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POND PREFERENCE BY AMPHIBIANS (AMPHIBIA) ON THE KARST PLATEAU AND IN SLOVENIAN ISTRIA

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ABSTRACT

Some habitat determinants and related presence of amphibians in 7 karst ponds in Slovenian Istria and 10 ponds on the Karst Plateau were surveyed from March to August 1999. The presence of different species of amphibians was established by sampling according to standard methods for amphibians. 9 amphibian species were recorded in the surveyed ponds. A canonical correspondence analysis was carried out to determine amphibian habitat preference. 6 species and 14 habitat determinants were included in the analysis. The type of terrestrial habitat near the ponds and the vegetational cover of the water surface in July seemed to be the most important habitat determinants. The presence of fish in ponds was important, too. The European Tree Frog and the Edible Frog turned out to be the most selective species in terms of habitat preference.

Key words: amphibians, Amphibia, karst pond, habitat determinants, canonical correspondence analysis

SCELTA DELLO STAGNO NEGLI ANFIBI (AMPHIBIA) DEL CARSO E DELLA COSTA SLOVENA

SINTESI

Da marzo ad agosto del 1999, l'autrice ha raccolto dati inerenti la presenza di anfibi nonché i valori di determinati fattori ambientali in sette stagni situati sulla costa slovena e dieci stagni carsici. La presenza di diverse specie di anfibi é stata determinata con la metodologia standard per il campionamento di anfibi. Negli stagni ricercati sono state registrate nove specie di anfibi. Per determinare le preferenze di habitat degli anfibi é stata usata l'Analisi Canonica delle Corrispondenze. Nell'analisi sono state incluse sei specie e quattordici fattori ambientali. Le caratteristiche ambientali più importanti sono risultate il tipo di habitat terrestre in prossimità degli stagni e la copertura vegetale sulla superficie dell'acqua in luglio. Molto importante é risultata anche la presenza di pesci negli stagni. Nella scelta dello stagno le più selettive si sono dimostrate la raganella (Hyla arborea) *e le specie appartenenti al gruppo delle rane verdi.*

Parole chiave: anfibi, Amphibia, stagno carsico, fattori ambientali, Analisi Canonica delle Corrispondenze

INTRODUCTION

Artificial water bodies, called karst ponds, were built in the past in Slovenian Istria and on the Karst Plateau to retain rainwater. They were used as water supply for the cattle, for watering and washing and sometimes even for obtaining the ice (Dolce *et al.*, 1991; Lešnik *et al.*, 2000). Today the fast natural succession of overgrowing and drying out of the ponds is accelerated by human destructive activity (Alberti, 1985). Various authors (Polli & Alberti, 1969; Alberti, 1985; Dolce *et al.*, 1991; Grošelj, 1993; Kalc, 1993; Vardjan, 1994; Bressi & Stoch, 1999; Poboljšaj & Kotarac, 1999; Lešnik *et al.*, 2000) have written a number of articles about the significance of karst ponds today and in the past, as well as about the problem of their gradual disappearance.

In the environments where water bodies are scarce or even nonexistent, karst ponds are important habitats for aquatic plants and animals. One of the most endangered (Vidic, 1992; Gregori, 1996) animal groups that share this aquatic habitat are the amphibians. A lot of biotic and abiotic factors influence the amphibian choice of karst ponds as breeding sites and summer habitats. Several authors (Beebee, 1985; Pavignano, 1988; Pavignano *et al.*, 1990; Ildos & Ancona, 1994) studied these factors, attempting to establish how they affect habitat preference. Beside basic requirements as the living space, water quality, food availability and protection from predators, some other more specific conditions are needed for the existence of amphibian species (Oldham & Swan, 1997).

Factors that determine the suitability of a certain water habitat are complex and diverse (Beebee, 1985; Pavignano *et al.*, 1990). Some of the habitat determinants as the presence of aquatic and marshy vegetation, the type of terrestrial habitat near the pond, the age of the pond and the rate of human impact can considerably affect the success of amphibian breeding (Pavignano *et al.*, 1990).

Even species known as ecological generalists (*e.g.* Edible Frog (*Rana kl. esculenta* Linnaeus, 1758) and Common Toad (*Bufo bufo* Linnaeus, 1758), appear to be selective in terms of breeding site choice (Ildos & Ancona, 1994). Nevertheless, according to some surveys, the Edible Frog and the Common Toad are less demanding in terms of breeding habitat selection in comparison with the Agile Frog (*Rana dalmatina* Bonaparte, 1840), European Tree Frog (*Hyla arborea* Linnaeus, 1758), Smooth Newt (*Triturus vulgaris meridionalis* Boulenger, 1882) and Italian Crested Newt (*T. carnifex* Laurenti, 1768), which have more specific requirements (Pavignano *et al.*, 1990).

Beebee (1985) established the importance of geological structure of the ground and type of terrestrial habitat in the pond surroundings, while the type of vegetation cover and overgrowing of the pond were set out as the most important habitat features by Ildos & Ancona (1994). Chemical and physical characteristics of the water (*e.g.* pH, conductivity) seem not to be as important for amphibians as other environmental characters (Beebee, 1985). Nevertheless, if these characteristics appeared to be important, this was then due to the aquatic vegetation conditions (Ildos & Ancona, 1994).

On the Italian side of the Karst Plateau, ponds are being carefully studied and are subject of a certain degree of protection and/or management (Bressi & Stoch, 1999). In the absence of similar studies in Slovenia, the objective of the present study was to illuminate the importance of these unique water bodies as breeding habitats for the survival of amphibians.

MATERIAL AND METHODS

In the period between March and August 1999, 7 ponds along the Slovenian coast and 10 ponds on the Karst Plateau were surveyed in order to find habitat determinants important for amphibians. The investigated ponds were chosen on the basis of various criteria: vicinity of an urban area, vicinity of other ponds, shape and structure of the ponds (*e.g.* bottom type, depth, bank inclination and presence of rocky walls), quantity of aquatic vegetation and presence of fish. Geographic positions of the investigated ponds as well as of other karst ponds in the surveyed area are shown in Figure 1. The investigated ponds are labelled "I" for Istria, "K" for Karst and numbered. The list of surveyed ponds is shown in Table 1.

Ponds were visited once a week from March 11, in the period of the initiation of spring migrations to breeding sites, to August 18, when most amphibians were already metamorphosed and when many ponds had dried up. Data collected during the fieldwork and used for successive analysis were as follows: pond area (m^2), depth (m) and bottom type, water transparency, presence of fish, minimal and maximal bank inclination (°), extent of aquatic vegetation cover in April and July (%), average distance from ruts, roads and houses (m), percentage of grassland, wood, arable land and urban area in the pond's surrounding (100 m). Most of these parameters are numerical, while water transparency, bottom type and presence of fish are attributive parameters that were evaluated as follows: 1 was used for silt bottom, 2 for mixed silt and rocky bottom, 3 for rocky bottom and 4 for concrete. In case fish were present in the pond, No. 1 was used, while fishless ponds were evaluated with 0. Water transparency was only estimated and Nos. from 1 to 3 were used, 1 indicating water transparency of a few centimetres, 2 medium transparency, and 3 completely transparent water.

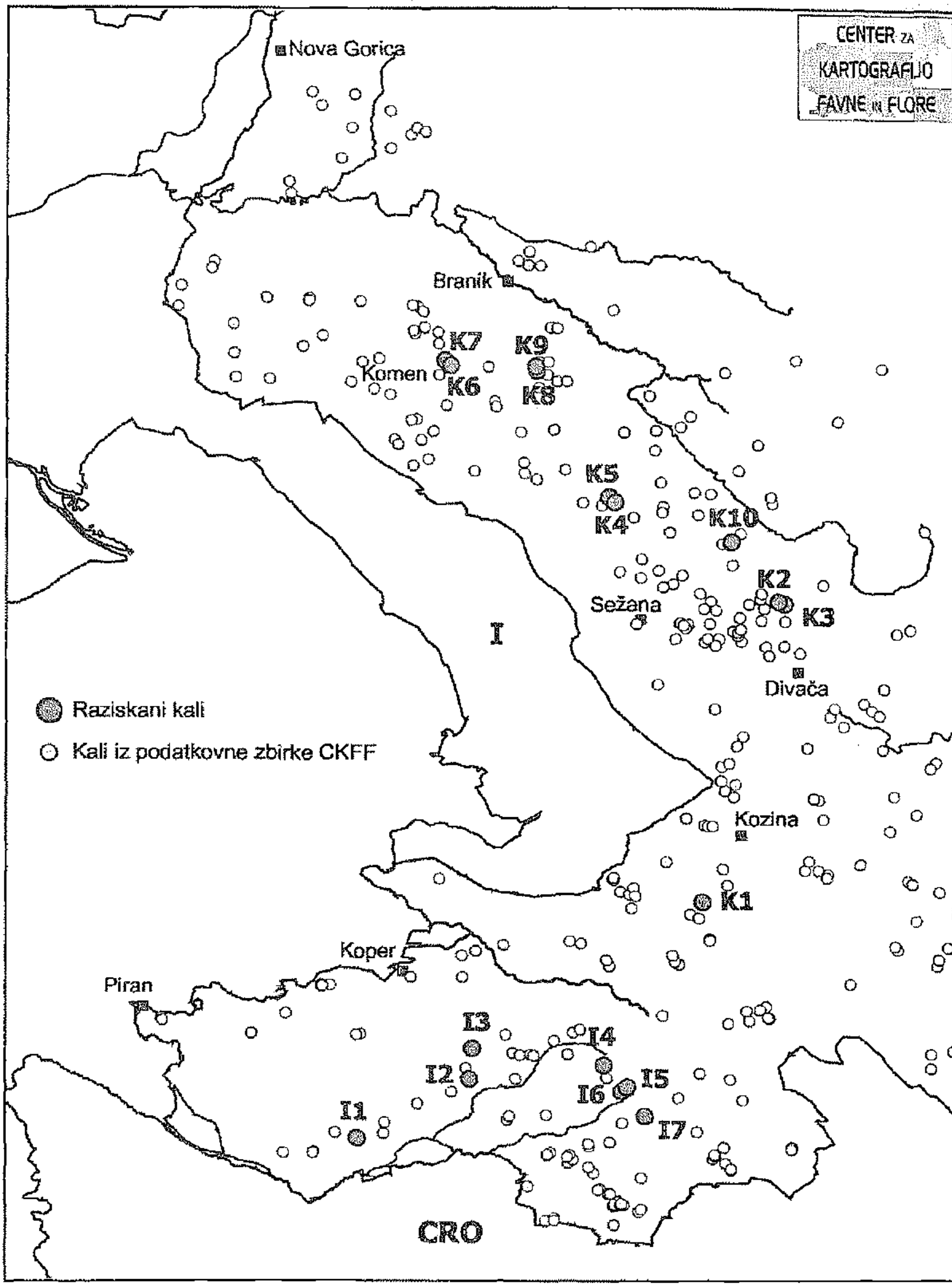

Fig. 1: Map of the surveyed area with presently recorded karst ponds from database by courtesy of the Centre for Cartography of Fauna and Flora (CKFF). The surveyed ponds are indicated with larger circles and numbers.
Sl. 1: Karta območja raziskave z do sedaj evidentiranimi kali iz podatkovne zbirke Centra za kartografijo favne in flore (CKFF). Raziskani kali so označeni z večjimi krogi in številkami.

Tab. 1: List of 17 surveyed ponds in Slovenian Istria and on the Karst Plateau.
Tab. 1: Seznam 17 obravnavanih kalov v Slovenski Istri in na Krasu.

Ponds in Slovenian Istria	
I1	Pond "Pri kalu" near Krkavče
I2	Pond at Rojci
I3	Pond "Pri Lokvi" near Mali Čentur
I4	Pond near Hrib
I5	Big pond near Poletiči
I6	Small pond near Poletiči
I7	Pond at Gračiška Vala

Ponds on the Karst Plateau	
K1	Pond "Na potoku" near Petrinje
K2	Pond "Globočaj" near Brestovica pri Povirju
K3	Pond "Kalužca" near Brestovica pri Povirju
K4	Pond at Tomaj
K5	Pond near Tomaj
K6	Pond at Divči near Komen
K7	Pond in old nursery at Komen
K8	Old pond at Kobjeglava
K9	Renewed pond at Kobjeglava
K10	Pond "Šafarjev kal" at Štorje

Tab. 2: Input data for the canonical correspondence analysis (CCA): presence, estimated abundance and breeding success of amphibian species in ponds in Slovenian Istria and on the Karst Plateau. 0: species not present in pond, 1: presence of some adult individuals or in some cases of other developmental stages, 2: presence of individuals of different developmental stages, mostly of adults and spawn or eggs, 3: presence of a middle number of adults, eggs or spawn and larvae, 4: presence of a high number of adults, eggs or spawn and larvae, 5: presence of a high number of adults, eggs or spawn and larvae and/or confirmed metamorphosis in juveniles.
Tab. 2: Vhodni podatki za kanonično korespondenčno analizo: zastopanost, ocenjena številčnost in uspešnost razmnoževanja vrst dvoživk v kalih v Slovenski Istri in na Krasu. 0: vrsta ni zastopana, 1: zastopanost posameznega odraslega osebka, v nekaterih primerih pa drugega razvojnega stadija, 2: posamezna zastopanost več razvojnih stadijev, največkrat odraslih in mrestov, 3: zastopanost srednjega števila odraslih, mrestov oz. jajc in ličink, 4: zastopanost velikega števila odraslih, mrestov oz. jajc in ličink, 5: zastopanost velikega števila odraslih, mrestov oz. jajc in ličink in/ali potrjena preobrazba v mladostne osebke.

	Triturus carnifex	*T. vulgaris meridionalis*	*Bufo bufo*	*Hyla arborea*	*R. esculenta* complex	*Rana dalmatina*
I1	0	0	1	0	0	0
I2	3	0	0	4	0	2
I3	4	3	0	3	0	0
I4	0	0	0	0	0	0
I5	0	0	5	1	0	5
I6	1	5	0	2	0	1
I7	5	5	0	5	0	5
K1	3	5	3	3	3	5
K2	4	5	2	5	5	5
K3	3	5	0	0	3	5
K4	3	1	5	0	0	5
K5	0	1	2	0	0	3
K6	1	2	5	0	0	5
K7	1	3	5	0	0	5
K8	1	1	4	0	0	1
K9	1	1	3	0	0	1
K10	0	0	4	0	1	2

The presence and abundance of different species of amphibians were established by sampling according to standard methods for amphibians (Heyer *et al.*, 1994): for the sampling of newts and adult frogs we used the "Survey at breeding sites" method, while for the sampling of tadpoles the "Quantitative sampling of amphibian larvae" was applied. We used water net with the straight side of 27 cm.

The amphibian species included in the analysis were those commonly found in ponds: Smooth Newt, Italian Crested Newt, Common Toad, European Tree Frog, Agile Frog and species from the Green Frog group *(Rana* *esculenta* complex). The species were ranked into 6 classes according to the presence, estimated abundance and reproduction success in specific ponds. Occurrence, abundance and breeding success of each analysed species in 17 ponds are shown in Table 2. A canonical correspondence analysis (CCA) (CANOCO 3.12, ter Braak, 1991) was carried out for the 6 amphibian species and 14 habitat determinants mentioned above.

We performed the Monte Carlo permutation test to establish the statistical significance of the effect of each environmental variable. The test was run with 99 permutations.

RESULTS

The canonical correspondence analysis (CCA) was carried out on 6 amphibian species and 14 habitat determinants from 17 ponds. The CCA method elucidates the relationship between biological assemblages of species and their environment and is used mainly in aquatic ecology studies (ter Braak & Verdonschot, 1995). Several of studied ponds characteristics can be seen from ordination diagram (Fig. 2). Ter Braak & Verdonschot (1995) report the interpretation mode of ordination diagram.

The Monte Carlo permutation test showed that the first ordination axis explains the relationship between species and environmental determinants at the 1% significance level with the F value being 2.57, while for all 4 ordination axes significance was on limit at 5% level ($F=2.31$, $p=0.06$, n.s.). However, we can assume that the ordination diagram, which shows only the first two axes, explains the relationship and differences between amphibian species, localities and environmental variables in a satisfactory manner. This assumption is confirmed by the fact that the ordination diagram displays a high percentage of weighted variance in the abundance of species ("inertia"=75%) and a high percentage of variance in the weighted averages and class totals of species with respect to the environmental variables (84%). The first two axes of the ordination diagram display 81.2% of variance of relationship between species and environmental variables (Tab. 3).

Species indicated in the ordination diagram by triangles are arranged according to their abundance and breeding success. Species being closer in the diagram have higher similarity in the distribution than species being more distant from each other. Thus, the Common Toad and the Agile Frog have similar distribution and rate of breeding success in ponds. In this regard, similar distribution can be seen also for the two species of newts as well as for the Italian Crested Newt and the European Tree Frog. The Green Frog group is the most distant from other species in the diagram, as it was found only in 3 ponds. The distance between the Common Toad and the European Tree Frog is also large, reflecting the fact that they occurred in the same pond only in two cases.

Ponds are indicated by circles in the ordination diagram and are arranged according to the values they have in relation to the first two axes. Ponds being closer together are thus more similar in terms of amphibian species composition and their breeding success. Karst ponds (from K4 to K9) turned out to be very similar between each other, while most of the ponds in Slovenian Istria (except I1 and I5) are arranged on the opposite side of the ordination diagram and are not so close together. Pond I4 is missing on the diagram, as none of the amphibian species was present in it.

The relative length of the line representing the determinate environmental variable indicates the importance of this variable. Diagram shows that the most important environmental variables for the distribution of species are those determining the terrestrial habitat in pond vicinity (e.g. average distance from roads and houses, presence of arable land and urban area) as well as the extent of the aquatic vegetation in July. Other important variables are water transparency, presence of fish and maximal bank slope. Variables that according to the line length appear to be less important are the extent of aquatic vegetation in April, minimal bank slope and presence of wood in the pond's immediate surrounding. Some other authors (Beebee, 1985; Pavi-

Tab. 3: Some values displayed by the axes of the ordination diagram. The latter displays only the first two axes.
Tab. 3: Nekatere vrednosti, ki jih izkazujejo osi razvrstitvenega diagrama CCA. Razvrstitveni diagram prikazuje le prvi dve osi.

Axes of ordination diagram	Eigenvalues	Correlation between species occurrence and environmental variables	Cumulative percentage of variance of species data	Cumulative percentage of variance of species-environment relation
1st axis	0.363	0.993	56.2	59.9
2nd axis	0.128	0.998	76.1	81.2
3rd axis	0.054	0.913	84.5	90.1
4th axis	0.040	0.904	90.7	96.8

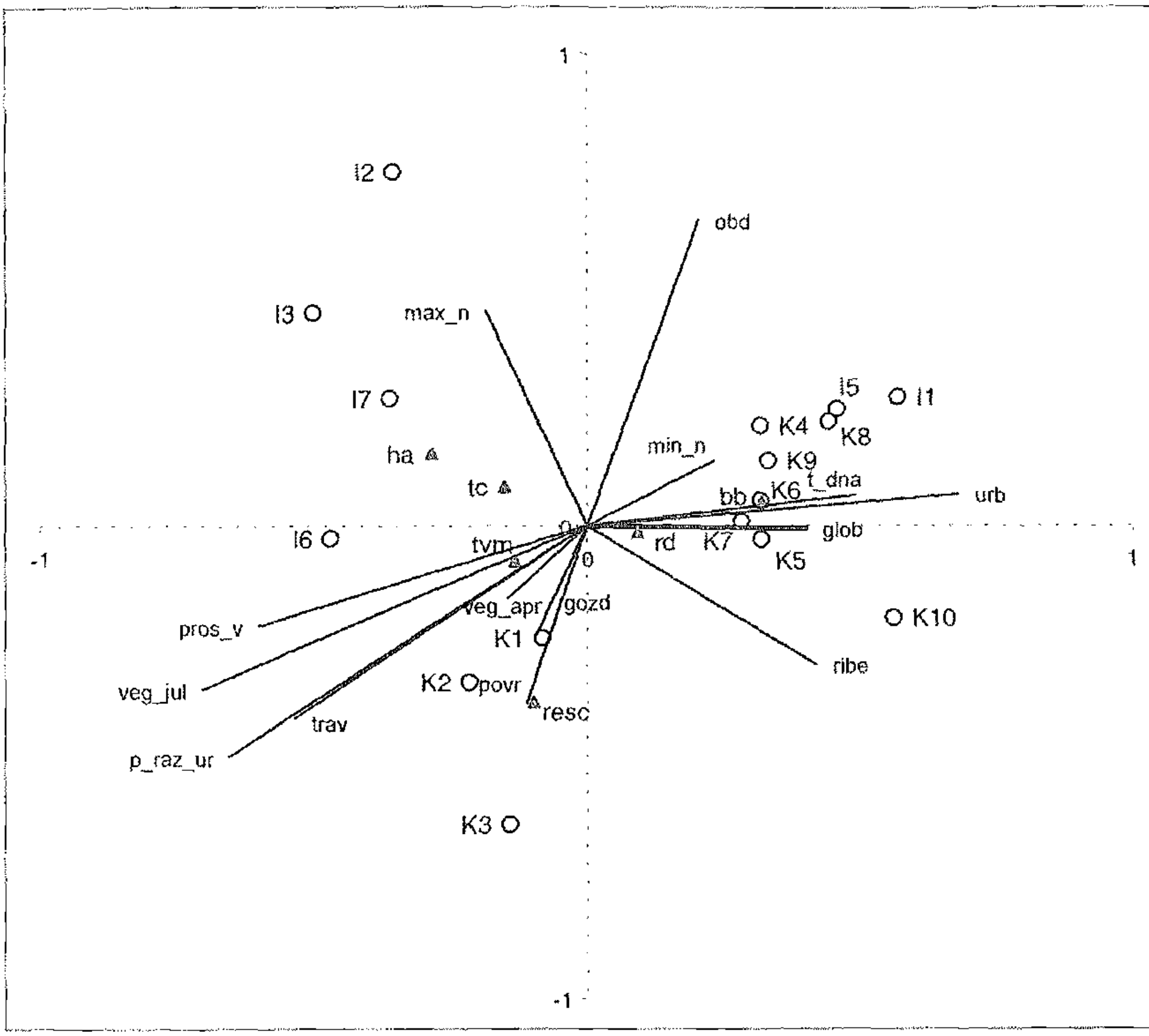

*Fig. 2: Ordination diagram of CCA. The eigenvalue of the first axis is 0.36; eigenvalue of the second axis is 0.13. Diagram shows 75% of weighted variance in the abundance of species ("inertia") and 84% of variance in the weighted averages and class totals of species with respect to the environmental variables. Amphibian species (triangles): Tvm–*Triturus vulgaris meridionalis*, Tc–*T. carnifex*, Bb–*Bufo bufo*, Ha–*Hyla arborea*, Rd–*Rana dalmatina* and Resc–*R. esculenta* complex; ponds (circles and pond number); environmental variables (solid lines): povr–pond surface, glob–water depth, pros_v–water transparency, t_dna–bottom type, ribe–presence of fish, min_n, max_n–minimal and maximal bank slope (respectively), veg_apr, veg_jul-extent of aquatic vegetation in April and July (respectively), p_raz_ur–average distance from ruts, roads and houses, trav, gozd, obd, urb-percentage of grassland, wood, arable land and urban area (respectively) in the ponds' surroundings (100 m).*

*Sl. 2: Razvrstitveni diagram CCA. Lastna vrednost prve osi je 0,36, lastna vrednost druge osi je 0,13. Diagram izkazuje 75% obtežene variance ("inertia") v gostotah vrst in 84% variance v obteženih povprečjih vrst glede na okoljske dejavnike. Vrste dvoživk (trikotniki): Tvm–*Triturus vulgaris meridionalis*, Tc–*T. carnifex*, Bb–*Bufo bufo*, Ha–*Hyla arborea*, Rd–*Rana dalmatina* in Resc–*R. esculenta* complex; kali (krogci in številka kala); okoljski parametri (daljice): povr–površina kala, glob–globina vode, pros_v–prosojnost vode, t_dna–tip dna, ribe–zastopanost rib, min_n, max_n–minimalni in maksimalni naklon brežin, veg_apr, veg_jul- zaraščenost vodne površine v aprilu in juliju, p_raz_ur–povprečna oddaljenost kala od kolovozov, cest in naselij; trav, gozd, obd, urb-odstotek pokritosti neposredne bližine kala (100 m) s travnatimi, gozdnatimi, obdelanimi in urbanimi površinami.*

gnano *et al.*, 1990; Ildos & Ancona, 1994) found the same importance of terrestrial habitat near breeding sites and of the extent of aquatic vegetation for the habitat selection among amphibians. Beside this, Beebee (1985) also reports of the importance of geological structure of the ground, the factor we did not include in the analysis.

The arrangement of environmental lines indicates correlation between environmental variables themselves. Correlation is shown by the projection of the free end of the line on the other variable line. If the projection points in the same direction as the line, the correlation is positive, if it points in the opposite direction, the correlation is negative. The ordination diagram thus shows some logical interdependencies. With growing distance from the urban area, there is more grassland and wood in the ponds' vicinity, and ponds are more overgrown with vegetation. On the other hand, when in the vicinity of the populated area, ponds have more arable land in the immediate surrounding and fish are more common in the pond water. In the urban area, ponds are being cleaned up regularly, thus the water in these ponds tends to be deeper than in other ponds. Water transparency has positive correlation with the spread of vegetation in July. This is expected as the aquatic vegetation depletes nutrients from water, which consequently is clearer. The bottom type and the vicinity of the urban area also show positive correlation. In the evaluation of the bottom type, the score was namely growing from silt to concrete bottom. So, with descending distance from the urban area, more ponds have rocky or even concrete bottom.

The effect of a certain environmental parameter on the occurrence of a species is illustrated by the projection of species point on the environmental line. The farther the projection lies on the line to positive or negative direction, the higher is the positive or the negative correlation between parameters and species. Environmental determinants thus do not have a substantial impact on the species that are scattered around the origin (0.0) of diagram (representing the mean value of the environmental variable). In our case, such species are the Agile Frog, Smooth Newt and Italian Crested Newt. However, all relationships between the species, localities and environmental determinants are not expressed in a proper manner, since the diagram shows only the first two ordination axes.

DISCUSSION

The Smooth Newt and the Italian Crested Newt show low but positive correlation with parameters that indicate ponds outside the populated area. Both newts are therefore often found in ponds surrounded by grassland and woods, which are considerably overgrown in July, and appear to prefer shallow water. Similar preferences are reported by Pavignano *et al.* (1990). Nevertheless, differences between the habitat preferences of the two newt species do exist, as the Italian Crested Newt is known as a more demanding species, and in water bodies it is not as common as the Smooth Newt (Pavignano, 1988). However, we found the two newts generally together in ponds and the same was shown by an investigation in northwestern Italy (Pavignano, 1988).

The Italian Crested Newt's preference for deeper ponds with open water and less aquatic vegetation (Pavignano, 1988; Ildos & Ancona, 1994) can be also seen from the ordination diagram. The ordination diagram shows that the vicinity of populated area has a negative impact on the presence of newts in the ponds, as the highest abundance of adult newts and their larvae was found in the ponds far from villages. Results of other studies (Ildos & Ancona, 1994) indicate, on the other hand, that the Smooth Newt is abundant in water bodies inside urban areas. Both species appear to be sensitive to the presence of fish. Although adult newts were also observed in ponds inhabited by fish, they successfully breed only in fishless ponds. Some other authors (Ildos & Ancona, 1994; Andreone, 1998) report the same. Pond I1, where we did not observe any amphibians in 1999, supported a large population of the Italian Crested Newt (Poboljšaj, 1993) before the introduction of fish. A factor that Ildos & Ancona (1994) also report to have negative impact on the newt habitat choice is steep banks. This is not clearly visible from the present study results, which indicate that both species have positive correlation with maximum bank slope. In the same time it appears that newts prefer ponds with gently sloping banks. This apparent nonsense can be explained with the fact that the same pond often has partly steep and partly gently sloping banks. It is thus more probable that newts prefer gently sloping banks that allow them an easy access to the water.

The European Tree Frog is known as a more selective species in terms of breeding site selection than its sympatric species (Beebee, 1996). Pavignano *et al.* (1990) suggest that the typical European Tree Frog's breeding site is a small pond with rich and heterogeneous vegetation. The ordination diagram shows that it has similar requirements as the two newts. Among all species, the European Tree Frog exhibits the highest negative correlation with the presence of fish in the ponds. As local people reported to us, the European Tree Frog's population had bred in the pond K9 in Kobjeglava every year before the introduction of gold fish. A similar case is known from pond I1 near Krkavče: Poboljšaj (1993) reports about the presence of the European Tree Frog in this pond. Bressi & Stoch (1999) also describe this species as sensitive to fish presence. Among the studied ponds, those surrounded by grassland with well-developed aquatic vegetation were usually preferred by the European Tree Frog. Similar results were obtained during the study by Ildos & Ancona (1994). Surprisingly, the ordination diagram points out that woodland in the pond's vicinity has a negative impact on the presence of the European tree frog. Namely, trees and shrubs are very important terrestrial habitat features for this species, and Stumpel (1999) reports that the European Tree Frog is more sensitive to the suitability of terrestrial habitat, that is to the quality of water body. However, only 100 m zone around the ponds was included in the analysis, while woods and shrub could be present outside this zone but still within reach of the European Tree Frog. It is also possible that on the arid Karst Plateau, the European Tree Frog spends most of the time in the pond's immediate surroundings on aquatic and marsh vegetation and does not migrate to the terrestrial habitat. With regard to the pond area, the ordination diagram displays that the European Tree Frog prefers small ponds with shallow water. This seems to be a common preference of the species since Beebee (1996) and Pavignano *et al.* (1990) obtained the same results.

The present study shows that the species from the Green Frog group are very selective as regards habitat preference. We observed their presence only in 3 Karst ponds. On the other hand, other authors (Pavignano *et al.*, 1990; Ildos & Ancona, 1994) describe Green Frogs as non-selective and very adaptable animals. The only apparent preferences of the Green Frogs are breeding sites with rich aquatic vegetation on geologically older ground (Ildos & Ancona, 1994). The ordination diagram indicates that Green Frogs are the only group of amphibians in this study, which show high positive correlation with water body surface. This probably reflects the fact that Green Frog tadpoles reached metamorphosis only in the pond of Globočaj (K2), which is the largest among all surveyed ponds. The results indicating that Green Frogs select ponds with rich aquatic vegetation and wood in their surroundings resemble those reported by Ildos & Ancona (1994). Beside this, we found positive correlation between Green Frogs' presence and shallow pond water, gently sloping banks and distance from the urban area. Green Frogs exhibit positive correlation with presence of fish as well, showing that fish do not affect their reproduction cycle, as is the case with the newts and the European Tree Frog. Bressi & Stoch (1999) even discovered that in fishponds Green Frogs as well as Common Toads become dominant among amphibians. Nevertheless, it is probable that fish have a negative impact on the development of Green Frog tadpoles. As Green Frog tadpoles could be observed in K1 pond only for a short period of time, it is likely that they ended as fish prey before they reached metamorphosis. A lot of diverse microhabitats with shallow water, where tadpoles can find shelter from predators, allowed Green Frogs' tadpoles to develop and reach metamorphosis in the pond of Globočaj (K2) despite high fish abundance. Ildos & Ancona (1994) even discovered that Green Frogs did not breed at all in water bodies with fish.

The Common Toad is known to be a very adaptable species, too (Giacoma, 1998; Bressi & Stoch, 1999). This has been confirmed by our results as well, for we found this species in a fairly high number of ponds (11). The species was recorded mostly in ponds in or near the urban areas (see the ordination diagram, Fig. 2). The most important breeding habitat feature turned out to be relatively deep water, while the most important terrestrial habitat is arable land. Similar results about the Common Toad's habitat preference are displayed by Beebee (1985), Giacoma (1998) and others. Deep-water bodies are not suitable for snakes and waterfowl that are the main predators of the Common Toad (Ildos & Ancona, 1994). As indicated by the ordination diagram, Common Toad appears to be the only species that showed negative correlation with the extent of aquatic vegetation. However, a detailed examination of the occurrence of Common Toad in ponds revealed that this species bred successfully in ponds with rich vegetation as well as in ponds without it. This again confirms a high adaptability of the Common Toad. Like Green Frogs, Common Toad shows positive correlation with the presence of fish in ponds. Similar results are reported by Beebee (1985). Common Toad tadpoles are thought to be a frequent fish prey only at the very beginning of their development (Giacoma, 1998), while the production of toxins that begins after few weeks make them inedible and therefore not sensitive to fish presence (Beebee, 1986; Giacoma, 1998). Nevertheless, fish probably do affect the development of Common Toad tadpoles as they reached metamorphosis only in two fishponds while in others we did not observe any metamorphosed juveniles. In any case, the ability of the Common Toad to adapt to different environments allows this species to be less sensitive to habitat changes and to disappearing of water bodies in comparison with other amphibian species (Giacoma, 1998).

If we consider the high number of ponds, in which the Agile Frog was present during our survey (14 ponds of 17 examined), this species should be defined as the most adaptable and less selective in terms of habitat preference. Boano (1998), too, describes this frog as one of those adaptable amphibian species, which frequently choose small and often artificial ponds as their breeding sites, as well as ponds that dry out in the summer period. Bressi & Stoch (1999) report that this brown frog species is very common on the Italian side of the Karst Plateau. The central position of the point indicating the Agile Frog on the diagram shows that it has a low correlation with all habitat determinants. It is clear, however, that this frog is more common in ponds with less aquatic vegetation and in those near or in the urban areas. The Agile Frog is relatively insensitive to the presence of fish. In contrast with our expectation, the Agile Frog tadpoles reached metamorphosis in almost all ponds with fish. Such results would be more appropriate for the Common Toad whose tadpoles produce toxins that deter predator fish (Giacoma, 1998). The expected positive correlation with the occurrence of wood in the ponds' surroundings reported by Pavignano *et al.* (1990) was not found in the present study. Despite its adaptability, the Agile Frog is a threatened species in some parts of Europe (Bressi & Stoch, 1999).

Chemical and physical parameters (e.g. oxygen concentration, pH, and water conductivity) were not included in this analysis due to the fieldwork and material restrictions. Other authors (Beebee, 1985; Pavignano *et al.*, 1990) report that these special parameters do not affect the amphibian habitat choice in the extent environmental parameters do. Nevertheless, chemical and physical parameters should be included in the future analysis in order to be able to compare ponds in this regard as well. For a better comparability with results of various other studies, the future research should contain a higher number of water bodies, and terrestrial habitat features from a larger range around ponds should be considered. Moreover, the correlation between the species occurrence and environmental variables should be tested with multivariate discriminant analysis. To test whether both multivariate analyses (CCA and discriminant analysis) are comparable, the two analyses should be carried out with the same data sets.

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IZBIRA KALA PRI DVOŽIVKAH (AMPHIBIA) NA KRASU IN V SLOVENSKI ISTRI

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POVZETEK

V obdobju od marca do avgusta 1999 smo preučevali okoljske dejavnike in z njimi povezano pojavljanje dvoživk v 7 kalih v Slovenski Istri in 10 kalih na Krasu. Kale smo obiskovali enkrat tedensko. Z vzorčenjem po standardnih metodah za dvoživke smo ugotavljali različne vrste dvoživk. Pogoste vrste, ki so se v obravnavanih kalih tudi razmnoževale, so bile: robati pupek (Triturus vulgaris meridionalis), *veliki pupek* (Triturus carnifex), *navadna krastača* (Bufo bufo), *zelena rega* (Hyla arborea), *rosnica* (Rana dalmatina) *in vrste iz skupine zelenih žab* (R. esculenta complex). *Izbiro kala smo analizirali s kanonično korespondenčno analizo. V analizo smo vključili 6 vrst dvoživk in 14 okoljskih dejavnikov. Korelacije med vrstami, okoljskimi dejavniki in kali prikazuje razvrstitveni diagram. Najpomembnejši pri izbiri kala so bili dejavniki, ki opredeljujejo terestrični habitat v okolici kala, ter zaraščenost vodne površine v juliju. Eden izmed pomembnih dejavnikov so bile tudi ribe, ki imajo v kalih izrazito negativen vpliv na pojavljanje dvoživk. Pri izbiri kala so bile najbolj selektivne zelena rega in vrste iz skupine zelenih žab. Kot najmanj selektivne, zelo prilagodljive vrste pa diagram prikazuje obe vrsti pupkov in rosnico.*

Ključne besede: dvoživke, Amphibia, kal, okoljski dejavniki, kanonična korespondenčna analiza

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