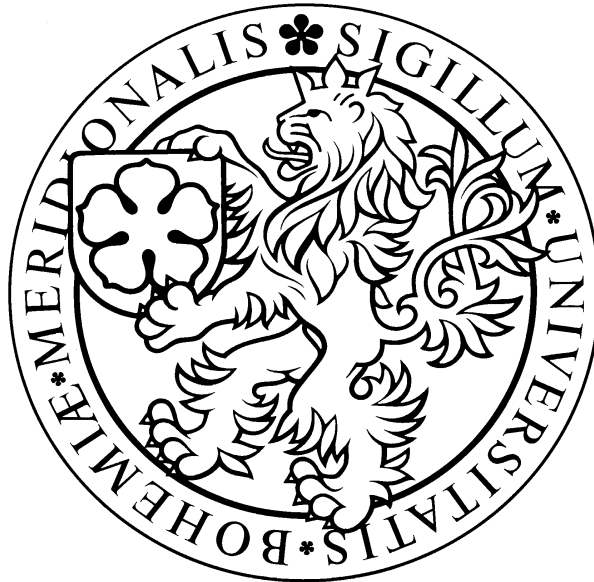


Fish community in man-impacted cascade reservoirs on the Vltava River

Vladislav Draštík

A wide, calm river flows through a landscape. In the background, a small town with red-roofed houses is nestled among green trees and hills. The sky is a clear, pale blue. In the foreground, a wooden pier extends into the water, with a small white sign on top.

University of South Bohemia
Faculty of Science



Fish community in man-impacted cascade reservoirs on the Vltava River

Ph.D. Thesis

Vladislav Drašík

Supervisor: Doc. RNDr. Jan Kubečka, CSc.
Biology Centre of the AS CR, v.v.i., Institute of Hydrobiology

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Annotation

Ichthyofauna with emphasis on fish fry community was studied in cascade reservoir complex of the Vltava River. Fish spatial distribution and species composition was observed along longitudinal axis of Kamýk, Slapy, Štěchovice and Vrané reservoirs using hydroacoustic, trawling and beach seining.

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Vladislav Draščík

Declaration of originality

Coauthors listed below fully acknowledge that Vladislav Drašík is the first author of all papers presented here. Also he did the major contribution in data processing and writing the manuscripts. All papers contain original results and are published or submitted to renowned international journals. The coauthors support this statement with their signatures.

Doc. RNDr. Jan Kubečka, CSc.

Doc. RNDr. Josef Matěna, CSc.

RNDr. Martin Čech, Ph.D.

Ing. Jaroslava Frouzová, Ph.D.

Mgr. Mojmír Vašek, Ph.D.

RNDr. Jiří Peterka, Ph.D.

RNDr. Marie Prchalová

Mgr. Milan Říha

Mgr. Tomáš Jůza

Bc. Oldřich Jarolím

Mgr. Michal Kratochvíl

Mgr. Michal Tušer

RNDr. Tomáš Mrkvička, Ph.D.

Ing. Pavol Šovčík

RNDr. Milan Hladík, Ph.D.

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Curriculum vitae

Vladislav Drašík was born on 10 November 1978 in Pardubice, Czech Republic. In 1997 he finished the final exams at Gymnazium of Josef Ressel (secondary school) in Chrudim and attended the University of South Bohemia, Faculty of Biological Sciences in České Budějovice. In 2000 he defended the thesis focused on “Avoidance reaction of fish to surveying vessel” (Supervisor: Dr. Jan Kubečka) and achieved bachelor degree (B.Sc.) at the same university. He continued in the same topic and received master degree (M.Sc. – diploma in Ecology) after defending thesis focused on “Fish avoidance of acoustic survey boat in shallow waters” (Supervisor: Dr. Jan Kubečka) in 2003. Since 1998 till 2003, he was employed at the Hydrobiological Institute, Academy of Sciences of the Czech Republic (HBI AS CR) in České Budějovice as a student assistant worker. He participated in scientific research of many freshwater reservoirs in the Czech Republic, Netherlands and Austria, being engaged in assessment of fish stocks using hydroacoustics. In 2002 he participated in project FISHSTRAT of European Union aimed on research in tropical reservoirs and introducing hydroacoustic methods to the scientist from Thailand, Sri Lanka and Philippines. In 2003 he started his Ph.D. at the University of South Bohemia, Faculty of Science with Ph.D. thesis focused on “Fish community in man-impacted cascade reservoirs on the Vltava River”. Since the same year, he has worked as a scientific and developmental worker of the Department of Plankton and Fish Ecology of the HBI AS CR. His scopes of interest include ecology of fish in cascade reservoirs especially fish distribution and behaviour and acoustic assessment of fish in lakes and reservoirs and cooperating in development of post-processing software for acoustic data (more info: <http://www.hbu.cas.cz/fishecu/staffmembers/drastik.html>). Vladislav Drašík has been a member and of the Czech Fishing Union since 1986.



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- Paper II Draštík V., Kubečka J., Tušer M., Čech M., Frouzová J., Jarolím O. & Prchalová M. 2008. The effect of hydropower on fish stocks: comparison between cascade and non-cascade reservoirs. *Hydrobiologia* (in press) 22
- Paper III Draštík V., Kubečka J., Jůza T., Jarolím O., Hladík M., Kratochvíl M., Prchalová M., Říha M. & Tušer M. 2006. Fish diversity and spatial distribution of YOY fish in Vltava cascade reservoirs. *Biodiversity of fishes of the Czech Republic VI*: 29-34 (in Czech with English summary) 38
- Paper IV Draštík V., Kubečka J., Čech M., Frouzová J., Říha M., Jůza T., Tušer M., Jarolím O., Prchalová M., Peterka J., Vašek M., Kratochvíl M., Matěna J. & Mrkvička T. 2008. Hydroacoustic estimates of fish stocks in temperate reservoirs: day or night surveys? *Aquat. Living Res.* (submitted) 44

Fish community in man-impacted cascade reservoirs on the Vltava River

Introduction

Canyon-shaped dam reservoirs represent a special water ecosystem defined by well-developed abiotic and biotic gradients driven by the reservoir inflow. Many papers have been published focused on describing these gradients; i.e. the total phosphorus (Hejzlar & Vyhnálek 1998; Hejzlar et al. 2000), phytoplankton and zooplankton density (Nakashima & Leggett, 1975; Fernandez-Rosado et al., 1994; Sed'a & Devetter, 2000; Fernandez-Rosado & Lucena 2001). Fish distribution reflects these gradients also. Several authors described the strict patterns in fish distribution on the longitudinal profile of the reservoir sampled by using hydroacoustics, gillnets or other fishing gear (Siler et al., 1986; Fernando & Holčík, 1991; Świerowski, 2000; Vašek et al., 2003; Vašek et al., 2004 and 2006; Prchalová et al., 2008).

Fish abundance and biomass appeared to decline along the longitudinal axis of the reservoir with their maximums in the tributary area (Siler et al., 1986; Świerowski, 2000; Vašek et al., 2003; Vašek et al., 2004; Matthews et al., 2004). These distribution patterns are common for temperate reservoirs during summer season. Tributary area is usually very eutrophic in summer and trophic level declines towards the dam (Straškraba, 1998; Lind et al., 1993). Exceptions could be the local flood events when the spatial distribution of adult fish becomes more random. However, complete flush out of the existing community of fish fry from the upper part of the reservoir was reported after the flood event (Čech et al. 2007a). The reservoir tributary was described as an important area for the reservoir fish for two reasons: it represents the most productive part of the reservoir on a longitudinal trophic gradient and it forms an important area for fish reproduction (Vostradovský, 1974; L'Abée-Lund & Vøllestad, 1987; Lucas & Baras, 2001; Hladík & Kubečka, 2003). High abundance of fish fry was observed here in late summer (Vašek et al., 2003; Vašek et al., 2004).

Fish species composition in canyon-shaped reservoirs in the Czech Republic is usually dominated by cyprinids that can form up to 93% of overall fish stock (Vašek et al., 2004; Vašek et al., 2006; Prchalová et al., 2008). Main species are roach (*Rutilus rutilus*), bream (*Abramis brama*) and bleak (*Alburnus alburnus*) complemented by small proportion of perch (*Perca fluviatilis*). Such a composition represents the climax state in a fish succession in reservoirs (Kubečka, 1993a). The cyprinid phase was found to have a great resistance and resilience in time (Říha, 2008).

Special cases of canyon-shaped reservoirs represent the reservoirs in a cascade complex, i.e. reservoirs on the Vltava River. These reservoirs were built one immediately after another, there is no river section between them. Locations of reservoirs and their hydropower generating use resulted in a different hydrological regime than that is common for other canyon-shaped reservoirs. The outflow of an upstream reservoir highly influences the limnology of downstream reservoir.

Usually hypolimnetic water is being released which alters the temperature and oxygen profiles and stability of summer stratification in the downstream reservoir (Straškraba & Javornický, 1973; Straškraba et al., 1973; Hrbáček, 1984; Vostradovský, 1990; Baruš et al., 1997; Prokeš et al., 1998; Prokeš et al., 1999; Straškraba & Hocking, 2002). Together with a daily water level fluctuation and short retention time, it causes the overall decrease of good ecohydrological status in the tributary zone or even in whole reservoir (compensatory reservoirs). The tributary zone serves as important spawning area for reservoir fish (Vostradovský, 1974; L'Abée-Lund a Vøllestad, 1987; Lucas a Baras, 2001; Hladík a Kubečka, 2003).

Releasing of cold and low oxygen saturated water from the hypolimnion of the upstream reservoir and the daily water level fluctuation form an inconvenient environment for fish reproduction and for surviving and growth of fish fry. Even large fish kills have been reported, caused by oxygen deficits at the end of summer in small cascade reservoirs (Trnka, dam keeper of Kamýk Reservoir, pers. comm.). The saturation of oxygen was lowered by more than 50% in the tributary of the Slapy Reservoir after filling the upstream reservoir. Similar decrease was reported for temperature. The difference in surface temperature before and after filling the upstream reservoir was more than 6 degrees of Celsius during vegetation season (Straškraba et al., 1973). Primary production also decreased significantly (Javornický & Komárková, 1973; Hrbáček, 1984). The above mention events have a fundamental influence on fish community in the cascade reservoirs.

Unfortunately compared with other canyon-shaped reservoirs there is a very limited knowledge about fish community in the cascade reservoirs in the Czech Republic. Only available information is known about the assessment of angler's catches (Jankovský, 2007) and inshore community sampled by beach seines and lift nets (Hanel & Čihař, 1983; Hanel 1988). The fish stock of the Slapy Reservoir consisted of roach (42%), ruffe (*Gymnocephalus cernuus*, 28%) and perch (24%) in adult fish abundance. Considering fish fry the fish stock was dominated by roach (51%) and perch (31%) in abundance. Recently the early fry community was studied in the longitudinal and vertical profile of the Slapy Reservoir (Jůza et al., 2006, Čech et al., 2005 and 2007b). This rather qualitative and miscellaneous information indicates the fish stock with balance of percids (mainly perch,) and cyprinids (mainly roach and bleak), simultaneously with low proportion of bream. This composition was affiliated to the 'transient' type of fish fauna, which is quite rare in Central Europe compared to widespread cyprinid-dominated fauna (Kubečka, 1993a).

Results

This Ph.D. thesis consists of four chapters – three papers already published (paper I, paper II, paper III) and one submitted (paper IV) to scientific journals.

Paper I

Hydrology and angler's catches in the Czech reservoirs

Draštík, V., Kubečka, J. & Šovčík, P. 2004. Hydrology and angler's catches in the Czech reservoirs. *Ecohydrology & Hydrobiology* 4: 429-439

Anglers catch statistics is used to examine the fish species composition in 15 Czech reservoirs with different ecohydrological conditions. Three groups of reservoirs were defined: 1. reservoirs with relatively natural regime ("natural reservoirs"), 2. cascade reservoirs and 3. reservoirs with extreme power generating use ("extreme reservoirs"). Two ordination analyses revealed differences between reservoirs. Fish species composition in cascade reservoirs differs from other types of reservoirs. Extreme reservoirs have much higher stocking rate of cyprinid species than other reservoirs. Stocking could 'recover' fish species composition even in reservoirs with very disturbed ecohydrological conditions, so the angler's catch composition is similar to 'natural reservoirs'. Bream/perch ratio in the angler's catch was found to be good criterion to differentiate between the reservoirs types. It is negatively correlated with water level fluctuation and positively correlated with retention time. Cascade reservoirs have bream/perch ratio below one, usually between 0.5 – 0.1 (2-10 times more perch). Ecohydrological disturbances can alter the fish stock succession from natural tendency to cyprinid-dominated fish stock (eutrophic conditions) to perch dominance (mesotrophy).

Paper II

The effect of hydropower on fish stocks: comparison between cascade and non-cascade reservoirs

Draštík V., Kubečka J., Tušer M., Čech M., Frouzová J., Jarolím O. & Prchalová M. 2008. The effect of hydropower on fish stocks: comparison between cascade and non-cascade reservoirs. *Hydrobiologia* (in press)

Spatial distributions of fish were studied in two types of reservoir by means of hydroacoustics during the summer season. Different patterns of fish distribution were found in non-cascade (Římov, Želivka) and cascade (Kamýk, Slapy, Štěchovice, Vrané) reservoirs. Maximum biomass and density of fish were observed in the tributary area of the non-cascade reservoir. The biomass declined towards the dam area. Average weight of fish showed the opposite

trend – maximum average weight was observed in the dam area and declined towards the tributary area. In the cascade reservoirs fish distribution was found to be more complicated but the maximum biomass and density of fish were observed in the dam areas whereas the tributary areas were nearly fishless. Poor ecohydrological conditions in the tributaries of cascade reservoirs are likely to be responsible for the low abundance of fish in these areas. This was evident in the example of Vrané Reservoir which has two major inflows. Low biomass and density of fish were observed in the cold and low oxygen saturated inflowing cascade the Vltava River while higher biomass and density were observed in the warm and well oxygen saturated the Sázava River inflow. Average weights of fish followed the same trend as in non-cascade reservoirs – the maximum was in the dam area and it declined towards the tributary area. The vertical distribution of fish is driven by the fully developed stratification of temperature and oxygen during the summer season in non-cascade reservoirs. A significantly lower biomass of fish was observed below the thermocline in vertical surveys in both non-cascade and cascade reservoirs. Summer stratification in cascade reservoirs is weakly developed or is not developed at all due to hypolimnetic releases of cold water and short retention times. High transparency suggests lower primary production in cascade reservoirs.

Paper III

Fish diversity and spatial distribution of YOY fish in Vltava cascade reservoirs

Drašník V., Kubečka J., Jůza T., Jarolím O., Hladík M., Kratochvíl M., Prchalová M., Říha M. & Tušer M. 2006. Fish diversity and spatial distribution of YOY fish in Vltava cascade reservoirs. *Biodiversity of fishes of the Czech Republic VI*: 29-34 (in Czech with English summary)

Fish communities of YOY were studied in four cascade reservoirs by beach fry-seining and fry trawling. Highest fish fry density was found in Slapy and Vrané reservoir. Lowest density was found in Kamýk and Štěchovice reservoir, two small reservoirs with shortest retention time, lowest oxygen concentration and temperature. Pelagic fish fry assemblages had much lower density than littoral assemblages and follow general fish longitudinal gradient. Littoral assemblages were more difficult to interpret due to more factors which can play important role in fish fry spatial distribution (such as bottom substrate and slope, complexity of shoreline, availability of water vegetation). Cyprinid species (bleak (*Alburnus alburnus*), roach (*Rutilus rutilus*), bream (*Abramis brama*)) prevailed in most reservoirs, only in Kamýk reservoir percid species (perch (*Perca fluviatilis*), ruffe (*Gymnocephalus cernuus*)) prevailed. – in Czech with English summary.

Paper IV

Hydroacoustic estimates of fish stocks in temperate reservoirs: day or night surveys?

Drašník V., Kubečka J., Čech M., Frouzová J., Říha M., Jůza T., Tušer M., Jarolím O., Prchalová M., Peterka J., Vašek M., Kratochvíl M., Matěna J. & Mrkvička T. 2008. Hydroacoustic estimates of fish stocks in temperate reservoirs: day or night surveys? *Aquat. Living Res.* (submitted)

Day and night acoustic surveys were used to compare fish stock estimates at eight European reservoirs and one flooded mining pit. Distinctions were noted in trophic status, retention time, transparency, species composition and reservoir use. More fish were observed by horizontal beaming than by vertical beaming either during the day or at night. Fish were present in the epilimnion (water column above the thermocline) during summer period. Volume scattering coefficient (sv), fish biomass, abundance and average fish weight were found to be different during the day and night. On average, sv and fish biomass were three times higher and fish abundance and average fish weight were two times higher at night than during the day at four studied reservoirs. On the other hand, acoustic estimates of sv and fish biomass were ten times higher and fish abundance and average fish weight were three times higher during day than at night at three reservoirs.

At three studied waterbodies fish size distributions were found to be different between day and night. A higher proportion of 1+ and older fish was found during the day at two reservoirs; it was higher at night at the flooded mining pit. In general, it is not possible to decide whether day or night acoustic surveys give more reliable fish stock assessments. Both day and night surveys gave accurate fish estimates at different reservoirs. So we advise performing both. For a complete fish assessment it is very desirable to accomplish acoustic mobile surveys by direct capture at least for the most problematic points – estimation of small fish and surveys in tributary zones (gillnets, trawls, purse seines) and estimation of littoral fish assemblages (beach seines).

Conclusion and perspective

The submitted Ph.D. thesis represents the first holistic assessment of fish fauna performed at the lower part of the Vltava River cascade complex. Fish distribution was studied on longitudinal (tributary-dam), transversal (littoral-open water) and vertical (epilimnion-hypolimnion) reservoir axes and compared with results from other canyon-shaped reservoirs in the Czech Republic.

First step in the evaluation of fish fauna in cascade reservoirs was to analyse angler's catch statistics. Despite the angler's catch statistics are highly selective (Pivnička, 1985), it is still possible to reflect the differences in available fish stock. Ordination methods distinguished cascade reservoirs from other Czech reservoirs in terms of fish species composition. Further

analyses revealed higher proportion of perch at expense of cyprinids (bream and roach) that is likely to reflect higher proportion of perch in fish stock of cascade reservoirs than is common in other Czech reservoirs. Similarly the bream/perch ratio was found below 1 (1 equals same bream as perch biomass) at cascade reservoirs while it was above 1 at other reservoirs. Long-term course of bream/perch ratio showed great decline after filling the upstream reservoir. Relative decrease of bream connected with increase of roach and perch was reported at the Slapy Reservoir comparing their abundance and biomass before and after filling the upstream Orlík Reservoir (Hanel & Čihař, 1983; Hanel, 1988).

Spatial distribution of fish was observed by means of hydroacoustics. Considering vertical pattern of fish distribution the majority of fish were located above the thermocline in the epilimnion, which is a well-known feature of fish behaviour in stratified reservoirs (Kubečka & Wittingerová, 1998; Matthews et al., 2004; Vašek et al., 2004). The fish were not distributed randomly in reservoirs. Different patterns were found at the cascade and other canyon-shaped reservoirs. Fish distribution gradients were described along longitudinal axis with maximum abundance and biomass in the tributary area (Vašek et al., 2003; Vašek et al., 2004; Matthews et al., 2004; Prchalová et al., 2008). At non-cascade reservoirs, the dam area was found as poorest on fish. The average fish weight showed opposite pattern with maximum in the dam area. On the other hand, at all cascade reservoirs high fish abundances and biomasses were observed in the dam area while tributary and upper parts were usually found to be very poor on fish. The average fish weight followed the same pattern as at other canyon-shaped reservoirs with maximum in the dam area. Generally, fish seemed to avoid the most hostile environment in the tributary area and preferred more convenient conditions in lower reservoir parts (dam area) or in second non-cascade inflow if available (Vrané Reservoir).

The Vltava River catchment was hit by a catastrophic flood in 2002 (Brazdil et al., 2006), which brought a number of allochthonous fish (Rutkayová et al. 2006). The flood shifted adult fish communities, so it was decided not to sample adults by the direct capture in 2004. The effort was concentrated on the fry community, which reflected the reproduction conditions for fish in the reservoir rather than the effect of flood. Great variability was observed in the littoral fish fry among studied reservoirs. While fish fry was dominated by percids (perch and ruffe) in one compensatory reservoir (Kamýk Reservoir), cyprinids (roach and bleak) strongly dominated in other cascade reservoirs. In the main sampling year (2004) surprisingly abundant cyprinid community consisting of roach, bleak and partly bream was observed (Paper III, Jůza et al., 2006 and 2007). This fry fish composition was in contradiction with previous reports indicating smaller presence of cyprinids (Hanel & Čihař, 1983; Hanel, 1988). Surprisingly high proportion of cyprinid species over percids could be partly explained by an extremely favourable spawning condition after a filling of terrestrial vegetation in the tributary and littoral zones in the year of study. The water level of Slapy Reservoir was low in 2003 due to dam repairs allowing terrestrial vegetation to grow on suitable littoral. Flooding in 2004 allowed successful spawning of cyprinids and their high densities in 2004 are not usual for the Slapy Reservoir. Fish fry abundance in cascade reservoirs was found to be

comparable to other Czech reservoirs except of in compensatory reservoirs (Kamýk and Štěchovice) where it was very low.

The important question arose when we were performing hydroacoustic surveys. What time of the day is more appropriate for acoustic surveying, day or night? Results from day and night surveys didn't follow the same pattern at all studied reservoirs. At four reservoirs the night survey was found more accurate. The volume scattering strength (sv) and fish biomass were three times higher at night than in day survey. Volume scattering strength and fish biomass showed very good correlation. At three studied reservoirs the day survey gave better results with ten times higher estimates of sv and fish biomass. Also fish size distributions were found to be different. More 1+ and older fish were observed during day in the open water while they migrated to the shore or bottom for night (Kubečka, 1993b; Wolter and Freyhof, 2004; Jacobsen et al., 2004). Only at the flooded mining-pit more adults were recorded during night. It was more likely that adult fish formed big schools (Čech, Peterka and Říha, pers. comm.) in very clear water (transparency was 5.5 m) during day and could avoid be recording by hydroacoustics.

This PhD. thesis managed to answer some fundamental questions regarding the fish fauna at the reservoir cascade of the Vltava River and to compared these findings with the information of fish communities known from other canyon-shaped reservoirs in the Czech Republic. However, many other questions arose during the study. One of them is what is the true composition of adult fish? The analyses of angler's records gave just a rough guidance. A more precise assessment of adult fish community is required for better understanding. Sampling in both littoral and pelagic areas would provide a more detailed look into adult fish community and confirm (or not) the higher proportion of perch in fish species composition at the cascade reservoirs as was reported by previous studies (Hanel & Čihař, 1983; Hanel, 1988).

Another question is pointed on fry fish community. The dominance of cyprinids at three of four studied cascade reservoirs was in conflict with previous reports. What is a typical fry composition remains still unknown and should be the subject of further investigations. Was the year of study exceptionally poor for perch fry or is there an increasing trend of cyprinid fish in cascade reservoirs? Was the 2004 sampling year rather exceptional due to previous flooding or are the data well characterizing the fry in the cascade?

In recent two years a shift in zooplankton community was observed which could be an indirect indication of changes in fry community in Slapy Reservoir. The length of average biomass (Hrbáček, unpubl. data) of Cladocerans increased recently while the biomass remained on the same level. Copepods did not show any significant trend. It is a well-known fact that the main part of fish diet consists of the zooplankton in the first year of life (Gerking 1994). Finally more information about fish fauna could serve as background for the proper management of cascade reservoirs on the Vltava River. Combined perch and cyprinid and even a potential for salmonid (cold water) fish stocks could form attractive localities for sport fishing bringing diversity to the mostly cyprinid dominated reservoirs in the Czech Republic.

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Chapter I

Hydrology and angler's catches in the Czech reservoirs

Drašník, V., Kubečka, J. & Šovčík, P. 2004. Hydrology and angler's catches in the Czech reservoirs. *Ecohydrology & Hydrobiology* 4: 429-439

Hydrology and angler's catches in the Czech reservoirs

Vladislav Drašík¹, Jan Kubečka¹, Pavol Šovčík²

¹Hydrobiological Institute, Academy of Sciences of the Czech Republic,
Na Sádkách 7, 370 05 České Budějovice
e-mail: vladislav.drastik@bf.jcu.cz

¹Faculty of Biological Sciences, University of South Bohemia,
Branišovská 31, 370 05 České Budějovice, Czech Republic
e-mail: kubecka@hbu.cas.cz

²Mendel University of Agriculture and Forestry,
Zemědělská 1, 613 00 Brno, Czech Republic
e-mail: pavol.sovcik@email.cz

Abstract

Anglers' catch statistics are used to examine the fish species composition in 15 Czech reservoirs with different ecohydrological conditions. Three groups of reservoirs were defined: 1. reservoirs with a relatively natural regime ("natural reservoirs"), 2. cascade reservoirs and 3. reservoirs with extreme power generating use ("extreme reservoirs"). Two ordination analyses revealed differences between reservoirs. Fish species composition in cascade reservoirs differs from that in the other types. Extreme reservoirs have a much higher stocking rate of cyprinid species than other reservoirs. Stocking could 'recover' fish species composition even in reservoirs with very disturbed ecohydrological conditions, so the anglers' catch composition is similar to 'natural reservoirs'. Bream/perch ratio in the anglers' catch was found to be a good criterion to differentiate between the reservoirs types. It is negatively correlated with water level fluctuation and positively correlated with retention time. Cascade reservoirs have bream/perch ratio below one, usually between 0.5 - 0.1 (2 - 10 times more perch). Ecohydrological disturbances can alter the fish stock succession from natural tendency to cyprinid-dominated fish stock (eutrophic conditions) to perch dominance (mesotrophy).

Key words: angler's catch, fish species composition, PCA, RDA, bream/perch ratio, reservoirs.

Abstrakt

Druhové složení rybí obsádky bylo vyhodnoceno na základě úlovků sportovních rybářů z 15 českých nádrží lišících se svými ekohydrologickými podmínkami. Použity byly 3 skupiny nádrží: 1. nádrže s relativně normálním provozním režimem („přirozené nádrže“), 2. nádrže v kaskádě a 3. nádrže se silným hydroenergetickým využitím („extrémní nádrže“). Použití

dvou metod ordinačních analýz odhalilo rozdíly mezi nádržemi. Druhové složení rybí obsádky z kaskádových nádrží se odlišovalo od ostatních nádrží. Umělé nasazování kaprovitých ryb bylo zdaleka nejvyšší do extrémních nádrží. Umělé nasazování v těchto extrémních nádržích mohlo vytvořit podobné druhové složení rybí obsádky, takže složení úlovků sportovních rybářů se neodlišovalo od přirozených nádrží. Poměr cejna a okouna v úlovcích sportovních rybářů se ukázal být dobrým kritériem pro rozlišení mezi skupinami nádrží. Poměr cejna a okouna je negativně korelován kolísáním vodní hladiny a pozitivně s dobou zdržení. Kaskádové nádrže měli poměr cejna a okouna menší než 1, obvykle mezi 0,5 – 0,1 (2 – 10× více okouna než cejna). Narušení ekohydrologických podmínek může ovlivnit obvyklou sukcesi rybí obsádky od přirozených kaprovitými rybami dominovaných nádrží (eutrofní podmínky) zpět k dominanci okouna (mesotrofní podmínky).

Klíčová slova: úlovky sportovních rybářů, druhové složení rybí obsádky, PCA, RDA, poměr cejna a okouna

Author's contribution:

Vladislav Draštík is the first author of this paper. The share of her work is approximately 90%.

Chapter II

The effect of hydropower on fish stocks: comparison between cascade and non-cascade reservoirs

Drašník V., Kubečka J., Tušer M., Čech M., Frouzová J., Jarolím O. & Prchalová M. 2008. The effect of hydropower on fish stocks: comparison between cascade and non-cascade reservoirs. *Hydrobiologia* (in press, DOI: 10.1007/s10750-008-9393-1)

The effect of hydropower on fish stocks: comparison between cascade and non-cascade reservoirs

Vladislav Drašík^{1,2,*}, Jan Kubečka^{1,2}, Michal Tušer^{1,2}, Martin Čech¹, Jaroslava Frouzová¹, Olřich Jarolím^{1,2} & Marie Prchalová

¹ *Biology Centre of the AS CR, Institute of Hydrobiology, Na Sádkách 7, 370 05 České Budějovice, Czech Republic*

² *Faculty of Biological Sciences, University of South Bohemia, Branišovská 31, 370 05 České Budějovice, Czech Republic*

(*Author for correspondence)

Key words: abundance, biomass, cascade, longitudinal gradient, vertical and horizontal distribution

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Abstract

Spatial distributions of fish were studied in two types of reservoir by means of hydroacoustics during the summer season. Different patterns of fish distribution were found in non-cascade (Římov, Želivka) and cascade (Kamýk, Slapy, Štěchovice, Vrané) reservoirs. Maximum biomass and density of fish were observed in the tributary area of the non-cascade reservoir. The biomass declined towards the dam area. Average weight of fish showed the opposite trend – maximum average weight was observed in the dam area and declined towards the tributary area. In the cascade reservoirs fish distribution was found to be more complicated but the maximum biomass and density of fish were observed in the dam areas whereas the tributary areas were nearly fishless. Poor ecohydrological conditions in the tributaries of cascade reservoirs are likely to be responsible for the low abundance of fish in these areas. This was evident in the example of Vrané reservoir which has two major inflows. Low biomass and density of fish were observed in the cold and low oxygen saturated inflowing cascade Vltava River while higher biomass and density were observed in the warm and well oxygen saturated Sázava River inflow. Average weights of fish followed the same trend as in non-cascade reservoirs – the maximum was in the dam area and it declined towards the tributary area. The vertical distribution of fish is driven by the fully developed stratification of temperature and oxygen during the summer season in non-cascade reservoirs. A significantly lower biomass of fish was observed below the thermocline in vertical surveys in both non-

cascade and cascade reservoirs. Summer stratification in cascade reservoirs is weakly developed or is not developed at all due to hypolimnetic releases of cold water and short retention times. High transparency suggests lower primary production in cascade reservoirs.

Abstrakt

Prostorová distribuce ryb bylo studováno ve dvou typech nádrží pomocí akustických metod během letní sezóny. Rozdílné typy prostorového rozmístění ryb byly pozorovány v nekaskádových (Římov, Želivka) a kaskádových (Kamýk, Slapy, Štěchovice a Vrané) nádržích. V nekaskádových nádržích bylo maximum rybí biomasy a hustoty pozorováno v přítokové oblasti. Biomasa klesala směrem k hrázi. Průměrná rybí váha ukazovala opačný trend – nejvyšší byla pozorována v hrázové části nádrže a klesala směrem k přítoku. V kaskádových nádržích bylo prostorové rozmístění ryb komplikovanější, ale maximum rybí biomasy i hustoty bylo pozorováno vždy v hrázových částech zatímco přítoky byly skoro bez ryb. Důvody pro malou početnost ryb byly s největší pravděpodobností špatné ekohydrologické podmínky v těchto oblastech. Nejvíce zřejmé to bylo na příkladu nádrže Vrané, která má dva hlavní přítoky. Nízká rybí biomasa a hustota byla pozorována ve vltavském rameni se studenou a málo okysličenou vodou zatímco větší rybí biomasa a hustota byla pozorována sázavském rameni s prohřátou a dobře okysličenou vodou. Průměrná rybí váha sledovala stejný trend jako u nekaskádových nádrží – největší byla v hrázové části a klesala směrem k přítoku. Vertikální distribuce se řídila podle plně vyvinuté teplotní a kyslíkové stratifikace obvyklé během letní sezóny v nekaskádových nádržích. Podstatně menší biomasa ryb byla pozorována pod termoklinou během vertikálních průzkumů jak v nekaskádových tak v kaskádových nádržích. V kaskádových nádržích je často letní stratifikace málo vyvinutá nebo není vyvinutá vůbec v důsledku přitékání studené vody a krátké době zdržení.

Klíčová slova: hustota, biomasa, kaskáda, podélný gradient, horizontální a vertikální distribuce

Author's contribution:

Vladislav Draštík is the first author of this paper. The share of her work is approximately 90%.

Chapter III

Fish diversity and spatial distribution of YOY fish in Vltava cascade reservoirs

Draščík V., Kubečka J., Jůza T., Jarolím O., Hladík M., Kratochvíl M., Prchalová M., Říha M. & Tušer M. 2006. Fish diversity and spatial distribution of YOY fish in Vltava cascade reservoirs. *Biodiversity of fishes of the Czech Republic VI*: 29-34 (in Czech with English summary)

Biodiverzita ichtyofauny ČR (IV): 29-34 (2006)

DIVERZITA A PROSTOROVÁ DISTRIBUCE TOHOROČNÍHO PLŮDKU V NÁDRŽÍCH VLTAVSKÉ KASKÁDY

Fish diversity and spatial distribution of YOY fish in Vltava cascade reservoirs

Vladislav DRAŠTÍK, Jan KUBEČKA, Tomáš JŮZA, Oldřich JAROLÍM, Milan HLADÍK, Michal KRATOCHVÍL, Marie PRCHALOVÁ, Milan ŘÍHA, Michal TUŠER

Hydrobiologický Ústav, AV ČR, Na Sádkách 7, 370 05 České Budějovice

Jihočeská Univerzita, Biologická Fakulta, Branišovská 31, 370 05 České Budějovice

Summary

Fish communities of YOY were studied in four cascade reservoirs by beach fry seining and fry trawling. Highest fish fry density was found in Slapy and Vrané reservoir. Lowest density was found in Kamýk and Štěchovice reservoir, two small reservoirs with shortest retention time, lowest oxygen concentration and temperature. Pelagic fish fry assemblages had much lower density than littoral assemblages and follow general fish longitudinal gradient. Littoral assemblages were more difficult to interpret due to more factors which can play important role in fish fry spatial distribution (such as bottom substrate and slope, complexity of shoreline, availability of water vegetation). Cyprinid species (bleak (*Alburnus alburnus*), roach (*Rutilus rutilus*), bream (*Abramis brama*)) prevailed in most reservoirs, only in Kamýk Reservoir percid species (perch (*Perca fluviatilis*), ruffe (*Gymnocephalus cernuus*)) prevailed.

Souhrn

Rybí plůdkové společenstvo bylo studováno ve čtyřech kaskádových nádržích pomocí plůdkových záťahů a tralů. Největší hustota rybího plůdku byla pozorována v nádržích Slapy a Vrané. Nejmenší byla pozorována v nádržích Kamýk a Štěchovice, dvou malých nádržích s nejkratší dobou zdržení, nejnižší koncentrací rozpuštěného kyslíku a nejnižší teplotou vody. Pelagické plůdkové společenstvo dosahovalo výrazně nižších hustot než litorální a vykazovalo známý podélný gradient. Litorální společenstvo bylo mnohem hůře interpretovatelné kvůli více faktorům, které mohly hrát roli v prostorové distribuci plůdku (např. sklon a substrát dna, složitost břehové linie, přítomnost vodních či zatopených rostlin). Ve většině nádrží převládaly kaprovité druhy ryb (ouklej (*Alburnus alburnus*), plotice (*Rutilus*

rutilus), cejn (*Abramis brama*)) pouze v Kamýku převládaly okounovité ryby (okoun (*Perca fluviatilis*), ježdík (*Gymnocephalus cernuus*)).

Author's contribution:

Vladislav Draštík is the first author of this paper. The share of her work is approximately 90%.

Chapter IV

**Hydroacoustic estimates of fish stocks in temperate reservoirs:
day or night surveys?**

Drašník V., Kubečka J., Čech M., Frouzová J., Říha M., Jůza T., Tušer M., Jarolím O., Prchalová M., Peterka J., Vašek M., Kratochvíl M., Matěna J. & Mrkvička T. 2008. Hydroacoustic estimates of fish stocks in temperate reservoirs: day or night surveys? *Aquat. Living Res.* (submitted)

Hydroacoustic estimates of fish stocks in temperate reservoirs: day or night surveys?

V. Drašík^{1,2,*}, J. Kubečka^{1,2}, M. Čech¹, J. Frouzová¹, M. Říha^{1,2}, T. Jůza^{1,2}, M. Tušer^{1,2}, O. Jarolím^{1,2}, M. Prchalová^{1,2}, J. Peterka¹, M. Vašek¹, M. Kratochvíl^{1,2}, J. Matěna¹, T. Mrkvička^{1,2}

¹ *Biology Centre of the AS CR, Institute of Hydrobiology, Na Sádkách 7, 370 05 České Budějovice, Czech Republic*

² *Faculty of Science, University of South Bohemia, Branišovská 31, 370 05 České Budějovice, Czech Republic*

submitted to Aquatic Living Resources

Abstract

Day and night acoustic surveys were used to compare fish stock estimates at eight European reservoirs and one flooded mining pit. Distinctions were noted in trophic status, retention time, transparency, species composition and reservoir use. More fish were observed by horizontal beaming than by vertical beaming either during the day or at night. Fish were present in the epilimnion (water column above the thermocline) during summer period. Volume scattering coefficient (sv), fish biomass, abundance and average fish weight were found to be different during the day and night. On average, sv and fish biomass were three times higher and fish abundance and average fish weight were two times higher at night than during the day at four studied reservoirs. On the other hand, acoustic estimates of sv and fish biomass were ten times higher and fish abundance and average fish weight were three times higher during day than at night at three reservoirs.

At three studied waterbodies fish size distributions were found to be different between day and night. A higher proportion of 1+ and older fish was found during the day at two reservoirs; it was higher at night at the flooded mining pit. In general, it is not possible to decide whether day or night acoustic surveys give more reliable fish stock assessments. Both day and night surveys gave accurate fish estimates at different reservoirs. So we advise performing both. For a complete fish assessment it is very desirable to accomplish acoustic mobile surveys by direct capture at least for the most problematic points – estimation of small fish and surveys in tributary zones (gillnets, trawls, purse seines) and estimation of littoral fish assemblages (beach seines).

Keywords: hydroacoustics, abundance, biomass, horizontal diel migration, day and night survey, freshwater fish

Abstrakt

Denní a noční akustické průzkumy byly použity pro srovnání rybích odhadů v osmi evropských nádržích a v jednom zaplaveném dole po těžbě hnědého uhlí. Vodní plochy se lišily v trofii vody, dobou zdržení, průhledností, druhovým složením a funkcí nádrže. Více ryb bylo pozorováno při horizontální nastavení vysílače než při vertikálním jak ve dne tak v noci. Většina ryb byla přítomna v epilimniu (sloupec vody nad skočnou vrstvou) během letní sezóny. Objemový odrazový koeficient (sv), rybí biomasa, početnost a průměrná rybí váha se lišily během dne a noci. V průměru, sv a rybí biomasa byly 3× vyšší a početnost a průměrná rybí váha byly 2× vyšší v noci než během dne ve čtyřech nádržích. Na druhé straně, akustické odhady sv a rybí biomasy byly 10× vyšší a početnosti a průměrné rybí váhy byly 3× vyšší během dne než v noci ve třech nádržích.

Velikostní složení ryb ve dne a v noci se lišilo ve třech studovaných nádržích. Větší podíl 1+ a starších ryb byl pozorován během dne ve dvou nádržích; byl větší v noci v zatopeném povrchovém dole. Nakonec není možné z dostupných dat rozhodnout, jestli je spolehlivější denní či noční akustický průzkum. Jak denní tak noční akustické průzkumy dali spolehlivé odhady rybích obsádek v různých nádržích. Proto doporučujeme provádět oboje. Pro kompletní odhad rybí obsádky je velmi žádoucí doplnit akustické mobilní sledování přímými odlovnými prostředky, alespoň v nejproblematictějších místech – odhad malých ryb a průzkumy v přítokových zónách (tenatní sítě, traly, košelkový nevod) a dále odhady litorálního rybího společenstva (zátahy).

Klíčová slova: hydroakustika, početnost, biomasa, horizontální denní migrace, denní a noční průzkumy, sladkovodní ryby

Author's contribution:

Vladislav Draštík is the first author of this paper. The share of her work is approximately 90%.

