



Fig. 1. Habitats of *Umbra krameri* on the river Mura catchment area in Slovenia:

- 1 - oxbow Kapitany lap
- 2 - oxbow Gyula marof
- 3 - oxbow Bednjaj (Bobri)
- 4 - oxbow at village Petišovci
- 5 - oxbow Szent kiraly
- 6 - oxbow Beloviči
- 7 - oxbow at village Kot
- 8 - oxbow Podkev (Podkova)
- 9 - oxbow at village Hotiza
- 10 - channel near village Hotiza
- 11 - oxbow below village Gaber
- 12 - oxbow I near village Podturn
- 13 - oxbow II near village Podturn



Physio-chemical and biological characteristics of oxbows and gravel pit

The results of measurements performed in summer 1989 show that oxygen content and saturation are very low at that time (Table 1). In autumn, oxygen content is normal, while in winter it is even higher. Very high chemical consumption of oxygen and low oxygen content in summer may be ascribed to rapid decomposition of plant remains. During the winter, the consumption is almost three times lower, since decomposition and thus oxygen consumption proceed more slowly. Total water hardness ranges between 11.2 to 12.7 German degrees, pH values of water range from 7.0 to 7.8.

Bottom fauna and aquatic flora

In a single sample from late autumn, 19 different animal organisms were found in Beloviči oxbow, 14 in Podkev, and only 5 in the gravel pit (Table 2). The oxbow flora is very rich and divers. In Beloviči oxbow 14 algal taxa were identified and 13 higher aquatic plants, in Podkev oxbow 9 algal taxa and 6 different macrophytes were found (Table 3).

Ichthyofauna of oxbows

In 12 oxbows and one channel we found 18 different fish species from 8 families. Three fish species are introduced. KUX & LIBOSVARSKY (1957) found only 9 different native fish species co-occurring with mudminnows.

Table 1: Physio-chemical characteristics of oxbows Beloviči and Podkev, and the gravel pit in which *U. krameri* was released, measured on February 2, and November 25, 1990 (localities 1 - 3), and temperature, oxygen content and saturation with O₂ (%) in three oxbows inhabited by *U. krameri* on June 17, 1989 (localities 4 - 6).

No.locality date	T °C	Turbidity	pH	Total Hardness	KPK	O ₂	Saturation O ₂ (%)
1. Beloviči oxbow							
22.2.1990	12.3		7.9	12.0	44.6	12.3	112
25.11.1990	12.2	Brown-50	7.9	11.2	146.0	8.4	80
2. Podkev oxbow							
22.2.1990	8.2		7.8	12.7	52.0	9.3	76
25.11.1990	13.1	Brown-40	7.0	12.5	135.0	7.6	70
3. Gravel pit near Čarda							
25.11.1990	13.0	Clear	7.6	15.5	140.0	8.3	81
4. Kapitany lap oxbow							
17.6.1989	14.6	-	-	-	-	2.3	23
5. Oxbow 1 near Podturen							
17.6.1989	14.1	-	-	-	-	2.6	30
6. Oxbow 2 near Podturen							
17.6.1989	16.0	-	-	-	-	1.6	10

An interesting observation, made by accident, deserves to be mentioned. Until 1988, ichthyological investigation in oxbows has been always conducted during summer months. At that time catching a specimen of *U. krameri* was the exception rather than the rule. In 1989, however, fish were caught in oxbows Beloviči, Podkev, Kapitany lap and others for the first time in winter. Numerous specimens were captured in a small area. For example, more than hundred specimens were easily caught in an hour. We may assume that in summer they withdraw from warm surface water towards the oxbow bottom, where the water is cool.

Threat and conservation measures

Major factors which are threatening *U. krameri* may be summarized as follows:

1. Vanishing of the oxbows in a natural way and river regulation.
2. Pollution by pesticides, herbicides, and artificial fertilizers.

A most important conservation measure enforced in Slovenia in 1993 is the "Provision of the protection of threatened animal species" (Official Journal of the Republic of Slovenia No. 57/1993). By this decree it is prohibited to catch *U. krameri* or destroy its habitats. Preservation of river flooding and meandering would be another optimum protective measure. We also considered the possibility to prevent ageing of already filled-in oxbows, of raising the species in controlled conditions or finding a substitute habitat.

The following pilot experiments were made to find solutions for the protection of the species:

Table 2: Qualitative biologic analysis of bottom fauna of oxbows Beloviči and Podkev, and of gravel-pit near Čarda area (+ species is present).

Species	oxbows		gravel-pit near Čarda
	Beloviči	Podkev	
Gastropoda			
<i>Lymnea</i> sp.	+	+	-
<i>Gyraulus</i> sp.	+	+	-
Lamelibranchiata			
<i>Pisidium</i> sp.	+	+	-
Oligochaeta			
<i>Nais</i> sp.	+	+	-
<i>Tubifex</i> sp.	-	+	+
Hirudinea			
<i>Hemiclepis marginata</i>	-	+	-
<i>Erpobdella octoculata</i>	+	-	-
<i>Helobdella stagnalis</i>	+	-	-
Crustacea			
Phyllopoda	+	+	+
Ostracoda	+	+	+
Isopoda (<i>Asellus</i> sp.)	+	+	-
Ephemeroptera			
<i>Baetis</i> sp. (larva)	+	-	+
<i>Cloeon</i> sp. (larva)	+	+	-
<i>Caenis</i> sp. (larva)	-	+	-
Odonata			
<i>Calopteryx splendens</i> (larva)	+	-	-
Heteroptera			
<i>Corixa</i> sp. (larva)	+	-	-
<i>Ilyocoris cimicoides</i>	+	-	-
Neuroptera			
<i>Sialis</i> sp. (larva)	-	+	-
Coleoptera			
<i>Helophorus griseus</i> (imago)	+	-	-
Diptera			
Chironomidae (larva)	+	+	+
<i>Bezzia</i> sp. (larva)	+	-	-
Amphibia			
<i>Triturus</i> sp. (larva)	+	-	-
tadpoles	+	+	-

1. Introduction of *U. krameri* in a substitute biotope - a gravel pit

(1) A gravel pit of about 300 m² in size, located near the oxbow Beloviči, which is inhabited by *U. krameri*, was selected as a substitute habitat. Its physio-chemical (Table 1) and biological characteristics (Table 2, 3) were analyzed in 1990. No significant differences were found between parameters of the two oxbows and the gravel pit, with the exception of water hardness, where values were considerable different. The effect of hardness on *U. krameri*, however, is not known at present.

The water in the gravel pit was clearer than in the oxbows, which may be attributed to minimal decomposition of vegetational remnants. There were no macrophytes in the gravel pit except some individual stands of *Typha* sp. in one part. Among the algae, diatom species were the most abundant (Table 3). Its bottom was stony, without mud.

Table 3: Qualitative biologic analysis of aquatic flora of oxbows Beloviči and Podkev, and of gravel-pit near Čarda area (+ species is present).

Species	oxbows		gravel-pit near Čarda
	Beloviči	Podkev	
Algae			
<i>Cymbella</i> sp.	+	-	+
<i>Pinnularia</i> sp.	+	+	+
<i>Synedra ulna</i>	+	+	+
<i>Eunotia</i> sp.	+	+	-
<i>Diatoma vulgare</i>	+	+	+
<i>Asterionella formosa</i>	+	-	-
<i>Navicula cuspidata</i>	+	+	-
<i>Achnanthes lanceolata</i>	+	-	-
<i>Tabellaria</i> sp.	+	+	+
<i>Gyrosigma acuminatum</i>	+	-	-
<i>Cymatopleura</i> sp.	+	+	+
<i>Melosira varians</i>	+	+	+
<i>Cocconeis</i> sp.	+	+	+
<i>Pinnularia interrupta</i>	+	-	-
Higher aquatic plants			
<i>Salvinia natans</i>	+	-	-
<i>Utricularia</i> sp.	+	-	-
<i>Lemna trisulca</i>	+	-	-
<i>Lemna</i> sp.	+	+	-
<i>Spirodella polyrrhiza</i>	+	-	-
<i>Stratoides aloides</i>	+	-	-
<i>Nuphar luteum</i>	+	-	-
<i>Ranunculus</i> sp.	+	-	-
<i>Riccia fluitans</i>	+	-	-
<i>Elodea canadensis</i>	+	-	-
<i>Typha</i> sp.	+	+	+
<i>Hippuris</i> sp.	+	+	-
<i>Myriophyllum</i> sp.	+	+	-
<i>Hydrocharis morsus ranae</i>	-	+	-
<i>Potamogeton crispum</i>	-	+	-

Despite these considerable differences we decided to introduce *U. krameri* in the gravel pit in 1991. On March 20, 1991, 22 males and 21 females were captured with electro-fishing gear in the nearby Beloviči oxbow. Big females, full of eggs, were selected for the purpose. Water temperature in the oxbow was 15.5 °C and 13.5 °C in the gravel pit. The fish were recaptured in the gravel pit in November 1991. At that time, the water was slightly brown in colour. Ten specimens of *U. krameri* were caught (23 %), all of them in one part of the gravel pit, where the bottom was covered with a thick layer of decaying leaves. The next control captures were carried out on April 14 and September 20, 1992. No *U. krameri* were caught.

Results of the analysis of physio-chemical parameters, bottom fauna and flora in oxbows and in the gravel pit suggest that, at present, gravel pits are not the most adequate substitute habitats for *U. krameri*. Other abandoned, older and more overgrown gravel pits, containing more mud, should be examined in detail, and physio-chemical properties of water analyzed. Introduced fish would have to be tagged.

Table 4: Ichthyofauna of 12 oxbows and one channel in Slovenia and in the waters in Slovakia. 1 - Kapitany lap; 2 - Gyula marof; 3 - Bednjaj; 4 - at village Petišovci; 5 - Szent kiraly; 6 - Beloviči; 7 - at village Kot; 8 - Podkev (Podkova); 9 - at village Hotiza; 10 - channel near village Hotiza; 11 - below village Gaber; 12 - near village Podturn - I; 13 - near village Podturn - II; R = reference (KUX & LIBOSVARSKY 1957).

	1	2	3	4	5	6	7	8	9	10	11	12	13	R
Umbridae														
<i>Umbrakrameri</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Cyprinidae														
<i>Aspius aspius</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Rutilus rutilus</i>	-	+	+	+	+	+	+	+	+	-	-	-	+	+
<i>Scardinius erythrophthalmus</i>	-	+	+	+	+	+	+	+	+	-	-	-	-	+
<i>Tinca tinca</i>	-	+	+	+	+	+	+	+	+	-	-	-	+	+
<i>Alburnus alburnus</i>	-	+	+	-	-	-	-	-	-	-	-	-	-	+
<i>Blicca bjoerkna</i>	-	+	+	+	-	-	-	-	-	-	-	-	-	+
<i>Abramis brama</i>	-	+	+	+	+	-	-	-	-	-	-	-	-	-
<i>Rodeus s. amarus</i>	-	-	+	-	+	-	-	-	-	-	-	-	-	-
<i>Carassius carassius</i>	+	-	+	+	+	+	+	+	+	+	+	+	+	+
<i>Carassius auratus gibelio</i>	-	-	-	+	-	-	-	-	-	-	-	-	+	-
<i>Leuciscus cephalus</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Cobitidae														
<i>Cobiti taenia</i>	-	+	-	+	-	-	-	-	-	-	-	-	-	+
<i>Misgurnus fossilis</i>	-	-	-	-	+	+	-	+	+	-	-	-	+	+
Ictaluridae														
<i>Ictalurus nebulosus</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Siluridae														
<i>Silurus glanis</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Esocidae														
<i>Esox lucius</i>	-	+	+	+	+	+	+	+	+	-	-	+	+	-
Percidae														
<i>Perca fluviatilis</i>	-	+	+	-	+	-	-	+	+	-	-	-	+	-
Centrarchidae														
<i>Lepomis gibbosus</i>	-	+	+	+	+	-	+	-	+	-	-	-	+	-
Total number of fish species	2	13	13	12	12	7	7	8	9	3	2	4	9	9

The observations mentioned lead to the conclusion that the only adequate substitute habitats of *U. krameri* are the existing oxbows in Slovenia and in other parts of its distribution area.

2. Re-vitalization of oxbow

Until now, there has been only one such re-vitalization case. It has been carried out by hunters in order to improve the oxbow habitat for ducks. Part of the Beloviči oxbow was deepened and after a short time, a considerable population increase of *U. krameri* was observed. In the previous years only individual, very big specimens were caught in this oxbow. Since it has been deepened many fish of different size have been captured (Povž 1990). Re-vitalization of oxbows seems to be the most adequate and efficient protective

measure. A comprehensive re-vitalization plan should be made, based on a list of oxbows and a survey of their physio-chemical, biological, and geomorphological features. Austrian re-vitalization schemes could serve as an example (GEPP & al. 1985). If the number of habitats of *U. krameri* is increased, the species will be less endangered.

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