

## Observations of food and feeding of angler-caught huchen, *Hucho hucho* (L.), in Slovak rivers in winter

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**Abstract.** The stomach contents of 41 specimens of huchen, *Hucho hucho* (L.), from six rivers in Slovakia were analyzed. Of the total number of fish examined (n=41), the stomachs of 17% were empty; thus, they were not analyzed further. A total of 116 animal prey items were found and identified in the 34 specimens analyzed. Eleven taxonomic categories were identified. The diet of *H. hucho* mainly consisted of fish, but one huchen had frogs in its stomach. Cyprinids and salmonids dominated the diet in winter months of November and December. Spirlin, *Alburnoides bipunctatus* (Bloch), and chub, *Leuciscus cephalus* (L.), were the primary prey of *H. hucho*. These results confirm that the huchen occupies a top position in the food chain of montane and submontane rivers and could play an important role in structuring fish assemblages.

**Keywords:** huchen, diet, foraging, fish, predator feeding strategy

Huchen, *Hucho hucho* (L.), is the world's largest salmonid (Holčík et al. 1988). The natural range of *H. hucho* is limited to the upper drainage of the Danube River system (Witkowski et al. 2013), and in Slovakia it occurs in the Danube, Váh, Orava, Turiec, Kysuca, and Hron rivers (Holčík 1990), and it was introduced into the Poprad, Dunajec, and Hornád rivers (Witkowski and Kowalewski 1989, Holčík

1998, Koščo and Holčík 2008, Witkowski et al. 2013). The occurrence of huchen in streams is sporadic and isolated (Holčík 1990,) and its abundance is decreasing primarily because of pollution, stream regulation and fragmentation, and poor fishery management (Holčík 1980a, 1998, Rothschein 1980, Koščo and Holčík 2008). According to Holčík (1995), the huchen is a critically endangered fish species, because its abundance is very low and continually decreasing.

Data on the feeding of *H. hucho* are scarce. As a top predator, huchen used to play a key role in structuring the food-chain. The diet of juveniles is composed of benthic invertebrates (Nikcevic et al. 1998), but after attaining lengths of 50-90 mm, the diet shifts to fish (Holčík 1990). Knowledge about food of the *H. hucho* is very important, especially for the management of fish populations in rivers (Witkowski and Kowalewski 1982). Together with other indicators, these data permit implementing rational management strategies (Holčík 1980b). The aim of the present study was to analyze the diet of the huchen with a focus on differences related to river and fish size.

The material analyzed was collected from the following Slovak rivers: the Váh (n=20), the Orava (n=17), the Poprad (n=2), the Dunajec (n=1), the Hron (n=1) by angling from 1985 to 2010. Most of the fish were obtained from recreational anglers for

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**Table 2**Share of particular fish species in the food of huchen (*H. hucho*) in Slovak rivers

Species	Minimum and maximum number of prey in stomach	Frequency of occurrence (%)	Percentage composition by number (%)	Size of prey (cm)	Prey size as % of predator size
<i>Salmo trutta</i>	1 - 2	26.5	12.9	12 - 35	11.2 - 33.3
<i>Oncorhynchus mykiss</i>	1 - 4	11.8	6.0	20 - 25	20.0 - 25.0
<i>Thymallus thymallus</i>	1	5.9	1.7	20 - 27	21.5 - 25.2
<i>Leuciscus cephalus</i>	1 - 9	29.4	22.5	14 - 55	10.6 - 48.0
<i>Chondrostoma nasus</i>	1 - 4	11.8	6.0	20 - 46	18.2 - 40.1
<i>Barbus barbus</i>	1 - 3	20.6	9.5	40 - 55	31.5 - 45.6
<i>Abramis brama</i>	2	2.9	1.7	42 - 43	36.8 - 37.7
<i>Alburnoides bipunctatus</i>	12 - 20	5.9	27.6	8 - 14	7.4 - 13.1
<i>Alburnus alburnus</i>	9	2.9	7.8	10 - 16	8.1 - 12.9
<i>Perca fluviatilis</i>	1	2.9	0.9	-	-
Frogs ( <i>Rana</i> sp.)	4	2.9	3.4	-	-

trophy mounting. The material was collected in the winter months of November and December, which is the huchen fishing season. Each of the fish was measured to the nearest mm for total length (TL) and weighed to the nearest g. The stomachs and pyloric caeca of each *H. hucho* were cut open and the contents flushed out onto a plastic plate. Of the total number of fish examined (n=41), the stomachs of 17% were empty, and were excluded from further analysis. The remaining stomachs (n=34) were then analyzed. The fish prey in the stomachs was identified to the species, but since the non-fish prey was extremely rare, it was identified to the genera. The contents of the intestine were not studied. After organisms in the stomach were identified, they were measured. When the prey was in an advanced stage of digestion, it was identified based on cyprinid pharyngeal teeth and other characteristic bones, such as salmonid jaw bones. The wet weights of each fish prey and other food item were determined to the nearest g for each of the 22 huchen examined. Percentage and frequency of occurrence were used to estimate the dietary importance of each prey category. The feeding strategy was analyzed with the Costello graphic method modified by Amundsen et al. (1996) in which prey specific abundance is plotted against the frequency of occurrence. The differences

between the number of prey per stomach of huchen from the Váh and Orava rivers was analyzed with the U Mann-Whitney test. The dependence between fish size and the amount of prey consumed by *H. hucho* was analyzed with Spearman's correlation.

A total of 116 different prey items was determined in the stomach contents of 34 fish, while seven specimens (17%) had empty stomachs. Witkowski and Kowalewski (1984) found that 12% of huchen in the Dunajec River had empty stomachs. The mean total length of the specimens examined was 114.6 cm (range 90-136 cm), and mean body weight was 15.7 kg (range 7.0-24.8 kg). Eleven taxonomic categories were identified. Cyprinids (75.9%) and salmonids (2.7%) were the most abundant food category in all of the rivers (Table 1). Cyprinidae exceeded Salmonidae both in number and frequency of occurrence (Table 2). These fish comprised mainly spirin, *Alburnoides bipunctatus* (Bloch), followed by chub, *Leuciscus cephalus* (L.), at 27.6% and 22.5%, respectively. Brown trout, *Salmo trutta* L., and barbel, *Barbus barbus* (L.), were also consumed frequently, whereas perch, *Perca fluviatilis* L., common bream, *Abramis brama* (L.), and grayling, *Thymallus thymallus* (L.), were rarely noted. Only four frogs, *Rana* sp., were recorded in the stomach of one huchen from the Váh River (3.4% of the number of

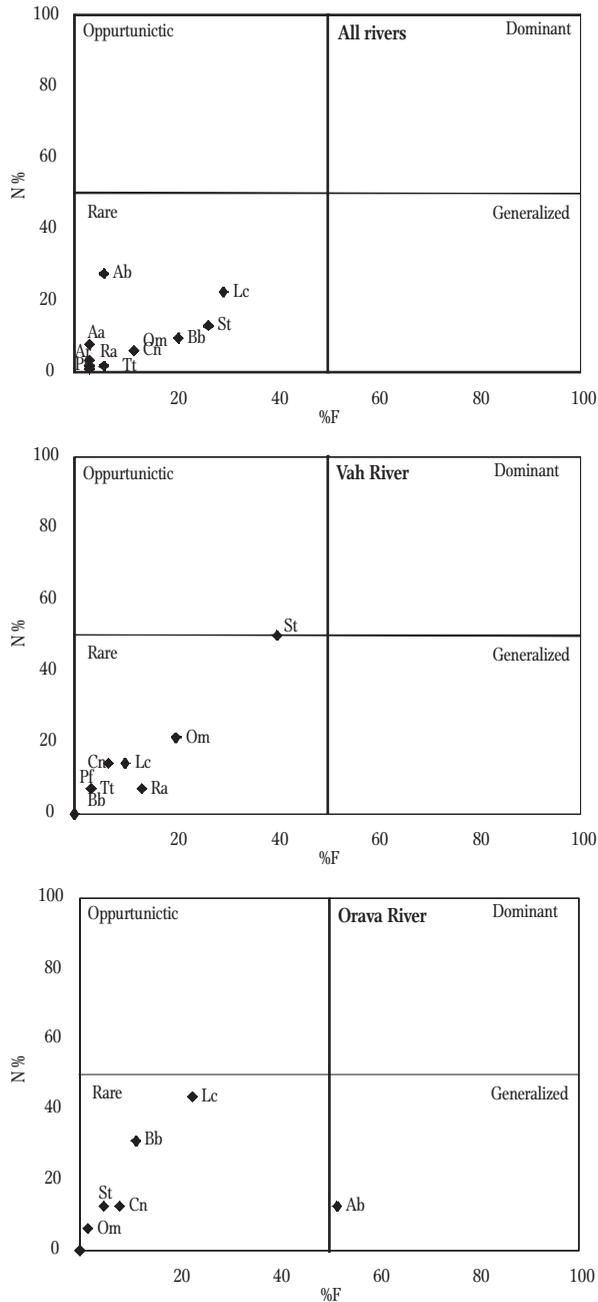


Figure 1. Costello's (1990) graphic interpretation, modified by Amundsen et al. (1996), of the role of particular food items in the *H. hucho* diet on six rivers (upper graph), the Váh River (middle graph), and the Orava River (lower graph). The four quadrants represent feeding strategy (generalized and opportunistically consumed) and prey importance (dominant and rare taxa). The points represent different food categories in forested regions. Aa – *A. alburnus*; Ab – *A. bipunctatus*; Ar – *A. brama*; Bb – *B. barbus*; C.n – *Ch. nasus*; Lc – *L. cephalus*; Pf – *P. fluviatilis*; Ra – *Rana* sp.; St – *S. trutta*; Tt – *T. thymallus*. % N – percent composition by number, % F – frequency of occurrence.

prey species). Nagy (1976) found only eight species in the food of huchen from the Orava, Váh, Turiec, and Poprad rivers, while Šnarevič and Moščuk (1957) found six fish species in the stomachs of huchen caught in the rivers of Bucovina. Witkowski and Kowalewski (1984) found 14 prey species in the diet of huchen in the Dunajec River, where cyprinids were the dominant prey (80.5%). In the Dunajec River the main dietary components were *Barbus petenysi* Heckel (47%); gudgeon, *Gobio gobio* (L.), and chub (both 15.7%); and bleak, *Alburnus alburnus* (L.) (13.7%) (Witkowski and Kowalewski 1984). Cyprinidae comprised as much as 92% of the food biomass (three nase, *Chondrostoma nasus* (L.), with a total weight of 3.3 kg; six barbel (5.1 kg); and ten chub (5.5 kg). Salmonidae comprised up to 8% (three brown trout with a total weight of 1.2 kg). Similarly, Witkowski and Kowalewski (1984) found that cypriids were dominant in the food biomass of the huchen from the Dunajec River.

The mean number of prey per huchen stomach was  $3.4 \pm 4.46$  SD. The number of prey per stomach of the fish from the Orava River ( $3.6 \pm 1.54$  SD) was higher than in the Váh River ( $2.1 \pm 1.12$  SD), but this difference was not statistically significant (Mann-Whitney U test,  $P = 0.878$ ). The maximum number of prey items in one huchen stomach was 20 in an individual from the Orava River. Witkowski and Kowalewski (1984) reported that the maximum number of prey items in an *H. hucho* stomach from the Dunajec River was nine. Most often one, or rarely two or three, prey items were noted. Nagy (1976) reported from one to three fish in individuals from the Orava River system, while Bastl and Holčík (1968) noted one or two prey items per stomach.

The size of *H. hucho* had little effect on prey number and food consumption, and the number of prey consumed by *H. hucho* did not increase with size (Spearman correlations,  $r = -0.160$ ,  $P > 0.05$ ,  $N = 34$ ). The sizes of the items consumed ranged from 8 cm (spirin) to 55 cm (chub and barbel) (Table 2). Generally, for salmonids that are primarily piscivores, prey size increases linearly with body length (Keeley and Grant 2001), but *H. hucho* mainly consumed prey that was a small fraction of their body size;

however, they sometimes consumed large prey. A chub measuring 55 cm in length was noted in a huchen stomach (TL = 132 cm, BW = 14.8 kg) from the Orava River, while another fish from this same river (TL = 120 cm, BM = 17.5 kg) had consumed a barbel measuring 55 cm in length. It is also interesting that a fish from the Orava River (TL 104 cm, BW 10.5 kg) had preyed upon a chub (TL 50 cm, BW 1.8 kg) that was 48% of its own body length, especially since huchen are known to feed mainly on prey that are small in relation to their own body size. Nagy (1976) observed that the length of fish consumed by *H. hucho* ranged from 6 to 26 cm, which corresponded to approximately 13-45% of their own total length. The size of the fish consumed by *H. hucho* in the Dunajec River ranged from 5 to 35 cm, which corresponded to 7-42% of their own body length (Witkowski and Kowalewski 1984).

*H. hucho* is specialized to consume fish. Based on Amundsen's method, *H. hucho* pursues a generalist feeding strategy. All items are located in the lower left corner of the plot representing rare prey with low frequencies of occurrence and a relatively low prey-specific abundance (Fig. 1). The food of huchen depends mostly on the species that are dominant in a given river or in a given sector of a river. Salmonids dominate the fish communities in the Váh River and were the main food items *H. hucho* (63.3%) consumed in it, while the population from the Orava River consumed cyprinids (93.5%). The huchen is not a selective predator, and its diet features the most numerous or most available fish (Bastl and Holčík 1968, Witkowski and Kowalewski 1984, Holčík 1990). The preference of the huchen for particular fish species is a function of the quantitative and qualitative structure of the trophic base in the particular stream it inhabits (Holčík et al. 1988). Salmonids (12.3%) and cyprinids (79.4%) were the main food items consumed by *H. hucho* in the upper course of the Dunajec River, while it only preyed upon rheophilous cyprinids (93.1%) and cottids (6.9%) in the middle course of the river (Witkowski and Kowalewski 1984). For this salmonid, habitat type had a greater impact on the size and composition of the diet than did taxonomy (Keeley and Grant 2001).

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