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Osteocranium of the Sailfish (*Istiophorus platypterus*, Shaw & Nodder, 1792) from Malacca Strait

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ABSTRACT The features and morphometrics of the sailfish's osteocranium are examined in this study (*Istiophorus platypterus*, Shaw & Nodder, 1792). I. platypterus has a total weight of ±20 kg with a total length of ±218 cm. The stages of the research process included preparing samples, preparing osteocraniums, documenting photos, editing images, and identifying terminology related to osteocraniums. The Laboratory of Mathematics and Natural Sciences at Almuslim University handled every aspect of the research. The osteocranium preparation process was carried out physically and chemically. Each bone was documented using a camera and edited using Adobe Photoshop CS6. The neurocranium is divided into four components: the olfactory (ethmoidal), which comprises 6 bones. The orbitale comprises 4 bones, the otic comprises 5, and the occipital comprises 4 bones. The branchiocranium is divided into five components: the oromandibular structure consisting of 3 bones, the mandibular arc (suspensorium) composed of 4 bones, the opercular apparatus consisting of 4 bones, and the hyoid arc composed of 6 bones, and the branchial arc composed of 4 bones.

Keywords: Bones; *Istiophorus platypterus*; osteocranium; Sailfish

INTRODUCTION

The skull bone (osteocranium) protects the brain and sensory organs in the fish head (Hilton, 2011; Zulfahmi et al., 2019). The skeletal structure of the osteocranium of adult teleost fish consists of ±60 interconnected bone parts (Aerts, 1991). The skull bone is divided into several main components, namely the neurocranium (consisting of the ethmoidal, orbital, and occipital bones), the jaw (consisting of the upper and lower jawbones), the suspensory, the opercular, the branchial, and the hyoid arch (Nikmehr et al., 2016).

The shape of the osteocranium of each fish species is influenced by the individual's genetic composition and other environments, such as foraging behaviour and water conditions (Zulfahmi et al., 2019). Löffler et al. (2008) stated that the mechanism of breathing and diet are also factors that can affect the shape of the skull. Fish that eat small invertebrates have a mouth equipped with a relatively long snout. In contrast, fish with large prey have a flexible mouth circle like predatory fish from the genus *Dunkleosteus* having a solid and sharp jawbone structure that can provide excellent bite pressure to the prey body during the jaw-closing process (Anderson & Westneat, 2007). In addition, variations in fish body shape also affect the shape of the osteocranium, such as the body shape of a fusiform, compressed and depressed (Bhagawati et al., 2013).

Istiophorus platypterus belongs to the family Istiophoridae and is also known as the Indo-Pacific sailfish. This species still has a close relationship with the Xiphiidae and Xiphiorhynchidae families (Fierstine, 1990). *I. platypterus* has a fusiform body or a torpedo shape, a streamlined form to move in the waters without many obstacles (Rohit, 2022). This species is also known as a fast swimmer because it has a strong tailbone and forked caudal fin with a swimming speed of 110 km/hour; and is also included in the types of beaked fish that often comes to the surface with a developed dorsal fin (Hoolihan, 2006). In addition, I. platypterus has an upper snout twice as long as the lower snout and a lower jaw much shorter than the upper jaw and has a long dorsal fin similar to a ship's sail (IOTC, 2012). According to Setyadji & Nugraha (2016), there are six species of billfish identified in Indonesian waters. One species belongs to the family Xiphiidae (*Xiphias gladius*), while the other belongs to Istiophoridae (*Istiophorus platypterus*, *Makaira mazara*, *M. indica*, *Tetrapturus audax*, and *T. angustirostris*). Fish of this group are distributed in the tropical and subtropical waters (Rodríguez, 2006) and generally live epipelagic in the waters around the islands (Gottfried, 1982). In Indonesia, *I. platypterus* is still very abundant (Gottfried, 1982); supported to data from the Ministry of Maritime Affairs and Fisheries (MMAF, 2010), the production of *I. platypterus* from 2004 to 2008 was supported by data of 13.408 tons with an average increase of 19.07%. This finding is also strengthened by Suprapto (2017) results in the waters of the Exclusive Economic Zone of the Indian Ocean. At fishing port (TPI) Lampulo, Banda Aceh, the catch of I. platypterus was still high, with a catch percentage of 12.5%.

Skeletal structure studies of several fish families have been reported, including the Alestidae (Murray, 2004), Characidae (Bogutskaya et al., 2008), Cichlidae (Dierickx et al., 2017), Cyprinidae (Jalili et al., 2016; Akmal et al., 2018; Akmal et al., 2020; Zulfahmi et al., 2020), Mugilidae (Batubara et al., 2021), Nemacheilidae (Mafakheri et al., 2015), and Zoarcoidei (Hilton & Kley, 2005), but studies on the skeleton structure *I. platypterus* has never been reported so that this study is essential to do. The study of fish skeleton structure is essential in preparing future fish resource management plans (Khayra *et al*., 2016). In addition, this study is also needed as a preventive measure in analyzing skeletal system abnormalities (Deschamps & Sire, 2010) and the impact of genetic, pathological, and physiological disorders. The lack of minerals (especially phosphorus) in the waters is one of the causes of skeletal abnormalities (Zulfahmi *et al*., 2019). Skeletal abnormalities generally appear in the early developmental stages of fish (Cahu *et al*., 2003; Lall & Lewis McCrea, 2007).

In Indonesia, the study of skull bones of sailfish has not been reported yet. This information is essential to know in preparing the ecomorphology of fish in the future. Therefore, the present study aims to examine the characteristics and morphometrics of the skeleton structure of *I. platypterus* from Malacca Strait, Indonesia.

MATERIALS AND METHODS

I. platypterus used in this study was obtained from the fishing port (TPI) Kuala Jeumpa, Bireuen Regency, Aceh Province, Indonesia, at the point of capture coordinates 5°2'37.33 "N 96°38'31.73"E, water depth of 76 m distance from the beach of ±40 km (Figure 1). A total of three fish sample has a total weight of ± 20 kg (range of 18-21 kg) and a total length of ± 218 cm (range of 210-228 cm) (Figure 2). This research was conducted from February to April 2020. The research stages included sample preparation, osteocranium preparation, photo documentation, image editing, and identification of osteocranium terminology. All stages of the research were carried out at the Mathematics and Natural Sciences Laboratory, Almuslim University, Bireuen Regency, Aceh, Indonesia.

Figure 2. The phenotype of *Istiophorus platypterus* Shaw & Nodder, 1792.

Osteocranium preparation

Preparation of fish osteocranium was carried out by separating the skin on the skull bone by immersing it in hot water at a temperature range of 80-90°C. The muscles on the fish skull were cleaned with a knife and tweezers. The remaining meat on the skull was cleaned using a soft brush (Akmal *et al*., 2020). The neurocrania bones were separated from the branchiocranium bones. The lower jaw bone (mandibulare) was separated from the bones of the operculum (operculare), the gill bones and oesophagus (arcus branchialis), and the bones of the tongue and throat (arcus hyoideus). All bones that had been separated were cleaned using a soft brush and tweezers (Akmal *et al*., 2020).

Immersing bone preparations using a 10% formalin solution for seven days. Furthermore, immersion in 100% ethanol solution for 24 hours removes water and residual fat attached to the bones (Taylor & Van Dyke, 1985). Then the bone preparations were dried in the sun for seven days. Each part of the loose bone preparation

Figure 1. Map of Istiophorus platypterus catching area.

was cracked back into its original point and stored in a container for analysis (Akmal *et al*., 2020).

Morphological identification and morphometric measurement of osteocranium

The clean osteocranium preparations were assembled into a single unit to be analyzed for each part. Naming nomenclature and bone structure based on Nakamura (1983) and Davie (1990). The morphology of the osteocranium was photographed using a Canon EOS 700D camera. The photos obtained were edited using Adobe Photoshop CS3. The morphometric measurements of the skull bones of I. platypterus were carried out in two parts, namely neurocranium and branchiocranium bones from the dorsal, lateral, anterior, ventral and posterior sides, referring to Akmal *et al*. (2020). Morphometric measurements were performed using a digital calliper (error 0.01 mm). The measurement data were then transformed using the Schindler and Schmidt (2006) formula:

$$Mtrans = M \times \frac{100}{TL}$$

Where: Mtrans = Transformed morphometric character values; M = Morphometric character measurement data; TL = Total length of neurocranium.

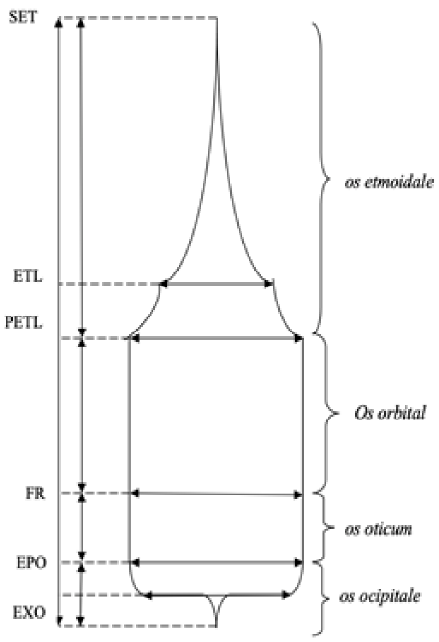

Figure 3. Morphometric characters were measured in this study.

Morphometric measurements of *I. platypterus* osteocranium were performed from anterior to posterior (Figure 3). Measurement of the neurocranium included four parts, namely on the ethmoidal, orbital, otic, and occipital sides. The first measurement starts from the preethmoidal to the ethmoidal, the second measurement starts from the ethmoidal to the frontal, the third measurement starts from the frontal to the epiotic, and the fourth measurement starts from the epiotic to the exoccipital (Akmal *et al*., 2020).

Data analysis

The terminology of osteocranium structure was based on nomenclature (Langille & Hall, 1987; Löffler *et al*., 2008). Meanwhile, morphometric data analysis was carried out using descriptive tests and presented in figures.

RESULTS AND DISCUSSION

Results

The skull was divided into two main parts: the neurocranium and the branchiocranium. The neurocranium in *I. platypterus* has a complex structure and is formed from fused bony elements resembling the shape of a spearhead, where the anterior part is relatively longer than the posterior. The neurocranium was divided into four parts, namely the ethmoidal, orbital, otic, and occipital (Table 1).

Neurocranium structure

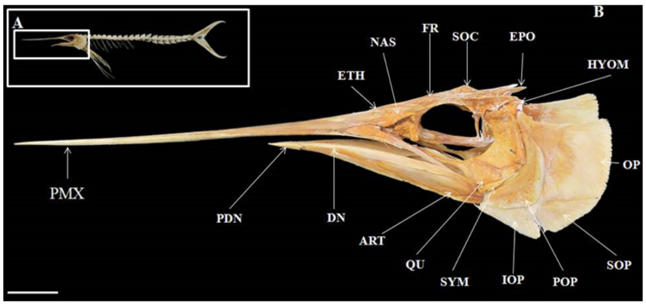

Figure 4. Lateral view of *I. platypterus* osteocranium, where B is an insert from A. PMX: premaxillary; PDN: predental; DN: dental; ART: articular; QU: Quadratum; SYM: simleticum; IOP: interoperculum; POP: preoperculum; SOP: suberoperculum; OP: operculum; HYOM: hyomandibular; EPO: epiotic; SOC: supraoccipital; FR: frontale; NAS: nasale; ETH: ethmoidale. Scale bar 2 cm.

The ethmoidal structure consists of the premaxillary, maxillary, ethmoidal, lateral ethmoidal, nasal, and vomerale bones. In the dorsal view, this section has a long-tapered shape resembling a spear on the anterior, while the posterior has a relatively square shape. Premaxillary is the longest bone compared to other bones in the neurocranium, located in the front and has a smooth basic bone structure. Maxillary covered by premaxillary bone. The nasal cavity is a pair of bones located on the dorsal side of the osteocranium, where the ethmoid bones separate these bones in the middle of the cranium (Figures 4, 5 and 6). The lateral ethmoid in the bone separates the ethmoid from the orbital. The vomelare lies anterior to the parasphenoidale and is squeezed from both sides of the anterior maxillary (Figures 4, 5 and 6). Etmoidale has an average size of 50.55 cm.

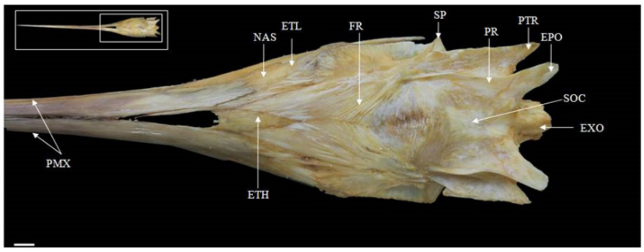

Figure 5. Dorsal view of the *I. platypterus* neurocranium. PMX: premaxillary; ETL: lateral ethmoid; NAS: nasale; FR: frontale; SP: spenoticum; PTR: pteroticum; SOC: supraoccipital; EXO: exoccipital; EPO: epiotic; PR: pariental; ETH: ethmoidale. Scale bar 1 cm.

Table 1. Terminology and osteocranium structure of *I. platypterus*.

Skull Bone	Bone	Consists	Code
Ossa neurocranii	Ethmoidale	premaxillare	PMX
		ethmoidal	ETH
		ethmoidal lateraris	ETL
		nasale	NAS
		vomelare	VO
		maxillary	MX
	Orbital	pterosphenoidale	PTS
		frontale	FR
		parasphenoidale	PAS
		infraorbitalia	IO
	Otic	parientale	PR
		sphenoticum	SPL
		pteroticum	PTR
		epioticum	EPO
		prooticum	PRO
	Occipital	intercalary	INTR
		exoccipitale	EXO
		basioccipitale	BAS
		supraoccipitale	SOC
Ossa branchiocranii	Oromandibular	predentale	PDN
		dentale	DN
		articulare	ART
	Apparatus operculare	operculum	OP
		suboperculum	SOP
		interoperculum	IOP
		preoperculum	POP
	Arcus mandibulare (Suspensory)	hyomandibulare	HYOM
		metapterygoideum	MTP
		sympleticum	SYM
		quadratum	QU
	Arcus branchial	epibranchialia	EB
		ceratobranchalia	CB
		infra-pharyngobranchialia	IB
		basisbranchialia	BB
	Arcus hyoideus	hypohylia	HH
		cerathohyale	CH
		epihyale	EH
		urohyale	UHY
		radii branchiostegii	RB
		glossohyoidues	GH

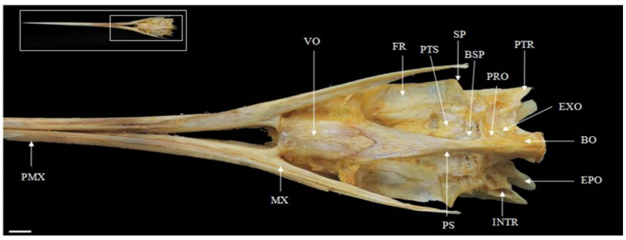

Figure 6. Ventral view of the *I. platypterus* neurocranium. PMX: premaxillary; VO: vomerale; FR:frontale; PTS: pterosphenoidale; PS: sphenoticum; BSP: basephenoidale; PRO: prooticum; PTR: pteroticum; ITR: intercalar; EXO: exoccipitale; BO: basioccipitale; EPO: epioticum; PS: parasphenoidale; ETL: lateral ethmoid; MX: maxillary. Scale bar 1 cm.

The orbital plays a role in protecting the sensory organs, especially the organs of vision (Figures 4, 6, and 7), wherein the *I. platypterus* orbital length is 6.3 cm. Orbital is composed of frontale, infraorbital, peterosphenoidale and parasphenoidale. Frontale is a pair of jagged bones and has a larger size than the other bones that make up the dorsal skull. The petrosphenoidale is a pair of left and right bones located on the ventral side of the neurocranium, while the parasphenoidale is a single bone situated in the middle of the neurocranium. The infraorbital, also known as the circumorbital bone, is the bone that holds the eyeball. In *I. platypterus*, the infraorbitalia resembles a crescent shape with six bones, of which the infraorbital 1, 2, and 3 are wider (Figure 8[b]).

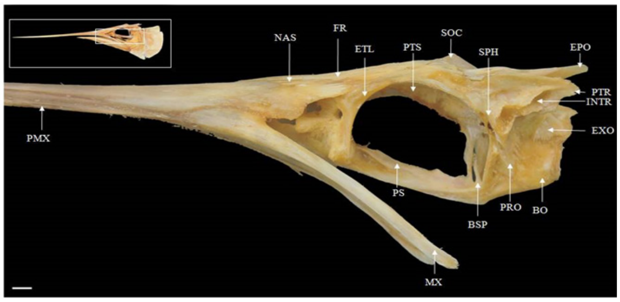

Figure 7. Lateral view of the *I. platypterus* neurocranium. PMX: premaxillary; NAS: nasale; FR: frontale; ETL: lateral ethmoid; PTS: pterosphenoid; SOC: supraoccipital; EPO: epioticum; PTR: pteroticum; INTR: intercalare; EXO: exoccipitale; SPL: sphenoticum; BO: basioccipitale; PRO: prooticum; BSP: basephenoidale; PAS: parasphenoidale; VO: vomerale; MX: maxillary. Scale bar 1 cm.

The otic bone has an average length of 3.43 cm and is located on the dorso-posterior side of the skull, consisting of the spenoticum, pterosticum, epiotic, prooticum, pariental bones (Figures 5, 7, and 8[a]). The anterior side of this bone coincides with the frontale, while the posterior coincides with the occipitale. Spenoticum is a pair of bones on the right and left sides that are fused and have a complex structure, extending towards the latero-ventral from the frontale, and do not have a sphenotic processus that is generally found in the Cyprinidae family (Akmal *et al.*, 2020; Akmal *et al.*, 2022). The pterosticum is located medial to the parietal on the lateral side of the opercular apparatus.

The occipitale of *I. platypterus* measures 1.72 cm in average length and is the shortest bone in the cranium. This bone has a relatively pointed shape towards the anterior ventral. This bone is also the part of the skull directly related to the vertebrae. The occipitale consists of the exoccipital, basioccipital, supraorbital and intercalare bones. The Supraorbital is located towards the outer posterior. The vental portion of this bone coincides with the exoccipital, while the lateral portion coincides with the epioticum. The exoccipital is a bone at the back of the skull that has a relatively sizeable foraman magnum. The brancioccipitale is where the first centrum of the vertebrae attaches (Figure 8[a]). Intercalare is the bone where the hyomandibular is attached to the ventral part of the pteroticum. The posterior part of the intercalare is related to the prooticum, a ridged bone that coincides with the basioccipitale.

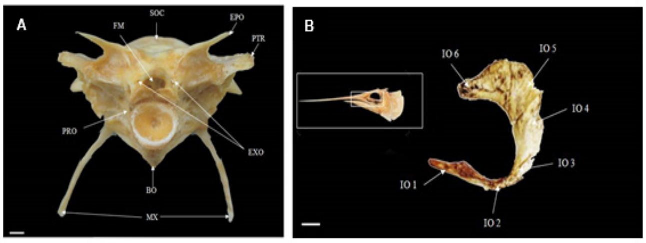

Figure 8. Posterior view of the *I. platypterus* neurocranium (A) and lateral view of the infraorbital bone (B). SOC: supraoccipital; FM: foramen magnum; PRO: prooticum; BO: basioccipitale; EXO: exoccipitale; IO1: infraorbital 1; IO2: infraorbital 2; IO3: infraorbital 3; IO4: infraorbital 4; IO5: infraorbital 5; PTR: pteroticum; EPO: epioticum; MX: maxillare. The scale bars are 2 cm (A) and 1 cm (B).

Branchiocranium structure

The branchiocranium is a bone that makes up the facial area, which originates from the development of the splanchnic mesoderm. Branchiocranium is divided into oromandibular bones, apparatus operculare, arcus branchial, arcus mandibular (suspensory) and arcus hyoideus (Table 1). The oromandibular consists of the bones that make up the lower jaw, namely articulare, dentale, and predentale (Figure 9). The predentale is a hard bone that resembles a cap at the tip of the lower jaw and is directly attached to the dentale and articulare. A thick cartilaginous structure characterizes dentale as a substitute for teeth in direct contact with the articulare. Articulare is a bone that is directly connected to the right and left mandibular arches and plays a vital role in the mobility of the mandible.

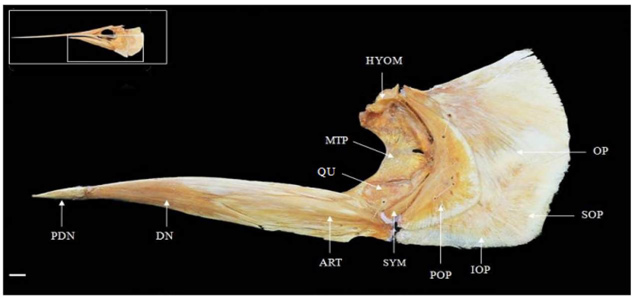

Figure 9. Medial view of the *I. platypterus* branchiocranium. PDN: predentale; DN: dentale; ART: articulare; QU: quadratum; POP: preoperculare; IOP: interoperculare; SOP: suboperculare; OP: operculare; HYOM: hyomandibular; MTP: metapterygoideum; SYM: symplecticum. Scale bar 1 cm.

The opercular apparatus is the bones that make up the gill cover which consists of preopercular, interopercular, subopercular, and opercular bones. The opercular bone has the most significant size compared to other bones. The interopercular and subopercular are fused to form a union with the operculare. The preopercular is a crescent-like bone that overlaps the interopercular, suboperculare, and operculare and is directly connected to the region of the arcus mandibular (metapterygoideum, quadratum, and hyomandibular) (Figure 9).

The arcus mandibular is a collection of bones that support the mandible and the opercular apparatus. This structure consists of the hyomandibular, metapterygoideum, symplecticum and quadratum bones. The hyomandibular bone has the most significant size compared to other bones in the arcus mandibular. The metapterygoideum and quadratum bones are in direct contact with the hyomanibulare, while the symplecticum is a single bone that was pointed and attached to the underside of the quadratum and adjacent to the preoperculare (Figure 9).

Arcus branchial is where the gills are attached and consists of bones of epibranchial, ceratobranchial, infra-pharyngobranchial, and basibranchial (Figure 10[a]). The infra-pharyngobranchial are four cartilage bones located in the epibranchial bone. This bone develops in tandem with the epibranchial bone. The three pairs of ceratobranchial are long, thin and canal-like, while the fifth bone is modified into an actual bone separated and attached to the hypobranchial. Basisbranchial is the most anterior bone attached to the hypobranchial.

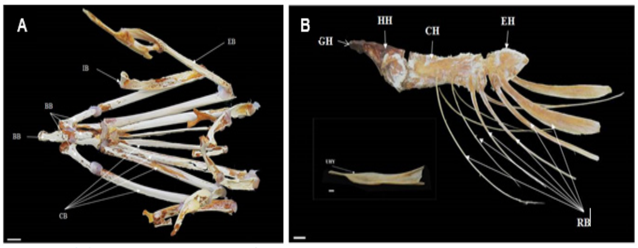

Figure 10. Dorsal view of the *I. platypterus* arcus branchial (A) and Dorsal view of the arcus hyoid (B). BB: os basibranchial; HB: hypobranchial; CB: ceratobranchial; EB: epibranchial; IB: infra-pharyngobranchial; GH: glossohyodues; HH: hypophylia; CH: ceratohyale; EH: epihyale; RB: radii branchiostegii; UHY: urohyale. Scale bar 1 cm.

The arcus hyoid consists of the ventral gill cover bones, namely the hypohylia, cerathohyale, epihyale, urohyale, radii branchiostegii, and glossohyoid (Figure 10[b]). The glossohyoid bone is at the front and is fused with hypohylia. The hypohylia bone is on the anterolateral side and forms an arch that connects to the ceratohyale. The epihyale bone has a flat triangular shape and is in direct contact with the ceratohyale, a flat rectangular bone to which the radii branchiostegii are attached. Urohyale is a single bone that is directly related to hypohylia. Radii branchiostegii is a long-curved pee bone in the number of six pairs and is attached to the ceratohyale and epihyale bones.

Osteocranium morphometric

Morphometric measurements were used to describe the morphology of the osteocranium skeleton of *I. platypterus*. The morphometric character value of the osteocranium of *I. platypterus* in the ethmoidal region has the most extended ratio of 82.86%. The orbital region has a ratio of up to 10.32%. Meanwhile, the otic and occipital regions had a lower ratio than the ethmoidal and orbital regions, with 5.62% and 2.81%, respectively (Figure 11).

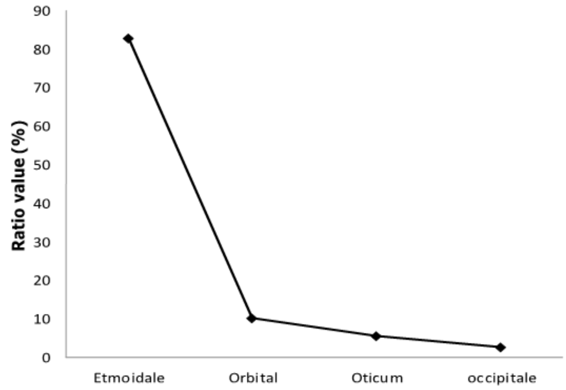

Figure 11. The ratio value of the osteocranium morphometric characters of *I. platypterus*.

Skeletal anatomy in fish is very complex and related to inter-species variation in shape, size, and level of swimming mobility (Akmal *et al.*, 2022). Fish skull bones provide excellent protection for the brain and sensory organs and play essential roles in respiration and digestion (Herbing *et al.*, 1996; Koumoundouros *et al.*, 2000; Löffler *et al.*, 2008). The basic design of the mouth structure has an important influence on the predation ability and diet of fish (Akmal *et al.*, 2020).

The snout of *I. platypterus* is characteristic of fast-swimming fish. The osteocranium structure between fish species is formed based on genetic and environmental elements that influence bone development (Aljanabi, 2021). The location of the mouth of *I. platypterus* is terminal type, where the direction of the mouth is parallel to the horizontal. The premaxillare bone of *I. platypterus* is longer than the lower jaw and immobilizes and monitors prey (Fierstine, 1990). In addition, the premaxillare bone is used for defence from predators and to withstand high mechanical loads (Habegger *et al.*, 2015). In *Xiphias* sp., the snout is more suitable for lateral movement to immobilize prey, whereas, in Makaira nigricans, it allows attacks from many different places (Habegger *et al.*, 2015). *I. platypterus* initiates attack by striking a rapid and sideways bending (Porter & Motta 2004; Lauder 2000). One jaw with optimal speed, giving them a speed advantage in hunting elusive prey (Kammerer *et al.*, 2006). Add some information regarding prey items of this species.

The ethmoidal structure has a kinematic role in supporting the maxillary opening (Diogo *et al.*, 2000; Ostrander & Hopkins, 2000). In addition, this region also acts as a chemosensory system in the form of receptors for the olfactory organs located in the olfactory apparatus in the nostrils of fish (Sarkar & de, 2011). The orbital structure comprises the frontal, infraorbital, peterosphenoidal, and parasphenoidal bones. This structure plays a role in protecting sensory organs, especially the organs of vision (Zulfahmi *et al.*, 2019). Fish that forage by relying on the organ of vision generally have bones that make up the orbital structure that is more developed, such as the infraorbital, pterosphenoidal, and supraorbital bones (such as the family Amiidae) (Hilton, 2011; Schmitz & Wainwright 2011). Morphometric analysis of the osteocranium on *I. platypterus* showed that ethmoidal had the most extended ratio value of 82.86%, followed by orbital at 10.32%, otic at 5.62%, and occipital at 2.81%.

The otic and occipital structures protect the brain, spinal cord, and cranial nerves. Almost all fish have a hard and thick otic and occipital structure. The occipital is a skull component in direct contact with the vertebrae in the Weberian apparatus. Otic is located in the posterior part of the skull and consists of the parietal, spenotic, pterostic, epiotic, prootic, and pariental bones located in the dorso-posterior part of the neurocranium. The occipital consists of the intercalar, exoccipital, basioccipital and supraorbital bones. Predatory fish such as *Ariosoma gilberti* (family Congridae) have an otic shape that tapers towards the anterior end to form a spatula on the snout (Eagderi & Adriaens, 2014). Fish living in bottom waters, such as the family Amiidae, generally have a wider otic and occipital towards the posterior. Hilton (2011) research shows that *Amia calva* is wider parietale than *Tor* sp., and extrascapular bone is found. This is thought to be a form of adaptation to more significant water pressure on the head than fish living in the water column.

The branchiocranium structure is divided into five components, including (1) oromandibular consisting of the articular, dental, and predental bones. (2) The mandibular arch consists of the hyomandibular, meta-pterygoideum, symplectic, and quadratum bones. (3) The opercular apparatus consists of preopercular, interopercular, subopercular, and opercular bones. (4) Arcus hyoideus consists of bones hypohylia, cerathohyale, epihyale, urohyale, and radii branchiostegii. (5) arcus branchialis is the bone where the gills are attached, which consists of epibranchialia, ceratobranchalia, infra-pharyngobranchialia, and basebranchialia. Oromandibular, arcus mandibulare and arcus hyoideus have an essential role in helping the digestive process of fish. The kinematic digestion process occurs in the jaw joint supported by the adductor muscles (Westneat, 2003). The basic design of the mouth structure has an important influence on the predictability and diet of fish. The kinematic digestion of food in many groups of fish is influenced by the performance of the premaxillare, maxillary, and kinethmoid bones (Drucker & Jense, 1991; Hernandez *et al*., 2007; Gidmard *et al*., 2012).

Arcus hyoideus and arcus mandibularis play an essential role in taking food by pulling the hyoid arch in a posteroventral direction to expand the buccal cavity (Wilga, 2010; Tomita *et al*., 2013; Wainwright *et al*., 2004). However, this is different from predatory fish such as Ariosoma gilberti from the family Congridae, which have a thinner and thinner shape with different numbers (Eagderi & Adriaens, 2014). The buccal cavity in predatory fish is reasonably large due to pressure in the hyoid arcus region. This serves to accommodate and attract prey more quickly so that it cannot escape during the towing process (Carroll *et al*., 2004; Van Wassenbergh & Rechter, 2011).

Arcus branchialis plays a vital role in supporting the respiratory process of fish (Koumoundouros *et al*., 2000; Saka *et al*., 2008). Fish that live in waters with high oxygen content generally have a more developed arcus branchialis area than fish in low oxygen waters. There are modifications in the bones that make up the arcus branchialis region in fish that live in waters with low oxygen content, such as pharyngobranchialia to infrapharyngo-branchialia in *Oxynoemacheilus kiabii* fish from the Nemacheilidae family (Mafakheri *et al*., 2015).

CONCLUSIONS

Based on the mouth location, *I. platypterus* is a terminal type, where the direction of the mouth is parallel to the horizontal. The osteocranium of *I. platypterus* is divided into two main structures, namely the neurocranium and the branchiocranium. The neurocranium is divided into four components: the olfactory (ethmoidal), which comprises 6 bones, and the orbitale is made up of 4 bones. And the otic is made up of 5, and the occipital is made up of 4 bones. The branchiocranium is divided into five components: the oromandibular structure consisting of 3 bones, the mandibular arc (suspensorium) composed of 4 bones, the opercular apparatus composed of 4 bones, and the hyoid arc consisting of 6 bones, and the branchialis arc consisting of 4 bones.

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