

**Distribution and density of pelagic 0+
fish in canyon-shaped reservoirs and
effectiveness of their sampling by fry
trawls**

Tomáš Jůza

University of South Bohemia
Faculty of Science



Distribution and density of pelagic 0+ fish in
canyon-shaped reservoirs and effectiveness of their
sampling by fry trawls

Ph.D. Thesis

Mgr. Tomáš Jůza

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

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Annotation

Patterns in 0+ fish distribution along longitudinal and depth profiles were studied in five canyon-shaped reservoirs in the Czech Republic. In two canyon-shaped and one shallow well-mixed reservoirs the efficiency of fry trawls was investigated during late summer for juveniles and in one canyon-shaped reservoir the efficiency of ichthyoplankton trawls was investigated during spring for larvae and early juveniles.

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In České Budějovice, 22 March 2011

Tomáš Jůza

Declaration of originality

Coauthors listed below fully acknowledge that Tomáš Jůza is the first author of all papers presented. Most of the processing as well as most of the statistical analysis were performed by Tomáš Jůza. He also did the major contribution in writing the manuscripts. All papers contain original results and are published or submitted to Czech or international journals. All coauthors hereby consent to the publication of the papers in dissertation of Tomáš Jůza and 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, Ph.D.

RNDr. Vladislav Draštík, Ph.D.

Mgr. Michal Kratochvíl

Mgr. Milan Říha

Mgr. Michal Tušer

RNDr. Oldřich Jarolím

Mgr. Eva Hohašová, Ph.D.

RNDr. Jaromír Sed'a, CSc.

RNDr. Jiří Žaloudík CSc.

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Photo by David Boukal

Curriculum vitae

Tomáš Jůza was born on 5 April 1981 in České Budějovice, Czech Republic. In 1999 he finished the final exams at Gymnazium of J. V. Jirsík (secondary school) in České Budějovice and attended the University of South Bohemia in České Budějovice, Department of Zoology. In 2003, he successfully defended his Bachelor theses (Growth of fish in different types of waters in the Czech Republic; supervisor Dr. Jindřich Novák) and since 2002 he has been employed in the Institute of Hydrobiology in České Budějovice (HBI AS CR). In 2006 he successfully defended his Master theses and passed final exams for the degrees of M.Sc. – diploma in Zoology. The Master theses was focused on “Sampling of open water fry communities by trawls“: supervisor Dr. Jan Kubečka. In 2006 he started his Ph.D. at the University of South Bohemia, Faculty of Science with Ph.D. focused on “Fry communities in reservoirs“. Since 2006 he has worked as scientific and developmental worker of the Department of Plankton and Fish Ecology (Fish Ecology Unit; www.fishecu.cz) of the HBI AS CR and with FishEcU team he participated in scientific research of many freshwater reservoirs and lakes in the Czech Republic, Netherlands, Austria, Germany, Spain and Puerto Rico. His scopes of interest include especially ecology of fish in reservoirs, fish ageing and fry and adult trawling.

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Distribution and density of pelagic 0+ fish in canyon-shaped reservoirs and effectiveness of their sampling by fry trawls.

Introduction

Study of fry communities is one of the most important requirements for understanding the fish communities as a whole. The knowledge of recruitment in each year is very important for prediction of the fish stock in the future and by return, the fry community reflects the adult fish community and indicates success of the natural reproduction (Slavík & Jurajda, 2001), which is usually closely connected with environmental conditions. For accurate assessment of different population parameters as growth rates, food habits, mortality and year-class strength throughout the first year of life a quantitative sampling program is essential (Nelson et al., 1968).

Fry communities in Czech reservoirs have been intensively studied in the inshore areas in summer of the first year of life (Vostradovský, 1965, Kubečka & Švátora, 1993, Jurajda et al., 1997, Jurajda & Regenda, 2004), however data from pelagic fry communities have been largely lacking. For understanding fry behaviour in reservoirs, knowledge of the fry density, species composition, length frequency distribution, spatial and temporal distribution and food preferences is essential not only in the inshore areas but in the large volumes of open water too.

Pelagic fry sampling is crucial especially during the early fry stages (ichthyoplankton) sampling (May-June), because many dominant fish species of reservoirs in the Czech Republic undergo the obligate pelagic phase during early ontogeny (larval – early juvenile) with percids being found in open water immediately after hatching and cyprinids, which migrate to the open water later (Matěna, 1995). Čech et al. (2005) discovered by combination of acoustic and direct sampling methods that in open water two distinct survival strategies of most numerous percid fry species can be used during the day – one group inhabiting the epilimnion (epipelagic fry) and another group migrating to the hypolimnion during the day (bathypelagic fry). Diel vertical migrations were observed in the subsequent studies using acoustic (Čech & Kubečka, 2006, Čech et al., 2007) and seem to persist for the most of the first season of perch life. Cyprinid fry do not undergo extensive vertical migrations and their daytime pelagic occurrence seems to be limited to larval period only. The densities of percid fry recorded by the acoustic methods and by direct capture by ichthyoplankton nets and

during day and night did not always correspond (Čech et al., 2005, Kratochvíl et al., 2010) and one of the most obvious explanation of potential underestimating of ichthyoplankton density in net catches in comparison with acoustic and in day catches in comparison with night ones could be avoidance reactions in front of the net.

Another important period in juvenile fish sampling is late summer of the first year of life (August-September). Besides different body length and ontogenetic period, the main ecological difference between ichthyoplankton stage introduced above and the fingerlings stage (fry are often called fingerlings during late summer period) is the absence of fingerling cyprinids in the pelagic zone during the day. Gliwicz & Jachner (1992) described horizontal migrations of fingerlings of some species between littoral and pelagic zones and discovered pelagic fry community at night. This community as a whole received only minimum attention till Vašek et al. (2006), who described the distribution and diet of fingerlings within the canyon-shaped reservoir. Quantitative information on fingerlings is at least as important as ichthyoplankton studies. Density of late summer fingerlings is likely a more reliable ecological parameter for prediction of the strength of particular year class compared to density of ichthyoplankton because fingerlings have undergone the critical period of early stages (Černý & Pivnička, 1973). Also at this period, unlike the larval period, species identification of fingerlings is relatively easy and reliable (Slavík & Jurajda, 2001). In addition, fingerlings are believed to have a significant grazing effect on zooplankton community (Mehner & Thiel, 1999, Romare & Bergman, 1999), which further validates the assessment of fingerlings species composition, density and distribution.

The first step for assessing pelagic fry communities is the standardization of sampling method and knowledge of efficiency of sampling tools (Noble, 1970). For sampling the early life stages of fry, ichthyoplankton trawl nets have been successfully used in many studies (Anderson et al., 1998, Čech et al., 2005, Claramunt et al., 2005, Kratochvíl et al., 2008), however the efficiency of these nets was not well understood. Trawl nets are, as the other sampling methods, potentially selective and their catchability depends on many factors. The most important factors influencing the efficiency of trawling are light intensity (Buijse et al., 1992), net size (Mous et al., 2002, Claramunt et al., 2005), fish body length (Godø et al., 1990, Gartz et al., 1999) and speed of towing (Itaya et al., 2007). As the fry grow during the first year of life, it is necessary to change the sampling tool design and because the ability to escape increases, fry trawls used in late summer for fingerlings sampling should have larger mouth opening and mesh size than trawls used earlier for ichthyoplankton sampling. The same way as ichthyoplankton trawls it is necessary to quantify the efficiency of these fry

trawls and find out the avoidance behaviour of fingerlings in late summer. Without the awareness of the efficiency of ichthyoplankton trawls and fry (fingerlings) trawls, obtained results are unreliable, ecologically difficult to interpret and have little practical utility in fisheries management.

During earlier sampling we discovered that using fry trawls we were able to catch robust samples of fry in the open water areas of different Czech reservoirs and we compared open water fry communities between different reservoirs, which can be characterized as a water bodies with one principal river tributary with pronounced longitudinal gradient of nutrients (Straškrabová et al., 1994, Hejzlar & Vyhnálek, 1998), phytoplankton (Desortová, 1998), zooplankton (Sed'a & Devetter, 2000) and adult fish (Vašek et al., 2004, Prchalová et al., 2008). Comparisons of pelagic fry communities between reservoirs of different types (cascade – more reservoirs constructed in cascade complex one immediately after another, non-cascade – separately standing reservoirs) and of different productivity regimes (mesotrophic, eutrophic) were made. In more detailed investigations we focused on pelagic fry community in a canyon-shaped Římov Reservoir during seven years period (change of species composition and density, spatial distribution, factors influencing density). A data summary on the pelagic fingerlings community was the first objective of my dissertation.

The second objective was to assess the efficiency of different fixed-frame trawls and evaluate this method as a quantitative tool for fish sampling during the first year of life. As described above, trawl efficiency depends on many factors and we tried to understand fry behaviour in mouth opening of the trawl both in larval and early juvenile stage in May and June and during fingerlings stage in August and September.

Results

This dissertation is composed of five papers – four papers already published (papers I, II, III and IV) and one paper submitted (paper V) to scientific journal.

Paper I – Sampling of the offshore fry fish communities of reservoirs by trawls

Jůza, T., Kubečka, J., Čech, M., Draštík, V., Jarolím, O., Peterka, J., Vašek, M. 2006.

Sampling of the offshore fry fish communities of reservoirs by trawls. *Biodiversity of fishes of the Czech Republic VI*: 71-78 (in Czech with English summary).

The offshore area of six Czech reservoirs was sampled by pelagic fry trawl (mouth size 3x3m) during late summer in 2003-2005 (mesh size 6,5mm in the mouth, 4mm in the cod end). The net was towed behind the research vessel of speed 1m/s⁻¹. In Římov, Želivka, Vrané and Slapy reservoirs cyprinids dominated in offshore area. The main species here were roach, bream and bleak. In Lipno and Nýrsko reservoirs percids dominated in offshore area (Lipno-pikeperch, Nýrsko-perch). In Římov reservoir, density differs strongly between years 2003 and 2005. Trawling in offshore areas revealed that almost all 0+ fish were caught in the surface stratum (0-3m depth). In reservoirs where percids and cyprinids occurred together, cyprinids dominated in 0-3m depth while percids usually prevailed in catches of 0+ fish from 3-6m depth. In ordinary canyon-shaped reservoir like Římov and Želivka the 0+ fish abundance decreased from the upstream end toward the dam, so the biggest abundance was in tributary area. In cascade reservoirs like Slapy and Vrané, the offshore area in tributary is almost without fish. The peak of abundance is more downstream and from this place, the trend is similar to non-cascade reservoirs.

Paper II – The efficiency of three fry trawls for sampling the freshwater pelagic fry community

Jůza, T., Kubečka, J. 2007. The efficiency of three fry trawls for sampling the freshwater pelagic fry community. *Fisheries Research* 85: 285-290.

Avoidance reactions of young-of-the-year fish assemblages were investigated in the offshore zone of three reservoirs in the Czech Republic during late summer. Pikeperch (*Stizostedion lucioperca*) strongly dominated in the Lipno Reservoir in 2003, bream (*Abramis brama*) and bleak (*Alburnus alburnus*) were the most abundant species in the Slapy Reservoir in 2004 and roach (*Rutilus rutilus*) and bleak dominated in the Želivka Reservoir in 2004 and 2005. Densities of fry ranged between 1.09 ind./100m³ in the Lipno Reservoir and 2.95 ind./100m³ in the Slapy Reservoir. In each reservoir, three trawl nets of different widths (dimensions 1.5mx3m, 3mx3m, 6mx3m) were used in the pelagic area at night. For each trawl the estimated fish density was determined as the catch per 100 m³ of water and was compared between all three trawls. The fish length frequency distribution was also compared between all the trawls. Day catches were much lower compared with those taken at night. Adult fish showed very clear avoidance of fry trawls. At night, no statistically significant differences in

estimated fry density, obtained by these trawls, were observed in any locality for any fish species, nor in the length distribution of important species between trawls. According to these results, the avoidance reactions of fry in the late summer (August, September), at night, are unimportant. At this time of year, nighttime pelagic trawling appears to be an effective method for quantitative fry sampling. We recommend the 3mx3m trawl for quantitative night sampling of the fry community as a good compromise between assured efficiency and relatively easy handling.

Paper III – Pelagic underyearling communities in a canyon-shaped reservoir in late summer

Jůza, T., Vašek, M., Kubečka, J., Sed'a, J., Matěna, J., Prchalová, M., Peterka, J., Říha, M., Jarolím, O., Tušer, M., Kratochvíl, M., Čech, M., Drašík, V., Frouzová, J., Hohausová, E., Žaloudík, J. 2009. Pelagic underyearling communities in a canyon-shaped reservoir in late summer. *Journal of Limnology* 68: 304-314.

The community of pelagic fish fry present during late summer was studied in the canyon-shaped and eutrophic Římov Reservoir, Czech Republic, using nighttime trawling over seven years. Cyprinid fish dominated in the open water area throughout the period investigated. The highest mean density of fry in the surface water layer was observed in 1999 (15 ind 100 m⁻³), the lowest in 2000 (0.1 ind 100 m⁻³). A pronounced spatial gradient in the distribution of fry was observed in the reservoir in all years, with the highest densities in the upstream area and the lowest densities near the dam. Occurrence of cyprinids was highest in the upper area, while percid fry were distributed more regularly throughout the horizontal gradient from the lower to upper areas of the reservoir. Vertically, the cyprinids were confined almost entirely to the near-surface water layer, whereas the percids dominated in the deeper strata (3-6 m depth) in all years investigated. Catches in the deepest layer sampled (between 6 and 9 meters) were only sporadic. No significant correlations between fry density and biotic or abiotic factors were observed during the seven years investigated, neither for the dominant fish species pooled together nor for separate fish species. The observed spatial gradients of fry density, both horizontal and vertical, are similar to spatial gradients of older fish. The longitudinal gradient of fry density seems to be a result of reservoir morphology (a gradient of the relative volume of the littoral) rather than other limiting biotic or abiotic factors.

Paper IV - The influence of the trawl mouth opening size and net colour on catch efficiency during sampling of early fish stages

Jůza, T., Čech, M., Kubečka, J., Vašek, M., Peterka, J., Matěna, J. 2010. The influence of the trawl mouth opening size and net colour on catch efficiency during sampling of early fish stages. *Fisheries Research* 105: 125-133.

The efficiency of different sized (0.5x2, 1x2, 2x2, 4x2 m) and coloured (black, white) ichthyoplankton trawl nets and the densities of fry between day and night were investigated in the surface stratum of the Římov Reservoir (Czech Republic) during two surveys in mid-May and early June 2007. In mid-May, perch (*Perca fluviatilis*) was the most abundant fry species in the open water, whereas cyprinids (*Cyprinidae*) dominated two weeks later. Minor fry species in the trawl catches were pikeperch (*Sander lucioperca*) and ruffe (*Gymnocephalus cernua*) in both surveys. The comparison of fry densities during day and night revealed significantly higher day densities for the dominant perch and cyprinids, whereas for pikeperch and ruffe significantly higher densities were observed during the night. No significant differences in efficiency and body lengths of the fry sampled were found for any taxa when black and white trawl nets were compared. Comparison of the efficiencies of different sized trawl nets revealed different patterns for the dominant perch and cyprinids during both day and night. For perch, the lowest efficiency was observed for the smallest trawl, whereas the greatest efficiency was observed for the largest trawl net. The efficiencies were significantly different between trawls during day and night only for perch. For cyprinids, the efficiencies of different sized trawl nets were insignificantly different during both day and night. For pikeperch and ruffe similar trends in efficiency of different sized trawl nets were revealed. The lowest efficiency was reached with the smallest trawl but during the day a significant decline in efficiency of the largest trawl was also observed. Our results indicate that for sampling perch fry during both day and night and for sampling ruffe and pikeperch fry, especially during the day, a trawl net with a 1 m² mouth is not sufficiently efficient and the density of these fry species is significantly under estimated with such small nets. The fry body lengths sampled by different sized trawl nets did not differ significantly.

Paper V - The influence of the trawl mouth opening size and net colour on catch efficiency during sampling of early stages of perch (*Perca fluviatilis*) and pikeperch (*Sander lucioperca*) in the bathypelagic layer of a canyon-shaped reservoir

Jůza, T., Čech, M., Kubečka, J., Vašek, M., Peterka, J., Kratochvíl, M., Frouzová, J., Matěna, J. 2011. The influence of the trawl mouth opening size and net colour on catch efficiency during sampling of early stages of perch (*Perca fluviatilis*) and pikeperch (*Sander lucioperca*) in bathypelagic layer of canyon-shaped reservoir. *Fisheries Research*, submitted.

The efficiency of different sized (0.5x2, 1x2, 2x2, 4x2 m) and coloured (black, white) ichthyoplankton trawl nets was investigated during daytime in the bathypelagic layer of the Římov Reservoir (Czech Republic) in late May 2008. Perch (*Perca fluviatilis*) and pikeperch (*Sander lucioperca*) were almost the only fry species in this layer. We did not find any significant differences between the densities of either species when black and white nets were compared. The same results were revealed from comparisons of different sized nets. No differences in body lengths were observed between the trawls compared. Our results indicate that during sampling with an ichthyoplankton trawl net, both perch and pikeperch fry are quite passive, without any avoidance behaviour in the bathypelagic layer.

General discussion, conclusions and perspectives

In most reservoirs cyprinids dominated pelagic fry community and typically fry densities were relatively low (several individuals per 100 m³ of water maximally). Between cascade and non-cascade reservoirs different pattern in fry spatial distribution was observed. In non-cascade reservoirs, the highest fry density was in tributary area, which is in agreement with common fish distribution in this type of reservoir (Fernando & Holčík, 1991, Vašek et al., 2004, Prchalová et al., 2008), whereas in cascade reservoirs tributaries are strongly influenced by cold, oxygen-poor water from the reservoir upper in the cascade, so these parts are usually very poor on fish. This is supported by hydroacoustic assessment conducted by Draščík et al. (2008). On vertical profile we did not observe any differences between non-cascade and cascade reservoirs. Most of fry occupied surface open waters, where they found suitable temperature, oxygen and food conditions.

Fry density and species composition in canyon-shaped Římov Reservoir differed strongly between years and we did not find any correlation between fry recruitment and biotic and abiotic factors, which can potentially influence fish reproduction and survival of fry. Instead of these factors, diurnal horizontal fry migrations (Bohl, 1980, Gliwicz & Jachner, 1992) in

combination with the morphology (change in littoral/open water ratio) of the reservoir in different parts along longitudinal profile can be the main reason of non-uniform fry distribution. The same trend described above was recorded on longitudinal reservoir profile for non-cascade reservoirs with highest fry density in tributary zone. Considering vertical pattern of distribution, the majority of fry were located above the thermocline in surface water stratum as has also been observed for adult fish in other stratified lakes and reservoirs (Vašek et al., 2004, Järvalt et al., 2005, Kahl & Radke, 2006). Spatial distribution of two dominant families of fry was different in the reservoir. Cyprinids preferred tributary area and surface water stratum, whereas percids dominated in middle part of the reservoir and in deeper stratum sampled between 3-6m.

Higher fry density should be expected using larger trawl, because for actively escaping fish is much easier to escape the trawl with smaller mouth opening (Mous et al., 2002). Because larger fish are better able to avoid the net (Wardle, 1993, Gartz et al., 1999), we also assumed that in case of avoidance behavior, larger fish should be captured by larger trawl. We did not observe any differences in efficiency and size distribution of different sized trawls for any of dominant species during fingerlings sampling in late summer nights. According to these results we concluded that night trawling for fingerlings seems to be quantitative.

At the turn of May and June in epipelagic (surface) layer, we observed no differences in density between ichthyoplankton trawls of different sizes for cyprinids both during day and night. Perch densities were significantly higher in the biggest trawl and were significantly lower in the smallest trawl both during day and night. Early stages of perch fry are apparently more active than early stages of cyprinid fry in epipelagic layer of the canyon-shaped reservoir and perch densities in many studies can be underestimated by using ichthyoplankton trawl with small mouth opening. No differences in efficiency were observed when white and black ichthyoplankton trawls were compared in epipelagic layer so it does not matter, which netting colour is used for ichthyoplankton sampling.

There were no significant differences between different sized trawls catches for bathypelagic community of perch and pikeperch, which suggests low gear avoidance ability of early fry stages in bathypelagic layer probably because of low temperature and extremely low light intensity. As well as in epipelagic zone, we did not observe any significant differences in efficiency of different coloured trawls in bathypelagic layer.

For any fry species no differences in length frequency distribution between trawls were found during trawling for ichthyoplankton both in epipelagic and bathypelagic layers.

This Ph.D. thesis addresses issues which are fundamental for understanding the fish stocks in reservoirs. We know that, with regard to the volume of pelagic zone, the pelagic fry community is a very important component of the fry community of whole reservoir and that we are able to sample this community with fry trawls. Thanks to the relatively small mouth opening of these fixed-frame trawls it is possible to sample in relatively narrow and shallow tributary areas to obtain data of fry distribution from all parts of reservoirs. We know that especially during late summer we sample quantitatively without any apparent avoidance behavior. In contrast, perch, which is very often the target pelagic fry species in lakes and reservoirs (Coles, 1981; Treasurer, 1988; Urho, 1996; Čech et al., 2007) can be underestimated significantly by using of ichthyoplankton trawl with small mouth opening in epipelagic layer.

While this research fulfilled its objectives, a numbers of possible areas of future research were identified.

A fundamental but very important issue addressed in this research is the variability of the fry community species composition and density. It is surprising how variable was the species composition of fry within the same reservoir in relatively stable population of adult fish (Říha et al., 2009) and how the density of fry can vary from year to year (Jůza et al., 2009). We tried to determine the unusually high fry density in 1999 and abnormally low fry density in 2000 by taking different biotic and abiotic factors into account but we were not able to explain the reasons for these highly variable recruitment patterns.

Pelagic fry community has apparently some day-to-day variation, which is very important to understand and using of data from even consecutive nights caused real problems in comparing the catch of fry and ichthyoplankton trawls of different size (Jůza & Kubečka, 2007, Jůza et al., 2010). This phenomenon should be investigated in the future by repetitive trawling in the same locality during more nights.

Since the data collection for this Ph.D. thesis, pelagic fry communities of many more reservoirs not only in the Czech Republic have been studied as very important limnological parameter. These (according to our results) reliable data lead to tackling the question how many fish would survive another important bottleneck during the juvenile stage, which is the first winter. One step would be to compare late summer data with next year data sampled by beach seine (Říha et al., 2008), gill nets (Prchalová et al., 2008) or eventually fry trawls (T. Jůza, unpublished data.).

Our results indicate that the density and biomass of fingerlings in late summer was usually relatively low. Data obtained by adult trawling in the same time in open water area of Czech reservoirs found adult bream and bleak to be relatively abundant (M. Říha, unpublished data) and it appears that fingerlings may play a more minor role as the factor shaping zooplankton community than anticipated.

All late summer trawling in our studies was done during the night. We of course attempted daytime trawling for fingerlings but we were much less successful. Future studies should explore if low efficiency of the fry trawl during the day was caused by better avoidance during the day (Buijse et al., 1992), by creating shoals during the day (Probst et al., 2009), which can escape the trawl more efficiently than individuals or by the real absence of the fry (especially cyprinids) during the day, which get into open water only at night (Gliwicz & Jachner, 1992).

It is obvious that comparative studies of pelagic and littoral fry communities are needed to provide information on fry species composition, density, length distribution and potential migrations. According to our results it appears that typically pelagic species are fry of roach, bream, bleak and pikeperch during the night but these data need direct comparison with data on species composition and densities of littoral fry communities obtained by beach seining or electrofishing from more reservoirs.

It is evident from this short enumeration of perspective “questions”, which arose during our open water sampling by fixed frame trawls that fish in our reservoirs still keep a lot of secrets and there are still many challenges to disclose them. On the other hand our understanding of fry pelagic communities will provide the basis for improved year-class strength and survival analyses during many significant periods of life such as ichthyoplankton, fingerlings and probably also yearlings. With regard to the general uncertainty about the efficiency of different sampling methods especially in ichthyological surveys of such large water bodies as reservoirs and lakes are (Kubečka et al., 2009), the results of this work showing close to quantitative sampling by frame trawls are very encouraging for filling the gap in knowledge in the ecology of open water fry and its ecological significance.

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Snímkování pelagických plůdkových společenstev ryb nádrží pomocí tralů

Sampling of the offshore fry fish communities of reservoirs by trawls

Tomáš JŮZA^{1,2}, Jan KUBEČKA^{1,2}, Martin ČECH^{1,2}, Vladislav DRAŠTÍK^{1,2}, Oldřich JAROLÍM^{1,2}, Jiří PETERKA^{1,2}, Mojmír VAŠEK^{1,2}

¹*Hydrobiologický ústav AV ČR, Na sádkách 7, 37005 České Budějovice*

²*Biologická fakulta, Jihočeská univerzita, Branišovská 31, 37005 České Budějovice*

The offshore area of six Czech reservoirs was sampled by pelagic fry trawl (mouth size 3x3m) during late summer in 2003-2005 (mesh size 6,5mm in the mouth, 4mm in the cod end). The net was towed behind the research vessel of speed 1m/s⁻¹. In Římov, Želivka, Vrané and Slapy reservoirs cyprinids dominated in offshore area. The main species here were roach, bream and bleak. In Lipno and Nýrsko reservoirs percids dominated in offshore area (Lipno-pikeperch, Nýrsko-perch). In Římov reservoir, density differs strongly between years 2003 and 2005. Trawling in offshore areas revealed that almost all 0+ fish were caught in the surface stratum (0-3m depth). In reservoirs where percids and cyprinids occurred together, cyprinids dominated in 0-3m depth while percids usually prevailed in catches of 0+ fish from 3-6m depth. In ordinary canyon-shaped reservoir like Římov and Želivka the 0+ fish abundance decreased from the upstream end toward the dam, so the biggest abundance was in tributary area. In cascade reservoirs like Slapy and Vrané, the offshore area in tributary is almost without fish. The peak of abundance is more downstream and from this place, the trend is similar to non-cascade reservoirs.

Volná voda šesti nádrží v České republice byla vzorkována pelagickými plůdkovými traly (velikost vstupního otvoru 3x3m) v průběhu léta v letech 2003-2005 (velikost ok tralu byla 6mm v ústí a 4mm v koncové části). Síť byla vlečena za lodí rychlostí 1m/s⁻¹. Ve volné vodě nádrží Římov, Želivka, Vrané a Slapy dominovaly kaprovité druhy ryb. Hlavními druhy zde byly plotice, cejn a ouklej. Na nádržích Lipno a Nýrsko dominovaly ve volné vodě

okounovité druhy ryb (Lipno-candát, Nýrsko-okoun). Na nádrži Římov se dosažené density plůdku výrazně lišily mezi roky 2003 a 2005. Téměř všechny tohoroční ryby byly loveny v hladinové vrstvě volné vody (0-3m). Na nádržích kde se okounovité a kaprovité ryby vyskytovaly současně dominovaly kaprovité ryby ve vrstvě 0-3m, zatímco okounovité ryby obvykle dominovaly v hloubce 3-6m. V běžných kaňonovitých nádržích jako Římov a Želivka klesala početnost tohoročních ryb od přítoku směrem ke hrázi, takže největší byla zaznamenána v přítokových částech nádrží. V kaskádových nádržích jako Slapy a Vrané byla volná voda přítokových částí nádrží prakticky bez ryb. Maximum početnosti bylo o něco níže po proudu a od tohoto místa byl trend podobný nekaskádovým nádržím.

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The efficiency of three fry trawls for sampling the freshwater pelagic fry community

T. Jůza^{a,b,*}, J. Kubečka^{a,b}

^aBiology Centre, Institute of Hydrobiology, Academy of Sciences of the Czech Republic, Na sádkách 7, 370 05 České Budějovice, Czech Republic

^bFaculty of Biological Sciences, University of South Bohemia, Branišovská 31, 370 05 České Budějovice, Czech Republic

*Corresponding author. e-mail: tomas.juza@seznam.cz

tel: +42 0602 190715, fax: +42 38 530 0248

Avoidance reactions of young-of-the-year fish assemblages were investigated in the offshore zone of three reservoirs in the Czech Republic during late summer. Pikeperch (*Stizostedion lucioperca*) strongly dominated in the Lipno Reservoir in 2003, bream (*Abramis brama*) and bleak (*Alburnus alburnus*) were the most abundant species in the Slapy Reservoir in 2004 and roach (*Rutilus rutilus*) and bleak dominated in the Želivka Reservoir in 2004 and 2005. Densities of fry ranged between 1.09 ind./100m³ in the Lipno Reservoir and 2.95 ind./100m³ in the Slapy Reservoir. In each reservoir, three trawl nets of different widths (dimensions 1.5mx3m, 3mx3m, 6mx3m) were used in the pelagic area at night. For each trawl the estimated fish density was determined as the catch per 100 m³ of water and was compared between all three trawls. The fish length frequency distribution was also compared between all the trawls. Day catches were much lower compared with those taken at night. Adult fish showed very clear avoidance of fry trawls. At night, no statistically significant differences in estimated fry density, obtained by these trawls, were observed in any locality for any fish species, nor in the length distribution of important species between trawls. According to these results, the avoidance reactions of fry in the late summer (August, September), at night, are unimportant. At this time of year, nighttime pelagic trawling appears to be an effective

method for quantitative fry sampling. We recommend the 3mx3m trawl for quantitative night sampling of the fry community as a good compromise between assured efficiency and relatively easy handling.

Únikové reakce plůdkových společenstev byly zkoumány v létě ve volné vodě tří nádrží v České republice. Candát obecný (*Stizostedion lucioperca*) dominoval na nádrži Lipno v roce 2003, cejn velký (*Abramis brama*) a ouklej obecná (*Alburnus alburnus*) dominovali na nádrži Slapy v roce 2004 a plotice obecná (*Rutilus rutilus*) a ouklej dominovaly na nádrži Želivka v letech 2004 a 2005. Density plůdku se pohybovaly v rozmezí 1.09 ind./100m³ na Lipně a 2.95 ind./100m³ na Slapech. Ve volné vodě každé nádrže byly v noci použity různě široké traly (rozměry 1.5mx3m, 3mx3m, 6mx3m). Pro každý tral byla spočítána dosažená denzita plůdku jako úlovek na 100 m³ vody a následně byla porovnána mezi všemi třemi traly. Také velikostní složení plůdku bylo porovnáno mezi všemi traly. Denní úlovky byly mnohem nižší ve srovnání s nočními. Dospělé ryby vykazovaly jasnou únikovou reakci před plůdkovým tralem. V noci nebyly zaznamenány statisticky průkazné rozdíly v dosažené denzitě různě velkých tralů na žádné lokalitě pro žádný druh a ani velikostní složení dominantních druhů plůdku se mezi jednotlivými traly nelišilo. Vzhledem k těmto výsledkům se zdají být únikové reakce plůdku v létě (srpen, září) v noci málo významné. V této části roku se noční plůdkové tralování jeví jako zcela kvantitativní metoda a doporučujeme proto 3mx3m trawl pro kvantitativní noční vzorkování plůdkových společenstev jakožto dobrý kompromis mezi zaručenou účinností a relativně snadnou manipulací.

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Pelagic underyearling communities in a canyon-shaped reservoir in late summer

Tomáš Jůza^{1,2,*}, Mojmír Vašek¹, Jan Kubečka^{1,2}, Jaromír Sed'a¹, Josef Matěna^{1,2}, Marie Prchalová¹, Jiří Peterka¹, Milan Říha^{1,2}, Oldřich Jarolím^{1,2}, Michal Tušer^{1,2}, Michal Kratochvíl^{1,2}, Martin Čech¹, Vladislav Draštík¹, Jaroslava Frouzová¹, Eva Hohausová¹, Jiří Žaloudík¹

¹ Biology Centre of the Academy of Sciences of the Czech Republic, 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

* corresponding author: e-mail: tomas.juza@seznam.cz

The community of pelagic fish fry present during late summer was studied in the canyon-shaped and eutrophic Římov Reservoir, Czech Republic, using nighttime trawling over seven years. Cyprinid fish dominated in the open water area throughout the period investigated. The highest mean density of fry in the surface water layer was observed in 1999 (15 ind 100 m⁻³), the lowest in 2000 (0.1 ind 100 m⁻³). A pronounced spatial gradient in the distribution of fry was observed in the reservoir in all years, with the highest densities in the upstream area and the lowest densities near the dam. Occurrence of cyprinids was highest in the upper area, while percid fry were distributed more regularly throughout the horizontal gradient from the lower to upper areas of the reservoir. Vertically, the cyprinids were confined almost entirely to the near-surface water layer, whereas the percids dominated in the deeper strata (3-6 m depth) in all years investigated. Catches in the deepest layer sampled (between 6 and 9 meters) were only sporadic. No significant correlations between fry density and biotic or

abiotic factors were observed during the seven years investigated, neither for the dominant fish species pooled together nor for separate fish species. The observed spatial gradients of fry density, both horizontal and vertical, are similar to spatial gradients of older fish. The longitudinal gradient of fry density seems to be a result of reservoir morphology (a gradient of the relative volume of the littoral) rather than other limiting biotic or abiotic factors.

Pelagické plůdkové společenstvo bylo studováno v létě v kaňonovité eutrofní nádrži Římov, Česká republika, za použití nočního tralování v průběhu sedmi let. Plůdek kaprovitých druhů ryb dominoval ve volné vodě v celém sledovaném období. Nejvyšší průměrná denzita plůdku v hladinové vrstvě byla zaznamenána v roce 1999 (15 ks./100 m⁻³), nejnižší v roce 2000 (0.1 ks./100 m⁻³). Zřejmý prostorový gradient v distribuci plůdku byl zaznamenán ve všech sledovaných letech s největší denzitou plůdku v přítokové části nádrže a naopak nejnižší u hráze. Výskyt kaprovitých druhů plůdku byl nejvyšší v přítokové části nádrže, zatímco plůdek okounovitých druhů byl přítomen pravidelněji na podélném profilu nádrže. Na hloubkovém profilu se plůdek kaprovitých druhů ryb vyskytoval téměř výhradně v hladinové vrstvě, zatímco plůdek okounovitých druhů ryb dominoval v hloubkové vrstvě 3-6 m ve všech sledovaných letech. Úlovky v nejhlubší sledované vrstvě (mezi 6 a 9 m) byly pouze ojedinělé. V průběhu sedmi let sledování nebyly pozorovány průkazné závislosti mezi denzitou plůdku a biotickými nebo abiotickými faktory ať už pro všechny druhy dohromady nebo jednotlivě. Pozorované prostorové gradienty denzit plůdku jak na podélném tak hloubkovém profilu nádrže jsou shodné s prostorovými gradienty starších ryb. Podélný gradient denzity plůdku se zdá být výsledkem morfologie nádrže (gradient relativních objemů litorálu) spíše než jiných limitujících abiotických a biotických faktorů.

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The influence of the trawl mouth opening size and net colour on catch efficiency during sampling of early fish stages

Tomáš Jůza^{1,2,*}, Martin Čech¹, Jan Kubečka^{1,2}, Mojmír Vašek¹, Jiří Peterka¹, Josef Matěna^{1,2}

¹ Biology Centre of the Academy of Sciences of the Czech Republic, 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

* corresponding author: e-mail: tomas.juza@seznam.cz, telephone: +420387775831
fax: +420385310248

The efficiency of different sized (0.5m x 2m, 1m x 2m, 2m x 2m, 4m x 2m) and coloured (black, white) ichthyoplankton trawl nets and the densities of fry between day and night were investigated in the surface stratum of the Římov Reservoir (Czech Republic) during two surveys in mid-May and early June 2007. In mid-May, perch (*Perca fluviatilis*) was the most abundant fry species in the open water, whereas cyprinids (*Cyprinidae*) dominated two weeks later. Minor fry species in the trawl catches were pikeperch (*Sander lucioperca*) and ruffe (*Gymnocephalus cernua*) in both surveys. The comparison of fry densities during day and night revealed significantly higher day densities for the dominant perch and cyprinids, whereas for pikeperch and ruffe significantly higher densities were observed during the night. No significant differences in efficiency and body lengths of the fry sampled were found for any taxa when black and white trawl nets were compared. Comparison of the efficiencies of different sized trawl nets revealed different patterns for the dominant perch and cyprinids

during both day and night. For perch, the lowest efficiency was observed for the smallest trawl, whereas the greatest efficiency was observed for the largest trawl net. The efficiencies were significantly different between trawls during day and night only for perch. For cyprinids, the efficiencies of different sized trawl nets were insignificantly different during both day and night. For pikeperch and ruffe similar trends in efficiency of different sized trawl nets were revealed. The lowest efficiency was reached with the smallest trawl but during the day a significant decline in efficiency of the largest trawl was also observed. Our results indicate that for sampling perch fry during both day and night and for sampling ruffe and pikeperch fry, especially during the day, a trawl net with a 1 m² mouth is not sufficiently efficient. The density of these fry species is significantly under estimated with such small nets. The fry body lengths sampled by different sized trawl nets did not differ significantly.

Účinnosti různě velikých (0.5m x 2m, 1m x 2m, 2m x 2m, 4m x 2m) ichtyoplanktonních tralů a ichtyoplanktonních tralů s různou barvou síťoviny (černá, bílá) a denzity ichtyoplanktonu v průběhu dne a noci byly sledovány v hladinové vrstvě nádrže Římov (Česká republika) v polovině května a na začátku června 2007. V polovině května byl nejhojnějším druhem ve volné vodě nádrže okoun říční (*Perca fluviatilis*), zatímco plůdek kaprovitých druhů ryb (*Cyprinidae*) dominoval o dva týdny později. Méně hojnými druhy v průběhu obou průzkumů byl plůdek candáta (*Sander lucioperca*) a ježdíka (*Gymnocephalus cernua*). Při porovnání denzit plůdku mezi dnem a nocí byly zaznamenány průkazně vyšší denní denzity plůdku dominantního okouna a kaprovitých druhů ryb, zatímco vyšší denzity plůdku candáta a ježdíka byly zaznamenány v průběhu noci. Pro žádný druh pelagického plůdku nebyly zaznamenány statisticky průkazné rozdíly v účinnosti ani ve velikostním složení mezi černým a bílým ichtyoplanktonním tralem. Porovnání účinnosti různě velikých tralů ukázalo rozdíly pro plůdek dominantního okouna a kaprovitých ryb v průběhu dne i noci. Nejnižší denzita okouna byla zaznamenána v nejmenším tralu, největší naopak v největším tralu. Účinnosti mezi traly byly během dne a noci průkazně odlišné pouze pro okouna. V případě plůdku kaprovitých ryb nebyly účinnosti dosažené různě velkými traly průkazně odlišné v průběhu dne a noci. Pro plůdek candáta a ježdíka byly zaznamenány podobné trendy v účinnosti různě velikých tralů. Nejnižší účinnost byla zaznamenána pro nejmenší tral, ale v průběhu dne byl zaznamenán výrazný pokles účinnosti největšího tralu. Naše výsledky naznačují, že pro vzorkování plůdku okouna v průběhu dne a noci a pro vzorkování plůdku ježdíka a candáta především ve dne není tral o velikosti vstupního otvoru 1m² dostatečně účinný. Denzita

plůdku těchto druhů je při vzorkování takto malými traly výrazně podhodnocena. Velikost plůdku se mezi různě velkými traly průkazně nelišila.

Tomáš Jůza is the first author of the manuscript. The share of his work is 80% approximately.

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Short communication

The influence of the trawl mouth opening size and net colour on catch efficiency during sampling of early stages of perch (*Perca fluviatilis*) and pikeperch (*Sander lucioperca*) in the bathypelagic layer of a canyon-shaped reservoir

Tomáš Jůza^{1,2,*}, Martin Čech¹, Jan Kubečka¹, Mojmír Vašek¹, Jiří Peterka¹, Michal Kratochvíl¹, Jaroslava Frouzová¹, Josef Matěna¹

¹ Biology Centre of the Academy of Sciences of the Czech Republic, 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

* corresponding author: e-mail: tomas.juza@seznam.cz, telephone: +420387775831
fax: +420385310248

The efficiency of different sized (0.5x2, 1x2, 2x2, 4x2 m) and coloured (black, white) ichthyoplankton trawl nets was investigated during daytime in the bathypelagic layer of the Římov Reservoir (Czech Republic) in late May 2008. Perch (*Perca fluviatilis*) and pikeperch (*Sander lucioperca*) were almost the only fry species in this layer. We did not find any significant differences between the densities of either species when black and white nets were compared. The same results were revealed from comparisons of different sized nets. No differences in body lengths were observed between the trawls compared. Our results indicate

that during sampling with an ichthyoplankton trawl net, both perch and pikeperch fry are quite passive, without any avoidance behaviour in the bathypelagic layer.

Účinnost různě velkých (0.5x2, 1x2, 2x2, 4x2 m) ichthyoplanktonních tralů a ichthyoplanktonních tralů s různou barvou síťoviny byla testována v průběhu dne v bathypelagické vrstvě nádrže Římov (Česká republika) na konci května 2008. Jedinými druhy plůdku, které se v této vrstvě vyskytovaly, byl okoun říční (*Perca fluviatilis*) a candát obecný (*Sander lucioperca*). Nezaznamenali jsme průkazné rozdíly v denzitách jednotlivých druhů mezi černými a bílými traly. Stejně výsledky byly zaznamenány také při porovnání účinnosti různě velkých tralů. Nebyly zaznamenány žádné rozdíly ve velikostech těla plůdku mezi různými traly. Naše výsledky naznačují, že při vzorkování ichthyoplanktonními tralovými sítěmi v bathypelagické vrstvě je plůdek okouna i candáta spíše pasivní bez zřejmých únikových reakcí.

Tomáš Jůza is the first author of the manuscript. The share of his work is 80% approximately



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