Swimming ontogeny in *Dicentrarchus labrax*

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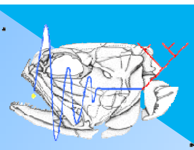


Introduction

Swimming is an essential function involved in many behaviours such as predation, feeding, schooling etc. During growth, a lot of parameters can influence swimming ontogeny as a changing in viscous and inertia forces importance, flukes, skeletal, muscular and nervous systems developments.

D. labrax Photo by Crocetta F., 2003 (www.fishbase.org)

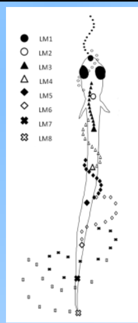
In this study, we observed the swimming movements in *Dicentrarchus labrax* from newly hatched larvae to juvenile stages.

Objectifs

To determine when and how the swimming abilities take place throughout ontogeny.

Materials & Methods

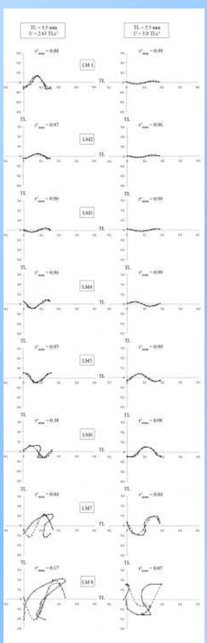
Larvae of *D. labrax* were sampled from hatching to 288h (12 days post-hatching). Juveniles were collected on days 40, 79 and 104 post-hatching. Swimming movements were recorded using a high-speed video camera. On each frame, 8 equidistant landmarks were then plotted on fish midline.



The coordinates x-y were measured for tracing the landmarks trajectory during swimming movements. This allowed to calculate several parameters such as swimming speed, tail-beat frequency, amplitude and sinusoidal trajectory of each landmark.

Fig. 1. Drawing of a swimming movement executed by a larva of seabass (*Dicentrarchus labrax*). The eight paths made up of different kind of dots represent the trajectory of every landmarks (LM1, LM2,...) during the execution of a complete undulatory swimming movement. Bigger forms indicate the landmarks placed on the fish body.

Results & Discussion



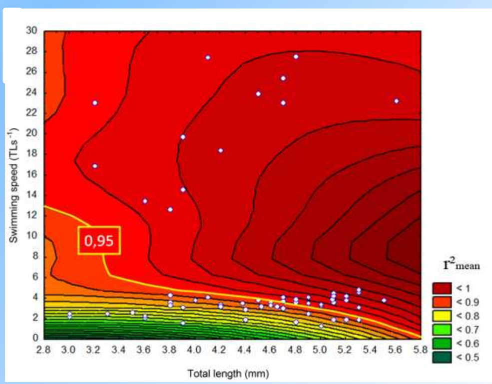


Fig. 3. Contour plot representing the changes in mean coefficient of determination (r^2_{mean}), as a function of total fish length (TL) and relative swimming speed of larvae of seabass (*Dicentrarchus labrax*). The index value increases from dark green to dark red. The white circles represent observations made during the present study; each circle corresponds to one fish. These data were used to fit the isoclines by using the weighted least square distance method. The yellow line represents the threshold value of 0.95. White circles located to the left of this line correspond to fish that did not execute fully developed swimming movements, whereas those to the right of this line correspond to fish with established swimming movements.

Fig. 2. (on the left) Trajectories of the eight landmarks on two *Dicentrarchus labrax* larvae, measuring respectively 3.5 and 5.5 mm TL during execution of one complete undulatory swimming movement. LM1 is located at the head-tip and LM8 at the tail-tip. Each continuous lines shows the observed trajectory and dotted line represents the theoretical sinusoid calculated from the observed path (which should correspond to adult motion). The data on the x and y axes are expressed as percentages of the total length of the observed fish. For LM7 on the 3.5 mm fish and for LM8 on both fish, the landmarks trajectories do not approach a sinusoid form. Therefore, it was impossible to determine the theoretical trajectory that should be followed by the landmark.

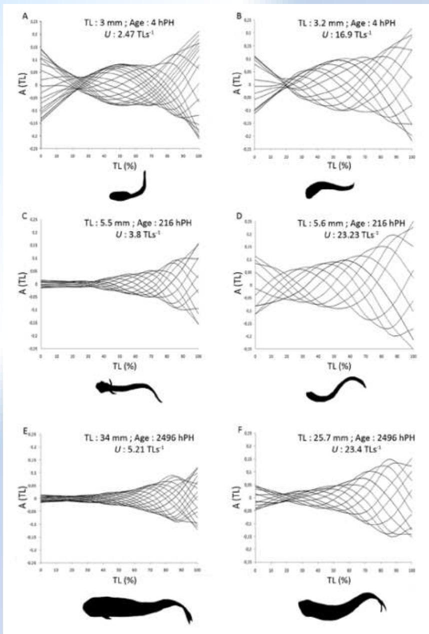


Fig. 4. (on the right) Midline kinematics of larvae and adults of seabass (*Dicentrarchus labrax*) during cyclic swimming at different stages of ontogeny (A-D: larvae; E-F: juveniles) and at different swimming speed regimes (A,C,E: cruise swimming; B,D,F: burst swimming). The superimposed midlines (time step 4 ms) of one tail-beat cycle show the amplitude envelope of the body wave. Each amplitude envelope corresponds to the fish represented by the black shape. The amplitude is expressed as a proportion of total fish length (TL), the x-axis represent the total fish length in percentage. *U* is the relative swimming speed.

1. At hatching, only swimming movements at high speed were established (Fig. 1)

2. During growth, we observed a more sinusoidal trajectory of the Landmarks (Fig. 2). At 5.2 mm TL, all swimming movements were established (Fig. 1)

3. Larvae swam with an anguilliform mode while juveniles displayed a subcarangiform mode. In anguilliform mode, the amplitude along fish body linearly increased backwards from the head to the tail. In subcarangiform mode, the increase was more exponential with the amplitude becoming important in the posterior part of fish body (see amplitude enveloppe on figure 4).

All these changes in the swimming movements during growth can be related to anatomical and morphological developments as flukes and skeletal, muscular and nervous systems.