THE JAW MECHANISM DURING GROWTH OF A GENERALIZED HAPLOCHROMIS SPECIES: H. ELEGANS TREWAVAS 1933 (PISCES, CICHLIDAE)

by

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SUMMARY

This paper deals with the jaw mechanism of Haplochromis elegans, a generalized species. The central issues are the kinematics and statics of the mechanism and the way these are influenced by its proportions. These proportions change during growth and differ in related species. A mathematical computer model is formulated to deal with the kinematics and the statics of the mechanism. A calculation procedure is developed to determine the importance of the position of anatomical points in the mechanism for force-transmission during biting. It is also possible to change the position of all relevant anatomical points gradually and thereby improve the whole mechanism for the function of biting. In this way a prediction is made about the proportions expected in a powerful biting haplochromine species such as H. nigricans. The predictions made are correct in six of the seven specialized proportions of H. nigricans. A simplified kinematical model is presented which demonstrates the essence of protrusion in cichlid fishes and in many other acanthopterygian fishes.

The differences in proportions of an adult and a first free-swimming stage of H. elegans are evaluated with the computer model. It appears that some proportions are more favourable for biting in the young stage, others are unfavourable due to the relative size of the eye.

I. INTRODUCTION

The description of the mechanism of the protrusible upper jaws of acanthopterygian fishes given by ALEXANDER (1967) was based on Lates, Perca and Sebastes. This was called the generalized acanthopterygian protrusion mechanism. Protrusion in Pterophyllum, a South American cichlid fish, did not accord with this mechanism and consequently Alexander used another description of high simplicity for the cichlid type of protrusion mechanism. To unravel the kinematics and statics of the protrusion mechanism in cichlid fishes, a more com-

1 H. elegans is considered to be generalized because of its morphologically central position amongst haplochromine fishes. (BAREL et al., 1976 and GREENWOOD, 1973).

2 Greenwood referred Haplochromis elegans to the genus Astatotilapia. For a discussion of the phylogenetic rationale behind this generic placement see GREENWOOD (1979).
plicated and realistic description is needed. Alexander did not include the maxilla, nor its tendon from the musculus adductor mandibulae 1, the Alt, in his description of the protrusion mechanism. On closer examination, these elements appear to be of vital importance, both for the kinematics and the statics of the protrusion mechanism. Therefore it was decided to calculate the force transmissions of the adductor muscles on the prey and to simulate protrusion movements by means of mathematical models introduced by Elshou (1980) including the maxilla and its connections.

Even in relatively simple kinematic chains, force transmission is poorly predicted by intuition alone, since the human mind is ill equipped to deal with multiparameter systems. For this reason exact models are not just fashionable tools provided by computer technology, but necessary aids. On the other hand, Anker (1974) demonstrated that drawing-board extensions of a sharp intuition may lead to highly reliable descriptions of complex mechanisms. In such instances however, comparison of several species or ontogenetic stages is very laborious.

To be able to understand proportional differences in jaw mechanisms and their adaptive meaning, forces have to be included. When the whole mechanism, its kinematics and its statics have been described, the importance of the positions of the anatomical points of the mechanism have to be considered. These positions change during growth and they differ in related species. In this way, statements can be made about the functional meaning of the proportions of the mechanism.

II. MATERIAL AND TECHNIQUES

Two wild caught specimens of *H. elegans* both of Standard Length 67 mm. (S.L. as defined by Barel et al., 1977) were embedded in epon and serial sections of 10μm. thickness were prepared. One specimen had an almost closed mouth, no protrusion of the premaxillae and only slightly abducted suspensoria, while the other specimen had extreme mouth-opening, protrusion and abduction. From these serial sections the coordinates of anatomical points and articulation surfaces were derived.

Comparative material of several cichlid species from the Leiden collection of cichlid fishes were examined.

The specimen of a first free-swimming stage was the same one as described by Ottén (1981) where the preparation procedure is described. The mathematical model of the jaw mechanism as presented in this paper uses techniques explained in Elshou (1980)