Skeletal Organization of Caudal Fin in *Syngnathus abaster* (Osteichthyes, Syngnathidae)

Organización Esqueletal de la Paleta Caudal en *Syngnathus abaster* (Osteichthyes, Syngnathidae)

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SUMMARY: The caudal skeleton is one of the most important tools to evaluate teleostean interrelationships, but just the anatomy of few species have been investigated. Black-striped pipefish *(Syngnathus abaster)* has never been examined for its caudal morphology. Here, red alizaryn is applied as specific staining for calcified structures, providing a better understanding of caudal skeleton organization. Our results and interpretation just partially fit with previous knowledge on other *Syngnathus* species. This emphasizes both the importance of facing same problems with new technics and methodologies, and the existence of a heterogeneous situation between close-related taxa.

KEY WORDS: Caudal skeleton; *Syngnathus*; Teleosts; Red alizaryn.

INTRODUCTION

The evolution of the caudal fin has become such an important tool in systematics that "nearly every investigator who has discussed the evolution of vertebrates has commented on the caudal fin of ray-finned fishes (Actinopterygii)" (Lauder, 1989).

The caudal skeleton is a major character complex used in the evaluation of teleostean interrelationships. In a large number of cases, the development of various structures of the caudal skeleton corroborates interrelationships based on adult structures (Mehta *et al.,* 1989; Schultze & Arratia, 1989). The Haeckelian recapitulation theory or biogenetic law, which has been discredited in its absolute form, finds quite impressive correspondence in caudal fin evolution.

Only few taxa have been investigated about the skeleton anatomy of caudal fin and new results and improvements are expected by the examination of other teleost species (Schultze & Arratia).

In modern teleosts, a reduction of many skeletal elements of the caudal fin can be observed. This progressive simplification has independently interested several lineages at different taxonomic levels, through fusion and lost of parts (Gosline, 1961) and a today interpretation could represent an interesting but not easy task.

Exterior caudal fin shape is related to different ways of swimming and to ecological features of species (Norman, 1963), but only anatomical studies of skeleton can give systematic and phylogenetic information.

Caudal skeleton of *Syngnathus abaster* has never been investigated and few observations have interested other specie of the same genus. Although their close systematic position, we expect to find morphological differences in this small pipefish, and thanks to improved staining technic, a better understanding of internal caudal anatomy.

MATERIAL AND METHOD

Alizaryn and alcian-blu staining (Dingerkus & Uhler, 1977; Park & Kim, 1984) is a very useful method for *in toto* staining of skeletal and cartilagineous tissues. This is why it has found large application in embryology and small size vertebrates research, while the same kind of observations on large organisms need X-rays radiography.

Three adult and one juvenil specimens of *S. abaster* were fixed in 28% NaH_2PO_4 buffered formaldehyde (10%) and these fixed samples were kept in dark for better

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preserving before staining. After a dehydration with increasing alcohol concentrations, samples were treated with a solution 10 mg of alcian blue 8 GX, 80 ml alcohol 95% and 20 ml glacial acetic acid. Then they were re-hydrated with decreasing alcohol concentrations and passed through an enzymatic solution with 30 ml of a sature $NaBO_4$ solution, 70 ml distilled water and 1-4 g purified 4xpancreatic trypsine. 0,02-3% H_2O_2 has been used to eliminate chromatophores. Staining with a solution 0,5% KOH and 0,03-0,04 g of red Alyzarin-S. Clarifing with glycerol for an easier observation of skeletrical structures (Park & Kim; Taylor & Van Dyke, 1985). Anatomical terminology used is according to Schultze & Arratia and Matsuoka (1987).

External bony plates that cover pipefishes' body are fully stained in consequence of their strong calcification. A dissection of the last eight caudal segments has removed external bony plates for a clear observation of underneath structures.

RESULTS

In the caudal skeletal system (Fig. 1) there are a superior and an inferior hypurals (H). Hypural diastema well separates them, defining the upper and lower lobes of the caudal fin. Hypurals are short and large in shape offering a wide surface for the attachment of caudal rays. 5 rays are connected to the superior hypural and 5 to the inferior; this provides a symmetric no specialized homocercal tail with 10 rays. Lepidotrica are unbranched and only in adults segmented. Epurals and uroneurals are lacking.

Preural centrum (PU1) is well distinguished with its ventral parhypural (PH) and dorsal neural arch (NAPU1). Parhypural is separated from hypurals, but anchylosed with the inferior one, and it doesn't support any caudal ray. Dorsal view shows that PU1 has two lateral processes (Fig. 2). No ural centra are present in *S. abaster*. The following vertebral centrum has two well distinguished lateral processes on each side, but only one hemal spine (Fig. 2).

Like most vertebrae of *Syngnathus* column, preural centra have dorsal neural arches with a complex morphology. They extend along the whole length of centra, but their massive form is lightened by many lateral openings on both sides.
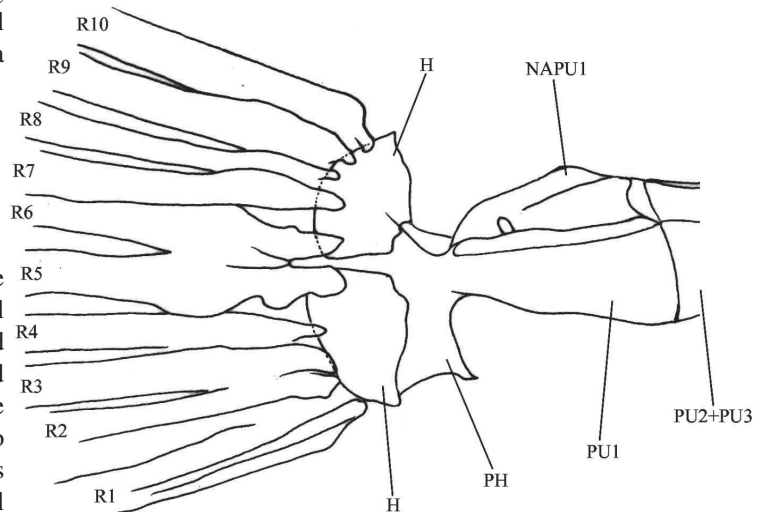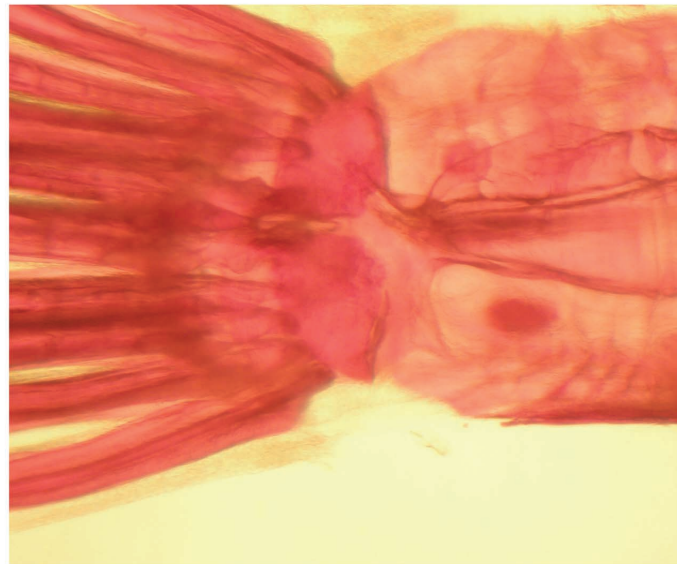

Fig. 1. Caudal skeleton of adult *Syngnathus abaster* in lateral view, picture and light camera drawing. Abbreviations: hypural (H); parhypural (PH); preural centrum (PU); preural neural arch (NAPU); ray (R).
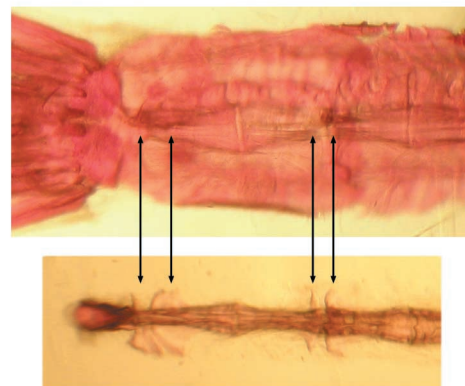

Fig. 2. Caudal skeleton of adult *S. abaster* in lateral and dorsal view.

DISCUSSION

Inferior hypural is probably the result of fusion of the first two hypurals (H1 and H2). About the superior hypural we don't know if it develops from only H3 or it represents the fusion of more elements. We exclude Hoedeman's interpretation (1961) of this superior hypural as the back portion, or posterior hemiconus, of the last vertebral centrum. This is not only in consequence of their common shape, mostly related to their same function, but also because of their common intesity to the staining reaction.

In many teleosts caudal rays are attached also to the parhypural (PH) and to the hemal spine of the preural 2 (PU2). In *S. abaster* caudal rays are joined to hypurals like in anguilliform fishes and in that species with a narrow tail fin (Schultze & Arratia).

Dorsal elements associated with ural centra, epurals and uroneurals, that are present in most of teleosts, are lacking in pipefishes. The presence of uroneurals is considered to be a distinctive feature of the Teleostei (Patterson, 1968; Lauder & Liem, 1983), but a progressive decrease of these structures has been observed from Jurassic to Recent teleosts (Patterson). They have been lost independently in *Syngnathus* like in *Scarus, Gobius, Merluccius* and other acanthopterygians (Monod, 1968).

It is widely accepted that homocercal tail of Teleost is formed by two ural centra. They are the ontogenetic and phylogenetic result of fusion of several vertebral centra that can be still distinguished in most primitive teleosts and in their ancestors. This is often demonstrated by a higher number of hypurals than vertebral centra (Gosline, 1971; Schultze & Arratia and Nybelin, 1973).

In many teleosts the two ural vertebrae reduce to one and sometimes are fused both with preural 1 (Schultze & Arratia) like it has happened in *S. abaster* in which no ural centra are present.

Monod proposed the fusion of preural centra 2 and 3 (PU2 + PU3) in another species of the same genus, *Syngnathus acus*, on the evidence of two hemal arches under the same vertebral centrum. In *S. abaster* only one hemal arch can be distinguished and lateral processes are doubled. The evolutionary process of reduction and fusion of preural vertebrae is common to both species and presumably to the genus *Syngnathus,* but different residual elements are left.

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RESUMEN: El esqueleto caudal es una de las más importantes herramientas para evaluar las interrelaciones de teleósteros, pero la anatomía de pocas especies han sido investigada. Nunca se ha estudiado la morfología de la cauda del pez aguja de río de rayas negras *(Syngnathus abaster)*. Se usó una técnica específica de tinción con alizarina roja, para visualizar estructuras calcificadas, obteniéndose un gran conocimiento de la organización del esqueleto caudal. Los resultados e interpretación de ellos coinciden parcialmente con los hallazgos en otras especies de *Syngnathus*. En ambos casos se enfatiza la importancia de tratar los problemas con nuevas técnicas y metodologías.

PALABRAS CLAVE: Esqueleto caudal; *Syngnathus*; Teleóstero; Alizarina roja.

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