



**New data on *Pankowskichthys libanicus* (Pycnodontiformes, Gladiopycnodontidae),
a fossil fish from the marine Upper Cretaceous of Lebanon**

**Nouvelles données concernant *Pankowskichthys libanicus* (Pycnodontiformes, Gladiopycnodontidae),
un poisson fossile du Crétacé supérieur marin du Liban**

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Résumé: Un spécimen mâle de *Pankowskichthys libanicus* est décrit et comparé avec l'holotype de l'espèce, considéré comme femelle. La comparaison avec *Ducrotayichthys cornutus* est également faite.

Mots-clés: *Pankowskichthys libanicus*, Pycnodontiformes, Gladiopycnodontidae, Cénomaniens marin, Liban, dimorphisme sexuel

Abstract: A male specimen of *Pankowskichthys libanicus* is described and compared with the holotype of the species, considered as a female. The comparison with *Ducrotayichthys cornutus* is also done.

Key words: *Pankowskichthys libanicus*, Pycnodontiformes, Gladiopycnodontidae, marine Cenomanian, Lebanon, sexual dimorphism.

INTRODUCTION

Pankowskichthys TAVERNE & CAPASSO, 2014 is a pycnodontiform fish genus from the marine Cenomanian (Upper Cretaceous) of Lebanon. The genus is monospecific. Until recently, its unique species, *Pankowskichthys libanicus* TAVERNE & CAPASSO, 2014, was known by the holotype only, a small specimen (IRSNB P 9278) of 41 mm in total length (TAVERNE & CAPASSO, 2014: figs 17, 18).

Pankowskichthys libanicus belongs to the Gladiopycnodontidae, one of the three families that constitute the superfamily Coccodontoidea. All three are endemic in the Lebanese marine Cenomanian deposits but the superfamily probably has an origin in the Erythrean Channel that began to separate during the Jurassic the two large provinces of Gondwana, the western South America-Africa, on the one hand, and the eastern Madagascar-India-Antarctica-Australia, on the other hand (TAVERNE, 2019: 31).

The family Gladiopycnodontidae contains ten genera. They are highly specialized fishes (TAVERNE & CAPASSO, 2013, 2014, 2016; TAVERNE, MAISEY & CAPASSO, 2015; MARRAMA *et al.*, 2016). Their snout is elongated in a rostrum that is formed by the sutured prefrontal and premaxilla. The pectoral girdle is closely associated with the skull, forming a sort of cephalothorax. The cleithrum is greatly enlarged, with a wide ventral posterior process. Some of them exhibit frontal, occipital and nuchal horns. A large pectoral spine is present but the pectoral fin is lost, except in one species that re-acquires the fin (MARRAMA *et al.*, 2016).

Recently, CAWLEY & KRIWET (2017) described a second specimen of *Pankowskichthys libanicus* (MNHN HAK 1950) very similar to the holotype but, however, with a few anatomical differences. The new sample has three ventral tips at the basis of the prefrontal. Its frontal ("parietal" in CAWLEY & KRIWET, 2017) bears two well marked horns. The orbitosphenoid is pressed against the mesethmoid. The nuchal horn is almost vertically oriented. In the holotype, the prefrontal has no ventral tip, the frontal only bears a median protuberance, the orbitosphenoid is hook-like and separated from the mesethmoid and the nuchal horn is obliquely oriented. CAWLEY & KRIWET (2017) interpret these differences as the result of a sexual dimorphism, the new specimen being considered as a male and the holotype has a female.

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Such a sexual dimorphism was already described in another coccodontoid species, *Hensodon spinosus* (HENNIG, 1907), where males and females exhibit marked differences in their horns and spines on the skull and the pectoral girdle (CAPASSO *et al.*, 2010). Thus, we agree with the conclusions of our two colleagues when they consider the differences between the holotype and the new sample as the consequence of a sexual dimorphism.

Unfortunately, specimen MNHN HAK 1950 is not very well preserved and the description given by CAWLEY & KRIWET (2017) remains rather superficial. A better preserved male sample of *Pankowskichthys libanicus* (CLC S-1822) exists in the CAPASSO collection in Chieti. It allows a more accurate description and more detailed comparison with the holotype. That is the aim of our present paper.

MATERIAL AND METHODS

The specimen hereafter described belongs to the CAPASSO collection (CLC) in Chieti (The Abruzzi, Italy) and was studied with a stereomicroscope Leica Wild M 8. The figures are drawn by the first author (L. T.). The photos are made by Mr. Luciano LULLO, from the Università “G. d’Annunzio” di Chieti-Pescara.

Material from the Royal Institute of Natural Sciences of Belgium (IRSNB) and from the “Muséum National d’Histoire Naturelle de Paris” (MNHN) is also mentioned.

The CAPASSO collection is legally registered and was declared part of the Italian cultural heritage by a decree of the Ministero per I Beni e le Attività Culturali under the date of October 11th 1999, following the disposition of the Italian law of cultural heritage protection N° 1089/1939. The specimens of this collection were also subject to prescription in order of conservation and availability to the studies on the basis of the article 30 of the Italian law N° 42/2004. The Soprintendenza per I Beni Archeologici dell’Abruzzo-Chieti has authorized the authors to study this collection by two letters bearing the dates of May 5th, 2011 (ref.: MBAC-SBA-ABR PROT 0004537 05/05/ 2011 Cl. 34.25.01/2.1) and July 30th, 2014 (ref.: MBAC-SBA-ABR PROT 0005618 31/07/2014 Cl. 34.25.01/2.1).

List of abbreviations used in the text-figures

AN	=	angular
ART	=	articular
ASPH	=	autosphenotic
DHYOM	=	dermohyomandibula
DN	=	dentary
DPTE	=	dermopterotic
DSOC	=	dermosupraoccipital
DSPH	=	dermosphenotic
ENPT	=	entopterygoid (= endopterygoid)
FR	=	frontal
HO fr.	=	frontal horn
HO n.	=	nuchal horn
HYOM	=	hyomandibula
METH	=	mesethmoid
MPT	=	metapterygoid
MX	=	maxilla
OP	=	opercle
OSPH	=	orbitosphenoid
PA	=	parietal
PMX	=	premaxilla
POP	=	preopercle
PRART	=	prearticular
PRFR	=	prefrontal
PS	=	parasphenoid
PT	=	posttemporal
SCL	=	sclerotic bony ring
SCU	=	dorsal scutes
SPI p.	=	pectoral spine
VO	=	vomer

SYSTEMATIC PALEONTOLOGY

Subclass Actinopterygii KLEIN, 1885
Series Neopterygii REGAN, 1923
Division Halecostomi REGAN, 1923 *sensu* PATTERSON, 1973
Superorder Pycnodontomorpha NURSALL, 2010
Order Pycnodontiformes BERG, 1937 *sensu* NURSALL, 2010
Superfamily Coccodontoidea TAVERNE & CAPASSO, 2013
Family Gladiopycnodontidae TAVERNE & CAPASSO, 2013
Genus *Pankowskichthys* TAVERNE & CAPASSO, 2014
Species *Pankowskichthys libanicus* TAVERNE & CAPASSO, 2014

Material

Sample CLC S-1822, a complete male specimen seen in left view (Fig.1). Total length: 35 mm. Standard length: 26 mm.

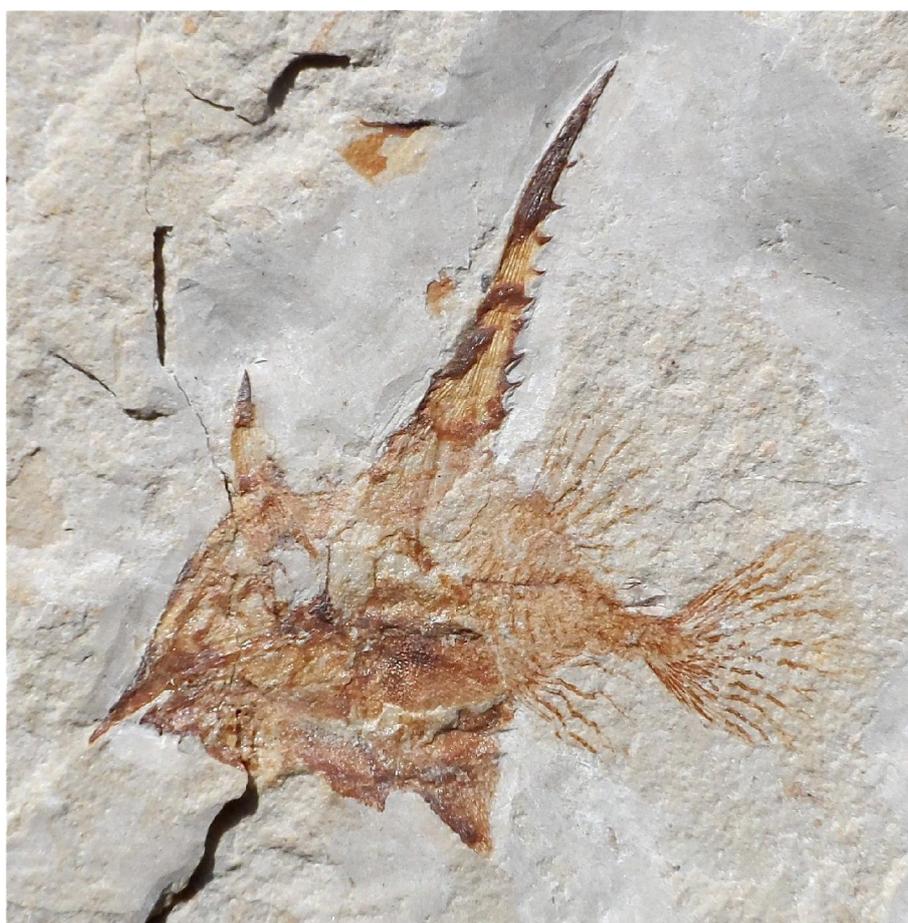


Figure 1: *Pankowskichthys libanicus* TAVERNE & CAPASSO, 2014. Specimen CLC S-1822 (male). Total length: 35 mm.

Formation and locality

Marine Upper Cenomanian deposits of Hgula, Lebanon.

Morphometric data (Fig. 1)

The weak ossification of the axial skeleton and the absence of body scales indicate that the concerned specimen is a juvenile fish.

The morphometric data are given in % of the standard length (26 mm) of specimen CLC S-1822.

Length of the head (parietal included)	69.4 %
Length of the cephalothorax (cleithrum included)	75.0 %
Depth of the cephalothorax (nuchal horn not included)	75.0 %
Length of the nuchal horn	72.2 %
Maximum depth of the body (just behind the nuchal horn)	45.0 %
Predorsal length	76.7 %
Basal length of the dorsal fin	16.6 %
Preanal length	73.9 %
Basal length of the anal fin	16.1 %
Depth of the caudal peduncle	8.3 %

Osteology

The skull (Fig. 2)

As in all Gladiopycnodontidae, the skull and the pectoral girdle are closely imbricated together, forming a sort of cephalothorax that is enormous when compared to the body size. The dermal bones of this cephalothorax are ornamented with alveoli and small tubercles.

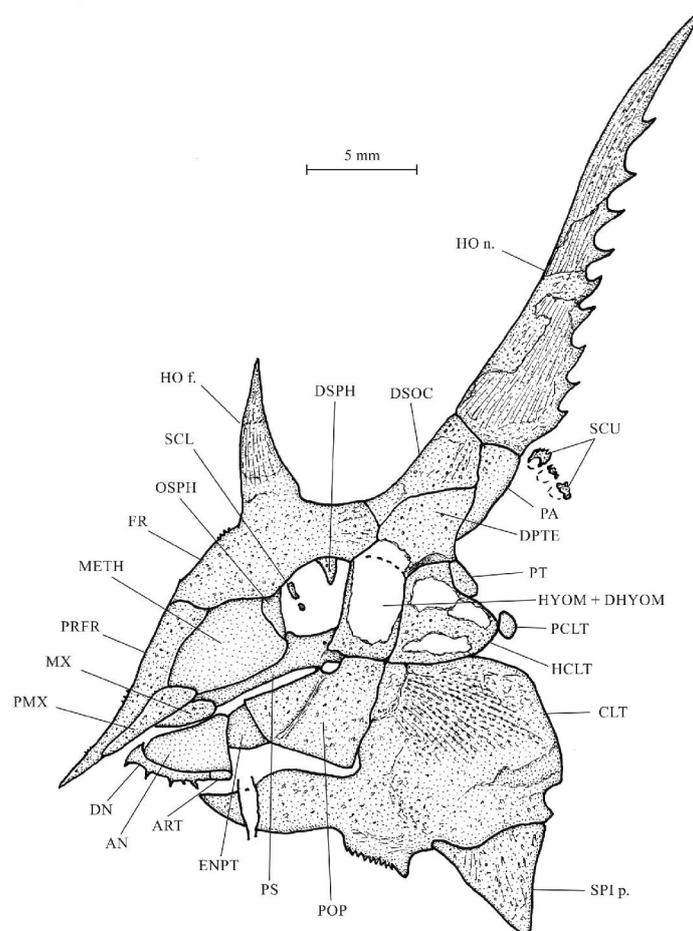


Figure 2: *Pankowskichthys libanicus* TAVERNE & CAPASSO, 2014.
Skull and pectoral girdle of specimen CLC S-1822 (male).

The snout is elongated, with an acuminate anterior extremity that is formed by the prefrontal only. The rostrum greatly outpaces the lower jaw level. Posteriorly, the prefrontal reaches the frontal. CAWLEY & KRIWET (2017: 33) mention “three ventral pointed tips projected from the base of the prefrontal” in their specimen. These tips are not present in sample CLC S-1822. It is possible that the lower jaw is strongly pressed against the rostrum in specimen MNHN HAK 1950 and that “the three ventral tips” are the spines located at the ventral margin of the dentary. The toothless premaxilla is shorter than the prefrontal and is firmly sutured to this bone all along its length. The vomer is completely hidden by the premaxilla. A large part of the massive mesethmoid is visible between the prefrontal, the frontal and the parasphenoid.

The frontal is broad but rather short. Posteriorly, it reaches the dermosupraoccipital and the dermopterotic but not the parietal. The frontal bears a well developed and pointed horn. CAWLEY & KRIWET (2017: 33) describe two horns on the frontal. It seems that the two frontals are disjoined on MNHN HAK 1950, each frontal bearing its own horn (ibid., 2017: fig. 1 b). In CLC S-1822, the two frontals are joined and only the left frontal and its horn are visible. The right horn probably is entirely hidden under the left horn. The dermopterotic is a large bone. The parietal is deep but narrow and is devoid of brush-like process. The dermosupraoccipital is elongated, with a narrow anterior part and a broader upper part.

The nuchal horn is long and ornamented with ridges. Its posterior margin bears nine well marked spines, as in the holotype (TAVERNE & CAPASSO, 2014: figs 17, 18). The spaces separating these spines are concave. The horn has a slightly oblique orientation and is supported by the dermosupraoccipital and the parietal but not by the dermopterotic.

The parasphenoid is long, straight and toothless. The orbitosphenoid is located at the anterior border of the orbit and is pressed against the posterior margin of the mesethmoid. Neither a pleurosphenoid nor a basisphenoid are visible. A part of the entopterygoid is exposed below the preopercle.

Both the premaxilla and the maxilla are toothless. As already written, the premaxilla is completely sutured to the prefrontal. The maxilla is small and more or less ovoid. It is positioned just below the posterior extremity of the premaxilla to which it is attached. The dentary is reduced to its ventral branch and seems toothless. Its ventral margin bears four strong spines. A smaller spine is located between the third and the fourth strong spines. Traces of three ovoid molariform teeth belonging to the prearticular are visible under the angular. A small articular is present just behind the dentary.

The orbit is wide. A small dermosphenotic is suspended to the frontal at the level of the orbital posterior margin. No other bone of the orbital series is visible. There is a sclerotic bony ring.

The anterior margin and the lower region of the hyomandibula-dermohyomandibula are the only preserved parts of the bone. The preopercle is well developed, deep and broad but with the ventral region broader than the upper one. The hyomandibula is almost as deep as the preopercle. The opercle is missing. This apparent loss probably is due to a taphonomic event.

The girdles (Fig. 2)

The cleithrum is greatly hypertrophied and strongly ornamented with large alveoli that are ranged in regular ranks in the upper part of the bone. The long, pointed and broad anterior ventral branch extends to the lower jaw level. The dorsal branch is considerably broadened, forming a wide posterior process that completely covers the abdominal cavity. There is no pectoral fin. A short but very broad pectoral spine takes its place. The spine is articulated on the posterior part of the ventral region of the cleithrum. The suture line between the spine and the bone is less clearly visible on the holotype, the cleithrum and the spine being already partly fused. Just before the pectoral spine, the ventral border of the cleithrum bears a small process with a spiny margin. A large hypercleithrum (= supracleithrum) overhangs the dorsal branch of the cleithrum. A small posttemporal and a still smaller postcleithrum are pressed against the posterior margin of the hypercleithrum.

The pelvic girdle is not visible. This structure is reduced and often completely hidden by the gigantic cleithrum in *Gladiopycnodontidae*.

The axial skeleton (Fig. 1)

The axial skeleton is poorly ossified and its posterior region is crushed. So, the exact number of neural and haemal spines is unknown. The notochord is not surrounded by the vertebral arches. The first four neural spines are elongated. They are located just behind the hypercleithrum and seem autogenous. The eight following neural are short and fused with small neural arches. Fragments of at least six haemal spines are present but no haemal arch is visible.

If present, the postcoelomic bone is completely hidden by the cleithrum, a frequent case in *Gladiopycnodontidae*.

The dorsal and anal fins (Fig. 1)

The dorsal fin contains 9 segmented rays that are branched at their distal extremities. Anteriorly, the fin does not reach the nuchal horn. Three small dorsal ridge scutes separate the fin from the horn.

The anal fin begins with a short spine that is followed by 6 segmented rays. The first and the sixth rays are shorter than the four other rays. It seems that the distal extremity of the rays is not branched.

The caudal endoskeleton and fin (Fig. 1)

Traces of 5 hypochordals are present. The first four are narrow, while the fifth one is strongly hypertrophied as in the holotype of the species (TAVERNE & CAPASSO, 2014: fig. 20). The epichordals and the eventual urodermal are not visible.

The caudal fin contains 13 principal rays, 8 dorsal and 6 ventral procurrent rays (= basal fulcra). The most dorsal and the most ventral principal rays are segmented and not branched. The eleven other principal rays are segmented and branched at their posterior extremities. The distal border of the fin is convex (POYATO-ARIZA & WENZ, 2002: fig. 36 B).

The squamation

No scales are visible on the body. However, a few fragments of large scales ornamented with tubercles are preserved in the caudal peduncle. These scales are similar to those present on the holotype of the species (TAVERNE & CAPASSO, 2014: fig. 21).

As already mentioned, three small and spiny dorsal ridge scutes are visible between the nuchal horn and the origin of the dorsal fin.

DISCUSSION

The sexual dimorphism in *Pankowskichthys libanicus* (Fig. 3)

The male sample CLC S-1822 and the female holotype IRSNB P. 9278 share the same general morphology. At first sight, the two specimens seem to be very similar. However, as we will see hereafter, the differences between the two sexes of *Pankowskichthys libanicus* are numerous, much more numerous than the four ones mentioned by CAWLEY & KRIWET (2017).

- (1) The mesethmoid is well exposed in CLC S-1822, while it is almost entirely hidden by the prefrontal in IRSNB P. 9278.
- (2) The frontal reaches the dermosupraoccipital and the dermopterotic but not the parietal in CLC S-1822. In IRSNB P. 9278, the posterior region of the frontal is elongated. The bone is sutured to the dermosupraoccipital and to the parietal but reaches the dermopterotic in only one point.
- (3) The frontal bears a well developed horn in CLC S-1822 but has only a median protuberance in IRSNB P. 9278.
- (4) The parietal is much smaller in CLC S-1822 than in IRSNB P. 9278.
- (5) The dermopterotic is much wider in CLC S-1822 than in IRSNB P. 9278.
- (6) The parasphenoid is very long and greatly outpaces the level of the hypercleithrum in IRSNB P. 9278 but does not outpace the rear of the skull in CLC S-1822.
- (7) The orbitosphenoid is pressed against the mesethmoid in CLC S-1822. This bone is hook-like and well separated from the mesethmoid in IRSNB P. 9278.
- (8) The premaxilla exhibits a short anterior hook-shaped process not attached to the prefrontal in IRSNB P. 9278 but has an acuminate anterior extremity sutured to the prefrontal in CLC S-1822.
- (9) The dentary bears two very small teeth in IRSNB P. 9278 but is toothless in CLC S-1822.
- (10) The ventral margin of the dentary is ornamented with four or five well developed spines in CLC S-1822 but has only a series of microspines on IRSNB P. 9278.
- (11) The hyomandibula is almost as deep as the preopercle in CLC S-1822 but is much more reduced in IRSNB P. 9278.
- (12) In IRSNB P. 9278, the preopercle completely covers the metapterygoid and the entopterygoid. A large part of the entopterygoid is visible on CLC S-1822.
- (13) The nuchal horn is proportionally shorter (72.2 % of the standard length) in CLC S-1822 than in IRSNB P. 9278 (83.5 % of the st. l.).
- (14) The nuchal horn is more upright in CLC S-1822 than in IRSNB P. 9278 that has an obliquely oriented horn.
- (15) The spaces between the spines of the nuchal horn are concave in CLC S-1822 but almost straight in IRSNB P. 9278.

- (16) The abdominal cavity, the pelvic girdle and the postcoelomic bone are entirely covered by the dorsal branch of the cleithrum in CLC S-1822. In IRSNB P. 9278, portions of ribs, parts of the ventral fins and of the postcoelomic bone are exposed behind the cleithrum.
- (17) The ventral anterior branch of the cleithrum is broad in CLC S-1822 but narrow in IRSNB P. 9278.
- (18) In CLC S-1822, a broad process with a spiny ventral margin is present on the ventral border of the cleithrum, just before the pectoral spine. Such a process does not exist in IRSNB P. 9278.
- (19) The dorsal and anal fin rays are much longer in CLC S-1822 than in IRSNB P. 9278.
- (20) There are three spiny dorsal ridge scutes between the nuchal horn and the dorsal fin in CLC S-1822. In IRSNB P. 9278, there is no dorsal ridge scute and the dorsal fin begins immediately after the nuchal horn.

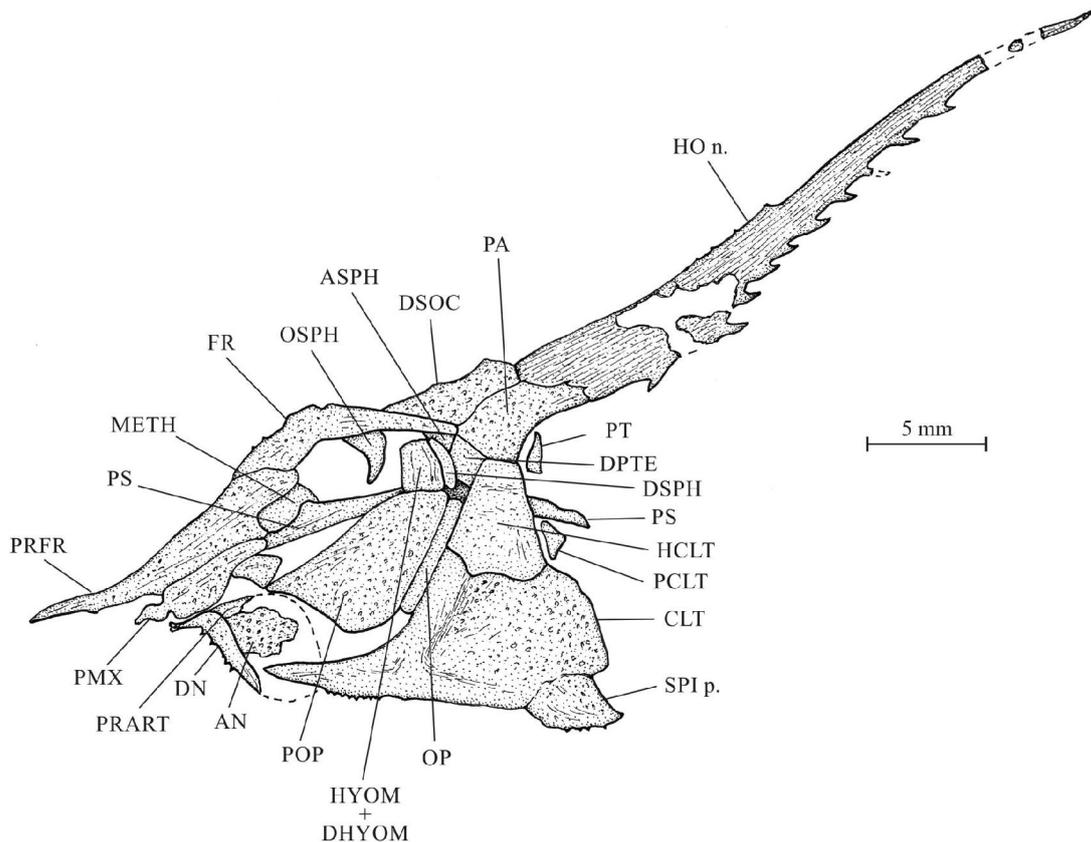


Figure 3: *Pankowskichthys libanicus* TAVERNE & CAPASSO, 2014. Skull and pectoral girdle of holotype IRSNB P. 9278 (female) (modified from TAVERNE & CAPASSO, 2014: fig. 19 and reversed).

As previously mentioned, another case of sexual dimorphism is known in Pycnodontiformes. It concerns the species *Hensodon spinosus*, a coccodontoid fish, (CAPASSO *et al.*, 2010) but the number of sexual differences recorded in *Pankowskichthys libanicus* is considerably more important than those occurring in *H. spinosus*. However, these numerous differences only concern osteological details and not really important characters. It is why we consider that CLC S-1822 does not represent a new species but is the male version of *P. libanicus*, the holotype of the fish being the female version.

***Pankowskichthys libanicus* and *Ducrotayichthys cornutus* (Fig. 4)**

The data concerning *Ducrotayichthys cornutus* used in this subchapter come from TAVERNE & CAPASSO (2015). *D. cornutus* also belongs to the Gladiopycnodontidae and is known by only one specimen.

With a well developed frontal horn and the presence of dorsal ridge scutes, CLC S-1822, the male version of *Pankowskichthys libanicus*, is much more alike *Ducrotayichthys cornutus* than is IRSNB P. 9278, the female version of *P. libanicus*.

Both species share the same general morphology. They have a frontal and a nuchal horn, an acuminate rostrum, a well exposed mesethmoid, a short but broad pectoral spine located at the posterior extremity of the ventral margin of the cleithrum, a few spiny dorsal scutes between the nuchal horn and the dorsal fin and a small body.

But there are also many important differences. In *Ducrotayichthys cornutus*, the acuminate tip of the prefrontal bears small spines. The premaxilla is long and it reaches the frontal. The maxilla is positioned just below the anterior extremity of the premaxilla and is not attached to that bone. The anterior region of the dermosupraoccipital broadens and bears a well marked hunch, while the posterior region of the bone largely extends on the basis of the nuchal horn. The highly enlarged preopercle covers a great part of the cleithrum? Three bones, the dermosupraoccipital, the parietal and the dermopterotic, support the nuchal horn. The ventral margin of the cleithrum is devoid of spiny process. The hypercleithrum is small. The body scales are strongly reduced and needle-like.

For all these characters, CLC S-1822 completely differs from *D. cornutus*. *Pankowskichthys libanicus* and *Ducrotayichthys cornutus* obviously are two different species and can not be synonymised.

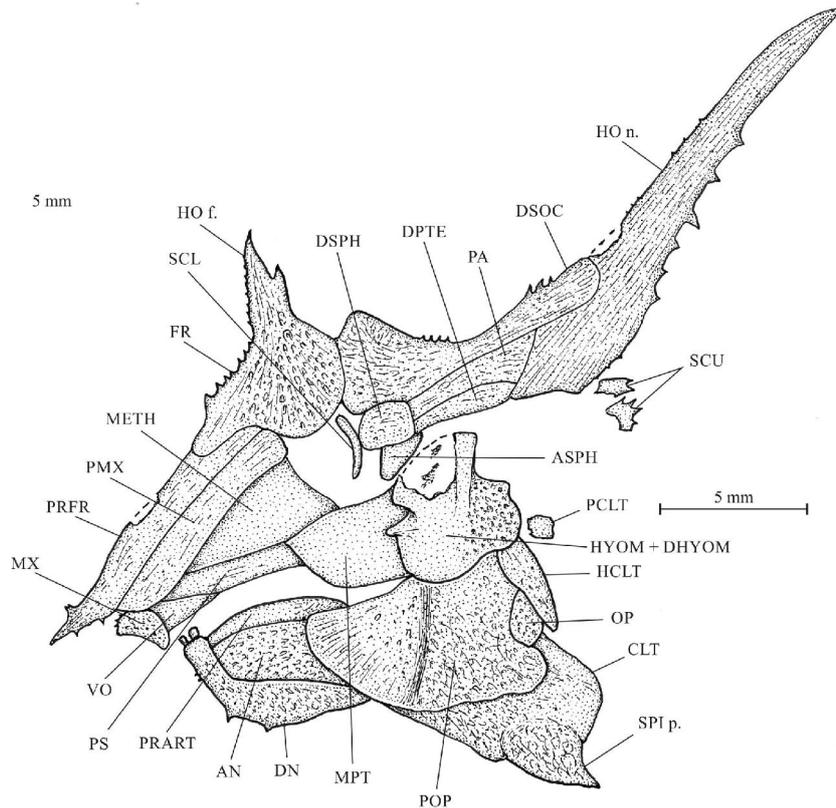


Figure 4: *Ducrotayichthys cornutus* TAVERNE & CAPASSO, 2015. Skull and pectoral girdle of holotype CLC S-591 (modified from TAVERNE & CAPASSO, 2015: fig. 5).

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