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Osteological features of Cobia, *Rachycentron canadum* (Linnaeus 1766)

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Abstract

The Cobia, *Rachycentron canadum* (Linnaeus 1766), is a large, fast-growing coastal pelagic fish belonging to the monotypic family Rachycentridae. In this study, we describe in detail the osteological characters of the Cobia from Indian waters. The skull, appendicular, and axial skeletons were disarticulated, examined, and illustrated. We characterize the species based on morphometry, meristic counts, and osteological features and briefly review the phylogenetic relationships proposed for the species.

Key words: fishes, osteology, Perciformes, morphology, taxonomy, systematics, bones, skull.

Introduction

The Cobia, *Rachycentron canadum* (Linnaeus 1766) is a large, fast-growing coastal pelagic fish belonging to the monotypic family Rachycentridae in the Order Perciformes. The six to nine independent, short, stout, and sharp spines making up the spinous dorsal fin is an important diagnostic feature of this species. The etymology of the generic and family name allude to these dorsal spines (from the Greek words *rhakhis* meaning ridge, to New Latin *rhachis* meaning spine or shaft or vertebral column, and the Greek word *kentron* meaning a sharp point).

Rachycentron canadum is the only species belonging to the family Rachycentridae and no subspecies are recognized (Shaffer & Nakamura 1989). Linnaeus (1766) originally described this species as *Gasterosteus canadus* based on specimens collected from Carolina, USA (type locality) and classified the species under the Order Gasterosteiformes, Family Gasterosteidae, and Genus *Gasterosteus* Linnaeus 1758. Numerous revisions of the nomenclature and classification of Cobia took place between 1766 and 1905 (Bloch 1793, Lacepede 1802, Mitchill 1815, Kaup 1826, Cuvier & Valenciennes 1829, 1831, Swainson 1839, DeKay 1842, Gosse 1851, Gronow 1854, Gunther 1860, Jordan & Evermann 1896, Jordan 1905), with no further revisions.

An in-depth analysis of morphological, meristic and osteological characters of *Rachycentron canadum* occurring in Indian waters was performed by the first author in an unpublished dissertation (Sajeevan 2011). The species descriptions to date are mainly based on external morphological characters and relatively less attention has been paid to the osteological features of the species (but see Starks 1926, Gregory 1959, and, in particular, O'Toole 1999, 2002). In this study, we describe and illustrate in detail the morphological and osteological characters of specimens collected from Indian waters.

Materials and Methods

The present study was based on samples collected from the catches of the M. V. *Matsya Nireekshani*, a trawler belonging to the Fishery Survey of India, Mumbai. This vessel operated along the northwest coast of India. Samples collected from landing centers at Mumbai, (New Ferry Warf and Sassoon Dock) were also used for the study. Specimens were identified using standard references (Day 1878, Munro 1955, Fischer & Bianchi 1984, Smith & Heemstra 1986). Morphometric and meristic data were obtained from fresh specimens. All measurements were taken from point to point on the left side of the fish with one mm precision (Philip 1994). Fin rays, branchiostegal rays, and gillraker counts were made manually by the first author.

In total, 93 specimens were subjected to morphometric measurements and body measurements are presented as percentage of total length and head measurements are presented as percentage of head length. The aspect ratio of the caudal fin was calculated following Ngatunga and Allison (1996). The caudal-fin surface area was calculated using image-processing with image J (Abramoff *et al*. 2004); three images were used and the average aspect ratio was calculated.

For the osteological study, adult specimens were obtained frozen from onboard the vessel, while fresh specimens were obtained from the landing centers. Dry skeletons of the adult specimens were prepared following Bemis *et al*. (2004). We follow the standard osteological terminology of Patterson and Johnson (1995), O'Toole (2002), and Hilton and Johnson (2007).

Results and Discussion

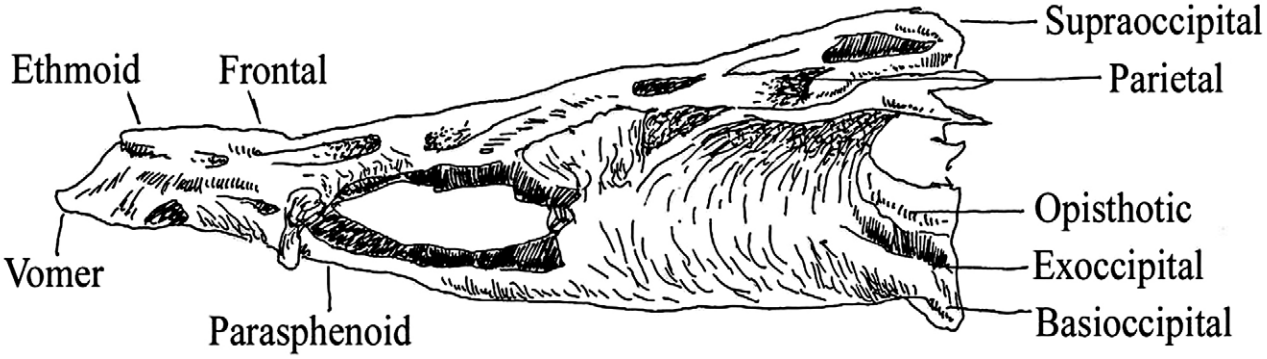
Morphometry. Cobia have an elongated, sub-cylindrical body with a body depth of 12.5% of total length on average. The head is large, flattened and broad, and occupies almost one fifth of the body: head length averages 19.9% TL and head width averages 55.6% HL. The eye is positioned almost in the center of the lateral aspect of the head. The interorbital space occupies almost 50% of the head; interorbital width averages 48.7% HL. Presumably the broad head and large mouth allows for capturing larger prey.

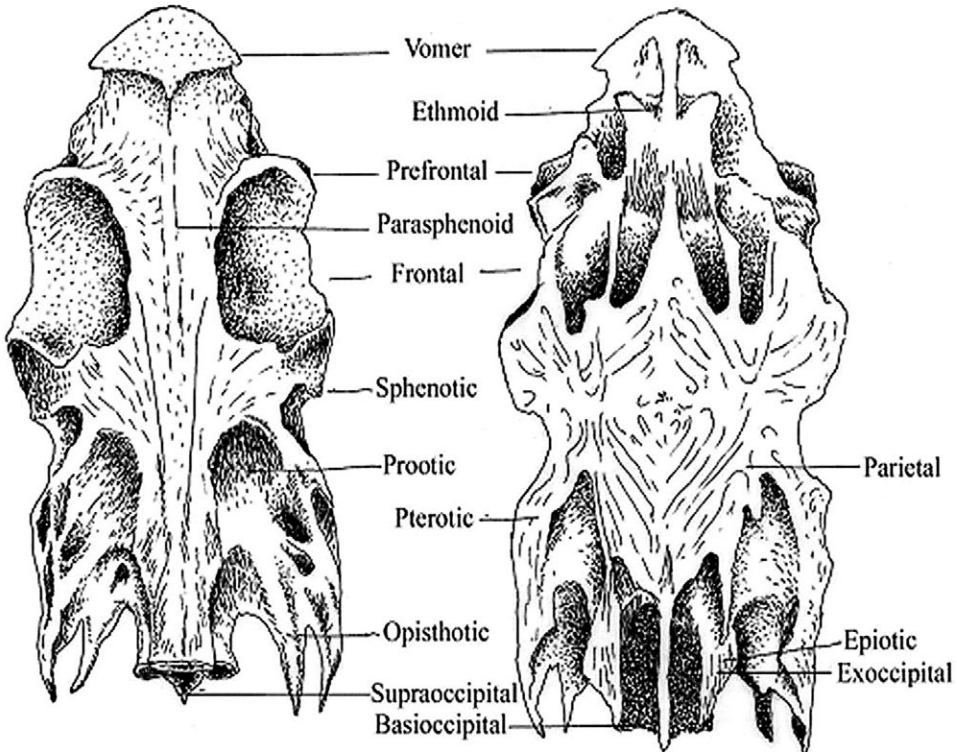
The base of the two dorsal-fins is long, averaging 54.3% TL, and the anal fin originates behind the dorsal-fin origin. The first dorsal fin comprises 7-9 (usually 8) short and stout isolated spines which are not connected by any membrane and fold down into grooves in the body. The spinous portion of the dorsal fin averages 17.6% TL. The second dorsal-fin base is also long, averaging 36.7% TL, comprises 31-34 rays, and its anterior rays are somewhat elevated in adults. The anal fin is similar in profile to the second dorsal fin, but shorter, with two spines (embedded in the body) and 24-26 rays; the pelvic fins each have one spine and 5 rays. The pectoral fins are long and pointed, becoming more falcate with age, and fixed in the horizontal position, with 20 –21 rays. The caudal fin is lunate in adults, with the upper lobe longer than lower (caudal fin rounded in young), and the central rays much prolonged, with 17-22 rays. The aspect ratio of the caudal fin averaged 1.33, less than the estimate of 0.99 cited in FishBase (www.fishbase.org). Typically, demersal fishes (e.g. *Otolithus ruber* with 1.22) have a low aspect ratio while larger pelagic fishes like tunas (e.g. *Euthynnus affinis* with 9.51) have a high aspect ratio (Christensen & Pauly 1992). In general, the morphometric features of Cobia, such as the separated dorsal spines without membranes and fitting into grooves in the body, the pointed snout, long fins, and high aspect ratio of the caudal fin are clearly adaptations for speed and acceleration.

Osteological features. The detailed osteology of Cobia is illustrated. We summarize the cogent features in list form:

Neurocranium (lateral view, ventral and dorsal view, posterior view)

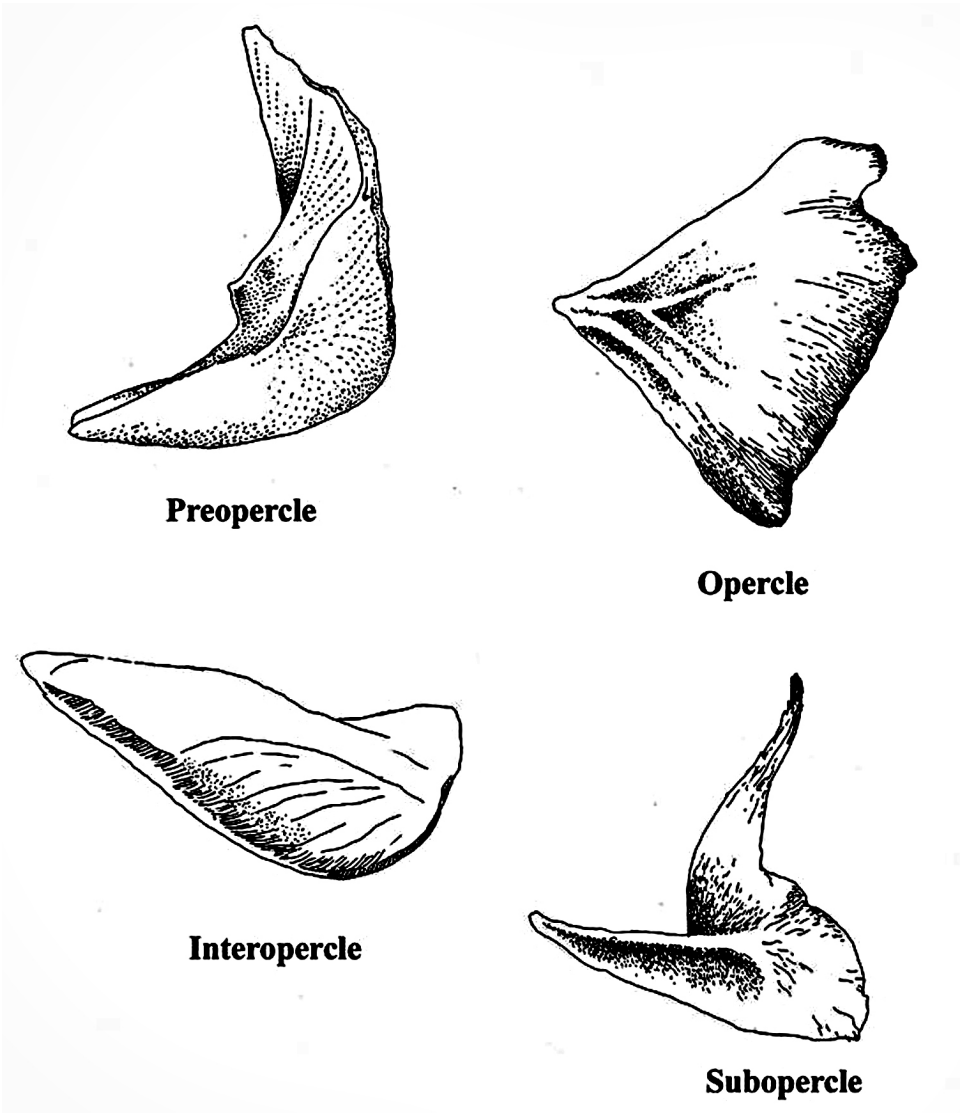
1. Cranium somewhat depressed.
2. Medium-sized supraoccipital extends from mid orbit to exoccipitals of cranium.
3. Supraoccipital crest absent.
4. Parietal pointed medially with three sides.
5. Dorsal surface of frontal almost level and without any crest.
6. Small and rhomboid ethmoid, extended anteriorly.
7. Vomer on ventral side of ethmoid.
8. Sphenotic square-shaped with a lateral projection.
9. Parasphenoid process of vomer pointed.





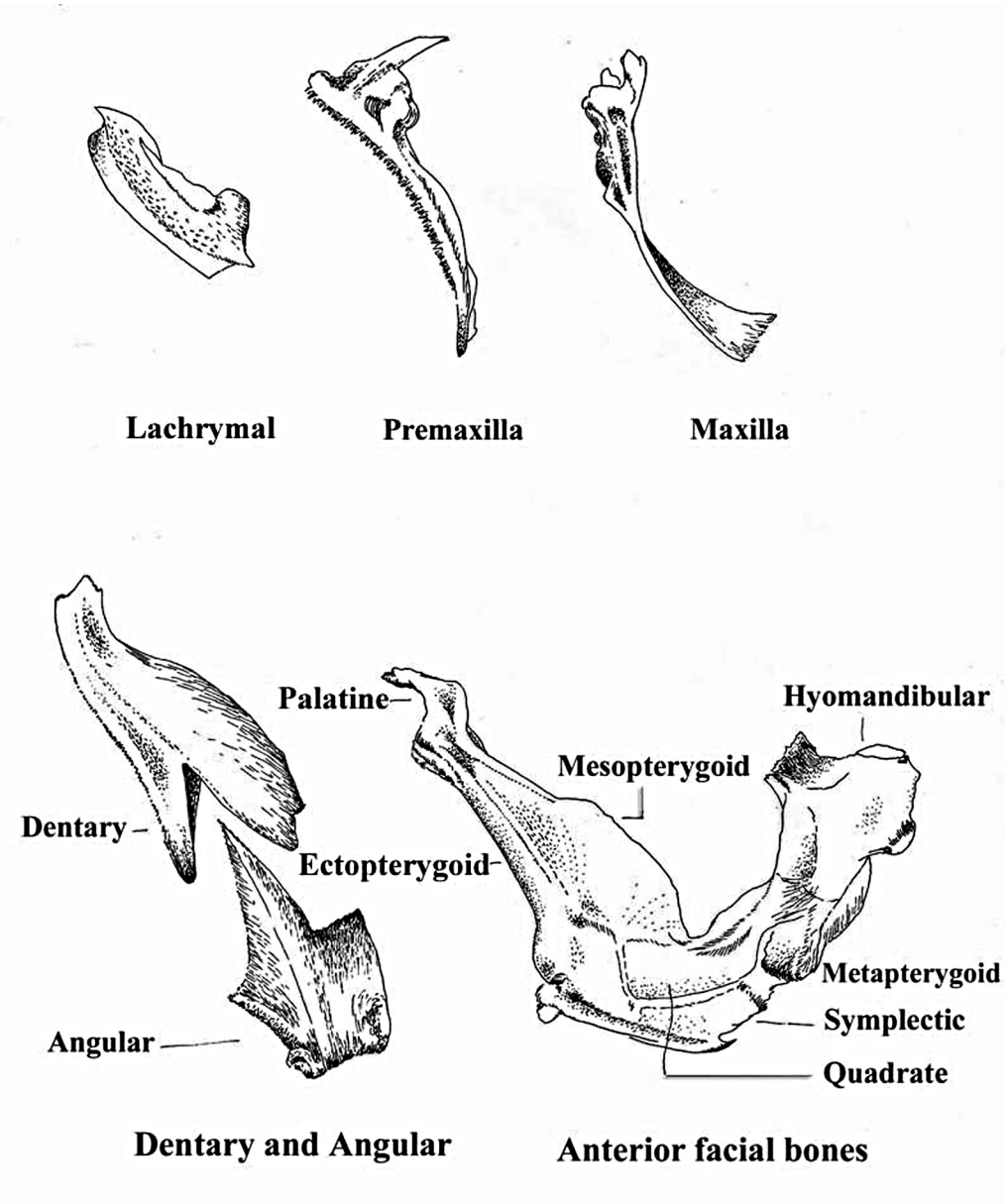
Opercle Bones

1. Posterior margin of opercle with a notch on upper side.
2. Opercle length almost equal to width.
3. Dorsal margin of opercle straight.
4. Dorsally oriented anterior spur on subopercle small, reaches midway point of opercle and hyomandibular articulation.
5. Interopercle small.



Anterior Facial Bones

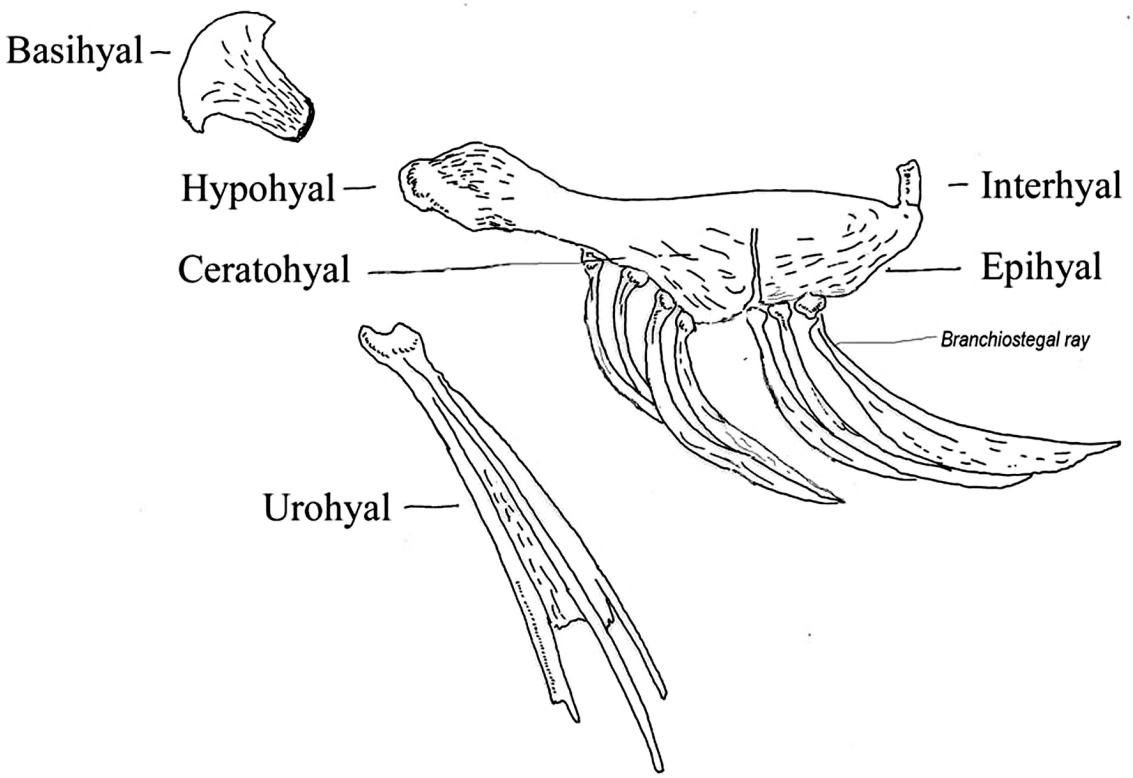
1. Palatine teeth present.
2. Short and wide hyomandibular.
3. Metapterygoid deeper than symplectic.
4. Endopterygoid present and ectopterygoid with posterior projecting process.
5. Metapterygoid overlaps with posterior process of ectopterygoid
6. Supramaxilla absent.
7. Anterior groove present on maxilla.
8. Small canine teeth present on premaxilla.
9. Slightly recurved canines of equal size in several rows present on dentary.
10. Notch on dorsal margin of lachrymal bone.



Hyoid bones

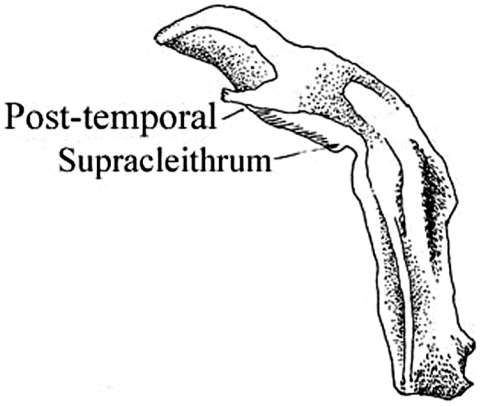
1. Seven branchiostegal rays present.
2. Four branchiostegal rays inserted on ceratohyal and three on epihyal.
3. Interhyal long and rectangular.
4. Urohyal with longer peg for articulation, projecting anteriorly.
5. Urohyal expanded laterally forming wings with posterior branch.
6. Teeth present on basihyal.
7. Lower pharyngeal tooth plate well developed.
8. Epibranchial 1 thin and rod-like.
9. Epibranchial 2 wide anteriorly.

Lateral view of the hyoid bones

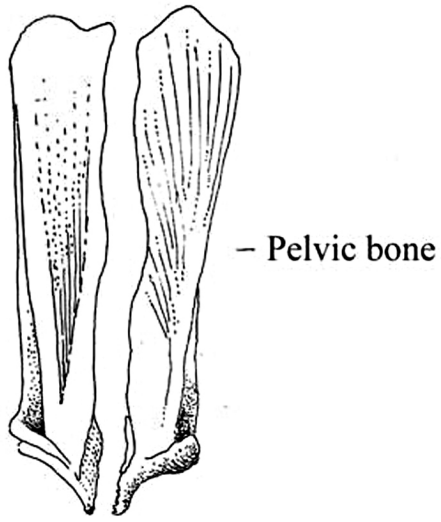


Pectoral and Pelvic Girdle

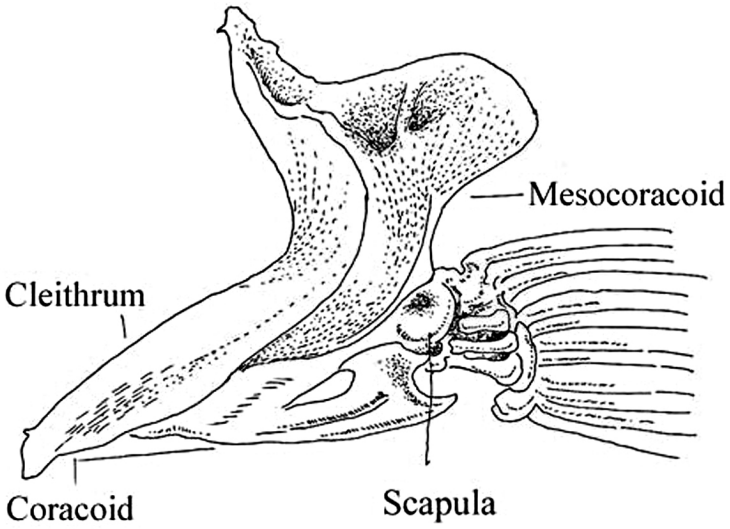
1. Postcleithrum present.
2. Supracleithrum rectangular.
3. Post-temporal median process longer and broader than lateral process.
4. Coracoid articulated to scapula through cartilage.
5. Posterior process of pelvic girdle short, shorter than width.
6. Pelvic girdle long, almost equal to four times width.
7. Dorsal wing of pelvic girdle flat with slight dorsal expansion.



Pectoral girdle
Post temporal and supraclethrum



Ventral view of pelvic girdle



Pectoral girdle

Dorsal Pterygiophores, Anal Spine and Vertebral Column

1. Seven to eight thick and stout dorsal spines and two anal spines.
2. Slight expansion on proximal pterygiophore of first dorsal.
3. Posterior portion of basal laterally expanded in all pterygiophores in spiny portion of dorsal fin.
4. Distal portion laterally expanded throughout the spiny portion of dorsal fin.
5. Neural spine present in first three vertebrae.
6. Parapophysis extended laterally and ventrally.

Caudal Skeleton

1. Three thin rod-like epurals present over ural centrum.
2. Haemal spine present on preural centrum 3.
3. Small neural spine present on preural centrum 2.
4. Long neural spine on preural centrum 3.

Interrelationship of the Species

Johnson (1984, 1993) and Smith-Vaniz (1984) recognized Nematistiidae, Carangidae, Coryphaenidae, Rachycentridae and Echeneidae as comprising a distinct suborder Carangoidei. They listed the anterior extension of the anterior nasal canal surrounded by two tubular ossifications (Freihofer 1978) and the presence of small cycloid scales as the synapomorphy of the group. Within the Carangoidei, the three families, Coryphaenidae, Rachycentridae and Echeneidae, have been grouped into the superfamily Echeneoidea (Johnson 1993). The superfamily is characterized by the absence of predorsal bones, anterior shifting of the first dorsal-fin pterygiophore, the presence of several anal-fin pterygiophores anterior to the first hemal spine, the absence of the beryciform foramen in the ceratohyal, tubular ossifications surrounding both pre-nasal canal units, and elongate-shaped larvae with late dorsal fin (Johnson 1984, Smith-Vaniz 1984). Within this group, Regan (1912) suggested the possibility of a close relationship between Rachycentridae and Echeneidae, based on external appearance and similar osteology. Gudger (1926) also pointed out the remarkable similarity between the young of certain echeneids and the young of *Rachycentron canadum*. Alternatively, Johnson (1984) proposed a Coryphaenidae-Rachycentridae clade based on larval characters.

Our analysis of the morphological, meristic, and osteological features of *Rachycentron canadum* agree broadly with the conclusions of O'Toole (1999, 2002), who, in his thesis, analysed the comparative osteology of the Echeneoidea. *Rachycentron canadum* and echeneids share a depressed cranium without a supraoccipital crest, while *Coryphaena* have a prominent supraoccipital crest. The link to echeneids is further supported by the apparent modification of the first dorsal fin to detached spines in *Rachycentron canadum* and then to the unique sucker apparatus in echeineids.

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