

The Cranial Nerves of *Mastacembelus armatus* (LACÉPÈDE)

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Introduction

The Mastacembelids are believed to have evolved in India and spread over to China in the east and to Africa in the west (CHAUDHURI, 1916). REGAN (1912) considered these fishes related to the Percomorphi, but much more specialized than them. JOB (1914) mentioned them to have arisen from a percoid fish remotely allied to Nandidae. BHARGAVA (1953) stated them to descend from the family Blenniidae.

A correct idea of the relationship of Mastacembelids can only be had after the morphology of the various genera of the family Mastacembelidae, Nandidae and Blenniidae is available. In view of this consideration I was advised by Dr. B. M. SINHA to take up investigations on the morphology of *Mastacembelus armatus* (LACÉPÈDE). The present paper is restricted to the account of the cranial nerves of the fish.

I am highly indebted to Dr. B. M. SINHA, Professor of Zoology, Meerut College for guiding the work at every step. My thanks are due to the authorities of Jankidevi Bajaj College of Science, Wardha, and to the authorities of Meerut College, Meerut, for providing necessary facilities for work in their laboratories.

Observations

The *nervus olfactorius* (olf. n. 3A, B) arises from the anterior end of olfactory lobe and runs directly forwards in the cranial cavity, closely pressed in its early run against its fellow of the other side. It passes between the two oblique muscles of eye and traverses the orbito-nasal canal in the lateral ethmoid. Emerging from the canal it enters the olfactory chamber and divides into three branches, one running along the outer border of chamber and the other two along the inner border. The nerve supplies the folds of olfactory rosette.

The *nervus opticus* (op. n. 2 & 3B) originates from the optic thalamus of dien-cephalon. It forms the optic chiasma beneath the fore-brain, with the left nerve lying above the right. Running forwards and outwards each nerve emerges into its orbit through the recess between the pleurosphenoids. It pierces the retina and spreads over its inner surface.

The *nervus oculomotorius* (ocul. 2, 3B & 4) emerges from the side of mid-brain, its origin being concealed by the inferior lobe. The nerve follows the lateral margins

of the inferior and optic lobes and comes out of the cranium through a narrow canal in the pleurospenoid. On reaching the base of posterior rectus muscle, it separates into a thin superior and a stout inferior division. The *superior division* runs forward and innervates the superior rectus muscle. The *inferior division* passes below the posterior rectus muscle and separates into two branches one over the other. The upper branch runs forward lying ventral to the rectus inferior and rectus anterior muscles and supplies the inferior oblique muscle. The lower branch runs forward and bifurcates into two branchlets, one innervating the rectus inferior and the other passing above this muscle supplying the rectus anterior. Before its separation into its branches the inferior division gives off a fine strand to the eye ball.

The *nervus trochlearis* (troch. 3B & 4) originates from the dorso-lateral surface of mid-brain between the optic lobe and cerebellum. It runs forward and enters the orbit piercing the pleurospenoid. In the orbit it lies dorsally to all the other eye muscle nerves and innervates the superior oblique muscle.

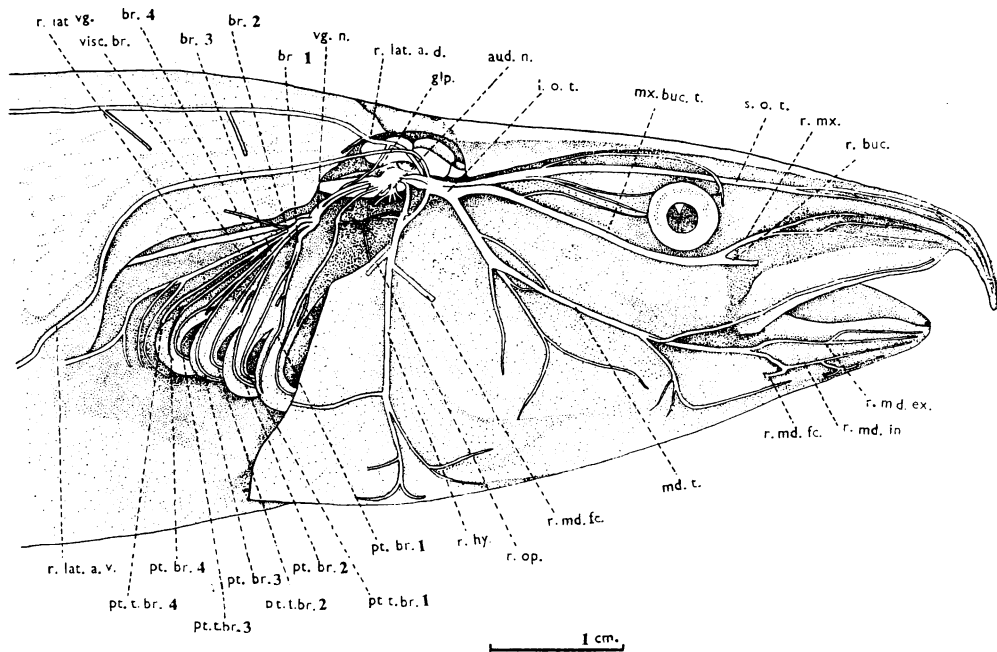


Fig. 1. Side view of the cranial nerves of *M. armatus* (LACÉPÈDE). **aud. n.**, nervus acusticus; **br. 1-4**, branchiales first, second, third and fourth; **glp.**, nervus glossopharyngeus; **i. o. t.**, infraorbital trunk; **md. t.**, ramus mandibularis trigemini; **mx. buc. t.**, maxillo-buccalis trunk; **r. buc.**, ramus buccalis; **r. hy.**, ramus hyoideus; **r. lat. a. d.**, ramus lateralis accessorius dorsalis; **r. lat. a. v.**, ramus lateralis accessorius ventralis; **r. lat. vg.**, ramus lateralis vagi; **r. md. ex.**, ramus mandibularis externus; **r. md. fc.**, ramus mandibularis facialis; **r. md. in.**, ramus mandibularis internus; **r. mx.**, ramus maxillaris; **r. op.**, ramus opercularis; **pt. br. 1-4**, pretrematic first, second, third and fourth; **pt. t. br. 1-4**, posttrematic first, second, third and fourth; **s. o. t.**, supraorbital trunk; **vg. n.**, nervus vagus; **visc. br.**, ramus visceralis.

The *nervus abducens* (abd. 2 & 3B) arises from the ventral side of medulla, posterior to the origin of trigeminal nerve. After piercing a ridge on the cranial surface of prootic, the nerve runs forward lying below the inferior lobe. It passes through a canal formed by the parasphenoid and prootics and supplies rectus muscle.

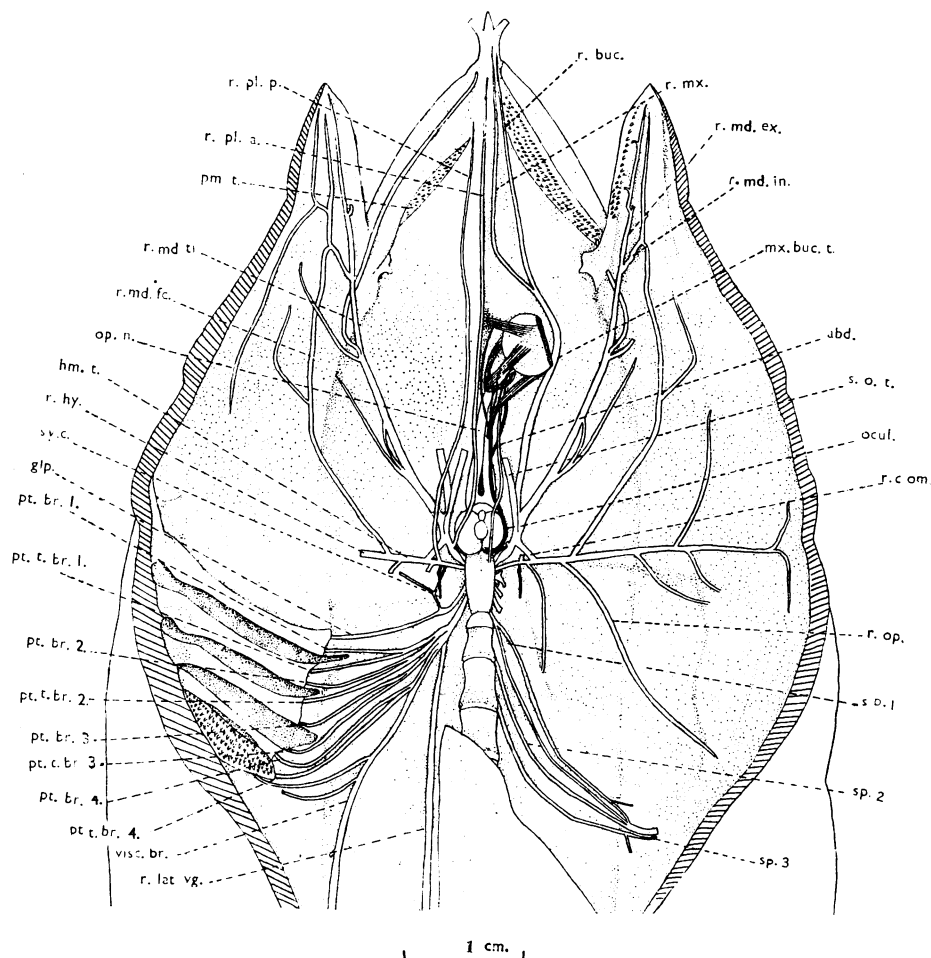


Fig. 2. Ventral view of the cranial nerves of *M. armatus* (LACÉPÈDE). **abd.**, nervus abducens; **glp.**, nervus glossopharyngeus; **hm. t.**, hyomandibular trunk; **mx. buc. t.**, maxillo-buccalis trunk; **ocul.**, nervus oculomotorius; **op. n.**, nervus opticus; **pm. t.**, premaxillary teeth; **pt. br. 1-4**, pretrematic first, second, third and fourth; **pt. t. br. 1-4**, posttrematic first, second, third and fourth; **r. buc.**, ramus buccalis; **r. com.**, ramus communicans; **r. hy.**, ramus hyoideus; **r. lat. vg.**, ramus lateralis vagi; **r. md. ex.**, ramus mandibularis externus; **r. md. fc.**, ramus mandibularis facialis; **r. md. in.**, ramus mandibularis internus; **r. md. tr.**, ramus mandibularis trigemini; **r. mx.**, ramus maxillaris; **r. pl. a.**, ramus palatinus anterior; **r. pl. p.**, ramus palatinus posterior; **sp. 1-3**, first, second and third spinal nerves; **s. o. t.**, supraorbital trunk; **sy. c.**, sympathetic cord; **visc. br.**, ramus visceralis.

The trigeminal and facial nerves (t. f. c. 4) take their origin from the antero-lateral surface of medulla by two large roots, an anterior and a posterior. Immediately after its origin, the posterior root divides into an anterior facialis branch and a posterior hyomandibular branch. The facialis branch runs forward and fuses with the anterior root to form the trigemino-facial complex. The complex gives off the ramus palatinus anterior, ramus lateralis accessorius dorsalis, ramus communicans and ramus lateralis accessorius ventralis. The ramus communicans and ramus lateralis accessorius ventralis come out after the emergence of complex from the cranium. After giving these branches the trigemino-facial complex divides into the supra-orbital and infraorbital trunks.

The *ramus palatinus anterior* (r. pl. a. 2 & 4) traverses a tunnel formed by the parasphenoid and prootics. It runs parallel to the nervus abducens in its early course and with the ramus palatinus posterior in the later course. The nerve extends up to the anterior end of snout supplying the lining of mouth cavity.

The *ramus lateralis accessorius dorsalis* (r. lat. a. d. 1 & 4) rises up by the side of cerebellum and forms an intracranial anastomosis with the dorsal root of nervus vagus beneath the parietal. The nerve pierces the supraoccipital and runs backward along the mid-dorsal line of the body serving as a collector of the dorsal rami of spinal nerves. The *ramus lateralis accessorius ventralis* (r. lat. a. v. 1 & 4) arises from the dorso-lateral aspect of the trigemino-facial complex and runs upward and backward passing through a tunnel in the sphenotic and pterotic. On emergence from the tunnel it courses in the direction of pectoral fin running along the posterior border of operculum. The nerve reaches the ventral side of body and runs along the mid-ventral line up to the posterior end. Throughout its course the nerve receives branches from the spinal nerves.

The *supraorbital trunk* (s. o. t. 1 & 2) runs forward as the common trunk of the ophthalmicus superficialis trigemini and ophthalmicus superficialis facialis. It passes along the ridge of frontal keeping dorsal to the other nerves and muscles of eye. Beyond the orbit it traverses a canal between lateral ethmoid and frontal and runs forward lying below the nasal. On entering the olfactory chamber it separates into an outer slender and an inner stout branch. The outer branch runs forward superficially receiving transverse branchlets from the inner branch. Soon on emergence from the trigemino-facial complex the supraorbital trunk gives off fine nerves, which supply the skin of eye. The supraorbital trunk innervates the supraorbital canal of lateral-line system.

The *infraorbital trunk* (i. o. t. 1) immediately divides into the maxillo-buccalis trunk and the ramus mandibularis trigemini. The *maxillo-buccalis trunk* runs forward giving fine branches to the skin of eye. Beyond the orbit, the trunk separates into the ramus maxillaris and the ramus buccalis.

The *ramus maxillaris* (r. mx. 1 & 2) runs along the inner border of olfactory sac separating into two branches one over the other. The branches continue up to

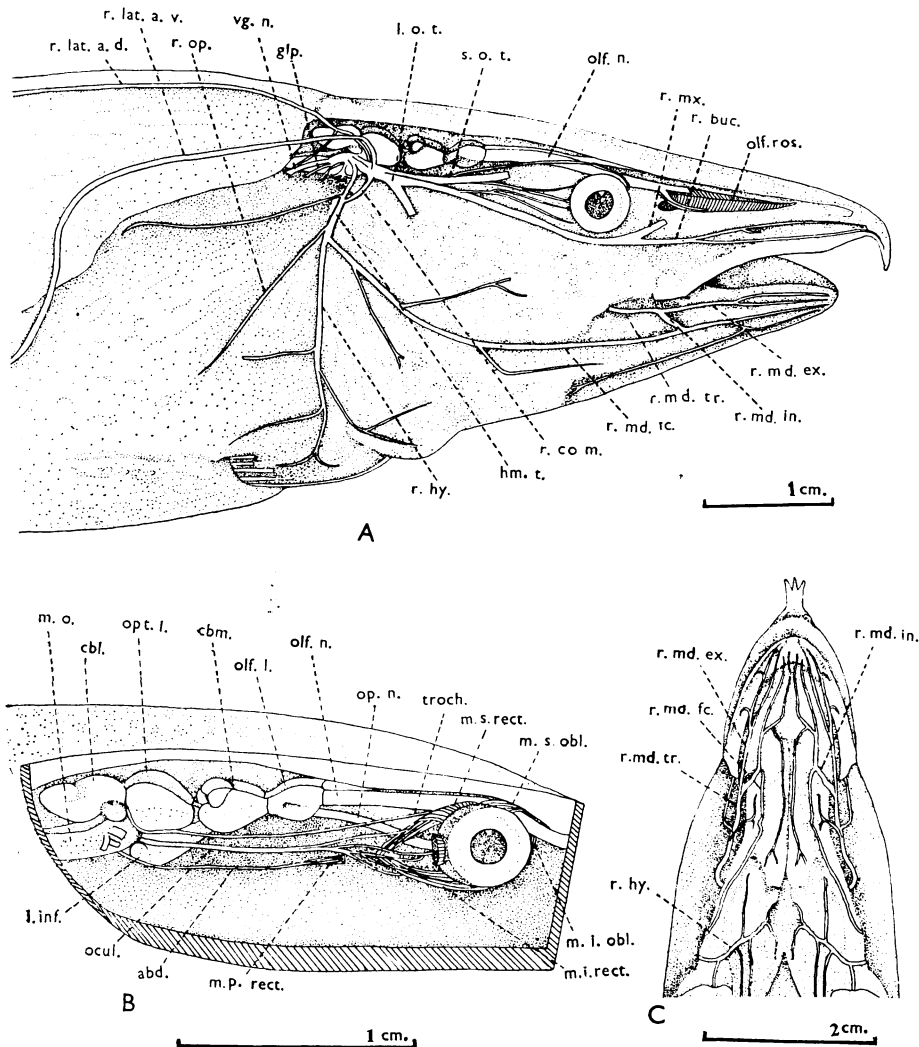


Fig. 3. Cranial nerves of *M. armatus* (LACÉPÈDE). A. Side view, B. Eye muscle nerves, C. Ventral nerves. *abd.*, nervus abducens; *cbl.*, cerebellum; *cbm.*, cerebrum; *glp.*, nervus glossopharyngeus; *hm. t.*, hyomandibular trunk; *i. o. t.*, infraorbital trunk; *i. inf.*, inferior lobe; *m. in. obl.*, inferior oblique muscle; *m. in. rect.*, inferior rectus muscle; *m. p. rect.*, posterior rectus muscle; *m. o.*, medulla oblongata; *m. s. obl.*, superior oblique muscle; *m. s. rect.*, superior rectus muscle; *ocul.*, nervus oculomotorius; *olf. l.*, olfactory lobe; *olf. n.*, nervus olfactorius; *olf. ros.*, olfactory rosette; *opt. l.*, optic lobe; *op. n.*, nervus opticus; *r. buc.*, ramus buccalis; *r. com.*, ramus communicans; *r. hy.*, ramus hyoideus; *r. lat. a. d.*, ramus lateralis accessorius dorsalis; *r. lat. a. v.*, ramus lateralis accessorius ventralis; *r. md. ex.*, ramus mandibularis externus; *r. md. fc.*, ramus mandibularis facialis; *r. md. in.*, ramus mandibularis internus; *r. md. tr.*, ramus mandibularis trigemini; *r. mx.*, ramus maxillaris; *r. op.*, ramus opercularis; *s. o. t.*, supraorbital trunk; *troch.*, ramus trochlearis; *vg. n.*, nervus vagus.

the anterior end of snout and supply the upper lip. The *ramus buccalis* (r. buc. 2 & 3A) runs below the lacrymal and divides into two branches, which run more or less parallel to each other. Both the rami innervate the infraorbital trunk of lateral-line system.

The *ramus mandibularis trigemini* (md. t. 1) runs forward diverging gradually from the maxillo-buccalis trunk. It gives a branch, which soon reunites with it. About the level of eye it gives a branch, which passes forward in the direction of upper jaw and terminates at its anterior extremity. At the angle of mouth, the nerve separates into the *ramus mandibularis externus* and *ramus mandibularis internus*, which enter separate canals in the dentary. The *ramus mandibularis externus* (r. md. ex. 1 & 3A, C) runs in the upper canal of dentary and supplies the mandibular teeth and lower lip. The *ramus mandibularis internus* (r. md. in 2 & 3A, C) enters the lower canal of dentary separating into two branches, which supply the skin and muscles of lower jaw. From the inner branch of *ramus mandibularis internus* arises a nerve of equal strength, which runs backward along the mid-ventral line of head supplying the skin and muscles.

The *hyomandibular branch* (hm. t. 3A & 4) comes out of the cranium through a separate foramen in the prootic lying just behind the foramen of trigemino-facial complex. On emergence, it gives in front the *ramus palatinus posterior* (r. pl. p. 2 & 4) to the roof of buccal cavity and behind a nerve to the muscles of operculum. After giving these two rami, the hyomandibular branch receives the *ramus comunicans* from the trigemino-facial complex to form the hyomandibular trunk. It passes beneath the hyomandibula, where it gives the *ramus opercularis* to the operculum. The main trunk pierces the hyomandibula and inside the hyomandibular canal bifurcates into the *ramus mandibularis facialis* and *ramus hyoideus*.

The *ramus mandibularis facialis* (r. md. fc. 2 & 3A, C) comes out of the hyomandibular canal through its anterior opening. It pierces the symplectic to reach the inner side of dentary, where it fuses with the *ramus mandibularis internus trigemini*. In its course the nerve supplies the operculo-mandibular canal of lateral-line system. The *ramus hyoideus* (r. hy. 1 & 3A, C) emerges from the hyomandibular canal through its posterior opening and runs in the direction of branchiostegal rays passing beneath the preopercle and interopercle. The nerve gives branches to the opercle, subopercle, interopercle and branchiostegal rays.

The *nervus acusticus* (aud. n. 4) arises from the lateral surface of medulla behind the roots of trigemino-facial complex. Immediately on emergence it divides into an anterior and a posterior division. The anterior division supplies the utriculus and ampullae of the anterior and horizontal semicircular canals. The posterior division sends branches to the sacculus, lagena and ampulla of posterior semicircular canal. The posterior division of the nerve also forms an intracranial anastomosis with the dorsal root of *nervus vagus*.

The *nervus glossopharyngeus* (glp. 1, 2 & 4) arises from the brain by two roots.

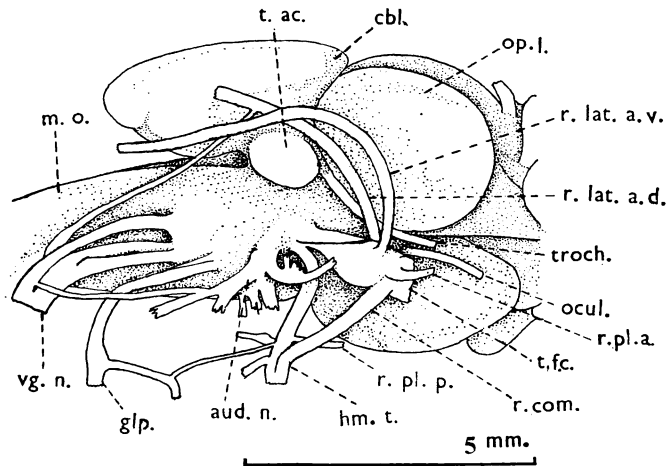


Fig. 4. Side view of the hind brain showing the origin of various nerves of *M. armatus* (LACÉPÈDE). **aud. n.**, nervus acusticus; **cbl.**, cerebellum; **glp.**, nervus glossopharyngeus; **hm. t.**, hyomandibular trunk; **m. o.**, medulla oblongata; **ocul.**, nervus oculomotorius; **op. l.**, optic lobe; **r. com.**, ramus communicans; **r. lat. a. d.**, ramus lateralis accessorius dorsalis; **r. lat. a. v.**, ramus lateralis accessorius ventralis; **t. f. c.**, trigemino-facial complex; **troch.**, nervus trochlearis; **vg. n.**, nervus vagus.

and comes out of cranium through a foramen in the exoccipital. On emergence it separates into an anterior and a posterior branch. The anterior branch runs forward and on receiving a communicating branch from the hyomandibular trunk continues downward in the direction of the pseudobranch. After giving a branch to the pseudobranch the anterior branch passes forward and supplies the roof of buccal cavity. The posterior branch runs downward in the direction of the first gill. At the base of gill it gives a fine branch to its mucous membrane and running along its anterior border supplies its anterior lamellae.

The *nervus vagus* (vg. n. 1 & 4) arises from the medulla by three distinct roots, one dorsal and two ventral, which unite before the nerve pierces the exoccipital. While in the cranium the nerve gives off a fine branch, which forms an anastomosis with ramus lateralis accessorius dorsalis. On emergence from the cranium the nerve forms a swelling and divides into three trunks. The first trunk immediately separates into the first and second branchialis; the second trunk into the third and fourth branchialis and visceralis; and the third trunk continues backward as the ramus lateralis vagi. Each branchialis runs in the direction of the corresponding gill and separates into the ramus pretrematicus and ramus posttrematicus.

After giving the pharyngeal branch to the roof of pharynx, the *ramus pretrematicus* (pt. br. 1-4. 1 & 2) runs along the hind border of gill and supplies its posterior lamellae. The *ramus posttrematicus* (pt. t. br. 1-4. 1 & 2) runs backward and passing along the front face of succeeding gill innervates its anterior lamellae. In this way the first, second, third and fourth branchiales supply the first, second,

third and fourth gills. The ramus posttrematicus of fourth branchialis runs behind the fourth gill and supplies the mucous membrane of branchial cavity. The *ramus visceralis* (visc. br. 1 & 2) runs along the fourth branchialis up to the base of fourth gill, where it gives branches downwards and inwards to supply the heart and pericardium. The main trunk of *vesceralis* passes backward and enters the body cavity supplying the organs of viscera.

The *ramus lateralis vagi* (r. lat. vg. 1 & 2) passes backward in a deeper course running parallel to the lateral-line canal up to the posterior end of body. Immediately after its origin, the nerve gives a prominent branch, which runs backward and reaches the supracleithrum. The main trunk of *ramus lateralis vagi* supplies the lateral-line canal all along its course.

Discussion

The nervus olfactorius is small and slender in *Parasilurus* (ATODA, 1936) and *Wallago* (SINHA, 1956). It is well developed in *Scomber* (ALLIS, 1903), *Lampanyctus* (RAY, 1950) and *Mastacembelus*. In *Scomber* and *Scorpaena* (ALLIS, 1903, 1909), the nerve runs dorsal to the origin of both oblique muscles of eye, while in *Mastacembelus* like *Menidia* (HERRICK, 1899), it passes between the oblique muscles.

The nervus opticus enters the orbit through the optic foramen in *Wallago* (SINHA, 1956), while it enters the orbit directly in *Scomber* (ALLIS, 1903), *Lampanyctus* (RAY, 1950) and *Mastacembelus*. At the decussation, the right nerve lies above the left in *Scomber* (ALLIS, 1903) and below the left in *Lampanyctus* (RAY, 1950) and *Mastacembelus*.

The supply and relation of the nervus oculomotorius to the muscles of eye ball in *Mastacembelus* is similar to *Cottus* (STANNIUS, 1849), *Amia*, *Scomber* and *Lepidotrigla* (ALLIS, 1897, 1903, 1909) and *Lampanyctus* (RAY, 1950) and it appears to be characteristic of teleosts. The only exception is that branch of nervus oculomotorius, which innervates the rectus anterior, lies above the rectus inferior in *Mastacembelus* and below this muscle in *Amia* (ALLIS, 1897) and *Lampanyctus* (RAY, 1950).

The trigemino-facial complex arises by a single root in *Amia* (ALLIS, 1897), *Menidia* (HERRICK, 1899), *Argyropelecus* (HANDRICK, 1901) and *Wallago* (SINHA, 1956), and by two roots in *Scomber* and *Scorpaena* (ALLIS, 1903, 1909), *Parasilurus* (ATODA, 1936) and *Mastacembelus*. The ophthalmicus superficialis trigemini and ophthalmicus superficialis facialis rami of supraorbital trunk are distinct in most of the teleosts. The supraorbital trunk does not separate into the two rami in *Menidia* (HERRICK, 1899) and in *Mastacembelus*.

The ramus palatinus is single in *Amia* (ALLIS, 1897) and *Lampanyctus* (RAY, 1950), but in *Amia* it separates into an anterior and a posterior division. *Mastacembelus* resembles with *Scomber* (ALLIS, 1903), *Parasilurus* (ATODA, 1936) and *Wallago* (SINHA, 1956) in having two distinct palatines.

The ramus communicans is present between the ramus maxillaris and the hyomandibular trunk in *Iota* (GORONOWITSCH, 1896), *Argyropelecus* (HANDRICK, 1901) and *Scomber* (ALLIS, 1903). It lies between the trigemino-facial complex and the hyomandibular trunk in *Mastacembelus*. An anastomosis is found between the ramus mandibularis facialis and the ramus mandibularis trigemini in *Lampanyctus* (RAY, 1950), but the ramus mandibularis facialis fuses with the ramus mandibularis internus trigemini in *Mastacembelus*. The ramus lateralis accessorius is absent in *Lampanyctus* (RAY, 1950) and a single nerve is observed in other fishes. A feature of special interest in *Mastacembelus* is the presence of two lateralis accessorius nerves, a dorsal and a ventral.

The nervus glossopharyngeus issues from the cranium through the vagus foramen in *Argyropelecus* (HANDRICK, 1901) and through a separate foramen in *Cyclothone* (GIERSE, 1904), *Parasilurus* (ATODA, 1936), *Lampanyctus* (RAY, 1950) and *Mastacembelus*. ALLIS (1903) mentioned a JACOBSON'S anastomosis between the pretrematic branch of this nerve and the hyomandibular trunk in *Scomber*. A similar anastomosis is present in *Mastacembelus* as well.

The ramus lateralis vagi originates from the medulla separately and forms a large distinct extracranial ganglion in *Amia* and *Scomber* (ALLIS, 1897, 1903), *Menidia* (HERRICK, 1899), *Argyropelecus* (HANDRICK, 1901), *Cyclothone* (GIERSE, 1904) and *Lampanyctus* (RAY, 1950). It issues from the main trunk of nervus vagus before its separation into the branchialis and visceralis in *Wallago* (SINHA, 1956) and at the level of its separation into the branchialis and visceralis in *Mastacembelus*. An anastomosis between the root of nervus vagus and nervus acusticus is mentioned in *Argyropelecus* (HANDRICK, 1901) and *Cyclothone* (GIERSE, 1904). A similar anastomosis and a connection between the nervus vagus and the ramus lateralis accessorius dorsalis are observed in *Mastacembelus*.

Summary

1. The nervus olfactorius is well developed, owing to the olfactory lobe being situated close to the cerebrum. It supplies the olfactory rosette by three branches.

2. The nervus opticus enters its orbit through the recess between the pleurospenoids. At the decussation the left nerve lies above the right. The nervus oculomotorius and nervus trochlearis come out of the cranium through separate foramina in the pleurospenoid. The nervus abducens pierces a ridge on the cranial surface of prootic and emerges into the orbit through a tunnel formed by the parasphenoid and prootics.

3. The trigemino-facial complex arises by two roots. The facialis branch of posterior root forms the trigemino-facial complex with the anterior root. The hyomandibular branch of the posterior root receives ramus communicans from the trigemino-facial complex and forms the hyomandibular trunk. The trigemino-facial

complex separates into the supraorbital and infraorbital trunks on emergence from the cranium.

4. The supraorbital trunk runs as the common trunk of the ophthalmicus superficialis trigemini and ophthalmicus superficialis facialis. The infraorbital trunk separates into the maxillo-buccalis and the mandibularis trigemini. The maxillo-buccalis divides into the maxillaris and buccalis rami beyond the orbit. The mandibularis internus and externus trigemini enter separate canals of the dentary.

5. The ramus mandibularis facialis fuses terminally with the ramus mandibularis internus trigemini. Two rami lateralis accessori arise from the trigemino-facial complex and run along the mid-dorsal and mid-ventral lines of the body.

6. The nervus glossopharyngeus and nervus vagus emerge from the cranium by separate foramina. The pretrematic branch of glossopharyngeus develops an anastomosis with the hyomandibular trunk. The nervus vagus separates into a trunk of the first and second branchialis, another trunk of the third and fourth branchialis and visceralis and the third trunk of the lateralis vagi.

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