TAXONOMIC POSITION OF THE CICHLIDAE (PISCES, PERCIFORMES) AS DEMONSTRATED BY THE MORPHOLOGY OF THEIR OTOLITHS

by

PIETER A. M. GAEMERS

(Rijksmuseum van Geologie en Mineralogie, Hooglandse Kerkgracht 17, 2312 HS Leiden, The Netherlands)

SUMMARY

The otoliths (sagittae) of Cichlidae are described, and compared with those of supposedly related families (Labridae, Embiotocidae, Pomacentridae, Centrarchidae) and of various other perciform families. The examination of their otoliths shows the Cichlidae to be a closely coherent family. A diagnosis for this family is given. All investigated cichlid otoliths reveal a particular type of anterocaudal pseudocolliculum, the synapomorphic character which strongly indicates the monophyly of the family. A survey of the occurrence of pseudocolliculi in teleost otoliths is also presented.

Conclusions: the Cichlidae are most closely related to some subfamilies (probably the Cheilininae and Epibulinae) of the family Labridae; cichlid otoliths may well be a useful means of unraveling intrafamilial relationships at various taxonomic levels; the origin of the family Cichlidae must be dated back to at least the Early Turonian (early Late Cretaceous), i.e. about 93 million years ago, as based on continental drift data.

INTRODUCTION

Otoliths are calcareous bodies found in the inner ear of teleost fish. On either side of the brain a teleost has three otoliths, each of which is situated in a small sack under the semicircular canals. In most teleosts, including the Cichlidae, the sagitta is the largest otolith. It is situated in the saccus, and primarily serves the hearing function (Fay & Popper, 1980). Sagittae consist for 90-99.8% of aragonitic crystals radiating from the centre (nucleus), and for the rest of a special protein (otoline) deposited in concentric bands (Degens et al., 1969) which constitute the matrix for the aragonitic crystals. Growth rings result from changes in the percentages of aragonite and protein due to rhythmical changes in the environment. The smallest increments are daily growth layers; but weekly, fortnightly, monthly, yearly and even spawning rings can also be observed (Pannella, 1971).

The possibility of identifying fish species by their otoliths was used by the German palaeontologist Koken (1884) for the first time. In most sediments, complete skeletons of fossil fishes are seldom if ever found; moreover, the examination of isolated bones and teeth of
teleosts is usually insufficient to identify a particular species, so that palaeoichthyologists must resort to otoliths for the reconstruction of most fossil fish faunas and of evolutionary lineages. Otoliths are composed of many different parts. They present a wide variety of shapes, which are virtually devoid of symmetry. This greatly increases the range of distinctive features on which classification can be based, thus making otoliths a powerful taxonomic tool. In most teleost families, closely related species with very similar external characteristics can be distinguished by their otoliths, and otoliths are often even the easiest means to identify species (Schmidt, 1969). Moreover, otoliths are sufficiently conservative in their characteristics to indicate relationships between species, genera and families.

NOMENCLATURE, TECHNIQUES AND MATERIALS

Nomenclature

A large number of technical terms is used in the study of otoliths. The most important ones for cichlid otoliths are given in figs. 1 and 2; for comparison they are also given for centrarchid otoliths (fig. 3). A more comprehensive list is presented below.

Otoliths

Otolith: earstone of teleost. Each teleost has three different types of otolith: 1. sagitta, pl. sagittae: lit. arrow; the largest otolith in most fish. N.B. In this paper, unless stated otherwise, the term otolith refers to sagittae only. 2. asteriscus, pl. asterisci: lit. little star. 3. lapillus, pl. lapilli: lit. little stone.

General features

Inner surface: medial surface of otolith, directed towards the brain.
Outer surface: lateral surface of otolith, directed from the brain.
Anterior rim: part of outline comprising rostrum, excisura ostii and antirostrum.
Dorsal rim: part of outline between antirostrum and postdorsal angle.
Posterior rim: part of outline between postdorsal angle and posterior end.
Ventral rim: part of outline between rostrum and posterior end.

Sculpture: ornamentation along rims and on inner and outer surfaces of otoliths; may be absent (smooth otoliths), undulating, knobbed, serrated or spinous, and regular or irregular.

Details of the outline

Rostrum: lowermost (ventrally situated) and usually largest protrusion along anterior rim.
Antirostrum: uppermost (dorsally situated) and usually smallest protrusion along anterior rim.

Excisura ostii (or excisura for short): lit. excision in the ostium; can also be defined as: indentation between rostrum and antirostrum.

Angles: at certain places the outline is curved more sharply than at others, thus forming so-called angles which are characteristically situated and shaped in each species. In their most striking development they form distinct kinks in the rims. Depending on their position along the outline they are called: pre-, mid-, and postdorsal