

Review of PhD thesis:

Spatial distribution of fish in reservoirs and lakes

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Spatial distribution of fish in water bodies is highly interesting theme related not only to a basic research but the results are relevant for fish production, which has a long tradition in south Bohemia.

The Phd thesis includes two scientific papers, where Milan Muška is the first author, one paper where he is the second author and one unpublished manuscript. The work has a common introduction, results with a short description of main results of individual papers, and general discussion and conclusions. Since the papers are mostly published, which means already reviewed, my review will be focused on the conception of entire work, particularly assessing the ability of author to make synthesis from individual results

I have several comments to the work:

The papers included in the work have many co-authors (even 13). I miss information, which part of these papers was done by Milan Muška. I need explanation including information, what was the main author's contribution.

Page 3. Acronym DHM is not explained. It should be diel horizontal migrations but it is not mentioned (Just technical notice).

Page 4. I do not understand why the nearby similarity of localities causes problem for statistical testing. In contrary it confirms, that non-random fish distribution is not related to the environmental variables but to the fish behavior. Maybe you think autocorrelation of values in nearby localities, but it is not clear from the text.

Page 7 I do not understand how the amount of fish can be positively correlated simultaneously with depth and light intensity. Furthermore, author describes negative correlation with the distance from the bank (DFB) and simultaneously positive correlation with the depth during night time. Please explain.

I miss main aims and hypotheses of the work, which typically arise from a review-introduction chapter. The individual aims are mentioned in the papers, however there are needed more general questions which help to understand the work in a complex way.

General results: I do not consider it is appropriate to use for general results just a copy of abstract from related paper (e.g. paper 4).

I miss general conclusions of fish behavior in the freshwater bodies which should be a synthesis based on the individual results mentioned in the papers. This is partly made in a chapter Perspectives, however, I expected more synthetic information.

Paper I. In the case of Turkana Lake, the author mentioned the decreasing number of fish during a last three decades, but the same biomass, which means lower number of bigger individuals. What is

in your opinion the main reason for that? Is there any evidence of influence of Nile perch (*Lates niloticus*) on the small fish species as in Victoria Lake?

Paper II. (horizontal fish migration). The data were collected during three days in August. Does author estimate which time period are the results representative for? Except spawning, is there any research about horizontal fish migration during spring and autumn water mixing?

Paper three. Chapter "Statistical method". The test of threshold distance for autocorrelation is described vaguely. Why you did not calculate semivariance for different distance to see the measure of spatial relations?

Paper III. Author mentioned high part of explained variability for depth (R^2 0,36) in spatial lag models. However, it does not work for most of other surveys. What is the main reason for that?

Paper III. What could be the next variables explaining significant part of variability of spatial fish distribution?

Paper III. I miss evaluation of lag spatial model and discussion about suitability of using this model for fish distribution. What are the other methods for such data interpolation?

I please author to explain to what extent the results of the work based on one lake and one reservoir represent a typical behavior of fish and which part is caused by local specific condition. For example you mentioned majority of fish in epilimnetic layer in Římov reservoir. However, there are reservoirs with different vertical fish distribution including near benthic layer. Please explain.

What role a trophic level of freshwater plays in diel vertical and/or horizontal migration? Could the other environmental variables like retention time, morphology of water body etc. play some role?

The literature sources across all the work are relevant and sufficient. Author confirmed good knowledge of literature related to the fish distribution and used not only regional but also international scientific papers.

Despite all my critical comments the PhD thesis is well written, understandable and the papers make together interconnected unit. According to me the thesis bring valuable results, well documenting a fish migration behavior in the fresh water. Therefore I recommend the work for PhD defense and the final decision should be influenced by the proper answering of required questions and explanations.

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Ph.D. thesis by Milan Muška

“Spatial distribution of fish in reservoirs and lakes”

With the development of scientific hydroacoustics, a number of basic questions related to patterns and processes of fish ecology can be resolved at improved spatial and temporal scales. One of the central topics is the fine-scale analysis of spatial distribution of fish in standing waters, and the detection and exploration of potential predictors and drivers of fish movements. In his thesis, Milan Muška has combined four publications (three already printed or accepted) which all focus on the analysis of temporal and spatial variability of fish distributions in lakes or reservoirs. The basic data have been obtained by hydroacoustics. Particular interest is devoted to differences in distribution between day and night, pointing to diel horizontal migrations (DHM) of fish between onshore and offshore sites. The publications add interesting details to the still underexplored DHM research, and show that fish may follow simple rules when choosing their appropriate habitats over 24 hours cycles. Overall, the studies demonstrate that Milan Muška has achieved a profound understanding on the ecology of fish distribution, and is capable of applying scientific hydroacoustics to a range of scientific questions. I recommend the faculty to accept the thesis for graduation.

While reading the thesis, I have accumulated a number of questions and comments. They primarily focus on general aspects of fish distribution and on details of paper III (the single unpublished manuscript). However, I list my comments following the organisation of the thesis.

1. In the introductory part, the scale dependency of extrinsic and intrinsic processes is mentioned, and in addition the relative contributions of stochastic and deterministic processes along differing scales are stressed. I would like to know a few more details why stochastic and intrinsic processes should be expected to dominate at smaller scales.
2. It is stated that DHM is the typical migration of fish in standing waters in which depth or anoxic or cold hypolimnia prevent diel vertical movements. Can this statement be generalised, or can other factors be added which may contribute to the prevalence of DHM or DVM in certain water bodies?
3. Spatial autocorrelation has to be considered when hydroacoustic surveys are analysed. What exactly is spatial autocorrelation, how can it be analysed, and for which type of analyses it has to be considered (and for which questions it is less important)?
4. How much general understanding and prediction on fish distribution can be gained from a single study conducted once over 48 hours (on which papers II to IV are all based)?

Paper I:

1. Fig. 4 shows regressions between lake water level and fish biomass in Lake Turkana. What is the concept behind this figure? Why should both variables be correlated?
2. In comparison with earlier fish density estimates, the abundance has substantially declined in Lake Turkana, but the biomass remained fairly constant. How can this discrepancy be explained?

Paper II:

1. Autocorrelation was avoided by using only transects with odd numbers. In which way this approach avoids autocorrelation? Has it been tested whether the basic results are similar when using even-number transects?
2. In Fig. 5, fish biomass increases simultaneously in both offshore and onshore records between 9 am and 3 pm. How can this synchrony be explained within the concept of DHM?

Paper III:

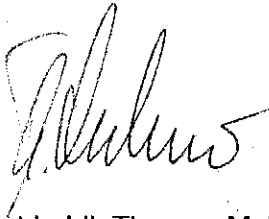
1. Zooplankton distribution may have strong influence on fish distribution. In which way was it tested whether there is a potential spatial correspondence between predator and prey?
2. In the statistical model, S_v is tested against the single effect of four predictors. How are interactions and collinearity considered? How exactly is the spatial weight matrix included into this formula?
3. Table 2 gives the results of statistical modelling. Were the descriptors simultaneously included into the model, or separately tested? What was the % predicted variance of the models?
4. There was a strong, but opposite effect of distance to the bank on fish density between day and night. What exactly can be concluded from this result for the understanding of causes of fish migrations?
5. There was a positive effect of light on fish biomass. In DVM theory, the 'antipredation window' suggests that fish should be located in depths at which light is just sufficient for feeding, but not sufficient

for fish predators to detect prey fish. Can you disentangle these different explanations?

6. Why is migration to structured littoral areas maladaptive at reservoir conditions?

Paper IV:

1. Individual interactions seem to be more important than environmental predictors for fish distribution. This seems to be a contradiction to the results of papers II and III. Can you explain what you mean here, also with respect to predator avoidance as cause of DHM which is also a kind of individual interaction?
2. Most fish are concentrated in groups and move in an area of about 87 m² (disc with radius of 5.23 m). Is this plausible? Which 'rules' may follow individual fish while swimming?



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