

STUDIES ON THE CRANIAL OSTEOLOGY OF THE INDIAN CLUPEOID FISHES

III. SKULL OF *THRISSOCLES PURAVA* (HAM.)*

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The skull of *Thrissocles purava* (Ham.) has been studied in detail, and its features have been compared with those of other engraulid fishes described so far, viz. *Setipinna phasa*, *Engraulis encrasicholus*, *Coilia nasus*, *Coilia dussumieri* and *Anchoa compressa*. The study justifies the placement of this fish in the family Engraulidae. After comparing the skulls of the above-mentioned fishes, it has been suggested to place *Thrissocles*, *Setipinna*, *Engraulis* and *Anchoa* in the subfamily Engraulinae and *Coilia* in the subfamily Coilinae.

INTRODUCTION

Thrissocles purava is one of the commercially important Indian clupeoid fishes and is abundantly available towards the western sea-coast. The study of osteology of this fish has been taken up to provide relevant data for the use by the systematists. On a perusal of the available classifications of clupeoid fishes, it has been noticed that *Thrissocles* has been variously classified by different workers. Day (1878) classified it in the family Clupeidae under the group Engraulina and Boulenger (1904) placed it in the subfamily Engraulini of the family Clupeidae. Ridewood (1904b) suggested its inclusion in a separate family Engraulidae with a status equal to Clupeidae but Regan (1929) again placed it in the family Clupeidae. Berg (1947) and Norman (1957) have again put it in the family Engraulidae. It has, therefore, been found necessary to study the osteology of the fish in detail to seek clarification of its systematic position.

From the existing literature it is revealed that, with the exception of the accounts of skulls of *Engraulis encrasicholus* and *Coilia nasus* (Ridewood 1904b), *Anchoa compressa* (Chapman 1944) and *Setipinna phasa* and *Coilia dussumieri* (Moona 1959, 1960), work on the skulls of other genera has not been pursued.

* P. J. P. Whitehead (1965) has discussed the synonymy of this fish and has preferred to call it *Thryssa purava* (Hamilton-Buchanan).

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MATERIAL AND METHODS

Specimens of *Thrissocles purava*, measuring 12 to 16 cm in standard length, were collected fresh from the catches arriving at Sassoon Dock, Bombay. The skulls were prepared by immersion in hot water and clearing off the muscles. Detailed study of the bones was done at the Taraporevala Aquarium, Bombay. A few alizarin-stained transparencies were prepared to confirm the findings. The nomenclature of bones has been adopted from de Beer (1937).

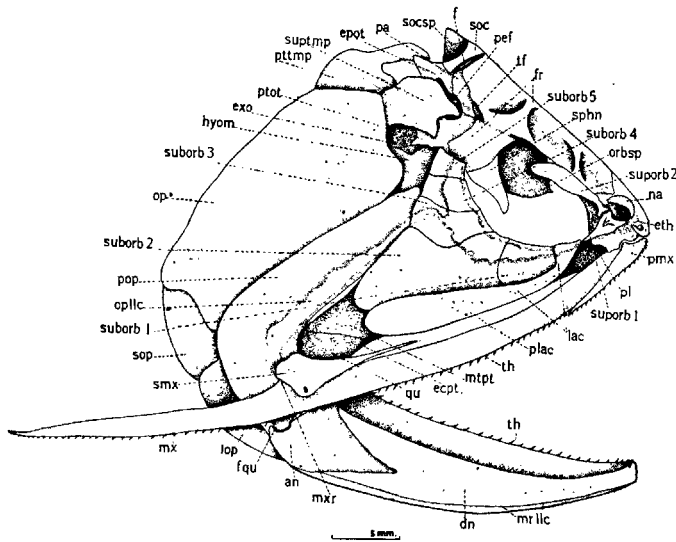


FIG. 1 (*an*, angular; *dn*, dentary; *ectpt*, ectopterygoid; *epot*, epiotic; *eth*, ethmoid; *exo*, exoccipital; *f*, fontanelle; *fqu*, facet on the quadrate; *fr*, frontal; *hyom*, hyomandibular; *iop*, interopercular; *lac*, lacrymal; *mrlc*, mandibular lateral line canal; *mtpt*, metapterygoid; *mx*, maxilla; *mxr*, ridge on the maxilla; *na*, nasal; *op*, opercular; *oplc*, operculo-mandibular lateral line canal; *orbsp*, orbitosphenoid; *pa*, parietal; *pef*, pre-epiotic fossa; *pl*, palatine; *plac*, process of the lacrymal; *pmx*, premaxilla; *pop*, preopercular; *ptot*, pterotic; *pttmp*, post-temporal; *qu*, quadrate; *smx*, supramaxillary; *soc*, supraoccipital; *socsp*, supraoccipital spine; *sop*, subopercular; *sphn*, sphenotic; *suborb*, suborbital; *suporb*, supraorbital; *suptmp*, supratemporal; *tf*, temporal fossa; *th*, teeth). Lateral view of the skull of *Thrissocles purava* (Ham.).

OBSERVATIONS

The Skull

The skull (Fig. 1) is laterally compressed and triangular in form. The axis of the hyomandibular is inclined backwards in correlation with the large gape of the mouth. Mouth is inferior and the lower jaw is long. The vomer, palatines, maxillae, premaxillae, dentaries and bones of branchial skeleton are toothed.

The Cranium

The cranium (Figs. 2, 3, 4) is characterized by the presence of a longitudinal mid-dorsal ridge, beginning from the ethmoid and terminating on the supraoccipital. On each side of the ridge over the frontal there is a pair of transverse bony struts (*br*). In the posterior region of the roof of the cranium is a pair of fontanelle and on either side is a small temporal fossa and a large pre-epiotic fossa.

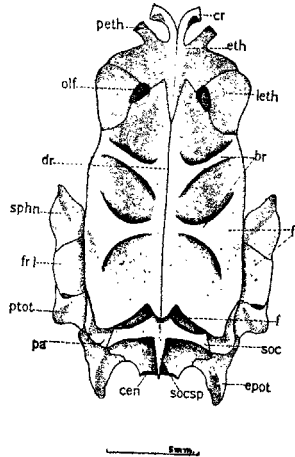


FIG. 2 (*br*, bony struts over the frontal; *cen*, centrum; *cr*, cornu; *dr*, dorsal ridge; *epot*, epiotic; *eth*, ethmoid; *f*, fontanelle; *fr*, frontal; *frl*, frontal limb; *leth*, lateral ethmoid; *olf*, olfactory fenestra; *pa*, parietal; *peth*, process of the ethmoid; *ptot*, pterotic; *soc*, supraoccipital; *socsp*, supraoccipital spine; *sphn*, sphenotic). Dorsal view of the cranium of *Thrissocles purava* (Ham.).

The Ethmoid Region

The *ethmoid* (Figs. 2, 3, 4, *eth*) projects ahead of the vomer and is forked in front into a pair of small ethmoid cornua. Along its front face is a groove for articulation with the premaxilla. From the sides of the bone is given off a pair of stout projections which articulate with the palatines. Between the ethmoid and frontals is a pair of *lateral ethmoids* (Figs. 2, 7, *leth*) which extend inwards below the frontals and meet in the middle line. Each lateral ethmoid slopes forward to form the anterior boundary of the orbit and, in association with the ethmoid and frontal of the side, it encloses a foramen for the olfactory tract. It articulates with the parasphenoid, but fails to meet the orbitosphenoid.

The *vomer* (Figs. 3, 4, 13, *vo*) is a triangular bone attached below the ethmoid. Its broad anterior region bears a deep groove below with a row of small teeth on either side. On each side, the bone gives off a projection for articulation with the palatine. Its posterior narrow end lies below the front end of the parasphenoid. The *nasals* (Fig. 1, *na*) are small loose bones, applied

on the lateral sides of the ethmoid. Each bone forms the inner boundary of the olfactory capsule and the supraorbital branch of the lateral line system terminates on it.

The Temporal Region

The *frontals* (Figs. 2, 4, *fr*) are large L-shaped bones roofing over the cranium. The inner margin of each is raised and joined with that of the other frontal forming the characteristic mid-dorsal ridge. The surface of the bone is depressed above into a trough to lodge the supraorbital lateral line canal and over the trough lies a pair of transverse bony struts. The bone partially

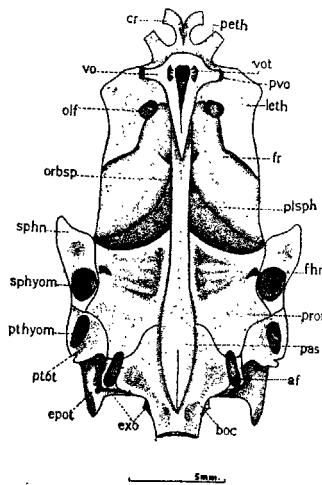


FIG. 3 (*af*, auditory fenestra; *boc*, basioccipital; *cr*, cornu; *epot*, epiotic; *exo*, exoccipital; *fhm*, foramen for the hyomandibular nerve; *fr*, frontal; *leth*, lateral ethmoid; *olf*, olfactory fenestra; *orbsp*, orbitosphenoid; *pas*, parasphenoid; *peth*, process of the ethmoid; *plsph*, pleurosphenoid; *prot*, prootic; *pthyom*, depression on the pterotic for the hyomandibular head; *ptot*, pterotic; *pvo*, process of the vomer; *sphn*, sphenotic; *sphyom*, depression on the sphenotic for the hyomandibular head; *vo*, vomer; *vot*, vomerine teeth). Ventral view of the cranium of *Thriassocles purava* (Ham.).

overlaps the parietal and supraoccipital behind and its limb articulates with the sphenotic and pterotic on the side. Articulating with the parietal it forms the temporal fossa (Fig. 4, *tf*).

The *orbitosphenoid* (Figs. 4, 8, *orbsp*) is a laterally compressed bone lying medially below the frontals. Above, it is bifurcated and the two edges join the frontals leaving a space through which run the olfactory tracts. The orbitosphenoid does not join the parasphenoid and lateral ethmoids. It abruptly ends in front and fails to form the interorbital septum.

The *parietals* (Figs. 2, 4, 12, *pa*) are small bones situated behind the frontals. Each articulates with the epiotic and pterotic behind and takes

part in the formation of the pre-epiotic fossa. The two parietals do not meet in the middle line and are separated by the supraoccipital.

Forming the front wall of the brain case is a pair of quadrangular *pleuro-sphenoids* (Figs. 4, 8, *plsph*). Each articulates in front with the orbitosphenoid, behind with the prootic of its side, below with the basisphenoid and above with the frontal of its side. The two bones meet each other in the middle line and surround the optic foramen. A small median *basisphenoid* (Fig. 9, *bsph*) lies between the lower ends of the pleurosphenoids and forms the base of the optic foramen. It is a small H-shaped bone, having no spicular process to reach the parasphenoid and hence it does not bisect the mouth of the myodome.

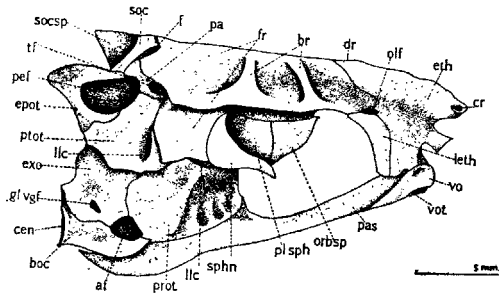


FIG. 4 (*af*, auditory fenestra; *boc*, basioccipital; *br*, bony struts on the frontal; *cen*, centrum; *cr*, cornu; *dr*, dorsal ridge; *epot*, epiotic; *eth*, ethmoid; *exo*, exoccipital; *f*, fontanelle; *fr*, frontal; *glvgf*, foramen for the glossopharyngeal and vagus nerves; *leth*, lateral ethmoid; *llc*, lateral line canal; *olf*, olfactory fenestra; *orbisp*, orbitosphenoid; *pa*, parietal; *pas*, parasphenoid; *pef*, pre-epiotic fossa; *plsph*, pleurosphenoid; *prot*, prootic; *ptot*, pterotic; *soc*, supraoccipital; *socsp*, supraoccipital spine; *sphn*, sphenotic; *tf*, temporal fossa; *vo*, vomer; *vot*, vomerine teeth). Lateral view of the cranium of *Thrissocles purava* (Ham.).

The *parasphenoid* (Figs. 3, 4, 13, *pas*) is a long splint-like bone occupying the mid-ventral region of the cranium. In front it articulates with the vomer, in the middle by a pair of projections with the prootics and behind with the basioccipital. The bone becomes spoon-like behind and further bifurcates into a pair of small processes, which terminate before reaching the occiput.

The Orbital Region

The *circumorbital ring* (Fig. 1) is incompletely formed of two supraorbitals, five suborbitals and a lacrymal. The supraorbitals rest on the outer side of the lateral ethmoid and frontal and form the dorsal boundary of the orbit. The *first supraorbital* (Fig. 1, *suporb 1*) is irregular and forms the outer boundary of the nasal capsule. Its thin lower end articulates with the lacrymal. The *second supraorbital* (Fig. 1, *suporb 2*) is longer than the first and is applied to the outer edge of the frontal. The suborbitals are closely connected and form the posterior and ventral boundary of the orbit. The first *suborbital*

(Fig. 1, *suborb 1*) lies behind the lacrymal followed by the second and third suborbitals, which are articulated to the preopercular. The second *suborbital* (Fig. 1, *suborb 2*) is larger than the first suborbital and is followed by third, fourth and fifth *suborbitals* (Fig. 1, *suborb 3, 4, 5*). The *lacrymal* (Fig. 1, *lac*) is produced behind into a long strip of bone lying below the first and second suborbitals. The infraorbital branch of the lateral line system runs through the suborbitals and terminates in the lacrymal.

The Otic Region

The *prootics* (Figs. 3, 4, 10, *prot*) are the prominent bones on the floor of the cranium. They give out inwardly directed projections, which meet in the middle line above the parasphenoid and form a bridge over the myodome. The anterior half of each bone is depressed towards the inner side, while

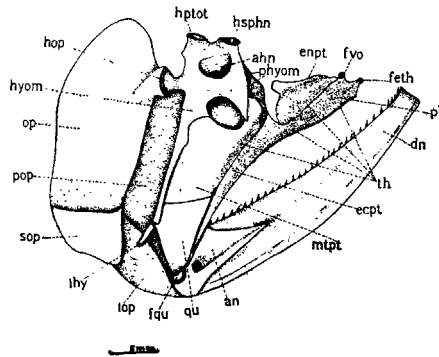


FIG. 5 (*ahn*, aperture for the hyomandibular nerve; *an*, angular; *dn*, dentary; *ecpt*, ectopterygoid; *enpt*, entopterygoid; *feth*, facet for the ethmoid; *fqu*, facet on the quadrate; *fvo*, facet for the vomer; *hop*, hyomandibular knob for the opercular; *hptot*, hyomandibular head for the pterotic; *hsphn*, hyomandibular head for the sphenotic; *hyom*, hyomandibular; *ihy*, interhyal; *iop*, interopercular; *mtpt*, metapterygoid; *op*, opercular; *phyom*, process of the hyomandibular; *pl*, palatine; *pop*, preopercular; *qu*, quadrate; *sop*, subopercular; *th*, teeth). Inner view of the bones of opercular, hyomandibular, palatopterygoquadrate and mandibular series of *Thrissocles purava* (Ham.).

the posterior half bulges to form a well-developed bulla to accommodate the anterior vesicle of the swim bladder. Between the prootic and pleurosphenoid is a large foramen for the trigeminofacial nerve complex, the hyomandibular branch of which comes out through a foramen on the ventral side of the prootic.

The *sphenotics* (Figs. 2, 3, 4, *sphn*) are small triangular bones, which project laterally into pointed processes. Each articulates behind with the frontal and inwards with the prootic. Below, it bears a large depression for articulation with the hyomandibular. The *epiotics* (Figs. 2, 3, 4, *epot*) are also small and triangular in shape. The base of each bone articulates with the

supraoccipital and exoccipital and the apex projects freely behind to support the superior limb of the post-temporal. In association with the pterotic and parietal, it forms a large pre-epiotic fossa.

The *pterotics* (Figs. 3, 4, *ptot*) lie on the sides of the cranium in front of the epiotics. Each bears a small depression (Fig. 3, *pthyom*) below for articulation with the hyomandibular. On its inner side is a groove for the posterior vertical semicircular canal of the internal ear and a small bulla for the diverticulum of the swim bladder. Through the upper part of the bone runs a conduit for the postorbital canal of the lateral line system. The usual pterotic spine is wanting. The *opisthotics* are absent in the fish.

The Occipital Region

The supraoccipital (Figs. 2, 4, *soc*) is produced in front into a stout process to support the two frontals, and behind into a laterally compressed supraoccipital spine. Uniting with the frontals and parietals it forms a pair of fontanelle on the dorsal side, which lead into the cranial cavity. The supraoccipital articulates with the parietal and epiotic on either side and with the exoccipital below.

The *exoccipitals* (Fig. 4, *exo*) lie beneath the supraoccipital and meet in the middle line surrounding the foramen magnum completely. Each bone is irregular in form and gives off a small projection below, which articulates with the outer side of the occipital condyle. The bone bears a common foramen (*glvgf*) on the lateral side for the glossopharyngeal and vagus nerves and surrounds the auditory fenestra (*af*) in association with the prootic and basioccipital of the side.

The *basioccipital* (Figs. 3, 4, 11, *boc*) is broad with a pair of large depressions above, separated by a vertical median ridge. In the depressions lie the otoliths of the internal ear and the ridge extends up between the two exoccipitals. The bone bears an oval occipital condyle behind for the vertebral column. Ventrally it has a narrow canal for the eye muscles and the lateral edges of the canal join with the processes of the parasphenoid. The basioccipital meets the prootic in front and exoccipital above.

The Visceral Skeleton

The visceral skeleton has been described under the mandibular, hyoid and branchial arches.

(a) *The Mandibular Arch*

The Palatopterygoquadrate Series

The *palatine* (Fig. 5, *pl*) is a small stout bone bearing fine teeth on its inner surface. Its hind end articulates with the entopterygoid and ectopterygoid, while the front end bears a pair of facets (*feth*, *fvo*) for articulation with the ethmoid and vomer.

The *ectopterygoid* (Fig. 5, *ecpt*) is splint-like and toothed and it is sharply pointed behind. Its front end interdigitates with the palatine and entopterygoid and the rest of the bone is attached to the metapterygoid and quadrate. The *entopterygoid* (Fig. 5, *enpt*) is a small flap-like bone articulated with the palatine and ectopterygoid but fails to meet the metapterygoid in this fish. The bone bears fine teeth on the inner surface. Articulated to the front of the hyomandibular is a quadrangular *metapterygoid* (Fig. 5, *mtpt*), bearing a patch of fine teeth on the inner side. The bone articulates with the hyomandibular by its two processes and below with the quadrate and ectopterygoid.

The *quadrate* (Fig. 5, *qu*) is a stout triangular bone, with a facet below for the angular. Its hind margin articulates with the shank of the hyomandibular and the upper margin meets the metapterygoid.

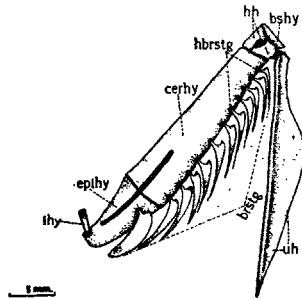


FIG. 6 (*brstg*, branchiostegal rays; *bshy*, basihyal; *cerhy*, ceratohyal; *epthy*, epihyal; *hbrstg*, holes for the branchiostegal rays; *hh*, hypohyal; *thy*, interhyal; *uh*, urohyal). Hyoid cornu series and branchiostegal rays of *Thrissocles purava* (Ham.).

The Maxillary Series

The *premaxilla* (Fig. 1, *pmx*) is much smaller than the maxilla and articulates with the bone of the other side in front of the ethmoid, forming the front part of the snout. The bone is toothed and its major portion is applied to the anterior end of the maxilla. The *maxilla* (Fig. 1, *mx*) is very long and projecting behind the operculum, reaches the base of the pectoral fin. It bears teeth all along its lower margin, except for a small anterior part, which is covered by the premaxilla. The anterior end of the bone has two facets for articulation with the ethmoid and vomer and its upper margin is raised in the middle to support the supramaxillary. Both the premaxilla and about half of the maxilla take part in forming the upper margin of the large gape of the mouth. The *supramaxillary* (Fig. 1, *smx*) is a small, laterally compressed spicular bone, applied to the maxilla by its posterior broad end.

The Mandibular Series

The *dentary* (Figs. 1, 5, *dn*) is toothed and is comparatively longer than the angular in correlation with the extensive gape of the mouth. Its narrow

front end meets the bone of the other side forming the mandibular symphysis and the hind end is notched to receive the angular. The *angular* (Figs. 1, 5, *an*) is a triangular bone, the apex of which lies behind and bears a facet for articulation with the quadrate. The front end of the bone fits into the notch at the posterior end of the dentary. Through the lower edge of the dentary and the angular runs the mandibular lateral line canal (*mrllc*). A *retroarticular* and a *sesamoid* angular are absent in the fish.

(b) *The Hyoid Arch*

The Hyomandibular Series

The *hyomandibular* (Fig. 5, *hyom*) is quadrangular in form, produced below into a narrow elongated shank. Its upper margin has two heads for articulation with sphenotic and pterotic, while the hind margin bears a projected knob for articulation with the opercular. Anteriorly, the bone gives off two processes, which meet with similar processes of the metapterygoid to form a broad enclosure for the muscles. In the middle of the bone there is a conduit for the passage of the hyomandibular nerve. The lower end of the shank articulates directly with the quadrate and to its tip is attached a small interhyal. The *symplectic* is absent in the fish.

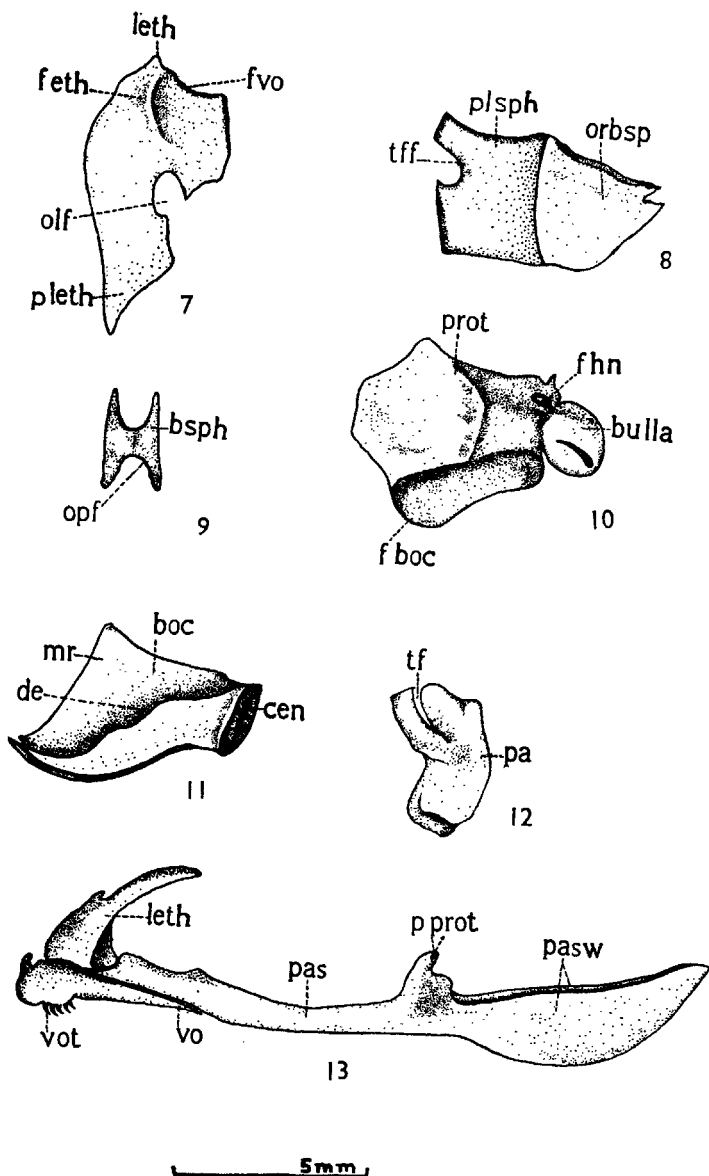
The Hyoid Cornu Series

The *epihyal* (Fig. 6, *epihy*) is triangular in form bearing behind a facet for the interhyal. On the outer surface of the bone there is a longitudinal groove which is continued over the *ceratohyal*. The *ceratohyal* (Fig. 6, *cerhy*) is nearly thrice as long as the *epihyal* and its lower margin bears ten apertures in a row for the articulation of the *branchiostegal rays*. The two *hypohyals* (Fig. 6, *hh*) lie one over the other in front of the *ceratohyal*. To the front ends of the *hypohyals* of the two sides is attached a small *basihyal* (Figs. 6, 14, *bshy*), which articulates with the first *basibranchial* (*bbr 1*).

There are twelve *branchiostegal rays* (Fig. 6, *brstg*), the first ten of which articulate with apertures on the *ceratohyal*, while the eleventh and twelfth are applied on the outer side of the *ceratohyal* and *epihyal* respectively. Below the *hypohyals* is a long *urohyal* (Fig. 6, *uh*), which extends backwards medially underneath the branchial arches. A small *interhyal* (Figs. 5, 6, *ihy*) articulates with the hyomandibular and serves to suspend the hyoid-cornu.

The Opercular Series

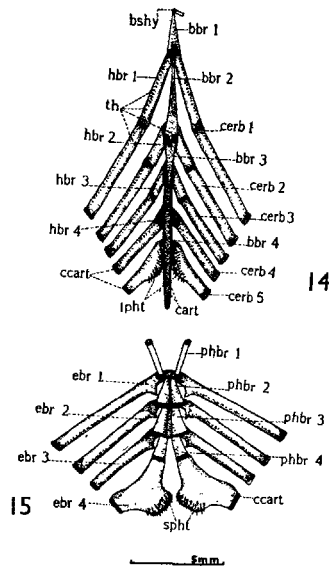
Of the opercular bones (Fig. 1) the *subopercular* (*sop*) is the smallest. At the upper anterior edge of the *opercular* (*op*) is a socket for articulation with the hyomandibular knob. The *preopercular* (*pop*) is large and crescentic and it lies over the *hyomandibular*, *opercular*, *subopercular* and *interopercular*. The *operculomandibular* canal of the lateral line system runs through the front margin of the *preopercular*.



FIGS. 7-13 (*bsph*, basisphenoid; *boc*, basioccipital; *bulla*, bony bulla for the vesicle of the swim bladder; *cen*, centrum; *de*, depression; *fboc*, facet for the basioccipital; *feth*, facet for the ethmoid; *fhn*, foramen for the hyomandibular nerve; *fvo*, facet for the vomer; *leth*, lateral ethmoid; *mr*, median ridge; *olf*, olfactory fenestra; *opf*, optic foramen; *orbsp*, orbitosphenoid; *pa*, parietal; *pas*, parasphenoid; *pasw*, parasphenoid wings; *pleth*, process of the lateral ethmoid; *plsph*, pleurosphenoid; *pprot*, process for the articulation to the prootic; *prot*, prootic; *tf*, temporal foramen; *tff*, trigeminofacial foramen; *vo*, vomer; *vot*, vomerine teeth). Disarticulated bones of cranium of *Thrissocles purava* (Ham.). 7, lateral ethmoid; 8, pleurosphenoid and orbitosphenoid; 9, basisphenoid; 10, prootic, inner view showing bulla for the vesicle of the swim bladder; 11, basioccipital; 12, parietal; 13, parasphenoid with lateral ethmoid and vomer.

(c) *The Branchial Arches*

The first four *branchial arches* (Figs. 14, 15) are complete except that the fourth pair of *hypobranchials* (*hbr 4*) are not ossified and the fourth and fifth *basibranchials* are represented by a cartilaginous strip (*cart*), which runs behind from the third *basibranchial* to a little beyond the fifth arch. The first pair of *pharyngobranchials* (*phbr 1*) articulate with the *prootics* and assist in suspending the branchial basket. The *basibranchials* of the first three arches are beset with fine teeth on their upper surfaces. Other bones of the branchial skeleton also bear denticulate sheaths on their buccal surfaces. The fifth arch is represented by the *ceratobranchials* (*cerb 5*) only, the *basibranchial* having indistinctly fused with the fourth. The *ceratobranchials* bear *inferior pharyngeal teeth* (*ipht*) opposing the *superior pharyngeal teeth* (*spht*) on the fourth *epibranchials*.



FIGS. 14 and 15 (*bbr*, basibranchial; *bshy*, basihyal; *cart*, cartilaginous rod representing fourth basibranchial; *ccart*, connecting cartilage; *cerb*, ceratobranchial; *ebr*, epibranchial; *hbr*, hypobranchial; *ipht*, inferior pharyngeal teeth; *phbr*, pharyngobranchial; *spht*, superior pharyngeal teeth; *th*, teeth). 14, lower part of the branchial skeleton; 15, upper part of the branchial skeleton of *Thrissocles purava* (Ham.).

DISCUSSION

From the family Engraulidae, accounts of skulls of *Engraulis encrasi-cholus* and *Coilia nasus* have been published by Ridewood (1904a), of *Anchoa compressa* by Chapman (1944) and of *Setipinna phasa* and *Coilia dussumieri* by Moona (1959, 1960). On comparing these accounts with that of *Thrissocles purava*, a number of features of resemblance and difference has been

noticed. With the exception of *Coilia* species, the cranium in all other genera bears a median longitudinal ridge on the dorsal side and on either side of the ridge there is a pair of bony struts which roof over the wide channel. Laterally it bears a temporal foramen and a pre-epiotic fossa and ventrally an auditory fenestra for the entrance of the tubular prolongation of the swim bladder. In *Coilia nasus*, although a small pin-point-like temporal foramen has been described, the pre-epiotic fossa and auditory fenestra are absent. In *Coilia dussumieri* none of these structures is found. The posterior surface of the cranium in *Coilia* alone is curved and sloping, whereas in others it is vertical.

The ethmoid in *Thrissocles purava* projects well in advance of the vomer. The lateral ethmoid lies lateral to the ethmo-frontal joint leaving in between an aperture for the olfactory tract. The vomer is toothed in *Thrissocles purava*, *Coilia nasus*, *Anchoa compressa* and *Setipinna phasa*, and is edentulous in *Coilia dussumieri* and *Engraulis encrasicolus*. The nasal is reduced and forms the inner boundary of the olfactory capsule.

The frontals in *Thrissocles purava* do not bear conduits for the lateral line canals, instead they get depressed into troughs lodging the exposed portions of supraorbital canals covered only by a pair of bony struts. The form of the strut is more or less similar in all the engraulids, except in *Coilia* species in which the anterior strut is complete and the posterior one is incomplete. The orbitosphenoid is small in *Engraulis encrasicolus*, *Coilia dussumieri*, *Setipinna phasa* and *Thrissocles purava*. The bone in *Coilia nasus* is large and extends down and comes into extensive relation with the prootic bone (Ridewood 1904b). In *Setipinna phasa* it is small and gives off a curved spur-like process in front, which fails to reach the lateral ethmoids and parasphenoid.

The parietals are small and separated by the supraoccipital in *Engraulis encrasicolus*, *Setipinna phasa* and *Thrissocles purava*. In *Anchoa compressa* the two bones meet broadly over the supraoccipital behind the frontals. In *Coilia nasus* the two bones nearly meet each other, but in *Coilia dussumieri* the bones are separate except that their thin processes meet behind the supraoccipital. The two pleurosphenoids meet in the middle and form the front wall of the cranial cavity. The basisphenoid is absent in *Coilia* species only and in others it is present as a small bone lying between the pelurosphenoids. The parasphenoid shows a good deal of variation. In *Coilia* species the bone bears no wings and terminates on meeting the basioccipital. In *Thrissocles purava*, *Setipinna phasa* and *Engraulis encrasicolus* small wings are found, which terminate before reaching the occiput, but in *Anchoa compressa* the wings are well developed and extend behind the occiput to articulate with the first two vertebrae.

The circumorbital ring is incomplete in all these genera and consists of seven to eight bones investing the lateral line canals.

The prootic and pterotic bones bear bullae for the vesicles of the swim bladder. The epiotic supports the superior limb of the post-temporal and takes part in the formation of the pre-epiotic fossa except in *Coilia* species. The opisthotic is present in *Anchoa compressa* but is absent in other genera. The supraoccipital meets the frontals in front and gives off a small supraoccipital spine behind, except in *Coilia* species where no spine is given off, since the posterior surface is sloping. The foramen magnum, as usual, is completely surrounded by the exoccipitals. The basioccipital bears a pair of depressions above for the otoliths and a groove below for the accommodation of the eye muscles, except in *Coilia* species in which the ventral groove is absent. The palatine, ectopterygoid and entopterygoid are toothed and in *Thrissocles purava* teeth have also been located on the metapterygoid. In *Anchoa compressa*, exceptionally, two entopterygoids have been described when only one is seen in others. The quadrate articulates with the symplectic in *Coilia* species and *Anchoa compressa* and in others it articulates with the hyomandibular directly.

The premaxillae and maxillae are toothed in all the fishes under consideration. Both the premaxillae and maxillae take part in the formation of the large gape of the mouth. In *Thrissocles purava* the maxilla is very long and its free posterior end reaches the base of the pectoral fin. In others the bone ends on or before reaching the opercular margin. The significance of the posterior prolongation of maxilla up to the pectoral fin is not known. Only one supramaxillary is present in *Thrissocles purava* and *Setipinna phasa*, while two have been noticed in others.

The lower jaw is formed by the angular and dentary bones in *Thrissocles purava*, *Engraulis encrasicolus*, *Setipinna phasa* and *Coilia* species. In *Anchoa compressa*, an articular also takes part in its formation.

The axis of the hyomandibular is inclined backward; consequently, the gape of the mouth is large. It bears two heads for articulation with the sphenotic and pterotic, except in *Coilia* species, where only one head has been described. The symplectic is present only in *Engraulis encrasicolus* and *Setipinna phasa*.

In the hyoid cornu series, the epihyal, ceratohyal and a pair of hypohyals have been described in all the fishes. In *Coilia dussumieri* the upper hypohyal does not articulate with the ceratohyal but articulates with the lower hypohyal alone. The basihyal is absent in *Coilia* species and *Anchoa compressa* only. The number of branchiostegal rays is fairly constant ranging between 10 and 12. In *Thrissocles purava* the subopercular is smaller than the interopercular while the reverse case has been seen in others.

CONCLUSIONS

These observations lead us to conclude that *Thrissocles purava* resembles, in its important characteristics, *Engraulis encrasicolus*, *Setipinna phasa*,

TABLE I

Features	1 <i>Thriassoles</i> <i>parava</i>	2 <i>Engranalis</i> <i>encrasticolus</i>	3 <i>Seipinna</i> <i>phasa</i>	4 <i>Anchoa</i> <i>compressa</i>	5 <i>Coilia</i> <i>nasus</i>	6 <i>Coilia</i> <i>dasumieri</i>
1. Temporal foramen ..	✓	✓	✓	✓	×	×
2. Pre-epiotic fossa ..	✓	✓	✓	✓	pin-point	×
3. Auditory fenestra ..	✓	✓	✓	✓	×	×
4. Posterior surface of cranium ..	vertical	vertical	vertical	vertical	curved	curved
5. Teeth on vomer ..	✓	×	✓	✓	✓	×
6. Parietals ..	separate	separate	separate	meet broadly	nearly meet	meet by their processes
7. Basisphenoid ..	✓	✓	✓	✓	×	×
8. Posterior wings of parasphenoid ..	✓	✓	✓	✓	×	×
9. Opisthotic ..	×	×	×	✓	×	×
10. Supraoccipital spine ..	✓	✓	✓	✓	×	×
11. Ventral groove on basisphenoid ..	✓	✓	✓	✓	×	×
12. Symplectic ..	×	×	×	✓	✓	✓
13. Articular heads on hyomandibular ..	2	2	2	2	1	1
14. Basihyal ..	✓	✓	✓	×	×	×

✓ mark denotes presence and × mark denotes absence.

Anchoa compressa and *Coilia* species and its skeletal features justify its inclusion in the family Engraulidae.

The comparison of the skulls of engraulid fishes taken into consideration shows that *Thrissocles purava*, *Engraulis encrasicolus*, *Setipinna phasa* and *Anchoa compressa* are nearer to each other than to *Coilia* species (see Table I). It may therefore be suggested that *Thrissocles purava*, *Engraulis encrasicolus*, *Setipinna phasa* and *Anchoa compressa* be placed in the subfamily *Engraulinae* and the *Coilia* species in the subfamily *Coilinae*, under the family Engraulidae. On the basis of this comparison it is now possible to assign a few characters to each of these subfamilies.

Subfamily Engraulinae: Characteristics of skull

- (1) The cranium bears the temporal foramen, pre-epiotic fossa and auditory fenestra.
- (2) Both the bony struts on each frontal are complete and roof over the wide channel lodging the exposed portion of the supraorbital canal.
- (3) The posterior part of the parasphenoid bifurcates into a pair of wings.
- (4) A basisphenoid is present.
- (5) The hyomandibular bears two heads for articulation with the sphenotic and pterotic bones separately.
- (6) The symplectic is absent.

Subfamily Coilinae: Characteristics of skull

- (1) The temporal foramen is reduced or absent and the pre-epiotic fossa and auditory fenestra are absent.
- (2) The posterior strut over the frontal is incomplete.
- (3) The parasphenoid does not bifurcate and thus has no wings. It articulates with the front end of the basioccipital.
- (4) Basisphenoid is absent.
- (5) The hyomandibular bears a single head which articulates partly with sphenotic and partly with pterotic.
- (6) The symplectic is present.

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