnaeus, 1758); *Cobitis elongatoides* Băcescu & Maier 1969; *Perca fluviatilis* (Linnaeus, 1758); *Lepomis gibbosus* (Linnaeus, 1758); *Ameiurus melas* Rafinesque, 1820; *Proterorhinus semilunaris* (Heckel, 1837)). Fish and newt species distribution is presented in Table 1. The species diversity/habitat varied between H=1.81 and H=0. The total diversity of the fish community was H=2.80, but the total diversity index of both fish and newts had a value of H=3.04. The most frequent fish was *C. elongatoides*, followed by *M. fossilis, R. sericeus* and *P. parva* (Table 1). The highest percentage abundance was registered by *R. amarus, C. elongatoides* and *P. parva* (Table 1).

U. krameri populated only aquatic habitats which neighboured swamps. Significant differences were found between assemblages from habitats surrounded by grasslands and agricultural areas (p=0.02). Habitats with or without trees on the banks had no significantly different assemblages (p=0.775). The differences between the communities from streams and canals were significant (p=0.022). Some species were present only in streams (*U. krameri*, *P. fluviatilis*, *S. eritrophthalmus*, etc.). The number of *L. vulgaris* individuals was higher in canals than in streams, but the distribution was almost equal for *T. dobrogicus*. We only found 9 fish species in canals. The difference between assemblages by the habitats' distance from the agricultural fields was significant (p=0.0005). In habitats close to agricultural areas only eight fish species (51 individuals) were present. In habitats situated at more than 10 meters from the agricultural areas 17 species were present. Newts populated both habitat types, but their number was higher in those located at a distance from the agricultural fields. *R. sericeus, C. elongatoides, P. parva* and *R. rutilus* were mostly linked to habitats situated at a distance from agricultural areas. Endemic species are linked to streams situated more than 10 m from agricultural areas, surrounded with trees and swamps (Fig. 2).

Table 1. Fish and newt species distribution in the studied localities, frequency of occurrence (f%) and percentage abundance (P%) (Td - *T. dobrogicus*, Lv - *L. vulgaris*, Pf - *P. fluviatilis*, Lg - *L. gibbosus*, Pp - *P. parva*, Cg - *C. gibelio*, Cc - *C. carassius*, Ce - *C. elongatoides*, Se - *S. eritrophthalmus*, Mf - *M. fossilis*, Ra - *R. amarus*, Uk - *U. krameri*, Rr - *R. rutilus*, Ps - *P. semilunaris*, Bs - *B. sapa*, Aa - *A. alburnus*, Am - *A. melas*, El - *E. lucius*, Ld - *L. delineatus*, Gg - *G. carpathicus*).

Locality	**Td**	**Lv**	**Pf**	**Lg**	**Pp**	**Cg**	**Cc**	**Ce**	**Se**	**Mf**	**Ra**	**Uk**	**Rr**	**Ps**	**Bs**	**Aa**	**Am**	**El**	**Ld**	**Gc**
Andrid	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vezendiu 2	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Vezendiu 1	-	-	-	-	-	-	-	x	-	x	-	-	-	-	-	-	-	-	-	-
Tiream/Vezendiu	-	x	-	-	-	-	-	x	-	x	x	-	-	-	-	-	-	-	x	-
Tiream	x	x	-	-	-	-	-	x	-	x	-	-	-	-	-	-	-	-	-	-
Carei	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Piscolt	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sacuieni 2	-	-	-	-	-	x	-	x	-	x	-	-	-	-	-	-	-	-	-	-
Sacuieni 1	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	-	-	-	-
Diosig	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
Parhida	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Niuved 2	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Niuved 1	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriu Sancrai	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Giungi	-	-	-	-	-	-	-	x	-	x	x	-	-	-	-	-	-	-	-	-
Ghilvaci/Terebesti	x	-	-	x	x	-	x	x	-	-	x	-	x	-	-	-	x	x	-	-
Moftin	-	x	-	-	x	x	-	x	-	-	x	-	x	-	-	-	-	-	-	-
Doba	-	x	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Doba/Boghis	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
Boghis	-	x	-	x	-	-	x	x	-	-	x	-	-	-	-	-	-	-	-	-
Dacia	x	x	-	-	-	x	-	x	-	x	-	-	-	-	-	-	x	-	-	-
Carei 2	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carei 1	-	-	-	x	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Salacea/Otomani	-	-	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	-	x
Chereusa	-	x	x	-	-	x	-	x	-	x	-	-	-	-	-	-	-	-	-	-
Santau	-	x	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Ghilesti	x	x	-	-	x	x	-	-	-	x	x	-	-	-	-	-	-	-	-	-
Cauas/Hotoan	-	x	-	-	x	-	-	x	-	-	x	-	x	-	x	x	-	-	-	-
Ghenci/Carei	x	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Galospetreu/Vasad	-	-	-	-	-	-	-	x	-	x	x	-	-	x	-	-	-	-	-	-
Tarcea 2	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tarcea 1	-	x	x	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buduslau	x	x	x	x	x	-	-	x	-	-	x	-	x	-	-	-	-	-	-	-
Irina	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Andrid	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-
Curtuiuseni/Piscolt	x	-	-	-	-	-	-	x	-	x	-	x	x	-	-	-	-	-	-	-
Vasad 2	x	x	-	-	-	-	-	x	-	x	-	x	-	-	-	-	-	-	-	-
Vasad 1	-	-	-	-	-	x	-	x	-	-	x	-	-	-	-	-	-	-	-	-
Cherechiu 2	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cherechiu 1	x	x	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Otomani	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Ciocaia	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaida 2	x	-	-	-	-	-	-	x	x	-	-	-	-	-	-	-	-	-	-	-
Vaida 1	x	-	-	-	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
f%	29.60	42.60	5.56	7.41	22.20	13.00	7.41	38.90	1.85	33.30	22.20	5.56	9.26	1.85	1.85	1.85	3.70	1.85	1.85	3.70
P%	40.40	59.60	0.55	2.06	15.50	1.79	3.71	27.20	0.14	4.81	31.60	0.82	5.08	0.41	0.14	0.96	0.27	0.14	1.65	3.16

T. dobrogicus presents a weak positive and not significant relation with *L. vulgaris* (r=+0.232, p=0.090), but it has no relationship with any fish species (r between -0.031 and +0.153, p between 0.264 and 0.965). *T. dobrogicus* presents significant (p<0.05) correlations with the pH (r=+0.400), salinity (r=+0.309) and cyanobacteria (r=+0.563). *L. vulgaris* presents positive correlation with *C. elongatoides* (r=+0.358, p=0.007), *R. sericeus* (r=0.302, p=0.026), *R. rutilus* (r=+0.286, p=0.036) and with the number of fish individuals (r=+0.289, p=0.033). Neither *L. vulgaris* is negatively correlated with any fish species (r between -0.029 and +0.160). This species is correlated positively with the water pH (r=+0.350, p=0.009) and negatively with the water's redox potential (r=-0.367, p=0.006).

Most fish species do not present any relation with the water characteristics. *P. parva* is positively influenced by the dissolved oxygen of the water (r=+0.302, p=0.0026) and by the trees near water (r=+0.272, p=0.046). *M. fossilis* is positively influenced by the distance between the aquatic habitat and the agricultural field (r=+0.338, p=0.012). The habitat's distance from the agricultural field negatively influences the water conductivity (r=-0.305, p=0.024). Conductivity (r=-0.329, p=0.015) and dissolved solid particles (r=-0.297, p=0.028) negatively influence species diversity. The number of species is negatively influenced by water conductivity (r=-0.403, p=0.002) and dissolved solid particles (r=-0.371, p=0.05) and positively influenced by water resistivity (r=+0.373, p=0.005). The number of individuals did not show any relation with water parameters. The similarity (Jaccard index) between the species composition of canals and streams was J=0.50. The highest similarity was observed between the communities from waters surrounded by pastures or agricultural areas (J=0.53), and the lowest between wetlands surrounded by agricultural areas and grasslands (J=0.33). Between habitats with or without trees on the banks the similarity of the communities was J=0.55, but it was J=0.38 between habitats situated at less or more than 10 m from the agricultural fields.

DISCUSSION

In the small aquatic habitats from north-western Romania, newts and fish do not seem to exclude each other, even if there is evidence of the negative effect of fish on amphibians (e.g. HECNAR & M'CLOSKEY, 1997; SMITH et al., 1999; RESHETNIKOV, 2003; MANENTI & PENNATI, 2016; WINANDY et al., 2017; MIRÓ et al., 2018). Fish and newts coexisted without any negative correlation in almost half of the investigated waters. Although predator fish generally negatively affect amphibians (e.g. HECNAR & M'CLOSKEY, 1997; POREJ & HETHERINGTON, 2005; HARTEL et al., 2007), such effects were observed even in non-predator fish (e.g. LEU et al., 2009; WINANDY et al., 2017). The presence of fish modified the newt feeding behaviour (WINANDY & DENOËL, 2015), cancelling or reducing their reproductive success (WINANDY et al., 2015). It is unlikely that in the small-sized studied habitats, the breeding newts do not come into contact with fish, because we many times captured both in the same net. Newts and fish are in contact in the common habitats, and it seems that, since newts continue to exist, they can reproduce. This can be a consequence of the rich aquatic vegetation, which advantages amphibians in habitats with fish (e.g. SPOLWIND & PINTAR, 1997; JOLY et al., 2001; HARTEL et al., 2007; LANDI et al., 2014). Some fish (*U. krameri*, *M. fossilis*, *P. parva*) also prefer waters with vegetation (BĂNĂRESCU, 1964; BĂNĂRESCU et al., 1995; MEYER & HINRICHS, 2000; KOTTELAT & FREYHOF, 2007). Amphibians and fish were also recorded together in natural habitats from the western Pannonian Plain (SPOLWIND & PINTAR, 1997). *T. dobrogicus* and *U. krameri* survived in the glacial periods in some areas from the Pannonian Basin (VÖRÖS et al., 2016; MARIĆ et al., 2017), and their habitats share the same characteristics (BĂNĂRESCU, 1964; COGĂLNICEANU et al., 2000). These two species were registered in the same habitat in other cases (COVACIU-MARCOV et al., 2018). Thus, they were in contact for a long time, achieving strategies that insured their coexistence. Probably, before the drainage of the wetlands, fish and newts could use different habitats, but the drainage pushed them together. Nevertheless, because the drainage had started more than 150 years ago (e.g. UJVÁRI, 1972) and newts are still here, the region's native fish do not eliminate newts from the common habitats.

Many previous studies were made in ponds, usually artificial (e.g. HECNAR & M'CLOSKEY, 1997; SMITH et al., 1999; JOLY et al., 2001; HARTEL et al., 2007; CABRERA-GUZMÁN et al., 2017), where even native fish were introduced. Unlike these, we studied the remnants of old and large wetlands. In the first case the newts and fish have met recently in a new habitat, but in our case, they had been sharing for a long time a territory that was recently reduced. Large sized fishponds differ from the small linear habitats invaded by vegetation. Also, unlike other studies where the data on fish were recorded visually or from fishermen or angler associations (e.g. HECNAR & M'CLOSKEY, 1997; HARTEL et al., 2007; MANENTI & PENNATI, 2016), we captured the fish and newts in the same habitat, at the same time, and with the same method.

The native vertebrate fauna from small waters, remnants of the ancient wetlands in north-western Romania, had coexisted a long time without excluding each other. Today they continue to coexist in the last remains of habitats in a "sea" of arable land. Both fish and newts face similar dangers unrelated to each other. The difference between the assemblages from habitats situated closer or further than 10 m from arable land was significant. The main danger for these survivors of a lost world is the fact that the arable lands, intensively exploited, are coming closer and closer to their aquatic prison. The influence of the uncultivated strip width near the aquatic habitats upon newts' abundance is known (JOLY et al., 2001). The absence of fish and newts from some habitats can be explained by the pesticides used for agriculture, as previously indicated (TELCEAN et al., 2014). The increased water conductivity because of the agricultural fields seems to support this, amphibians preferring waters with lower conductivity (e.g. VOJAR et al., 2016). The closer the agricultural areas are to the water, the easier it is for substances to get into the water modifying its conductivity and negatively influencing the species diversity. Seven of the nine habitats without fish or newts were linked with agricultural fields. There are cases of pesticides considered to be more dangerous for amphibians than introduced fish (DAVIDSON & KNAPP, 2007). Moreover, the vicinity of arable land reduces the available terrestrial habitats, which are very important for newts (e.g. MARNELL, 1998; MÜLLNER, 2001; JOLY et al., 2001; DENOËL & LEHMANN, 2006; GUSTAFSON et al., 2011).

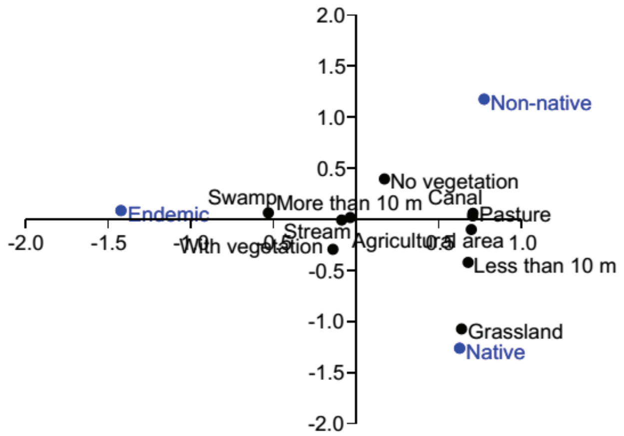

Figure 2. Correspondence analysis between the fish categories (endemic/native/non-native) and habitat type (canal/stream), vegetation (absence/presence) on the banks, the surrounding habitat types (swamp/agricultural area/pasture/grassland) and the distance of agricultural fields from the water (more than 10 m/less than 10 m).

Lissotriton vulgaris and *T. dobrogicus* are the only newt species present in the region (e.g. COGĂLNICEANU et al., 2013). The ratios among them were also expected, *L. vulgaris* being usually more numerous than the crested newts (e.g. MÜLLNER, 2001; CICORT-LUCACIU et al., 2011; BOGDAN et al., 2012; DENOËL et al., 2013). The fish species were also mentioned in the region (e.g. WILHELM et al., 2001-2002; 2004; TELCEAN et al., 2002; 2014; TELCEAN & CUPŞA, 2009). Their number is lower than in the region's main rivers (e.g. TELCEAN et al., 2002; TELCEAN & CUPŞA, 2009; GYÖRE et al., 2013), but higher than in small rivers (e.g. WILHELM et al., 2004; JUHÁSZ, 2011; TELCEAN et al., 2014; WILHELM & ARDELEAN, 2015). They met our expectations ecologically, zoogeographically, and as working method. Nevertheless, we found unexpected fish, like *B. sapa*, which is a species characteristic to slow flowing large watercourses (BĂNĂRESCU, 1964). Even if five of the 18 fish species are non-native, the natives prevail, the region's sensitive native fauna (newts, *U. krameri*) is still surviving. *U. krameri* is more exposed than newts. It was found in only three habitats. Unlike newts, *U. krameri* was not identified together with non-native fish. It is the rarest fish in the area, because of its preference for the natural waters, surrounded by natural humid areas, situated at some distance from the agricultural areas. Another species related to streams with specific bank aspect is *R. amarus*. It was not identified in artificial canals probably because of the absence of the shells it needs (BĂNĂRESCU, 1964), but numerous individuals are present in streams. The importance of areas with woody vegetation on the banks was previously mentioned (e.g. DALE JONES III et al., 1999; SULLIVAN et al., 2004; TEIXEIRA-DE MELLO et al., 2016). Also, in our case, the native species prefer habitats surrounded by trees. The region's aquatic vertebrate fauna could survive if there is some distance between the habitats and agricultural terrains.

We found rich fish and newt assemblages in the same small, slow-flowing habitats, with rich aquatic vegetation. They are extremely vulnerable because of the intense agriculture developing in place of a former wet area. These wet areas represent only a tiny component of the region's present landscape. The chemisation of agriculture and the further reduction of the humid zones near waters will eliminate these last remnants of the ancient fauna. The only solution, we believe, is to keep at least the present statute of the waters which still have something to conserve. Although there are protected areas in the region, the economic pressure is extremely high. The world, of which last image we just emphasized, will be, in this manner, probably eradicated in short time.

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