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COMMENT

RNA/DNA ratios and growth of herring larvae

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A recent paper published in this journal concluded that RNA/DNA ratios were not valuable for estimating growth in herring *Clupea harengus* larvae (Mathers et al. 1994). These conclusions are in contrast to previous findings (Clemmesen 1989, Ystanes 1993), and were based on the findings that significant reductions in RNA, DNA and protein after 7 d of starvation were only encountered in 65 d old larvae, whereas no significant reductions were found in 14 and 53 d old larvae. We have some comments about the results and methodology presented in the paper and question the validity of the conclusions presented.

First some general comments about experimental studies on growth and growth characterization of fish larvae: (1) it is strongly recommended that any values for average growth be accompanied by survival data, (2) the observed growth rates should if possible be compared with those from other experimental growth studies on the same species, and (3) comparisons between wild and reared larvae should if possible be made on larvae of the same stock.

The herring larvae used by Mathers et al. were initially fed in excess and this should have been corroborated by high survival rates. The apparent increase in growth rate around Day 40 (Fig. 2, op. cit.) may have entirely been an artifact due to size-selective mortality. This is impossible for the reader to resolve if no mention is made of survival in the experimental groups.

The average growth rates presented in Figs. 1 & 2 (op. cit.) are indeed very low, and a significant proportion of the larval herring population must have been starving in spite of 'excess feeding'. This could have been due to the use of an inappropriate feeding protocol. Based on our own experience it is possible to rear Norwegian spring-spawning herring on natural zooplankton at 8°C at an average growth rate of 10% d^{-1} and 70% survival from Day 10 to 38 (average final dry weight of 2.1 mg; unpubl. results). This is substantially higher than the average growth rates of 2.5 to 3% d^{-1} from Day 7 to 35 at 8°C for the Scottish spring spawning herring as presented by Mathers et al. (1994). These growth rates are more in accordance with those found for a group of North Sea autumn-spawned herring larvae grown under very poor feeding conditions in a mesocosm, where initial food density was around 0.1 prey l^{-1} (Moksness et al. 1995). Other growth studies on herring larvae are also available which suggest that the presented growth rates were well below expected (e.g. Gamble et al. 1981, Øiestad & Moksness 1981. Fraser et al. 1987, Moksness 1992b).

Mathers et al. (1994) also attempted to compare characteristics of laboratory-reared and field-caught larvae. The value of this comparison is doubtful for 3 reasons: (1) the reared larvae and wild larvae originated from different stocks (spring-spawned reared larvae and autumn-spawned wild larvae), (2) the environmental temperature encountered by the wild larvae was not documented, and most likely differed from the temperature regime of the reared larvae, and (3) the wild-caught herring larvae were sampled in January, during a period of the year characterized by short day length and low food availability — conditions completely opposite to those of the reared larvae in May. Previous studies on growth in larval herring in the North Sea have shown that larvae from the region where Mathers and co-workers sampled herring larvae are characterized by slower growth compared to larvae sampled from other areas of the North Sea (Munk et al. 1986, Moksness 1992a, Fossum & Moksness 1993). The comparison between reared and wild larvae was thus a comparison of virtually starving wild larvae versus reared larvae that were fed in excess. Consequently the differences observed are not useful in assessing the validity or suitability of the methods involved.

The paper is also burdened by erroneous data. The data on dry weight of the starved group at Day 14 presented in Fig. 1 and Table 4 must be wrong. A dry weight of 0.039 mg at Day 14 would imply a daily weight reduction of 25% d^{-1} from Day 7 to 14 in this group, based on a dry weight of 0.220 mg at Day 7 (see Fig. 1). As a result of this error, all the following dry-weight-specific data presented for the Day 14 starved group in Table 4 are wrong (most likely off by a factor of 5). The weight-specific protein content is, for example, claimed to be 1.7 g protein g^{-1} dry matter. Unfortunately these errors are not typographical errors since they appear consistently in both Fig. 1 and Table 4, and are confirmed by the results of the statistical tests in the table.

Although it was not possible to confirm the origin of the dry weights used in Table 2, it seems that the same erroneous dry weight/wet weight relationship mentioned above was used for the starved larvae at Day 12. The dry-weight-specific nucleic acid content for this group is 3 to 5 times higher than that of the fed group at Day 10. In addition we question the statistics of the comparisons between the RNA/DNA ratios using the 2 different methodologies. For example, the values (mean ± SE) presented for fed larvae at Day 7 obtained by Method 1, 5.84 ± 0.06 (n = 6), and by Method 2, 2.76 ± 0.04 (n = 8), are not significantly different at the 5% level according to Mathers and co-workers. We agree with the authors that the observed differences in RNA/DNA ratios using different methodologies need further evaluation, but at present this is a problem of analysis techniques, not a problem of RNA/DNA ratios as a growth index per se.

Most likely there are no significant differences in weight, protein or nucleic acid content between the fed and the starved groups at Day 14, and this is a confirmation of the poor initial growth performance of the larvae in the experiment. It is not surprising, therefore, that the RNA/DNA ratios were not able to detect a starvation signal in the starved group compared to the fed group, simply because both groups were starving.

Finally, it is important to continue the development of new methods for assessing larval nutritional status and growth in order to answer fundamental questions related to recruitment in fishes (Anderson 1988, Ferron & Leggett 1994). The need to critically evaluate these new methods is strongly emphasized, and we applaud the initiative of Mathers and co-workers in this respect. However, more work with well-defined larval groups is clearly needed.

This comment was submitted to the editor

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