MATHEMATICAL BIOMECHANICS AND THE "WHAT!”, "HOW?” and "WHY?” IN FUNCTIONAL MORPHOLOGY

by

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SUMMARY

In functional morphology, the "what”, "how” and "why” about form and function of specific structures is one type of question (case-studies). When the hypothesis erected to answer these questions cannot be tested experimentally, an alternative approach can be the application of mathematical models. In order to reduce the speculative nature of this approach, the following points must be considered: (1) a detailed morphological study is required to obtain accurate structural and geometrical data; (2) framing the hypothesis should be based on the critical interpretation of the morphological data within the framework of known physical and physiological information; (3) the mathematical reduction must rather tend to express the plausibility of the hypothesis instead of to quantify the physical phenomenon in question (i.e. model construction is determined by the selection of the right output parameters); (4) the applied physics must be relevant to the phenomenon being investigated; (5) the “theoretical environment of the model” and the input values for the environmental variables must fit reality. Two case-studies on aspects of the form and function of the head of fishes will illustrate the application of these principles.

KEY WORDS: Biomechanics, models, functional morphology.

INTRODUCTION

Depending upon the trend of interest, biomechanics can be used to serve several purposes in functional morphology. On the one hand it can be applied to solve questions about the actual fitness of a biological design in its actual environment, or in other words, to study for instance the elephant from the point of view of the elephant (e.g. ALEXANDER, 1988b; LIEM & WAKE, 1985; WAINWRIGHT, 1988; WEB & WEIHS, 1983). On the other hand, one can ask how the elephant became an elephant, which means that biomechanics can also be used in studies about the evolution of biological constructions (e.g. LIEM & WAKE, 1985; WAINWRIGHT, 1988).

Apart from these two, to me, complementary study options, there may be a third group of functional morphologists who ask very specific how, what and why questions about the form and function of particular structures. This kind of research, what we may call case-studies, is tolerated, but becomes often regarded as inferior or at least
incomplete because there is no immediate or apparent link with one of the two above mentioned "exalted" goals.

It even becomes worser when nowadays one carries out such case-studies without the employment of the current advanced technology, which has provided for the exponential increase of the functional morphological-knowledge during the last decades. As already accused by Dr. Herring at the annual meeting of the Society of American Zoologists (HERRING, 1988), people who dare to postulate something on form-function relationships without extended and sophisticated experimental verification have almost to justify themselves in front of the forum.

I would like to advocate now those people (myself certainly included) who dare to perform case-studies without taking the benefit of the luxury of the advanced technology, in order to obtain the deserved appreciation in the light of the higher mentioned "fundamental" aspects of functional morphology.

It would be wrong to assume there should be no interest for these aspects, neither for the use of advanced technology. On the contrary! But just like explaining biological design requires consideration of historical aspects (e.g. BOCK, 1988; GANS, 1985), also in the case of research development, history can play a determinative role.

The moment one starts a scientific career associated to an established laboratory, it is the reigning scientific tradition which dominates the initial steps of the research development. The impact of this tradition cannot be underestimated as this does not only determine the infrastructural environment, but also the composition of the dominant scientific community, which both in turn influence the growth and diversification of the subsequent generations of junior researchers. In my own case, there was a definite tradition in taxonomy and comparative morphology, and although the functional morphological research was already initiated by Dr. Verraes, working on the ontogeny of fishes, such a "climate" does not allow a saltatoric evolution, the more when one is thus unlucky to carry out his research outside the domain of the "newspaper-sciences", being, unfortunately, in many cases the conditio sine qua non for any financial support.

Most of the time, specific how, what and why questions emerge while performing morphological and/or behavioural observations (e.g. what is the role of this ligament, why is this bony process thus long or thick, or how does this animal open its mouth?). When the hypothesis erected to elucidate the particular question cannot be tested experimentally, due to infrastructural limitations, but also in cases