

The evolution of the Weberian apparatus: A phylogenetic perspective

Terry GRANDE & Mario de PINNA

Abstract

The evolution of the Weberian apparatus in otophysan fishes has been a source of confusion and debate among ichthyologists. This paper reexamines this debate in light of a proposed sister-group relationship between clupeomorphs and ostariophysans. Results from this study suggest that the Weberian apparatus may not have evolved as a single unit as indicated by the presence of a tripus-like structure found in some clupeomorphs. Otophysic structures thought to be restricted to otophysans but found in some clupeomorphs (e.g., pristigasteroids) may reflect a possible common homology. Although not intended to be a revision of otocephalan relationships, this paper provides a reexamination of the anterior vertebral and otophysic morphology of the group. Our results suggest that important phylogenetic information from the anterior vertebral region in these fishes may provide new insight into the sister-group relationship between Clupeomorpha and Ostariophysi as proposed by LECOINTRE & NELSON (1996). New interpretations for the homologies of certain Weberian ossicles (e.g., claustrum and tripus) are also proposed based on developmental, topological and phylogenetic data. A cladistic analysis of all informative characters (e.g., skull, caudal skeleton) is necessary to test hypothesized homologies based on the anterior vertebral characters proposed here.

Introduction

The Weberian apparatus, diagnostic of the Otophysi (ROSEN & GREENWOOD 1970) consists of a series of modified anterior centra, neural arches, supraneurals and pleural ribs, that connect the gasbladder to the back of the skull. When the gasbladder pulsates in a sound field, high frequency vibrations are transmitted from it via the Weberian ossicles to the inside of the skull and then to the inner ear (ALEXANDER 1962, 1964). This system, along with the lateral line system, enables these fishes to receive a wide range of sound sources (LADICH 1999). Hypotheses involving the evolution and development of different Weberian elements have been proposed by many authors (e.g., KRUMHOLZ 1943, ALEXANDER 1964, ROSEN & GREENWOOD 1970, FINK & FINK 1981, GAYET & CHARDON 1987, VANDEWALLE et al. 1990, CHARDON & VANDEWALLE 1997). Some of these hypotheses appear in conflict with each other (see CHARDON & VANDEWALLE 1997). For example, GAYET (1985) followed by COBURN & FUTEY (1996) argued that the claustrum in otophysans is derived from the first supraneural, while FINK & FINK (1981) argued that the claustrum forms from a disassociated part of the first neural arch. Based on the examination of fossil taxa thought to exhibit an intermediate or ancestral condition of a functioning Weberian apparatus, GAYET (1982a, 1985, 1986a, 1993), argued for a multiple origin of this structure within Otophysi. In contrast to GAYET (1982a, 1985, 1986b, 1993), FINK & FINK (1996), while not assuming that all ossicles evolved at once, argued for a single evolution of the functioning Weberian apparatus in otophysans.

In this paper we discuss the development of individual Weberian ossicles and in some cases present new interpretations and hypotheses of their homology (e.g., tripus and claustrum). Based on the recent studies of VANDEWALLE et al. (1990), GRANDE (1996), GRANDE & POYATO-ARIZA (1999), GRANDE & SHARDO (2002) and GRANDE & YOUNG (2004), it appears that although the adult functioning Weberian apparatus is homologous within Otophysi, the development of some Weberian ossicles is not the same in all otophysan subgroups (e.g., in catfishes the scaphium develops solely from the first basidorsal, while in some cyprinids an embryonic mesenchyme contributes to its formation).

The whole contribution can be purchased as PDF file.

Availability

Generally all our publications are available as PDF files; full publications as a general rule after the printed version is out of print. If you have questions concerning particular contributions please contact us by e-mail:

pdf@pfeil-verlag.de.

The PDF files are protected by copyright.

The PDF file may be printed for personal use.

The reproduction and dissemination of the content or part of it is permitted.

It is not allowed to transfer the digital personal certificate or the password to other persons.

Prices

Books: Prices are to be found in the catalog.

Articles in journals and single contributions or chapters in books:

10 EURO basic price per order (including the first 10 pages),
and

0.50 EURO per page, beginning with the 11th page.

Page numbers are found in the contents of the publications.

Orders

Use our order form for PDF files or send your order informal per e-mail (pdf@pfeil-verlag.de). The only accepted payment is by credit card. While using the order form for PDF files, your data will be transmitted by secure link (ssl). You also may send the informations informally by e-mail, fax, phone or mail.

Handling

As soon as possible, depending on our business hours and your order, you will receive your PDF file together with the certificate and password by e-mail.

Larger PDF files can be downloaded from our webpage, if necessary.

Your invoice will be sent out by e-mail after we charged your credit card.

To open the encrypted PDF files you have to install your personal certificate after your first order. All PDF files with the same certificate can be opened from that time on.

Dieser Beitrag kann als PDF-Datei erworben werden.

Verfügbarkeit von PDF-Dateien

Prinzipiell sind von allen unseren Publikationen PDF-Dateien erhältlich. Komplette Publikationen in der Regel erst nachdem die gedruckte Version vergriffen ist. Anfragen bezüglich bestimmter Beiträge richten Sie bitte per E-Mail an pdf@pfeil-verlag.de.

Die PDF-Dateien sind urheberrechtlich geschützt.

Ein Ausdruck der PDF-Dateien ist nur für den persönlichen Gebrauch erlaubt.

Die Vervielfältigung von Ausdrucken, erneutes Digitalisieren sowie die Weitergabe von Texten und Abbildungen sind nicht gestattet.

Das persönliche Zertifikat und das Passwort dürfen nicht an Dritte weitergegeben werden.

Preise

Bücher: Die Preise sind dem Katalog zu entnehmen. Zeitschriftenbeiträge und einzelne Kapitel aus Sammelbänden bzw. Büchern:

10 EURO Grundbetrag pro Bestellung (einschließlich der ersten 10 Seiten),
und

0,50 EURO pro Seite ab der 11. Seite.

Den Umfang der Beiträge entnehmen Sie bitte den Inhaltsverzeichnissen.

Bestellungen

Bestellungen sind mit dem PDF-Bestellformular oder formlos per E-Mail (pdf@pfeil-verlag.de) an uns zu richten. Die Bezahlung ist ausschließlich per Kreditkarte möglich. Bei Verwendung unseres Bestellformulars werden die Kreditkartendaten über eine gesicherte Verbindung (ssl) übermittelt. Sie können die Daten aber auch formlos per E-Mail, Fax, Post oder telefonisch übermitteln.

Abwicklung

So bald wie möglich, aber abhängig von unseren Bürozeiten und der gewünschten Bestellung, schicken wir Ihnen die PDF-Datei(en) zusammen mit Ihrem persönlichen Zertifikat und dem zugehörigem Passwort per E-Mail. Größere Dateien bieten wir Ihnen gegebenenfalls zum Herunterladen an.

Der fällige Betrag wird von Ihrer Kreditkarte abgebucht und Sie erhalten die Rechnung ebenfalls per E-Mail.

Um die verschlüsselten PDF-Dateien öffnen zu können, muss bei der ersten Bestellung das passwortgeschützte persönliches Zertifikat installiert werden, welches anschließend auf dem Rechner verbleibt. Alle mit diesem Zertifikat verschlüsselten Dateien können anschließend auf diesem Rechner geöffnet werden.