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DIET IN PIKE (*ESOX LUCIUS*) IN NORTHWESTERN VOJVODINA (SERBIA)

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We possess little information on diet of the pike (*Esox lucius* L.) in nearly natural water habitats in the Balkans. Between 2006 and 2010, 528 pike were captured at 20 locations in three different water habitats. The capture of pike was done with an angling system a minimum of four times a month. Pike were mainly caught in autumn with the highest number in October. Furthermore, we also found that feeding intensity was highest in autumn. Altogether 15 prey fish species were recorded in pike stomachs. The most frequent prey fish was the Crucian Carp (*Carassius auratus gibelio*), followed by the Common Roach (*Rutilus rutilus*) and Common Bleak (*Alburnus alburnus*). In conclusion, species composition of prey fish and the proportion of vertebrate and invertebrate prey mainly differed from other studies probably due to different geographical areas.

Key words: piscivorous feeding, water habitat, stomach content, cannibalism, aquatic food web

Méró, T. O.: Ishrana štuke (*Esox lucius*) u sjeverozapadnoj Vojvodini (Srbija). *Nat. Croat.*, Vol. 23, No. 1, 27–34, 2014, Zagreb.

Malo je poznato o ishrani štuke (*Esox lucius* L.) u skoro potpuno prirodnim vodenim staništima na Balkanu. U razdoblju od 2006. do 2010. ulovljeno je 528 primjeraka štuke na 20 lokacija u tri različita vodena staništa. Štuka je lovljena udicom minimalno četiri puta mjesečno. Štuke su uglavnom hvatane u jesen, s najviše ulova u listopadu. Osim toga, u jesen je zabilježen i najveći intenzitet hranjenja. U želucima štuka pronađeno je ukupno 15 vrsta ribljeg plijena. Najčešća riba plijen bila je babuška (*Carassius auratus gibelio*), slijedile su bodorka (*Rutilus rutilus*) i uklija (*Alburnus alburnus*). Zaključeno je da se sastav ribljeg plijena i udio kralježnjaka i beskralježnjaka u plijenu uglavnom razlikuju od drugih istraživanja, vjerojatno zato što su istraživana područja bila geografski različita.

Ključne riječi: piscivori, vodena staništa, sadržaj želuca, kanibalizam, hranidbeni lanac kopnenih voda

INTRODUCTION

The pike (*Esox lucius* Linnaeus, 1758) is a solitary, almost entirely piscivorous top fresh water predator fish species that inhabits lakes, slow flowing rivers and floodplain ponds in the Arctic and temperate zones of the northern hemisphere (DIANA *et al.*, 1977; GUTI *et al.*, 1991; DGEBUADZE *et al.*, 2010). Pike are able to control fish assemblage composition through piscivorous feeding and as keystone predators they have an important role in fresh water ecosystems (PREJS *et al.*, 1994; BERG *et al.*, 1997). Together with other predatory fish they do not only deplete their immediate prey supply but also modify their aquatic food web (LIAO *et al.*, 2002). Often the diet of predators including the pike appears

to be very narrow, dominated by one or two prey species even if there is a wide range of prey species available (ERRINGTON, 1963; DIANA, 1979).

The morphology and anatomy of the pike body would appear to be a piscivorous feeding mode (BUCKE, 1971). The short esophagus, a large pouch and the short intestine are related to a piscivorous diet (BUCKE, 1971). The diet of young (< 50 mm) pike primarily consisted of entomostracans and insects (HUNT & CARBINE, 1951; FROST, 1954; DGEBUADZE, 2010), while larger individuals are strongly piscivorous (FROST, 1954; DIANA, 1979; BREGAZZI & KENNEDY, 1980; DGEBUADZE, 2010) and only occasionally consume macro-invertebrates (SKOV *et al.*, 2003). The maximum size of the prey grows in accordance with the dimensions of the pike, but large pike eat small prey fish too. Therefore, the correlation between the largeness of the prey and the dimension of the pike is not significant (DIANA, 1996). The kind and quantity of prey a habitat offers is important. If prey availability is scarce, cannibalism may show up or be more frequent (HARVEY, 2009). However, it is not only the supply of prey that leads to cannibalism, for the density of pike, i.e. between 5.45 and 81.4 individuals per m² (WRIGHT & GILES, 1987; GRES *et al.*, 1996), temperature (DIANA, 1996) and the absence of hiding places leads also to cannibalism (SKOV *et al.*, 2003; LEHTNIEMI, 2005). In natural populations cannibalism can regulate the sizes of pike populations (MILLS & MANN, 1985). Furthermore, pike occasionally feed on amphibians (ALP *et al.*, 2008), birds (BROWN & MCINTYRE, 2005) and small mammals (HARVEY, 2009). Based on large number of captured pike in north-western Vojvodina (N Serbia) the aim of this study was to present the prey abundance and species composition of prey fish. Furthermore, this study provides information on monthly difference in feeding considering both sexes.

STUDY AREA AND METHODS

Research area

The study area lies in north-western Vojvodina (N Serbia), characterized by semi-dry continental climate with mean annual temperature is 10.7°C. July is the warmest month with a mean monthly temperature of 21.1°C and January is the coldest with a mean monthly temperature of 0.8°C (TOMIĆ, 1996). This study was conducted on three different water habitats:

Danube - Contains the studied part of the Danube River and the ponds in floodplain area (66 km; the Gornje Podunavlje Special Nature Reserve, Serbian bank). The mean width of the Danube is here ca. 700 m (measured in Apatin), at water level 450 cm. In spring the water varies between 250 and 750 cm, but in summer and early autumn this value is lower (range 50-200 cm). The water depth varies from 2 to 32 m (mean 15 m). The gradient of the river here varies between four and six cm/km. The meandering of the river has created smaller backwaters and many ponds in the floodplain area. Ponds are rich in *Myriophyllum* sp. while in the river zoo- and phytoplankton are common. Pike were captured at seven different locations (Fig. 1).

Canals - This category contains lateral (up to 10 m) and wide (up to 30 m) canals of the detailed canal net and the hydrosystem Danube-Tisza-Danube. The water level of canals depends mainly on the regulations of the water management companies. The height of the water level in lateral canals often depends on the large local fishponds. Pike were captured at eight locations (Fig. 1). The submerged vegetation is rich in vascular species (Tab. 1). The water surface of narrow canals is rarely covered with floating water-

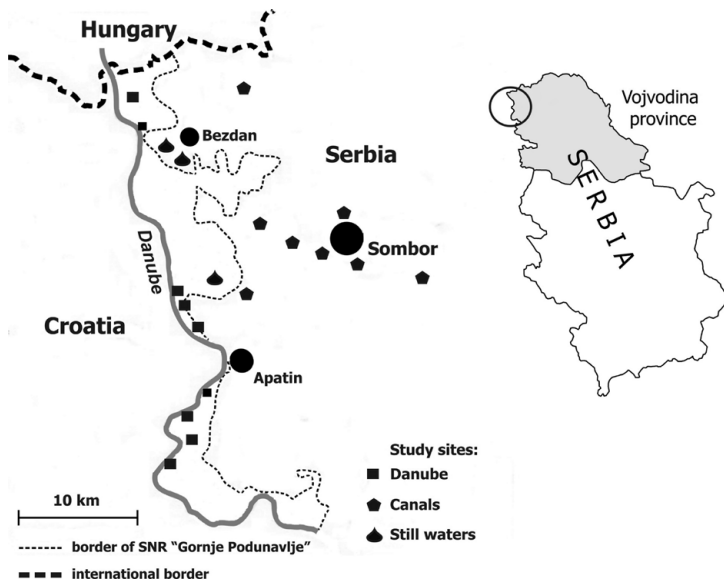


Fig. 1. Distribution of sampling locations in north-western Vojvodina.

Tab. 1. Main characteristics and vascular water vegetation of water habitats.

Water habitat		Depth of water at locations (m)	Ground	Dominant vascular water vegetation	Hiding places for pike
DANUBE	Danube River	1.5-4.5	sand, clay, mud, rock	-	dead trees, pits, rocks
	Floodplain ponds	0.8-2.5	mud, sand	<i>Myriophyllum</i> sp., <i>Potamogeton</i> sp., <i>Trapa natans</i> , <i>Nymphoides peltata</i>	dead trees, pits, water-plant
CANALS		0.5-3.5	mud, clay	<i>Vallisneria</i> sp., <i>Myriophyllum</i> sp., <i>T. natans</i> , <i>Nuphar luteum</i>	water-plant
STILL WATERS		1.0-4.0	mud	<i>Myriophyllum</i> sp., <i>N. luteum</i> , <i>T. natans</i>	water-plant

vegetation, e.g. Common Duckweed (*Lemna minor*) and Spotless Water-meal (*Wolffia arrhiza*).

Still waters - Lakes and ponds were once backwaters of the Danube but after the river regulation process they were cut off by dams. These water habitats have occasionally eutrophic characteristics. During summer the water surface can be completely covered with *Myriophyllum* sp., rarely with Water Caltrop (*Trapa natans*, Tab. 1). The water level depends mainly on precipitation amount and ground water level. Field work was done at three locations (Fig. 1).

Sampling and statistical methods

Pike were captured in a five year period (2006-2010), during the whole year. Each water habitat was visited monthly at least four times (total number of visits: 423), how-

ever, in late spring and summer, because the dense non-specific macrophyte vegetation covered the top of water, it made pike angling impossible in still waters. Natural baits and lures were used to capture the pike. The weight and length of the pike were measured with a scale and a ruler. Date of capture, period of day (morning, afternoon and evening), water habitat, sex and stomach contents were recorded. To make a stomach content exam possible the fish had to be sacrificed immediately after the capture to avoid further digestion. On average, the stomach content was examined after 4-5 hours. The post-mortem digestion did not affect the the identifiability of prey-fish. The following abbreviation was used in the article: SC - for individuals whose stomachs contained prey.

Mean length and weight of pikes with standard deviation were calculated. Student's t-test was used to check the differences between: mean length and weight of males and females; mean weight among different habitats; number of prey fish found. For the statistical tests I used SPSS statistical software program.

RESULTS

In total, 528 pike with a mean length of 45 ± 6.9 cm, and a mean weight of 728 ± 491.1 g were captured between 2006 and 2010 (Tab. 2). Most individuals were females, $N = 338$ (64%); the number of males was 190. The mean length between males and females differed (Student's t-test, $t_1 = 15.52$, $p = 0.041$), while mean weight did not ($t_1 = 4.49$, $p = 0.139$). Mean weight of pike did not differ between water habitats ($t_2 = 3.833$, $p = 0.0618$). From the total number of captured pike 22% ($N = 117$, Tab. 2) were SC ($N = 87$ females; $N = 30$ males). Mean number of captured pike was the highest in October while the lowest number was recorded in late spring and February (Fig. 2). The number of SC pike showed similar monthly distribution in relation to the mean number of monthly captured individuals (Fig. 2 and 3).

The most frequently consumed prey fish was the Crucian Carp (*Carassius auratus gibelio*; $t_8 = 2.81$, $p = 0.022$; Fig. 4). Cannibalism was found in 3.4% of cases (Fig. 4). Eight species (6.9%) were selected into a group "other prey fish"; Common Bream (*Abramis brama*), Common Carp (*Cyprinus carpio*), Grass Carp (*Ctenopharyngodon idella*), Ruffe (*Gy-*

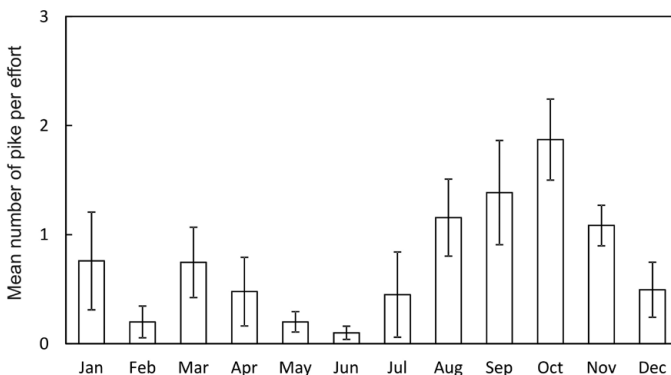


Fig. 2. Monthly mean number of captured pike per effort (number of monthly captured individuals/number of monthly fieldwork days) (2006 – 2010). Error bars present standard error, SE.

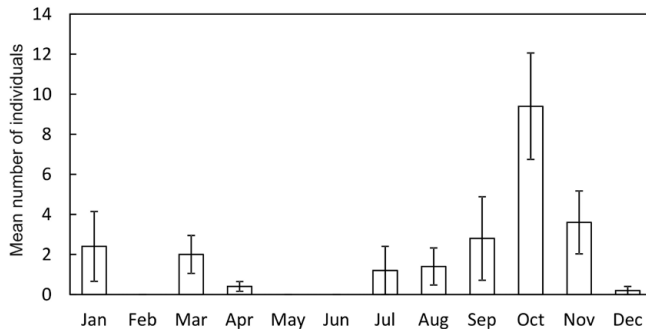


Fig. 3. Monthly mean number of SC pike (2006 – 2010). Error bars present standard error, SE.

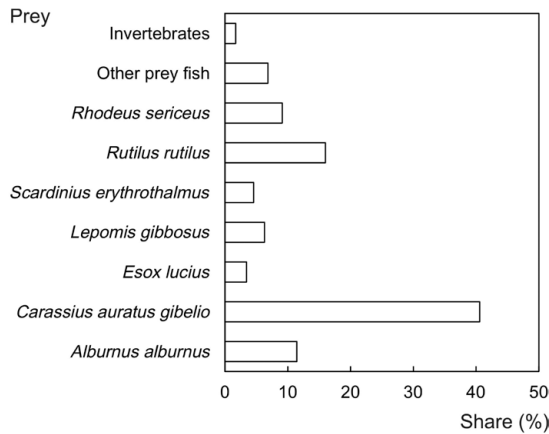


Fig. 4. Share of prey found in SC pike in north-western Vojvodina.

mnocephalus cernuus), Silver Carp (*Hypophthalmichthys molitrix*), Brown Bullhead (*Ictalurus nebulosus*), Topmouth Gudgeon (*Pseudorasbora parva*) and Zander (*Sander lucioperca*). Only in 1.7% (three individuals) of the SC pike were invertebrates found (Fig. 4).

DISCUSSION

In comparison to other studies the share of empty stomachs in this study was high (78%), e.g. 12% in CHAPMAN *et al.* (1989), 46% in FROST (1954), 47% in DIANA (1979), 50% in DOMINGUEZ & PENA (2000) and 54% in ALP *et al.* (2008), probably due to the uncommon sampling method. In the present study pike were almost exclusively piscivorous; invertebrates were found only in 1.7% (Fig. 4). In Hungary early summer diet of one year old pike (65-165 mm) consisted of 40% prey fish, 56% insects, 2% water louse (*Asellus aquaticus*) and 2% gastropods, which changed in August to 97% prey fish and only 3% gastropods (GUTI *et al.*, 1991). DIANA (1979) also reported that invertebrates were rarely eaten (Lac Ste. Anne, Alberta, Canada).

I found mainly (74%) female pike which may imply that their feeding is more intensive than that of males. This assumption is supported by the finding in HARVEY (2009).

Tab. 2. The total number and number of SC pike captured per water habitat per month during a five years period.

	Water habitat	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total number of pike	Danube	3	3	0	0	0	1	26	25	71	66	6	0
	Canals	47	1	19	5	3	0	6	35	34	39	38	12
	Still waters	0	0	10	14	1	0	0	0	0	39	22	2
	Total	50	4	29	19	4	1	32	60	105	144	66	14
SC pike	Danube	0	0	0	0	0	0	5	4	11	12	1	0
	Canals	12	0	6	0	0	0	1	3	3	21	12	1
	Still waters	0	0	4	2	0	0	0	0	0	14	5	0
	Total	12	0	10	2	0	0	6	7	14	47	18	1

We captured most individuals in spawn development period (from August till February in this region), which might highly affect the feeding intensity of females. The development of spawn is an energy-intensive process, so their food requirement might be higher. An English study, BREGAZZI & KENNEDY (1980), presented results which are partially contrary to my opinion. They reported that pike ate intensively in summer and autumn while in winter and in the spawning period their appetite was lower. However, the timing of spawn development can vary strongly between different geographical regions. Similarly to our results, BREGAZZI & KENNEDY (1980) also found that SC pike were mainly captured in autumn, while DOMINGUEZ & PENA (2000) found more SC individuals during the spawning period - February and March.

The introduced Crucian Carp from China (KISS, 1997) was brought to Europe in the second half of the 20th century, and inhabits all water habitats in the sampling area in large number (*pers. obs.*). This might account for this prey fish species being found predominantly in the stomachs of pike in this study. The native prey fish species appeared between 9 and 16% in stomachs, while the introduced Pumpkinseed (*Lepomis gibbosus*) appeared also quite regularly in stomachs of pike (Fig. 4). GUTI *et al.* (1991) reported that pike in the summer preferred the Common Rudd (*Scardinius erythrophthalmus*), but after that period pike ate Pumpkinseed more. Furthermore, GUTI *et al.* (1991) reported that in autumn the prey composition changed to 31% prey fish, 31% insects and 38% amphipods. In England the summer and autumn diet of pike was almost exclusively piscivorous (99%) - 61% Common Roach, 34% European Perch (*Perca fluviatilis*), 4% European Eel (*Anguilla anguilla*) (BREGAZZI & KENNEDY, 1980). In absence of prey fish pike are able to adapt to invertebrate feeding, but such diet imposes a trophic bottleneck that can lead to stunting (VENTURELLI & TONN, 2006). Furthermore, I found that feeding activity was highest in autumn (Fig. 3). ALP *et al.* (2008) tested stomach fullness of pike for the entire year and concluded that most of these specimens were caught in spring. The lowest feeding intensity was recorded mainly in winter (ALP *et al.*, 2008). Species composition of prey fish in pike does not change only seasonally. Long-term studies report about prey fish composition change during three decades, from salmonids to pikes, perch and cyprinids (WINFIELD *et al.*, 2008; 2010; 2012).

In conclusion, I found that species composition of prey fishes differed only in studies done in another geographical area (BREGAZZI & KENNEDY, 1980; DOMINGUEZ & PENA, 2000). Furthermore, the proportion of prey fish species differed from other studies probably due to the difference in aquatic food web and geographical area, too. The proportion of vertebrate and invertebrate prey was similar to that of BREGAZZI & KENNEDY (1980), while other studies reported a higher portion of invertebrate feeding. But this difference is probably due to various age of pike studied.

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