A REVIEW OF WESTERN ATLANTIC CAT SHARKS, SCYLIORHINIDAE, WITH DESCRIPTIONS OF A NEW GENUS AND FIVE NEW SPECIES

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ABSTRACT

A new genus *Schroederichthys* is described, together with its type species *Schroederichthys maculatus* from the western Caribbean and a second species *Schroederichthys tenuis* from the Atlantic off Brazil. *Scyliorhinus meadi* from the east coast of Florida, *Scyliorhinus hesperius* from the western Caribbean, and *Galeus cadenati* from the vicinity of Panama are also described. All 15 of the known western Atlantic species are illustrated, and species characters thought to be of value for revisionary studies are noted.

The purpose of this paper is to review the western Atlantic cat sharks with especial attention to description of those characteristics of genera and species that are of interest for a revision of the cat sharks of the world; and also to describe new material collected by exploratory fishing vessels of the Bureau of Commercial Fisheries in the western Atlantic, including representatives of a new genus and five new species.

For a revision of the family, more material should be examined than is now available in American museum collections. The distinctions between the genera *Scyliorhinus* and *Halaelurus*, for example, appear to be somewhat superficial, but a revision of generic arrangement is impractical without a survey of all known species and the use of a greater number of diagnostic characters than can be gleaned from the terse and noninformative descriptions of many of the nominal species. A family revision which is in progress will provide a better opportunity for treatment of genera.

SOURCES OF MATERIAL

Collections of cat sharks made by the Bureau of Commercial Fisheries exploratory fishing vessels, *Oregon*, *Silver Bay*, and *Combat*, are the principal source of material for this report. Studies of these collections were supplemented by examination of the relatively small numbers of cat sharks in the U.S. National Museum, the Museum of Comparative Zoology at Harvard College, and the Natural History Museum of Stanford University. An important series of *Apristurus* in the Museum of Comparative Zoology collected by the *Cap'n Bill II*, a fishing vessel chartered by the Woods Hole Oceanographic Institution, was examined. For purposes of comparison, an excellent series of the Pacific species, *Apristurus brunneus* (Gilbert) was assembled from specimens collected from the research vessels of the University of Washington College of Fisheries and by the exploratory vessel *John N. Cobb* of the Bureau of Commercial Fisheries. Similarly a young example of *Cephaloscyllium uter* (Jordan and Gilbert) and also a series of the Pacific cat shark *Parmaturus xaniurus* (Gilbert) were obtained for comparison with Atlantic scyliorhinids from collections made by the research vessel *N. B. Scofield* of the California Department of Fish and Game. The type of *Scyllium laurussonii* Saemundsson was loaned by the Natural History Museum, Reykjavik, Iceland, for examination.

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No specimens from the coast of Argentina were seen. *Halaelurus bivius* (Smith) has been recorded from Argentina by Berg (1895), Lahille (1921, 1928), and Norman (1937). *Halaelurus chilensis* (Guichenot) mentioned by Lahille (1928) as a synonym of *Halaelurus bivius* (Smith) probably is a valid species and two species referrable to *Halaelurus* occur in Argentine waters according to information received from Professor Elvira M. Siccardi (personal communication). Professor Siccardi also found a population of *Scyliorhinus* on the coast of Argentina, either *S. boa* (Goode and Bean) or an undescribed species very similar to *S. boa*. Species found on the coast of Argentina are given very brief treatment here, based chiefly on photographs, measurements, and records of specimens that Professor Siccardi has kindly allowed me to see. Illustrations in this paper of *Halaelurus* are of specimens from Chile in the collection of the U.S. National Museum.

Ideal study series, that is, series including adults of both sexes, young in various states of growth, and specimens collected from a number of localities sufficient to outline the probable limits of geographical and vertical distribution, are not available for any of the 15 species treated here. For example: available specimens of *Scyliorhinus retifer* (Garman) satisfy ideal requirements except that no adult females with eggs have been examined; the series of *Apristurus riveri* Bigelow and Schroeder includes two adult males and three adult females, one with a partly extruded egg case, and a few young examples, material sufficient to show sexual dimorphism in the teeth of the adults and to show the oviparous habit, but the series lacks immature males.

Family SCYLIORHINIDAE

The definition of the family given by Bigelow and Schroeder (1948, pp. 195–196) is followed provisionally. Separation of the cat sharks from members of the family Orectolobidae on the basis of external form is comparatively simple when dealing with American material. No Atlantic American cat shark has barbels or has the nostrils connected with the mouth by a groove, while orectolobids in general have these characteristics. One Indian Ocean genus, *Conoporoderma*, referred to Scyliorhinidae by Bigelow and Schroeder, has barbels and another, *Haploblepharus*, does have the nostrils connected with the mouth by a groove. Otherwise the use of these characters to separate the Scyliorhinidae from the Orectolobidae is the most practical one. Of the characters given by Bigelow and Schroeder for separartion of the two families, Orectolobidae and Scyliorhinidae (1948, pp. 178 and 195), the only characterization of the Scyliorhinidae always applicable is that the scyliorhinids have three rostral cartilages, united at their tips; whereas orectolobids have none, one, or three rostral cartilages which are small and, if present, are not united at their tips. I have verified this only in a few western Atlantic species. Even tooth characters do not hold unless exceptions are noted. Adult males of *Apristurus riveri* Bigelow and Schroeder, instead of having small teeth with several cusps as in all other known scyliorhinids including female *A. riveri*, have single cusped teeth in about 20 median rows.

Grace White (1936), commenting on forms generally known as cat sharks, states that variation in the catuloids (cat sharks and allied groups) is so extreme as to make the distinction even among genera difficult. Certainly it is difficult to find family characteristics to which there are no exceptions and which set off scyliorhinids sharply from obviously related families. Although there has been reasonably general agreement on the kinds of sharks constituting the group known by the common name cat shark, precise morphological definitions of the family or families constituting the cat sharks and their allies have been various and apparently not entirely satisfactory even to those proposing the definitions. The cat sharks are, with few exceptions, small demersal forms of moderately deep water, and, again with exceptions, are not well known and are poorly represented in study collections. It is not unlikely that the group contains representatives of several evolutionary lines and that at the family level most of the classifications that have been proposed embrace horizontal groupings.

Müller and Henle (1841) placed all the sharks known by them to be egg layers in the family Scyllia, including both the scyliorhinids and the orectolobids without making a distinction between sharks in which egg cases are resorbed after formation or are retained in the oviducts until hatching (ovoviviparous species) and forms that discharge eggs in leathery cases at an early stage in development (oviparous species). It has long been known that orectolobid species are either oviparous or ovoviviparous, but according to Bigelow and Schroeder (1948, p. 196), the scyliorhinids so far as known are oviparous. Poll (1951) and Cadenat (1959) subsequently reported the ovoviviparous condition in one species of *Galeus*. Probably more data will show that additional scyliorhinid species are ovoviviparous.

Regan (1908) separated the scyliorhinids and orectolobids as families and included *Pseudotriakis* in the Scyliorhinidae. He recognized only two other genera in the family and included especially divergent species within the genus *Scyliorhinus*. White (1937), with the intention of providing a vertical classification that would better reflect phylogenetic lines, proposed two new families, Aetelomycteridae and Halaeluridae, and retained the family Catulidae (= Scyliorhinidae). All genera of these three families of White excepting *Pristiurus* (= *Galeus*) were included in Regan's genus *Scyliorhinus*.

Bertin (1939) in a review of the classification of the cartilaginous fishes placed the cat sharks together with the orectolobids in the family Scyliorhinidae, but placed *Pseudotriakis* and *Pentanchus* in monotypic families. *Pseudotriakis* has a very long and low first dorsal fin with its base entirely in advance of the pelvic fins, and this is the primary morphological feature separating it from the scyliorhinids which have short-based dorsal fins (or single dorsal fin) located posteriorly, over or behind the pelvics. *Pseudotriakis* is represented by two large species, one, *Pseudotriakis microdon* Brito Capello, reported from the western Atlantic. Both species are larger than any known cat sharks. Although *Pseudotriakis* is not treated here as a member of the family *Scyliorhinidae*, its relegation to another family may not be warranted. The distinctive arrangement of tooth rows as diagonal bands characteristic of *Pseudotriakis* also occurs to a lesser degree in *Atelomycterus* and has some similarities to the tooth arrangement in *Apristurus*. Additional similarities are found between *Pseudotriakis* and the small scyliorhinid shark from the coast of Chile originally designated *Scyllium canescens* Günther, 1878.

Pentanchus profundicollis Smith and Radcliffe, 1912, was described from a single Philippine specimen as a notidanoid shark intermediate between the Hexanchidae and Chlamydoselachidae but with five gill openings instead of six or seven characterizing the former. It is so close to the scyliorhinids of the genus *Apristurus* in general appearance and details of gross structure, however, that except for the presence of only one instead of two dorsal fins, it would certainly fall within that genus. Regan (1908) was of the opinion that *Pentanchus* belonged in the family Scyliorhinidae and suspected that the absence of one dorsal fin was abnormal or accidental. Although additional specimens are not yet known, the type USNM 70260 is an adult male in fair condition. This specimen, disregarding the number of dorsal fins as a characteristic, does not fit the description of any known species of *Apristurus*. Furthermore, there is no evidence from external examination or the appearance in radiographs that the absence of a dorsal fin (absent from the position occupied by the first dorsal in *Apristurus*) is in any way a result of accident or structural abnormality. Short sections of the vertebral column from the trunk and caudal portions of the type were missing when I examined the type specimen but dissections had been carefully made somewhat off center and should not have affected fin-base vestiges had these been present. It appears to me that the separation of *Pentanchus* and *Apristurus* (as in Bigelow and Schroeder, 1948) is justified and that the two genera are properly to be placed in the family Scyliorhinidae.

Distribution and Segregation

About 58 species in 14 genera are known in the family Scyliorhinidae. With the exception of the Indian Ocean species, *Atelomycterus marmoratus* (Bennett), cat sharks appear very rarely in warm waters and inhabit shore waters only in the higher latitudes or in comparatively cool-water areas. The common rough-dog, *Scyliorhinus caniculus* (Linnaeus), of Europe, which figures as a laboratory animal in much of the physiological and experimental work on sharks, is an example of a species entering shallow waters. *Cephaloscyllium uter* (Jordan and Gilbert) of the California coast frequents relatively shallow water. In the western Atlantic one species is occasionally taken on the continental shelf north of the Carolinas and another species is said to frequent the shallow shore waters in the vicinity of Cape Horn, but from the

Carolinas to Argentina cat sharks are exclusively inhabitants of the continental slopes. Atlantic American records of *Apristurus* are for the most part from depths of 750 to 1500 meters, and lower latitude records of other cat sharks in the region are from depths of 200 to 750 m.

Along Atlantic American coasts, fewer hauls have been made in depths in excess of 1,000 m. than in shallower water and trawling has been limited in areas where rough bottom topography produced severe gear losses. Deficiencies in the representative quality of the collections are due chiefly to these factors.

Ford (1921), writing about *Scyliorhinus canicula* at Plymouth, England, noted that there is a curious alternating seasonal predominance of the sexes in adults. In the winter the males were found to be the predominant sex, whereas in the summer the females were the more numerous. Differential preferences by the sexes for depth (and by inference for temperature) were noted by Springer (1960) in shallow-water carcharhinid sharks. This may be true also of some of the cat sharks. The importance of segregation by size as a means for protecting the young against predation by members of their own species is less apparent for cat sharks than for the large voracious carcharhinids, but perhaps is a useful trait. It is of interest in this connection that Ford (1921) reports *Scyliorhinus stellaris* feeding on the smaller *S. caniculus* in the Plymouth area.

Nearly all specimens of cat sharks from the western Atlantic have been taken in trawls. Most of those collected by exploratory vessels were caught in shrimp trawls having 1¾- or 2-inch mesh (stretched). Only the smallest sizes, less than 6 inches, would be able to escape through the meshes; larger cat sharks, over 24 inches long, might sometimes evade the nets.

WESTERN ATLANTIC GENERA

The cat sharks known from the western Atlantic fall into five well marked groups corresponding to the five genera recognized here. Differences of species within genera in the western Atlantic are not great except between the two species of *Halaelurus* reported from Argentina. Of the five western Atlantic genera, one genus, *Apristurus*, is probably cosmopolitan in waters of suitable depth outside of Arctic and Antarctic Regions. *Galeus* is present both in the North Atlantic and North Pacific Oceans but has not yet been found in the Southern Hemisphere if recognition is accorded Whitley's genus *Figaro* (1934). *Schroederichthys* is restricted to the Caribbean and tropical Atlantic. Western Atlantic members of the genus *Scyliorhinus* form a compact infrageneric group differing less from one another than from species found in the eastern Atlantic or in the western Pacific. *Halaelurus*, as understood here, includes species from the Indo-Pacific region and the Southern Hemisphere.

The area of marine situations suitable to most of the species of cat sharks is very small in comparison to the total ocean area. *Apristurus*, which on Atlantic American coasts is found most commonly at depths from 750 to 1,500 m. and may range into deeper water, occurs over a much greater geographical area than species of other genera, possibly being present in ocean basins of moderate depths. Figure 1 showing the extent and distribution of bottom along the Atlantic coast of temperate North America at depths between 100 and 500 fathoms illustrates the rather narrow bands in some areas to which cat sharks may be restricted. Along tropical and subtropical western Atlantic continental slopes, the ranges of cat sharks other than *Apristurus* are extremely narrow bands.

The largest of the western Atlantic species probably do not ordinarily attain a length as great as 80 cm., and the smaller species (one species of *Scyliorhinus*, one *Apristurus*, the three American *Galeus*, and *Schroederichthys*) probably do not exceed 50 cm. Some eastern Atlantic and South African species are larger. *Scyliorhinus stellaris* (*Linnaeus*) of the eastern Atlantic reaches a length of 150 cm. in the Atlantic but only about 75 cm. in the Mediterranean (Tortonese, 1956). Smith (1949) gives maximum sizes of 4 feet (122 cm.) or more for *Scyliorhinus capensis* (Müller and Henle) and *Conoporoderma africanum* (Gmelin) of South African coasts.

At the present time, a revision of the family involving a review of generic or family classifications using some of the more advanced modern methods that are available is impractical because insufficient descriptive data exists for most named species. Furthermore, it is very likely that a rela-

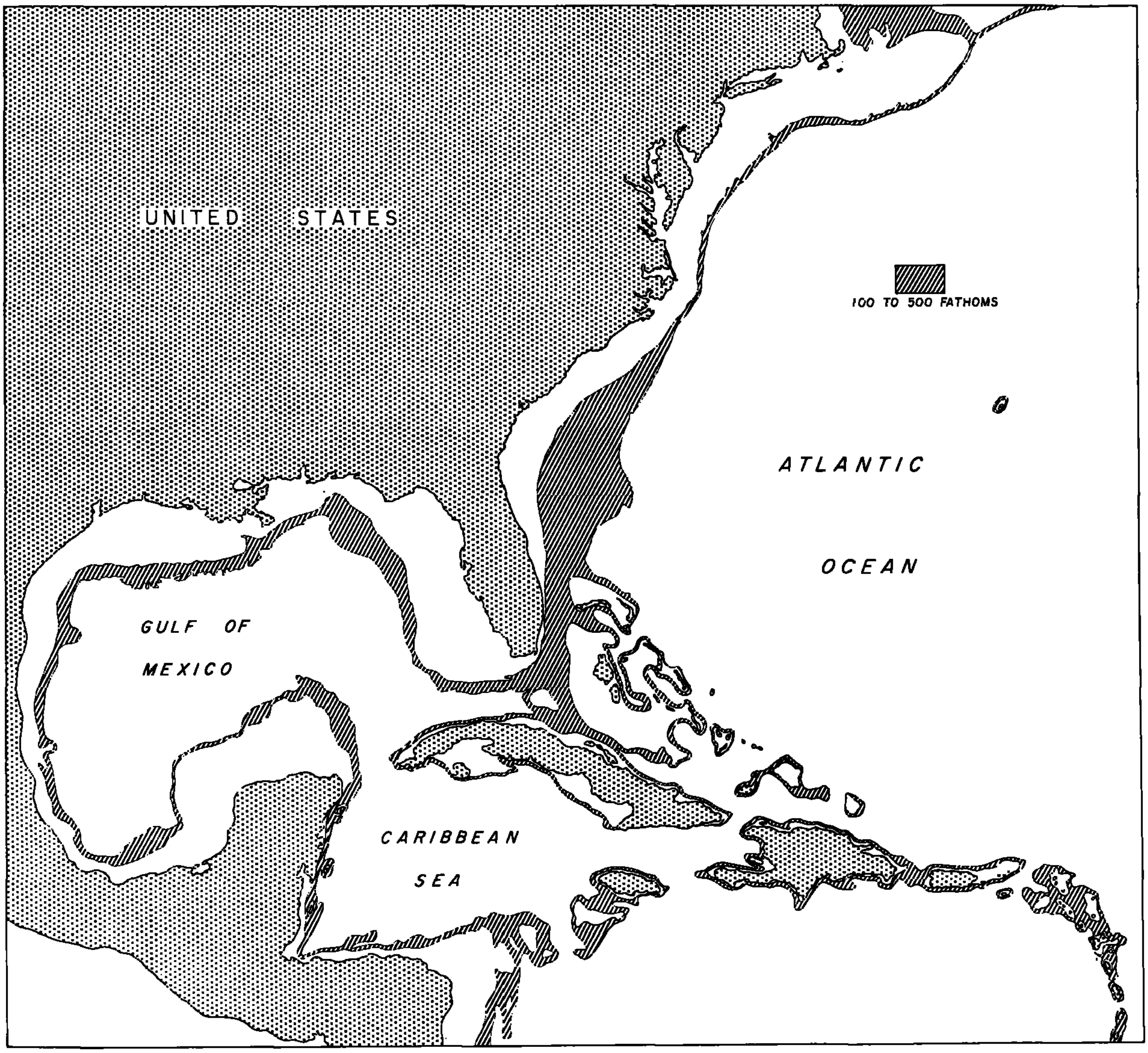


FIGURE 1.—More than 95 percent of the specimens of scyliorhinids from the western North Atlantic available for study have been collected within the 100- to 500-fathom (183- to 914-m.) depth range shown here.

tively large number of unnamed species exist, undescribed not because their differences from other species have not been recognized, but undescribed because examples have not yet been caught. For this study, more than half the specimens have been collected within the past five years.

To anticipate in detail the needs of future studies is presumptuous, but some of the characters of the genera of the cat sharks of the western Atlantic that have been little used in orthodox or classical studies seem worth discussion even though these cannot be fully utilized in reaching taxonomic decisions in this geographically limited study.

Color and color pattern

Western Atlantic cat sharks fall in two groups with respect to color pattern. All *Apristurus* are nearly uniform in color, and preserved specimens are either black or dark brown of various shades but with no tendency to the formation of any pattern. A few specimens that I have seen brought to the surface from hauls in the northern Gulf of Mexico were uniform black, but these became either very dark gray or dark brown after preservation. Areas of skin not covered by denticles, around the gills for example, remained darker; and edges of fins, where denticles are sometimes either more numerous or are absent, became a different shade of brown or black than the rest of the body surfaces after preservation. The material examined suggests that there is no diagnostic significance to brown or black color in museum specimens because color changes variously after preservation.

Excepting *Apristurus*, all Atlantic American cat sharks now known are somewhat darker above and lighter below, and furthermore, all have some pattern of spots, blotches, or lines on the dorsal surfaces, either lighter or darker than the background color. This does not pertain outside the western Atlantic where the genus *Galeus*, for example, is represented by some species without markings, at least as adults, and other genera, *Parmaturus* for example, are represented by species that are uniformly dark.

The two species of western Atlantic *Galeus* have color patterns that differ in intensity among the three forms but show more resemblances to one another than to color patterns in any other genus. The patterns in *Galeus* are complex and difficult to describe. Because pattern differences in this genus are obscured by differences in intensity of pattern, they are of low value in field identification and other characters are not only more easily described but also may be more reliable.

Species of the three other genera as represented in the western Atlantic, *Scyliorhinus*, *Schroederichthys*, and *Halaelurus*, have essentially similar basic color patterns but have diagnostically useful modifications of the basic patterns. As indicated by the few species of which juvenile examples are available, and in its simplest and most persistent form, the basic pattern consists of a series of seven dorsal saddles or blotches. Depending upon species, either more saddles may be present in intermediate positions or some of the main saddles may be obscure.

A parallel development of pattern in *Scyliorhinus torrei* Howell-Rivero and *Schroederichthys maculatus* (one of the new species described here) illustrates this. Both species have the seven dorsal saddles appearing in some individuals but generally more prominent in the young. In adults of both species, however, the saddles may become quite indistinct with a partial substitution of a pattern of small white spots on a tan background color. The tan color here is the color in life and is not brought about by preservation. The saddles seem to become more distinct with preservation. In life or when freshly preserved the two species are so similar in appearance of the color and pattern that the rather great structural differences may be overlooked easily.

Variation in pattern within species in the material at hand is moderate and reasonably well defined. Figure 2A shows a rather extreme example of the absence of full development of a reticulate pattern characteristic of *Scyliorhinus retifer* (Garman), whereas figure 2B shows a specimen with the reticulate pattern fully, but not uniformly, developed. Although this pattern is variable, it can be distinguished readily from patterns made up of discrete black spots or white spots.

Reproduction

Most cat sharks lay eggs in cases which, when first laid, are impervious and sealed against the entry of seawater. During development of the embryo, slits appear in corners of the egg cases to permit a flow of sea water through the egg case. Tendrils, one from each of the four corners of the egg case, attach it to objects on the bottom when the eggs are laid.

In addition to information on the egg laying habits of *Apristurus riveri*, available records and material show that *Scyliorhinus retifer* and *Schroederichthys maculatus* lay eggs. No positive information is at hand for other western Atlantic species, but an egg case with developing embryo (fig. 3) may be presumed to be either *Scyliorhinus meadi* or *S. torrei* on indirect evidence of locality.

The genus *Galeus* is represented in the eastern Atlantic, including Icelandic waters, by four species among which are two little-known forms without markings or color patterns; these were described from specimens from the Hebrides and from Iceland. The remaining eastern Atlantic forms include *Galeus melastomus* Rafinesque, an egg layer, and *Galeus polli* Cadenat, an ovoviviparous species that retains eggs in the oviduct until after the egg shell has been absorbed and after the embryo has completed absorption of the yolk sac. No positive evidence has been found to

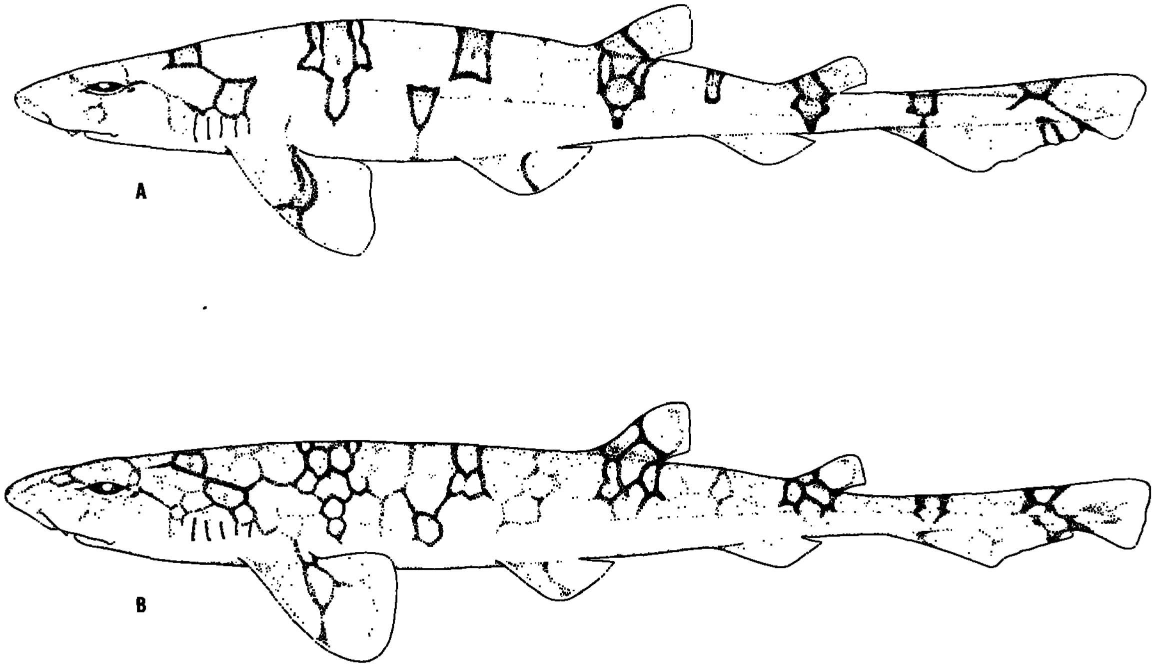
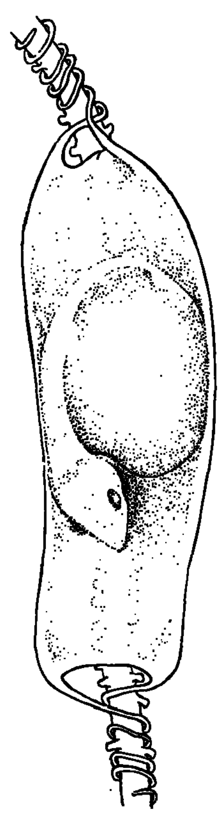


FIGURE 2.—*Scyliorhinus retifer* (Garman): A, Drawn from a 465-mm. female; B, drawn from a 380-mm. female. Both specimens collected in 365–385 m. off Pensacola, Fla. The upper figure shows a specimen with seven major saddles but with the addition of one intermediate saddle between the two dorsal fins. The darker reticulations in the lower figure can be seen to delineate seven major saddles.



show whether or not western Atlantic species produce living young. Probably both western Atlantic species are ovoviviparous. No shelled eggs have been found in oviducts of the many adult female specimens that have been examined, and no unidentified egg cases small enough to belong to *Galeus* have been seen.

Claspers and clasper siphons

Leigh-Sharpe has proposed that more consideration be given to the structure of the claspers and clasper siphons or clasper glands in taxonomic studies of elasmobranchs. In a series of papers published between 1920 and 1926 he described these

FIGURE 3.—Egg case of a cat shark collected off Cape Kennedy, Fla., showing a developing embryo within its entirely transparent and colorless case and showing the characteristic method of attachment of the case. The degree of transparency of the egg case, the shape, and the nature of surface markings on it vary with species. Transparent egg cases which may be quite free from color when fresh may become brownish after storage in alcohol. The embryo color pattern and the site of collection of the egg case suggests that it is *Scyliorhinus meadi*. Drawn from an egg case approximately 1.4 by 4.0 cm. exclusive of tendrils.

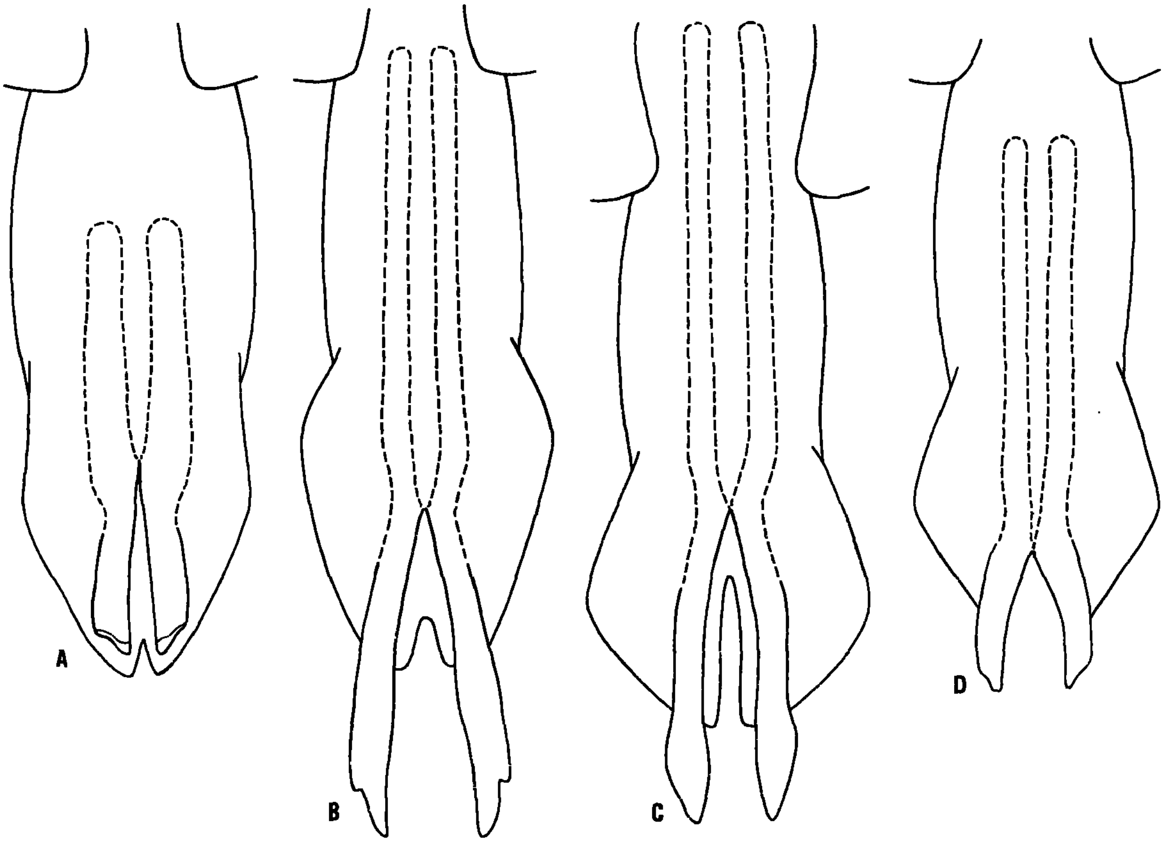


FIGURE 4.—Diagrams showing general shapes of claspers and clasper siphons in adult male cat sharks: A, *Scyliorhinus torrei* and B, *Galeus arae*, both from the Florida Straits; C, *Schroederichthys maculatus* from the western Caribbean; and D, *Apristurus riveri* from the southwestern Caribbean. Each drawn to scale but scales are unequal.

structures in some scyliorhinids in detail (Leigh-Sharpe 1920, 1922, 1924, 1926a, and 1926b). In practical application for taxonomic studies, however, there is some difficulty because of inadequate series of specimens. Of the 15 western Atlantic scyliorhinids treated here, for example, adult male specimens were not available for 6 species.

Diagrams outlining the general size and shape of claspers in relation to the pelvic fins and outlining roughly the extent of the clasper siphons are shown in figure 4 for representatives of four western Atlantic genera. No important differences in gross examination were noted among adult males of the two species of western Atlantic *Galeus*. Supplementary examination of a few adult male *Galeus* from the eastern Atlantic and from the Pacific failed to reveal substantial differences in clasper structures within the genus excepting the presence of hooks on specimens of western Atlantic species examined and the absence of these on the only eastern Atlantic adult male available. The available material is insufficient to show whether clasper structures of western Atlantic scyliorhinids are useful in the diagnosis of species, but from a necessarily cursory review it appears that they might be quite useful as generic characters.

Hooks were present on claspers of the species of *Galeus* but were absent on *Apristurus* and *Schroederichthys* and from the claspers of western Atlantic *Scyliorhinus* examined. Hooks were not found on a clasper of one *Galeus melastomus* from the eastern Atlantic.

The denticles on the surfaces of claspers in all of the specimens examined have their points directed forward toward the base of the clasper. The reversal of direction of the denticles is noted as occurring in *Scyliorhinus stellaris* (=*Scyllium* *catulus*) by Leigh-Sharpe (1920) and apparently is a feature common to all galeoid sharks but not to sharks of other suborders.

Shape of body and fins

The caudal axis in the family Scyliorhinidae is little elevated and, excepting adults of *Scyliorhinus*, the overall shape of western Atlantic species is slender. One genus, *Schroederichthys*, has a very elongate postpelvic trunk region.

The length of the body cavity relative to the overall size of the fish (volume) differs considerably in the four genera found in the tropical and northern Atlantic. This difference is reflected in the size of the liver and it appears likely that with sufficient material for study it would be found that liver characteristics would be useful as taxonomic criteria. The general shape of the liver is shown in figure 5.

A series of Pacific *Apristurus brunneus* examined in comparison with *Apristurus riveri* from the Atlantic show some apparently constant differences in liver shape. In *A. brunneus* the liver is larger and in most specimens the right and left posterior lobes are united for most of their length, excepting only that part just anterior to and extending past the cloaca. In *A. brunneus* the liver almost completely covers the visceral cavity when viewed from the ventral aspect. Only the falciform ligament and the rectum are visible in addition to the liver when the body cavity is opened ventrally. Thus it would seem from casual inspection that large ripe eggs from the ovary located under the liver when viewed from the ventral aspect (only right ovary functional in scyliorhinids) would have to make a remarkably long or tortuous journey to reach the opening of the oviducts.

It may be significant in indicating possible derivation of the orectolobids which have quite short snouts with reduced or absent rostral cartilages, that western Atlantic *Scyliorhinus* and *Halaelurus* have relatively short snouts, *Schroederichthys* has a moderately short snout, but both *Galeus* and *Apristurus* are long-snouted. Associated with the long snouts of *Galeus* and *Apristurus* is the comparatively greater prominence of the external pores for the Ampullae of Lorenzini. The extensive pore system of the Ampullae of Lorenzini in *Apristurus* may be associated with its habitat

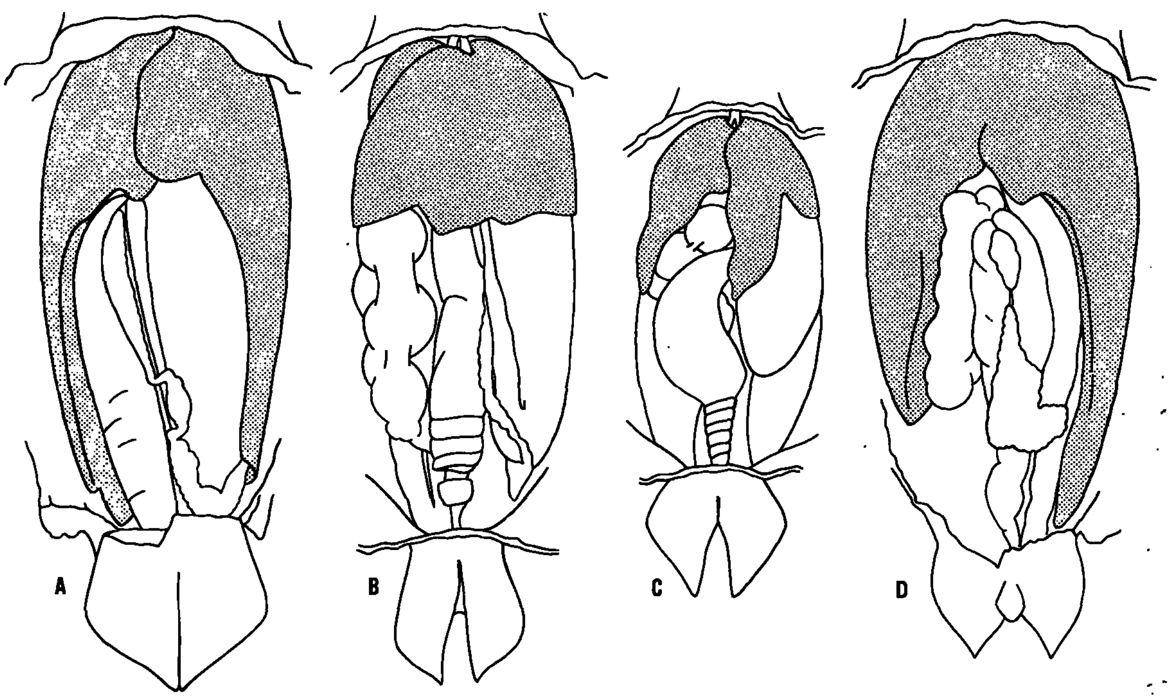


FIGURE 5.—Diagrams of the arrangement of visceral organs showing liver shapes (stippled areas) in representatives of four western Atlantic genera: A, *Scyliorhinus retifer;* B, *Galeus arae;* C, *Schroederichthys maculatus;* and D, *Apristurus riveri.*

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which is in comparatively deeper water than any of the other cat sharks. Pineal windows were not seen in the specimens of *Apristurus* or any other cat sharks examined. Among sharks, these are consistently present in the squaloid genus *Etmopterus*, members of which are black.

Dermal denticles

The size, arrangement, and structure of dermal denticles are often quite useful characters for practical problems in identification of sharks. Ordinarily the typical dermal denticles used in descriptive accounts of species are those from a lateral surface near the first dorsal fin but below the middorsal line. Here, unless some specific location is indicated, denticle descriptions are from denticles taken at a point about halfway along a line between the axil of the pectoral fin and the origin of the first dorsal fin. In some instances, differences in the denticle structure are the most reliable and definite means of determining species. For example, *Squalus blainvillei* is readily distinguished from *Squalus cubensis* by great differences in denticle shapes. Among scyliorhinids of the western Atlantic, denticle differences are either less well marked or need qualification as to location or as to the size or age of the specimens involved in comparisons.

In *Scyliorhinus retifer* the denticles increase in size as the shark becomes larger and the denticles change somewhat in shape. In some sharks it is evident that the number of denticles increases as the shark grows large, but in the series of *S. retifer* examined, positive evidence of an increase in the number of denticles with increasing size was not apparent in a cursory examination. The general aspect of a section of skin surface with denticles is shown in figure 6.

In *Scyliorhinus retifer* denticle shapes on different parts of the body vary and the variation follows a pattern more or less characteristic of all galeoid sharks. On the ventral surfaces the denticles have much less prominent ridges and the lateral points are generally absent. On leading edges of fins the denticles are usually smoother and flattened so that there are no projecting points. On the head and especially those parts of the head used sometimes for bumping objects, the denticles are somewhat shorter with thicker edges or points.

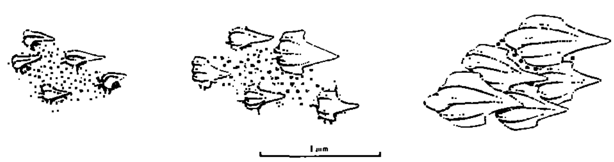

Figure 6.—Dermal denticles from a series of female *Scyliorhinus retifer* from the Gulf of Mexico. Left from a specimen 175 mm., center from a 295-mm. specimen, and right from a 465-mm. specimen. Camera lucida drawings to the scale indicated.

Denticles of *Galeus* and *Apristurus* follow this plan to a less marked degree. The denticles of ventral surfaces are about the same shape as those of the dorsal surfaces, but their construction is lighter.

Specialized dermal denticles forming a crest along the upper margin of the caudal fin are found on all species of the genus *Galeus*, varying slightly among species but probably not sufficiently to be used in practical field identification. The genus *Figaro* Whitley has been described from Australian waters and differs in having the specialized scales on both the upper and lower margins of the caudal fin. The eastern Pacific genus *Parmaturus*, quite unlike *Galeus* in many respects, has a denticle crest on the upper caudal fin margin.

Although not having a definite crest, *Apristurus profundorum* has several rows of compactly arranged, imbricate denticles along the upper margin of the caudal fin. The body and sides of the fins in that species are quite sparsely clothed with denticles which are nearly erect.

The young of *Scyliorhinus caniculus* and *S. stellaris* have a series of enlarged scales, one series on each side of the middorsal line extending from the shoulder area back to the first dorsal fin. According to Ford (1921), these scales are visible in embryos of *S. caniculus* taken at Plymouth, England, when the embryos are 44 mm. long. They persist for a short time after hatching, but similar scales are present on *S. stellaris* and may still remain in place until the sharks are over a foot long.

Enlarged scales are present on an embryo (fig. 8) presumed to be *S. retifer*. They are not visible in specimens of 150 mm. or more, but on specimens of newly hatched *S. retifer* they are represented sometimes by a series of scars. Enlarged denticles in a similar position but widely spaced are present in *Halaelurus* from Chile, usually surrounded by a ring of somewhat modified smaller denticles. Series of enlarged denticles are present on both

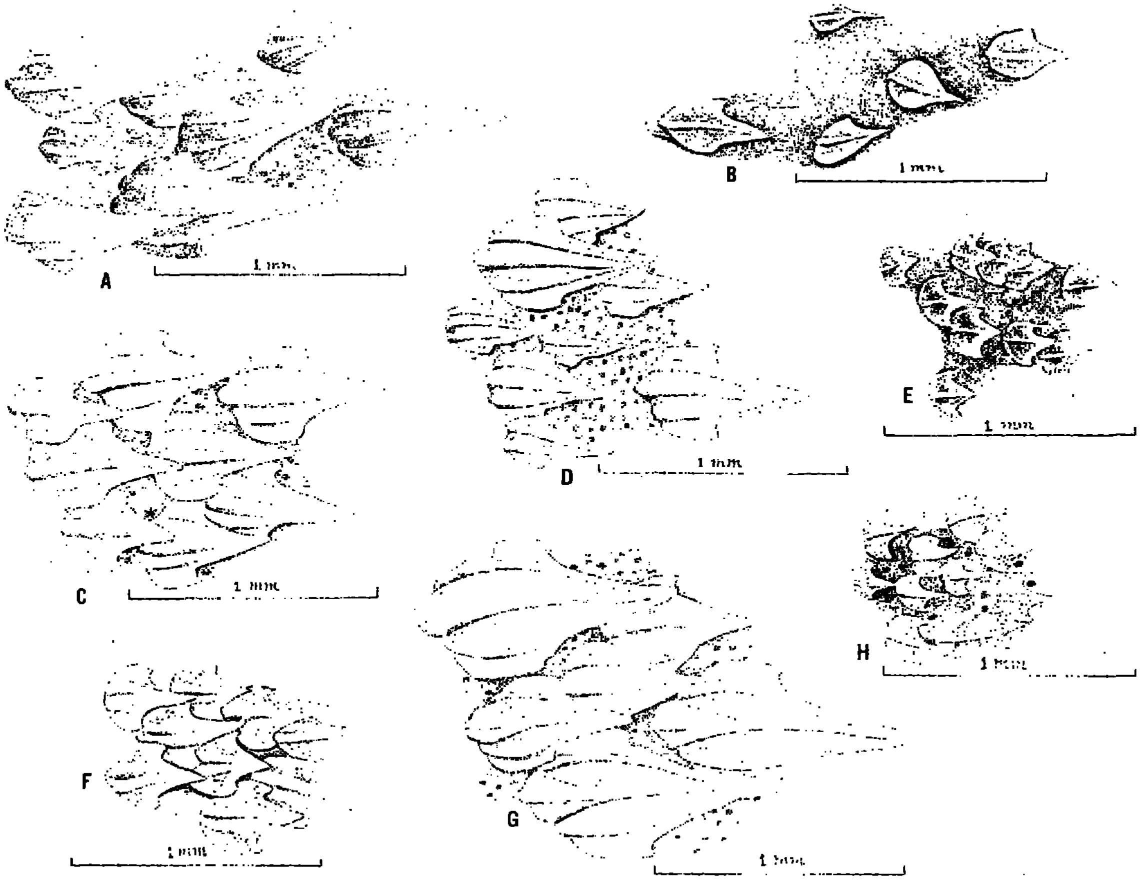

FIGURE 7.—Camera lucida drawings of denticles from some western Atlantic catsharks: A, *Scyliorhinus meadi* from 264-mm. immature male; B, *Apristurus profundorum* from 380-mm. immature female; C, *Scyliorhinus torrei* from 243-mm. adult male; D, *Scyliorhinus hesperius* from 296-mm. immature male; E, *Apristurus riveri* from 450-mm. adult female; F, *Schroederichthys maculatus* n. sp., from 295-mm. adult female; G, *Scyliorhinus retifer* from 410-mm. adult male; H, *Galeus arae* from 287-mm. immature female. Note: Denticles of *Apristurus profundorum* are more erect over most of the body surfaces than shown here, their points projecting almost perpendicularly from the plane of the skin surface.

sides of the middorsal line of a 160-mm. specimen of *Cephaloscyllium uter* from Monterey Bay, Calif.

Teeth

The teeth of scyliorhinid sharks are small, most commonly with a larger central cusp having one or more smaller lateral cusps on each side. In some species of *Apristurus* the teeth nearer the corners of the mouth may have many cusps (as many as nine have been noted) with the central cusp but little higher than adjacent ones. In *Atelomycterus* from the Indo-Pacific, the cusps of some of the teeth near the corners of the mouth are much reduced and the rows are fitted so close together as to form an almost smooth grinding surface.

Except for specimens of *Apristurus*, the tooth form does not vary greatly in the scyliorhinid specimens examined from the western Atlantic and it is probably impractical to attempt to distinguish most species from teeth alone. Western Atlantic *Apristurus*, as a general rule, have teeth with more cusps and, in some *Apristurus*, crowding of some of the lateral cusps in front of the central cusp (see fig. 9D) is frequent.

In *Apristurus riveri* the most extreme tooth dimorphism yet reported for sharks occurs. The two adult males that constitute our entire series of

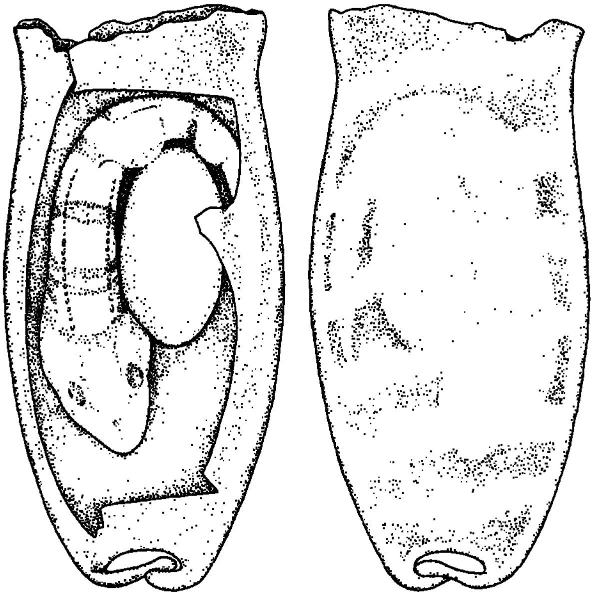

FIGURE 8.—Egg case of a cat shark collected from 100 fathoms off the coast of North Carolina, showing an embryo with the two series of enlarged denticles that characterize the young in some species of scyliorhinid sharks. Presumably this is an embryo of *Scyliorhinus retifer*. The somewhat opaque white banding in the shell has not been reported previously and may not always be evident in egg cases of the species.

males of that species not only have teeth twice as long as the teeth of females of comparable size but the teeth of the males are also quite different in shape from those of the females, with lateral cusps entirely absent on the teeth of the central part of the jaws. A few teeth with lateral denticles or cusps are present among the last few rows toward the angles of the jaws.

This degree of dimorphism illustrated by the accompanying diagram (fig. 10) does not occur in the other species of *Apristurus* that are represented by sufficient material to check. The teeth of males of the Pacific species, *Apristurus brunneus*, are somewhat larger than the teeth of females of comparable size, but there is no important difference in tooth shape. No significant dimorphism is present in A. *profundorum*, A. *indicus*, or A. *laurussoni*.

It is suggested that the modification in teeth would function effectively to hold the female, perhaps by the pectoral fin, during copulation.

With reference to *Halaelurus* from Patagonia, Vaillant (1891) states that one finds great vari-

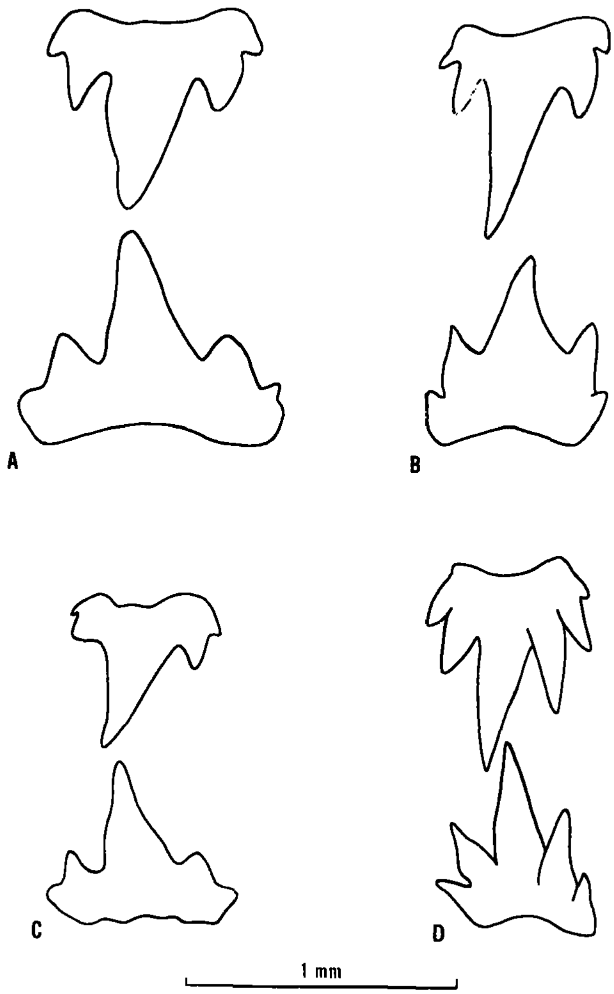

FIGURE 9.—Camera lucida outlines of teeth from upper and lower jaws, shark's right side, fifth lateral row counting from the symphysis: A, *Scyliorhinus hesperius*, a 272-mm. female; B, *Galeus arae*, a 365-mm. male; C, *Schroederichthys maculatus*, a 220-mm. male; and D, *Apristurus indicus*, a 430-mm. female.

ation in the teeth of the lower jaw with differences following size and perhaps sex. Also in a table of differences between *Scyllium bivium* and *S. chilense* (*Scyllium*=*Halaelurus*), Vaillant notes that the lower jaw teeth of *bivium* are not very small and are either without lateral cusps or with lateral cusps not very distinct, whereas the teeth of the lower jaw in *chilense* are very small and have no lateral points. In spite of complications of nomenclature and contradictions in the literature, it is obvious that South American *Halaelurus* exhibit a transition in tooth form. A more thorough study is necessary to determine whether

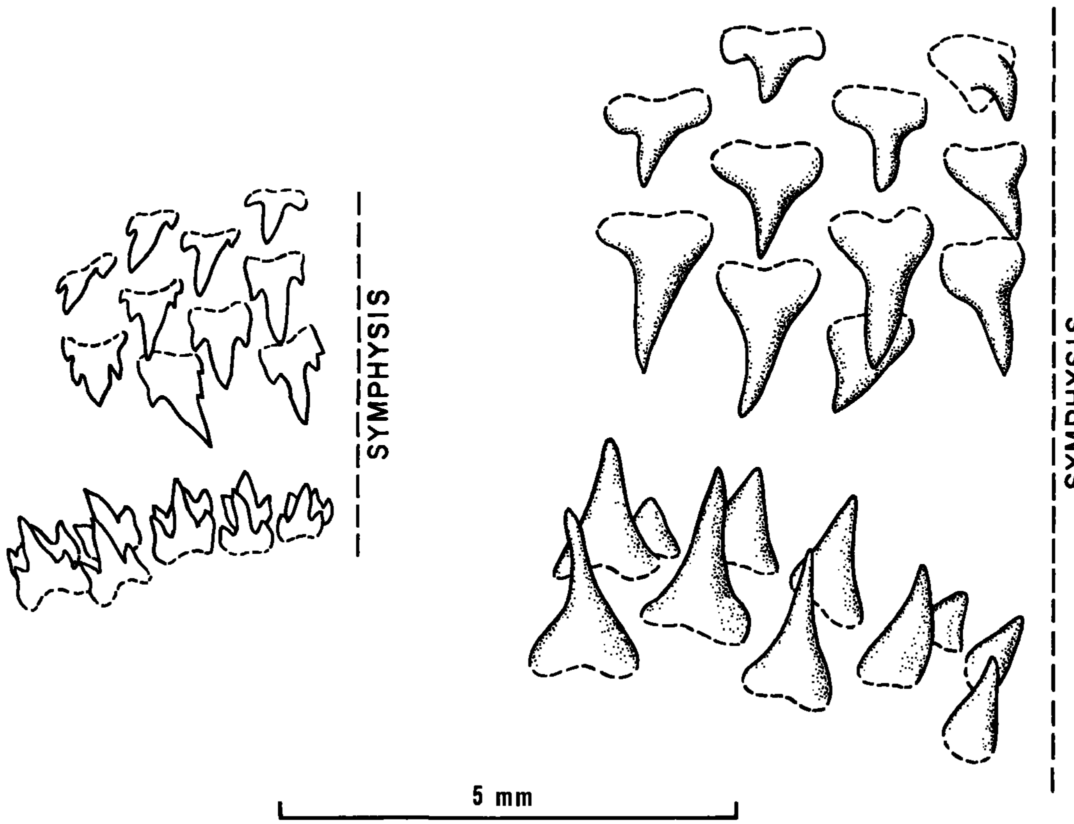

FIGURE 10.—Camera lucida outlines of teeth of 405-mm. adult female *Apristurus riveri* (left) compared with same scale outlines of teeth of 430-mm. adult male (right) both specimens from 860- to 914-m. depth off the Caribbean coast of Panama.

changes in tooth form occur at sexual maturity or whether several species with different tooth forms are involved with or without changes during growth. South American *Halaelurus* (not including the deeper water form *Scyllium canescens* Günther) shows a trend toward development of spike dentition in the lower jaw. Spike teeth in the lower jaw and cutting teeth in the upper jaw always characterize species of the larger and more specialized galeoids wherever differences in apparent function between upper and lower jaws exist. In contrast, in the notidanoids and squaloids it is the upper jaw that has spike teeth.

It has been customary to express a tooth formula for extant sharks simply as the number of teeth in the upper jaw over the number of teeth in the lower jaw. In sharks having only one functional band of teeth, the counts are rather easily determined. In *Carcharhinus leucas*, for example, this would be 27/25 where 27 is the number of teeth on the upper jaw and 25 is the number on the lower jaw. A refinement of this kind of formula, used for example by Bigelow and Schroeder (1948), breaks down the count to indicate the number of very small teeth at or near the jaw symphyses. In *C. leucas* such a count might be expressed as 13+1+13/12+1+12, where 13 is the number of teeth on each side of the upper jaw, 12 the number on each side of the lower jaw and 1 represents the number of very small teeth at the symphysis. Leriche (1905) developed a classification of the various types of teeth found in the jaws of fossil sharks which permits the use of a more descriptive and meaningful formula to express conditions found in various species. Applegate (1965) has proposed some modification of the Leriche system and an extension of its use to extant species. This system has obvious merits although its formulas are perhaps less informative about scyliorhinids than about species in most other shark families. No attempt has been made to use it here because of this and because only about half the scyliorhinid genera are being reviewed.

Strasburg (1963), in discussing tooth replacement in a squaloid species, *Isistius*, used the terms independent dentition, alternate overlap, imbricate overlap, and mixed alternate and imbricate overlap to describe the arrangement of teeth in a transverse band and to distinguish these arrangements from the modified imbricate overlap found in *Isistius*. He found no pure alternate dentition in the species he examined, but these did not include a scyliorhinid.

In scyliorhinids several transverse series of teeth are functional. For the purposes of this discussion a series of teeth is defined as a file or array of teeth along a single line running parallel to the jaw cartilage axis from one corner of the jaw opening to the other. A row of teeth on the other hand is defined as a file of teeth in a line extending from a germinal area on the inner surface of the jaw to the outer rim of the jaw or lip. Rows of teeth are frequently, but not always, arranged in a line on a plane perpendicular to the axis of the jaw cartilage.

In all scyliorhinid sharks several series of teeth are functional, and in addition two or more series of developing teeth are present along the inner side of the jaw. The developing teeth are covered there by the lining of the mouth which forms a protected space in which tooth buds form. In *Scyliorhinus*, *Galeus*, and *Schroederichthys* four or five functional series are usually present in each jaw and in *Apristurus* five or six functional series. Impressions or scars of tooth bases are often visible at the outer ends of tooth rows. If two series are considered together as one band, the arrangement is alternate, the teeth in the outer series being present in half the tooth rows with their bases overlapping the alternately occurring teeth of the next functional series. The teeth of all specimens of scyliorhinids examined were somewhat crowded with a considerable degree of overlap (see fig. 11). Alternate dentition with less crowding is to be found in some sharks of other groups. The arrangement of teeth which, following Strasburg (1963), would probably be called modified alternate dentition if found in *Pristiophorus*, but with less crowding has a quite different appearance from the typical arrangements in scyliorhinids. In *Pristiophorus* (fig. 12) the number of rows of teeth are readily counted, and no confusion results from the appearance of diagonal files of teeth.

FIGURE 11.—Head of a 430-mm. adult male *Apristurus riveri* showing diagonal files of teeth in the lower jaw at the left side of the photograph. Dentition in this specimen is alternate throughout. Reflections from base of some of the teeth appear in the photograph to depict accessory cusps, but in reality none are present on teeth that are shown in the photograph.

The presence or absence of a separation of the teeth of one side of a jaw from teeth of the other side by a band of fleshy material seems to be a variable in the scyliorhinid specimens examined. Many specimens of *Apristurus* have such a separation either in the upper or lower jaw or both, whereas some do not. Furthermore this variation occurs in series of the same species. The extent to which this variation may be the result of stretching of ligaments at the symphysis has not been determined.

The number of tooth rows in some scyliorhinids is difficult to count for a variety of reasons. The teeth are small, and toward the angles of the jaws low-crowned multicusped teeth are not clearly defined. The teeth are crowded, and in a few specimens, or perhaps a few species, the arrangement of the teeth is not a simple alternate arrangement but is mixed. Similarities between the cat sharks,

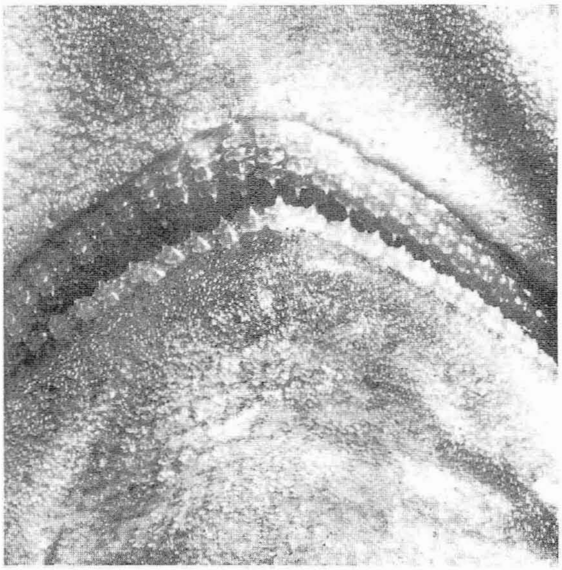

FIGURE 12.—Teeth of the saw shark, *Pristiophorus schroederi* (Pristiophoroidea), showing a modified alternate tooth arrangement differing from the arrangement found in the *Scyliorhinidae* (Galeoidea) chiefly in the lesser degree of crowding. Photograph by Los Angeles County Museum.

Scyliorhinidae, and the false cat sharks, Pseudotriakidae, already have been noted. The upper and lower jaw teeth of *Pseudotriakis microdon* Bocage and Capello are illustrated in Bigelow and Schroeder (1948) and are described and discussed in more detail by Jaquet (1905). The arrangement of teeth in the lower jaw in *Pseudotriakis* and *Apristurus* have some similarity in appearance due to the rather well defined diagonal files of teeth. Gross examination of the type specimen of *Pseudotriakis acrages* Jordan and Snyder (SU 12903) shows the diagonal files of lower jaw teeth continuing widely separated, but with the teeth within a file quite close together, back to the germinal area (see fig. 13). This appears to indicate a diagonal movement of the teeth from the area of budding into the functional position, but such an explanation is superficial. A study of the comparative histology of the developing teeth in several families of sharks should prove helpful in indicating relationships.

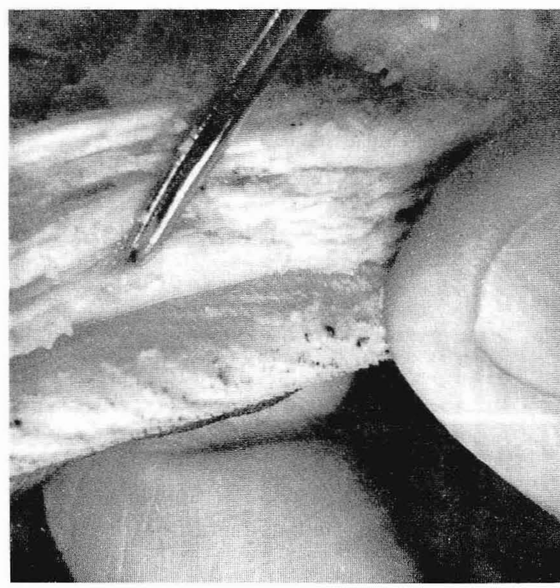

FIGURE 13.—Upper photograph showing diagonal files of teeth in the lower jaw of the type specimen of *Pseudotriakis acrages* Jordan and Snyder (SU 12903). Lower photograph, same jaw rolled outward with the tooth germinal area exposed and showing continuation of the files diagonally on the dental lamina where they become progressively smaller and softer to the point of their apparent origin.

NUMBER OF VERTEBRAE

Vertebrae were counted from radiographs of specimens of the family, but the diplospondylous vertebrae near the tail tips were difficult to count. Furthermore, in some radiographs it was not possible to determine whether all of the terminal vertebrae appeared. Since it was always possible to count the number of monospondylous vertebrae with confidence, only these counts are given here (table 1).

The series reported here is too small for definitive use, but is sufficient to give promise that a more comprehensive study would be helpful in species diagnosis. Several kinds of interpretive factors may require consideration in a more comprehensive study. Some variation in meristic characters would not be surprising in a sample collected over a large geographical range. In our series of 33 counts from *Apristurus indicus*, the counts vary from 35 to 41, and localities of capture range over 20 degrees in latitude. In the series of 25 counts for *Apristurus laurussoni* a single count, higher than the cluster, is the count for the holotype, taken about 20 degrees north of any of the other specimens of the series.

The reliability of counts of vertebrae for purposes of numerical analysis or for identification is reduced because of abnormalities occasionally present. In the distribution of counts in 34 specimens of *Schroederichthys maculatus*, for example, where 33 are clustered but one count is somewhat apart, the high count in this specimen appears to be attributable to an uneven transition to diplospondyly. Here a few displospondylous vertebrae appeared well forward in the trunk region.

MORPHOMETRICS

The conventional ways to measure sharks are comprehensively illustrated by Garrick and Schultz (1963, figs. 1A and 1B), and this system of measurement is used here insofar as possible. Unfortunately measurements very useful for some sharks are difficult to apply to others. In the scyliorhinids, for example, the axis of the caudal fin is not perceptibly elevated and the point at which the upper lobe of the caudal fin begins is merely an estimate. The fins of scyliorhinid sharks, especially *Apristurus*, are soft and are generally rounded or lobelike structures making fin measurements difficult to define.

Most diagnostic accounts of scyliorhinids rely greatly upon morphometrics as key characters to separate species or genera. These characters are at least accessible and their use does not require a microscope. As applied to scyliorhinids, however, some kinds of comparative measurements seem to be particularly unreliable.

In comparing fin sizes, for example, the statement that the length of the base of the anal is 4 times the length of the base of the first dorsal fin in one species, but only 2½ times the length in another species, introduces a variety of difficulties in practical application. Precise measurements of the length of fin bases are not easily made because of the gradual slope of the forward end of the fin. This is sometimes complicated by the distortion or shriveling of the specimen in preservation. The lengths of fin bases may vary independently. Thus a comparison that seems quite clearly to differentiate species when some specimens are compared may be quite inadequate for other specimens.

In scyliorhinids there are occasionally specimens having much longer gill slits on one side than on the other, and gill slits are especially subject to distortion in length or even in position by preservation.

The ease with which data on measurement can be communicated and the difficulty of correctly and adequately describing shape seem to have led to overemphasis of measurements and less than

TABLE 1.—*Frequency of occurrence of various numbers of monospondylous vertebrae in some western Atlantic cat sharks*

Species	Number of monospondylous vertebrae																				
	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	38	49
Scyliorhinus retifer											2	5	8	7	1						
Scyliorhinus boa												4		1		1					
Scyliorhinus meadi															1			1		2	1
Scyliorhinus hesperius											2	3	2	1							
Scyliorhinus torrei		1	3	2	3	2															
Schroederichthys maculatus	6	22	3	2			1														
Schroederichthys tenuis				1		1															
Galeus arae					1	12	14	8	2												
Galeus cadenati					4	7	1	1													
Apristurus profundorum					1	1	4	1													
Apristurus riveri		1	6	3																	
Apristurus indicus							2	1	4	13	8	4	1								
Apristurus laurussoni									3	2	8	7	4		1						

desirable treatment of other characters. Measurements remain useful in description, but some better balance and the use of a large number of characters, including some that can best be described in illustrations, seems desirable and perhaps necessary for a revision of the family.

KEY TO GENERA OF WESTERN ATLANTIC SCYLIORHINIDAE

The following key to western Atlantic genera is sufficient for their separation, but the degree of difference between them is better illustrated in the chart given as table 2.

KEY TO WESTERN ATLANTIC GENERA OF SCYLIORHINIDAE

1A. Color uniform black or dark brown except for lighter or darker fins in some species .... *Apristurus*
1B. Color variegated with spots, blotches or saddles, lighter below .... 2A or 2B
2A. Crest of enlarged denticles along upper edge of caudal fin .... *Galeus*
2B. No crest of enlarged denticles along upper edge of caudal fin .... 3A or 3B
3A. Tip of snout to anus about one-third of total length .... *Schroederichthys*
3B. Tip of snout to anus about three-eighths to one-half of total length .... 4A or 4B
4A. Labial fold present only along lower jaw *Scyliorhinus*
4B. Labial fold around corner of mouth extending along both jaws .... *Halaelurus*

Genus *Scyliorhinus* Blainville 1816

Type species—*Squalus canicula* Lacépède, designated by Gill, 1861.

Western Atlantic species of *Scyliorhinus* differ from one another primarily in color pattern although one species, *Scyliorhinus torrei*, is much smaller than the other four and another, *S. meadi*, has more erect and slightly larger denticles than any of the others, giving it a somewhat shaggy appearance.

Scyliorhinus torazame (Tanaka) [=*Halaelurus rudis* (Pietchmann)] of Japanese waters, *S. stellaris* (Linnaeus) and *S. canicula* (Linnaeus) of eastern North Atlantic waters, and *S. capensis* (Müller and Henle) of South Africa and the eastern Indian Ocean, all differ in details of color pattern from one another and from American species. No eastern Pacific species are known. Specimens of *S. torazame* that have been examined have the pelvic fins united to a point somewhat nearer their tips than most specimens of the American species and have enlarged and nearly erect dorsal denticles rather regularly scattered on dorsal surfaces among more numerous smaller ones; but the larger denticles are not arranged in rows, and the character seems to be variable. The American species, excepting *S. torrei*, have slightly longer snouts than other species. The European *S. canicula* has the two nasal flaps united at the midline, and the confluent flap reaches the edge of the upper lip. As for other members of the genus, nasal flaps are often smaller in examples of the American species than in others, but specimens can be selected from series of *S. stellaris* and *S. retifer*, for example, in

TABLE 2.—*Characteristics of genera of the family Scyliorhinidae as present in western Atlantic species*

Characters	*Scyliorhinus*	*Halaelurus* (shortest snout)	*Galeus*	*Schroederichthys*	*Apristurus* (longest snout)
Color	Variegated; dorsal saddles present but sometimes obscure.	As in *Scyliorhinus*	Plain color or variegated but without well-marked saddles.	As in *Scyliorhinus*	Black or sometimes brown; color uniform without strong markings.
Caudal crest	None	None	Present	None	Absent except partly developed in one species.
Labial grooves	Weak; present only on lower jaw.	Strong on both jaws	Moderate on both jaws	Moderate on both jaws	Strong on both jaws.
Union of pelvic fins posterior to anus.	About two-thirds united.	Basal one-fourth to one-half united.	Basal one-half to two-thirds united.	No union	Only trace of union.
Enlarged dorsal denticles.	Present in embryos; and scars in very young.	A few remain in some adults.	Few scars on very young.	Not found on material available.	Not found.
Claspers	Short; hooks weak or absent.	Not examined	Long; hooks present	Long; no hooks	Short; no hooks.
Clasper siphons	Moderately short	Not examined	Moderately long	Long	Short.
Egg retention	Oviparous as far as known.	Oviparous as far as known.	Both oviparous and ovoviviparous species.	Oviparous as far as known (in 1 species).	Oviparous as far as known (in 2 species).
Sexual dimorphism in tooth shape.	Not found	Said to be present to slight degree.	Not found	Not found	Strong tooth dimorphism in 1 species, not in 3 others.
Pores on snout	Not prominent	Not prominent	Prominent	Not prominent	Very prominent.
Liver size in adults	Large; posterior tips usually reach as far back as anal opening.	Not examined	Moderate; posterior tips of liver lobes not reaching as far back as anus.	Short; small; not extending appreciably into posterior half of body cavity.	Large; very long; tips reaching posterior to anus.

which there are no appreciable differences in the shape of the nasal flap or its nearness to the mouth.

Thus throughout the genus *Scyliorhinus*, excepting only *S. canicula* where the nasal flaps do provide a structural feature differing from that found in all other species, the best and by far the most reliable character for identification of specimens is their color pattern. Differences in proportions do exist, and there are other differences in denticle and tooth structure and in the shape and position of fins; but these differences seem to be of little practical usefulness at this stage of the study of the family except in the analysis of series of specimens and in preliminary determinations of probable relationships.

KEY TO WESTERN ATLANTIC *SCYLIORHINUS*

Note.—Preservatives dissolve oil from shark livers, adding yellowish pigments to specimens, sometimes turning gray colored specimens to brown.

1a. Dorsal surfaces (except fins) with randomly arranged but almost uniformly spaced, light-colored and nearly round spots in a brown background (brown in life as well as in preservative); darker areas representing seven saddles may be present but are usually obscure; lighter below, without spots.

S. torrei; Florida Straits, off northern coast of Cuba.

1b. Dorsal surfaces neither brown in life (but may be brown in preservative) nor covered by randomly arranged white spots; all species with variations on a basic pattern of seven saddles, a prepectoral, a pectoral, postpectoral, first dorsal, second dorsal, precaudal, and caudal saddles; additional darker areas (blotches or saddles) may occasionally appear in intermediate positions such as between the dorsal fins, but such blotches or saddles are usually more obscure than the seven principal saddles; lateral pattern, when present, sometimes with a series of blotches roughly alternating with saddles.

2a. Saddles made up of simple blotches of darker color, usually without included darker lines or darker spots; lighter areas within saddles sometimes present but rather indistinct, not appearing as round whitish spots smaller than diameter of eye; intermediate saddles and spots outside basic pattern few or absent.

S. meadi new species; Florida Straits, St. Augustine to Santaren Channel.

2b. Saddles and lateral blotches with nearly round, white or light-colored spots included within their margins, these spots usually smaller than diameter of eye; no dark lines or dark spots within the saddles; some specimens with reduced number of saddles.

S. hesperius new species; western Caribbean, off Honduras, Nicaragua, and Jamaica.

2c. Dorsal saddles with black marginal lines enclosing areas of the lighter background color, the enclosed areas usually not round, in most specimens the lines forming a reticulate pattern; the reticulate pattern commonly extended to form intermediate patterns obscuring basic pattern of saddles, but in a few specimens reduced and showing only as saddles with marginal lines but without reticulating lines (fig. 2A and 2B show patterns near extremes of variation in material examined); no round white spots and isolated black spots few.

S. retifer (Garman); southwestern edge of Georges Bank (New England) along the outer continental shelf and the continental slope to the Carolinas and along the continental slope southward; off both east and west coasts of Florida; along the continental slope in the Gulf of Mexico and the western side of the Yucatan Channel; present on western Caribbean Banks including Pedro Bank as far south as Latitude 13°30′ N. Not yet reported from Cuba or the Antillean side of the Straits of Florida.

2d. Pattern of saddles usually outlined by small rounded black spots which may be present also outside the pattern; in some specimens black spots are so numerous as to obscure saddles; no white spots.

S. boa (Goode and Bean); Lesser Antilles and continental slopes of South America from Venezuela to northern Argentina.

Scyliorhinus torrei Howell-Rivero, 1936

Figures 4, 7, 14, and 27; tables 1, 3, and 4.

Scyliorhinus torrei Howell-Rivero, Proc. Boston Soc. Natur. Hist. 41(4): 43–44, pl. 9, 1936 (type locality off Havana in deep water).

S. torrei is the smallest species of the genus, the males becoming mature at about 250 mm. In this connection it should be noted that Ford (1921) finds no marked difference in sizes attained by males and females in *Scyliorhinus canicula* and that the series of all scyliorhinids examined in this study show no indication that there is a disparity in size attained by the sexes. The numbers of adult specimens examined, however, are too few to show this conclusively for any western Atlantic species. The largest specimen of *S. torrei* recorded is 209 mm. (Bigelow and Schroeder 1948). As might be expected from its small size and slender form, *S. torrei* has a short liver occupying only a part of the anterior half of the body cavity. Proportionally large ovarian eggs (in the right ovary in adult females) with diameters up to 10 mm. crowd other organs. In gross appearance the nidamental gland and oviducts in *S. torrei* are much the same as in other western Atlantic scyliorhinids, but it is not known whether *S. torrei* is oviparous or ovoviviparous.

Howell-Rivero (1936) in describing *S. torrei* noted the presence of a nictitating membrane and by this (among other characters) distinguished it from *S. torazame* of Japanese waters. Among specimens of both species examined for this study there is some difference in the degree of development of the subocular fold. Gilbert and Oren (1964) have called attention to inconsistencies in use of the terms subocular fold and nictitating membrane or nictitans, and I follow their recommendation in restricting the meaning of subocular fold to indicate a poorly developed lower eyelid. The presence of a nictitans or its state of development has sometimes been assumed from the presence of a subocular fold or its length relative to the length of the eye. Although there are differences in the extent of development of the subocular fold in different species, there is also much variation within species apparent in museum specimens, some of it due to differences in methods of preservation. Winking by the nictitans was observed in the two European *Scyliorhinus* Gilbert (1963), but its functional movement has not been observed and reported for other scyliorhinids.

In males the extent of union of pelvic fins along their inner edges is variable in the material examined. In one immature male the inner edges are united throughout, and one adult male has fins that are not united at all. Other males examined have fins united along two-thirds to three-fourths of their inner margins. Bigelow and Schroeder (1948) state that male *S. torrei* have claspers extending far beyond the tips of the pelvics. The illustration (1948, fig. 35), however, shows that the claspers of their largest specimen reach only a short distance beyond the pelvic tips. In the material at hand, the fully calcified claspers of one adult male (the largest) fail to reach the tips of the pelvics. In two others the claspers extend a very short distance beyond the tips of the pelvics. The ventral (outer) surfaces of the claspers, in the unflexed condition, are covered with denticles except for the extreme tip. Denticle points are directed anteriorly (toward the clasper base) as in other sharks of the suborder Galeoidea. The inner surface does not have either denticles or hooks in the position indicated by Schmidt (1930) for hooks on claspers of *Scyliorhinus torazame* (Tanaka). On the adult male *S. torrei* at hand, there are somewhat irregular series of slightly enlarged denticles having sharp points directed ante-

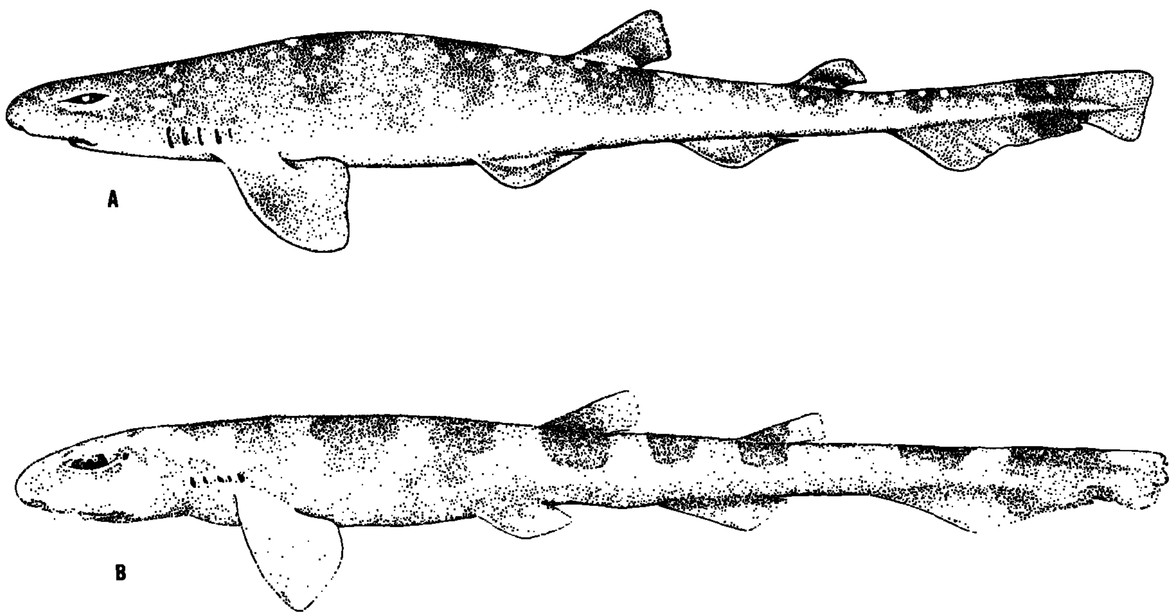

FIGURE 14.—A, *Scyliorhinus torrei* Howell-Rivero, drawn from a 258-mm. adult female collected at M/V *Silver Bay* station 2457; B, *Scyliorhinus meadi* new species, drawn from a 190-mm. young male taken at M/V *Combat* station 51.

riorly (toward the base of the clasper), but these denticles are on the side of the rhipidion adjacent to the main axis of the shark and in quite a different poistion than the hooks of the claspers of *S. torazame*.

The claspers of *S. torrei* are quite small and simple structures as compared with the claspers of *Galeus area*. The claspers of an adult male *Galeus arae* 275 mm. long are obviously more than 10 times the weight or volume of the claspers of an adult male *Scyliorhinus torrei* 272 mm. long and are considerably more complicated.

The stomach on one *S. torrei* contained cephalopod remains (beaks) including a cartilaginous eye capsule (*Sepia?*) 12 mm. in minimum diameter. Also present were several fish scales 4 to 7 mm. in breadth.

In addition to specimens for which measurements are summarized in table 4 (M/V *Silver Bay* stations 2457 and 3474 in Santaren Channel), specimens have been seen from M/V *Silver Bay* stations 2475 and 2477 in Santaren Channel; from M/V *Oregon* stations 1340 and 1343, also in the Santaren Channel; from M/V *Oregon* stations 2482, 3474, and 3512, northward from the Santaren Channel to the offing of Jupiter, Florida; and from M/V *Oregon* station 2650, near the Virgin Islands. Previously recorded specimens were from the north coast of Cuba (Bigelow and Schroeder, 1948). All recorded captures were from 366 to 550 m. except the one near the Virgin Islands which was in 229 m.

The teeth in the specimens at hand are in 21+21/20+2+20 to 23+23/21+1+21 rows. The tooth shape is similar to that of other Atlantic species of *Scyliorhinus*. In the specimens examined, the cusps of the extreme lateral teeth of the lower jaw are variably reduced, in some almost absent.

Scyliorhinus meadi new species

Figures 3, 7, 14, and 27; tables 1, 3, and 4.

Holotype.—An immature male, USNM 188049, 247 mm. in total length, taken at M/V *Silver Bay* station 3711, lat. 28°21′ N., long. 78°51′ W., at 329-m. depth off Cape Kennedy, Fla., January 26, 1962.

Additional material examined.—The species is known only from the holotype, an immature male and two immature females from the same station as the holotype, an immature male from M/V *Silver Bay station* 2475 from 549-m. depth in Santaren Channel, and an immature male from M/V *Combat* station 51, off St. Augustine, Fla. in 329-m. depth.

Diagnosis.—*S. meadi* differs from other species of the genus *Scyliorhinus* in color pattern. The upper parts are light gray in fresh specimens (brownish in specimens preserved in alcohol) with seven quite distinct darker rectangular blotches or saddles extending across the middorsal area, the first anterior to the pectorals, the second and largest (in specimens of the type series) at the level of the pectoral tips, the third anterior to the pelvic origin, the fourth through the first dorsal fin, the fifth through the second dorsal fin, the sixth at the base of the caudal fin, and the seventh across the caudal fin, anterior to the notch. In additional to the dorsal saddles, a series of lateral blotches of color alternate in more or less checkerboard fashion with the first three or four dorsal saddles, some of these extending indistinctly to the upper surfaces of the pectoral and pelvic fins. Traces of additional dorsal blotches are present between some of the principal dorsal saddles in some of the specimens. Lighter colored areas are included in some of the blotches, but these are indistinct and larger than the eye.

Two species of *Scyliorhinus*, *torrei* and *retifer*, are present in the same geographical area as *meadi*, but the color patterns of these are so strikingly different from that of *meadi* that there should not be any possibility for confusing them. No intergrades have been observed.

S. meadi appears to be closest in appearance to *S. hesperius* which is described in the following pages. Differences in color pattern between the two are constant in the material examined.

S. meadi also differs from other American members of *Scyliorhinus* in having the typical dermal denticles of dorsolateral surfaces somewhat larger in comparison with specimens of equal size, somewhat more erect, somewhat narrower, and somewhat more widely spaced. These differences are all a matter of degree and are not necessarily apparent unless specimens of similar size are compared. The differences do, in combination, give *S. meadi* a more shaggy appearance than any of the other American representatives of the genus.

Description of holotype.—An immature male, 247 mm. in total length and having dimensions as given in table 3. Body robust, caudal axis little elevated; head broad; snout broadly rounded, short; nasal flaps rather large, separated from one another in the midline, nearly reaching mouth, no groove connecting nasal apertures with mouth; mouth broad, strongly arched; well-developed labial folds along the inner sides of the jaws extending about one-fourth the distance toward the symphysis, no labial folds along outer margins of jaws; orbital opening elongate, slitlike, a well-developed fold below the eye, not touching eyeball; spiracle small, its diameter less than one-fifth length of eye, located slightly below level of eye and at a distance about one-third the eye's longitudinal diameter from corner of eye; third gill slit above origin of pectoral, fourth, and fifth gill slits over pectoral; first dorsal fin slightly larger than second, its origin over the posterior half of base of pelvics and slightly nearer tip of snout than tip of caudal fin; pelvic fins united along their inner margins for about half the distance from cloaca to fin tips; pectorals broad, their free corners rounded, distal margins nearly straight.

Bases of typical denticles of dorsolateral surfaces separated from one another by distances one to four times the diameter of their bases; denticles three pointed, the central point long and heavy, lateral points weak and quite small with a strong central ridge, most denticles nearly erect, much longer than wide, their points directed upward and posteriorly; belly denticles similar; a few denticles of the edges of fins flattened, leaf-like, and without lateral points.

Teeth similar in the upper and lower jaws, three-cusped with an additional pair of lateral denticles on some teeth; the central cusp of teeth of the midportion of the upper jaw about twice as high as lateral cusps; teeth toward the angles of both jaws and in the lower jaw with somewhat lower central cusps; about three series of teeth functional, in about 25+0+25/25+0+25 rows.

Color pattern as described in preceding key and diagnosis.

Notes.—*S. meadi* specimens were collected within the general geographical range of *S. retifer* and adjacent to the areas in which *S. torrei* have been found. It is possible that all three species occupy different habitats. Species of *Scyliorhinus* taken by exploratory fishing vessels off the southeastern States and in the Caribbean have been, with one exception, collected from depths between 180 and 914 m. Along much of the Atlantic coast this is a relatively narrow strip (fig. 1). In the Florida Straits region, a wider band of sea-bottom falls within this depth range and supports a remarkably diverse fauna of sharks and rays. Collections in the area in general suggest that many of these have quite restricted distributions, possibly due to narrow habitat preferences.

S. meadi is named for Giles W. Mead, who first called my attention to a specimen of the species.

Scyliorhinus boa Goode and Bean, 1896

Figures 15 and 27; tables 1, 3, and 4

Scylliorhinus boa Goode and Bean, Spec. Bull. U.S. Nat. Mus., p. 17, 1896 (type locality, *Blake* station 291, off Barbados).

Catalus haeckelii Miranda-Ribeiro, Mem. Mus. Nac. Rio de Janeiro, 14:163, pl. 8, 1907.

Scyliorhinus fernandezi Weibezahn, Novedades Cient. Mus. Hist. Nat. La Salle, Caracas, Ser. Zool. No. 9: 3–7, 1953.

Goode and Bean (1896, p. 17) did not intend to describe the species but did, in fact, satisfy the requirements of a valid description by publishing a name and a diagnosis based on the single 6-inch specimen collected off Barbados which is the type (Harv. Mus. Comp. Zool., 1335). They note a general correspondence in color with *S. retifer* and state that in approximately the track of the narrow lines observable in Garman's specimen (*S. retifer*) may be found various spots and blotches of blackish-brown. The similarity to a basic color pattern in each of the Atlantic American species has been mentioned. In the 14 specimens of *S. boa* examined and reported in table 3 and a few other specimens that have been examined, the color pattern is consistent in the absence either of the reticulating black lines or of continuous unbroken black lines around saddles that characterize specimens of *S. retifer* at all ages. Also none of the specimens of *S. boa* examined have white spots in the saddles as do all of the specimens of *S. hesperius* examined.

The pattern of spots in *S. boa*, however, does vary considerably. The dorsal saddles or their outlines are obscure in one specimen, and small black spots are quite numerous and randomly distributed over the dorsal and lateral surfaces. In most of the specimens the saddles and lateral blotches are outlined by discrete black spots, more or less round and much smaller than the eye. The spots extend on to the upper surfaces of the pectoral and pelvic and are present on the dorsal fins and on both the upper and lower lobes of the caudal fin.

Species described as *Catulus haeckelii* Miranda-Ribeiro, 1907, and as *Scyliorhinus fernandezi* Weibezahn, 1953, are regarded here as being synonymous with *S. boa*. The geographical range of *S. boa* extends at least from the continental slope of central Venezuela eastward and southward to Rio de Janeiro where it was taken by Miranda-Ribeiro (1907). Dr. Elvira M. Siccardi has told me (personal communication) of the presence of *S. boa* or a closely allied population off the northerly coast of Argentina. A photograph of one specimen shows somewhat longer and larger black spots than characterize the specimens seen from Venezuela and the Guianas. Whether the juvenile specimen reported by Bigelow and Schroeder (1948) from the north coast of Cuba is correctly identified as *S. boa* now appears questionable. Material examined in this study in addition to the type is from 10 stations of the M/V *Oregon* off the coasts of Venezuela, the Guianas, and Brazil, from lat. 11°34′ N., long. 62°52′ W., to lat. 01°52′ N., long. 46°54′ W., in 293 to 402 m.

The teeth in *S. boa* in specimens examined were from 24+24/21+1+21 to 25+25/23+1+23. The teeth were somewhat smaller than the teeth of other western Atlantic *Scyliorhinus* of similar size. Also the central cusps are comparatively shorter, and nearly all teeth have five cusps, with only teeth of the central part of the upper jaw having the middle cusp of each tooth twice as long as the cusps next to it.

The dermal denticles of the dorsolateral surfaces differ from the denticles of *S. meadi* in being smaller, wider (some of them nearly as wide as long), set closer together, and less erect. The denticles of *S. boa* differ very little from denticles of other Atlantic American members of the genus. Denticle differences due to age and perhaps also to intraspecific variation are so great, however, that these are probably not ordinarily useful in identifying material.

S. boa seems to be a smaller species than *S. retifer* or *S. hesperius*, since a 346-mm. male is sexually mature. The claspers of this male reach 4 mm. past the tips of the pelvics which are united to one another along their inner margins to within 6 mm. of their tips. The claspers are not provided with hooks but have a few slightly enlarged denticles which have points directed anteriorly (toward the base of the claspers) as in the denticle arrangement on claspers of all galeoid sharks.

Scyliorhinus retifer (Garman), 1881

Figures 2, 5, 6, 7, 8, and 27 ; tables 1, 3, and 4

Scyllium retiferum Garman, Bull. Mus. Comp. Zool. 8:233, 1881 (type locality, lat. 38°23′ N., long 73°34′ W.).

This species is easily recognized by its unique pattern of reticulating lines sometimes reduced to black edging lines along margins of saddles and blotches. It is the only Atlantic American catshark known well enough to have acquired an English common name, the chain dogfish. It is frequently taken by trawlers operating off the Virginia Capes.

The known range of the species extends from the offing of southern New England and the southwestern edge of Georges Bank to Nicaragua. Bigelow, Schroeder, and Springer (1953) note that it has been taken at depths of 73 to 229 m. in the northern part of its range. Specimens of *S. retifer* have been seen from more than 100 stations of Bureau of Commercial Fisheries Exploratory Fishing vessels between the Virginia Capes, the lower Gulf of Campeche, and off central Nicaragua (lat. 13°30′ N., long. 82°00′ W.), along the continental slope. The station with the least depth was at 165 m. off Cape Henry, Va., where over 500 juveniles about 160 to 200 mm. long were taken in early May, 1961. Southward the collections were at greater depths, for the most part from 330 to 450 m. off Florida and in the Gulf of Mexico, but 500 to 550 m. off Nicaragua. One specimen of *S. retifer* was taken from M/V *Oregon* station 1883 on the continental slope off Honduras at 365 m. where a specimen of *S. hesperius* was also taken. Southward from this station along the continental slope for a distance of about 200 miles, where the two forms occupy adjacent or nearly overlapping ranges, *S. retifer* was taken in an average depth of 525 m. (460 to 550 m.) at 16 stations, while *S. hesperius* was taken at an average depth of 400 m. (274 to 530 m.) at 7 stations.

A peculiarity of the distribution of *S. retifer* is that records of it occurrence on the Antillean side of the Straits of Florida (off Cuba and the Bahama Banks) are absent. *S. torrei* records are chiefly from this area, and one of the three sta-

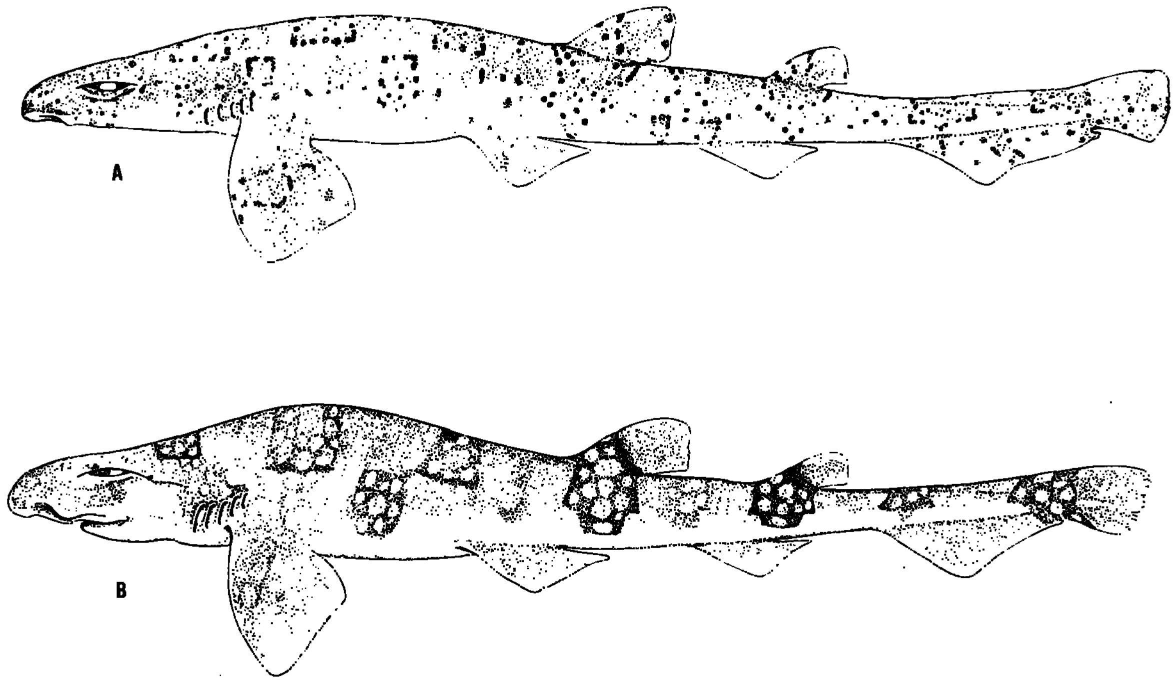

FIGURE 15.—A, *Scyliorhinus boa* (Goode and Bean) drawn from a 348-mm. female from M/V *Oregon* station 2351; B, *Scyliorhinus hesperius* new species, drawn from a 260-mm. female from M/V *Oregon* station 1883.

tions where *S. meadi* was taken is close to the Bahama Banks.

Despite the extensive collection of *S. retifer* available for study, few of the specimens are adults. A male, 395 mm. in total length, taken by the Bureau of Commercial Fisheries M/V *Delaware* in 128 m. off Delaware Bay, was the only specimen observed that was determined to be sexually mature.

A 475-mm. female taken from 402 m. off Pensacola, Fla., was the largest specimen examined. The ovary was extremely small, without evidence of developing eggs.

The stomach of the 475-mm. specimen contained 12 cephalopod beaks of more than one type.

Teeth of specimens of *S. retifer* are in 21+21/19+2+19 to 26+26/21+4+21 in specimens examined. In form, the teeth of *retifer* do not differ greatly or consistently from teeth of other Atlantic American species of *Scyliorhinus*.

Scyliorhinus hesperius new species

Figures 7, 9, 15, and 27; tables 1, 3, and 4.

Holotype.—An immature female, USNM 187732, 415 mm. in total length, taken at M/V *Oregon* station 3598, lat. 09°03′ N., long. 81°22′ W., at 360- to 400-m. depth on the Caribbean coast of western Panama, May 31, 1962.

Additional material examined. Twelve specimens, 177 to 466 mm. total length, taken at M/V *Oregon* stations 1870, 1883, 3522, 3565, 3574, 3575, 3598, 3599, 3626, 4480, and 4482, all in the western Caribbean from the vicinity of Jamaica and Honduras, southward to Panama and off Barranquilla, Columbia, in 274- to 530-m. depth.

Diagnosis.—*S. hesperius* resembles *S. boa*, *S. meadi*, and *S. retifer* in proportions and external structural features but differs from these species in having from 2 to about 35 round white spots, smaller than the diameter of the eye, within each of the dorsal saddles and lateral blotches. The species differs from *S. retifer* in the absence of reticulating lines or in the absence of darker margins around the saddles and blotches. It differs from *S. boa* in the absence of small black marketings either scattered or outlining the saddles and blotches. The presence of small white spots in *S. hesperius* separates it from *S. meadi* in all the specimens seen. The white spots in *S. hesperius* are concentrated in the saddles and blotches and are not more or less randomly distributed as in *S. torrei*.

Description of holotype.—An immature female, 415 mm. in total length and having dimensions as given in table 3. Body robust, caudal axis not elevated; head broad; snout broadly rounded, short; nasal flaps rather large, each with a central swelling dividing each flap into two portions which cover the two parts of each nasal aperture, separated from one another in the midline, nearly reaching mouth, no groove connecting nasal apertures with mouth; mouth broad, moderately arched; well-developed labial folds extending a short distance along the inner sides of lower jaws, no labial folds along outer margin of upper jaws; orbital opening elongate, slitlike, a well-developed fold below eye, not touching eyeball; spiracle small, located short distance from rear corner of eye, about same level as eye; fourth and fifth gill slits over pectoral base; first dorsal origin over end of base of pelvics, its area about twice that of second dorsal; second dorsal origin slightly in advance of posterior end of anal fin base; anal fin origin very slightly posterior to free tip of first dorsal, its free tip reaching end of base of second dorsal; caudal fin less than one-fourth total length; pectoral fins broad, short, their distal margins nearly straight; pelvic fins united along their inner margins about half the distance from anus to fin tips.

Denticles, three-ridged, imbricate, with a single strong apical (posterior) point with a weak lateral point on each side, denticle size not uniform, some twice as large as others.

Teeth similar in upper and lower jaws, small, in 24+0+24/22+2+22 rows; each tooth with 3 or more smooth-edged cusps, the central cusp longest, most teeth with two pairs of lateral cusps, the outer pair very small.

Color pattern of type approximately as illustrated for specimen shown in figure 15B.

Schroederichthys new genus

Type species—*Schroederichthys maculatus* n. sp.

Members of this genus differ from nearly all other sharks in having the postpelvic trunk region in advance of the caudal fin greatly elongated, the distance from the origin of the pelvics to the origin of the caudal fin lobes about one and three-fourths times the distance from the tip of the snout to the origin of the pelvics. In this character of body proportions, members of the genus *Schroederichthys* show a parallel development with some Australian sharks of the family Orectolobidae, particularly *Hemiscyllium*. These orectolobids, however, have quite different arrangements of parts near the mouth and have nasoral grooves and barbellike structures. In *Schroederichthys* also the anal fin is separated from the lower caudal lobe by a considerable distance (a distance equal to about two times the length of the base of the anal), whereas in some orectolobids (*Hemiscyllium* and related genera) only a notch separates the anal from the lower caudal lobe.

Schroederichthys differs from *Scyliorhinus* in having definite though short labial grooves along both upper and lower jaws at the corners of the mouth. It is similar to the two Chilean-Patagonian species provisionally referred to the genus *Halaelurus* in having upper labial grooves or folds. *Schroederichthys* differs from these species in having a somewhat longer postpelvic trunk, shorter labial grooves, and consistently (at all ages in *S. maculatus*) multicusped teeth in both jaws.

Generic description.—Small slender sharks of the family Scyliorhinidae having greatly elongated caudal regions with relatively short caudal fins; distance from tip of snout to vent about half the distance from vent to tip of tail; caudal axis little elevated, lower caudal fin not produced as a lobe; two dorsal fins, second dorsal slightly larger than first and similar in shape, first originating behind posterior end of pelvic base; anal fin relatively low, its base longer than base of either dorsal fin; pectoral fins relatively broad, their distal margins straight or very slightly convex, their outer corners rounded; pelvic fins with their inner-posterior corners somewhat produced and their distal margins oblique, pelvics of males united at bases for a very short distance, not forming an apron.

Snout only moderately rounded; nasal flaps small but extending across the nasal apertures; nostrils not united with mouth by a groove and separated from mouth by a distance as great as or greater than width of nasal flap; mouth strongly arched; labial grooves short but extending around corners of mouth; eye elongate, with well-marked fold below, not in contact with eye; spiracle small, on level of eye and close behind it; gill slits five, anterior longest, two posterior slits over pectoral base; no ridges or keels in skin, no precaudal pits, a shallow groove on midventral line posterior to pelvics and extending, interrupted by anal fin, nearly to lower caudal fin.

Teeth similar in upper and lower jaws (fig. 9), principal ones with three or five cusps, central cusp of each tooth much the longest, three to five series functional. Dorsolateral denticles (fig. 7F) for the most part imbricate, three pointed, the central posteriorly directed point much the longest, ventral denticles leaf-shaped, with a single point.

Vertebrae (in 36 specimens) 132 to 142, monospondylous vertebrae 29 to 35.

Type species oviparous, eggshells (fig. 19) with rather thick walls, their surfaces striated longitudinally, opaque, about 44 mm. by 14 mm., not including tendrils developed at the four corners.

Claspers of adult males of type species long, extending well beyond tips of pelvics, their tips tapered, without hooks; clasper siphons very large, long, extending under skin of belly as far forward as axils of pectorals.

Livers relatively small, occupying only the anterior half of body cavity in adults.

General pattern of seven dorsal saddles of darker color showing at least in young; sometimes obscure in adults in the type species.

The genus is named for William C. Schroeder, whose careful and pioneering work with Henry B. Bigelow on cartilaginous fishes contributed greatly to a renewal of interest in problems relating to this important group of marine animals.

Schroederichthys maculatus new species

Figures 4, 5, 7, 9, 16, 17, and 19; tables 1, 5, and 6.

Holotype.—Adult male 328 mm. total length, USNM 185556, collected in shrimp trawl at R/V *Oregon* station 1870, August 21, 1957, from about 410 m.; lat. 16°39′ N., long. 82°29′ W., in the Caribbean sea NNW of Cape Gracias a Dios, Honduras.

Paratype.—An adult female 335 mm. in total length, taken in the same haul with the holotype.

Diagnosis.—*Schroederichthys maculatus* is readily distinguished from sharks of all other genera by the proportionately greater length of the tail region. It differs from the other species of *Schroederichthys* described in this paper in color, in the shape of the nasal flap, which in *S. maculatus* is triangular with a somewhat bilobed distal margin as compared to the narrower, longer flap with a simple rounded tip of the other species. The color differences are so great between the two species of *Schroederichthys* that other differences are of comparatively little interest for practical identification of the two forms. *S. maculatus* has a color pattern almost identical with that of *Scyliorhinus torrei* Howell-Rivero. The dorsal surfaces are tan or light brown with round, ovoid, or irregularly shaped white or cream-colored spots about 1 to 3 mm. in diameter scattered over the dorsal surfaces except on the surfaces of the dorsal

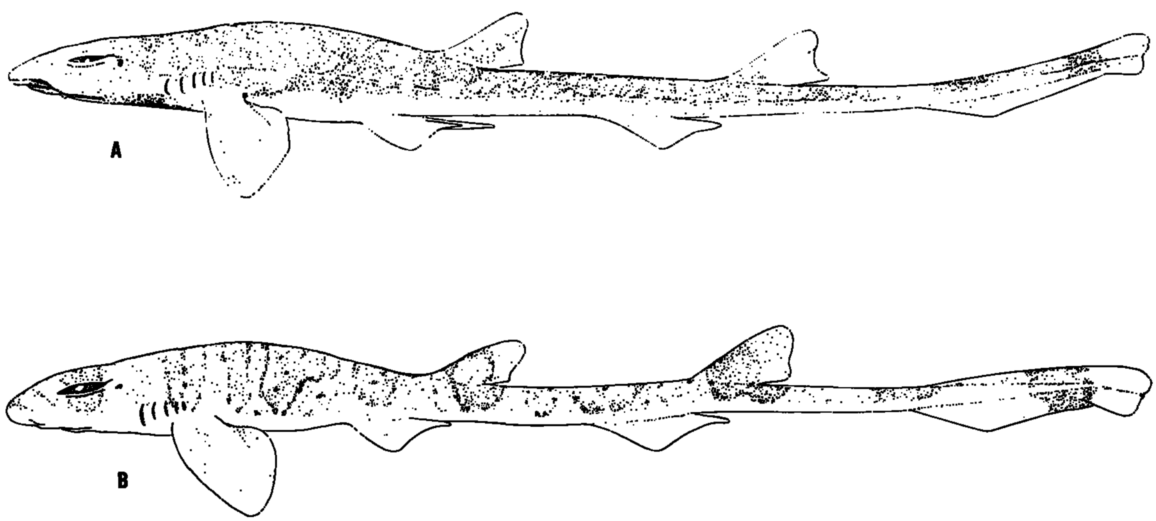

FIGURE 16.—A, *Schroederichthys maculatus* new species, drawn from the type, USNM 185556, a 328-mm. adult male; B, *Schroederichthys tenuis* new species, drawn from the type, USNM 188052, a 230-mm. immature male.

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fins and the paired fins, and with traces of 10 dorsal saddles appearing as areas of somewhat intensified brown color; these saddles are obscure or absent anteriorly in some adults. This color pattern is so close to that of *Scyliorhinus torrei* that specimens in a mixed lot of the two species are not readily distinguishable from one another on the basis of color. The other species of *Schroederichthys* resembles *Scyliorhinus boa* in general coloration, having a pattern of dark spots spots and lines on a lighter background.

Description of the holotype.—The holotype is shown in figure 16A, and measurements are given in table 5. Teeth in 24+2+24/(18+)+2+(18+) rows; most of them tricuspid but some with additional small lateral cusps; largest upper jaw teeth about 0.9 mm. high by 0.7 mm. in greatest width, central cusp projecting beyond base about five times length of lateral cusps, edges of cusps smooth, six or more low surface ridges extending from bases about half-way toward tips of cusps; lower jaw teeth similar but central cusps somewhat lower, length of central cusp of largest tooth about four times height of lateral cusps, surface ridges very short, present only on lower portion of the bases.

Typical denticles of dorsalateral surfaces about 0.4 mm. long by about 0.2 mm. wide, with three points directed upward and posteriorly, central point much the longest, not very close set, with skin surface showing around each denticle but points overlapping, imbricate.

Color of dorsolateral surfaces of body light brown with numerous round or oval spots of lighter color, about half the length of the eye or smaller and irregularly scattered; darker brown dorsal saddles without definite darker edging present but obscure anteriorly and extending to fins only as a trace of darker color; no definite spots on fins; ventral surfaces white, unmarked.

Notes.—*Schroederichthys maculatus* is known from 48 specimens, all from the Caribbean continental slope of Central America off Honduras and Nicaragua. The specimens were collected from depths of 190 to 410 m., most of them near Rosalind Bank and Quita Sueño Bank. The capture of more than 30 specimens in one net haul suggests that the species is locally abundant.

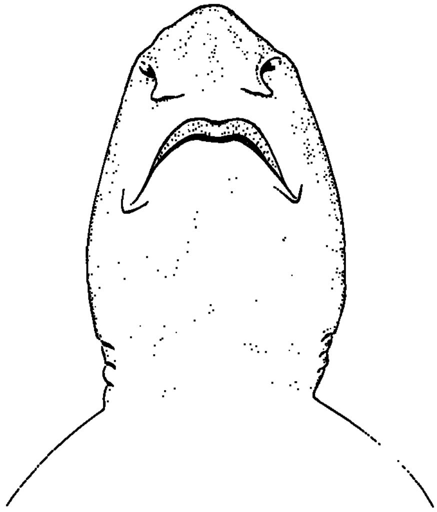

FIGURE 17.—*Schroederichthys maculatus* new species, ventral side of head of the type, USNM 185556.

Schroederichthys tenuis new species

Figures 16 and 18; tables 1, 5, and 6.

Holotype.—An immature male 230 mm. in total length, USNM 188052, collected in a shrimp trawl at M/V *Oregon* station 2083 on November 17, 1957, from about 410 m. at lat. 01°49′ N., long. 46°48′ W., in the Atlantic off the mouth of the Amazon River.

Paratype.—An immature male 180 mm. long, USNM 188053, taken in the same haul with the holotype.

Diagnosis.—*Schroederichthys tenuis* is known only from the types, both immature males. There appear to be no important differences in body proportions between these specimens and specimens of *S. maculatus* of comparable size. *S. tenuis* is, of course, readily separable from sharks of other genera. From *S. maculatus*, it differs greatly in color pattern. In addition, *S. tenuis* has a nasal flap longer than wide, and its tip is simply rounded, not pointed or bilobed. The typical dermal denticles of dorsal surfaces in *S. tenuis* are proportionally somewhat narrower than in *S. maculatus* and more erect. Some have three posteriorly directed points, but many of them lack lateral points and are needlelike, although usually showing a central ridge. The color pattern of *S. tenuis* is made up of dark spots on a lighter ground color, the spots assembled to form a series of dorsal saddles.

Description of holotype.—The holotype is shown in figure 16B and measurements are given in table 5. Teeth in 22+22/16+2+16 rows, about half with three cusps and half with five cusps. Color of dorsolateral surfaces light brown without lighter colored spots or markings; pattern of seven dorsal saddles plus several more or less distinct intermediate saddles edged with broken lines of darker color, saddles at the first dorsal and second dorsal fins more intense and extending across the fins, caudal fin strongly marked, paired fins and anal fin only faintly marked.

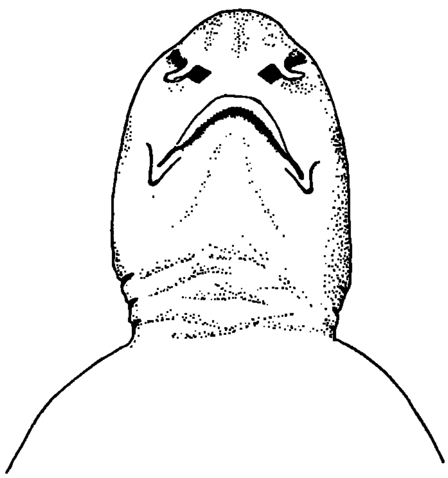

FIGURE 18.—*Schroederichthys tenuis* new species, ventral side of head of the type. USNM 188052.

Notes.—The collection of only two specimens of this species nearly 2,000 miles from the area from which *S. maculatus* is known illustrates the incompleteness of the sampling of the fauna from continental slopes.

Genus *Galeus* Rafinesque, 1810

Type species—*Galeus melastomus* Rafinesque, designated by Fowler, 1908.

Galeus is a genus with about eight nominal species, one of which, *Galeus melastomus* Rafinesque, of the eastern North Atlantic region, is well known. Members of the genus are characterized by the presence of a spiny crest of enlarged denticles on the upper margin of the caudal fin (fig. 21) and a comparatively long snout. An Australian scyliorhinid with enlarged denticles forming crests along both the upper margin of the upper caudal lobe and the anterior margin of the lower caudal lobe has been split off from *Galeus*

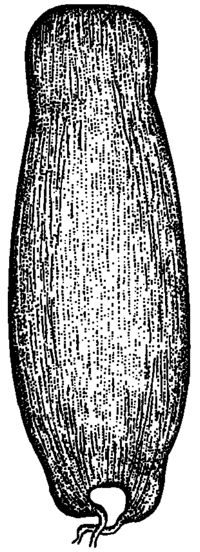

FIGURE 19.—Partially formed egg case of *Schroederichthys maculatus* taken from an oviduct of a 342-mm. female collected at M/V *Oregon* station 1870, August 21, 1957. The egg case was 44 mm. long by 14 mm. in greatest width, and the posterior tendrils (broken off in drawing) were 225 mm. long. The anterior end of the egg case was still within the nidamental gland area when taken, and anterior tendrils had not formed. The egg case wall was rather thick, opaque, olive colored, and striated longitudinally.

under the name *Figaro boardmani* (Whitley). A group of two Pacific scyliorhinid species, *Parmaturus xaniurus* (Gilbert) and *P. pilosus* Garman, have crests with specialized denticles along the upper margin of the caudal fin, but these crests extend somewhat onto the lateral surface of the upper caudal lobe, and the marginal scales, although enlarged, do not project outward from the tail to the degree characteristic of these scales in *Galeus*. Also, these sharks, *Parmaturus*, have comparatively short snouts and broad heads, much different in general shape from members of the genus *Galeus*. One other cat shark, *Apristurus profundorum* (Goode and Bean), also has denticles on the upper margin of the dorsal fin differing in size and shape as well as in spacing from denticles on the lateral surfaces of the tail and most other parts of the body (see fig. 23). The crest is less well defined in *Parmaturus* than in *Galeus*, and in *Apristurus profundorum* there are no enlarged and projecting denticles marking the margin of a crest.

The presence of an upper caudal crest with much enlarged marginal scales, the crest not extending appreciably onto the lateral surface of the tail, appears to be a unique feature of *Galeus* and sufficient for diagnosis in the present treatment of scyliorhinid genera. Other characters, such as the long and structurally specialized claspers, may also be useful in the definition of the genus; but until more Pacific and eastern Atlantic specimens have been examined, I wish to avoid tampering with generic definitions and will rely on characters clearly outlined in the literature.

Species of the genus as presently understood may be divided into two groups on the basis of color pattern. One group comprises plain colored species, sometimes with fin markings of contrasting color but without a pattern of cloudy spots or blotches generally distributed over dorsolateral surfaces. Plain colored species are *Galeus sauteri* (Jordan and Richardson) of the western Pacific and *Galeus jenseni* (Saemundsson) and *Galeus murinus* (Collett) of the northeastern Atlantic. Another western Pacific species, *Galeus hertwigi* (Engelhardt), said to have a short snout and a tail with contrasting color pattern, has been included in the genus *Galeus* by Fowler (1941).

The other group of the genus is characterized by the presence of a pattern of blotches or spots over the dorsolateral surfaces. This group includes *Galeus melastomus* Rafinesque of the eastern North Atlantic, *Galeus polli* Cadenat from the west coast of Africa, and the western Atlantic forms treated here. In addition, a Pacific species, *Galeus eastmani* (Jordan and Snyder, 1904), has been described as having "indistinct clouds of deeper shade." It appears from examination of the type (SU 7740) that these markings are less pronounced than in any of the western Atlantic forms. *Galeus eastmani* differs markedly from Atlantic species in being more slender, having a more sharply pointed snout, having a larger spiracle, and in having heavier denticles.

KEY TO ADULT SPECIMENS OF WESTERN ATLANTIC *GALEUS*

1A. Anal fin long, its origin under a vertical through the posterior tip of the first dorsal fin and its rear tip nearly reaching (to within one-half diameter of the eye) origin of lower caudal lobe__ *Galeus cadenati* n. sp.

1B. Anal fin short, its origin in back of a vertical through the posterior tip of the first dorsal fin and its rear tip separated from the origin of the lower caudal lobe by a distance equal to the horizontal diameter of the eye or more________ *Galeus arae* (Nichols)

Galeus arae (Nichols), 1927

Figures 4, 5, 7, 20, 21, and 27; tables 1, 5, and 6.

Galeus arae is a much smaller species than *G. melastomus* of the eastern North Atlantic and Mediterranean. None of the *G. arae* seen exceed 37 cm. while *G. melastomus* reaches a length of over 90 cm. *G. melastomus* lays eggs in leathery cases similar in general appearance to egg cases of other scyliorhinids. Although adult female *G. arae* with large ovarian eggs have been collected, none have been observed with eggs or embryos in the oviducts and no egg cases have been collected that can be referred with confidence to western Atlantic *Galeus*.

Galeus arae is very commonly taken in shrimp trawls off the coast of Florida, both in the Atlantic and the Gulf of Mexico. Examples have been recorded for more than 100 stations of exploratory fishing vessels, usually with several specimens from each station. Collections from single hauls indicate strong tendencies to segregation by size and sex, but no well-defined pattern in the depth of occurrence of immature or of adult males or females has appeared.

The records at hand show *Galeus arae* to be locally common from about 330- to 460-m. depth around Florida, from the offings of Jacksonville to Pensacola, and usually at greater depths, 400 to 620 m., in the Yucatan Channel, near Pedro Bank and Jamaica, and around some of the banks and islands of the Caribbean off the coasts of Nicaragua and Costa Rica southward to lat. 13°30′ N. Three atypical specimens from the vicinity of Puerto Rico, provisionally referred to *G. arae*, are from 293- and 402-m. depth. The Puerto Rican specimens are more robust than the typical *G. arae* and have a poorly defined pattern of spots (fig. 20C). They may represent an undescribed species, but closely resemble *G. arae* in morphology and proportions. Larger series are needed to assess the status of the Puerto Rican specimens.

Bigelow and Schroeder (1948), referring to a series of specimens taken off Tortugas and off the north coast of Cuba, note that one specimen of about 295 mm. has claspers falling short of the tip of the pelvics, while in another male of 317 mm., the claspers extend far beyond the tips of the

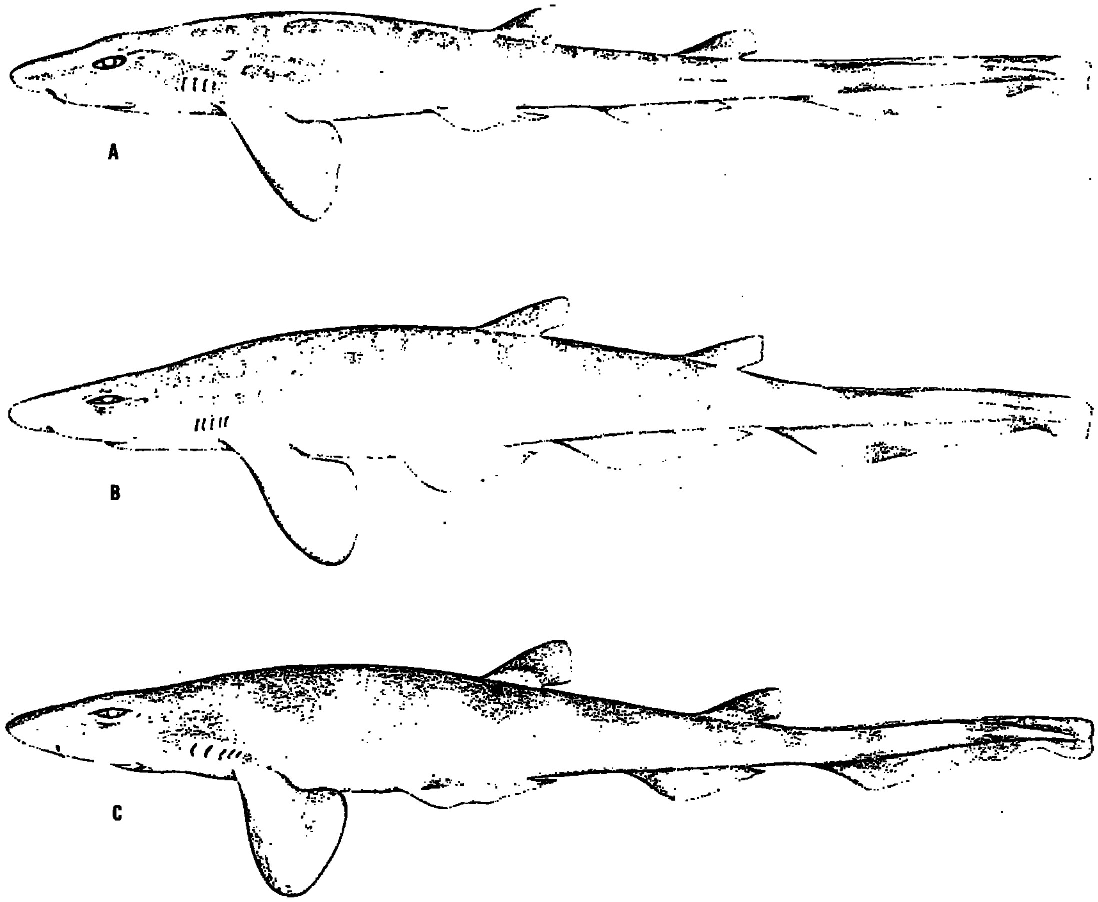

FIGURE 20.—A, *Galeus arae* (Nichols), drawn from a 290-mm. female; B, *Galeus cadenati* new species, drawn from a 300-mm. female; C, *Galeus arae*, drawn from a 320-mm. female from Puerto Rico, showing color pattern found on large examples from that area.

pelvics. From this they conclude that maturity is probably attained at about 300 mm. The extensive series of *G. arae* that I have examined includes large numbers of adult males from the Florida and Central American slope. These are 265- to 290-mm. specimens for the most part, and no examples of either sex exceed 330 mm. The specimens from Puerto Rico already mentioned include two adults, a 368-mm. male, and a 352-mm. female. They are not only appreciably larger than any observed from the continental slope but also differ in some body and fin proportions. As shown in table 6, the Puerto Rican specimens have a proportionally shorter anal fin and differ in other measurements from Florida examples of *G. arae*.

Galeus cadenati new species

Figures 20, 21, and 27; tables 1, 5, and 6.

Holotype.—A female 303 mm. in total length, USNM 260468, F1 collected at R/V *Oregon* station 3592, lat. 09°13′ N., long. 80°44′ W., in 439-m. depth off the Caribbean coast of Panama, May 30, 1962.

Diagnosis.—A small species of the genus *Galeus* differing from *G. arae* in having a comparatively longer anal fin (13.2 to 15.0 percent of total length compared to 8.7 to 13.6 percent in *G. arae*) with the tip of the anal reaching nearly to the lower caudal origin, separated from it only by a distance less than half the horizontal diameter of the eye as compared to separation by a distance equal to the horizontal diameter of the eye or more in *G. arae*. The pectoral fins and the two dorsal fins of

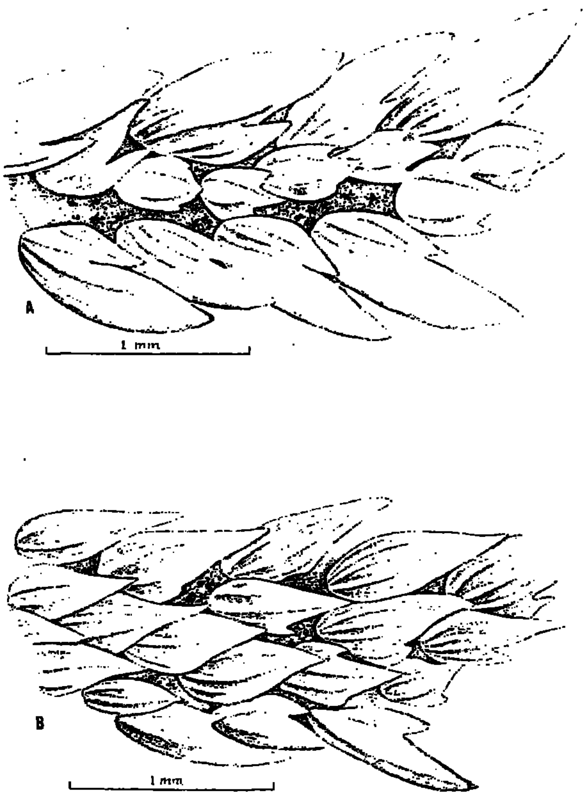

FIGURE 21.—Enlarged scales of caudal crests drawn from sections near the origin of upper caudal lobes of: A, *Galeus arae;* and B, *Galeus cadenati.*

G. cadenati are proportionally somewhat longer than the fins of *G. arae* (table 6). Minor differences in the caudal crest are shown in figure 21, the crest in *G. cadenati* being about three-fourths the width of the crests in *G. arae* of comparable size.

This species is similar to *Galeus polli* Cadenat, 1959, which is found abundantly on the west coast of Africa. I have compared specimens of the new species with a large series of *G. polli*, including examples from several localities, collected by vessels of the Guinean Trawling Survey and loaned to me through the Smithsonian Institution Sorting Center. Both *G. polli* and *G. cadenati* have long anal fins and are readily separable from *G. arae* on this basis. *G. polli* has a longer snout (as measured from the front of the mouth) and a narrower head than *G. cadenati*, but proportional differences in snout length and distance between the nostrils are not great in all specimens at hand. In Cadenat's table (1959) of proportions for four large adult *G. polli*, distances from the top of the snout to the front of the mouth are shown as 7.4 to 8.5 percent of total length as compared to 6.0 to 7.3 percent in our specimens of *G. cadenati.*

Differences between *G. polli* and *G. cadenati* that are not especially notable in comparison of measurements are easily seen in side by side comparison of the two species. *G. cadenati* has a more robust form, a wider and shorter head, and a wider and shorter mouth. The color differences in the specimens examined are also striking. The specimens of *G. cadenati* are brown with the spots and saddles of the posterior part of the trunk rather indistinct. All of the specimens of *G. polli* available for examination are grayish with black or nearly black spots and saddles. In most of the specimens the spots and saddles are more clearly defined; but a few specimens are dark all over, and the spots and saddles are indistinct.

Description of the holotype.—Measurements of the type, USNM 260468-F1, are given in table 5, and the color pattern in the type does not differ appreciably from that illustrated (fig. 20B) for the species. Body moderately slender, caudal axis not elevated, body sector (tip snout to anus) about two-fifths of total length; head broad, snout moderately pointed and not greatly flattened dorsoventrally, with large, medially located, and elongate patches of mucous pores above and below, the pore openings small, arranged in irregular rows; nasal apertures large, about half the length of snout measured to front of mouth, oblique, with a triangular flap covering the posterior opening when closed, well separated from mouth; mouth large with labial grooves above and below, the lower longer, reaching about one-fourth the distance toward the symphysis; eye large, oval, length of orbit more than two times its width, no functional nictitating membrane, but a subocular fold; spiracle moderate, located immediately behind and slightly below level of horizontal axis of eye; gill openings short, longest about half the horizontal diameter of eye, the fourth and fifth located above the origin of the pectoral; pectoral long, about two times length of snout and broad, its greatest width about two-thirds the length of its anterior margin, its distal corners rounded; first dorsal fin origin nearly over middle of pelvic base, its distal margin only slightly convex, its apical and lower tips moderately rounded; second dorsal fin about as large as first dorsal; dorsal fin bases separated by a distance about equal to length of anal base; second dorsal similar in shape to first dorsal, its origin posterior to middle of base of anal, its posterior tip separated from origin of caudal crest by a distance equal to one-half horizontal diameter of orbit; pelvic fins large and long, united and adnate to body for a short distance posterior to anus, their posterior tips pointed; anal fin long, its base 2½ times base of first dorsal, its height about equal to height of second dorsal; upper caudal with crest of modified denticles (see fig. 21B), caudal fin slightly less than one-third total length; lower caudal fin about same height as anal, its margin rounded without forming a pointed lobe, a notch near the tip.

Denticles over dorsolateral surfaces small, three pointed, the central point much the longest, similar to denticles of *G. arae* (see fig. 7).

Teeth relatively small, multicusped, largest three or five cusped with central cusp much the longest, similar in shape in upper and lower jaws, several series functional; upper teeth in 31+31 rows; lower teeth in oblique series, not readily counted by row.

Notes.—*Galeus cadenati*, so far as known, is found only in the southwestern Caribbean off the coast of Panama. Although this is quite near the range of *Galeus arae*, which occurs off the coast of Nicaragua, the collections seen show no overlapping.

Eastward and along the Caribbean or Atlantic coasts of Columbia, Venezuela, the Guianas, and northern Brazil, specimens of *Galeus* have not been reported although collections from these areas have produced many small sharks of other genera in depths at which *Galeus* would be expected to occur.

Genus *Apristurus* Garman, 1913

Type species *Scylliorhinus indicus* Brauer, 1906, by original designation.

The genus *Apristurus* as understood here (*Pentanchus profundicollis* Smith and Radcliffe is excluded) contains about 16 species. Four western Atlantic species are recognized. Members of the genus are small sharks, for the most part less than a meter long, with broad and flattened heads which are sometimes described as shovel-shaped. All of the known species are rather uniform black or dark brown in life. Lighter colors on some museum specimens (*Apristurus profundorum*) are thought to be due to handling accidents or to effects of preservatives.

Various sets of characters have been used in descriptions of species of *Apristurus*, but most authors have relied on morphometrics to define species. This has not been very satisfactory because some descriptions have had to rest on single specimens and at best the series are small. Added to this, specimens of *Apristurus* preserved in alcohol quickly become wrinkled and fragile. Measurements are difficult to make, and the body proportions and fin positions in the series measured appear to vary considerably within species.

So far as known, all species inhabit deep water, specimens for the most part being taken from depths of more than 600 m.

KEY TO WESTERN ATLANTIC *APRISTURUS*

1A. Denticles over most dorsolateral areas narrow, erect, not imbricate, their bases separated by distances greater than the diameter of a denticle base; a caudal crest of wide, imbricate denticles of about uniform size, their tips not pointed upward, forming a rather smooth surface, extending a short distance onto the lateral surface of the tail, the crest denticles in sharp contrast (see fig. 23) to the very sparsely scattered, narrow and erect denticles of the lateral surface of the tail; pelvic fins comparatively short, somewhat thickened, broadly ovate in shape; anal fin relatively high, its anterior and distal margins forming a continuous smooth curve ------------------ *Apristurus profundorum*

1B. Denticles over most dorsolateral surfaces moderately broad, close together, imbricate or at least very closely arranged with small spaces between bases; denticles of upper margin of tail not differing greatly in shape, size or density of arrangement from denticles of lateral surfaces of tail; pelvic fins comparatively long, lanceolate; anal fin either high or low but with its anterior margin and distal margin forming an angle, the two margins not rounded as a continuous curve-------------------- 2A or 2B

2A. Head comparatively narrow with narrow band of prominent mucous pores of underside of snout extending medially from front of mouth nearly to tip of snout in four or sometimes six longitudinal rows; tip of snout notably constricted at anterior end of nostrils; teeth comparatively large and sexually dimorphic -------------------- *Apristurus riveri*

2B. Head comparatively broad with a wide band of prominent mucous pores of underside of snout extending medially from front of mouth nearly to tip of snout in eight or more longitudinal rows; tip of snout not notably narrowed at nostrils; teeth comparatively small with no sexual dimorphism-------- 3A or 3B

3A. Second dorsal fin substantially greater in area than first dorsal fin; first dorsal fin origin usually behind posterior end of base of pelvic fins ---------- *Apristurus indicus*

3B. First and second dorsal fins of nearly equal area; first dorsal fin origin over the middle of the pelvic base ---------------------- *Apristurus laurussoni*

Apristurus profundorum (Goode and Bean), 1896

Figures 7, 22, 23, 25, and 27; tables 1, 7, and 8.

The type specimen of *A. profundorum*, USNM 35646, is in quite poor condition and very fragile. The fins are frayed, the skin looks scuffed, and the general impression given is that denticles, pieces of skin, and pieces of fins must be missing. Actually very little is missing although there is no doubt that the specimen had been severely damaged either when captured or during 69 years of its existence as a preserved specimen. Some questions about this specimen came up during the course of preparation of a report on sharks (Bigelow, Schroeder, and Springer, 1953), and if my memory is correct it fell to my lot to reexamine it. Apparently my reexamination missed some of the important features, and I am thus primarily responsible for failure to note that the material studied and held to be *profundorum* in that report included two species.

A. profundorum is easily separated from the other three western Atlantic species by the characters given in the preceding key. Several differences also are evident from table 8 which shows ranges of measurements in the series examined. These ranges of measurements show a lesser distance from the tip of the snout to the origin of the first dorsal fin than in the other three western Atlantic species and a lesser distance from the tip of the snout to the origin of the second dorsal. The table also shows a wide degree of variation in proportions for all *Apristurus*.

The teeth of the type, an adult male, are in 25+25/25+25 rows, and the teeth of a smaller female specimen, MCZ 38299, are in 31+31/25+25 rows. The teeth are difficult to count because they are arranged in alternate series, and the number of functional series varies from about five near the symphysis to three or less at the corners of the jaw.

The type of *profundorum* was collected from 1,492 m. off Delaware Bay, and the specimens included in the series of five specimens measured here was collected by the M/V *Cap'n Bill II* at depths from 686 to 1,317 m. off New Jersey and New England.

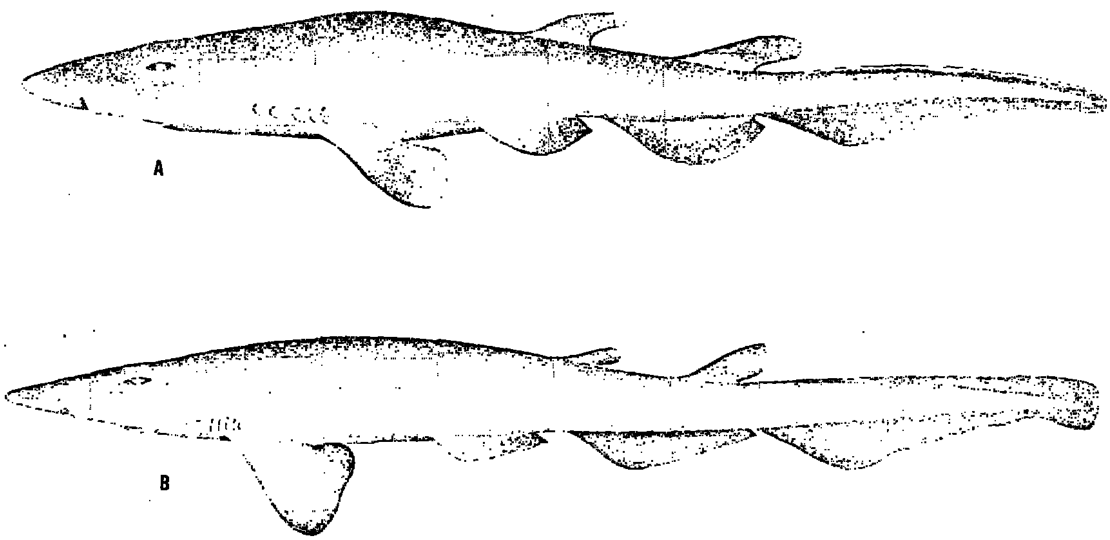

FIGURE 22.—*A*, *Apristurus profundorum* (Goode and Bean), drawn from a 390-mm. female, MCZ 38299; B, *Apristurus indicus* (Brauer), drawn from a 395-mm. female from M/V *Oregon* station 3586.

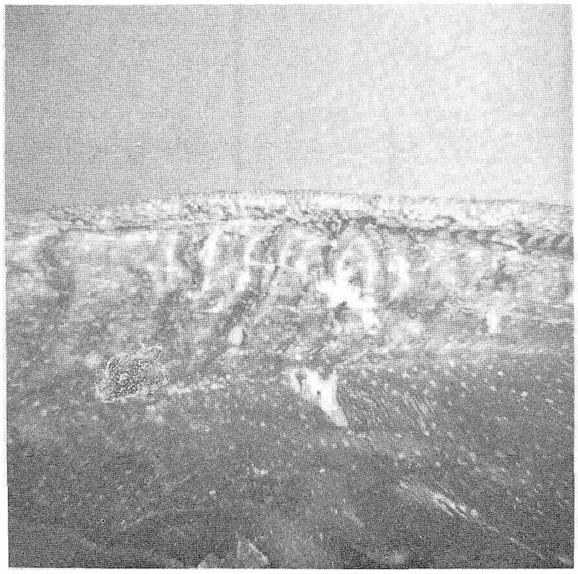

FIGURE 23.—Lateral view of portion of caudal fin of *Apristurus profundorum* (Goode and Bean), showing closely packed denticles on and near the upper margin of the fin and the widely spaced denticles on the lateral surfaces of the tail.

Apristurus indicus (Brauer), 1906

Figures 9, 22, and 27; tables 1, 7, and 8.

It is clear that the western Atlantic specimens of *Apristurus* at hand may be divided into four groups on the basis of characters given in the preceding key. Three of these groups of specimens clearly represent respectively *Apristurus profundorum* (Goode and Bean), *A. riveri* Bigelow and Schroeder, and *A. laurussoni* (Saemundsson). The fourth group includes specimens referred to *Apristurus atlanticus* (Koefoed) by Bigelow and Schroeder (1948) and Bigelow, Schroeder, and Springer (1953). The specimens available for examination are about 40 examples from the Gulf of Mexico, the Caribbean, and adjacent Atlantic waters, most of them immature. All are referred to *Apristurus indicus* (Brauer) with some missgiving because *A. indicus* has been regarded as restricted to the Indian Ocean.

Koefoed states (1927) that *atlanticus* is related both to *profundorum* Goode and Bean, and *indicus* Brauer, but that it differs in having a larger eye. From Koefoed's measurements of the type, a 247-mm. specimen from the Atlantic near Gibraltar, it can be calculated that the orbit is 4.9 percent of the total length. Among the specimens referred here to *A. indicus*, the orbit is 2.5 to 4.0 percent of the total length and in available specimens of other Atlantic species 2.2 to 3.9. Koefoed's figure of the type of *atlanticus* (1927, pl. 3, fig. 3) shows the second dorsal fin only slightly larger in area than the first. In Western Atlantic specimens of *A. indicus* the second dorsal fin has less than half the area of the first dorsal. Furthermore, Koefoed specifically states that the first and second dorsal fins of *atlanticus* are equally large.

The number of tooth rows in the western North Atlantic specimens of *A. indicus* at hand varies from 33+33/33+33 to 45+45/45+45. The teeth of these specimens are much smaller and more numerous than in *A. profundorum* and *A. riveri*. Although the teeth of *A. laurussoni* are slightly larger than in the *A. indicus* specimens, the difference is not great enough to be notable except on direct comparison of specimens of equal size.

Apristurus riveri Bigelow and Schroeder, 1944

Figures 4, 5, 7, 10, 11, 24, and 27; tables 1, 7, and 8.

In one haul with a 40-foot shrimp trawl at M/V *Oregon* station 3586 off the Caribbean coast of Panama, five *Apristurus* of about equal size were taken. The haul was made in 860 to 914 m. A temperature determination at the bottom was not made at this station but in nearby stations the following temperatures were recorded: 366 m., 11.6° C; 457 m., 8.8° C; 750 to 768 m., 5° C. Four of the specimens collected were adults of *A. riveri*, one male and three females. The fifth specimen was an immature example of *A. indicus*. Of the three female *riveri*, one had short filamentous processes of egg cases protruding. In all three the cloacal area was surrounded by a flattened ring of white tissue. All had large eggs (10–12 mm. diameter) in the single ovary, and one had egg cases with eggs in both oviducts. The egg cases were about 50 mm. long, not including filaments, and about 15 mm. in greatest width. The shells appeared to be smooth surfaced. The egg shells were not completely formed or finished at their inner ends, and the nature of the processes at the posterior ends could not be determined, except that they were not the single tendrils at each corner found in *Scyliorhinus* but were more numerous and arranged as a filamentous fringe across the end of the case. The cases were greenish, semitransparent, and with some longitudinal lines of lighter color.

The uniformly flattened cloacal area was apparent as an unusual feature of the specimens only when they were fresh or were preserved in formalin. After transfer to alcohol this flattening disappeared.

The presence of an adult male in the haul also revealed the remarkable difference in tooth size and shape (fig. 10) between adult males and females. Although later collections produced another adult male from near Key West, the only immature specimens seen thus far have been females, so it has not been determined when the tooth dimorphism first appears.

The teeth in the six specimens examined are in 24+0+24/19+0+19 to 29+0+29/22+0+21 rows with no teeth at the symphysis in either jaw. The teeth of the females are generally tricuspid in the central portion of the jaws but have five, seven, or nine cusps toward the angles of the jaws. The number and shape of the teeth of females of the series described here are about as described for *A. riveri by* Bigelow and Schroeder (1944, 1948). Using the definition of series of teeth given earlier in this paper, however, the number of functional series in *riveri* is five or six. The tooth arrangement, as in other *Apristurus* or, for that matter, in all scyliorhinids, is in alternate series with series defined as teeth arranged along a single line parallel with the axis of the jaw. This arrangement gives the appearance of diagonal rows (see fig. 11). It may be described also as Bigelow and Schroeder (1944) have done as an arrangement in quincunx.

In dealing with somewhat larger series than were available to Bigelow and Schroeder, some difficulties have appeared in the use of distances between gill openings and angles formed by the labial grooves as means for differentiating species, because of greater variation in the larger series. Among western Atlantic species the narrower head of *riveri* seems the most outstanding and reliable criterion for quick identification. The comparatively narrower head is shown quite clearly in figure 27. In *riveri* the band of pores on the underside of the snout is consistently narrower than in other western Atlantic species, generally being composed of about four rows of pores instead of eight or more.

The claspers of the adult males are rather short, reaching about 2.3 percent of total length beyond the tips of the pelvic fins, and quite stout. There are no hooks. The clasper siphons are also relatively short, extending only about 10 mm. in advance of the origin of the pelvics.

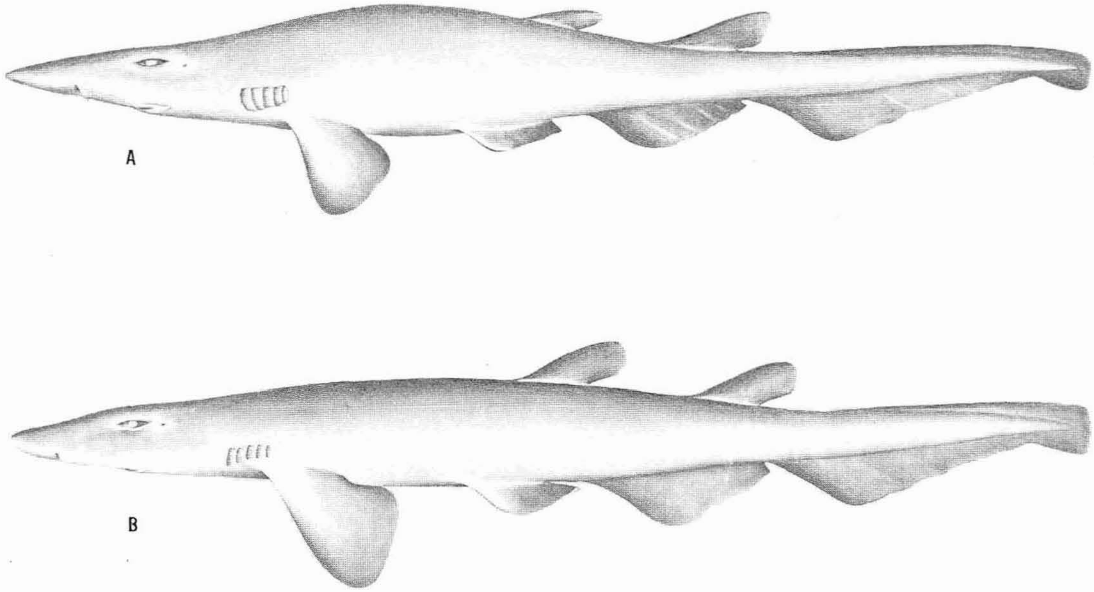

FIGURE 24.—A, *Apristurus riveri* Bigelow and Schroeder, drawn from a 400-mm. female from M/V *Oregon* station 3586; B, *Apristurus laurussoni* (Saemundsson), drawn from a 540-mm. male, MCZ 38406.

Apristurus laurussoni (Saemundsson), 1922

Figures 24, 25, and 27; tables 1, 7, and 8.

Saemundsson's only specimen, the type of *Scyllium laurussonii*, was a 673-mm. female. This specimen, which is in excellent condition, was examined through the courtesy of the Natural History Museum, Reykjavik, as a loan. It differs from the type specimen Goode and Bean of *Scylliorhinus profundorum* 1896, with respect to characters given in the preceding key.

The separation of the broadheaded *A. laurussoni* from the narrow-headed *A. riveri* and the separation of *A. laurussoni* from *A. profundorum* on the basis of the pelvic shape (see fig. 25) or the denticle distribution problem presents no difficulty except perhaps in very small specimens.

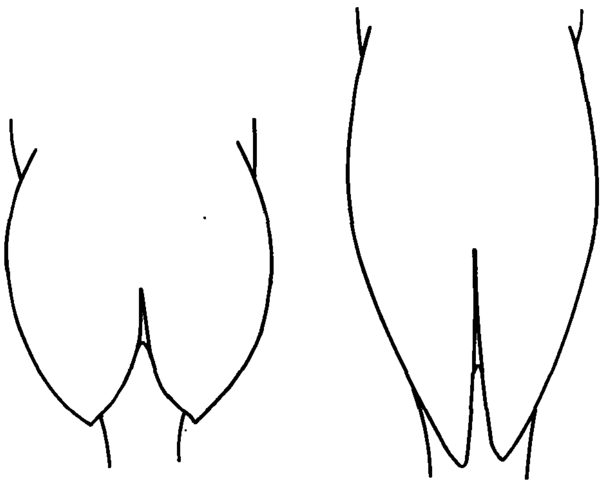

FIGURE 25.—Diagram to show shapes of pelvci fins: At left, *Apristurus profundorum*; at right, *Apristurus laurussoni*.

A. laurussoni differs from our specimens of *A. indicus* in having the two dorsal fins of approximately equal size. In A. indicus the first dorsal fin has about half the area of the second. Both *laurussoni* and *indicus* in the material examined are quite variable in number of tooth rows, number of vertebrae, and fin positions.

The teeth of *A. laurussoni* are small and comparatively numerous in 34+0+34/34+0+32 to 42+0+41/53+0+43 rows. The two largest males examined, 520 and 540 mm., are apparently immature, but there is no indication of sexual dimorphism in teeth in comparison with a 580-mm. female or the type, a 673-mm. female. Saemundsson (1922) noted that the teeth of the type are in 22 rows on each side of the symphysis. My count of the teeth of the type specimen is approximately 41 rows on each side. This difference is the result of a different method of counting rows. The alternate arrangement of teeth together with their generally small size makes routine tooth counting in *Apristurus* impractical. In many specimens the diagonal rows are very prominent and seem to be the logical ones to count. In our specimens if diagonal rows were counted, the tooth formula would be close to that given by Saemundsson.

It may be helpful to subsequent workers with the genus to note that Goode and Bean's type and only specimen of *profoundorum* is an adult male while their illustration (1896, pl. 5, fig. 16) appears to be a female. Saemundsson's text references to illustrations on plate V (1922, pp. 173 and 200) for *Pristiurus Jensenii* and *Scyllium Laurussonii* are reversed, and the illustration of the lateral view of a shark in Bigelow and Schroeder (1948, fig. 38) captioned as the type of *profundorum* may not represent that species since the illustration shows either a female or a male with claspers not showing, while the type is a male with claspers extending past the tips of the pelvics.

Exclusive of the type which was collected from 560-m. depth near Vestmanneyjar, off the southern coast of Iceland, I have examined about 25 specimens that I refer to the species. These are from the northern half of the Gulf of Mexico and from the Atlantic coast of the United States from latitude 40°40′ N. (off Massachusetts) southward to 38°41′ N. (off Delaware). Specimens were taken from depths of 760 to 1,460 meters.

Genus *Halaelurus* Gill, 1861

Type species—*Scyllium bürgeri* Müller and Henle, 1841, by original designation.

The group of scyliorhinid sharks usually assembled in the genus *Halaelurus* seems to include leftovers and poorly known species. It is in special need of nomenclatural revision. Changes can best be made in a general revision of the world's scyliorhinid genera, which will require more extensive collections than are available now.

The American representatives of *Halaelurus* have long and strong labial grooves along both upper and lower jaws and thus differ from American species of the genus *Scyliorhinus* which have weak and short labial folds only on the lower jaw. The two South American species considered here both have patterns of dorsal saddles somewhat resembling those in *Scyliorhinus* and from this feature can be readily separated from *Apristurus*. They have no caudal crests and so differ from *Galeus*. They differ from *Schroederichthys* in having caudal trunk sections somewhat shorter, in having much longer and more prominent labial folds, and

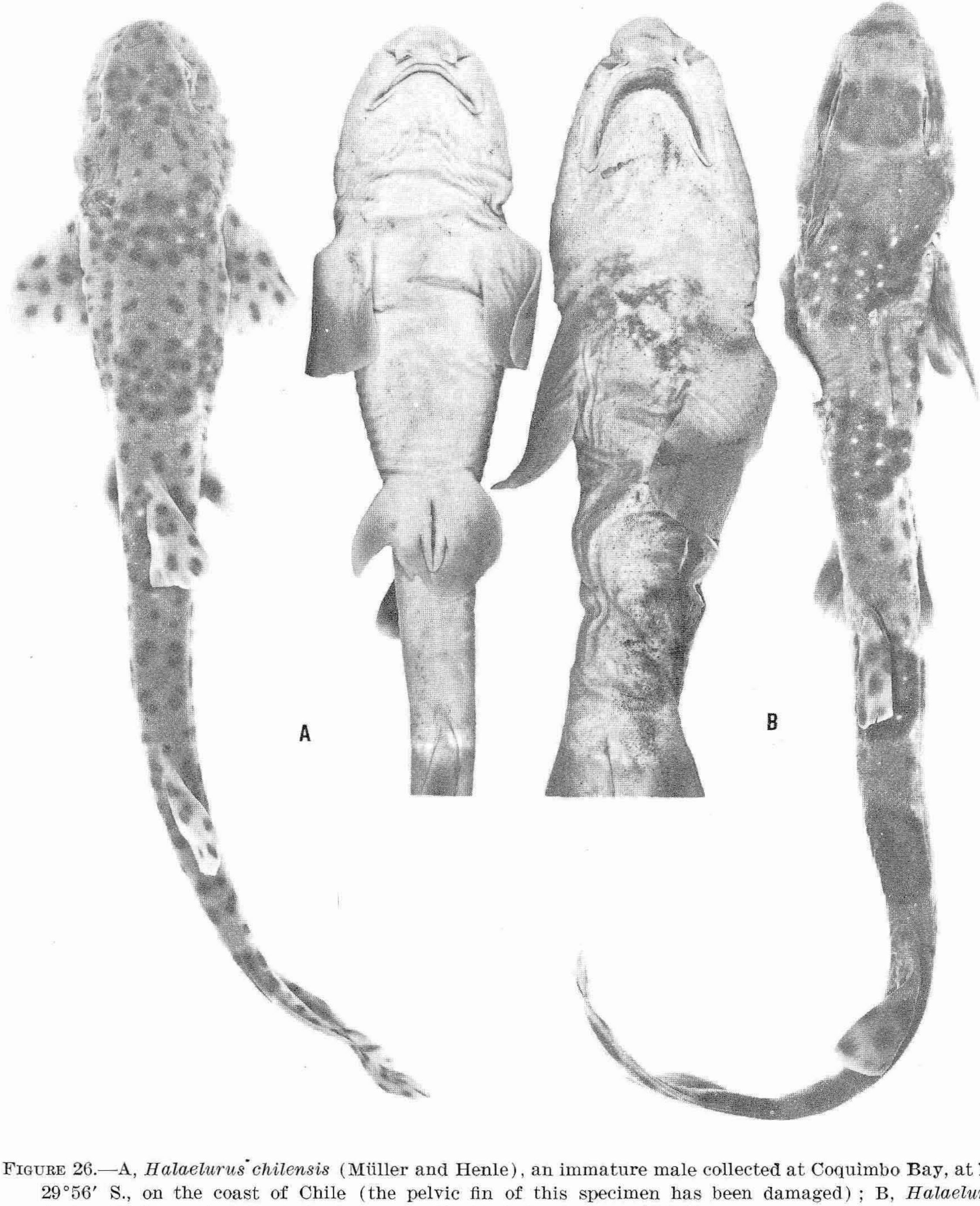

FIGURE 26.—A, *Halaelurus chilensis* (Müller and Henle), an immature male collected at Coquimbo Bay, at lat. 29°56′ S., on the coast of Chile (the pelvic fin of this specimen has been damaged); B, *Halaelurus bivius* (Guichenot), collected near Puerto Montt, Chile, at lat. 41°54′ S.

in having a reduction (in the larger specimens examined) in the number and size of the accessory cusps on the teeth of the lower jaw.

In many features the *Halaelurus* of the southern part of South America resembles *Schroederichthys*. Dr. Elvira Siccardi who has examined many specimens from Argentina has called my attention (in personal communication) to several

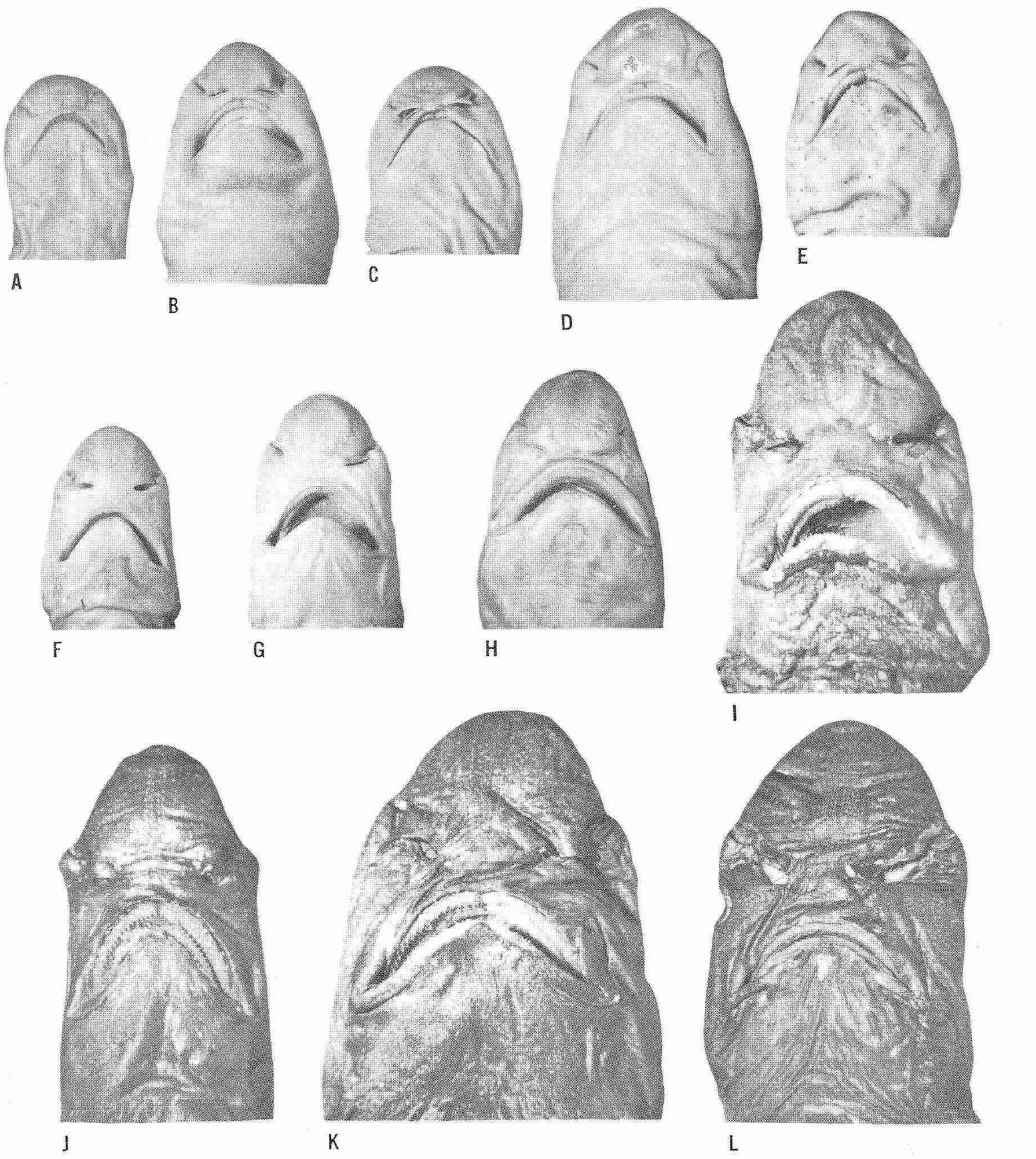

FIGURE 27.—Photographs of lower side of heads: A, *Scyliorhinus torrei;* B, *Scyliorhinus retifer;* C, *Scyliorhinus meadi;* D, *Scyliorhinus hesperius;* E, *Scyliorhinus boa;* F, *Galeus arae;* G, *Galeus cadenati;* H, *Galeus arae;* I, *Apristurus profundorum;* J, *Apristurus riveri;* K, *Apristurus laurussoni;* L, *Apristurus indicus.*

similarities such as the development of long, very slender nasal flaps in species of each genus (*H. bivius* and *S. tenuis*), the relatively short caudal lobes in combination with long postpelvic trunk in both groups, and certain somewhat subtle similarities in denticle structure.

Problems in connection with names to be applied to South American *Halaelurus* cannot be adequately treated here because of insufficient study material. My view that more species than *Halaelurus chilensis* (Guichenot, 1847) and *Halaelurus bivius* (Müller and and Henle, 1841) are involved in the material described by various authors has been strengthened by discussions with Dr. Siccardi.

Some unresolved questions on the status of types add to the difficulties with nomenclature. The types of both *H. bivius* and *H. chilensis* are stuffed specimens. The specimen designated as the type of *bivius* by Günther (1870) is said to be from southwest Africa but Günther's description is not in close agreement with the earlier description of Müller and Henle (1841). The confusing synonomy of *bivius* can be seen in the treatment given in Norman's work (1937) on Patagonian fishes.

It seems probable that all of the accounts of South American *Halaelurus*, including this one, have been based on material quite inadequate to delineate species. Available material suggests that considerable differences in some characters may exist between young and adults of the same species. This makes the development of meaningful synonymy impractical. It is possible that both Berg (1895) and Lahille (1921, 1928) discussed the form here referred to *H. chilensis* under the name *bivium* or *bivius*. Vaillant's account (1891), under *Scyllium chilense* Guichenot, states that he believes *Scyllium bivium* Smith is not a distinct species, but goes on to state that all the small examples he had seen were females.

A more extensive study of these scyliorhinids should provide some answers of great interest to the phylogeny of carcharhinid sharks because these sharks, perhaps considered together with *Schroederichthys*, have more characters approaching the carcharhinid line than do other scyliorhinids. The longer jaw of *H. bivius* together with lower jaw spikelike teeth is a feature more familiar in the Carcharhinidae than in the Scyliorhinidae. The claspers and clasper siphons of *Schroederichthys* bear many resemblances to those of the carcharhinids.

Halaelurus bivius (Müller and Henle), 1841

Figure 26; tables 7 and 8.

The specimens of *H. bivius* from Chile examined for this report are very easily separated from Chilean examples of *H. chilensis* by differences in general shape. As can be seen in the photographs (fig. 26), *H. chilensis* has a shorter head, a somewhat shorter and definitely less pointed snout, and a shorter and much less strongly arched jaw.

The specimens of *H. chilensis* examined were immature, showing a well-marked series of enlarged denticles in rows along the back, and in this differed from the adult *H. bivius* available for comparison. The specimens of *H. bivius*, however, had some enlarged dorsolateral denticles.

In direct comparison of *H. bivius* with *H. chilensis* specimens, it was noted that the nasal flaps of *H. bivius* were longer and narrower, the gill slits were somewhat longer, the anal fin base was somewhat longer (see table 7 and 8), and the denticles prevalent on dorsolateral surfaces had longer points.

Halaelurus chilensis (Guichenot), 1847

Figure 26; tables 7 and 8.

Based on specimens from the Pacific coast of South America, it appears that there are relatively great differences between *H. chilensis* and *H. bivius*. It should be noted, however, that all of the specimens of *H. bivius* seen were adult males while all the specimens referred to *H. chilensis* were immature.

SUMMARY AND COMMENT

To have accomplished its purpose, this study should have indicated some of the kinds of information about catsharks needed for an adequate revision of the family. Great variation within species, particularly in morphometrics, the occurrence of sexual dimorphism (at least in one species), and the finding of a new genus and several new species point to the need for more comprehensive collections from the continental slopes and from ocean basins as a basis for understanding the group.

Western Atlantic scyliorhinids all have been taken at depths where relatively cool temperatures prevail; and in the course of a more general study of the group, it will be interesting to note which, if any, species enter relatively warmer areas or shallow-water areas. The discovery by Poll (1951) and Cadenat (1959) that the ovoviviparous condition and the oviparous condition both occur within a single genus (*Galeus*) points to the need for much more observation on life histories of catsharks.

The order in which genera are taken up in this paper is not intended to have any phylogenetic implication. *Galeus*, *Apristurus*, and *Schroederichthys*, as far as these are known at present, are quite compact groups of similar species and are separable from each other and from other of the world's scyliorhinid genera by many differences.

The separation of *Scyliorhinus* from *Halaelurus* and from some other genera of the Indo-Pacific region has, in the past, been based primarily upon differences in the arrangement of skin folds near the mouth, by the presence or absence of nasoral grooves, and by the relative development of anterior and posterior nasal valves. Keys to genera and also to species used by Garman (1913) and by Fowler (1941) emphasize these characters. I have given little descriptive space to them because they appear to be of little use for determination of western Atlantic species and also because they are somewhat variable in the specimens at hand. I have also had some difficulty in understanding the terminology. For example, Garman (1913) states that nasal cirri are absent or rudimentary in *Scyliorhinus*, but he separates *Poroderma*, an Indian Ocean genus, from *Scyliorhinus* in his key by the complete absence in *Poroderma* of a rudimentary nasal cirrus. This rudimentary cirrus, in the material I have examined, is merely a thickening of a portion of the anterior nasal flap, broader and thicker near the base of the flap, narrower and thinner near the posterior margin of the flap, but not extending at all beyond the edge of the flap. If one is familiar with the shape of nasal cirri of orectolobid sharks, this structure looks like a nasal cirrus entirely embedded in the flap. I find it difficult to accept the idea that this is necessarily a rudimentary structure and suspect that it may function in directing the flow of water past the nasal aperture.

Nevertheless, differences in skin structures near the mouth and nasal apertures may be of great usefulness in the practical description of species and as criteria for their identification, especially among Indo-Pacific forms.

TABLE 3.—*Measurements of selected examples and type specimens of Atlantic* Scyliorhinus

Species	*S. retifer*	*S. meadi* (type)	*S. hesperius* (type)	*S. boa*	*S. torrei*	*S. caniculus*	*S. stellaris*
Museum No. or Station No.	ORE 4153	USNM 188049	USNM 187732	USNM 186195	SB 2457	USNM 195851	USNM 34352
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Total length	465	247	415	346	270	383	370
Tip of snout to—							
Anterior nasal aperture	12	8	11	10	6	7	9
Posterior nasal aperture	19	11	18	15	8	14	13
Front mouth	21	12	21	17	10	14	14
Eye	21	13	24	21	11	16	15
Gill I	74	36	69	50	35	46	52
Gill V	97	45	87	69	48	62	71
Origin pectoral	85	40	82	65	45	59	64
First dorsal fin	237	116	210	180	140	182	185
Pelvic fins	194	107	176	145	105	148	160
Anal fin	282	143	252	213	162	213	220
Second dorsal fin	314	153	283	238	188	251	242
Lower caudal fin	346	180	315	268	210	292	275
Upper caudal fin	354	185	320	274	215	298	285
Anus	203	112	190	155	114	156	170
Length upper caudal fin	108	63	95	72	55	85	85
Base first dorsal fin	28	15	26	23	18	25	26
Base second dorsal fin	24	13	21	17	12	20	24
Base anal fin	34	22	38	25	22	37	36
Distance between dorsal fins	52	26	44	37	33	46	32
Internasal distance	7	15	7	7	5	- - -	5
Length orbit	20	9	15	13	9	11	13
Length lower labial fold	9	5	7	3	5	12	8
Length upper labial fold	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Width mouth	34	20	34	25	19	22	25
Length mouth	20	11	14	15	10	9	16
Height gill I	9	6	7	6	5	9	6
Height gill V	4	4	4	4	2	4	3
Tip second dorsal to caudal	9	13	9	7	10	20	13
Tip pelvic to second dorsal	71	25	59	48	49	50	40
Tip pelvic to anal	44	13	33	31	25	21	22
Tip pelvic to lower caudal	106	55	95	86	76	100	77
Length outer margin pectoral	70	33	62	45	26	46	44
Length anterior margin first dorsal	45	25	41	32	22	33	39
Length anterior margin second dorsal	34	19	31	25	13	27	34
Length anterior margin anal	30	21	33	24	20	27	29
Distance eye to spiracle	3	3	3	3	2	3	4

TABLE 4.—*Range of total lengths and range of measurements expressed as percent of total length in western Atlantic* Scyliorhinus

Species	*S. retifer*	*S. meadi*	*S. hesperius*	*S. boa*	*S. torrei*
Number of specimens measured	10	5	13	7	7
Length range in millimeters	173–465	183–264	160–466	143–346	129–270
Tip of snout to—	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Anterior nasal aperture	2.3– 3.4	3.0– 3.8	2.3– 4.0	2.5– 3.5	1.4– 2.2
Posterior nasal aperture	3.6– 4.7	4.2– 4.5	3.7– 5.1	3.8– 4.9	2.7– 3.9
Front mouth	4.4– 5.8	4.4– 4.9	4.5– 5.7	4.2– 5.6	3.5– 4.7
Eye	4.5– 6.1	5.3– 6.0	5.0– 6.8	5.2– 6.3	4.1– 5.4
Gill I	14.1–16.5	13.1–15.8	14.5–16.6	13.7–16.0	13.0–14.7
Gill V	18.1–22.2	18.6–21.6	18.9–21.5	18.0–20.4	16.4–18.0
Origin pectoral	16.4–20.7	16.7–20.0	17.7–19.8	16.2–18.8	15.4–17.2
First dorsal fin	45.7–51.1	46.3–48.5	46.9–53.7	45.5–52.0	44.9–51.8
Pelvic fins	39.6–41.8	40.4–42.1	39.5–44.4	38.9–41.9	33.2–39.5
Anal fin	56.5–60.7	55.7–57.6	54.4–62.5	53.8–61.6	54.2–60.0
Second dorsal fin	62.5–67.5	62.8–64.8	61.8–69.1	63.6–68.9	63.6–69.6
Lower caudal fin	72.3–76.7	71.5–75.0	73.0–77.4	72.7–78.2	73.6–78.5
Upper caudal fin	71.7–78.2	73.6–75.9	74.4–79.3	74.8–79.5	75.2–79.6
Anus	41.0–44.4	43.2–45.5	41.2–51.0	40.1–44.8	37.9–42.2
Length upper caudal fin	21.6–25.4	25.2–28.0	20.7–27.5	19.9–25.2	20.4–24.0
Base first dorsal fin	5.5– 7.0	5.8– 6.8	5.6– 6.7	5.4– 6.8	5.9– 7.0
Base second dorsal fin	4.5– 5.8	5.3– 6.3	4.3– 5.2	4.4– 5.8	4.2– 4.7
Base anal fin	7.2– 9.1	7.8– 9.5	7.2– 9.2	7.2– 9.3	7.3– 9.4
Distance between dorsal fins	10.6–11.9	10.5–11.6	9.2–11.3	10.3–13.7	10.9–14.5
Internasal distance	1.5– 2.3	5.8– 6.8	1.7– 2.7	1.8– 2.8	1.6– 2.3
Length orbit	3.2– 4.3	2.6– 3.8	3.1– 4.7	2.9– 4.3	3.1– 3.5
Length lower labial fold	1.3– 2.1	1.6– 2.3	0.9– 1.9	0.4– 1.8	1.2– 2.0
Length upper labial fold	----------	----------	----------	----------	----------
Width mouth	6.3– 8.1	7.4– 8.9	6.9– 8.8	5.8– 7.8	6.1– 7.8
Length mouth	2.8– 4.5	3.3– 4.3	3.3– 4.4	2.8– 4.0	3.5– 5.5
Height gill I	1.6– 2.3	1.1– 2.6	1.5– 2.5	1.3– 1.9	1.6– 2.3
Height gill V	0.6– 1.2	0.5– 1.3	0.6– 1.5	0.6– 1.2	0.2– 1.2
Tip second dorsal to caudal	1.8– 3.7	2.7– 4.7	1.7– 4.2	2.0– 4.9	2.7– 4.7
Tip pelvic to second dorsal	13.6–15.9	10.5–13.2	9.6–15.4	13.0–16.3	14.7–18.2
Tip pelvic to anal	6.8–10.7	5.8– 8.4	4.3–10.2	6.3–11.5	6.2–10.1
Tip pelvic to lower caudal	21.3–25.6	21.1–25.0	20.8–25.4	22.3–26.6	24.6–28.2
Length outer margin pectoral	11.4–15.0	10.9–13.6	10.7–14.9	11.8–13.7	8.5–11.3
Length anterior margin first dorsal	8.1–10.0	8.8–10.6	7.5–10.1	8.0–10.4	7.8– 8.6
Length anterior margin second dorsal	5.7– 7.7	6.8– 8.7	5.7– 8.2	5.4– 7.9	4.2– 5.7
Length anterior margin anal	5.3– 8.2	6.8– 9.1	5.8– 9.2	6.9– 8.3	5.5– 7.4
Distance eye to spiracle	0.4– 1.2	1.1– 1.6	0.7– 1.5	0.7– 1.3	0.7– 1.2

TABLE 5.—*Measurements of type specimens of* Schroederichthys, Galeus cadenati *and selected examples of* Galeus arae

Species	*S. maculatus* (type)	*S. tenuis* (type)	*Galeus arae*	*G. arae*	*G. cadenati* (type)
Museum No. or Station No.	USNM 185556	USNM 188052	S.B. 2458	USNM 198164	ORE 3592
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Total length	328	230	290	368	303
Tip of snout to—					
Anterior nasal aperture	8	3	12	14	12
Posterior nasal aperture	11	7	14	18	15
Front mouth	14	9	18	22	20
Eye	15	10	20	25	22
Gill I	43	24	42	59	53
Gill V	53	32	53	75	61
Origin pectoral	50	30	52	73	57
First dorsal fin	126	82	131	156	133
Pelvic fins	100	69	115	144	109
Anal fin	172	120	165	214	151
Second dorsal fin	201	136	183	233	186
Lower caudal fin	260	179	210	270	210
Upper caudal fin	265	182	206	267	210
Anus	104	71	126	162	120
Length upper caudal fin	60	38	85	100	90
Base first dorsal fin	14	10	14	17	17
Base second dorsal fin	18	15	14	17	16
Base anal fin	24	21	30	32	45
Distance between dorsal fins	65	42	36	61	39
Internasal distance	8	6	8	11	8
Length orbit	11	7	10	13	9
Length lower labial fold	4	4	5	8	5.5
Length upper labial fold	4	3	3	5	4
Width mouth	19	13	20	26	21
Length mouth	11	6	12	15	12
Height gill I	5	4	5	6	4
Height gill V	2	2	3	3	3
Tip second dorsal to caudal	36	24	3	10	5
Tip pelvic to second dorsal	71	47	37	49	31
Tip pelvic to anal	42	30	20	24	2
Tip pelvic to lower caudal	135	92	63	81	59
Length outer margin pectoral	32	22	31	42	42
Length anterior margin first dorsal	23	18	21	29	30
Length anterior margin second dorsal	29	20	21	24	25
Length anterior margin anal	18	14	16	23	26
Distance eye to spiracle	3	2	3	4	4

TABLE 6.—*Range of total lengths and measurements expressed as percent of total length in* Schroederichthys *and* Galeus

Species	*S. maculatus*	*S. tenuis*	*Galeus arae*	*G. arae*	*G. cadenati*	*G. melastomus*
Number of specimens measured	49	2	10	4	10	5
Length range in millimeters	145–342	180–230	190–321	269–368	273–348	313–635
Tip of snout to—	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Anterior nasal aperture	1.4– 2.4	1.3– 1.7	3.1– 4.1	3.4– 3.9	3.2– 5.1	3.2– 4.8
Posterior nasal aperture	2.4– 3.9	3.0– 3.3	4.3– 5.2	4.5– 5.2	4.6– 5.8	4.2– 6.7
Front mouth	3.1– 4.7	3.9– 3.9	5.3– 7.1	6.0– 6.9	6.0– 7.3	6.3– 8.6
Eye	3.7– 5.2	4.4– 4.4	5.3– 7.5	5.9– 7.8	6.3– 7.6	6.3– 8.3
Gill I	9.9–13.1	10.4–11.1	13.8–16.0	14.9–16.7	15.5–18.5	12.6–17.5
Gill V	12.9–17.0	13.9–14.4	16.3–19.8	20.1–20.7	18.2–22.2	17.2–23.0
Origin pectoral	12.0–16.3	13.0–13.3	15.3–19.3	19.0–20.1	16.7–21.8	16.7–22.1
First dorsal fin	34.7–40.8	34.4–35.6	42.4–47.3	40.9–43.4	43.2–47.9	44.9–48.2
Pelvic fins	28.9–33.6	29.4–30.0	37.2–42.0	34.6–39.1	34.5–40.2	36.9–39.6
Anal fin	49.4–54.5	49.4–52.2	50.9–56.9	52.7–58.2	49.8–55.6	52.1–53.9
Second dorsal fin	58.3–62.6	57.2–59.2	59.0–67–7	59.8–63.3	60.1–64.7	61.5–63.9
Lower caudal fin	77.5–82.8	77.7–77.8	68.8–74.1	68.8–74.7	69.0–75.1	69.4–70.6
Upper caudal fin	79.3–83.5	79.1–79.4	67.5–72.0	68.4–74.5	69.3–75.1	70.0–72.5
Anus	28.7–36.4	30.5–30.9	39.8–46.3	39.8–44.0	39.5–45.5	40.3–42.8
Length upper caudal fin	15.9–20.7	16.5–20.5	28.0–31.6	26.2–30.1	24.5–29.7	27.9–30.2
Base first dorsal fin	3.5– 5.1	4.4– 4.4	4.2– 5.9	4.3– 5.1	4.9– 6.3	4.4– 5.1
Base second dorsal fin	5.2– 8.1	6.1– 6.5	4.4– 5.7	4.1– 5.2	5.0– 6.3	4.6– 5.4
Base anal fin	6.6– 9.0	7.8– 9.1	10.3–13.6	8.7– 9.5	13.2–15.0	12.8–15.5
Distance between dorsal fins	17.2–20.0	18.3–19.4	11.3–12.9	14.1–16.6	12.3–14.7	10.9–14.0
Internasal distance	1.9– 2.5	2.4– 2.5	2.5– 3.3	3.0– 3.3	2.4– 3.2	2.4– 3.5
Length orbit	2.7– 3.5	3.0– 3.1	3.4– 3.9	3.1– 3.7	3.0– 4.0	3.6– 4.5
Length lower labial fold	0.8– 1.7	1.7– 1.7	1.4– 2.2	1.7– 2.6	1.6– 2.2	1.3– 1.9
Length upper labial fold	0.6– 1.2	1.3– 1.7	1.0– 1.5	1.4– 2.0	1.3– 1.7	1.0– 1.6
Width mouth	5.2– 6.8	5.7– 6.1	6.2– 7.5	7.1– 9.2	6.6– 9.1	6.2– 7.9
Length mouth	1.8– 3.9	2.6– 2.8	3.2– 4.3	3.0– 4.1	3.2– 5.5	3.3– 5.4
Height gill I	1.2– 2.1	1.1– 1.7	1.3– 2.1	1.1– 1.7	1.3– 2.1	1.9– 2.8
Height gill V	0.3– 0.7	0.4– 0.7	0.6– 1.3	0.6– 1.1	0.7– 1.3	0.9– 1.4
Tip second dorsal to caudal	9.6–12.9	10.4–12.2	0.2– 1.5	1.5– 2.7	0.0– 2.2	0.5– 1.3
Tip pelvic to second dorsal	18.4–23.1	19.4–20.4	8.8–12.6	10.4–13.3	9.8–11.9	10.2–14.2
Tip pelvic to anal	9.3–13.4	12.2–13.1	1.6– 6.7	4.8– 7.1	0.7– 3.2	1.3– 3.6
Tip pelvic to lower caudal	37.2–42.0	40.0–40.0	18.4–21.7	19.7–22.0	17.9–22.6	19.5–20.4
Length outer margin pectoral	8.2–11.8	9.4– 9.6	10.5–12.2	9.9–11.9	12.9–15.6	11.9–13.2
Length anterior margin first dorsal	6.1– 8.4	7.2– 7.8	7.2– 8.3	6.3– 7.9	8.5–10.5	7.7– 8.9
Length anterior margin second dorsal	6.8– 9.9	8.7– 8.9	7.0– 8.0	6.1– 6.9	7.9– 9.2	7.6– 8.9
Length anterior margin anal	3.4– 6.8	6.1– 7.2	5.5– 8.0	5.7– 6.2	6.4– 8.6	6.4– 8.1
Distance eye to spiracle	0.5– 1.5	0.8– 0.9	0.8– 1.5	0.9– 1.5	1.1– 1.4	0.7– 1.3

TABLE 7.—*Measurements of a type specimen of* Apristurus *and of selected examples of* Apristurus *and* Halaelurus

Species Museum No. or other designation	*A. profundorum* MCZ 38299	*A. indicus* ORE 3654	*A. riveri* ORE 3586	*A. laurussoni* MCZ 38406	*H. bivius* Coast Chile 42° S.	*H. chilensis* Coast Chile 30° S.
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Total length	390	303	430	540	625	365
Tip of snout to—						
Anterior nasal aperture	21	18	20	24	------	------
Posterior nasal aperture	34	25	30	36	------	------
Front mouth	40	31	35	46	22	12
Eye	46	33	46	52	------	------
Gill I	85	67	85	110	100	55
Gill V	104	78	109	130	128	68
Origin pectoral	99	76	105	124	120	64
First dorsal fin	170	152	210	252	270	140
Pelvic fins	150	125	180	230	------	------
Anal fin	192	151	230	295	------	------
Second dorsal fin	212	185	270	338	------	------
Lower caudal fin	243	206	296	378	------	------
Upper caudal fin	253	210	308	390	509	293
Anus	164	139	195	257	250	135
Length upper caudal fin	115	93	123	148	116	72
Base first dorsal fin	23	12	17	35	39	27
Base second dorsal fin	29	17	27	35	42	32
Base anal fin	57	53	61	85	62	29
Distance between dorsal fins	28	25	33	47	100	60
Internasal distance	18	14	17	20	17	8
Length orbit	13	10	15	16	17	10
Lenth lower labial fold	15	6	12	14	17	8
Length upper labial fold	11	10	10	19	20	8
Width mouth	34	23	23	48	40	27
Length mouth	20	11	20	24	25	13
Height gill I	7	3	11	9	10	6
Height gill V	7	2	8	5	6	4
Tip second dorsal to caudal	−10	−3	------	------	------	------
Tip pelvic to second dorsal	30	27	38	44	------	------
Tip pelvic to anal	------	−4	8	------	------	------
Tip pelvic to lower caudal	56	49	70	85	------	------
Length outer margin pectoral	40	34	48	70	76	45
Length anterior margin first dorsal	34	15	27	50	64	40
Length anterior margin second dorsal	45	25	36	50	68	45
Length anterior margin anal	20	22	30	50	47	27
Distance eye to spiracle	6	3	4	6	------	------

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TABLE 8.—*Range of total lengths and measurements expressed as percent of total length in* Apristurus *and* Halaelurus

Species	*A. profundorum*	*A. indicus*	*A. riveri*	*A. laurussoni*	*H. bivius*	*H. chilensis*
Number of specimens measured	5	12	6	10	2	2
Length range in millimeters	230-390	235-475	338-460	212-580	555-625	365-392
Tip of snout to—	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Anterior nasal aperture	4.8- 7.2	4.2- 5.9	4.7- 6.3	3.8- 5.4		
Posterial nasal aperture	7.4-10.4	6.6- 9.3	6.5- 8.3	6.1- 8.3		
Front mouth	8.7-10.9	7.6-11.2	7.4-10.0	7.5- 9.6	3.5- 3.8	3.3- 3.3
Eye	10.9-13.0	8.4-11.9	10.0-11.8	8.0-11.5		
Gill I	19.1-22.8	16.8-22.0	18.3-21.3	17.0-21.4	15.1-16.0	15.2-16.6
Gill V	23.5-26.7	21.5-25.8	22.2-25.3	22.2-26.8	18.4-20.5	18.3-21.4
Origin pectoral	23.0-25.4	20.2-25.1	21.0-24.4	21.6-25.8	18.0-19.2	17.5-20.4
First dorsal fin	40.9-43.6	47.9-51.8	45.6-48.9	43.4-51.2	40.5-43.2	38.4-38.6
Pelvic fins	38.3-41.6	38.2-42.7	39.4-42.7	40.1-47.8		
Anal fin	46.1-50.8	49.5-53.6	47.9-53.6	47.5-57.9		
Second dorsal fin	53.9-58.3	58.5-63.6	56.8-62.8	59.0-67.2		
Lower caudal fin	61.3-64.4	65.6-71.8	64.5-68.8	63.6-72.4		
Upper caudal fin	64.8-66.9	67.2-72.6	65.1-71.6	66.0-79.3	78.0-81.4	74.7-80.3
Anus	42.0-44.3	42.8-49.6	43.5-47.7	42.9-51.2	37.9-40.0	37.0-38.2
Length upper caudal fin	29.5-33.5	29.3-32.2	28.3-32.1	25.9-31.0	18.6-22.0	19.7-20.2
Base first dorsal fin	4.8- 7.0	3.4- 4.8	3.3- 4.4	4.5- 6.6	5.6- 6.2	7.4- 7.7
Base second dorsal fin	6.5- 7.4	5.0- 6.8	5.4- 6.8	4.8- 7.3	6.7- 8.3	8.8- 9.2
Base anal fin	13.2-14.8	13.5-18.3	13.0-18.0	13.8-16.9	9.4- 9.9	7.9- 8.9
Distance between dorsal fins	6.0- 9.6	6.0- 8.8	5.9- 8.9	8.7-10.8	16.0-16.2	16.4-16.6
Internasal distance	3.6- 4.8	3.7- 4.7	3.7- 4.3	3.6- 5.0	2.3- 2.7	2.0- 2.2
Length orbit	2.2- 3.3	2.5- 4.0	3.3- 3.5	2.7- 3.9	2.7- 2.9	2.7- 2.8
Length lower labial fold	2.0- 3.8	1.6- 2.6	2.2- 2.8	2.1- 3.2	2.2- 2.7	2.2- 2.6
Length upper labial fold	1.6- 2.8	1.9- 3.9	2.2- 2.7	3.1- 3.9	2.7- 3.2	2.2- 2.6
Width mouth	5.7- 8.7	6.3- 9.4	5.3- 7.3	6.1-10.0	5.8- 6.4	7.4- 7.7
Length mouth	3.9- 5.1	3.3- 4.8	3.2- 5.2	3.3- 5.9	5.0- 5.6	3.6- 3.6
Height gill I	0.9- 2.0	1.0- 2.2	2.2- 2.6	0.8- 2.3	1.4- 1.6	1.6- 2.0
Height gill V	0.9- 1.6	0.4- 1.3	0.9- 1.9	0.5- 1.1	0.7- 1.0	0.1- 1.3
Tip second dorsal to caudal		0 - 1.3	0 - 3.5	0 - 1.8		
Tip pelvic to second dorsal	5.2- 9.3	6.7-12.6	7.4-11.5	6.6-10.8		
Tip pelvic to anal	−3.0- 2.0	−1.5- 2.5	0 - 2.0	0 - 1.7		
Tip pelvic to lower caudal	13.0-16.2	14.9-18.1	14.8-16.3	14.1-18.4		
Length outer margin pectoral	8.8-10.9	8.4-11.6	9.8-11.9	8.3-13.0	11.7-12.2	12.0-12.3
Length anterior margin first dorsal	7.0- 8.9	4.2- 7.5	5.4- 7.4	7.1- 9.3	9.0-10.2	10.4-11.0
Length anterior margin second dorsal	7.8-11.5	7.2- 9.7	8.4-11.0	7.4- 9.9	10.9-12.6	12.0-12.3
Length anterior margin anal	5.1- 6.0	5.8- 9.1	6.5- 8.1	7.1- 9.3	7.4- 7.5	7.4- 8.2
Distance eye to spiracle	0.9- 1.6	0.8- 1.3	0.9- 1.2	0.9- 1.2		

A look at the literature on scyliorhinids of the Indo-Pacific and an examination of very few specimens suggests that studies of Indo-Pacific species will provide a better basis for estimates of phylogenetic relationhips than can be made from Atlantic species alone. The Atlantic material does suggest, however, that more detailed study of dentition would be desirable, especially with attention to tooth development. For this review no positive evidence on scyliorhinid migration and very little information on habit patterns were found. Further studies of species found in the higher latitudes off South America appear most promising for estimating the course of scyliorhinid phylogeny.

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