Oponentský posudek na doktorskou práci

Martin ČECH

Diel vertical migrations, distribution and ontogeny of bathypelagic layer of European perch, *Perca fluviatilis* L. in reservoirs

Biologická fakulta Jihočeské univerzity, České Budějovice 2006
(školitel Doc. RNDr. J. Kubečka, CSc.)

Jde o pozoruhodnou dizertaci založenou na čtyřech původních vědeckých pracech publikovaných (nebo přijatých do tisku) v kvalitních impaktovaných časopisech (kandidát je ve všech případech prvním autorem!) a přinášející nové originální poznatky z etologie okouna říčního během raného údobí života v podmínkách údolních nádrží na Malši (Římov) a Vltavě (Orlík a Slapy) za použití inovačních hydroakustických experimentálních technologií doplněných paralelními kontrolními odlovy plůdkového společenstva ve stejných termínech a mikrohabitatech pomocí vlečných sítí. Autor zjistil zejména, že synusie tohoročního plůdku okouna říčního se ve významném počtu vyskytuje i v hlubších vrstvách pelagiálu a že je tvořena jednak složkou realizující každodenně vertikální migrace v rozsahu mnoha metrů mezi hypolimniem a epilimniem, jednak složkou nemigrující, trvale se zdržující v epilimniu. Epipelagická složka při tom početně vysoce převažovala a v průběhu jednoho necelého měsíce (od května do června) se podíl této nemigrující složky dále výrazně zvyšoval (ze 72 na 95 %).

K dizertaci mám několik dotazů a poznámek:

Při podélném výzkumu nádrží „kaňonovitého" typu autor pozoroval, že abundance BPF v nejhořejší třetině nádrže výrazně ubývá a vysvětluje to jako důsledek „extrémně chladné hypolimnetické vody" přitékající do nádrže (str. 3). Platí toto tvrzení i pro ÚN Orlík? Neznám dobře místní situaci, ale je vůbec v ÚN Hněvkovice vytvořena teplotní stratifikace a je její dopad pro ÚN Orlík natolik výrazný? Není pozorovaný jev důsledkem případně i jiných příčin (např. úbytek trdlišť v horní úzké části nádrže, podélný splach plůdku z horních do níže položených částí nádrže)?

Je vysoce pravděpodobné, a vyplývá to i z některých v práci citovaných publikací, že vzorce chování během raných period ontogeneze ryb jsou vrozené, fixované během evoluce.

Potom je však nelogické očekávat, že by studovaná populace okouna reagovala na aktuální početnost dravců v konkrétním biotopu změnou vzorců chování během larválního a juvenilního období života jak se kandidát domnívá na str. 4.

Proč není ve výčtu alternativních vysvětlení „sympatrického" výskytu EPB a BPF uvažována i ontogeneze? Nabízí se vysvětlení, že fotofobie ranějších vývojových stadií projevující se preferencí míst (vrstev) s nižší intenzitou osvětlení, je u pokročilejších stadií vývoje vystřídána pozitivní fototaxí a trvalým přechodem do vrstev s vyšší hladinou osvětlení v epilimniu.

Několik poznámek terminologických:

Bathypelagic – toto označení se mi nejeví výstižné pro složku plůdku vyskytující se střídavě jak v hypolimniu i v epilimniu

Layer – termín je v práci používán ve dvojím významu, jednak jako horizontální vrstva prostředí nádrže vymezená hloubkou (viz např. str. 18), jednak jako kategorie cenologická (socioekologická) – jde patrně o žargon a míní se tím zřejmě ta část synusie YOY, která se vyskytuje v určité konkrétní „vrstvě vodního sloupce". Rozhodně ale v práci vysvětlení (definice) tohoto pojmu nebo případný odkaz na literaturu chybí.

Stage – v ontogenetické literatuře je u ryb zvykem používat tento termín pro okamžitý, velmi krátkodobý stav vývoje organizmu. V daném případě se mi jeví vhodnější termín „phase".

Ontogeny – (poznámka k nadpisu práce); ontogeneze předmětem dizertace vůbec nebyla a nebyly používány ani morfologické vývojové znaky k popisu stavu vývoje larev a juvenilních jedinců. To samozřejmě není vzhledem k hlavnímu zaměření práce na závadu ale pak by asi bylo správnější hovořit spíše o *sezonních* nežli o *ontogenetických* změnách, navíc formulace *„ontogeny of bathypelagic layer"* nedává příliš smysl!

Závěr

Předložená dizertace, vycházející z dlouhodobého fyzicky, organizačně i intelektuálně velmi náročného výzkumu, je velmi solidním důkazem o vědeckém enthusiasmu a o schopnostech doktoranda samostatně vědecky pracovat (ale i týmově spolupracovat),

formulovat pracovní hypotézy, precizně analyzovat, přesvědčivě kauzálně vysvětlovat a vhodně interpretovat získané výsledky. Dizertace svojí kvalitou plně vyhovuje všem stanoveným požadavkům. Proto doporučuji, aby po úspěšné obhajobě byl doktorandovi udělen titul Ph.D.

Brno, 18. dubna 2006

Ing. Milan Peňáz, DrSc.
Ústav biologie obratlovců AVČR
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Review

of the thesis by RNDr.Martin Čech presented to the Faculty of Biology in partial fulfilment of the requirements for the degree of Ph.D. in Biology

Diel vertical migrations, distribution and ontogeny of bathypelagic layer of European perch, Perca fluviaitlis L. fry in reservoirs

The presented thesis which is 75 pages in length is composed of five mutually interconnected parts . Of these the thesis proper extends to 14 pages and represents summary of two already published articles, and two additional manuscripts submitted for publication to *Journal of Fish Biology.* The goal of the thesis was to demonstrate the spatial distribution of the European perch juveniles in reservoirs, their abundance and size of individual fishes, as well as the diurnal vertical migrations and their causes.

European perch is both typical fish species inhabiting majority of European man-made lakes and the most abundant percid fish. Both acoustic and complementary net data (both littoral and pelagic) were collected. The acoustic investigation was carried out by SIMRAD EY 500 split-beam scientific echosounder, transducer SIMRAD ES120-7G and the system was controlled by a personal computer. The system was calibrated in order to detect the young-of-the-year fish including larvae. Specific determinations were conducted from samples obtained by the ichthyoplankton net sampling. The investigation was also performed in littoral, four times per day at dusk, in the daytime, at dawn and in the night. All data were collected from the canyon-shaped man-made lakes Římov, Slapy and Orlík.

Results obtained can be summarized as follows:

- In the pelagial of all reservoirs investigated the perch juveniles were dominant and the most numerous;
- After hatching the perch juveniles pass from the litoral to pelagial way of life;
- Shortly after hatching and transfer to exogenous diet perch juveniles are solitary, with increasing age and size they form shoals;
- The shoal instinct appears in the growing season and ceases in winter;
- Perch juveniles are found both in the epi- and bathypelagial;
- Bathypelagial juveniles performs diurnal vertical migrations: during the day they appear below the thermocline up to 17 m depth , in night they ascend above the thermocline up to the water-surface;

- The density of perch juveniles varies from 3,000 to 166,000 ind.ha^{-1} depending on the season and place;
- The form and the occupancy of the shoal is under the influence of water temperature;
- During the flood the former continuous longitudinal settling of the reservoir changes: the perch juveniles are washed downstream close to the reservoir dam and their place is taken over by the cyprinid fish juveniles flushed downstream from the reservoir littoral and the tributaries; during this time the perch juveniles appear in shoals in the epipelagial, but are solitary in the bathypelagial;
- The shoaling behaviour is caused by the ontogenetic changes, especially by the lateral-line development;
- The absence of predators or their negligible abundance suggests that the bathypelagic perch juveniles shoals are created as a result of a social need rather than as a defence against predators;
- Along with perch juveniles also the juveniles of the sander (*Stizostedion* lucioperca) and ruffe (*Gymnocephalus cernuus*) appear in the pelagial of the investigated reservoirs.

The results obtained by Martin Čech confirm the theory that the inland standing water bodies i.e. mad-made lakes and natural geologically young lakes are colonized by fishes only in case when in the given water body are found fishes of marine origin, which are pre-adapted for the lacustrine way of life. The exception are the canyon-shaped reservoirs in pelagial in which adults but not juveniles of riverine fish species may occur. This exception happens if in a given river basin the fish species of a marine origin are found. In the case of studied Czech reservoirs these are percid fishes which are of a marine origin. All three species are eurytopic, their reproduction is limited to the littoral but the juveniles after hatching move to the pelagial.

I have only few, more or less formal question and/or notes:

1. Are the simultaneously occurring littoral, epipelagic and bathypelagic juveniles limited to places of their colonization i.e. to littoral, pelagial and bathypelagial?
2. If yes, is it possible to distinguish them and to explain the reasons of specific colonization?

3. What is the difference between the solitary occurrence and the shoaling?
4. What is the reason of the increasing size of the perch juveniles towards tributary?
5. Although the term *fry* is common and used by many both Anglo-Saxon and other authors, I recommend to substitute it by the term *juvenile*. The latter has been proposed and is used by the Professor Eugene K. Balon, the world expert of the ontogenetic development of fish. To be precise, the term *fry* has been derived from the kitchen activity *to fry, to bake, to roast* and it generally refers to small sized fish (not only to the young one) prepared for the human consumption. The term *fry* in ichthyology is therefore slogan and not scientifically supported.
6. I understand that this type of work needs participation and collaboration of several colleagues both in field and in the laboratory. However, because the papers by Martin Čech already published or submitted for publication (including those which form the basis of his PhD thesis) have two and/or several co-authors my question is, **what is the share of Martin Čech work in the presented thesis ?**

The PhD thesis of Martin Čech is of high quality. It presents the whole series of valuable results usable both in theory and practice. At the same time it prompts further research to clarify questions raised during his investigation. Undoubtedly Martin Čech is knowledgeable and experienced researcher with a good grasp of literature and has also foreign-training experiences. He is well educated also in other areas of ichthyology as is demonstrated in the comprehensive list of references. In addition, the presented thesis also attests the high quality of the supervisor's Institution. I propose and recommend therefore to accept this PhD thesis by the doctoral committee and to grant Martin Čech the degree of *philosophiae doctor*.

In Bratislava, 2006-04-21

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Date: 25 April 2006

Review of the PhD thesis submitted by RNDr. Martin Čech, M.Sc.
"Diel vertical migrations, distribution and ontogeny of bathypelagic layer of European perch, *Perca fluviatilis* L. fry in reservoirs"

The PhD thesis presented by Martin Čech consists of four manuscripts plus a short summary of the main results including conclusions and an outlook. Two of the manuscripts have already been published after peer review, one in Journal of Fish Biology and one in Biologia Bratislava, while the other two have been submitted to Journal of Fish Biology.

The thesis focuses on a particular aspect of perch biology that had passed almost completely undetected up to now, the existence of a pelagic layer of perch fry below the thermocline, termed bathypelagic layer. Although a scattering layer had been observed earlier in reservoirs, and there was some evidence that it might be caused by larvae and juveniles of perch, Čech et al. (2005) were the first to show unequivocally that this layer was formed by perch fry. This was possible through the combined use of hydroacoustics and net catches, which in addition allowed following the diel vertical migration of this layer.

In the second paper (Čech & Kubečka, 2006), the bathypelagic perch fry layer was observed by hydroacoustics during an entire growing season. The onset of shoaling is suggested to be mediated by the development of the lateral line system, while the authors argue that the ultimate cause of shoaling is not a defence against predators but due to a "social need".

The third manuscript (Čech et al., submitted) describes the longitudinal distribution of the bathypelagic perch fry layer in two reservoirs. Abundance and size of the fry increased from the dam towards the tributary in both reservoirs, following the trophic gradient that increases in upstream direction in these reservoirs. Cold water from the main tributary seemed to limit the upstream distribution of fry in one reservoir. The tendency to aggregate in a compact layer and later to shoal increased with size of the fry.

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Finally, in the fourth manuscript (Čech et al., submitted), the impact of a flood event on the longitudinal distribution of epipelagic perch fry is analysed. This event completely flushed the fry community out of the riverine part of the reservoir, and it was not re-established afterwards. In the lower part of the reservoir, after the flood event, bathypelagic perch formed two layers. The upper layer was dominated by shoaling fish, while non-shoaling fish formed the lower layer. As perch fry did not differ in size between both layers, it remained unclear why they segregated into two distinct layers.

The studies realised by the candidate are well designed, he used the most advanced hydroacoustic technology and carried out the studies very thoroughly. The results obtained represent a significant advance in our knowledge of the early life history of perch, and they will surely stimulate fruitful discussions about the adaptive values of the observed distribution patterns. The papers and manuscripts are logically structured, they are generally well written and nicely presented. Martin Čech has thus demonstrated convincingly that he is fully able to perform up-to-date scientific studies in the field of fish ecology and that he can contribute significantly to the advancement in his area of expertise.

There are, nevertheless, some questions that I would like to address during the defence.

We see on page 24, Fig. 7, that the depth of the main layer of bathypelagic perch fry is quite strongly correlated with light intensity at the water surface, but the regression lines are different for both months. This might be due to differences in vertical light attenuation between both dates. How do the relationships look like, when light intensity at the depth of the main layer is used as the independent variable?

Perch fry seem to adopt three different strategies at a time (littoral, epipelagic, bathypelagic). I would suggest that this could only be an evolutionary stable strategy if either all three strategies are equally successful (which I think is extremely unlikely), or if one or the other strategy is more successful than the others in different years. What factors could render one or the other strategy more or less successful?

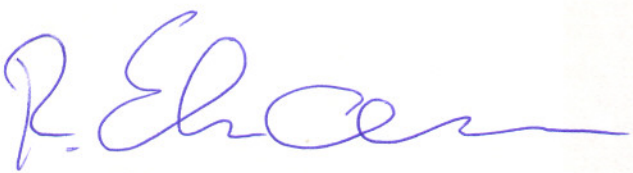
It is suggested on page 38 that shoal coherence is mediated by the development of the lateral line system. According to my understanding fish use the lateral line system for schooling *sensu* Pitcher, i.e. coordinated swimming with rather fixed interindividual distances rather than for shoaling. When shoals break up during darkness, this is generally an indication that vision is the main mechanism of shoal coherence. Do perch fry truly school, and were shoals observed during darkness?

As I do not know the paper by Morgan (1988), I would like to know what is the social need that is suggested as the main reason for shoaling. What is the adaptive advantage of this social need, how does it increase fitness in the evolutionary sense?

The abundance of larger perch, the only potential predators of perch fry, is said to be very low and therefore unlikely to provoke shoal formation as a defence against predation. I would like to see some educated guess of the predation risk of bathypelagic perch fry. This guess could be obtained by assuming some reaction distance of the large perch for detecting perch fry, some average cruising speed, and some capture probability. I would guess that even a few large perch could represent a significant mortality risk to the fry.

Can the higher TS in the upper reaches of Orlik reservoir be due to the fry staying at shallower depth (page 51)? Do you have any data how TS changes during vertical migration?

In Slapy reservoir, bathypelagic perch fry did not feed during the day but only at dusk when they reached the warm epilimnion. Do you know for how long the fry could feed in the epilimnion before it got too dark? Did you observe differences in stomach fullness among perch fry shortly after dusk?



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