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THE OSTEOLOGY AND RELATIONSHIPS OF THE MICROSTOMIDAE, A FAMILY OF OCEANIC FISHES

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THIS REPORT describes the bony structures and the gross visceral anatomy of *Nansenia schmitti* (Fowler), defines the family Microstomidae, and presents reasons why that family should be placed in the suborder Opisthoproctoidei rather than the Salmonoidea. A discussion of the genera and species of the family is given. *Microstoma* (*Euproserpa*) *schmitti* is placed in *Nansenia. Bathymacrops macrolepis* is placed in the synonymy of *Nansenia ardesiaca.* The relationship of the family Microstomidae to the other Opisthoproctoidei is discussed.

The Microstomidae comprises a small group of pelagic, oceanic fishes distributed in the Mediterranean, North and South Atlantic, off southern Africa, and in the western Pacific. Although the group has been known since Risso's (1810) description of *Microstoma microstoma* from the Mediterranean, and specimens have not infrequently been taken since, to the writer's knowledge the internal anatomy of the group has not been explored previously and the position of the fish in the ichthyological system has been, in consequence, not precisely understood. The fish were long included with the argentines, smelts, etc., in the family Salmonidae (Günther, 1866), a practice followed by some ichthyologists in recent years (Gilchrist and von Bonde, 1924). Gill (1861) placed the genus *Microstoma* in a separate family, Microstomatoidae. The Bathylagidae have often, even in recent years (Barnard, 1925), been included in the Microstomidae, but the ichthyological position of that group has recently been defined (Chapman, 1943).

The following observations are based on a single specimen of *Nansenia schmitti* (Fowler), a paratype from 4°12′10″ N., 118°38′08″ E. near Mabul Island. It is a pleasure to acknowledge the kindness of Dr. Leonard P. Schultz, Curator of Fishes, United States National Museum, in permitting me to dissect this specimen.

OSTEOLOGY

Ethmoid cartilage (Figs. 1, 2, and 3) considerably restricted in extent. Main portion not pierced by median foramen as in *Plecoglossus* and some Osmerids (Chapman, 1941*a* and *b*). Foramen of olfactory nerve lies mostly in notch on inner side of prefrontal and scarcely notches side of ethmoid cartilage.

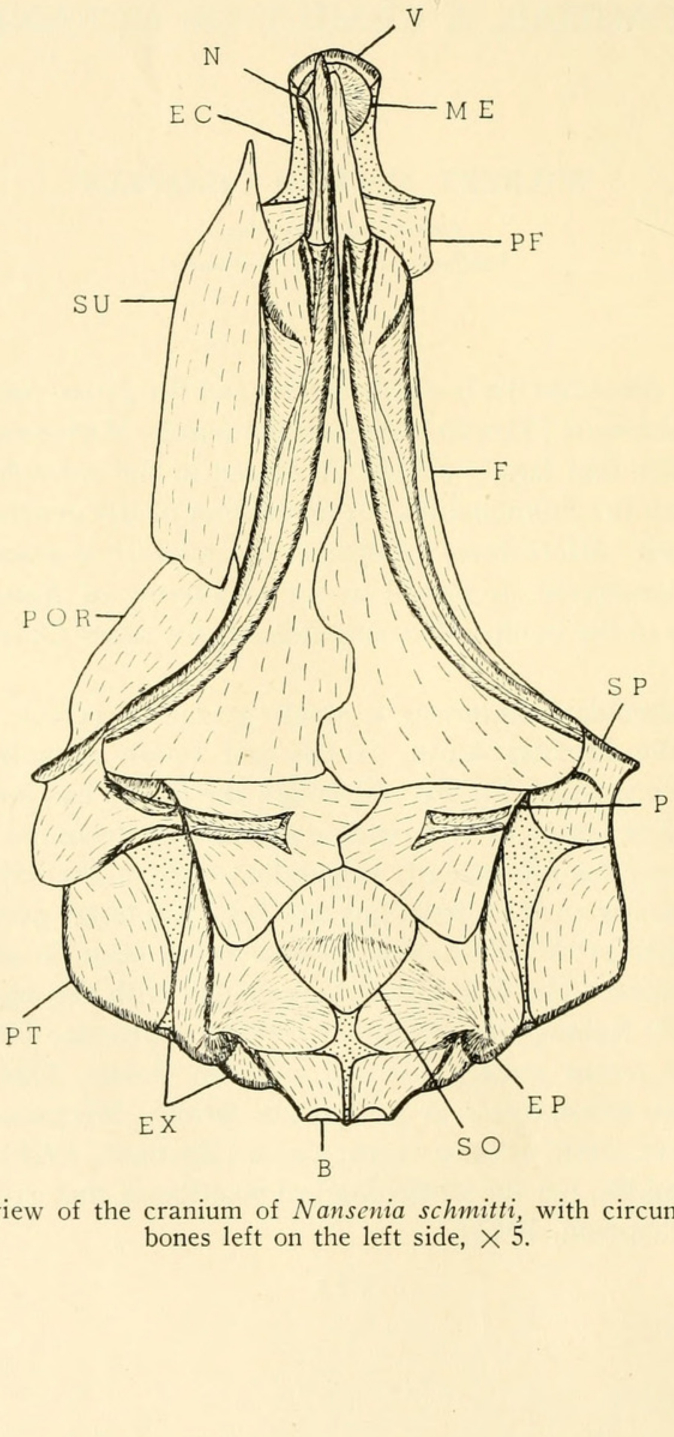

FIG. 1.—Dorsal view of the cranium of *Nansenia schmitti*, with circumorbital and nasal bones left on the left side, × 5.

Cartilage thinly separates frontals and prefrontals dorsally and extends back as thin band under frontals to lie between orbitosphenoid and alisphenoids below and frontals above to join chondrocranium of postorbital portion of cranium. Ethmoid cartilage a thin pad ventrally between mesethmoid above and vomer and parasphenoid below, rising upward to fill interior of irregularly conic mesethmoid, a rather thin ossification on surface of cartilage, and extending posteriorly along parasphenoid to end in point on that bone about halfway to pro-otics. Cartilage widest over parasphenoid and vomer, where it throws up a narrow column under each prefrontal for its support, and laterally projects outward to overlie median edges of mesopterygoids, binding those bones securely to parasphenoid.

Mesethmoid (Figs. 1 and 3) single, shaped like hollow cone which has been strongly flattened sideways. Considerably higher than in *Argentina* or *Bathylagus*. No ventral ethmoids (as in *Argentina* and most Osmerids) or lateral ethmoids (as in some Osmerids).

ABBREVIATIONS USED IN ALL FIGURES

AC	Actinost	N	Nasal
AL	Alisphenoid	O	Opercle
AN	Angular	OR	Orbitosphenoid
AR	Articular	OT	Opisthotic
B	Basioccipital	P	Parietal
BB	Basibranchial	PA	Palatine
BR	Branchiostegal ray	PAR	Parasphenoid
BS	Basisphenoid	PC	Postcleithrum
C	Ceratohyal	PF	Prefrontal
CB	Ceratobranchial	PG	Pterygoid
CL	Cleithrum	PM	Premaxillary
CO	Coracoid	POP	Preopercle
D	Dentary	POR	Postorbital
E	Epihyal	POT	Pro-otic
EB	Epibranchial	PT	Pterotic
EC	Ethmoid cartilage	PTT	Posttemporal
EP	Epiotic	Q	Quadrate
EX	Exoccipital	S	Symplectic
F	Frontal	SB	Suprabasal
G	Glossohyal	SC	Supracleithrum
H	Hyomandibular	SCA	Scapula
HB	Hypobranchial	SO	Supraoccipital
I	Interhyal	SOP	Subopercle
IN	Interopercle	SP	Sphenotic
LLB	Lateral line bone	ST	Supratemporal
M	Maxillary	SU	Supraorbital
MC	Mesocoracoid	SUB	Suprabranchial
ME	Mesethmoid	V	Vomer
MES	Mesopterygoid	VH	Ventral hypohyal
MET	Metapterygoid		

Vomer (Figs. 1, 2, and 3) curves downward strongly at anterior edge, on which it bears about twelve tiny, slender teeth in a single series. It curves upward around end of cranium to reach and slightly overlie lower edge of mesethmoid, with long, thin, posterior shank extending along ventral side of parasphenoid to end in sharp point at vertical from about midway between upper end of prefrontals and orbitosphenoid. Vomer strongly concave on its under side.

Long, spatulate anterior end of *parasphenoid* (Figs. 2 and 3) strongly concave underneath. Concavity broadest and deepest anteriorly over vomer and tapers back to point under basisphenoid where bone becomes just as strongly convex. Short, broad wings sent up along anterior edge of pro-otics, to fall short of trigemino-facialis foramina of latter. Convexity of parasphenoid to-

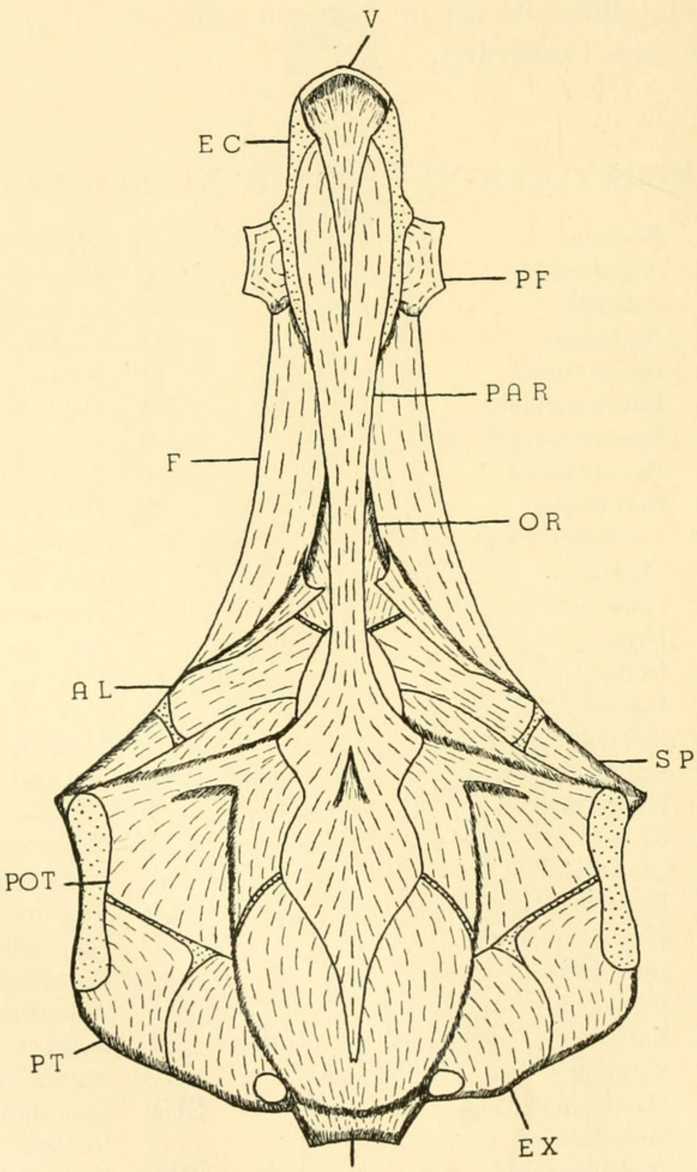

FIG. 2.—Ventral view of the cranium of *Nansenia schmitti*, × 5.

gether with narrow groove in cartilage between pro-otics and on basioccipital provides narrow and shallow myodome which opens by a tiny pore posteriorly. "Myodome" doubtfully functional, since no fibers of rectus muscles of eye were noticed upon lifting parasphenoid off other bones. There is evident again the peculiar correlation of the presence of a broad myodome with the presence of a mesocoracoid and the disappearance of the myodome with the disappearance of the mesocoracoid. In *Argentina* the myodome is commodious and opens broadly behind, and the mesocoracoid is well developed. In *Bathylagus,* the next closest known relative of the Microstomidae, the mesocoracoid is absent and so is the myodome. Even in the Osmeridae it was noted that in the *Thaleichthys* group of genera, where the mesocoracoid is well developed, the myodome opened broadly behind, and in the *Mallotus* group, where the mesocoracoid is more weakly developed, the posterior opening of the myodome is much restricted. It is hard to conceive of a functional relationship between these two organs.

Frontals (Figs. 1, 2, and 3) curiously interwoven on midline; first that of right side overlying that of left, then that of left overlying that of right, with result that none of underlying cartilage is exposed on midline. It is a relatively short step from this to the condition found in the Macropinnidae and Opisthoproctidae where the frontals are indistinguishably fused. Frontals not diverging anteriorly as in *Argentina* (Chapman, 1942*a*), but ending in single point on mesethmoid; overlying considerable portion of parietals and sphenotics posteriorly, but not quite reaching anterior edge of supraoccipital, which can be seen under parietals. Near lateral edge of each bone extends well-formed canal of sensory system. This deep canal not quite closed into tube dorsally at any place, and broadest anteriorly where it diverges over prefrontals to send one branch of nerve out over that bone and another through canal of basal bone to snout. Canal continued at posterior end down over postorbital and out onto circumorbital ring. On ventral side of frontal a wing extends down over upper

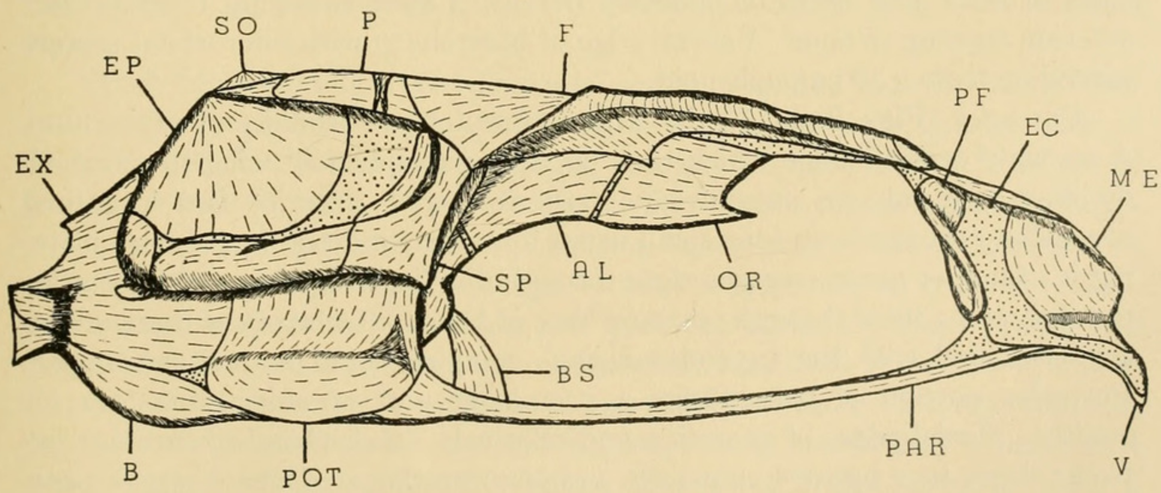

Fig. 3.—Lateral view of the cranium of *Nansenia schmitti,* × 5.

edge of alisphenoid and opisthotic, binding those bones and frontal together firmly.

Prefrontals (Figs. 1, 2, and 3) small, rather weakly ossified bones, mesial edge of each notched in middle for emergence of olfactory nerve into nasal capsule.

Large, flat *parietals* (Figs. 1 and 3) meeting broadly on midline, with that of left side overlying that of right for anterior three-fourths of their length. Nearly a third of their surface covered by frontals, and they in turn cover about half of supraoccipital as well as anterior tips of epiotics and small corner of sphenotics. Anteriorly they and frontals project slightly out over deep temporal fossae, but nothing like the deep caverns of *Argentina* is formed. Each parietal bears on its surface a flimsy trough for sensory canal.

Of half of *supraoccipital* (Figs. 1 and 3) exposed, about half forms dorsal surface and other half slopes downward on posterior surface of cranium. As in other fishes of this relationship, supraoccipital widely separated from foramen magnum, not only by exoccipitals but by protruding mesial wings of epiotics.

Epiotics (Figs. 1 and 3) high, broad, and narrowly rounded over semicircular canals of the ears.

Pterotics (Figs. 1, 2, and 3) merely flattened cones which surround horizontal semicircular canals of ears. Ventrally each bone bears posterior half of cartilage-lined surface of articulation for hyomandibular.

Ventral side of sphenotic (Figs. 1, 2, and 3) nearly entirely occupied by cartilaginous socket of hyomandibular, which extends to anterior edge of bone. Anterior face large and fills space between alisphenoid, pro-otic and frontal. About half of dorsal surface covered by frontal and rest covered by postorbital. Posterior surface largest and forms anterior end of enlarged temporal fossa.

Alisphenoids (Figs. 2 and 3) large, well-formed bones lying between orbitosphenoid and postorbital portion of cranium, not touching one another anywhere, but opening between them to brain cavity relatively narrow.

Orbitosphenoid (Figs. 2 and 3) a deep but narrow bone around olfactory lobes of brain and bases of olfactory nerves. Latter emerging from slit-like anterior opening of bone. Ventral edge of bone sharp with interorbital septum extending from it to parasphenoid.

Pro-otics (Figs. 2 and 3) the largest bones of postorbital part of cranium. A strongly ossified ridge which runs up from parasphenoid wing to sphenotic dividing bone into an anterior and posterior face. Anterior face large and somewhat concave, with four small nerve foramina, and two larger ones piercing it. Another nerve emerges right through dividing ridge, a second posterior to ridge, and a third through posterior face of bone. How many of these nerves are associated with the trigemino-facialis complex could not be determined. Posterior portion of bone forms a prominent part of enlarged bulges for otoliths. Mesial edges of pro-otics, and relatively slender band of cartilage between them, turn upward anteriorly and between this roof and wings of parasphenoid lies a shallow concavity in which rectus muscles of eyes are inserted.

Basisphenoid (Fig. 3*BS*) small and slender, curving downward from uplifted junction of pro-otics to parasphenoid, and capped with cartilage at its junction with parasphenoid, but not very strongly attached to that bone.

Basioccipital (Figs. 1, 2, and 3*B*) strongly constricted posteriorly to form entire occipital condyle, but thin and almost transparent forward where it bulges out to form posterior two-thirds of otolith expansions. Otoliths proportionately very large bones, plainly visible through basioccipital pro-otics, which extend from wings of parasphenoid back nearly to occipital condyle.

Exoccipitals (Figs. 1, 2, and 3) send broad wings up to form roof of foramen magnum. Each wing also extends over basioccipital on occipital condyle, but thin and forms none of junction with first vertebra. Exoccipital visible from dorsal aspect between pterotic and epiotic when opisthotic removed. Foramina of vagus nerves, which pierce bones near posterior edge of cranium, unusually large.

Opisthotics (Fig. 10) tiny, cup-shaped bones which cover junction of epiotic, exoccipital, and pterotic. Each little larger than ligament of posttemporal, which it attaches to cranium, and pulls off with it in position shown in figure.

Cartilage of postorbital portion of cranium considerably restricted. Largest expanse in bottom and mesial side of deep temporal fossa between sphenotic, pterotic, and epiotic; narrower expanse evident on posterior surface of cranium between epiotics, exoccipitals, and supraoccipital; and narrow band extends from this area down between exoccipitals. Long sockets of articulation of hyomandibulars lined with cartilage. Narrow band of cartilage evident between orbitosphenoid and alisphenoids, and between those bones and sphenotics and pro-otics.

Special Ossifications of Sensory System

Small bones associated with support of branches of lateral line system over head, while thin, broader and more extensive than in either *Argentina* or *Bathylagus*. This especially true of circumorbital bones, which cover entire cheek.

Seven bones present in *circumorbital series* (Fig. 5). Two thin bones over eye essentially same as in *Bathylagus* (shown in dorsal aspect on left side of Fig. 1). Both bones thin and projecting straight out over orbit to form dorsal protection for soft parts of eye. Neither of these bones supports sensory canal, which in this region courses through tube on lateral edge of frontal, except that suborbital branch of system crosses postorbital in open tube as it leaves frontal. Lachrymal small, with only about half area of succeeding bone. These two bones meet flush and form a sheath under which maxillary rests. Suborbital 4, largest bone of the series, completely covers space between orbit and preopercle, between suborbitals 3 and 5, and attaches securely by membranes to preopercle along entire ventral and posterior edges. Suborbital 5 and posterior plate of postorbital cover remaining area between orbit and preopercle. Suborbital branch of lateral line system runs around orbit from postorbital to its emergence from lachrymal along orbital edge of bones. Covered along its entire course by flange of thin bone that opens on side away from orbit to form a trough rather than tube. Suborbital bones all lined internally by brilliantly silvered membrane whose sheen is visible through thin, transparent bone.

Nasals (Fig. 1) small, thin, hollow tubes, incompletely closed dorsally, which lie over top of nasal capsules and support sensory canals from frontals to their anterior terminations.

Supratemporal (Fig. 4) thin and broad; attached loosely to sphenotic and pterotic on its dorsal edge, and extending ventrally over dorsal portion of opercle. Dorsal edge of bone curves over to form trough which does not completely close into tube. Supratemporal silvered on inner side like suborbital bones.

Extending posteriorly from sensory trough of supratemporal another semitubular bone attached to outer side of base of posttemporal (Fig. 10) serves to protect lateral line nerve from supratemporal to first enlarged scale of lateral line.

The Upper Jaw

Upper jaw (Fig. 4), except for small differences in shape of maxillaries, as in *Bathylagus*. Only *premaxillary* and *maxillary* present. Neither bears teeth; both thin. Premaxillary a simple curved bone loosely attached at anterior end between mesethmoid and vomer. Anterior end of maxillary prolonged and a little thickened where it lies against edge of mesethmoid. *In situ* broadened maxillary nearly completely hidden under first two suborbital bones. Upper jaw so weak and loosely attached to cranium as to have lost most, if not all, of function of aiding in ingestion of food.

Mandible

Mandible (Fig. 4) likewise essentially same as in *Bathylagus*. It consists of the *dentary, articular, angular, sesamoid articular, Meckel's cartilage,* and ossification of mandibular branch of sensory canal. Teeth larger and fewer than in *Bathylagus* but similar in shape, as closely pressed together, and borne in deep sockets along entire oral edge of dentary. Portion of tooth in socket as long as or longer than that protruding. Thirty-four teeth on each dentary in specimen examined. Angular larger than in *Bathylagus.*

Palatine Arch

Palatine arch (Fig. 4), as in *Macropinna* and *Bathylagus,* securely bound to ethmoid cartilage along its entire anterodorsal end, which includes palatine as well as cartilage behind it. Posterior to palatine cartilage of palatine arch rises in high and stout lump which is synchondrized with ethmoid cartilage at base of prefrontal. From this projection cartilage spreads posteriorly over anterior end of mesopterygoid to symplectic, but does not extend posteriorly to reach cartilage between hyomandibular and symplectic.

Palatine with a few teeth of same size as those on vomer, and extending in single line continuously back from latter. *Pterygoid* sends a wing dorsally along cartilage behind palatine which reaches to ethmoid cartilage, but is sep-

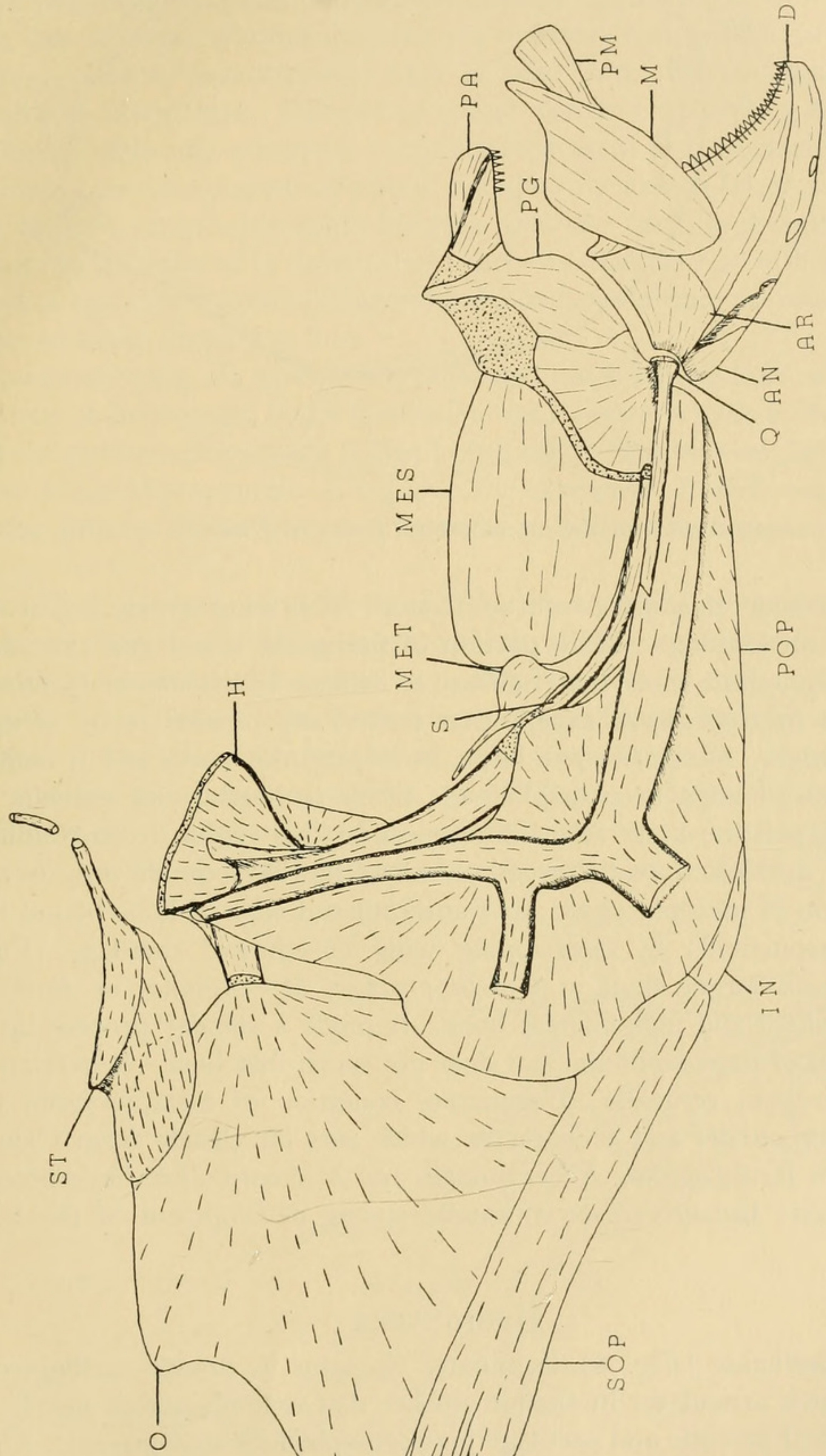

Fig. 4.—Lateral view of the suspensorium of *Nansenia schmitti*, with mouth parts pulled downward, × 5.

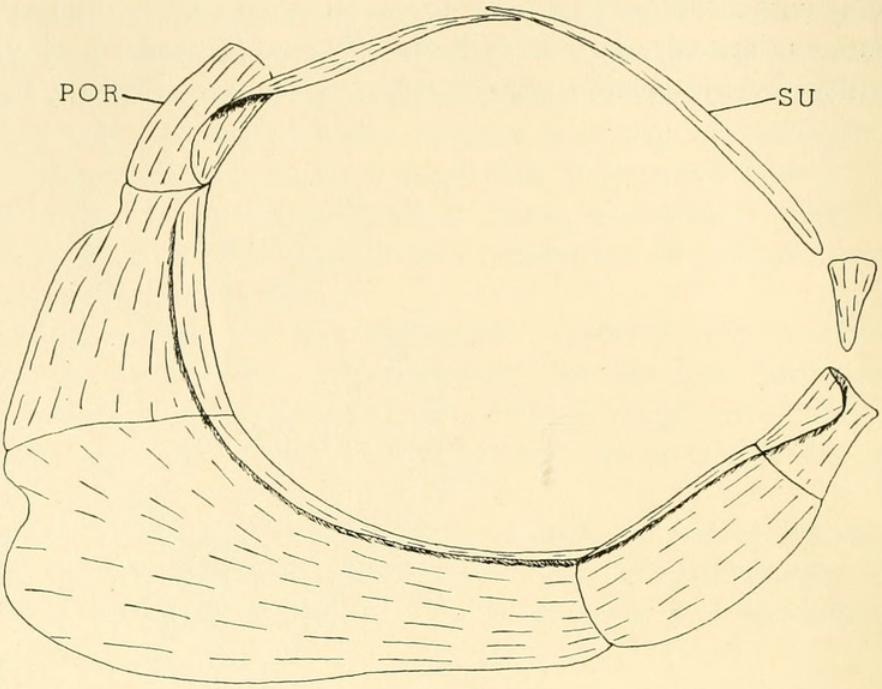

Fig. 5.—Lateral view of the circumorbital bones of *Nansenia schmitti*, × 5.

arated by considerable space from prefrontal. This wing merely a thin surface ossification on cartilage. Main portion of pterygoid broad and extends ventrally along quadrate more than halfway to condyle of that bone. *Quadrate* essentially as in *Bathylagus* except that posteriorly directed spur along preopercle is longer. *Mesopterygoid* large, broad, and thin; attached by membrane along its dorsal edge to parasphenoid; bears no teeth; and extends *under* cartilage of palatine arch. Two differences in this region from condition in *Bathylagus* notable. Levator arcus palatinus muscle extends only over posterior portion of mesopterygoid; and anteromesial edge of bone bound to cranium (parasphenoid) by overlapping wing of ethmoid cartilage (Fig. 2). *Metapterygoid* larger than in *Opisthoproctus, Macropinna,* or *Bathylagus,* but still a small and insignificant bone. It sends a slender process up along ventral shaft of hyomandibular but does not touch that bone. It overlaps edge of mesopterygoid ventrally. Degenerate condition of metapterygoid typical of Opisthoproctoidei and a character which sets off clearly from Osmeridae (with which Bathylagidae, Argentinidae, and Microstomidae have been associated in past) because of exceptionally strong development of the bone in Osmerids.

Hyoid Arch

Hyomandibular (Fig. 4) terminates dorsally in broad, cartilage-capped condyle which articulates in shallow socket that extends across nearly entire ventral face of pterotic and cartilage between sphenotic and pro-otic. Opercular condyle capped with cartilage, and longer than main articular head of bone, but narrow. Wing of thin bone present in angle between two condyles. Length of this process leaves space between opercle and preopercle filled, like space dorsal to opercular condyle between that structure and supratemporal, with dense and tough connective tissue. High flange of thin bone on lateral face of bone protecting truncus hyoido-mandibularis facialis nerve as it emerges on lateral face of bone. Foramen of that nerve enters bone a little below level of opercular condyle near anterior edge of bone and proceeds nearly straight ventrally to lateral face. Preopercle bound tightly to posterior edge of hyomandibular with only a narrow crack between them near ventral end of hyomandibular for re-entrance of ramus hyoidius facialis to inner side of skull. Wing of bone in anterior angle between articular head and ventral shaft of hyomandibular reduced in extent, but nearly as thick as rest of bone.

Rod of cartilage between hyomandibular and symplectic narrow, short, and straight so bones directly in line.

Symplectic (Fig. 4) narrow but thickened much longer than in *Bathylagus* and curve of bone much less. Membrane only between symplectic and metapterygoid and mesopterygoid. A small opening present between symplectic and angular flange of preopercle. Long anterior extension of bone bound tightly to posterior process of quadrate and extends a short way on main body of that bone.

Interhyal, epihyal, ceratohyal, and *hypohyals* (Fig. 6) essentially as in *Bathylagus,* interhyal a little smaller, ceratohyal more constricted in its middle, and ossification of dorsal hypohyal not extending broadly over dorsal side onto lateral surface of bone. Four *branchiostegal rays* broad, but thin and delicate. In Figure 6 they have been fanned out more than naturally. Most anterior of these attached to ceratohyal, others on cartilage around epihyal. First considerably shortest. All attached to epihyal-ceratohyal very loosely; held together and moved by broad and thin interhyoideus muscle which covers their

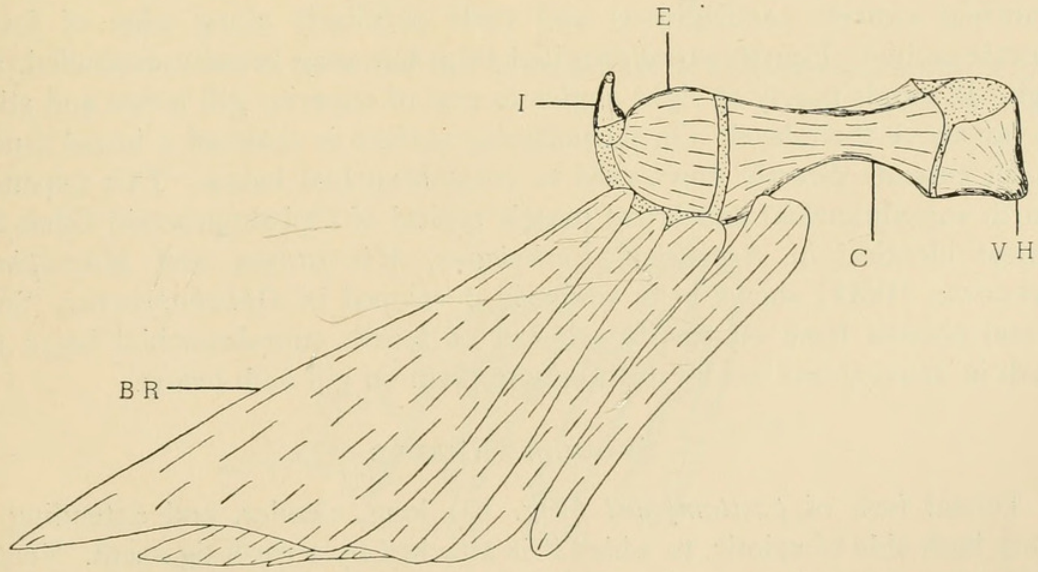

Fig. 6.—Lateral view of the hyoid apparatus of *Nansenia schmitti,* × 5.

surfaces. All covered on inner side by bright silvery pigment found under other bones of lateral surface of skull.

Opercular Apparatus

Opercle (Fig 4) a delicate, thin bone thickened only at small and shallow articular socket. Ventrally it overlaps dorsal edge of subopercle, to which it is tightly bound. Long, slender *subopercle* sends an arm dorsally around anteroventral corner of opercle which is covered by preopercle. From anterior edge of dorsal arm a short prong extends over dorsal edge of interopercle so all three opercular bones securely, but flexibly, joined together. Opercle and subopercle underlaid by same brilliantly silver pigment as circumorbital bones. Only small part of posterior end of long interopercle visible in lateral view, since it is hidden anteriorly clear to the angular by the preopercle.

Preopercle (Fig. 4) differs markedly from that of *Bathylagus* in broad posterior and ventral extensions, and in this character it resembles *Macropinna,* although the two preopercles do not overlap ventrally as in this latter genus. Good share of bone excluded from lateral view by broad, circumorbital bones. Bone tightly bound to hyomandibular, symplectic, and quadrate. Two prominent posterior projections from tube of sensory canal which courses it and, as in *Bathylagus,* tube closed on vertical arm of bone and open ventrally on large horizontal arm.

Gill Arches

Bones of *gill arches* (Figs. 7, 8, and 9) sturdy and resemble those of *Bathylagus* more than those of *Argentina.* Ossified portion of glossohyal larger than cartilaginous anterior part. Dental cement bone that it bears without teeth, flat, thin, and not curving downward around cartilage. Suprabasal bone likewise without teeth, simple, flat, and thin, much reduced from its prominent development in Osmerids. No first suprabranchial found. Fourth epibranchial entirely cartilaginous and curls peculiarly along edge of fourth suprabranchial. Fourth suprabranchial thin, but very broadly expanded, and high. It stands nearly at right angles to rest of superior gill bones and sticks up far above their level. On its posterior surface is inserted a broad muscle which extends directly downward to ceratobranchial below. This expanded fourth suprabranchial and broad muscle typical of Opisthoproctoid fishes and almost identical in *Argentina, Bathylagus, Microstoma,* and *Macropinna.* Trewevas (1933) shows bone similarly developed in *Opisthoproctus.* Small dental cement bone on cartilage ahead of fourth suprabranchial bears two teeth in *Microstoma* but no teeth oppose them on gill arch below.

Shoulder Girdle

Dorsal fork of *posttemporal* (Fig. 10) long, slender, and extending up along back side of epiotic, to which it is attached by a weak ligament. Ventral fork stout and stubby, sending a short, stout ligament to opisthotic. *Supra-*

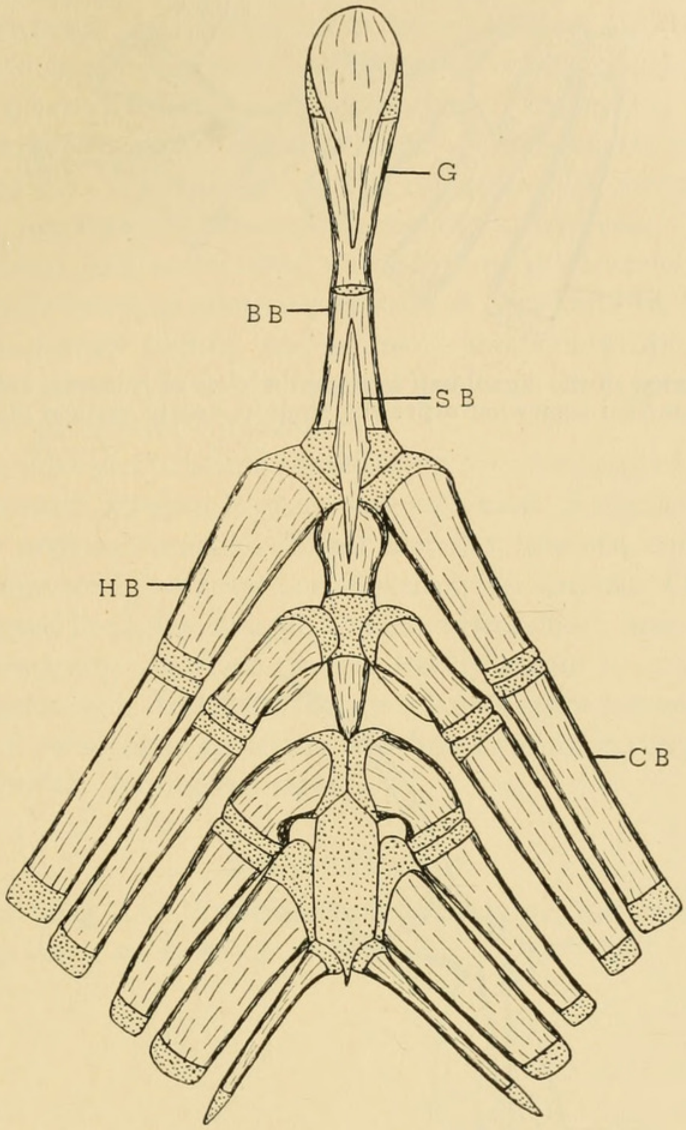

Fig. 7.—Dorsal view of the ventral half of the gill arches of *Nansenia schmitti*, × 5.

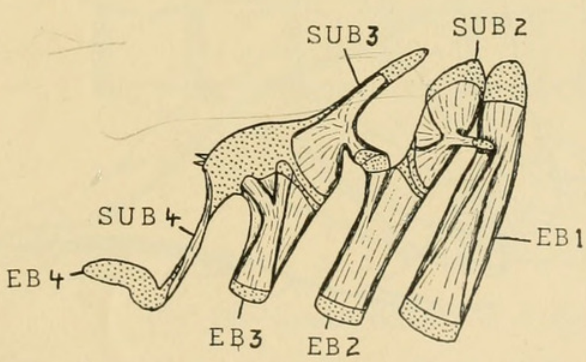

Fig. 8.—Dorsal view of the dorsal half of the gill arches of *Nansenia schmitti*, × 5.

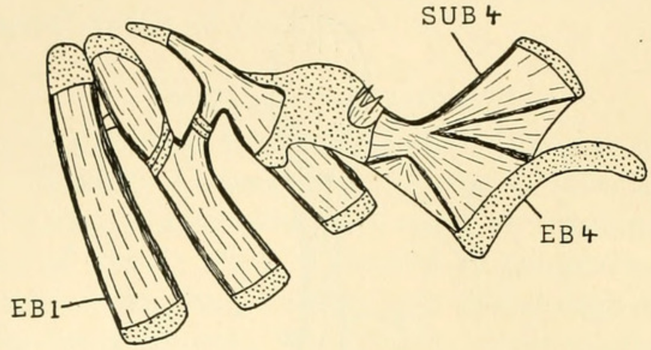

FIG. 9.—Ventral view of the dorsal half of the gill arches of *Nansenia schmitti*, with fourth suprabranchial somewhat depressed from its nearly vertical plane, × 5.

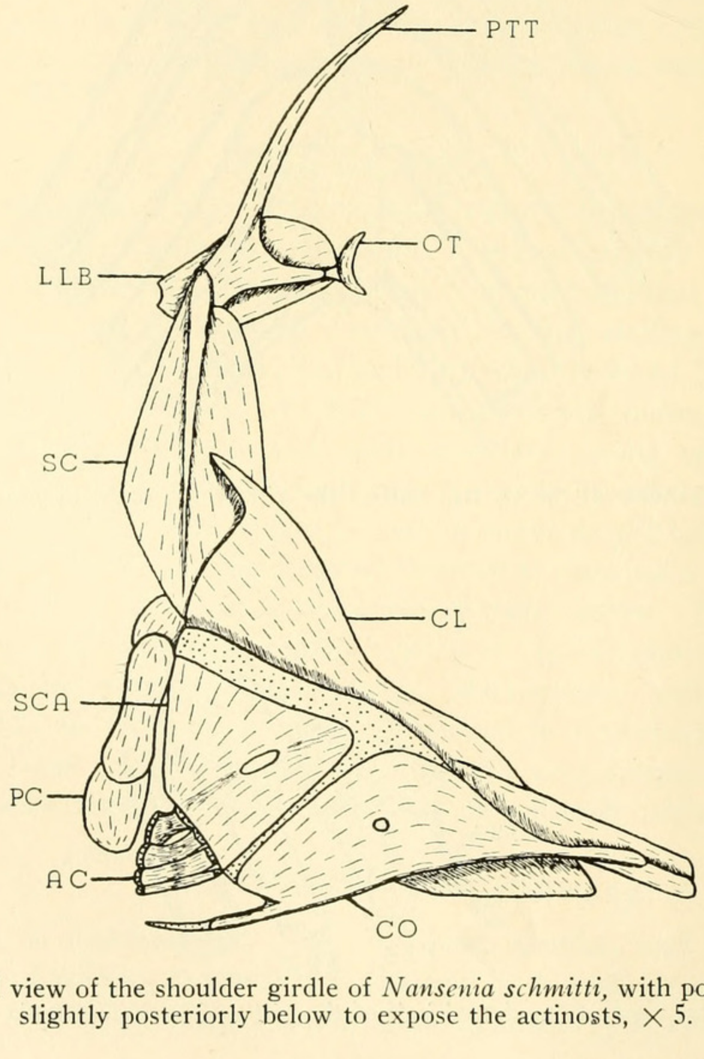

FIG. 10.—Mesial view of the shoulder girdle of *Nansenia schmitti*, with postcleithra pushed slightly posteriorly below to expose the actinosts, × 5.

cleithrum very thin, but on its mesial side a thin vane extends between the muscles and somewhat strengthens the bone. *Cleithrum* also thin and weakly ossified, except for a ray of denser ossification which extends dorsally to supracleithrum and the rod which extends anteriorly. On mesial side of bone a narrow ledge protrudes at an angle, to upper side of which attaches the primary shoulder girdle. A small, flat, special ossification of sensory canal bound to outer side of junction of posttemporal and supracleithrum. Three thin, flat *postcleithra* present just under skin, extending in a continuously overlapped row from supracleithrum to posterior process of coracoid. In Figure 10 these bones drawn backward slightly and primary shoulder girdle somewhat depressed to better show parts. In natural position lower postcleithrum lies against posterior process of coracoid.

Primary shoulder girdle bound to cleithrum by wide band of cartilage which continues downward between *scapula* and *coracoid.* Scapula nearly flat and has about same area as coracoid. Small scapular foramen entirely contained within bone. Four small *actinosts* borne entirely on scapula. Only dorsalmost actinost has normal hourglass shape. Coracoid bears both prominent posterior and anterior processes. Anterior process lightly bound to anterior extension of cleithrum, enclosing a considerable interosseous space between bones. Posterior process of coracoid is spike-like and bears rod of cartilage on posterior end, as in *Argentina.* No mesocoracoid.

Pelvic Girdle

Pelvic bones (Fig. 11) broad and relatively large, but rather lightly ossified. Similar in shape to those of *Argentina.*

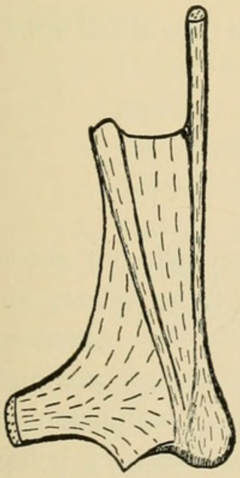

Fig. 11. — Ventral view of left pelvic bone of *Nansenia schmitti,* × 5.

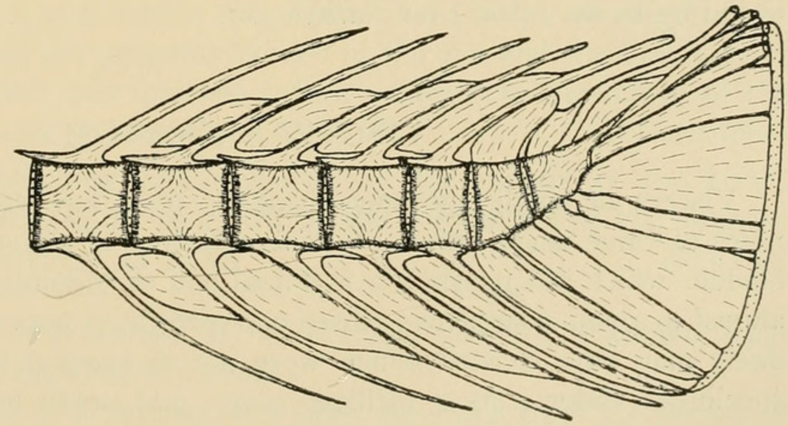

Fig. 12.—Caudal skeleton of *Nansenia schmitti,* × 5.

Axial Skeleton

Forty-three normal and a single upturned terminal vertebra present. It could not be determined with certainty if first vertebra bore ribs, but succeeding twenty-nine do, leaving 13 caudal vertebrae. Ribs long, slender, and flattened on proximal end, which is bound to a broad, heavy parapophysis. Neural spines lightly ossified and slender, not closing dorsally over neural canal until behind dorsal fin, where they become stouter and more spine-like. Thirteen broad and heavy interneurals present which form almost solid osseous line between cranium and dorsal fin. First particularly large, anastomosed to neural spine, and forms protective channel over spinal nerve as it emerges from foramen magnum. Interneurals project down to slender neural spines and efficiently protect spinal cord from above, besides giving broad areas for insertion of dorsal body muscles.

Besides terminal urostyle, five vertebrae and their neural and haemal spines modified for support of caudal fin (Fig. 12) and its muscles. Thin but broad wings of bone formed on anterior edges of these neural and haemal spines for insertion of caudal musculature so that interspaces between spines very restricted.

First basipterygium of dorsal fin inserted between twelfth and thirteenth neural spine and somewhat crowds last two interneurals. Nine of these bones present, all long and broad, like interneurals. First basipterygium of anal fin is inserted behind thirty-first vertebra's haemal spine. Supports of anal fin long and slender, unlike those of dorsal fin, and reach only to haemal spines, not between them.

Long, slender epineural inserted on broadened base of each neural spine of first seventeen vertebrae. Most posterior epineurals so slender and fine that they may have been accidentally removed from two or three other vertebrae. No epipleurals.

Body covered with rather large, thin cycloid scales, much like those illustrated by Beebe (1931) for *Bathylagus*.

VISCERAL ANATOMY

Viscera of single specimen available none too well-preserved, but some notes of value made. Most prominent feature of abdomen is large silvery air bladder which fills nearly whole dorsal half of abdominal cavity from cranium almost to anus. Completely closed and airtight at both ends, although vestigial ducts may have existed which were not discovered because of condition of specimen. Color a most brilliant silver, and organ has appearance of being made up of fine circular rings of bright, thin tinsel. Walls paper-thin; organ simple and blunt on both ends.

Kidney made up of same kind of granular matter filled with black specks as found in *Bathylagus* and *Macropinna;* restricted to posterior quarter of abdominal cavity, and gives appearance of being pushed into back corner by large air bladder.

Stomach long and slender, extending fully halfway back of abdominal cavity before turning forward again, with rugose external appearance and covered by dark-brown pigment. Pyloric end less than one-quarter length of cardiac end, but intestine runs forward under cardiac end nearly to its anterior end before flexing backward to run straight to anus. Three long, pyloric caeca present which all come off pyloris at same spot. Shortest extends back in crease between two arms of stomach to end of stomach; second little longer and bound tightly to wall of pyloric end of stomach; third slender and very long, extending along full length of stomach anteriorly and lying in crease between cardiac end of stomach and intestine, on left side.

End of intestine expanded somewhat, and bulbous. Anterior to this for about one-third length of intestine this organ filled internally by a series of lamellae which project inwardly so as to almost completely fill lumen of intestine. Although condition of specimen did not permit minute examination, it was assumed that this was a spiral valve similar to that found in *Argentina, Bathylagus, Leuroglossus,* and *Macropinna.*

Specimen examined was a female with eggs very minute and probably immature. As in *Bathylagus* and *Macropinna,* eggs arranged in thin, vertical lamellae which, lying closely one against the other, form the long, slender ovary.

THE GENERA AND SPECIES OF MICROSTOMIDAE

The family Microstomidae contains two genera: *Microstoma* Cuvier and *Nansenia* Jordan and Evermann. The following key will serve for their separation:

1 *a*. Dorsal fin placed well behind the middle of the body, the origin about midway between the posterior border of the eye and the first rays of the caudal; pelvic fins inserted a little anterior to the origin of the dorsal; no adipose fin; vertebrae 45 to 47. . . . . *Microstoma*

1 *b*. Dorsal fin originating approximately in the middle of the body; pelvic fins inserted under or a little behind the last dorsal ray; adipose fin present; vertebrae 43 to 45 . . . . *Nansenia*

A single species of *Microstoma, M. microstoma* (Risso), is known, from the Mediterranean and the Gulf of Guinea.

Six species referable to *Nansenia* have been described from the oceans of the world. *Nansenia groenlandica* was originally described by Reinhardt (1839) as *Microstomus groenlandicus* from a single specimen taken off the Greenland coast, and it was on his brief description that Jordan and Evermann (1896) based the genus *Nansenia.* More than 500 specimens of the species were subsequently taken by the Danish "Thor" expeditions (Schmidt, 1918) in the North Atlantic west of the British Isles, as far south as 48′ 43″ N. (west of Brittany), and as far west as Iceland. *Nansenia oblita* (Facciola) is known from the western half of the Mediterranean and off the west coast of Brittany (Schmidt, 1918). These two species have been capably differentiated by Schmidt (1918) as follows: *N. groenlandica;* predorsal length equals 43.4 to 50 percent of total length, preventral length equals 50 to 55 percent of total length, prepectoral length equals 21.4 to 22 percent of total length, greatest depth equals 9.5 to 12 percent of total length; whereas in *N. oblita:* predorsal length equals 52.7 to 58.7 percent of total length, preventral length equals 61.2 to 66.7 percent of total length, prepectoral length equals 28.2 to 30.5 percent of total length, greatest depth equals 16.0 to 18.6 percent of total length.

Three species have been described from the Western Pacific. Tanaka (1911) described a specimen from the Sagami Sea, Japan, as *Nansenia grönlandica.* On the basis of the reduced pelvic ray counts (9 to 10) given by Tanaka, the more posterior placement of the ventral fins, and the wide separation of locality from the North Atlantic species, Schmidt (1918) proposed that the Japanese form be recognised as a separate species to which he give the name *Nansenia tanakai.* Previously to this Jordan and Thompson (1914) described a new species *Nansenia ardesiaca* from a single specimen taken in Sagami Bay, Japan. This was known to Schmidt but the description was not available to him. Jordan and Thompson considered their species to be conspecific with Tanaka's, and if this were so their name would antedate Schmidt's. However, their description varies in some particulars from Tanaka's, the most important discrepancies being 12 plus 25 gill rakers on the first arch of their specimen as against 10 plus 11 on Tanaka's, and 50 scales in the lateral line to the base of the caudal as against 44 in Tanaka's. Unless the figure given by Tanaka for the raker count on the lower gill arch is a misprint for 21 it would be rather difficult to reconcile the descriptions. Until more Japanese specimens are available it will not be possible to determine whether two species are involved or if all the Japanese specimens are referable to *Nansenia ardesiaca.* At any rate the Japanese specimens agree with *N. groenlandica* in the depth of the body, but have fewer rays in the pectoral (Atlantic species 14 to 15, Japanese specimens 9 to 12), and agree with *N. oblita* in the number of pectoral rays but are more slender (greatest depth 5.4 to 6.2 in *oblita,* 7.5 to 8.0 in the Japanese specimens). Unfortunately no scale or gill raker counts are available in the literature for *oblita* or *groenlandica,* and a definite differentiation from the Japanese specimens cannot be made.

Fowler (1933) described *Microstoma schmitti* from the Philippines and Borneo, placing it in a new subgenus *Euproserpa.* The species has an evident adipose fin, 43 vertebrae, the dorsal fin is located in the middle of the body, and the ventrals are located slightly behind the dorsal. It is, therefore, a member of the genus *Nansenia,* rather than *Microstoma.* The species can be told from the Japanese specimens by the heavier body (greatest depth 6⅛ in body length), fewer scales (38 along the lateral line to the caudal base), and fewer gill rakers (8 plus 18 on first gill arch). It cannot be differentiated from *Nansenia oblita* by means of the available descriptions, but it is probable that the comparison of Mediterranean and Philippine material would show the species to be distinct.

A sixth species was described by Gilchrist (1922) from material taken off South Africa as *Bathymacrops macrolepis*. In a later account (Gilchrist and von Bonde, 1924) he compared it with Tanaka's description and said: "The S. African and Japanese do not seem to differ generically and only in small details, specifically such as the number of rays and scales, though the number of gill-rakers in the former is much larger." The genus does not differ from *Nansenia* and must be considered a synonym of the latter; the species does not differ from *Nansenia ardesiaca* and must be considered a synonym of that species.

SYSTEMATIC POSITION OF THE MICROSTOMIDAE

The above description reveals that the Microstomidae bear no especially close relationship to the Salmonoid fishes. *Nansenia* agrees with the Opisthoproctoid fishes in the following characters: Dentition lacking on premaxillaries and maxillaries, and these bones reduced in size and function; no supramaxillaries; palatine arch strongly bound to cranium anteriorly; enlarged mesopterygoid bound to parasphenoid dorsally and extending under cartilage of palatine arch ventrally; metapterygoid minute; vomer with long posterior shaft and single row of teeth around head of bone forming entire dorsal dentition of mouth; spiral valve present; etc. It thus must be considered a member of the suborder Opisthoproctoidei of the order Isospondyli.

Although they diverge widely from the Argentinidae in many important characters (Chapman, 1942*a*) such as the dentition of the tongue, absence of mesocoracoid, minor development of myodome, reduced number of vertebrae and branchiostegal rays, absence of ventral ethmoid, no roof over temporal fossae, etc., the Microstomidae agree with that family in having deep temporal fossae, parietals large and meeting broadly on midline, a ventral flange on frontal binding the alisphenoid and orbitosphenoid to that bone, basisphenoid present, postcleithra present, pelvic bone roughly rectangular, and the presence of a well-developed air bladder. They must therefore be classed as the nearest known relative of the Argentinidae, and in some respects intermediate between those fishes and the Bathylagidae, although the relationship between these three families is definitely not in a straight evolutionary line. Such characters of the Microstomidae as the broadened circumorbital bones, broadened preopercle, lack of epipleurals, overlapping of frontals and parietals on the midline, broadened caudal supports of the last five vertebrae, absence of ventral ethmoid, etc., are not associated with either of the other families.

While they possess many differences the progression of the Microstomidae and the Bathylagidae from the *Argentina*-like stock has been in the same manner, a loss or reduction of bones and organs, such as the reduction in number of vertebrae and branchiostegal rays, loss of dentition on the glossohyal and fifth ceratobranchial, reduction or loss of myodome, loss of mesocoracoid, first suprabranchial, etc. The Microstomidae have simply not progressed as far in this direction as the Bathylagidae and it cannot be demonstrated that they are progressive points along a direct evolutionary line to the more bizarre Macropinnidae and Opisthoproctidae. Of particular interest is the strong development of the air bladder in the Microstomidae and its complete absence in the Bathylagidae. An identical contrast was found in the outwardly similar Macropinnidae and Opisthoproctidae (Chapman, 1942*b;* Trewevas, 1933) and this leads one to wonder if in this group of fishes there have not been two parallel lines of evolution to the shortened, vertical-eyed *Macropinna-Opisthoproctus* type, one line (with air bladder highly developed) by way of *Microstoma* to *Opisthoproctus,* the other (without air bladder) by way of *Bathylagus* to *Macropinna.*

The following diagnosis will serve to separate the Microstomidae from other fishes.

MICROSTOMIDAE

Opisthoproctoid fishes with laterally directed eyes, basisphenoid, postcleithra, orbitosphenoid, parietals meeting on midline, temporal fossae deep but not roofed over by bone, highly developed physoclistous air bladder, four branchiostegal rays, about 43 to 47 vertebrae, frontals separately distinguishable but overlapped along entire mesial edge; and lacking teeth on glossohyal and fifth ceratobranchial, mesocoracoids, first suprabranchials, and epipleurals.

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