A COMPARATIVE STUDY OF THE DEVELOPMENTAL OSTEOLOGY OF SYNGNATHUS SCOVELLI AND HIPPOCAMPUS ZOSTERAE (PISCES: SYNGNATHIDAE) AND ITS PHYLOGENETIC IMPLICATIONS

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ABSTRACT

The sequence of ossification in fishes provides evidence of relationships on the familial, generic, and species level. In addition, it contributes to our understanding of structural homology and how morphology relates to function. Research in early osteological development in larval and juvenile fishes not only provides additional characters for utilization in identification, but may also affect the interpretation of adult osteological structures.

The developmental osteology of two species of syngnathoids, Hippocampus zosterae and Syngnathus scovelli, is described from early embryonic stages to approximately two months of age. Development of the dorsal, pectoral, and caudal fins, the visceral arches, vertebral column, and the cranium is described. The sequences of osteological development were established based upon a total of 16 adults, 226 juveniles, and 141 embryos from both species that were preserved, cleared, and stained.

As early as the embryonic period, there is precocious deposition of bone in many of the dermal structures of the adult: sixteen of twenty-three dermal bones in S. scovelli and fifteen of twenty-two in H. zosterae. Even endochondral bones, which progress through a series of processes of deposition, resorption, and remodeling are for the most part calcified before parturition, which underscores the importance of commencing developmental osteology studies early in ontogeny.

It has been established that early ossification is typically found in those structures which will endure a high degree of stress. Syngnathoids are no exception for upon parturition, these juveniles must be morphologically adapted to feed, locomote, and respire. Precocious development of adult characters might be an adaptation to minimize predatory pressure on juveniles for syngnathoids do not pass through a larval period.

The presence of the metapterygoid in the pterygoid series has long been disputed. In this study the cartilaginous precursor of the metapterygoid bone was observed in H. zosterae and S. scovelli embryos and calcification of the bone was noted. The morphology and intimate connection of the metapterygoid with the hyomandibular, symplectic, and quadrate was maintained, as in the typical teleost despite the elongation of the syngnathoid snout.

Fin development for the genera Syngnathus and Hippocampus follows the same sequence, excluding the caudal which is lacking in the latter. The simultaneous development of the pectoral and dorsal is followed by the anal. There was, however, a lag between the differentiation of the pectorals and dorsals and that of the anal in S. scovelli. The early development of the pectorals in both genera may coincide with the ossification of the cleithra. This fusion lends rigidity and support to which well developed pectoral muscles used for locomotion attach.

The pectoral fins were not fully differentiated with the adult complement of fin rays until very late in ontogeny with the development of pectoral fin rays preceding those of median rays. The radials of the pectoral fin arose as separate cartilaginous blocks in H. zosterae compared to foramina within the solid cartilaginous coraco-scapula plate in S. scovelli.

The anal fin is vestigial in both species; however, its precocious development in Hippocampus zosterae embryos was explained in terms of the fusion of its pterygial supports to the supporting elements of the dorsal fin through a single centrum. The ossification of centra shortly after the appearance of the dorsal and anal fins suggest the importance of these structures being in place prior to ossification.

From its incipient development the hypural element in the caudal structure in S. scovelli is a plate which divides into a superior and inferior member to which ten principal caudal fin rays attach. A single cartilage was detected in the penultimate position of the ossified vertebral column in H. zosterae. This cartilage never calcifies and was designated the vestigial hypural "plate" in H. zosterae.

Underlying the dorsal fin flattened, horizontal pterygiophores were observed attached to the neural arches in H. zosterae and in S. scovelli. It was suggested that this structure formed a base upon which the dorsal fin rays of each segment could oscillate independently. It is perhaps this structural adaptation which enables the seahorse to turn an arc of 180° without any lateral translation of the body. This phenomenon was not observed in other amiiform swimmers (Amia or Gymnarchus) suggesting that this adaptation evolved later in phylogeny.

Cartilaginous neural arches and centra formed from an anterior to posterior direction. Their ossification preceded the formation of the dermal plates. Haemal arch formation and ossification, which occurs in a posteroward direction, lags slightly behind that of the neural arches which form anteroward in S. scovelli. Structures involved with respiration are fully developed by the time the dermal plates appear, as the formation of the exoskeleton precludes the possibility of cutaneous respiration.

The direction, sequence, and ossification of the axial skeleton evidences some variability between the two genera.

Dermal armature is more prominent in the region of the frontals in Hippocampus while the lacrimal and the dermosupraoccipital is absent. In Syngnathus the dermosupraoccipital forms a suture between the posterior limit of the supraoccipital and the first vertebrae. Its absence in Hippocampus presumably makes possible the stridulant sounds produced by the snapping of the skull bone under the coronet. The lacrimal, the foremost bone of the circumorbital series, is not in the usual position below the orbit in Syngnathus nor does it function in connection with the lateral line system as these two species lack such a system. Rather its function seems to be one of protection.

Based on a number of developmental characters revealed in this study, a modification of a recent classification of the order Gasterosteiformes is proposed in which the syngnathoids and pegasids along with the ramphosids are placed in separate suborders Syngnathoidei and Pegasoidei, respectively. This separation is based upon the following osteological characters: the presence of a metapterygoid, ectopterygoid, and endopterygoid in syngnathoids (absent in pegasids); absence of pleural ribs (present in pegasids); the absence of parietals (present in pegasids); the absence of nasals (present in pegasids); branchiostegal rays reduced to two (five in pegasids); circumorbital bones 1-2 (3 in pegasids); the presence of palatine (absent in pegasids); the absence of a lateral line system (present in pegasids and passes through circumorbital bones); a single articulating facet of the hyomandibular to the skull (double articulating facet in pegasids); anterior three vertebrae fused (anterior six fused in pegasids); the radials number 5 (3 in pegasids).

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