

# 4. REPORT ON THE FISHES COLLECTED BY S.Y. "ROSAURA" IN THE NORTH AND CENTRAL ATLANTIC, 1937-38

PART I. FAMILIES CARCHARHINIDAE, TORPEDINIDAE,  
ROSAURIDAE (NOV.), SALMONIDAE, ALEPOCEPHALIDAE,  
SEARSIDAE, CLUPEIDAE

By DENYS W. TUCKER, B.Sc.,

British Museum (Natural History)

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With Plates 7 and 8 and Text-figs. 1-19

## SYNOPSIS

Specimens of *Carcharhinus leucas* (Müller & Henle); *Diplobatis pictus* Palmer; *Rosaura rotunda* nov.; *Salvelinus alpinus* (L.); *Leptoderma macrops* Vaillant; *Searsia koefoedi* Parr; *Perspersia taaningi* Parr; *Pellonula afzeliusi* Johnels; *Harengula pensacolae* G. & B.; and *Ilisha africana* (Bloch) are reported upon. The family *Rosauridae* is proposed for *Rosaura rotunda* nov., an aberrant new oceanic Isospondyl. The paper presents new observations and discussion of tumours in *Salvelinus*; of the structure and functions of the shoulder-organ of *Searsidae*; of the occurrence of lateral line papillae in *Alepocephalidae*; and of the general taxonomic significance of photophore systems.

## INTRODUCTION

As soon as the "Rosaura" fishes were received at the British Museum (Natural History) in 1938, a preliminary rough-sorting and assessment were carried out by Lieut.-Col. W. P. C. Tenison, D.S.O., who also made illustrations of six of the more bizarre deep-sea species which were included in a popular account by J. S. Colman published as an appendix to the late Lord Moyné's *Atlantic Circle* in the same year. (Another version of the same material is included in Colman, 1950, *The Sea and its Mysteries*.) With the approach of war the collection was set aside and remained unstudied until 1951, when I began my apprenticeship in ichthyology with a very laboured consideration of it. Many of the larvae and smaller specimens were still unnamed, and for a variety of reasons it was sometimes necessary to modify Lieut.-Col. Tenison's determinations; but his work had materially shortened the initial task of identification and is gratefully acknowledged.

The collection is especially rich in well-preserved bathypelagic species from the little-worked Caribbean and equatorial Atlantic, and the present report will lay greater emphasis upon these than upon the shore fishes.

A general list of species taken at each station will appear with the concluding instalment of the report, together with any minor addenda and corrigenda and general conclusions suggested by the work. Photographs used are acknowledged as applicable; all other figures are from drawings by the author. Except where specially stated, standard lengths (S.L.) of fishes are given, and denote the measurement from the tip of the snout to the base of the caudal fin.

My best thanks are offered to those specialists and museum curators in other institutions whose assistance is mentioned in the text. I am especially grateful for the interest, advice and guidance so gladly given by my colleagues Dr. Ethelwynn Trewavas and Mr. N. B. Marshall, and for the services rendered by the technical staffs of the Fish Section and Photographic Studio of the British Museum (Natural History). I am indebted to Mr. J. S. Colman (now Director of the Marine Biological Station, Port Erin, I.o.M.), who made this very fine collection and has permitted the reproduction of extracts from his field notes which appear as quotations in the text.

Order PLEUROTREMI

Family CARCHARHINIDAE

*Carcharhinus* sp., probably *C. leucas* (Müller & Henle), alternatively  
*C. longimanus* (Poey) or *C. obscurus* (Lesueur).  
(Pl. 7)

(1) *Carcharhinus (Prionodon) leucas* (Müller & Henle).

*Carcharias (Prionodon) leucas* Müller & Henle, 1841, *Syst. Besch. Plagiostomen* : 42. Berlin.  
*Carcharhinus leucas* Bigelow & Schroeder, 1948, *Fishes of the Western North Atlantic*, 1, Sharks : 337; Myers, 1952, *Copeia* : 268.

HAB. Western Atlantic, New York to Southern Brazil; (?) Peruvian Amazon.

(2) *Carcharhinus longimanus* (Poey).

*Squalus longimanus* Poey, 1861, *Memorias hist. nat. Cuba*, 2 : 338.  
*Carcharhinus longimanus* Bigelow & Schroeder, 1948, t.c. : 354.

HAB. Tropical and subtropical Atlantic; Mediterranean.

(3) *Carcharhinus obscurus* (Lesueur).

*Squalus obscurus* Lesueur, 1818, *J. Acad. nat. Sci. Philad.*, 1 : 223.  
*Carcharhinus obscurus* Bigelow & Schroeder, 1948, t.c. : 382.

HAB. Western Atlantic, New York to Florida & Bermuda; doubtfully southwards to Brazil.

St. 41. 18.xii.37. 0° 38' S., 43° 42' W. 2-metre stramin net, 900(-0) metres. One specimen (a female), 211 cm. total length. Notes and photographs taken; heart only preserved. Reg. No. 1953.3.6.1.

The following data are extracted from notes by J. S. Colman :

"Shark. Female. *Carcharhinus* sp. (acc. to Norman). Colour—grey dorsally, white ventrally. Two rows of teeth. No spines in front of fins. Ducti endolymphaticus present. 5 gill-slits each side. Stomach quite empty. Ovaries very immature; no eggs developing. I could find no parasites. Four Remoras accompanied it."

## Dimensions :

Snout to end of caudal fin ( <i>total length</i> )	.	211	cm.	
„ mouth (middle of upper lip)	.	14	„	( 6·6% T.L.)
„ eyes . . . . .	.	15	„	( 7·1% „ )
„ 1st gill-slit . . . . .	.	40	„	(18·9% „ )
„ 5th „ . . . . .	.	53	„	(25·1% „ )
„ base of pectoral fin . . . . .	.	52	„	(24·6% „ )
„ „ 1st dorsal fin . . . . .	.	66	„	(31·2% „ )
„ cloaca . . . . .	.	112	„	(53·0% „ )
„ base of 2nd dorsal fin . . . . .	.	132	„	(62·5% „ )
„ „ anal fin . . . . .	.	134	„	(63·5% „ )
„ „ caudal fin . . . . .	.	150	„	(71·0% „ )
Girth at 1st gill-slit . . . . .	.	84	„	
Max. girth (at base of 1st dorsal fin) . . . . .	.	88	„	
Min. girth (at base of caudal fin) . . . . .	.	27	„	
Spread of pectoral fins . . . . .	.	113	„	

On the following characters the specimen may be assigned to the family Carcharhinidae in the sub-order Galeoidea: A normally shaped head, not laterally expanded; five gill-slits, the last situated behind the origin of the pectoral fins; two series of teeth functional; two dorsal fins, which are not preceded by spines; first dorsal much shorter at base than caudal and terminating well before the origin of the pelvics; an anal fin present; caudal fin not lunate and occupying less than half the total length.

Indirect methods of identification, taking into account the absence of a spiracle, the short snout, and the relative sizes, shapes and insertions of the fins, allow the elimination of *Galeocerdo*, *Paragaleus*, *Prionace*, *Negaprion*, *Aprionodon*, *Scoliodon* and *Hypoprion*. There remains only *Carcharhinus*, with fourteen Western Atlantic species, of which one, *C. nicaraguensis*, is confined to fresh water, and others have notably longer snouts as well as differences in the fins which are unmistakable. Of three species one "possible," *C. leucas*, seems by far the most likely.

*C. leucas* has the reputation, consonant with a capture in a plankton net, of being a heavy, slow-swimming species. Against an almost complete correspondence with the smaller female described by Bigelow & Schroeder, the present specimen offers only very small differences in the more posterior insertions of the pectoral and first and second dorsals, and these seem negligible when considered against small differences likely from methods of measurement and probable ontogenetic and other variations.

*C. longimanus* agrees in the short snout and long, slender pectoral, and in the relative insertions of the fins, but has broader 1st dorsal and ventral fins and longer posterior tips to the 2nd dorsal and anal.

*C. obscurus* belongs to the group of species having a median dorsal ridge, the presence or absence of which cannot certainly be determined from the photograph.

It has a short snout and other characters in common with the present specimen, but appears to differ considerably in the shorter pectoral and lower second dorsal.

The Remoras mentioned by J. S. Colman are four examples of *Remora remora* (L), 102-195 mm. S.L. In view of a very interesting paper by Szidat & Nani (1951, *Rev. Inst. Ciencias nat. y Mus. Argentino*, 2 : 385) presenting evidence that Remoras feed upon the copepod ectoparasites of sharks and other large fishes, I made a point of examining these specimens. No recognizable organisms were found in the very small amount of food present in their mouths and stomachs; the result, though disappointing, is in accord with the field-note on the absence of shark parasites.

#### Order HYPOTREMI

#### Family TORPEDINIDAE

#### *Diplobatis pictus* Palmer

(Pl. 8)

Palmer, 1950, *Ann. Mag. nat. Hist.* (12) 3 : 480.

St. 35. I.xii.37. 9° 25' N., 59° 52' W.; otter trawl; 86(-) metres. One specimen (a female), 131 mm. total length. Reg. No. 1953.3.6.2.

St. 36. 2.xii.37. 7° 11' N., 57° 59' W.; otter trawl, 20(-) metres. Two specimens (females), 110-140 mm. total length. Reg. No. 1953.3.6.3-4.

HAB. Guiana Coast; mouth of R. Orinoco.

This species was previously represented in the Museum's collections by the unique holotype, Reg. No. 1950.5.15.4.

The specimen from St. 35 is badly deformed, extensive injuries to the body and pectorals having been followed by irregular healing and regeneration. Those from St. 36 (Pl. 8) agree adequately with the holotype, save that a rounder form replaces the slight narrowing of the body behind the eyes, the bodies are better nourished and the hinder edges of the pelvics have broader points. The last observation led to some conjecture whether the holotype might not be an immature male, but there is nothing else to support that view, and by analogy with other Torpedinidae recognizable claspers would be differentiated at a much younger stage.

Palmer's fig. 3, it must be noted, is very diagrammatic: the edge of the pelvic is not smooth as shown but includes three or four shallow undulations each beset with several small points, and anterior to the free hind tip there is a marked zone of fusion between the inner edge of the pelvic and the ventral surface of the tail.

Reproduction of Palmer's fig. 1 rather over-emphasizes the contrast in tone between the dark spots surrounding the light markings on the back and that of the remaining dark blotches on the body. In the smallest specimen now available the light spots on either side the back have an almost pearly whiteness which evidently becomes much clouded in ontogeny; also the tips of the dorsal fins are rounder in the young stage, as in the Pacific *D. ommata*, and become pointed with

age. The remaining differences described between *D. pictus* and *D. ommata* (the genotype and only other known species) are sustained by the present material.

Bigelow & Schroeder (1948, *J. Mar. Res. New Haven*, 7:43) give two main characters separating *Diplobatis* from other Torpedinidae: the subdivision of the nostril into two about the middle of its length by a bridge of stiff tissue, and a relationship of tooth bands to the thick, fleshy lips such that the teeth are entirely concealed when the mouth is retracted and closed.

In consideration of the possibility of ontogenetic variation in the Torpedinidae I have examined a long series of *Narcine brasiliensis* (Olfers) down to embryos with yolk-sacs attached, and find that at all stages the nostrils are undivided, so that the condition in *Diplobatis* may be regarded as distinctive enough. Nevertheless the character is of doubtful use to the taxonomist, since only in the smallest of the present specimens is the bridge intact, and even then it can hardly be described as being of "stiff tissue" throughout; rather does there seem to be a close approximation of a concave upper and convex lower surface with a little tenuous tissue between the two. In the remaining material it would be difficult to decide from superficial appearances whether a bridge ever existed. In the holotype (of *D. pictus*) it remains as figured only on the right side, and Mr. Palmer informs me that on the left side it was ruptured during study subsequent to his paper.

#### Order ISOSPONDYLI

#### Family ROSAURIDAE nov.

#### *Rosaura rotunda* gen. et sp. nov.

(Text-figs. 1-8)

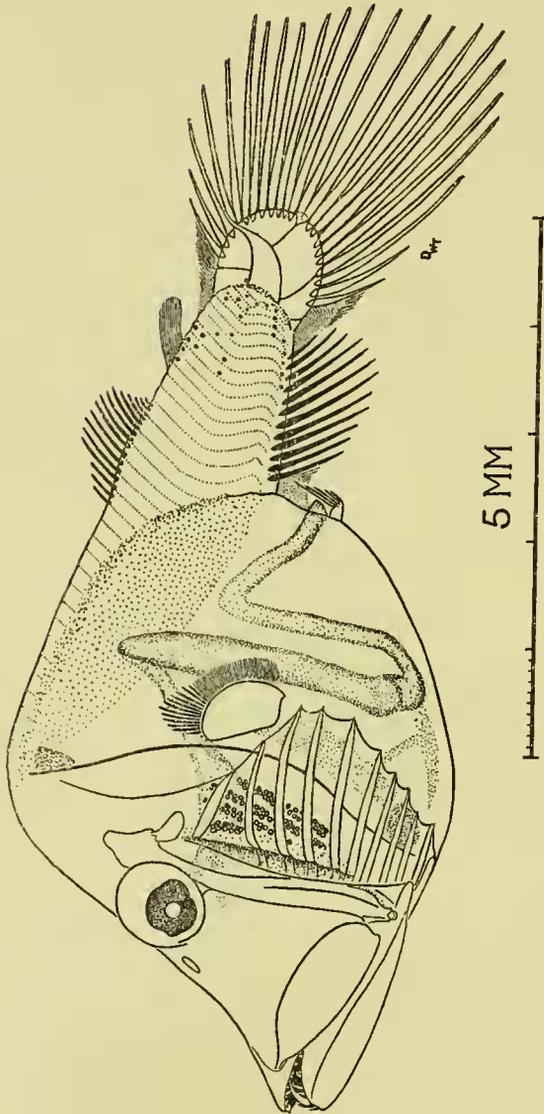
St. 42. 21.xii.37. 5° 51' S., 34° 38' W.; 2-metre stramin net, 1200(-0) metres. One specimen (holotype), 8.4 mm. S.L. Reg. No. 1953.3.6.11.

HAB. Deep Atlantic, N.E. from Brazil.

#### *Material and methods*

This solitary specimen, though but a post-larva, is sufficiently advanced in ossification and general development to be recognized as substantially different from all recent and fossil Isospondyli yet known.

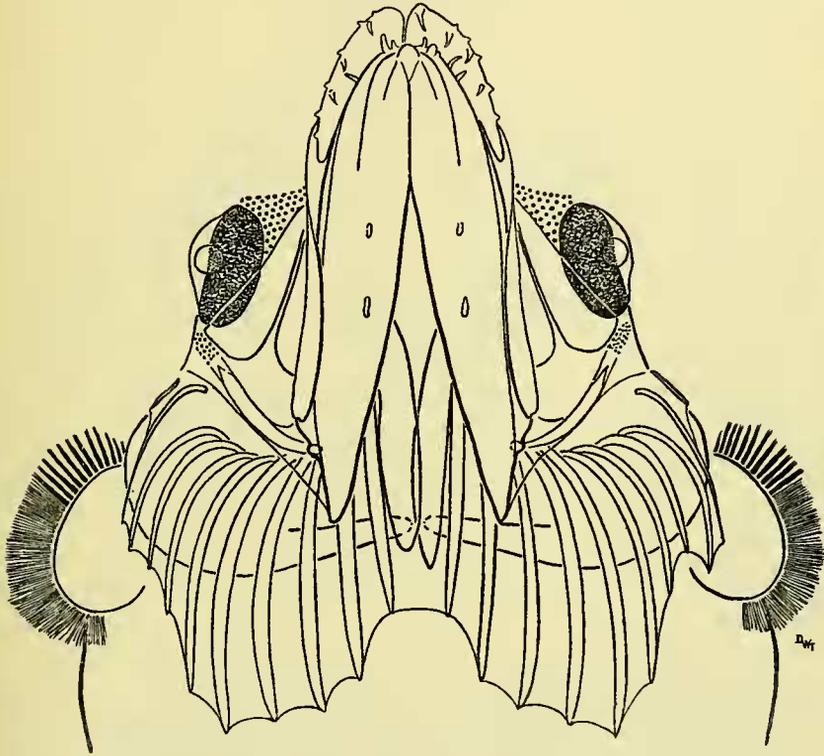
Its transparency aroused hopes of attaining a complete knowledge of the anatomy of the untreated fish, but these could not be realized fully without resort to artificial aids. I therefore made accurate notes of all structures visible in the material and then proceeded to clear and stain, controlling all stages under the microscope and employing, instead of the usual more elaborate methods (Hollister, 1934, *Zoologica*, 12: 89-101; Raitt, 1935, *J. Cons. Explor. Mer*, 10: 75-80) a simplification used in the British Museum (Natural History) for many years:



TEXT-FIG. 1. *Rosaura rotunda* gen. et sp. nov. Holotype, 8.4 mm. S.L. The specimen is shown in its condition prior to clearing and staining. Internal projection of dorsal myomeres into body-cavity shown stippled.

- (1) Preserved material in 70% spirit transferred to distilled water—15 minutes.
- (2) Partly cleared in 0.5% KOH solution—30 min.
- (3) Stained in an old deep purple solution of alizarin in distilled water—16½ hours.
- (4) 0.5% KOH solution—70 minutes. At this stage the specimen was still understained, so staining was repeated with a freshly-prepared solution.
- (5) Solution of about ¼ c.c. of alizarin powder in 200 c.c. distilled water—2 hours.
- (6) Solution of 2 volumes of 0.5 KOH to 1 volume of pure glycerine. During the next 24 hours glycerine was added a little at a time until the specimen could safely be transferred to pure glycerine containing a thymol crystal as preservative.

The untreated specimen had sustained compound fractures of the cleithra and wanted parts of two teeth. Processing was accomplished without further damage, but there were several breakages of caudal and branchiostegal rays during subse-



TEXT-FIG. 2. *Rosaura rotunda*. Anterior view of head from below.

quent study and manipulation, which do not seem very serious in proportion to the additional information gained.

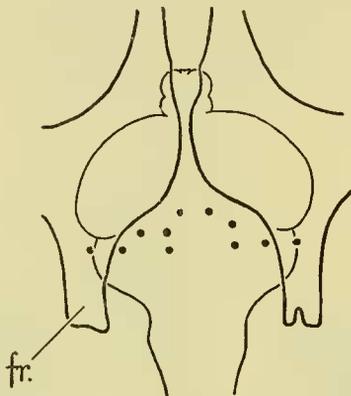
The text-figures were drawn freehand with the assistance of a 5 × 5 eyepiece graticule, calibrated with a stage micrometer.

*General appearance* (Text-figs. 1 and 2)

Radial formula D.16 + ; A.12 + ; C.23 + ; P.12 + ; V.5(L), 2(R).

Branchiostegal rays 10. Gills 4. Myomeres of body 37.

At first glance reminiscent of the larval Ceratioids, a minute fish with an overall length of 10.3 mm., transparent or translucent, scaleless and colourless save for a few isolated melanophores atop the head (Text-fig. 3) and on the caudal peduncle.



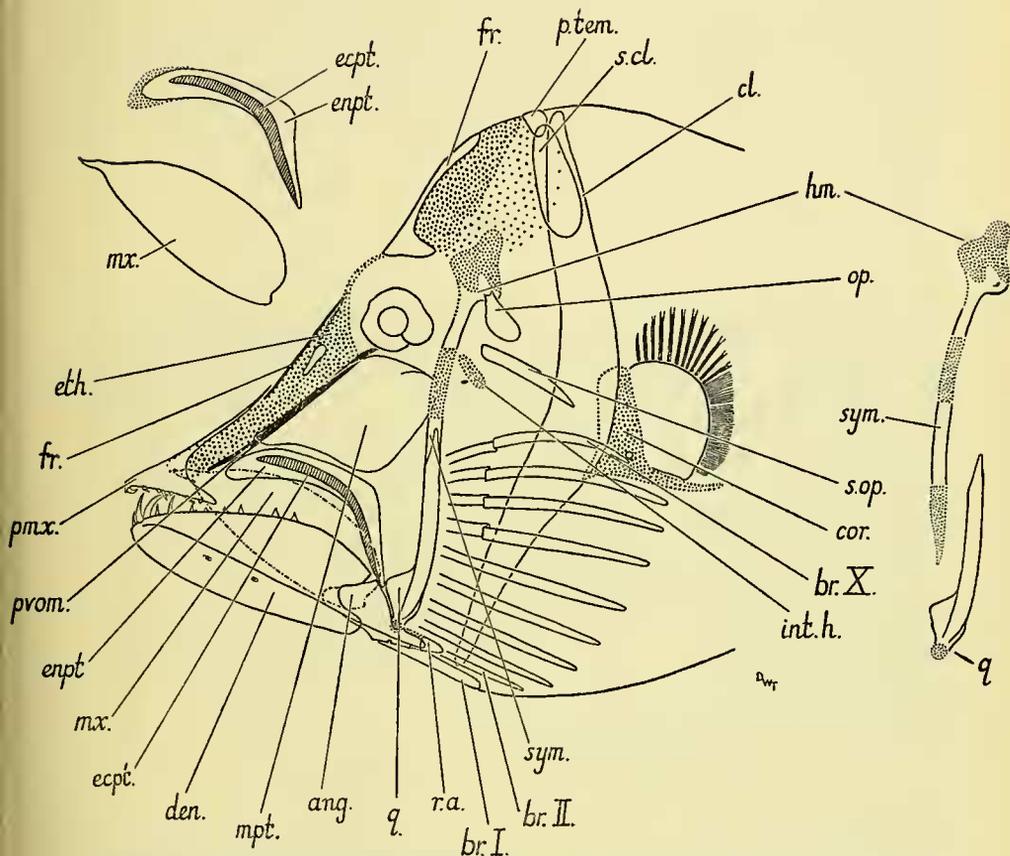
TEXT-FIG. 3. *Rosaura rotunda*. Disposition of melanophores on dorsal surface of head, shown in relation to the brain and frontal bones.

The greatest height is in the broad otic region. From this projects obliquely forwards and downwards the narrow ethmoid cartilage. The suspensorium is vertical, forming with the cranial axis and the jaws an approximately equilateral triangle. Behind this the vertebral column with its myomeres descends obliquely to the posterior end of the almost spherical body-cavity and is continued as a short caudal region.

The body-cavity is bounded in front by an almost vertically placed pectoral girdle, lightly curved forwards below, with the pectoral fins inserted about half-way in the height.

The origin of the dorsal fin is substantially in advance of that of the much larger anal. An adipose fin is present. The caudal fin is large and fan-like. A prominent anal papilla is flanked by a pair of minute abdominal pelvic fins.

The gill-openings are wide and bordered mainly by the branchiostegal membranes, which are continuous below (free from the isthmus), and supported by the much-reduced opercular and subopercular and by ten conspicuous, long, slender branchiostegal rays. Pre- and inter-opercular bones are absent. The large mouth is bordered by toothed premaxillaries and dentaries with prominent caniniform teeth. The maxillaries are toothless and probably enter the gape only to a very limited extent. The eye is small for an oceanic fish and is widely separated from the jaws. No division can be seen in either of the single pair of minute nostrils.



TEXT-FIG. 4. *Rosaura rotunda*. Osteology of head and pectoral girdle in a cleared and stained specimen, with optical dissections of the maxillary, palato-pterygoid and hyomandibular-symplectic-quadrate. Cartilage shown stippled. For key to abbreviations used see p. 181.

*Cranium* (Text-figs. 4 and 7)

A great part of the cranium is still unossified, and its description limited by the difficulty of interpreting a single small and delicate specimen which may not be dissected.

The antorbital portion of the cranium is a substantial part of the whole structure. The largest element is the ethmoid cartilage, which is arched above, flat below, a long cartilage extending half the length of the head and of uncertain lateral extent. Anteriorly it is overlain by the rostral processes of the premaxillaries; mesially it is exposed between the widely separated anterior limbs of the frontals, and posteriorly it sends thin supraorbital blades beneath the lateral processes of the frontals towards the auditory capsule. The vomer and parasphenoid are applied to its ventral surface.

The orbit is placed high on the head, laterally directed and remote from the jaws.

The postorbital portion of the cranium is an unossified chondrocranium, globose and including considerable auditory capsules. In dorsal view it is possible to see, through the frontals, edges of cartilage which run parallel and close to the optic lobes of the brain; whether these are in fact the anterior margins of fontanelles cannot be ascertained since posteriorly they become lost in the complications of the auditory region, but it seems very likely that they are.

The only bones present on the dorsal surface of the head are the frontals, which are widely separated in the middle line. They have slender anterior extensions reaching to the tips of the premaxillary rostral processes, short posterior extensions part over the auditory capsules, and broader lateral processes contributing to the roof of the orbit. Separate parietals are not present.

The vomer (seen only in lateral view) is a narrow sliver of bone extending to beneath the anterior part of the orbit, where it overlies the front end of the parasphenoid. The latter cannot be seen distinctly and is therefore not included in any of the figures.

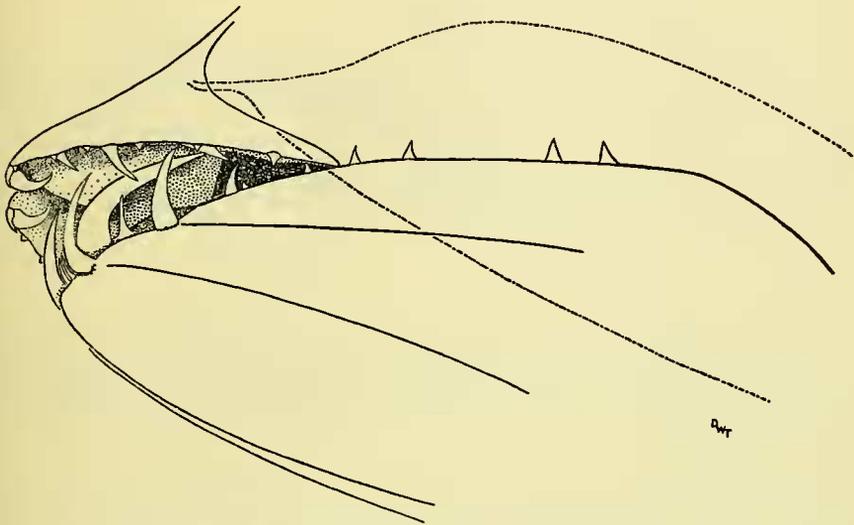
There is no mesethmoid, lateral ethmoid, or prefrontal ossified, nor are any bones of the otic or occipital series.

*Jaws* (Text-figs. 4, 5 and 7)

The toothed premaxillaries form the greater part of the upper boundary of the mouth. Each is V-shaped, the inner and longer arm of the V being a pointed rostral process which overlaps the anterior tip of the frontal of the same side, the outer and shorter arm being the dentigerous margin of the jaw. The premaxillaries are separated by a narrow median fissure which broadens anteriorly and posteriorly into wide notches.

The toothless maxillaries are broadly elliptical, much like those of the Sternopychidae, and can enter but little into the gape. Each maxillary narrows anteriorly to form a twisted process inserted into the ethmoid beneath the posterior angle of the premaxillary. The squarish posterior end of the maxillary has a broad shallow notch.

Meckel's cartilage persists throughout the length of the lower jaw, though almost entirely overlain by membrane bones. The large toothed dentary is an elongated oval with a broad notch in the wide posterior end receiving, and in part overlying, the much smaller angular. There is a marked tuberosity at the mandibular symphysis. The body of the angular is roughly an equilateral triangle with the articulating facet of the quadrate above its hinder corner, and with a short narrow limb posterior to this partly overlying the end of Meckel's cartilage. The hindermost tip of Meckel's cartilage is ossified as a truncated conical retro-articular. There is no other articular ossification.



TEXT-FIG. 5. *Rosaura rotunda*. Dentition, viewed from left and slightly below. The broken line shows the position of the maxillary.

#### Dentition (Text-figs. 5 and 6)

The dentition is highly raptorial. The teeth on the premaxillary are in two series: an external row of seven minute teeth downwardly and outwardly directed from the edge of the premaxillary, the most anterior of the series being weakly caniniform; and on the inner face of the premaxillary a series of four stronger, inwardly-directed and recurved teeth. The maxillary is toothless.

In the lower jaw the dentition is dominated by a pair of very large and strongly recurved caniniform teeth, set inside and a little behind the mandibular symphysis. Each dentary further carries five moderately recurved caniniform teeth of oddly-assorted sizes, and posterior to these a graded series of six to eight laterally com-

pressed, shearing teeth. So far as may be determined without manipulating the jaws there are no vomerine teeth. (The palatines are not ossified.)

Accessory structures present in the mouth may be related to the need for removing prey impaled on the enlarged mandibular teeth. The tip of the basihyal (Text-fig. 6) bears a similar pair of enlarged and recurved teeth (one with a replacement tooth behind it), evidently capable of some degree of motion between and behind the great teeth of the mandible. Above there is a median fleshy down-growth depending from the maxillary valve between these two pairs of teeth which may bear some functional relation to the lower dentition.

#### *Palatine arch* (Text-fig. 4 and detail)

The palatine end of the palato-pterygoid cartilage is unossified, but is not believed to be synchondrous with the lower end of the ethmoid cartilage. A broad  $\gamma$ -shaped endopterygoid, rounded at its anterior end and tapering to a point at the posterior, sheaths it on its inner side. The metapterygoid is a large rhomboidal bone covering much of the cheek between the orbit and the upper limb of the endopterygoid; its posterior end bears a suborbital prominence and is inserted mesiad to the hyomandibular-symplectic cartilage. A zone of cartilage lies exposed to the surface at the periphery of the metapterygoid.

#### *Hyoid arch* (Text-fig. 4, detail and 6)

The hyomandibular is ossified only in its middle portion, the head and lower end being cartilaginous. The head comprises two dorsal protuberances (unossified) and one ventral (ossified), the latter bearing a small condyle for the articulation of the minute opercular.

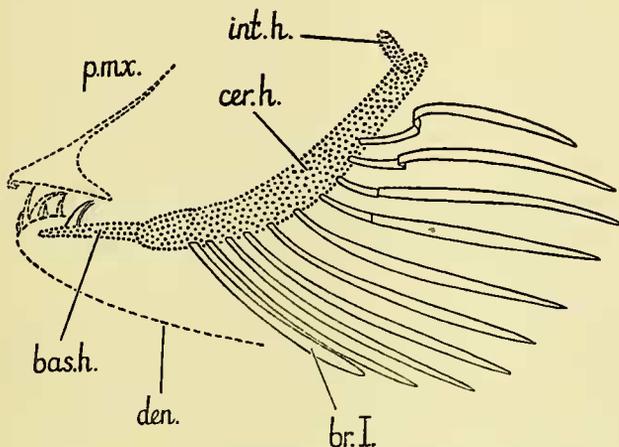
The symplectic, likewise ossified in the middle portion only, is rod-shaped. Its upper end is synchondrous with the hyomandibular. Part of the ossified portion, and the whole of the lower cartilaginous end, are overlain by the quadrate.

The quadrate is a short triangular ossification, the posterior edge of which is extended upwards as a long tapering rod. The articular condyle remains cartilaginous.

The interhyal is a short cylindrical cartilage attached at its upper end to the cartilage between hyomandibular and symplectic and at its lower end to the lower limb of the hyoid arch. It is not possible to distinguish with certainty between epi-, cerato- and hypo-hyal elements, and Text-fig. 6 shows as much as can be discerned under the limitations imposed by viewing through the suspensorium and unopened jaws. The basihyal element is more readily distinguished and bears a pair of enlarged teeth.

The branchiostegal rays are long, slender, tapered towards their extremities, and elegantly curved, giving a globose contour to the anterior body of the fish. The last four describe a somewhat S-shaped curve in traversing a vertical fold of the gill-cover; this curve is strongest in the uppermost (posterior) rays. The

second to sixth rays approach the hyoid arch in a smooth simple curve. The first (lowest) branchiostegal ray is twice as broad as the rest, slightly twisted, and passes well between the rami of the mandible. The curvature and apparent grouping of the branchiostegal rays suggest, by analogy with other fishes, that there may be a ceratohyal bearing six rays and an epihyal with four.



TEXT-FIG. 6. *Rosaura rotunda*. Hyoid arch. The ten branchiostegal rays are accurately represented; the basihyal and interhyal are also correct, but the remaining cartilages (epi-, cerato- and hypo-hyal) cannot be shown properly owing to difficulty of observation. The positions of premaxillary and dentary and of some of their teeth are shown by broken lines.

#### *Opercular apparatus* (Text-fig. 4)

The gill openings extend very nearly the full depth of the fish and are bordered by voluminous branchiostegal membranes which are continuous below (free from the isthmus). The branchiostegal membranes are supported by the opercular and sub-opercular bones and the ten branchiostegal rays; the pointed tips of the sub-opercular and last nine branchiostegal rays project beyond the hinder edge of the branchiostegal membrane like the ribs of an umbrella; the tips of the opercular and first branchiostegal ray do not reach to the margin of the membrane.

The opercular is a rudimentary, ventro-laterally directed, twisted, leaf-shaped bone articulating with a small condyle on the head of the hyomandibular. The sub-opercular is a narrow, pointed bone about twice as long as the preceding, converging with the tenth branchiostegal ray.

#### *Gills and gill-apparatus*

Viewed as they have been through the suspensorium, the gill-arches have yielded little information. There appear to be four only, bearing double rows of long and

not very numerous gill-filaments. The lower limbs of the arches bear minute conical denticles or rakers, about a dozen to each limb.

*Pectoral girdle and fin* (Text-figs. 4 and 7)

The post-temporal (Text-fig. 7) is a flat, spatulate bone which mesially comes near to meeting its fellow over the otic region of the cranium, and passes almost transversely and horizontally before the dorsal somites to overlie the upper tip of the supracleithrum.

The supracleithrum, so far as may be ascertained in its damaged state, is a flattened, oval bone, substantially smaller than the post-temporal; its broad postero-ventral end overlies the cleithrum a little below the latter's upper tip.

The cleithrum is very large and boomerang-shaped, and with its partner comes near to forming a complete bony ring round the body. The upper limb is nearly vertical; the lower is rather slender and curves forward and downward. The pectoral fin is inserted behind the posterior angle of the cleithrum at about the middle of the body-height.

The coracoid cartilage is perforated by a minute coracoid foramen and bears a prominent, posteriorly directed ventral spine, but has no trace of ossification nor of differentiation. Its anterior edge is inserted inside the hind edge of the cleithrum, and there is a small antero-ventral process which follows the edge of the cleithrum downward.

The pectoral fin of each side is much crumpled and the structure difficult to make out. Each appears to be a vertically-inserted reniform cartilaginous lobe, having no actinosts ossified as yet. Twelve adult rays have stained on the upper edge of the fin, and doubtless the number would have been increased later by the gradual replacement of the very numerous unossified larval rays.

*Pelvic girdle and fin* (Text-figs. 1 and 8)

There is a very slender and apparently unpaired pelvic cartilage lying transversely in the ventral body-wall before the anal papilla. The tapered ends of the pelvic cartilage turn downwards and backwards into the fin-bases; these are backwardly directed papilliform structures from which the short close-set rays project upwards and backwards. The fins are obviously in the early stages of development; that of the right side is placed higher and more anteriorly, and has but two rays compared with five on the opposite side.

*Axial skeleton* (Text-fig. 1)

The vertebral column is as yet entirely unossified. The surface of the stout notochord has the usual reticulate appearance; its posterior end is curved upwards and backwards and the slender tip projects between the bases of the 3rd and 4th upper caudal rays. There is a slight constriction in the notochord at the point

where it breaks the edge of the fin-lobe. The first two pairs of basidorsal elements at least are laid down in cartilage (Text-fig. 7).

The dorsal fin is supported by 16 cartilaginous basalia, each of which bears one ray. The fin is smoothly rounded; the middle rays are the longest, but do not quite reach to the adipose fin when depressed. There is a wisp or two of larval ray at the hinder end, but the full adult complement seems to be present. The fin base is slightly elevated.

The adipose fin is rather large, slightly hooked, and with a fimbriated edge.

The anal fin, though probably incompletely developed, is still very much larger than the dorsal. Anteriorly there is a fringed adipose blade in which further rays might have been differentiated; there are 12 cartilaginous basalia thus far, each with a ray. The fin is rounded, the middle rays are the longest, and the depressed fin reaches to the anterior rays of the caudal. The first anal ray corresponds to the same myocomma as the eleventh dorsal ray, while the anal fin base extends beyond the posterior end of the adipose. Discussion of verticals through fin origins would be unprofitable, as may be observed from Text-fig. 1.

The caudal fin is supported by the tip of the notochord, and by two epurals and three hypurals, all cartilaginous. Between the distal extremities of the hypurals are minute triangular supplementary cartilages. There are three epaxial and twenty hypaxial rays, all elegantly curved and tapered at their extremities; the broadest part of each ray lies a short distance from its insertion, as in a quill. The dorsal rays are a little more slender and closely set than the ventral; the rays are evenly gradated and form a considerable caudal fan. Anterior to the caudal rays on both dorsal and ventral edges is a fringed adipose blade in which it is evident that a substantial number of procurent caudal rays would have been differentiated.

Branching is incipient at the ends of most of the fin-rays.

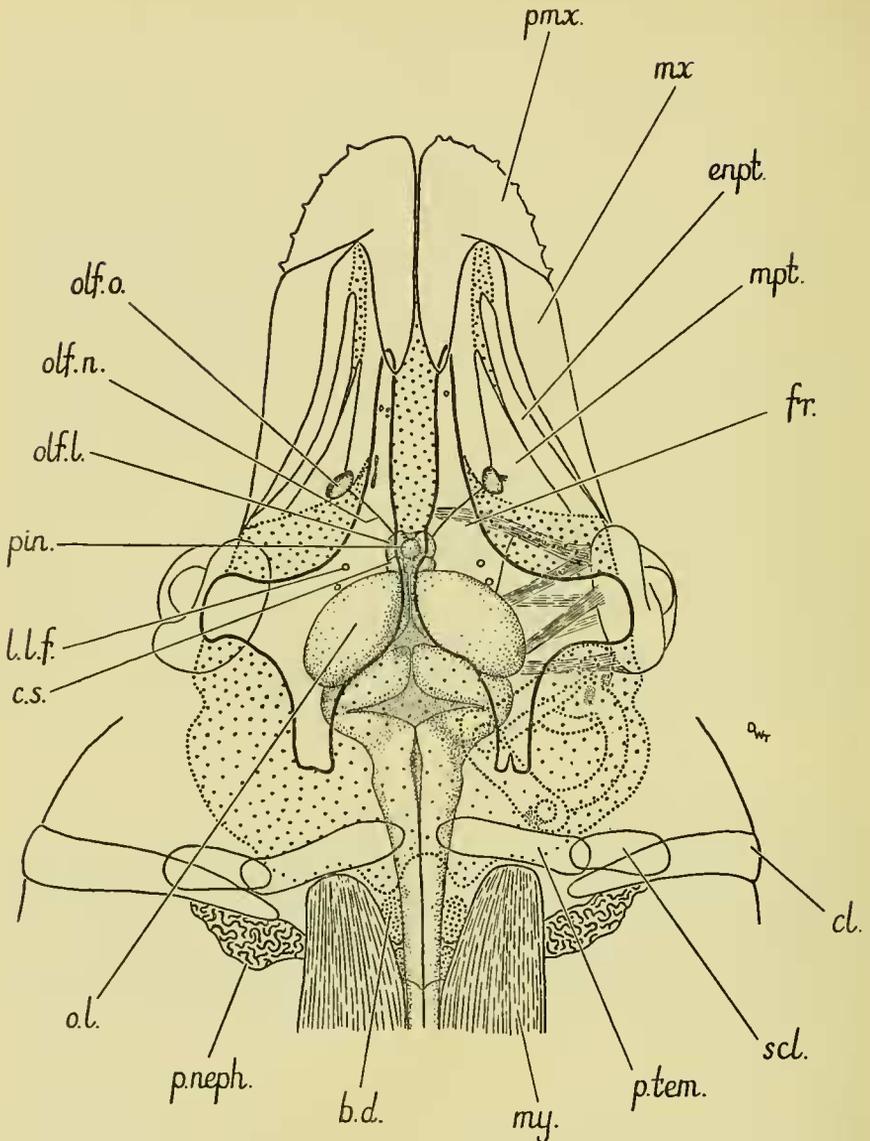
#### *Visceral anatomy* (Text-figs. 1 and 8)

The body-cavity is spacious and near-spherical.

The funnel-shaped pharynx narrows to a short oesophagus. The stomach is small with a median constriction. A single pyloric caecum bears subtle transverse surface undulations suggesting subdivision into three or four at a later stage. The intestine leaves the stomach to descend round the left side of the body, narrows as it runs transversely upon the lower body wall, ascends some distance up the right side, and then turns and runs obliquely downwards and backwards from right to centre to open on the anal papilla. There is some differentiation of texture and thickness in the regions of the gut, but no certain indication of a spiral valve nor of any rectal glands.

The pronephros was remarkably distinct even in the untreated material, a pear-shaped structure upon whose surface tubules are apparent, attached near the anterior somites and the upper end of the cleithrum.

The liver comprises two major lobes, narrowing as they run dorsally to left and right. A problematic strip of similar-seeming tissue may be pancreas; one cannot say.



TEXT-FIG. 7. *Rosaura rotunda*. Dorsal anatomy of the head: the lateral scale slightly exaggerated due to drawing with a twin-objective microscope. Cartilage coarsely stippled. The eye-muscles and auditory organ of the left side are omitted to avoid over-complication. For key to abbreviations used see p. 181.

Of the heart may be seen a large spherical auricle, a smaller thick-walled ventricle, and a structure which must almost certainly be the sinu-auricular valve, though the sinus itself is too transparent to be distinguished. A large vessel runs in the mesentery to the middle of the intestine.

There is no trace of gonad development.

### *Musculature, etc.*

The total number of myomeres developed is 37. Of these 16 are in front of the dorsal fin; the dorsal fin-base occupies  $6\frac{1}{2}$ ; there are  $2\frac{1}{2}$  between dorsal and adipose fins; the adipose fin-base occupies 3, and 9 remain to the end of the body. There are 22 myomeres before the anal fin, and the anal fin-base occupies  $9\frac{1}{2}$ . The dorsal muscle somites are shallowest and forwardly extended where they are approximated to the posterior end of the cranium, and become progressively deeper towards the origin of the tail. The ventral body musculature forms a thin continuous balloon-like surface, much crinkled in preservation, and with only here and there a line to indicate a myocomma.

The *m. adductor mandibulae* has a superficial component inserted on the inside of the angular in advance of the jaw-articulation; another component inserted nearby on the maxillary, and a deep component which turns sharply forwards and inwards to an adjacent insertion on the inside of the dentary. The long tendon of the *m. adductor mandibulae* runs along the anterior edge of the hyomandibular-symplectic to an insertion on the head of the hyomandibular or somewhere on the skull close by.

A very strong ligament runs from the hindermost tip of the lower jaw along the hinder edge of the suspensorium to the region of the opercular. As in *Chauliodus* (Tchernavin, 1953, *The Feeding Mechanisms of a Deep-sea Fish* (B.M. [N.H.])), however, the opercular is small and the *m. levator operculi*, if present, consequently likely to be weak and relatively useless in opposition to the *m. adductor mandibulae*. I cannot see any ligamentous connection between the hind end of the mandible and the posterior end of the epihyal, and therefore assume that the main work of opening the jaws is accomplished by the *m. sterno-hyoideus*, which is well developed in common with the other muscles in the floor of the mouth.

There is a patch of fibrous tissue binding the lower posterior end of the maxillary to the dentary.

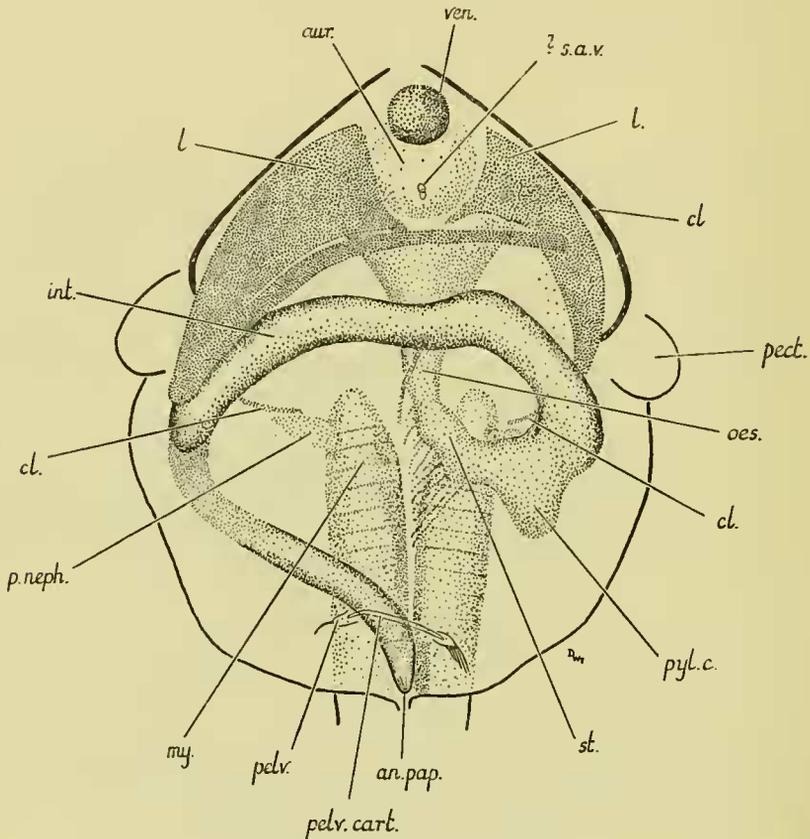
The latero-ventral boundary of the buccal cavity is formed by a thin sheet of tissue, probably smooth muscle, whose lateral edge extends as an arc from the level of the middle of the symplectic to the tip of the basihyal.

The *abductor pinnae pectoralis* is a thick muscle between the coracoid cartilage and the anterior face of the pectoral fin; its strong development adds another obstruction to the observation of the radialia.

Traces of muscles are visible upon the hypurals of the caudal fan, together with a loose aggregation of myoblasts behind the ultimate somite.

The eye muscles are long and slender (Text-fig. 7). The *m.m. recti* and *m. obliquus*

*inferior* require no special comment, but the *m. obliquus superior* is unusual in that it follows a very independent course to an insertion well forward on the ethmoid.



TEXT-FIG. 8. *Rosaura rotunda*. Abdominal viscera, viewed from a point behind and below the vent. For key to abbreviations used see p. 181.

#### *Nervous system and sense organs* (Text-fig. 7)

Differentiation of the brain is well advanced, though there are no structures that call for very special notice. There are olfactory lobes with olfactory tracts running forward and outward through the ethmoid cartilage to the olfactory organs; behind these lie corpora striata, and between them an epiphysis or pineal organ. The optic lobes are very large, as also is the cerebellum, and the third and fourth ventricles are readily distinguished. The swollen origin of the spinal cord is exposed between the anterior somites.

## Key to abbreviations used in text-figures

<i>ang,</i>	angular.	<i>oes,</i>	oesophagus.
<i>an.pap,</i>	anal papilla.	<i>o.l,</i>	optic lobe.
<i>aur</i>	auricle.	<i>olf.l,</i>	olfactory lobe.
<i>bas.h,</i>	basihyal.	<i>olf.o,</i>	olfactory organ.
<i>bd,</i>	basidorsal.	<i>op,</i>	opercular.
<i>brst,</i>	branchiostegal ray.	<i>pect,</i>	pectoral fin.
<i>cer.h,</i>	ceratohyal.	<i>pelv,</i>	pelvic fin.
<i>cl,</i>	cleithrum.	<i>pelv.cart,</i>	pelvic cartilage.
<i>cor,</i>	coracoid cartilage.	<i>pin,</i>	pineal body.
<i>c.s,</i>	corpus striatum.	<i>pmx,</i>	premaxilla.
<i>den,</i>	dentary.	<i>p.neph,</i>	pronephros.
<i>ecpt,</i>	ectopterygoid.	<i>p.tem,</i>	post-temporal.
<i>enpt,</i>	endopterygoid.	<i>pyl.c,</i>	pyloric caecum.
<i>eth,</i>	ethmoid cartilage.	<i>q,</i>	quadrate.
<i>fr,</i>	frontal.	<i>r.a,</i>	retro-articular.
<i>hm,</i>	hyomandibular.	<i>? s.a.v,</i>	? sinu-auricular valve.
<i>int,</i>	intestine.	<i>s.cl,</i>	supra-cleithrum.
<i>int.h,</i>	interhyal.	<i>sym,</i>	symplectic.
<i>l,</i>	liver.	<i>s.op,</i>	sub-opercular.
<i>l.l.f,</i>	opening of lateral line canal.	<i>st,</i>	stomach.
<i>mpt,</i>	metapterygoid.	<i>ven,</i>	ventricle.
<i>mx,</i>	maxilla.	<i>vom,</i>	vomer.
<i>my,</i>	myomere.		

The eyes are laterally directed, set high on the head, and rather small for an oceanic fish. They are loosely suspended in orbits too big for them, but there is nothing else to evidence a post-*Stylophthalmus* condition. The line of suture of the choroidal fissure is quite distinct (Text-fig. 4).

The olfactory organs are minute and extremely difficult to interpret; they are undivided, and seem to have the structure of very shallow thick-walled funnels whose openings are occluded to elliptical chinks. There is a wisp of tissue depending from the edge of one which is of dubious significance.

The auditory labyrinth is very well developed; the three semicircular canals with their ampullae are present, and the cristae acousticae of the ampullae clearly visible (Text-fig. 7). Part of the otolith can be seen in the bulla in dorsal view, but its shape cannot be distinguished through the complicated light-refracting surfaces of the auditory capsule.

Very little of the lateralis system was visible in the untreated specimen, and that has since disappeared in clearing. There are pits with sense organs on the frontals (Text-fig. 7) and on the dentaries (Text-figs. 2 and 4), and one or two other organs of the suborbital and preopercular-mandibular series were faintly seen. There is no trace of a lateralis system on the body.

Portions of the IInd, IIIrd, IVth, VIth and VIIth cranial nerves have been noticed, but the observations were typical and too fragmentary to merit comment.

The surface of the body has many minute pilose projections. It is unlikely that these indicate anything more than muscle-fibre-bundles, but since damage to this specimen would have been of an all-or-nothing character, and in view of the discussion of lateral line papillae in other deep-sea fishes elsewhere in this paper, it may be worth while to put the observation on record.

*Diagnosis and relationships of the Family Rosauridae*

Isospondylous fishes in which the premaxillaries have long rostral processes; the maxillaries are toothless but enter into the gape; there are no supramaxillaries; the opercular apparatus is much reduced, the opercular being minute and the sub-opercular but slightly less so; the branchiostegal rays are long, slender and relatively numerous (10 in *Rosaura*) and support voluminous membranes; the eyes are laterally directed; the metapterygoid is large; an adipose fin is present; there is an unpaired pelvic cartilage (bone?), and there is no post-cleithrum.

One known Genus *Rosaura* nov. with the characters of the Family, and with one species *R. rotunda* nov. based on a single immature specimen of 8.4 mm. S.L.

This definition is adequate to sustain the new family as distinct without involving characters likely to be modified in ontogeny. Additional characters present in the young *Rosaura rotunda* which will become significant if it can be shown that they are carried through to the adult stage are: the short, stout body; the non-telescopic eyes; the undivided nostrils; the absence of pre- and inter-opercular, pre-frontals and parietals.

In view of certain convergent similarities it may be as well to emphasize that the Rosauridae are readily removed from the Iniomi by their possession of premaxillaries which do not exclude the maxillaries from the gape; an unpaired ethmoid; an unforked post-temporal; and a reduced opercular apparatus.

Within the Isospondyli the affinities of *Rosaura* are difficult to trace, and it may indeed, like *Macristium*, represent one of those anomalous offshoots which are not likely to be related to any of the main branches. Perhaps its most likely relationship is to the Stomiatoids, which group have a moderate tendency towards the development of rostral processes, though less pronounced; a raptorial dentition (though usually with teeth on the maxillary, and supramaxillaries present); a tendency towards loss of the parietals and post-cleithrum, and a reduced opercular apparatus; and a high number of branchiostegal rays (19 in *Chauliodus*). The general body-form of *Rosaura* is not unlike that of the young stages of the Sternoptychidae. But none of these resemblances is very fundamental and the differences are formidable.

During a recent hurried visit Dr. Anton Fr. Bruun glanced at the specimen and drawings, and expressed the belief that he had seen this little fish in some numbers in the "Dana" Collections, and thought that a comparison with *Scopelengys tristis* Alcock might be worth making. I followed up his suggestion, but from a consultation of the literature and an examination of a specimen taken by the "John Murray" Expedition (Reg. No. 1939.5.24.463) find that the differences are very considerable.

## Family SALMONIDAE

*Salvelinus alpinus* (Linnaeus)

*Salmo alpinus* Linnaeus, 1758, *Systema Naturae* : 309.

*Salvelinus alpinus* БЕРГ, 1932, РЫБЫ ПРЕСНЫХ ВОД СССР И СОПРЕДЕЛЬНЫХ СТРАН : 170 (*Berg, Les poissons des eaux douces de l'U.R.S.S., Leningrad. Text in Russian, full synonymy*); Oliva, 1951, *Copeia* : 91, recent references).

St. 7. 9.ix.37. 60° 16' N., 44° 41' W.; trammel net at mouth of stream entering Tasermit Fjord, S. Greenland. (Pathological material.)

? Do. Three specimens, 222-330 mm. S.L. (No label.) Reg. No's. 1953. 3.6.8-10.

НАБ. Arctic Boreal. (Anadromous and lacustrine races.)

If not collected on the same occasion as the pathological material, the entire fishes must certainly be from one of the S. Greenland stations. Concerning a tumour-bearing lower jaw J. S. Colman notes :

"When these tumours occur on the Char the fish are poor and thin and the Greenlanders will not eat them. The authorities at Julianehaab, S.W. Greenland, are very anxious to find out their nature and cause."

This specimen has been submitted to Prof. Alexander Haddow, Director of the Chester Beatty Research Institute, Royal Cancer Hospital, who forwards the following report by Dr. E. S. Horning :

"Microscopical Examination : Subcutaneous Fibroma.

"Growth consists of fibroblasts and bundles of interlacing fibrous tissue, together with what appear to be, with this fixation," (Bouin) "elastic fibres. There is also a rather delicate stroma of connective tissue, in which run nutrient vessels lined by an irregular epithelium. This tumour has the appearance of a hard fibroma, as some areas show a tendency to undergo hyaline degeneration. It is definitely not a myxomatous type of growth, as there is no evidence of fatty degeneration."

Another case of tumours in *Salvelinus* has been described by Hoshina (*Jap. J. Ichthyol.* 2 (1952) : 81-88.

## Family ALEPOCEPHALIDAE

(For a recent generic revision and summary of literature, see

Parr, 1951, *Amer. Mus. Novitates*, No. 1531 : 1-21.)

*Leptoderma macrops* Vaillant

(Text-figs. 9-13)

*Leptoderma macrops* Vaillant, 1888, *Poissons Expéd. Sci. "Travailleur" et "Talisman"* : 166, pl. 13, fig. 2; Goode & Bean, 1895, *Oceanic Ichthyology* : 49 (Washington); Koehler, 1896, *Rés. Camp. Sci. "Caudan"* : 523; Roule & Angel, 1933, *Rés. Camp. Sci. Monaco*, 86 : 8; Fowler, 1936, *Bull. Amer. Mus. nat. Hist.* 70 : 193; Bertin,<sup>1</sup> 1940, *Bull. Mus. Hist. nat. Paris* (2), 12 : 275; Rey, 1947, *Ictiologia Iberica*, 2 : 92 (Madrid); (?) Alcock, 1892, *Ann. Mag. nat. Hist.* (6) 10 : 361.

(?) *Leptoderma affinis* Alcock, 1899, *Cat. Deep-sea Fishes "Investigator"* : 182. Calcutta; id., 1900, *Illust. Zool. "Investigator," Fishes* : pl. 32, fig. 3; id., 1902, *A Naturalist in Indian Seas* : 237, fig. 35 (London).

(?) *Leptoderma retropinna* Fowler, 1943, *Bull. U.S. Nat. Mus.* 100 Vol. 13, Pt. 2 : 55, fig. 5. *Leptoderma Springeri* Mead & Böhlke, 1953, *Texas Journ. Sci.* 5, No. 2 : 265 (received too late for inclusion).

St. 49. 1. ii. 1938. 28° 25' N., 13° 34' W.; Agassiz trawl, c. 1,300(-0) metres. Three specimens, 85-150 mm. S.L. Reg. No's. 1953.3.6.5-7.

HAB. Deep Atlantic off N.W. Africa; Gulf of Mexico; Gulf of Gascony; ? Indian Ocean, Philippines. 650-2,300 metres.

The British Museum (Natural History) formerly possessed only a paratype (from the same station as the holotype, *vide* Prof. L. Bertin<sup>1</sup> *in litt.*) of this species, Reg. No. 1890.6.16.44, still bearing the usual Paris tie-on label punched 85 \* 223. In all four specimens now available for study the delicate black skin has peeled forwards, leaving most of the body naked; as with Vaillant's other fifty-eight, therefore, "aucun des exemplaires n'est dans un état tout à fait satisfaisant." Koehler (1896) likewise complains: ". . . le tronc est complètement pelé." Roule & Angel (1933) fared no better: "Un exemplaire, en état défectueux . . . ."

The accounts of Goode & Bean (1895), Fowler (1936) and Rey (1947) appear to be dependent upon Vaillant's original description (1888); there is no evidence that these authors handled material themselves and all perpetuate Vaillant's errors. Koehler (1896) describes one specimen from the Gulf of Gascony. Roule & Angel (1933) merely add a locality record. Bertin (1940) lists Vaillant's material remaining in the Paris Museum as part of a general catalogue of types. Neglecting Alcock's very dubious specimen (1892, 1899, 1900, 1902) and Fowler's (1943) it appears that this species has been described only three times, and a new account may be of value.

GENERAL DESCRIPTION (BASED MAINLY ON THE LARGEST  
"ROSAURA" SPECIMEN)

Radial formula D.66; A.86; P.8; V.5-6; C.16.

Branchiostegal rays 6.

Gills 4 + pseudobranch.

Body naked, elongate, tapered, laterally compressed, especially in the long caudal region, where it becomes almost filiform (Text-fig. 9).

Head small, its length equal to the trunk and 5.55 in the length from tip of snout to caudal. Snout blunt, short, 1.27 times the interocular width and 1.40 in the diameter of the eye; it bears a short, blunt, laterally directed spinule on each

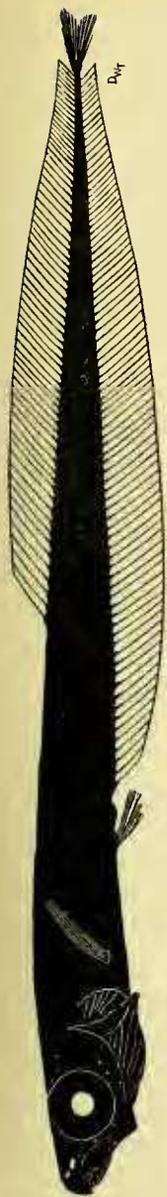
<sup>1</sup> Further consideration of Bertin's "Catalogue" reveals an unfortunate misapplication of the term "paratopotype," which affects not only the types of *Leptoderma macrops* but a great many others as well. Bertin states (*Bull. Mus. Hist. nat. Paris*, (2) 11 : 64, 1939) :

"Les autres sont des paratypes s'ils proviennent de la même localité que l'holotype ou des paratopotypes s'ils ont été pris dans d'autres régions."

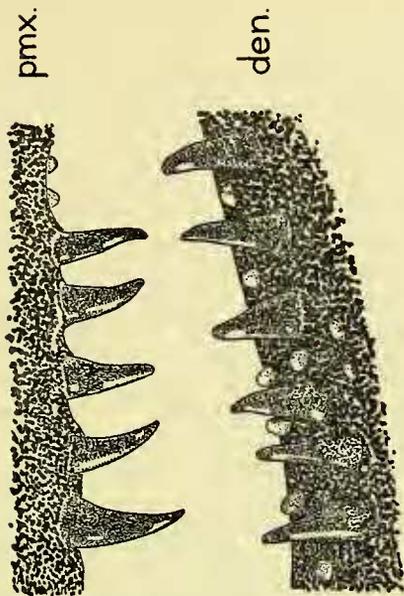
The term "paratype" need not necessarily imply any such geographic restriction, while "paratopotype" has hitherto denoted the exact opposite to Bertin's definition—c.f. Alexander, 1916 (*Proc. Acad. nat. Sci. Philadelphia*, 68 : 496), who introduces the term earlier in the same paper and on the page cited defines it by implication; also Frizell, 1933 (*Amer. Midland Naturalist*, 14 : 659) :

"Paratopotype" (= paratype + toptype)—a paratype from the same locality as the holotype."

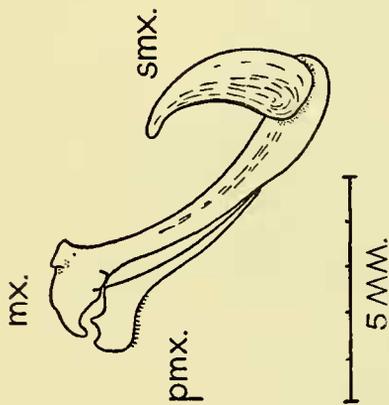
Bertin's two categories are already covered by the terms "paratype omotype" and "paratype allotype" proposed by Silvestri (in Holland, 1929, *Trans. 4th Inter. Congr. Entom. Ithaca* : 693); still-born expressions and unlamented by those who consider systematic zoology overburdened with redundant jargon. It is a pity that "paratopotype" is as well known as it is, for few users of Bertin's invaluable "Catalogue" will feel any need to refer back to his definitions and many will thus be misled.



TEXT-FIG. 9. *Leptoderma macrops*. Specimen of 150 mm. S.L. (Sensory papillae not shown). Text-figs. 10, 12 and 13 are taken from this specimen.



TEXT-FIG. 11. *Leptoderma macrops*. (Specimen of 130 mm. S.L.). Groups of teeth from the premaxillary and dentary, to the left of the symphysis in each case. The smaller, white structures are probably taste papillae.



TEXT-FIG. 10. *Leptoderma macrops*. Bones of the upper jaw. *pmx.*, premaxillary; *mx.*, maxillary; *smx.*, supramaxillary.

side arising from the anterior end of the maxillary. Interocular space very slightly convex, almost flat, 1.79 in the diameter of the eye. Eyes enormous, projecting considerably on either side of the head, 2.78 in the head length. Nostrils large, their mid-point (in the shrunken condition of the specimen) approximately midway between the eye and the tip of the snout, the anterior smaller than and slightly dorsal to the posterior.

Mouth small, terminal to inferior. Upper jaw 1.20 times as long as the snout, barely reaching to anterior rim of orbit when the mouth is closed; lower jaw 1.36 times as long as snout, reaching to below anterior eyeball. Premaxillary slender, toothed, elongate, almost excluding maxillary from gape. Maxillary long, toothless,<sup>1</sup> curved, a small blunt spinule on its clubbed anterior end and a large -shaped supramaxillary at the posterior (Text-fig. 10). The space between the upper ends of the maxillary and supramaxillary is spanned by membrane, and the whole upper jaw well shielded in a sac of thin, tough skin forming a sound functional unit. The upper jaw rotates about its anterior end when the mouth opens and discloses a lightly pigmented recess on the cheek. The moving maxillary is steadied against a broad coronoid process of the dentary.

Teeth<sup>1</sup> in a single row in each jaw, about 14-20 on the premaxillary, seldom

TABLE I.—*Leptoderma macrops*: *Table of Measurements and Comparative Proportions*

It should be noted that Vaillant writes variously "Longneur" and "Longueur totale." In the present case he gives the length of the caudal fin as 3 (?) mm.; the likely error in a false assumption of standard length is therefore of 0.1-0.4% underestimation in the figures quoted, and may be neglected.

	Rosaura specimen		Holotype
Total length . . . . .	152 mm.	}	" Longneur 164 mm."
Standard length . . . . .	150		
		Percentages of standard length	
Head length . . . . .	27 mm.	18.0%	17.6%
Tip of snout to pectoral fin . . . . .	32	21.3%	—
"  "  pelvic  "  . . . . .	49	32.6%	—
"  "  vent  "  . . . . .	55	36.6%	ca. 37.5% (3/8)
"  "  anal fin . . . . .	57	38.0%	—
"  "  dorsal fin . . . . .	75	50.0%	—
Greatest depth of head . . . . .	12.4	8.2%	—
"  "  body behind head . . . . .	11	7.3%	6.7%
"  thickness of body behind head . . . . .	8	5.3%	4.2%
Depth at vent . . . . .	9.7	6.4%	—
Length of pectoral fin . . . . .	12.2	8.1%	—
Longest ray of dorsal fin . . . . .	8	—	—
"  "  anal  "  . . . . .	9	—	—
Least depth of caudal peduncle . . . . .	0.7	0.4%	—
		Percentages of head length	
Snout . . . . .	6.9 mm.	25.5%	27.5%
Eye . . . . .	9.7	35.9%	37.9%
Interorbital width . . . . .	2.4	8.8%	17.2%
Interocular  "  . . . . .	5.4	20.0%	?
Upper jaw . . . . .	8.3	30.7%	—
Lower  "  . . . . .	9.4	34.8%	—
Greatest depth of head . . . . .	12.4	45.9%	—
"  breadth  "  (across eyes) . . . . .	14.6	54.0%	—

<sup>1</sup> I am unable to find the "single row of minute conical teeth" at the anterior end of the maxillary, described by Mead & Böhlke (1953). But theirs is a larger specimen (190:150 mm.).

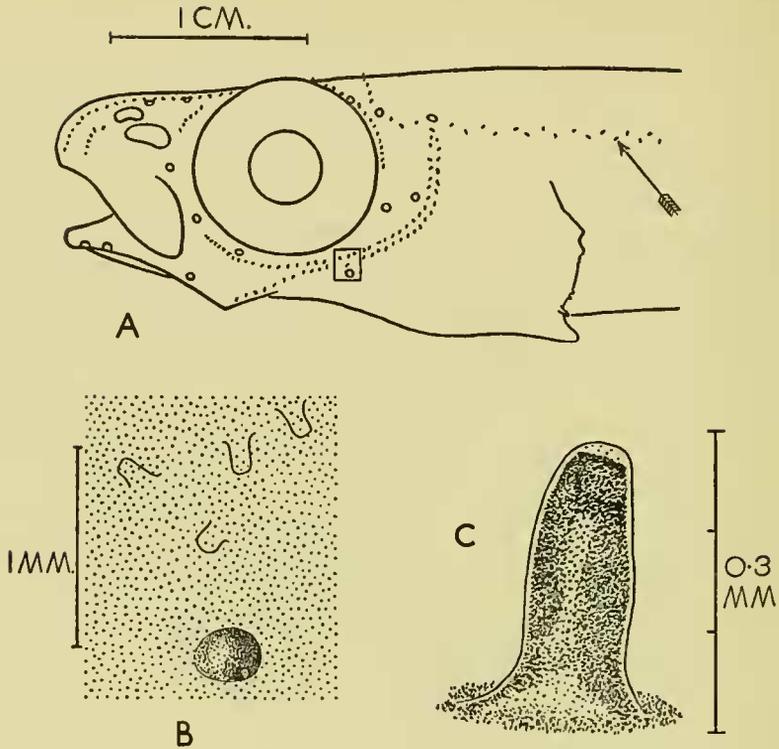
extending far to the side, and about 12-15 on the dentary. The teeth in each jaw are simple, slightly incurved, readily depressible fanglets (Text-fig. 11), and do not exceed 0.2 mm. in length in the largest specimen available. There is a danger of being misled into believing that the dentition is multiseriata, because rows of white structures (believed to be taste-buds rather than photophores) stand immediately behind the teeth, as well as being lavishly scattered over the lips (Text-fig. 11), and buccal cavity. The teeth may be largely concealed behind the lips; this condition varies in different specimens. There seem to be no palatine or vomerine teeth.

Gill-opening wide, though only extending upward to the level of the middle of the eye; membranes voluminous, posteriorly separate and free from the isthmus. The six branchiostegal rays and the opercular bones which together form the gill-cover are all concealed under heavily-pigmented skin, so that only the more prominent ridges of the bones show white at the surface and their boundaries are largely concealed. The preopercular has a long elbowed ridge extending from a point midway between the eye and the top of the gill-opening to the articulation of the jaw. The interopercular accounts for another ridge arising in the angle between pre- and sub-opercular and running some way with the former. The opercular has about a dozen ridges, some of which terminate in small denticulations at the hinder margin. The subopercular has one principal ridge which supports a small lobe at the lower posterior corner. The branchiostegal rays are slender and increase in length posteriorly; the sixth appears (without dissection) to be a rather stouter structure of T-shaped cross section (Hubbs' "branchioperculum").

Gills 4; a pseudobranch of half-a-dozen filaments present on the inside of the gill-cover. Gill-rakers 12 on lower limb of first arch; lanceolate with a few minute bristles. Gill-filaments rather short, leaf-like, shorter than rakers.

Pores of lateralis system of head few and large; 3 in the supra-temporal series, 3 or more in the supra-orbital, 4 in the infra-orbital, 5 in the preoperculo-mandibular (Text-fig. 12A). There may be others on the snout.

The thin skin of the body has been stripped forward and hangs in tatters about the head; it is possible, however, to paint a few centimetres of it back into position with a fine brush, and to decide pretty certainly that there were no lateral line pores on the body. Except that the skin tends to fold into a groove of uncertain significance neither is there any sign of a lateral-line canal upon the skin, nor upon the horizontal septum of the body. There are, however, upon the head and along the skin of the body large numbers of "tag organs" or lateral line papillae, in tracts corresponding to the theoretical lateralis distribution although quite possibly independently innervated (Text-fig. 12A, B). These papillae are compressed, closed, and of much the same shape and variability of form as the common littoral sponge *Grantia compressa*. The papillae of the body (Text-fig. 12C) and operculum are longest, and approach 0.3 mm.; they are heavily pigmented save at the tip and in a very narrow marginal zone, and have a core of connective tissue which is in some cases seen to be penetrated by a short branch of a nerve running along the papilla-tract. It is presumed that sensory cells were located in the tips of the papilla, but surface magnification reveals none, and since the fishes have taken a



TEXT-FIG. 12. *Leptoderma macrops*. A. Diagram showing disposition of lateral line pores and sensory papillae over the head and trunk. B. Three papillae of the sub-orbital series, and a papilla and a pore of the preoperculo-mandibular series. (The area enclosed in the square on A, more highly magnified.) C. A single sensory papilla from the body. (That arrowed in A, more highly magnified).

great deal of punishment in the trawl the chances of their preservation are considered too slight to justify sectioning for the present.

Upon the head the papillae become shorter and squarer, until on the tip of the snout and about the lips they become very small, lose their pigment, and become superficially identical with the presumed taste-organs inside the mouth. (See further discussion on p. 193.)

The vent opens on a slight prominence exactly three-eighths the standard length from the tip of the snout.

Pectoral fins long, narrow, obliquely inserted about one-fifth the body-height

from the ventral surface. All the rays except one are deeply forked, nearly to their bases.

Pelvics ventral, abdominal, separated by the width of one base, reaching to the anal.

Dorsal and anal fins very long, extending almost to the caudal, and each erected fin much taller than the body depth at the same level. The anal commences immediately behind the vent; the dorsal much further back at the level of the 15th anal ray.

Caudal with a distinct and very slender peduncle, ending in a rather prominent little fan-like expansion of hypurals. The caudal rays are much damaged, and both the length and the count likely to be underestimated.

*Colour* (in spirit) deep purple-black all over the body, inside the buccal cavity and gill-chamber (and probably inside the body-cavity); considerably lighter on the snout tip and eyeballs. There is no evidence of organized photophores, though this does not preclude general luminescence of the epidermal mucus.

The largest specimen to hand is a female, with opaque white eggs of varying diameters (0.4-1.2 mm.) extruding from the vent. The extrusion is probably a decompression phenomenon, although Vaillant has already commented upon the great variation in the sizes of the eggs in this species.

#### COMPARISON WITH VAILLANT'S DESCRIPTION (1888)

Vaillant's description is comprehensive, detailed, and for the most part more accurate than most work of his period. Despite the few marked discrepancies now to be noticed there could be no reasonable doubt but that the present material should be referred to Vaillant's *L. macrops*, even without the advantage of a paratype for comparison. The new account is more an expansion of Vaillant's than a correction, although paucity of material leaves his account of the internal anatomy unchecked.

Vaillant gives D. 48, A. 71 +, and his figure agrees, showing these fins extending nearly to the caudal. The paratype now to hand, a specimen of 123 mm. S.L., gives practically these counts in median fins ending abruptly more than a centimetre *before* the caudal, and beyond their terminations there remains little more than vertebral column and a few tattered caudal rays. Having regard to the spacing of the posterior rays, and assuming that the fins once reached nearly to the caudal, as they do in Vaillant's figure and in the "Rosaura" material (which, it must be noted, was collected not far from the type-locality and at a similar depth), I estimate D. 46 + *ca.* 20, A. 74 + *ca.* 12, a precise correspondence with the "Rosaura" specimens. It is possible that Vaillant's artist reconstructed the dorsal, anal and caudal in their correct relations, perhaps from a better specimen, and fitted in the rays in accordance with counts supplied by Vaillant himself from a different fish.

Later in his text Vaillant gives P. 15 (uncountable from the figure). Though at first I agreed, counting from the projection of the fin through a hole in the loose skin, I later found that I had merely repeated his error in counting the branches of rays which bifurcate close to their bases. Of the ventrals Vaillant remarks only

that they are "si rapprochées qu'elles semblent se confondre"; the figure appears to show V.5 or 6 and I count V.5 on the specimen.

The measurements available and shown in the comparative table (p. 186) show close agreement, except at one point where it seems evident that Vaillant's "inter-orbital" corresponds with my "interocular." He gives B.V + instead of B.VI; he slightly undervalues the length of the maxillary; he mentions the dorsal fin originating over the 23rd anal ray instead of the 15th—a likely variation and one common in other elongated fishes, such as *Notacanthus* for example; and he fails to notice the sensory papillae, which, with the condition of his material and the probable magnification used in examining his specimens, is understandable enough. (Vaillant seems to have been impressed by the minuteness of the teeth—"assez peu développées, pour n'être visibles qu'à un assez fort grossissement"—and the papillae of the lips and snout are smaller still, while, having decided that the lateral line was absent, Vaillant might well have felt no need to examine the skin of the body.)

COMPARISON WITH *LEPTODERMA AFFINIS* ALCOCK, 1899

Alcock (1892) described as *L. macrops* a single fish of  $8\frac{3}{4}$  inches (222 mm.) S.L., trawled by the "Investigator" at 753 fathoms (1,357 metres) in the Bay of Bengal; later (1899, 1900, 1902) he published a fuller description and figured it as *L. affinis*. Mr. A. E. Parr (Director of the American Museum of Natural History, at present engaged on a monograph of the Alepocephalidae) tells me that on inquiry of the Indian Museum, Calcutta, recently he learned that Alcock's unique holotype had been lost. No other records of Indian Ocean material have been given and Alcock's papers therefore provide the only evidence for consideration.

The invariably damaged condition of *L. macrops* in collections has been emphasized; *L. affinis* stands in striking contrast, although the conditions of its capture were not particularly auspicious. Alcock makes no mention of the skin peeling from the body and is able to describe the lateral line in its entirety; thus (1899):

" . . . a row of pores extends from the occiput to the caudal. In spirit the colour is purple, the contracted opaline epidermis forming a sort of bloom."

Again, the popular account (1902):

" . . . it is quite black and has no special phosphorescent glands, yet its entire skin is enveloped in a thick, opalescent epidermis, like a luminous 'bloom.' The only specimen captured glimmered like a ghost as it lay dead at the bottom of a pail of turbid seawater."

We can be satisfied as to the perfect condition of Alcock's specimen, and wonder indeed whether its apparent resistance to abrasion in the trawl may not indicate a specific difference from the Atlantic form. Alcock (1899) concludes:

" This species seems to differ from *Leptoderma macrops* Vaillant in having the body less elongate, the lateral line very distinct, and the rays of the dorsal and anal fins more numerous. It agrees fairly well with the figure but not with the description of that species, and is probably identical with it."

The revised fin-ray counts for *L. macrops* show a remarkable similarity to those for *L. affinis*. Adding pectoral and caudal counts taken from Alcock's figure (1900) to the incomplete formula published in 1899, we have :

<i>L. affinis</i>	D.ca. 66 ;	A.ca. 85 ;	P. 8 ;	V. 5 ;	C. 17
<i>L. macrops</i>	D. 66 ;	A. 86 ;	P. 8 ;	V. 5-6 ;	C. 16

Despite this similarity there remain several serious discrepancies between the two species.

(1) *Body proportions*.—From Alcock's publications it may be deduced that in *L. affinis* the body-height measures 12.6% and the head-length 25.7% in a standard length of 222 mm. (Alcock does not state whether "standard" or "total" length is intended in this case, but his frequent mention of "length without caudal" elsewhere in his report of 1899 sufficiently indicates his custom. The proportions given, being taken from his figure, are unaffected by this consideration). Comparative figures are 6.7%, 17.6%, 164 mm. for Vaillant's holotype, and 7.3%, 18%, 150 mm. for the largest "Rosaura" specimen of *L. macrops*.

It would be hard to attribute these wide differences to the effects of ontogenetic changes, geographic variation and the fortunes of preservation. There is in fact evidence that the relative size of the head decreases with age in *L. macrops*, whereas the identification of *L. affinis* with *L. macrops* would require a contrary tendency.

	<i>L. macrops</i>						<i>L. affinis</i> (Alcock)
	"Rosaura"	Paratype	"Rosaura"		Holotype		
Standard length (mm.) . . . . .	85	123	130	150	164	222	
Head as % S.L. . . . .	20.5	19.5	18.4	18.0	17.6	25.7	

One further explanation may be considered. The caudal peduncle in Alcock's figure is short and deep ; despite the disarming elegance of the caudal fork is it possible that the figure represents a truncated and regenerated tail ? If so, then estimates of the length of the missing portion based on computations of the length necessary to reconcile the proportions of *L. affinis* with those of *L. macrops* should show reasonable agreement.

	<i>L. macrops</i>	<i>L. affinis</i>	Estimated truncation.
Standard length . . . . .	150 mm.	222 mm.	—
Head length . . . . .	18.0%	57 "	94 mm.
Snout to anal . . . . .	38.0%	105 "	65 "
Snout to dorsal . . . . .	50.0%	129 "	36 "

This hypothesis is clearly untenable also.

(2) *Lateral line*.—Alcock comments upon the apparent difference between his species and Vaillant's in this respect ; it was a point which he would undoubtedly have verified. I have examined the skin and bodies of four specimens of *L. macrops* and find no pores save on the head ; it seems hardly likely that the stripping of the skin should destroy them so thoroughly as to defy microscopic examination. Yet is Alcock truly representing the case when he speaks of "a line of pores" ? His figure suggests, rather, a line of sense organs lying flush with the skin.

(3) *Sensory papillae*.—Nineteenth-century workers<sup>1</sup> did not often use very high magnifications when examining fishes, and Alcock may have overlooked papillae for this reason, as did Vaillant.

(4) *Supramaxillary*.—I find one supramaxillary in *L. macrops*, as also did Vaillant—"un sus-maxillaire distinct," "un petit osselet en serpe." Alcock (1899) on the other hand speaks of a maxilla which "is very broad and consists of three pieces." It is unthinkable that he should have included the entire premaxillary in this trio, but very likely, as his figure seems to indicate, that he mistakenly dissociated the posterior process of the premaxillary from that bone as a second supramaxillary.

(5) *Pectoral fin*.—The pectoral of *L. macrops* is low on the body and almost horizontally inserted. Alcock's figure shows that of *L. affinis* much higher and practically vertically inserted.

The evidence seems at the very least to support the retention of *Leptoderma affinis* Alcock as a distinct species. If Alcock reported correctly the presence of two supramaxillaries, moreover, we are faced with a distinction of generic importance, and one which Parr (1951) uses as the basis of the first dichotomy of his key to the genera of Alepocephalidae. Conversely, with the retention of *L. affinis* in *Leptoderma*, the key drafted by Parr will require modification of the stated body-proportions, as well as of the fin-ray counts corrected by the present work.

#### BIONOMICS AND ADAPTATIONS OF *LEPTODERMA MACROPS*

" . . . the 'Michael Sars' at Station 48, between the Canaries and the Azores, brought up an *Alepocephalus* in the large trawl towed at the bottom in 5,000 metres, just as these fishes have been captured by most deep sea expeditions; on the trawl-rope a small tow-net was fixed in such a way that it was towed about 1,000 metres above the bottom and in this net an *Alepocephalus* was also captured. Such facts warn us against hasty conclusions.

MURRAY & HJORT, 1912, *The Depths of the Ocean*: 412. London.

*Leptoderma macrops* has (on published records) been taken in ten trawl hauls; by the "Talisman" (6), "Caudan" (1), "Princesse Alice II" (1), "Oregon" (1), and now the "Rosaura" (1), in depths ranging from 650–2,330 metres. Of a total of 65 specimens 59 were collected by the "Talisman", 47 at St. 93 on the Banc d'Arguin. This paucity of records is remarkable when one considers the number of bottom hauls made by, say, the "Michael Sars," within the known range of the species and without results. Unless the "Talisman" encountered a breeding concentration the fish seems singularly capricious in its occurrence.

The association of predominantly bottom fauna with *L. macrops* is indicated in the reports of Vaillant (1888) and of Roule & Angel (1933). At "Rosaura" St. 49 it was accompanied by 2 *Bathypterois dubius* Vaillant (with minute eyes and tactile pectorals); 5 *Gadomus longifilis* (G. & B.), 1 *Gadomus arcuatus* (G. & B.), 5 *Bathygadus vaillanti* Roule & Angel, 1 *Halosaurus oweni* Johnson, 1 *H. johnsonianus* Vaillant and 29 *Synaphobranchus pinnatus* Gronov. In anticipation of the invertebrate papers, and by courtesy of Dr. M. Burton, Mr. N. Tebble, Dr. I. Gordon,

<sup>1</sup> Charles Darwin, for example, had a great preference for the simple microscope, and had no compound microscope with him on his "Beagle" voyage (*Life and Letters*, ed. F. Darwin, 1: 145. London, 1888).

Dr. W. J. Rees and Miss A. M. Clark, it is possible to report associated bottom fauna in the groups Porifera, Polychaeta, Decapoda, Mollusca (dead pteropod shells) and Echinodermata. Preliminary assessments indicate that no mid-water species were taken in any group.

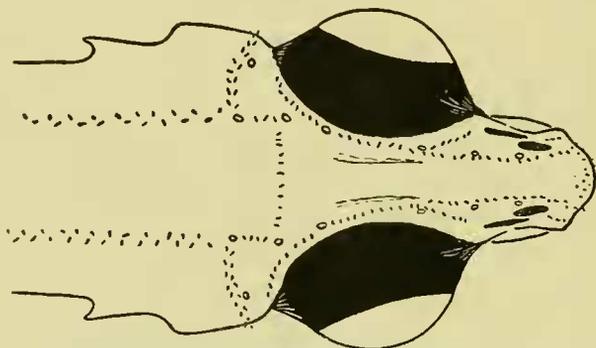
All the available evidence therefore points to *Leptoderma macrops* being a fish living on the bottom beyond the Continental Shelf. That it is of the select group of deep-sea fishes which perform considerable vertical migrations is unproven and unlikely: its general appearance makes this seem much more improbable than in the case of *Alepocephalus macrolepus* Koefoed (1910, *Sci. Rep. "Michael Sars,"* 4: 44), the fish whose exploit is recorded in the cautionary text at the head of this section.

Little can be learned from the gill-rakers. The filaments suggest that cutaneous respiration has permitted a reduction in their size. The small gape, puny dentition and unathletic form point to a fish living upon detritus and/or small and feeble prey. The jaws are not protractile, though the maxillaries are practically vertical when the mouth is fully opened, so that in one way the following comparison is invalid, but the great number of taste-organs in the mouth may point to the fish living like a deep-sea carp, sucking-detritus from the bottom and sampling it for nutritious particles. (I have not gutted the specimens, for obvious reasons, but a radiograph of the largest shows objects in the stomach which resemble a small lamelibranch shell and a couple of large sponge spicules.) The system of lateral line papillae, obviously useful in warning of enemies, may be used offensively against small prey such as polychaetes and crustaceans, a vibration in the water being followed by a reflex snap and a leisurely assessment of the catch by the taste organs. (See also p. 194ff.) In either case Walls' dictum holds: "Go far enough along the bottom (if you're a fish), and you're bound to bump into something good to eat."

The excellent summary of the eyes of deep-sea fishes by Walls (1942, "The Vertebrate Eye," *Bull. Cranbrook Inst. Sci.* 19: 391-405) is the starting point for the discussion which follows. Vaillant (1888) has admitted that his published figures do not adequately represent the lateral protrusion of the eyes of *Leptoderma*. The diagrammatic reconstruction presented in Text-fig. 13 attempts to do this, and, it is believed, with considerable accuracy. The largest "Rosaura" specimen was used for it, the left eye being undamaged, and in an apparently normal position in the orbit, and the shrunken cornea was gently pulled out to its proper convexity with fine forceps. The lens is not shown; in dorsal view it is concealed under the pigmented portion of the eyeball, and whether this condition is normal or not it is certainly very large, much larger than the diameter of the pupil.

These eyes are enlarged, but quite unlike those of the fishes of the twilight zone, such as *Epigonus* and *Aphanopus*. If Walls is correct in stating that the eyes of *Bathytroctes* and *Platytroctes* are "apparently in a half-way stage of evolution toward an eventual forward-aimed, tubular organ" like those of *Gigantura* and *Winteria*, then it must be admitted that *Leptoderma* is a great deal more advanced towards the same type. The parallel tubular eyes already cited are, like the upwardly directed ones of *Argyropelecus* and *Opisthoproctus*, most likely concerned with space-perception, assessing the distance of the infrequent flashes from the

photophores of other organisms. With a light penetration limited to 400 metres depth it is most unlikely that *Leptoderma* can ever aspire even to the twilight zone; the structure of its eyes makes it seem most unlikely that it can form a distinct image under whatsoever lighting conditions, and yet it is clear from Text-fig. 13 that if light-sensitivity be admitted as "vision" *Leptoderma* has, by moderate nasal asymmetry and considerable protuberance of the eyes, achieved a very fair degree of stereoscopic vision, if not of binocularity. If its eyes have largely lost their effectiveness as cameras through structural modification and conditions of intense darkness (and it will be noted that the small ocular photophores concerned with neuro-facilitation in fishes which rely on normal vision below the photic zone



TEXT-FIG. 13. *Leptoderma macrops*. Diagrammatic reconstruction of dorsal surface of head, showing lateral projection of the eyes.

are not developed in this genus), it is still obvious that they have a high degree of potential usefulness as range-finder photometers, capable of locating animal and bacterial luminescence and enabling assessment of its potentialities as food or foe.

The associated bottom fauna from St. 49 included numerous specimens of *Polycheles* spp. and *Heterocarpus* sp., crustacean genera whose Indian Ocean species at least are known to be luminous, and also the Asteroid *Brisingella coronata* which belongs to a family whose luminescence is in dispute. It is also interesting to note that in this one haul the enlarged eyes of *Leptoderma macrops* are paralleled in a polychaete *Robertianella* and a crustacean *Heterocarpus*, while the reduced eyes of *Bathypterois dubius* are paralleled in the crustacea *Nephropsis atlantica* and *Polycheles* spp.

#### OCCURRENCE AND SIGNIFICANCE OF SENSORY PAPILLAE IN DEEP-SEA FISHES

Papilliform lateral line organs have been reported in several quite unrelated groups of deep-sea fishes. Zugmayer (1911, *Résult. Camp. Sci. Monaco*, 35 : 92, pl. iv, fig. 3) records them among the Lyomeri in *Gastrostomus* (= *Eurypharynx*). Pfüller (1914, *Z. Naturw. Jena*, 52 : 1) in an intensive study of the lateral line organs

of the Macruridae gives accounts and figures sections of papillae in *Coelorhynchus* and *Macrurus*. Roule & Bertin (1929, *Dana Repts.* No. 4: 12) mention the co-existence of lateral line pores and papillae in the deep-sea eel *Nemichthys*, and the same authors (op. cit.: 53) and Trewavas (1933, *Proc. Soc. London*: 601) describe a variant of the same condition in the nearly-related *Cyema*. The most comprehensive demonstration of papilla variation is given by Regan & Trewavas (1932, *Dana Repts.* No. 2: 23), who describe and figure five distinct types in the Ceratioid Angler-fishes, and show that the several families may be classified into five corresponding groups. Their *Dolopichthys* papilla approaches most nearly to that of *Leptoderma*.

Among the Alepocephalidae, however, no very precise demonstration seems to have been given before the present. In the Alepocephalidae *sensu lato* (including Parr's Searsidae), Brauer (1906, *Wiss. Ergeb. Deutsch. Tiefsee-Exped. "Valdivia,"* 15: 17 *et seq.*) describes "papillen" in several species, with recognizable figures, but makes no functional distinction between photophores general and special, the "shoulder organs" of Searsidae, and true lateral line papillae. The species mentioned by Brauer, in none of which seems a *Leptoderma* condition to be clearly demonstrated, are:

Fam. Alepocephalidae

*Bathytroctes longifilis* (= *Nemabathytroctes longifilis* (Brauer)).

*Aleposomus lividus* (= *Rouleina lividus* (Brauer)).

*Aleposomus nudus* (= *Rouleina nudus* (Brauer)).

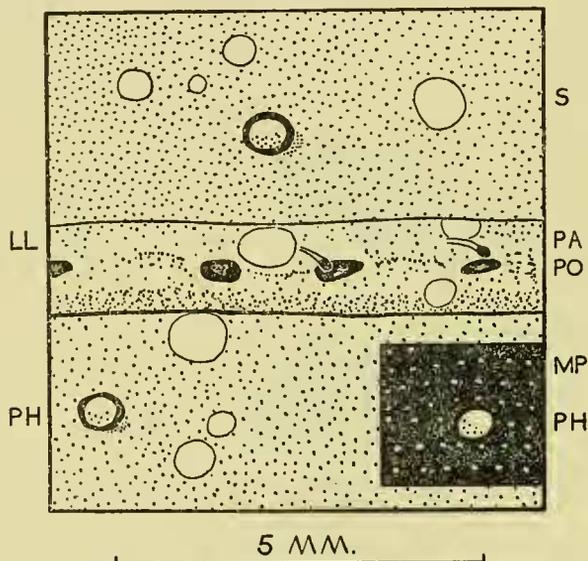
Fam. Searsidae

*Bathytroctes rostratus* (*nec* Günther) (= *Searsia koefoedi* Parr).

Beebe (1933, *Zoologica*, N.Y. 16: 17) describes a pattern of tubercles in his *Anomalopterus megalops*, but which can hardly be reconciled with a lateralis distribution (nor, for that matter, Beebe's species with *Anomalopterus* Vaillant (now *Anomalopterichthys* Whitley, the name being several times preoccupied). Beebe (op. cit.: 83) also describes small stalked structures in *Photostylus* which he regards as photophores, but which may well be primarily sensory papillae; these also are not regularly arranged.

Unfortunately many genera of Alepocephalidae are not yet represented in the collections of the British Museum (Natural History) but a rapid search for other forms bearing lateral line papillae has been rewarded. The holotype of *Xenodermichthys nodulosus* Günther (1887, *Sci. Rep. "Challenger" Zool.* 22: 230, pl. 58, fig. c) is much as Günther described it, with a normal tubular lateral line, and a tough skin scattered with minute white scale-like structures and small, nodular and undoubted photophores. Somewhat surprisingly Günther failed to notice that almost the whole of the head (including the isthmus) is unpigmented (save for the photophore rims), intact, and sharply distinguished from the body; a few years later and he must surely have noted an appearance strongly recalling the all-luminous head of *Aulastomatomorpha*. He also missed the lateral line papillae: minute, club-shaped, with slender colourless attachments and black tips (Text-

figs. 14 and 15). They are arranged in single and double linear tracts upon the head, corresponding to the *lateralis* distribution, and are upon the body rather sparsely placed immediately above the lateral line tube and upon the tube itself, either between or above the lateral line pores. Down the upper limit of the gill-cover, along the boundary between pigmented and unpigmented integument, the papillae are more elongate and their stalks whiter; they resemble photographic

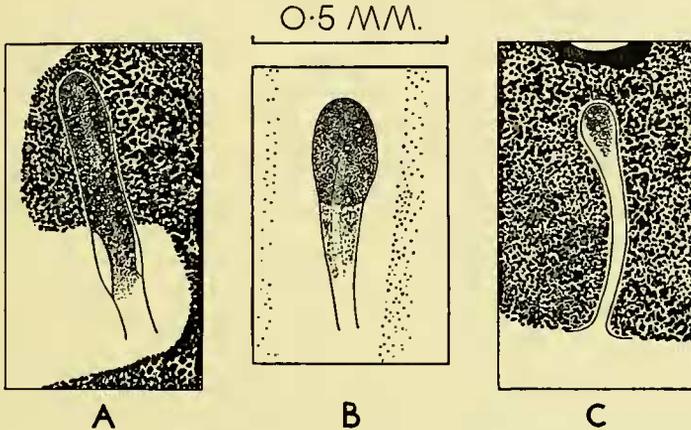


TEXT-FIG. 14. *Xenodermichthys nodulosus* Günther. (Holotype, 180 mm. S.L.). Portion of skin from the left flank. The lateral line, LL, crosses the centre of the figure. PO, lateral line pore; PA, papillae; s, rudimentary scale, three of which may be seen supporting the outer wall of the lateral line canal from within; PH, large photophores, arranged in alternating segmental rows so as to mark out rhomboidal areas on the body; MP, very numerous white spots, possibly luminous (mucus glands according to von Lendenfeld), arranged in close longitudinal rows.

negatives of the fungus *Xylaria hypoxylon*. Von Lendenfeld (1887, "Challenger" *Reps. Zool.* 22, Appendix B. : 307, pl. 53, figs. 49-53) has described the histology of the photophores and mucus glands, but again does not mention sensory papillae. It is likely that he was given a piece of tissue from the flank (missing in the specimen) which would not have borne any papillae, and that he did not receive the entire fish for examination. Rauther (1927, *Bronns Tierreich*, 6, Abt. I, Book 2 : 125) in his discussion of light organs in fishes regards the first-mentioned structures as sensory organs.

Convergent evolution of lateral line papillae in several widely separated groups of deep-sea fishes has not yet received an explanation, despite its clear adaptive

value. All the fishes concerned are forms of inconsiderable locomotive powers, not subject to violent water movements consequent upon their own swimming, and living at depths beyond the range of wave action and of strong currents. In such conditions extreme exposure of lateral line sense organs upon papillae results in no redundant irritation to the fish; on the contrary, it must materially assist the apprehension of the slightest local disturbance in the water, and be a vital asset in the collection of information from an environment that can impart so



TEXT-FIG. 15. *Xenodermichthys nodulosus*. Three types of sensory papillae. A. Stout papilla from occipital region, at the boundary between pigmented and unpigmented integument. The papilla bears two large photophores towards its base, and has a number of minute, intense white spots scattered over its surface, probably further photophores. B. Clavate papilla standing upon the supra-orbital canal. The papilla is traversed by a nerve, and has presumed minute photophores over its surface. This is a type which punctuates rows of similar papillae of about half the height in the lateralis system of the head. A similar size and type of papilla to this stands upon and above the lateral line canal of the body. C. Slender-stalked papilla, type confined to upper margin of operculum, along boundary between pigmented and unpigmented integument. (Text-figs. A, B and C are drawn to the same scale.)

little so reluctantly to the more orthodox sense organs. It is probable that the lateralis system in these fishes allows precise location and capture of small prey without any visual assistance. Experimental evidence in support of this theory may be derived from the experiments of Dykgraaf (1932, *Z. vergl. Physiol.* 17: 802), who showed that the freshwater minnow *Phoxinus* can be trained to snap at small bodies gently agitated in the vicinity of its caudal lateral line papillae; in this case, however, the sensory cells are situated at the bases of the tubular papillae, instead of at the tips as in the deep-sea fishes so far investigated. For a general introduction to this subject see Pfüller (*ante*) and Wunder, 1936 (in Demoll & Maier, *Handbuch der Binnenfischerei Mitteleuropas*, 2B: 49. Stuttgart).

## Family SEARSIDAE.

Parr, 1951, *American Museum Novitates*, No. 1531: 1-21.

## ALEPOCEPHALIDAE (part)

Günther, 1887, "*Challenger*" *Reps. Zool.* 22: 227-8.

Brauer, 1906, *Wiss. Ergeb. deutsch. Tiefsee-Exped. "Valdivia,"* 15: 17-18.

Beebe, 1933, *Zoologica N.Y.* 16: 36-56.

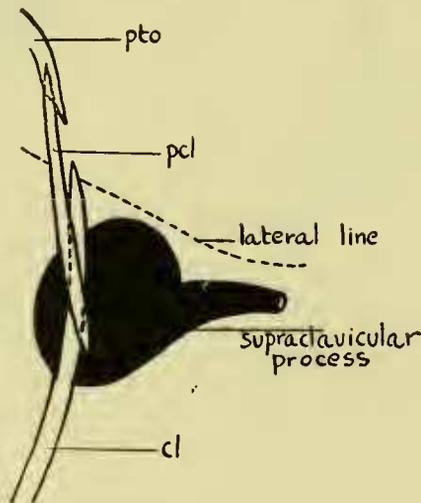
Parr, 1937, *Bull. Bingham Oceanogr. Coll.* 3: 12-19.

And numerous other authors.

## NOTES ON TAXONOMIC AND STRUCTURAL FEATURES

(1) *Shoulder organ*

The Searsidae have been separated off from the Alepocephalidae by Parr (1951), and are characterized by the possession of a peculiar structure which Parr, in this, his latest paper, calls the "shoulder organ," which name is the least unsuitable



TEXT-FIG. 16. Diagram of shoulder organ ("supraclavicular process") in a young Searsid, showing its relation to pectoral girdle and lateral line. *pto*, post-temporal; *pcl*, supraclavicular; *cl*, cleithrum. (From Beebe, 1933.)

of those so far applied. The new family forms a quite distinct group, and its recognition seems surprisingly overdue, although one regrets its immediate proliferation of new subfamilies, genera, and subgenera.

The shoulder organ, *alias* "supraclavicular organ/process" and "postclavicular organ," lies neither upon nor behind the shoulder-girdle, but within it (Text-fig. 16).

Overlooked by nineteenth century authors and their artists (as well as several later ones) it seems first to have been noted by Brauer (1906) :

"Dorsal von der Brustflosse liegt eine grössere nach hinten gerichtete Papille."

Beebe (1933) notes its gross structure, provides the figure here copied, and mentions ontogenetic changes :

"In cleared specimens the supraclavicular process is seen to be a retort-shaped sac, with a posteriorly directed neck terminating in a single pore. This seems to be the only opening, external or internal, to the organ, which arises just interior to the pectoral girdle at the junction of the supracleithrum and cleithrum, well below the lateral line. The posterior part of the sac and the entire neck are exterior to the body wall. It is possible that, instead of being greatly reduced in relative size in larger specimens, as is generally believed, the organ merely has a smaller part of its surface projecting exteriorly."

To this account I can add that in the smaller "Rosaura" specimen now available (Text-fig. 17) there is evident a complication in the neck of the shoulder-organ. Its opening is oblique, like that of a hypodermic needle, and its duct is supported by a tubular reinforcement, a modified scale or thin bone (? rudimentary post-cleithrum). This skeletal structure is flexible, and penetrates deeply towards the sac of the shoulder organ. Its presence in small *Searsia*s in which the squamation is undeveloped rather points to its being a specialized bone. I have not proceeded further with this investigation for the present, since most of the British Museum material is taxonomically significant as well as scanty, and haphazard dissection undesirable.

Parr (1937) first attached systematic importance to the shoulder organ in erecting the genus *Searsia*. In his latest publication (1951) he omits mention of reinforcement of the external tube, but adds certain information to Beebe's earlier account :

"The sac is lined with black integument and traversed from outer to inner wall by irregular strands or columns of soft tissues. There can be no doubt that this represents a secretory organ, and it seems quite likely that its function may be to secrete a luminous mucus. The sac discharges through a tube, also lined with black tissue . . . (this tube) is apparently quite strong since it seems to withstand considerable abrasion and the loss of all scales."

Is it not possible to go further than this, on the anatomical evidence now available ? Everything points to the shoulder organ being a structure for the reception of luminous particles *which are effectively blacked-out by the densest pigment in the body until required, and then expelled in a jet to form a luminous protective cloud*, as in the squid *Heteroteuthis dispar* and in several deep-sea crustacea—*Acanthephyra pellucida*, *Heterocarpus alfonsi*, *Pandalus alcocki*, *Aristaeus coruscans*, etc. (For encyclopaedic bibliography see Newton Harvey, 1952, *Bioluminescence*. New York). It is true that a *ductus ejaculatorius* or muscles in the wall of the sac have yet to be demon-

strated, but even in the absence of these a mesiad movement of the cleithrum could readily induce ejaculation: very light pressure on the pectoral girdle of a preserved specimen produces a strong current of preservative fluid.

If this case is established it is the first instance of a luminous cloud-thrower to be found among fishes. Ventral saccular luminous organs are known in many Macrourids and in *Physiculus* among the Gadids (references in Newton Harvey, *ante*), but anatomical evidence and field observation in these cases point to incomplete concealment of the luminous contents of the glands, and to a gradual emission of luminous slime onto the body.

## (2) *Light organs*

Light organs in animals are known or believed to subserve a variety of functions: attraction of prey; diversion and confusion of pursuing predators; local environment illumination as an aid to vision; neuro-facilitation of the optic nerve; self-indication of the state of the whole photophore system by means of "pilot lights"; intra-group (species) recognition; sex recognition, advertisement and maturity indication. So much is generally known, but it does not seem to be as generally realized that the relative evolutionary potentialities and consequent taxonomic significance of each type of photophore system must vary very widely in relation to the function performed.

In many cases selection-pressure will favour lighting systems having greater efficiency, and consequently bring about the convergent evolution of similar arrangements in unrelated groups. Analogous luminous cloud-projection devices in squids, crustacea and fishes have been discussed in the previous section (p. 199); special modification of homologous structures may also be replicated, as for example the terminal photophores on the first dorsal rays of *Chauliodus* and the Ceratioid Angler-fishes and the minute light organs on the eyeballs of *Chauliodus*, *Perspersia* and certain new Myctophids in the "Rosaura" Collection.

Once a luminous organ or organ-complex has attained a certain measure of efficiency, selection-pressure may, while maintaining that standard, permit such variation in detail as does not detract from the usefulness of the whole. Thus it happens that in the illicium (esca) of the Ceratioids and in the mental barbel of the higher Stomiatooids there is considerable inter-specific (and, to an unknown extent, intra-specific) variation. In the latter group it has sometimes been possible, without affecting the attractiveness of the mental barbel to prey, to superimpose a sexual dimorphism and thus fulfil two functions with the same structure.

Only in the case of recognition marks is there a strong tendency towards differentiation of photophore patterns, and that in definite steps with a rigorous disciplining of the range of variation at each stage. Selection-pressure in favour of such differentiation is least intense under conditions of allopatric speciation (which in the marine habitat has great possibilities in the third dimension, e.g., bathymetric stratification of species of *Cyclothone*) and strongest under conditions of sympatric speciation. The tendency is well demonstrated by the wide divergences between the fundamental photophore patterns of the deep-sea squids, the several families

of Stomiatoïd fishes and the Myctophids, and by the wonderful diversity within each of these groups.

It follows, therefore, that in cases where there is reason to believe that intra-species recognition is the primary function of a photophore system the variations of that system may be expected to provide the most sensitive index of speciation. Moreover, variations in recognition patterns, like variations in physiological tolerances, breeding behaviour, etc., themselves constitute isolating factors, and may thus precede or even initiate further genetic and therefore morphological differentiation of populations.

Conversely, if, after making due allowance for the disparity between the taxonomist's and the animals' assessment of a variation, that variation does not seem likely to be clearly characteristic at a distance, then one should be reluctant to apply it as an index of speciation in sympatric populations.

Having stated these general principles we may now consider the light organs in the two species introduced by Parr (1937) as *Searsia koefoedi* and *S. polycoeca*. Modest and probably relatively inconspicuous as photophore systems go, clearly distinguishable from the basic patterns of the Myctophidae and Stomiatoidea by their very economy, localized at a few points along the ventral surface, there can be little doubt that their primary function is intra-specific recognition. Yet in these two species the fundamental patterns are, in lateral view, absolutely identical (assuming no difference of colour): five lights placed at equivalent points along a straight line. Only in ventral view does the relatively subtle difference in disposition and relative sizes of the subventrals and postventrals appear (cf. Parr's figs. 4 and 5), and although the eyes of *Searsidae* have probably a wide field of vision (particularly in the young stages; my Text-fig. 19), there is no such obvious connection between upward binocular vision and downwardly directed photophores, as can be demonstrated in the Sternoptychidae. The differences between the lateral views of the photophore systems in these two species and in *Persparsia*, another genus of the same family (*post*, p. 209) support the case for lateral distant recognition.

Beebe, (1926, *The Arcturus Adventure*, N.Y.: 216, pl. 5) has very beautifully illustrated the sexual dimorphism in *Myctophum coccoi*; the male has conspicuous luminous scales along the upper side of the tail and the female along the lower side. To me the divergence between *Searsia koefoedi* and *S. polycoeca* for long seemed of much the same order and likely significance; a divergence of far less use than that in *Myctophum* as a means of recognition at a distance, but of likely utility in identifying the sexes to one another in a group of individuals of one species brought together by the general species recognition pattern of the remaining photophores. On that hypothesis I made a considerable effort (Table II) to justify the treatment of *S. polycoeca* as a synonym of *S. koefoedi*, but after the examination of material of each I am driven to accept them as distinct species. It will be interesting to see whether the promised 'Dana' Report on the *Searsidae* will fulfil the prediction now made that the Atlantic populations of these two species will prove to be geographically and/or bathymetrically isolated.

Although this hypothesis of sexual dimorphism in *Searsia* has proved unfounded, the general similarity of the photophore patterns remains a powerful argument

against the removal of *S. polycoeca* to another genus—*Holtbyrnia*—and within that genus to a sub-genus *Mentodus* containing one other species, *H. (M.) rostratus* (Günther), said to be known only from a unique holotype devoid of photophores.

The last-mentioned specimen has been badly cut about by successive investigators, but there is no doubt that it originally possessed no trace of light organs. The ventral squamation is complete and intact except at those points where exploratory borings have been made, and experiments on specimens of the more plentiful *Perspersia taaningi* indicate that abrasion of the photophores without damage to the body is highly unlikely. All the specimens identified as "*Bathytroctes rostratus* Günther" by other authors and examined by Parr have proved to be either *S. koefoedi* or *P. taaningi*.

Parr (1937) supports his argument against ontogenetic atrophy of the light organs in *B. rostratus* by citing from the literature a series of Searsids of ascending size in which those structures are present, including one (unfortunately not figured by its original author) of equivalent size to Günther's holotype. The critical specimen is still 10 mm. S.L. shorter than Günther's, and this may, in terms of age, be rather more significant in fishes apparently near their limit and presumably growing at a correspondingly slower rate. However, Krefft (1953, see my footnote, p. 206) in a paper received while the present was in the press, describes a photophore system constant in number and arrangement through a series from 87–174 mm. S.L. .

A specimen in our collections from "Discovery" St. 2074 (21.ix.37. 10° 10' N., 21° 13' W.; closing net, oblique haul; 875–400 metres, sounding 5,148 metres) bears a label "*Holtbyrnia polycoeca* Id. A. E. Parr." The salient characters of this fish are given in Table II, where it will be noted that it gives good agreement with the holotype of that species in all characters except the head length, which runs contrary to the expected allometry. There are, however, discrepancies in the light organs. The supraventrals and supra-anals are present and typical, but the posterior anals are marked only by small patches of dark pigment, the median subcaudal is very faint and has only a trace of pigment, the thoracic organ is very thin if it is present at all, and the subventrals and postventrals are altogether wanting. Since the specimen is in excellent condition I am inclined to regard the photophore system as undergoing degeneration.

### (3) Notes on taxonomy of Searsids

Beebe (1933) has interpreted Günther's (1887) figure of the snout of *Bathytroctes rostratus* in terms of the typical Searsid condition with forwardly directed tusks, and this interpretation was at first disputed by Parr (1937). On examining the specimen I find the premaxillaries thin and somewhat eroded, but the terminal lip-like projections are still present and prove to be hollow and capable of admitting a bristle for a fair distance. I regard these structures therefore as representing the broken stumps of tusks with their related pulp-cavities; alternatively and less probably, as the premaxillary sockets of tusks which have been shed (see also p. 208). The increased number of accessory teeth is a function of age and size, while the elaborate crenellation of the edge of the jaw is of a type common on the

edges of thin bones which have completed their major growth, comparable, for example, with the elaboration of the skull crests in *Melamphæes*.

Parr has also complained that Beebe (1933) shows a shoulder organ in a figure stated to be based on Günther's when the original and description do not include it. Perhaps Beebe saw the specimen at some time and erred only in the legend to his figure, otherwise it must appear very odd that both Beebe and Parr are correct; there is a shoulder organ present in the specimen, though not shown in the original figure. Only the tip of the tube, with its internal support, projects from the body, but the sac must still be quite large, for a fair amount of preservative fluid and air bubbles can be extruded from the tube by exerting moderate pressure on the shoulder girdle.

Parr (1951) modifies his earlier standpoint on this species by placing *B. rostratus* fairly among the Searsidae as *Holtbyrnia (Mentodus) rostratus*. Though he does not elaborate his reasons in what, after all, only purports to be a preliminary revision, we can fairly assume that he has made the above observations during one of his visits to the British Museum (Natural History).

The principal characters of three species of Searsids are tabulated in Table II. A number of identical or nearly identical features are omitted for brevity's sake, but all the salient points have been included.

Principal specific differences relate to the light organs (already discussed p. 201), the proportions of the head and upper jaw to standard length, the gill-raker counts, presence or absence of a dermal pit behind the shoulder, and the number and nature of the pyloric caeca. Having tested and rejected the hypothesis that *S. koefoedi* and *S. polycoeca* were sexes of the same species, I hoped at least to find support for a theory that *S. polycoeca* was a young stage of *B. rostratus*. Unfortunately this idea must be rejected also, although I am satisfied that *B. rostratus* and *S. polycoeca* are very closely related, and confidently expect that the young stages of *B. rostratus* when found will prove to possess photophores. I would advocate the inclusion of all three of these species in the genus *Searsia* as the expression of this close relationship.

The importance to be attached to the pyloric caeca may be questioned. Considering Parr's figures of the pyloric caeca in *S. koefoedi* and *S. polycoeca* (1937, figs. 1A & B), it may be seen that there is a fundamental similarity between them, for both have five primary caeca along the right side of the stomach and a further group of three along the anterior end adjoining these. Even the condition in *S. rostratus* which has been described as having "14 simple, straight pyloric appendages" can be reduced to this same basic pattern. Although the immediate impression is of fourteen simple caeca (11 + 3) packed side by side like the fingers of some polydactyl hand, closer inspection shows that there is one group of five primary caeca, of which the anterior one forks twice, the second, third and fourth once each and the last is simple, like the remaining group of three. The forking takes place very close to the stomach, and the sum of the terminal diverticula, 1.1.1.4.2.2.2.1, gives the total of 14. It may fairly be asked how much variation is due to individual differences and to ontogenetic changes? The new specimen of *S. polycoeca* presents a much simpler picture than the smaller holotype, while the

TABLE II.—Data for Types of *S. koefoedi* and *S. polycycoea* compiled from Parr (1937, 1951); remainder original

	<i>Searisia rostratus</i>		<i>Searisia koefoedi</i>		<i>Searisia polycycoea</i>		
	(Holotype) "Challenger" St. 120, 8° 33' S., 34° 30' W., 148	(Holotype) "Pawnee" St. 118, 23° 30' N., 76° 41' W., 69	(Paratype) "Pawnee" St. 9, 23° 55' N., 77° 09' W., 47	"Discovery" St. —, 13° 25' N., 18° 22' W., 46.5	"Rosaura" St. 46, 7° 27' N., 23° 08' W., 15.5	(Holotype) "Pawnee" St. 58, 33° 24' N., 64° 29' W., 48	(?) "Discovery" St. 2074, 10° 10' N., 21° 13' W., 72
Standard length mm.							
Percentages of S.L.:							
Head	33.1	30.4	20.8	31.3	34.1	27.0	36.1
Eye	8.7	10.0	10.6	9.6	11.6	10.4	10.4
Maxillary	19.2	14.5	14.9	16.1	16.7	20.8	20.5
Lower jaw	20.9	ca.	..	18.9	21.9	21.5	22.9
Snout	8.7	8.0	7.0	7.5	8.3	9.4	9.7
Depth	21.0	19.0	17.0	16.7	18.0	19.0	25.0
Snout—dorsal	62.8	64.5	64.0	60.2	66.4	64.5	65.2
Snout—ventral	54.7	51.0	51.0	48.6	60.0	55.0	50.2
Dorsal base	19.0	18.5	20.1	20.0	16.1	17.7	20.0
Anal base	16.5	17.0	18.5	17.2	15.9	17.0	17.0
Gill-raker	5.4	4.4	..	4.8	1.3	4.7	6.8
Radial formula	D. 20; A. 18; P. 18/17; V. 9	D. 21; A. 20; P. 23; V. ?	As holotype ?	D. 21; A. 20; P. 20; V. 7	D. 20 +; A. 17 +; P. 22-3; V. ? P. 20; V. 7	D. 20; A. 17; P. 22-3; V. ?	D. 21; A. 17; P. 20; V. 8
Branchiostegal rays	8	..	..	7	7	..	8
Vertebrae (radiograph)	49	..	..	..	..	..	..
Gill-rakers on first arch	8 1/2/20 (L.), 10 1/2/21 (R).	7 1/10 (1937) 29-35 (1951)	As holotype ?	8 1/18	0/1/9	6 1/15	6 1/15
Lateral line scales	ca. 110-120 (caudal tip to 100 (1951))	About 85 (1937)	..	ca. 80	Absent	Absent	ca. 90
Shoulder organ	Present	Present	Present	Present	Present	Present	Present
Dermal pit behind shoulder girdle	Absent	Absent	As holotype ?	Absent	Absent	No mention (1937) Present (1951)	..
Lateral line pores before post-temporal	Few present	..	..	..	..	Numerous	Numerous
Urogenital papilla	Present	Present	Present	Present	Absent ?	Absent ?	Present

Photophores	No trace	I linear	As in the holotype, but the subventrals seem to have coalesced. ? sex-difference	None developed	I linear	? Thoracic
		thoracic, 2 supra-ventrals, 2 post-ventrals, 2 supra-anals, 2 subcaudals.			2 supra-ventrals, 2 post-ventrals (vague), (large), 2 supra-anals, 2 postero-anals, 2 subcaudals.	2 supra-ventrals, 2 post-ventrals atrophied
		(Details in Parr, 1937.)	I antero-dorsal ocular ?		(Details in Parr, 1937.)	atrophied
		not desc. (1937)			No ocular ?	(faint)
	Yes	No	No	No	Yes	No ocular ?
Maxillary reaches to posterior margin of orbit ?						Yes
Dentition :						
Prenaxillary tusks	Broken or shed	Present	Present (2 on left side)	Not erupted	Present	Present
Vertical teeth below each tusk	" "	2	2	1	1	1
Other premaxillary teeth	14-15	4-6	4-5	5	4	4
Maxillary teeth	About 50	40-50	About 30-40	10+	20-25	Mx. eroded
Dentary teeth :						
Main series	About 50-60	Numerous	Numerous Rudiments	Numerous 2 + rudiments	?	Numerous
Outer series	6-9, strong	Short series or none			Few, minute	Few rudiments
Vomerine teeth	2	2	1		2	2
Palatine teeth	0-1	0	0	1	2	1
Pyloric caeca	" 14 simple, straight pyloric appendages" (Parr, 1951)	8 primary caeca, with 15 secondary branches and 10 terminal diverticula. (Data from fig., 1937)	5 primary caeca, with 12 secondary branches and 13 terminal diverticula	Damaged in dissection. Many small terminal diverticula	8 primary caeca, with 16 secondary branches and 25 terminal diverticula. (Data from fig., 1937)	6 primary caeca, with 12 secondary branches and 13 terminal diverticula
	8 primary caeca, with 12 secondary branches and 14 terminal diverticula—(D.W.T.)					
						" 6-8, some branched, but fewer than 10 terminal diverticles," (Parr, 1951)

larger new *S. koefoedi* is markedly different from the holotype of that species. It may well be that the primary forks remain as they are, while the total of tertiary divercula becomes reduced by subsequent growth at the secondary forks.

The British Museum (Natural History) now possesses the following material of this family :

- 1 *Searsia rostratus* (Günther) Holotype.
- 2 *Searsia koefoedi* Parr.
- 1 *Searsia polycoeca* Parr.
- 5 *Persarsia taaningi* Parr.
- 1 *Normichthys operosa* Parr.
- 1 *Pellisulus facilis* Parr.

As regards Parr's draft classification of 1951, I would modify it as already indicated to show the supposed affinities of the three species which I place in *Searsia*. There arises another problem, common enough when reticulate evolution has to be expressed in a two-dimensional classification, of indicating the affinity which appears to exist between *Normichthys operosa* and *S. polycoeca* alone among the *Searsia* group. *Normichthys* has a row of six large pits behind the shoulder, each containing three opaque white bodies (? photophores or sense-organs?), as well as a smaller pore in every scale of the body. The single dermal pit behind the shoulder of *S. polycoeca* seems to be the precursor of such a condition.

The grouping adopted in the key according to relative size of head and length of upper jaw is useful enough for taxonomic purposes, but does not impress me as a natural phyletic classification, for the reasons which have already been indicated.

### *Searsia koefoedi* Parr<sup>1</sup>

(Text-fig. 17)

Parr, 1937, *Bull. Bingham Oceanogr. Coll.* 3: 16, Fig. 4; Maul, 1948, *Bol. Mus. Municipal Funchal*, No. 3, Art. 5: 12, Fig. 3; Parr, 1951, *American Mus. Novitates*, No. 1531: 17.

*Bathytroctes (Talismania) homopterus* (non Vaillant) (part) Norman, 1930, "Discovery" *Reps.* 2: 269 (not fig.).

St. 46. 30.xii.37. 7° 27' N., 23° 08' W. 2-metre Stramin Net, 1000(-) metres. 1 specimen, 15.5 mm. S.L. Reg. No. 1953.3.6.12.

HAB. North and South Atlantic; Caribbean.

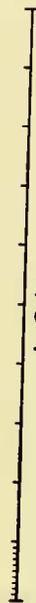
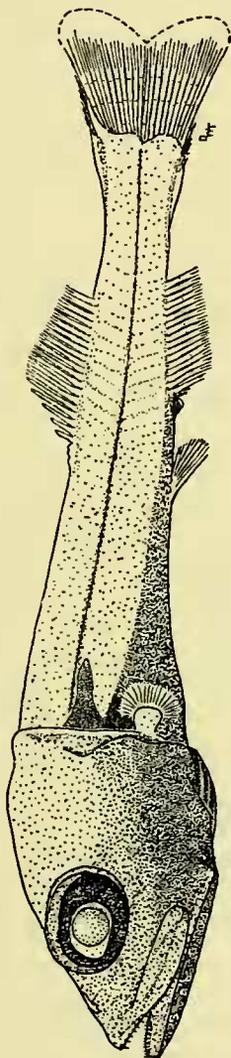
A young fish and contorted, its body bent downwards from behind the nape and its tail curved forwards along the left flank. The following information expands and supplements that given in Table II.

D.20 +; A.17 +; P.20±; V.7; C.7 +; XXII: 5 +

Branchiostegal rays 7. Gill-rakers on first arch 0/1/9.

Proportions in per cent of length without caudal (S.L.): length of head, 34.1; snout, 8.3; orbit, 11.6; interocular width, 7.0; upper jaw, 16.7; premaxillary, 4.5; posterior supramaxillary, 5.8; lower jaw, 21.9; snout to ventrals, 60.0; snout to dorsal, 66.4; snout to anal, 70.9; greatest depth of body, 18.0; least depth of caudal peduncle, 6.4; dorsal fin base, 16.1; anal fin base, 12.9.

<sup>1</sup> A paper by Kieff (1953, *Zool. Anz.* 151: 259-266) received while the present work was in the press, describes as new *Searsia schmakenbecki* from Iceland.



TEXT-FIG. 17. Young *Searisia koefoeati*, 15.5 mm. S.L. from "Rosaura" St. 46.

Least depth of caudal peduncle 35.7 per cent of greatest depth of trunk.

0.0625 S.L. = 0.97 ; 0.0375 S.L. = 0.58 (data for Parr's formulae).

**DENTITION.** Only the extreme tip of the forwardly directed tusk on the premaxillary is yet erupted. One downwardly directed fang at the front of each premaxillary, followed by five slightly smaller teeth which are fairly regularly spaced. Ten similar teeth on the maxillary, with indications of smaller teeth to be erupted between and within these. One pair of fangs on vomer, the largest teeth yet developed. One slender tooth on each palatine. On the dentary a single row of numerous very fine teeth, with a few (4-5) larger vertically directed ones outside these and probably of the same series. Of the horizontally directed series two teeth are erupted at the front end of each dentary and others unerupted may be seen opaque white in the jaw. A tiny projection below the dentary symphysis.

**EYES.** The orbits are slightly longer than high. The eyes project some way beyond the general contour of the head and must have wide and partly coincident fields of vision. The lens is pale green, large but slightly smaller than the pupil as fixed. There is a greyish-white retinal tapetum lucidum, which may be luminous.

**COLOUR.** Dorsally light brown, ventrally dusky. Outer integument over shoulder organ granular dark brown, with darker internal pigment of tube showing through. A darker triangular patch between the shoulder organ and the pectoral fin. A dark line along the lateral line. Fin bases pale.

There are no certain indications of light organs. The fins are well advanced, but the full complement of anterior dorsal rays, procurrent caudal rays, and possibly of anterior anal rays, is not complete. Gill-rakers moderately long and widely spaced; their complement also incomplete. Lateral line pores before ascending limb of post-temporal.

This specimen agrees very well with *Searsia koefoedi* in all general proportions. The relative distances from snout to dorsal and anal differ by 4.3% ("less than 4%")—a trivial difference against the likely error in measuring a difficult specimen. Lower counts for teeth, fin-rays and gill-rakers reflect the relatively small size of the fish, and in some respects show an approach to *S. polycoeca*.

Of the three specimens referred to *Bathytroctes (Talismania) homopterus* Vaillant by Norman (1930), the largest, from "Discovery" St. 269, proves to be *Normichthys operosa* Parr, as already noted in Parr (1951). The second specimen, from the same station, seems no longer to be in this Museum. The third, from an unnumbered "Discovery" station, is a fine *Searsia koefoedi* whose characters are given in Table II. It is of interest to note that in this specimen the left premaxillary tusk is laterally duplicated, which may be an indication of periodic replacement and so provides a possible explanation of the tusk-less condition of the holotype of *Searsia rostratus*.

### *Persparsia taaningi* Parr

(Text-figs. 18 and 19)

Parr, 1951, *American Museum Novitates* No. 1531: 18.

*Bathytroctes rostratus* (nec Günther) Norman, 1930, "Discovery" *Reps.* 2: 268, Fig. 1; Pl. 2,

Fig. 3; Beebe, 1933, *Zoologica*, N.Y. 16: 43, Figs. 8c, 8d.

*Searsia* n. sp. Parr, 1937, *Bull. Bingham Oceanogr. Coll.* 3: 16.

St. 33. 22.xi.37.  $11^{\circ} 00' N.$ ,  $75^{\circ} 43' W.$ ; 2-metre stramin net; c. 1,200(-0) metres. 1 specimen, 23 mm. S.L. Reg. No. 1953.3.6.13.

HAB. North and South Atlantic; Caribbean.

A young fish and badly contorted, the posterior half of the body twisted and bent forward to lie along the left cheek.

D.21; A.14; P.20  $\pm$ ; V.8; C.3 + : XXII : 2 +.

Branchiostegal rays 7. Gill-rakers on first arch  $4/1/12$ .

Proportions in per cent of length without caudal (S.L.): length of head, 40.0; snout, 10.8; orbit, 13.9; interocular width, 6.0; upper jaw, 20.8; premaxillary, 6.5; posterior supramaxillary, 7.8; lower jaw, 25.2; snout to ventrals, 62.1; snout to dorsal 63.4; snout to anal, 71.3; greatest depth of body, 16.5; least depth of caudal peduncle, 6.5; dorsal fin base, 20.4; anal fin base, 12.1.

Least depth of caudal peduncle 39.4 per cent of greatest depth of trunk.

0.0625 S.L. = 1.437; 0.0375 S.L. = 0.862 (data for Parr's formulae).

DENTITION. The forwardly directed tusks are present but not erupted. The premaxillaries are very thin and their edges damaged; teeth that remain at the hinder ends are like those of the maxillary. The maxillary has about 20 teeth with indications of very fine ones between these. Four fangs on vomer, the largest teeth yet developed. Two slender teeth on each palatine. The dentary has a small upwardly directed projection at the symphysis and many acicular teeth in a single row.

EYES. The eyes and orbits are elongated. The eyes project some way beyond the general contour of the head, and must have wide and partly coincident fields of vision, especially in the upward direction (Text-fig. 19). The lens is pale green and as large as the pupil as fixed. There is a greyish-white retinal tapetum lucidum.

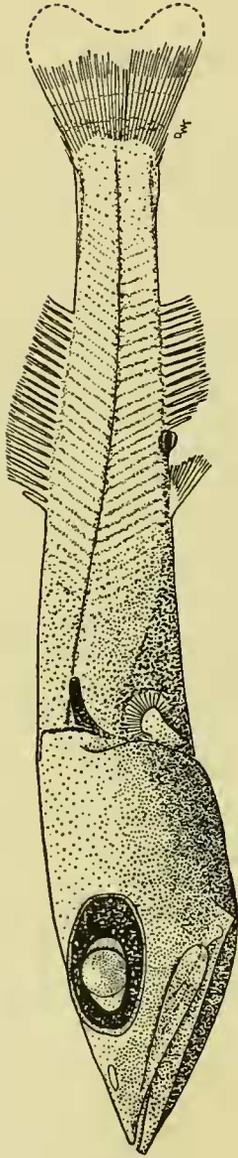
COLOUR. Dorsally light brown, ventrally dusky. Integument over shoulder organ dark brown. A dark line of pigment along the lateral line. Fin bases pale.

There are no certain indications of light organs. Gill-rakers long, the longest 0.9 mm. (3.9% S.L.). Gill-filaments numerous, short and stumpy. No lateral line pores before ascending limb of post-temporal.

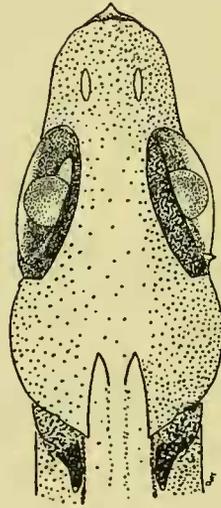
This fish shows a number of small divergences from Parr's diagnosis (1951), especially in the slightly longer head, longer lower jaw, and more posterior insertion of the ventrals. In view of the youth and twisted condition of the specimen it seems better not to attach much importance to these differences in face of the general agreement with *P. taaningi*.

Norman's (1930) figures from "Discovery" specimens which I identify with this species do not do full justice to the photophore system. In addition to those shown in his drawings and plate there are: two light organs on the eyeball,<sup>1</sup> in the upper and lower anterior corners; one on the skin over the lower posterior edge of the orbit; one near the hinder edge of the operculum, above the level of the pectoral fin base; in the largest specimen (47 mm. S.L.) a median one at the lower ends of the cleithra, and in the same specimen an additional median photophore between the supraventrals (not to be confused with the curious two-way light

<sup>1</sup> *Searsia schnakenbecki* Krefft (1953) has a photophore on the eyeball. Parr (1937) seems to figure one in *S. koefoedi* though he makes no mention of it in his text.



TEXT-FIG. 18. Young *Pesparsia taaningi*, 23 mm. S.L. from "Rosaura" St. 33.



TEXT-FIG. 19. Dorsal view of head of young *Pesparsia taaningi* shown in Fig. 18.

organ already noted by Norman). In addition to these special organs there are likely indications of a strip of luminous tissue extending from the occiput to the dorsal, and elsewhere about the fin bases. The few specimens available are small, and, while they provide indications that the light organs are not developed simultaneously, they are inadequate for a study of possible sexual dimorphism. The light organs on the eyeball are quite inconspicuous in the largest specimen available, but there is otherwise no evidence to support ontogenetic atrophy; on the contrary. Doubtless Parr will be dealing with this matter in full in his forthcoming monograph.

### Family CLUPEIDAE

#### *Pellonula afzeliusi* Johnels

Johnels, 1954, *Arkiv. f. zool. Stockholm* (2) 6 : 352.

*Pellonula vorax* (non Günther) Svensson, 1933, *K. Svensk. Vetensk. Handl.* (3) 12, No. 3 : 47, fig. 16 (young stages).

St. 48. 3.i.38. 13° 27' N., 15° 47' W.; 2-metre stramin net, 3(-0) metres. 526 specimens, 4-81 mm. S.L. Reg. No's. 1953.3.6.14-541.

HAB. Gambia River.

Apart from the other characters noted by Johnels, this species differs from *P. vorax* in the possession of much more trenchant keeled scutes between the isthmus and the ventrals.

#### *Harengula pensacolae* Goode & Bean

*Clupea humeralis* (part) Günther, 1868, *Cat. Fish. Brit. Mus.*, 7 : 422 ;

*Harengula pensacolae* Goode & Bean, 1879, *Proc. U.S. Nat. Mus.* 2 : 152 ; Regan, 1917, *Ann. Mag. nat. Hist.*, (8) 19 : 389.

St. (—) 28.x.37. 17° 28' N., 88° 11' W.; dip-net, at surface. 5 specimens, 60-98 mm. S.L. Reg. No's. 1953.3.6.542-6.

HAB. Gulf of Mexico ; Caribbean.

#### *Ilisha africana* (Bloch)

*Clupea africana* Bloch, 1795, *Naturgesch. Ausländ. Fische*, 9 : 45, pl. 407. (Type loc. Accra, Gold Coast.)

*Clupanodon africanus* Lacépède, 1803, *Hist. Nat. Poissons*, 5 : 469, 471.

*Pellona iserti* Cuvier & Valenciennes, 1847, *Hist. Nat. Poissons*, 20 : 307.

*Pellona gabonica* Duméril, 1858, *Arch. Mus. Paris*, 10 : 259, pl. 23, figs. 3, 3a.

*Pellona africana* Bleeker, 1863, *Natur. Verh. Holl. Maatsch. Wetensch.* (2) 18 : 122, pl. 27, fig. 1.

*Pristigaster dolloi* Boulenger, 1902, *Proc. zool. Soc. Lond.* : 271, pl. 30, fig. 3.

*Ilisha melanota* Derscheid, 1924, *Rev. Zool. Afr.* 12 : 278 ; Irvine, 1947, *The Fishes & Fisheries of the Gold Coast*, London : 111, fig. 39.

*Ilisha dolloi* Giltay, 1935, *Bull. Mus. roy. Hist. nat. Belg.* 11, fasc. 36 : 3, figs. 1 and 2.

*Ilisha africana* Fowler, 1936, *Bull. Amer. Mus. nat. Hist.* 70 : 178, fig. 71. Delsman, 1941, *Mem. Mus. roy. Hist. nat. Belg.* (2) Fasc. 21 : 50.

*Pristigaster martii* (non Agassiz) Fowler, 1936, op. cit. : 180, fig. 72.

[non *Pellona africana* Günther, 1868, *Cat. Fish. Brit. Mus.*, 7 : 455.]

[non *Ilisha africana* Norman, 1922, *Ann. Mag. nat. Hist.* (9) 11 : 4.]

St. 48. 3.i.38. 13° 27' N., 15° 47' W. 2-metre stramin net, 3(-0) metres. 2 specimens, 84-102 mm. S.L. Reg. No's. 1953.3.6.547-8.

HAB. Coastal waters and estuaries of W. Africa, Senegal to Angola.

Norman (1922) includes *Ilisha africana* in the first section of his key to the genus *Ilisha*:

"I. Less than 46 scales in a longitudinal series; 16-20 scutes before insertion of pelvics."

Bloch (1795) does not supply this information, but counts from his figure give 46 and 24 + respectively, and therefore rather better agreement with the second section of Norman's key:

"II. More than 46 scales in a longitudinal series; 20-28 scutes before insertion of pelvics."

At the time when Norman wrote, the British Museum (Natural History) did not, in fact, possess any material of Bloch's species, nor indeed any belonging to the genus *Ilisha* and of undoubted African origin. Norman followed Günther (1868) in mistakenly identifying with Bloch's fish a single specimen, B.M. (N.H.) No. 1852.9.13.175, which came originally, and without any locality data whatsoever, from the collections of the Zoological Society. This specimen should be assigned to *I. indica* (Swainson) or *I. brachysoma* (Bleeker), two doubtfully distinct species from India and the East Indies, from which region it very probably came. Its ventral scutes (20 + 8) give a lower pre-pelvic count than in any African *Ilisha* known, and are much less salient than those in the copious African material of *I. africana* (Bloch), (including specimens from Accra, the type locality), received at this Museum in recent years.

Norman's error has effectively bedevilled every subsequent author except Fowler (1936), who providentially overlooked his paper in the main body of *The Fishes of West Africa* and later mentions it without comment in an "Appendix" to this work.

Derscheid (1924) leaned heavily upon Norman's revision and advice and (Bloch's book being extremely rare) seems not to have checked the original description and figure of *I. africana*. Taking very literally Norman's statement that *I. africana* (non Bloch) is "scarcely distinct from *I. brachysoma*," Derscheid has apparently deduced a pseudo-description of the genuine *I. africana* by so modifying Norman's detailed account of *I. brachysoma* as to reconcile it with the few minor differences noted by Norman in his brief comments on a supposed *I. africana* which was, as we have seen, not Bloch's species. Derscheid then proceeds to detail the differences between his African material from the mouth of the Congo and this pseudo-*I. africana* whose antecedents, if they may be said to have any reality at all, are Asiatic. Naturally enough he fails to recognize his own material as the genuine *I. africana* (Bloch) and so *I. melanota* joins the lengthening list of synonyms. *Ex Africa semper aliquid novum!*

Giltay (1935), having examined the types of *I. melanota* Derscheid and of *Pristigaster dolloi* Boulenger (1902), makes *I. melanota* a synonym of *I. dolloi* (Boulenger).

This view will be supported in greater detail presently; for the moment it is merely emphasized that Giltay did not carry his synonymy back any further than Boulenger (1902), and merely includes "*Ilisha africana* Norman . . . (pro parte)" as an allusion to Norman's tentative synonymy of *P. dolloi* Boulenger with *I. africana* (Bloch).

Fowler (1936) overlooked Derscheid's paper as well as Norman's, and consequently makes no contribution to the *brachysoma-africana-melanota* tangle. Indirectly, however, he adds to the confusion by making *P. dolloi* Boulenger a synonym of *Pristigaster martii* Agassiz (Spix & Agassiz, 1829, *Pisc. Brazil*: 55, pl. 24a) and presenting a re-drawn version of Boulenger's figure of 1902 as "*Pristigaster martii*, modified from Boulenger." Ludicrous as it may seem after a comparison with the original figures, the error is liable to prove as dangerous as Norman's, for Spix & Agassiz is almost as rare a work as Bloch.

Delsman (1941) has questioned the validity of *I. melanota*, but upon the same false premises as led Derscheid to erect his species. Delsman concentrates upon the ventral scutes, which Derscheid gives as 18-20 + 7-8 in his pseudo-*I. africana* based on Norman's account of *I. brachysoma* and 25-27 + 7-8 in *I. melanota*, and endeavours to close the imaginary gap by citing counts of 22-24 + 7 from new material. Bloch's original figure (1795) shows ca. 24 + 5; if there is any problem it is presented by the post-pelvic rather than the pre-pelvic count, and if we allow the artist a small error in the pelvic fin insertion we can reconcile this difference without compromising the opening argument in the present article, for it is possible to postulate a correction from ca. 24 + 5 to ca. 22 + 7 without even invoking the probable scutes concealed by the operculum in Bloch's figure.

Norman (1924), Giltay (1935) and Delsman (1941) have all, from their several concepts of *I. africana*, queried the distinctness of *Pristigaster dolloi* Boulenger (1902). Boulenger introduced this species with a brief description and figure, and no discussion. Derscheid (1924), having compared the type of *P. dolloi* with his types of *I. melanota*, is unable to discover any other important difference than that the former lacks even the rudiments of pelvic fins. Giltay, working also from original material, gives an intensive comparison, together with a theoretical dissertation on the body-forms of fishes which, curiously enough, fails to make the obvious comparison with the Gastropoecidae. Giltay's very valuable contribution is to cite the work of Pellegrin (1926, *C.R. Acad. Sc. Paris*, 183: 1301) who examined 13 specimens of the African Clariid *Clariallabes variabilis* Plgr. and found 6 with both ventrals present, 2 with one only, and 5 with none. Hildebrand (1943, *Bull. Bingham Oceanogr. Coll.* 3 Art. 2: 140) reports 1 specimen lacking ventrals among 20 *Pterengraulis atherinoides* (L.) examined by him. Considering such precedents, the minute pelvic fins in *Ilisha*, and the close correspondence between Boulenger's unique holotype of *P. dolloi* and the many African specimens of *Ilisha* now examined by several authors, there exist no reasonable grounds for retaining Boulenger's species as distinct.

The considerable African material of *I. africana* (Bloch) received at the British Museum since Norman's time may properly be referred to *Ilisha* Gray & Richardson as generally understood, since it possesses a maxillary not adherent to the pre-

maxillary, and rounded at the posterior end; a ligament rather than a bone between the maxillary and premaxillary (but see Myers, *Copeia*, 1950:63), and no canine teeth.

A new world-revision of *Ilisha*, desirable as it appears, cannot be undertaken in the middle of a general report. I state therefore only a general impression that, on the material which I have handled for comparative purposes, there may be a case for recognizing the distinctness of *Ilisha africana* from the Indo-Pacific forms by the creation of a new sub-genus. Compared with *I. brachysoma*, *I. indica*, *I. kampeni*, *I. sladeni*, etc., it shows the following differences: the ventral scutes are far more salient; the lower jaw projects further, so that the mouth opening is carried further dorsad; the lower part of the body (ventral to the lower jaw) is more developed and keel-like, so that the overall body depth is greater and the pectoral fin, though maintaining the same relations to the head, is inserted proportionally higher; the pectoral fin, though obliquely inserted, tends to twist so as to project in a horizontal plane perpendicular to the surface of the body. In these same characters it approaches the related genera and species of the Atlantic coasts and rivers of South America.

Perhaps the most interesting feature of *Ilisha africana* is that in the development of the deep ventral keel, in the carriage of the pectoral fins, elongation of the anal, exaggeration of the lower lobe of the caudal, and incipient loss of the pelvics, (though not in the normal lateral septum), it foreshadows the form and probably also the habit of the Gasteropelecidae—South American Ostariophysi which "fly" by "a taxi-ing movement, with the large thoracic keel cleaving the water and the pectoral fins beating the surface" (Fraser-Brunner, 1950, *Ann. Mag. nat. Hist.* (12) 3:959). These characteristics of *I. africana* attain a full convergent evolution of the Gasteropelecid condition in the related South American *Pristigaster cayanus* Cuvier (1817, *Règne Animal*, 4, pl. 10, fig. 3). (*P. martii* Agassiz is a synonym of this species.) Parallel evolution of the same condition has occurred in the Indo-Pacific *Opisthopterus*, in which the correspondence to the Gasteropelecid form is increased by the smooth ventral profile and the more posterior insertion of the dorsal, which in this genus commences behind the anal origin.



Shark, *Carcharhinus* sp., probably *C. leucas* (Müller & Henle), taken at "Rosaura" Station 41.  
A female specimen, total length 211 cm. (Photo J. S. Colman.)



Electric Rays, *Diplobatis pictus* Palmer. Two female specimens, actual size, from "Rosaura" Station 36. The outlines have been retouched. (Photo British Museum (Natural History).)