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A Revision of the Catsharks, Family Scyliorhinidae

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CONTENTS

A Revision of the Catsharks, Family Scyliorhinidae

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ABSTRACT

The family includes 86 species in 17 genera. Species are characterized and most of them are illustrated. Summaries of biological studies pertinent to classification are included. Keys to genera and species are provided. Six new species and one new subspecies are described: *Parmaturus manis* of the western North Atlantic; *P. stenseni* of the Pacific continental slope off Panama; *P. campechiensis* from the Gulf of Mexico; *Galeus schultzi* from Philippine seas; *G. arae antillensis* from the West Indies; and two species of *Apristurus* from the western Atlantic, *A. canutus* Springer and Heemstra and *A. parvipinnis* Springer and Heemstra. Two populations close to *Galeus arae* and one population close to *G. melastomus* are treated here as subspecies; they are *G. a. antillensis* (new subspecies) and *G. a. cadenati* of the Caribbean region and *G. m. murinus* of northeastern Atlantic island slopes. Treatment emphasizes descriptive accounts thought to be useful for species identification.

INTRODUCTION

My interest in the small sharks of the family Scylio-
inidae developed incidentally from exploratory fishing
n the continental slopes and the deeper parts of the con-
nental shelves. Small sharks were found numerous
nough to be ecologically significant in the rich and
aried fauna of the upper slopes of the Gulf of Mexico.
ly first objective was to find names for deepwater
iarks and attempts to identify and characterize species
emained the core of my interest.

Excepting a few species, the scyliorhinids are poorly
nown with only one or a few specimens of many species
vailable in study collections. These collections will not
e expanded easily because a majority of the species can
e caught only with trawls or dredges such as are
perated by scientific survey ships on continental slopes
in areas not exploited by fisheries. Although many
cyliorhinids are poorly known, the number of nominal
pecies has increased greatly in the past and probably
ill continue to grow. Müller and Henle (1841) recog-
ized 12 species and Regan (1908b) 30 species in the
roup now comprising the family. Garman (1913) placed
7 species among 10 genera. Since then the number of
ominal species has more than doubled and additional
enera have been proposed. In spite of the lack of
aterial, I believe that it is important now for me to
rganize the data I have gathered on the family so that
hers may refine and reconstruct parts or all of my revi-
on.

For many species the inadequate data base has cur-
ailed treatment, especially in some of the keys where
ne poorly known species is compared with another
oorly known species with respect to a single character.
he user of keys in this review is cautioned to be suspi-
ious of oversimplification of key diagnoses.

I have recognized species and have included accounts of them if one character was found, either in the original description or in specimens examined, that would separate the species from all others. This brings an incomplete quality to this review that I could have corrected only by making subjective or arbitrary decisions to discard some names of populations that I found represented by one or a few specimens. Thus I have deferred to future workers by assuming from little evidence that several species are valid because I had no positive reasons for rejection. In this way I have avoided burying some significant observations of earlier writers. For example, I recognize *Apristurus maderensis*, a species known from only one adult female. It is distinguished from all other Atlantic specimens that I have seen by having pointed prolongations of the gill covers.

Changes in color pattern, in body proportions, and in denticle and tooth shapes accompany growth in many scyliorhinid species. Juveniles are identifiable usually to genus but not always to species. My descriptive accounts and diagnoses emphasize characteristics in adult specimens if adults were available to me for study.

The most important weakness of my study probably comes from the small data base for most species which prevented uniform treatment of species, or, in extreme instances, prevented good comparison of species characteristics. The inconsistencies of treatment, however, are due not only to lack of material but also to the long period of data assembly. When I began to gather data on scyliorhinids more than 25 yr ago, I omitted recording many details that I found later would have been useful but which were difficult or impossible to recover. Furthermore, my earlier studies did not include either dissection of specimens or thorough review of anatomical works on sharks. For the serious student of elasmobranchs, it is relevant that my interests are concentrated in the area of field studies about distribution, behavior, and functional anatomy so that these interests have contributed variously some bias or some strength to this review. My own field work, including examination of

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freshly caught specimens, was carried out off the Atlantic and Pacific coasts of North America, especially in the Gulf of Mexico and Caribbean Sea, and off the east coast of Africa.

All scyliorhinids are marine. Their fin shapes and fin positions suggest that they are weak swimmers and none are known to migrate over great distances. Most species are bottom-dwellers or near-bottom dwellers but a few, notably some species of *Parmaturus,* are part-time inhabitants of midwater (Lee 1969), far from the bottom. The majority of species live in the cool waters of the upper continental slopes, and specimens of the most speciose genus, *Apristurus,* are taken typically in depths greater than 500 m. A few species of the Australian region and of Indian Ocean coasts, however, are known only from comparatively warm, shallow waters, and some of the better known forms, such as *Scyliorhinus stellaris* of the eastern North Atlantic, *Cephaloscyllium ventriosum* of the southern California coast, and *Schroederichthys bivius* of the Straits of Magellan region, frequent cool and shallow waters near shore.

A few scyliorhinid species attain lengths of about 1.5 m but most are smaller. *Cephaloscyllium* is said to reach a length of 2.4 m (Graham 1956) in New Zealand waters, but the commonly recorded length for adult New Zealand *Cephaloscyllium* is 1 to 1.2 m.

Scyliorhinids feed chiefly on invertebrates and small fishes. They exhibit little variety in tooth and jaw structures that would suggest specialized feeding habits. Only a few species are taken by commercial fishermen and are of minor importance as food fish. *Scyliorhinus canicula* of the northeastern Atlantic and Mediterranean is an important experimental animal.

MATERIALS AND METHODS

Representative specimens of 77 of the 86 scyliorhinid species recognized here were examined during the study but large series, including adults of both sexes as well as immature specimens, were available for only about 25 species. Species not seen were *Apristurus atlanticus, A. investigatoris, A. maderensis, A. longicephalus, A. saldanha, A. microps, A. kampae, Galeus boardmani,* and *Poroderma marleyi.* Many of the specimens examined are designated by museum numbers. The museum or collections are abbreviated as follows:

AMS Australian Museum, Sydney, Australia
AMNH American Museum of Natural History, New York, N.Y.
ANSP Academy of Natural Sciences, Philadelphia, Pa.
BMNH British Museum (Natural History), London, England
DM National Museum (Dominion Museum), Wellington, New Zealand.
FMNH Field Museum of Natural History, Chicago, Ill.
HUMZ Hokkaido University Museum of Zoology, Hakodate, Japan.
LACM Los Angeles County Museum of Natural History, Los Angeles, Calif.
MCZ Museum of Comparative Zoology (Harvard), Cambridge, Mass.
NHMR Natural History Museum, Reykjavik, Iceland.
ORI Oceanographic Research Institute, Durban, South Africa.
SAM South African Museum, Cape Town, South Africa.
SPIO Sao Paulo University Institute of Oceanography, Sao Paulo, Brazil.
SU Stanford University Museum, Stanford, Calif. (fish collection now at California Academy of Sciences, San Francisco, Calif.).
UA University of Arizona, Department of Biology, Tucson, Ariz.
UBC University of British Columbia, Vancouver, British Columbia, Canada.
UMMZ University of Michigan Museum of Zoology, Ann Arbor, Mich.
UNCIMS University of North Carolina Institute of Marine Science, Morehead City, N.C.
USNM U.S. National Museum, Washington, D.C.
UTM University of Tokyo Museum, Tokyo, Japan.
VFC Vanderbilt Foundation Collection, now at California Academy of Sciences, San Francisco, Calif.
WAM Western Australian Museum, Perth, Western Australia.
ZMB Zoologisches Museum an der Humbolt-Universitat zu Berlin, East Berlin, Germany.
ZMK Universitetets Zoologiske Museum, Copenhagen, Denmark.
ZMO Zoological Museum, Oslo, Norway.
ZMUB Zoologisk Museum Universitetet I Bergen Bergen, Norway.
ZSI Zoological Survey of India (Indian Museum), Calcutta, India.

Measurements of specimens recorded here were made with calipers or with a fish measuring board, and recorded entries refer to dimensions taken in the manner exemplified in Figures 1 and 2. Vertebral counts were made from radiographs.

In this paper most of the measurements entered as length of shark or total length are unadjusted, projected distances from the tip of the snout to the tail tip with the shark placed in a straight position as near as possible. Longitudinal measurements given as tip of snout to points along the body are also projections, usually made on a V-shaped fishboard. Good measurements could not be made, however, if specimens were stiff and brittle and figures given for such measurements are estimates. All other measurements, such as fin base lengths, were made with calipers. The origin of any fin, except the upper caudal lobe, is here considered to be the midpoint of the curve beginning at the divergence of the fin from the body. The point of origin of the upper caudal lobe is obscure due to lack of elevation of the caudal axis so I have considered the upper fin lobe to originate at the beginning of the caudal crest, if the shark has one, and, if not, at the point where some elevation of the dorsal edge

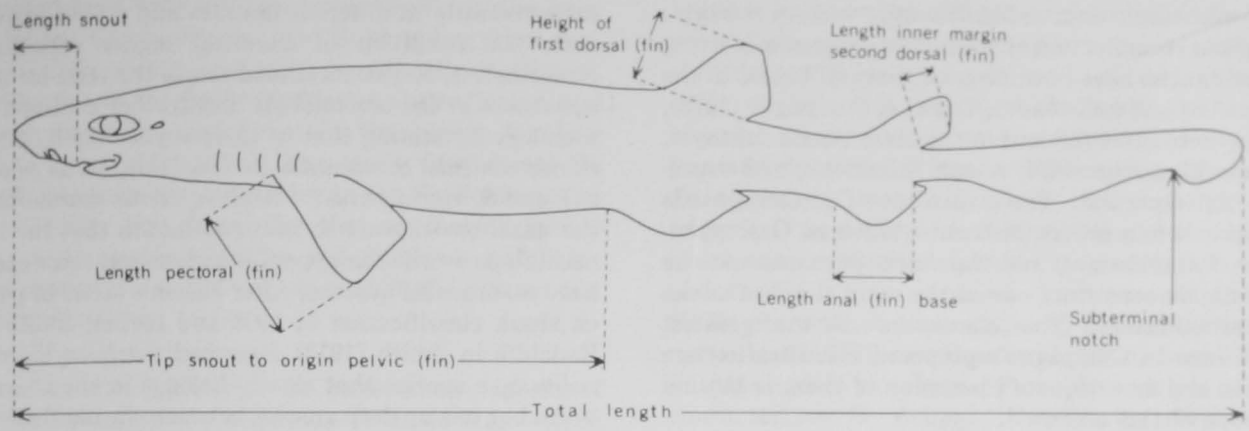


Figure 1.—Generalized outline of a scyliorhinid shark to illustrate terminology and methods of measurement.

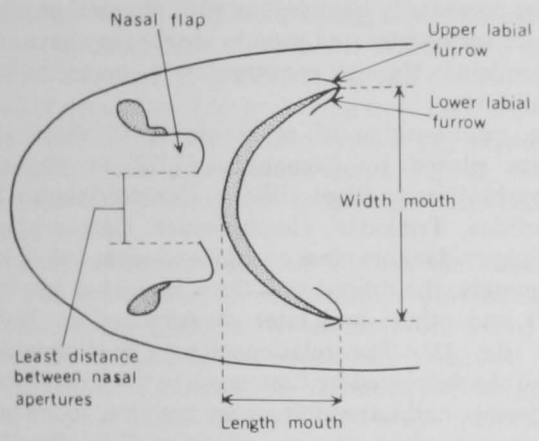


Figure 2.—Outline of ventral surface of head of a scyliorhinid shark.

the fin becomes apparent. The eye length, and also the ıgth of the orbit as used here, measures the horizontal ıgth of the opening in the skin surrounding the eye, not e bony orbit.

If I were to start again in the assembly of measureents of scyliorhinids, I would record additionally the eatest width of the head and the least distance across e top of the cranium between the bony orbits as well as e least distance across the top of the head between the per eyelids. I would also be sure to record least disnces between bases of adjacent fins.

At the beginning of each species account I have inıded a brief series of literature references. The first fers to the original species description in most inances but the rest were selected to list the more frelently used synonyms or were selected because the acunt of the species or the accompanying illustrations emed especially informative. I have omitted citing any sources either because I was unable to accept the ecies identification as correct or because the contained formation could be found in other papers.

FAMILY SCYLIORHINIDAE

Family diagnosis. Small galeoid sharks, maximum ıgth about 1.5 m (for possible exception see under *phaloscyllium isabella*); five gill slits, the 5th or 4th and 5th over the pectoral fin base; anal fin present; usually two dorsal fins (*Pentanchus profundicolus* has only one dorsal fin); dorsal fins without spines, either lobate or semilobate, the inner posterior tips sometimes sharply angled but not extended as a salient point; posterior end of base of first dorsal fin (or only dorsal fin) posterior to a vertical through the origin of the pelvic fin base; length of base of first dorsal less than length of caudal fin; caudal axis not elevated or little elevated; no keels or pits on caudal peduncle; nasal apertures of most species not connected to the mouth by channels crossing a depressed segment of the upper lip, but if channels present (as in a few species of the family), then no barbels extending from nasal flaps and no barbels elsewhere on head or body; pectoral fins usually short and broad, not falcate; eye openings longer than high, their anterior corners usually close to a vertical through the anterior edge of the upper lip; a fold of skin below eye (secondary lower eyelid), which in many species forms the lower border of a denticle-lined gutter below the primary lower eyelid; species not connected to the mouth by channels crossing moderately or strongly arched, mouth opening nearly confluent with curved arc of jaws; teeth small, numerous, their arrangement alternate with several transverse series functional; teeth of upper and lower jaws not greatly different in shape, always multicuspid in immature specimens and multicuspid in adults of most species but monocuspid in adult male *Apristurus riveri* and *Schroederichthys bivius*; dermal denticles of dorsal and lateral surfaces of adults typically imbricate with moderately broad blades on slender pedicles, the blades usually with ridges extending to three posteriorly directed points, the central point longest and strongest; lateral points and ridges often obsolete on denticles of ventral surfaces; denticles of juveniles typically narrower, more erect, sometimes spikelike; vertebral column moderately slender and weak, the transition from long monospondylous vertebrae to short diplospondylous vertebrae in pelvic region abrupt.

The foregoing definition omits reference to most of the internal anatomical characters that are needed to place the family within a general classification of elasmobranchs and to indicate relationships with other shark families.

Relationships and evolutionary history. Major changes in classification of the higher categories of living elasmobranchs have been proposed several times. In the most recent and well-reasoned, that of Compagno (1973), the Scyliorhinidae fall within the class Chondrichthyes, subclass Elasmobranchii, cohort Euselachii, and superorder Galeomorphii. The superorder Galeomorphii is divided into four orders: Heterodontiformes, Orectolobiformes, Lamniformes, and Carcharhiniformes, and the scyliorhinids constitute one of the eight families of the Carcharhiniformes. The characters of the greatest significance in Compagno's proposed classification are internal and an adequate discussion of them is beyond the scope of this account.

Skeletal characters and relationships of some scyliorhinid genera are discussed and illustrated in Nakaya's (1975) account of Japanese scyliorhinids.

Many sharks can be placed in the appropriate family by reference to obvious external features. Some scyliorhinids are similar in size, fin shape, fin position, and general appearance to the smaller orectolobids and without close examination might be confused with them. Differences in the head, and especially in the mouth, that can be seen without dissection distinguish the two families although important internal differences in the head cannot be seen without dissection. Some of the internal differences between scyliorhinids and orectolobids are shown in diagrams in Compagno's (1973, fig. 4B, C) paper on interrelationships in living elasmobranchs. The contrasting external appearances are also shown (Compagno 1973, plate 2C, D).

Separation of scyliorhinids from orectolobids is not difficult. The mouth of scyliorhinids is moderately or strongly arched with the mouth opening approximately superimposed on the line of occlusion of the upper and lower jaws, whereas the mouth of orectolobids is nearly transverse, not arched or little arched with the mouth opening not closely approximating the curve of the jaws. In most species of the Scyliorhinidae the upper lips do not have depressed areas forming channels between the nasal cavities and the mouth beneath enlarged nasal flaps, but in the few species with such a structure, barbels and barbellike structures are absent around the mouth or elsewhere on the head or body. Channels between the nasal cavities and the mouth, more or less protected or covered by structures of the lips, are present in all orectolobids and barbels are present either near the mouth or elsewhere on the head or body. The lips of scyliorhinid sharks are structurally simple, thin, and closely adherent to the jaws in contrast with the lips of orectolobids which are complex in form, relatively thick, and externally do not appear closely adherent to the jaws.

In a synopsis of the Scyliorhinidae, Regan (1908a) noted the absence of oronasal grooves but did not describe the structures. In his revision of the Orectolobidae, Regan (1908b) pointed out that the oronasal grooves in sharks merely correspond in position to the embryonic oronasal grooves of amniote vertebrates, and that they are specialized structures which have arisen independently in different families and do not approx mate the condition in ancestral higher vertebrate Nevertheless, Regan continued to use the term for thos structures in the orectolobids and further confused te minology by stating that in three scyliorhinids, *Scyli rhinus canicula, S. edwardsii* (= *Haploblepharus edwar sii*), and *S. marmoratus* (= *Atelomycterus marmoratus* the nasal cavities are so near the mouth that the lar nasal flaps overlie the upper lip and, hence, those speci have no oronasal grooves. After Regan's series of pape on shark classification in 1908 and earlier, Smith ar Radcliffe in Smith (1913) described *Cirrhoscyllium e politum*, a species that clearly belongs in the Orectol bidae but has no deep grooves between the nasal caviti and the mouth. In summary, it may be said that t channels connecting the nasal cavities with the mou are not necessarily homologous with oronasal grooves amniote vertebrates and even in sharks may have aris independently through convergence in orectolobids ar scyliorhinids.

The relationships of scyliorhinids to those sha families placed by Compagno (1973) in the ord Carcharhiniformes (Proscylliidae, Pseudotriakidae, Le tochariidae, Triakidae, Hemigaleidae, Carcharhinida and Sphyrnidae) are clear enough and seem to follow a proximately the traditional lines indicated by Whi (1937) and others and later diagrammed by Naka (1975, fig. 41). The relationships of scyliorhinids galeoid sharks placed by Compagno in the orders Heter dontiformes and Lamniformes are not clear to me but least seem to show no close affinities. Schaeffer (196 summarized evidence from fossil studies on the bro aspects of elasmobranch evolution and concluded th the three major groups of modern elasm branchs—galeoids, squaloids, and batoids—belong the same organizational level but that distinctive cha acters in each group pose unsolved problems of orig and mutual relationships. The earliest fossils sometim tentatively assigned to the Scyliorhinidae (Glikm 1964; Romer 1966) appear in the Upper Jurassic, b whether any such fossils should be placed in the fami as herein defined for extant species is open to questio

The modern Scyliorhinidae, Proscylliidae, Pseud triakidae, Leptochariidae, Triakidae, Carcharhinid and Sphyrnidae form a series of families with basic sim larities but increasing specialization. In a broad sense step by step trend appears in the series: in reproducti from oviparity as in most of the Scyliorhinidae to vi parity and the formation of pseudoplacentas in the mo advanced of the other families; from small avera species size in the Scyliorhinidae to medium size in t Triakidae to large size in some species of the Carch rhinidae and Sphyrnidae; from small, numerous mu cuspid teeth in the young of the Scyliorhinidae to larg less numerous, usually unicuspid teeth in some of t other families; from relatively few, long, and often poo calcified vertebrae in some of the Scyliorhinidae to son what greater numbers of shorter and more extensiv calcified vertebrae in the other families; from unp tected eyes in some species of the Scyliorhinidae to e

protected by a unique closing lower eyelid in the more specialized Carcharhinidae and Sphyrnidae; from flexible, usually small, and hydrodynamically inefficient, lobelike fins in the Scyliorhinidae to stiffer, larger, and hydrodynamically useful fins in the higher families; from a posteriorly placed and weak first dorsal fin suited only to eellike swimming in the Scyliohinidae to larger, stiffer, first dorsal fins that are located farther forward in the other families and provide a stabilizing plane against which the tail can push in the manner of a stern sculling oar.

Reproduction. Many of the better-known species of the Scyliorhinidae are oviparous. A single large-yolked egg is enclosed within a leathery capsule by nidamental glands when it passes through the anterior part of either of the two oviducts. Typically an egg capsule is extruded after a very brief period within the oviduct and usually becomes attached to an object on the sea bottom by means of slender tendrils projecting from each of the four corners of the capsule. The extruded egg capsules of scyliorhinids have a distinctive shape (Fig. 3), the posterior half with a somewhat greater diameter then the anterior half.

Although as recently as 1948 Bigelow and Schroeder (1948:196) stated that in scyliorhinids development is oviparous as far as known, it was later found that some species were ovoviviparous. Apparently it was Poll (1951) who first noted that not all scyliorhinids were oviparous. Later, Cadenat (1959) described the ovoviviparous form that Poll had seen as a new species, *Galeus polli.*

I can confirm from my own observations the reports that *Galeus polli* is ovoviviparous and add that *Cephalurus cephalus* should be so characterized. It is possible that a few other scyliorhinids are ovoviviparous also since details of the modes of reproduction are known for less than half the scyliorhinid species. Examinations of female reproductive organs do not show obvious, gross differences between oviparous and ovoviviparous species. The egg capsules of ovoviviparous species are membranous and may be difficult to detect if, indeed, they are not absorbed when embryos are well developed.

Kudo (1959) called attention to a variant form of oviparity in which several of the tough, leathery egg capsules are retained in oviducts until the embryos are partially developed. Nakaya (1975) called this mode of development in *Halaelurus buergeri* "multiple oviparity" to distinguish it from "single oviparity" in which one egg capsule at a time may occupy an oviduct and then for a brief period. Springer and D'Aubrey (1972) observed multiple oviparity in *Halaelurus boesemani* Bass (1973), and Bass et al. (1975) found it in *H. lineatus* and *H. natalensis.* Probably multiple oviparity characterizes *H. quagga,* but *H. lutarius* and *H. canescens* both have one capsule at a time in each oviduct, and multiple oviparity is not yet known from other scyliorhinid genera.

SOME CHARACTERS USED FOR THE IDENTIFICATION OF GENERA AND SPECIES

Supraorbital shelf and eyes. In six scyliorhinid genera the cartilage of the chondrocranium extends outward above the orbits forming narrow shelves (Fig. 4A) that usually can be detected by touch without dissection. In the 11 remaining genera the supraorbital shelf is absent (Fig. 4B). The anatomical term for the supraorbital shelf is supraorbital crest. As a general rule the species with a supraorbital crest have a firmer body, thicker skin, and stronger (more extensively calcified) vertebral column than other species. These characters suggest the possibility of dividing the family into two subfamilies. Although the eyes of all scyliorhinids are dorsolateral, the species with a supraorbital shelf appear to have their dorsal vision somewhat restricted by presence of the shelf but may have a better lateral field of vision.

The eyes in most scyliorhinids are proportionally large with the eye opening longer than high. Usually the only eye dimension practical to measure is the length of the opening because in preservation the lower eyelid may nearly close the eye, making the opening an elongate slit. A fold of skin, variously strong or weak in different species, sometimes not visible at all due to distortion of preservation, extends below the eye approximately parallel to, and separated from the lower eyelid by a

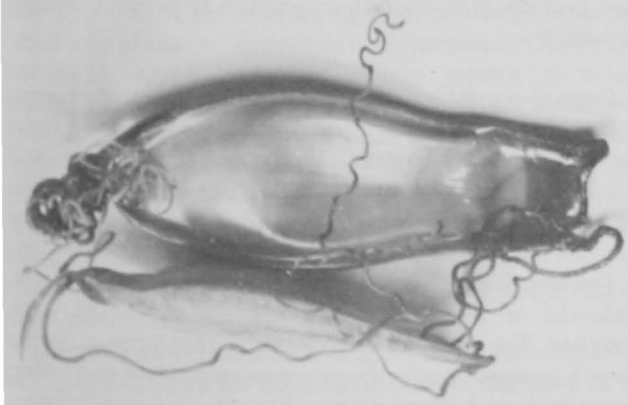


Figure 3.—Egg capsules of *Scyliorhinus stellaris* (BMNH specimens from Dungeness, England). The larger capsule is 115 mm long, not including horns or tendrils; its greatest width is about 45 mm. The lateral margins of *S. stellaris* capsules are notably thick and strong.

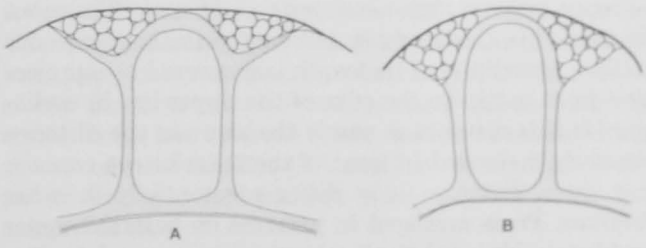


Figure 4.—Diagram of cross section of head through middle of eye (cartilage stippled). A. *Scyliorhinus canicula,* supraorbital shelf present. B. *Galeus arae,* supraorbital shelf absent. For detailed illustrations of cranium and visceral skeleton of *S. canicula* see Parker (1878, plates 36-38).

depressed channel sometimes called a subocular pouch but here called a subocular gutter. In the Scyliorhinidae, the subocular gutter is lined with denticles, except in some species with sparse denticle arrangement or in some juveniles. The subocular gutter is less obvious in some species than others but comparisons are difficult because its prominence depends considerably on whether or not the eye is fully open. Nevertheless, some comparisons are valid; for example, the subocular gutter is poorly or not at all developed in *Apristurus* but strongly developed in *Atelomycterus*. The lower eyelids of the scyliorhinids appear to be capable of partly or fully closing the slitlike openings to protect the eyes and even in those species with the more strongly developed subocular gutters the fold of skin below the eye does not come in contact with the eyeball or become a true secondary lower eyelid. In the more advanced species of the Carcharhinidae protection for the eye is afforded by a partly or fully closing lower eyelid sometimes called the nictitans (for discussion of structure and terminology of the carcharhinid eyelid see Gilbert and Oren 1964; Compagno 1970; Compagno and Springer 1971). Small spiracles, one located close to the posterior corner of each eye opening, are present in all scyliorhinids. In a few species, the spiracle lies within the posterior part of the subocular gutter which is as strongly developed posteriorly as anteriorly.

Mouth and labial furrows. In all scyliorhinids the mouth opening is moderately large and either broadly or steeply arched. The width of the mouth opening measured as the projected distance between mouth corners is occasionally useful in identification.

The presence or absence of labial furrows, whether or not the furrows are continuous around the mouth corners, and their comparative lengths along the upper and lower jaws are traditionally among the most used characters for the identification of scyliorhinids. I have found the character reliable except in *Halaelurus buergeri*, in which labial furrows may be either very short or sometimes absent at one or both mouth corners. Species of *Scyliorhinus* have an inconspicuous tab of the upper lip usually projecting slightly over the lower lip at each mouth corner. Its outer margin in some instances may look like a short upper labial furrow. Close examination will show, however, that it is not continuous with the lower labial furrow in *Scyliorhinus*.

Snout, pore arrangement, and nasal flaps. The snout as defined in this study is that part of the head anterior to the upper lip, and its length is measured as a projection from its tip to the edge of the upper lip. In scyliorhinids this distance is nearly the same as the distance similarly measured in front of the anterior eye corners, but these distances may differ substantially in other families. Pores arranged in patterns on both the upper and lower sides of the snout are conspicuous and more or less characteristic of species in some scyliorhinids. The arrangements appear to be somewhat variable within a species and hence I have referred to pore arrangements in only a few species diagnoses.

The nasal apertures of all sharks are partly divid into two openings by an internal septum extending fro the midpoint of the nasal cavity wall. The anterior a more lateral opening is generally without any coveri but the posterior and medial opening may be entire hidden, partly covered, or not covered at all by a flap skin that may extend from the anterior margin of t nasal aperture. In this study this structure is called t nasal flap. Regardless of its shape or function it is n here referred to as a cirrus or as a valve. In some scyli rhinids, a small and inconspicious, denticle-free fold membranous skin along the posterior margin of the po terior nasal opening may function, together with t nasal flap, as a valve to direct or reduce the outflow water.

Morphometrics. I have avoided the use of propo tional measurement differences for species diagnos whenever alternative characters could be found becau proportions may change during growth and becau preservation may variously affect measurements specimens. Bass (1973) proposed methods of descripti and analysis of proportional dimensions with math matical expressions of growth patterns for eight scyli rhinid species, the pattern for each species based measurements of 14 to 102 specimens. His illustrati (1973, fig. 9) of *Holohalaelurus regani* shows t remarkable difference in that species between a 129-m juvenile and a 393-mm adult. Scyliorhinids, like oth sharks, are subject to changes in proportions duri growth. As pointed out by Garrick (1960) in a discussi of New Zealand Squalidae, the rate of growth in parts the head or tail differs from the rate in midsections of t body. In some species the body cavity of females may i crease disproportionally in length at sexual maturit Proportional measurements are further complicat because specimens may either stretch or shrink in pr servative. In soft-bodied scyliorhinids, the bulky mass tissues of the trunk frequently shrink and pull the we vertebral column out of normal alignment, often, but n always, producing an unnatural hump in the back. In t same specimen the vertebral column of the caudal se tion may be stiff and strong enough to prevent mark distortion.

Dermal denticles. Two scyliorhinid genera, *Gale* and *Parmaturus*, differ from all others in having a cauc crest of modified denticles, somewhat larger a different (Fig. 5) in shape from the denticles of the late surfaces of the tail and separated from them by a narr strip of naked skin.

The denticles of juveniles of most species are narro spikelike or needlelike, and are not especially cl together. The replacement denticles that appear duri growth in most species are progressively larger and wid sometimes with three points (Fig. 6), and usually ov lapping.

Teeth. Teeth of all scyliorhinid sharks are small a numerous with several transverse series function

Upper and lower jaw teeth are similar in general shape. In all known juvenile scyliorhinids the teeth have three, five, or sometimes more, sharply pointed cusps. Typically the teeth of the central part of the jaws are symmetrical with the middle cusp much the longest, but teeth in

Figure 5.—Caudal crest denticles of *Galeus arae cadenati*. Crest denticles of marginal rows are usually asymmetrical at all ages in *Galeus* but only in adults of some *Parmaturus*.

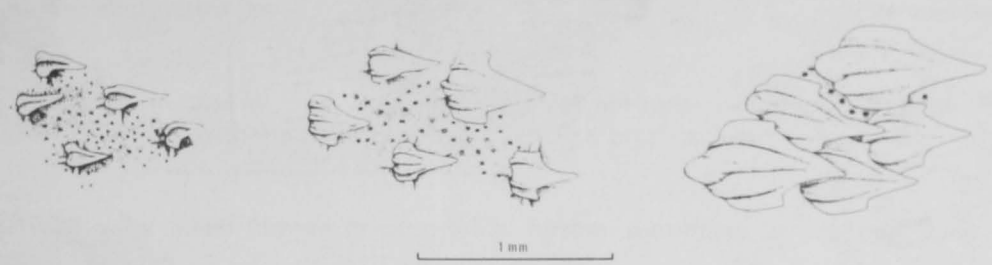


Figure 6.—Dermal denticles of dorsolateral surfaces from a series of female *Scyliorhinus retifer* from the Gulf of Mexico. Left: from a 175-mm specimen. Center: from a 295-mm specimen. Right: from one 465 mm long. Camera lucida drawings to the scale indicated.

the lateral parts of the jaws are progressively less symmetrical and have shorter and more numerous cusps.

Usually upper jaw teeth are slightly larger than lower jaw teeth but in adult male *Aulohalaelurus* (females and young not examined) the lower jaw teeth are substantially larger. Females and immature males of *Apristurus riveri* have multicuspid teeth typical of the family, but adult males have unicuspid teeth more than twice as large as the teeth of females of comparable size (Fig. 7). Other species of *Apristurus* in which both adult males and females are known do not exhibit such sexual dimorphism. A transition from multicuspid teeth to unicuspid teeth at maturity also occurs in *Schroederichthys bivius*. Tooth dimorphism of small magnitude may be characteristic of some other scyliorhinids but has not yet been noted.

The number of vertical rows of teeth (a row is defined here as a file of teeth crossing from the lingual to the labial side of the jaw approximately perpendicular to the jaw axis) remains constant during growth in many sharks, the more advanced carcharhinids for example. In those sharks the number of tooth rows may be characteristic of a species. I have not found evidence that the number of tooth rows changes with growth in scyliorhinids but I have not adequately investigated that possibility. In some batoids the number of tooth rows may increase greatly during growth (Templeman 1965; Springer and Collette 1971).

The teeth of scyliorhinids (Fig. 8) begin development in a germinal area on the lingual side of the jaws as in other modern sharks (Landholt 1947; James 1953), and, as new tooth buds form in the germinal area the developing teeth move toward the labial side of the jaws and into functional positions as they become fully formed and hard. Finally the teeth move to the outer transverse

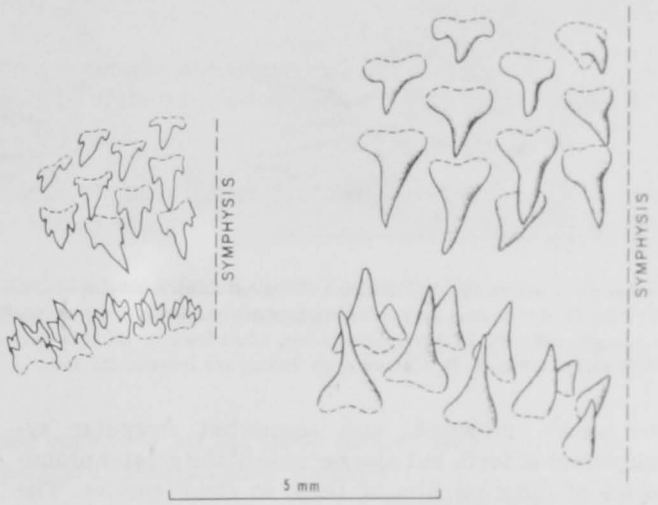


Figure 7.—Camera lucida outlines of teeth of a 405-mm adult female *Apristurus riveri* (left) compared with same scale outlines of teeth of a 430-mm adult male (right), both specimens from 860 to 914 m depth off the Caribbean coast of Panama.

series and are shed. Applegate (1965) found that in *Odontaspis taurus* (Odontaspididae) the size of the teeth was in approximate linear correlation with the size of the shark. The rate of tooth development and shedding in scyliorhinids has not been determined but evidence from species of other families (Ifft and Zinn 1948; Moss 1967) points to rapid replacement rates, especially for immature sharks.

Tooth arrangement in the Scyliorhinidae, following Strasburg's (1963) classification, is chiefly in the alternate overlap pattern which precludes shedding teeth in bands as in some squaloids. The number of vertical tooth rows is often difficult to determine, not only because of

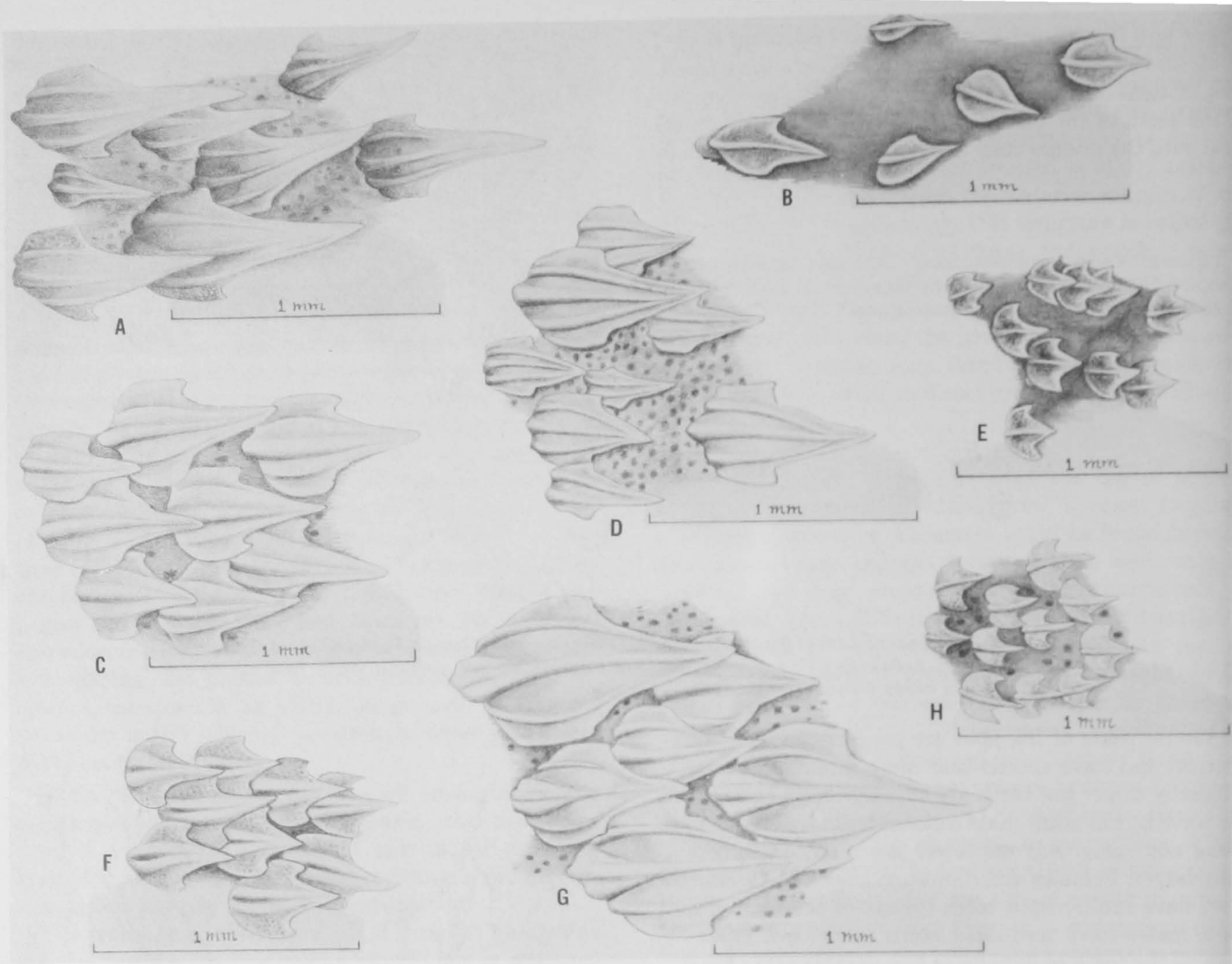


Figure 8.—Camera lucida drawings of typical flank denticles of some western Atlantic scyliorhinids: A. *Scyliorhinus meadi,* immature mal 264 mm; B. *Apristurus profundorum,* immature female, 380 mm; C. *Scyliorhinus torrei,* adult male, 243 mm; D. *Scyliorhinus hesperius,* imm ture male, 296 mm; E. *Apristurus riveri,* adult female, 405 mm; F. *Schroederichthys maculatus,* adult female, 295 mm; G. *Scyliorhinus retife* adult male, 410 mm; H. *Galeus arae,* immature female, 287 mm.

the small, crowded, and somewhat irregular arrangement of teeth but also because of the greater prominence of diagonal files of teeth in some species. The number of diagonal files is always substantially less than the number of rows perpendicular to the jaw axis. Thus, Saemundsson's (1922) count of tooth rows for the holotype of *Scyllium laurussonii* is less than mine because we used different definitions of a row. Because of the difficulties, I do not make substantial use of tooth counts for separating species.

Vertebral numbers. As pointed out by Springer and Garrick (1964), vertebral numbers are important characters in systematic studies of carcharhinid sharks and might also be important in the study of other families. In their comprehensive survey these authors reported numbers of both precaudal and caudal vertebrae. In the Scyliorhinidae, however, the caudal axis is not elevated and no pits or other reference points conveniently establish an exact point in separating precaudals from caudals. Furthermore, the terminal caudal vertebrae of some young scyliorhinids may not be visible on radio graphs. I have, therefore, indicated the number of mono spondylous vertebrae for all species that were availabl to me for X-ray examination. Total numbers of vertebra are also given for some species.

In scyliorhinid sharks the vertebral column has com paratively long vertebrae in the trunk region with a di tinct and visibly abrupt transition to shorter vertebra above the pelvic fins. The long vertebrae of the anteri region are here called monospondylous and the short vertebrae of the posterior region diplospondylous. I d not intend by the use of these terms to imply that I eith noted or looked for morphological differences in th vertebrae other than length. Goodrich (1930) called th transition from monospondyly to diplospondyly in *Scy lium* (= *Scyliorhinus*) short but gradual. It is true th the last monospondylous vertebra is somewhat short than the preceding one, but the length decrease betwe the last monospondylous and the first diplospondylous so marked that a precise point of change from one form the other can be seen easily.

KEY TO GENERA OF THE SCYLIORHINIDAE

(In the text following this key the arrangement of genera is alphabetical.)

1a. Supraorbital crest present (Fig. 4A) 2

1b. Supraorbital crest absent (Fig. 4B) 7

2a. Labial furrows present, at least along lower jaw 3

2b. No labial furrows along either jaw . . . . . *Cephaloscyllium* - 5 species

3a. No upper labial furrows present, and upper labial furrows not continued around each mouth corner; upper lip usually with a small projecting tab which overlaps lower lip at each mouth corner 4

3b. Both upper and lower labial furrows present; labial furrows continuous around each mouth corner, no upper lip tabs 5

4a. Nasal flap barbels absent or represented only by swollen areas in the nasal flap; tips of these swollen areas sometimes projecting posteriorly past margins of nasal flaps for a distance not greater than the diameter of the spiracle . . . . . *Scyliorhinus* - 13 species

4b. Nasal flap barbels present; longer than the diameter of the spiracle, and longer than the diameter of the bases of the barbels which extend from the margins of the nasal flaps . . . . . *Poroderma* - 3 species

5a. Nasal flaps of various lengths but none reaching past edge of upper lip; no depressed areas of upper lip forming broad channels between nasal cavities and mouth 6

5b. Nasal flaps large and very long, their posterior tips reaching past edge of upper lip; upper lip with broad depressed areas forming broad channels between nasal cavities and mouth . . . . . *Atelomycterus* - 2 species

6a. Nasal flaps large and long, their tips not quite reaching edge of upper lip; labial furrows very long, the upper extending about two-thirds the distance toward the upper jaw symphysis . . . . . *Aulohalaelurus labiosus*

6b. Nasal flaps moderately large, but their tips short of edge of upper lip; labial furrows short or moderately long, the upper extending less than half the distance toward the jaw symphysis . . . . . *Schroederichthys* - 4 species

7a. Two dorsal fins present 8

7b. Only one dorsal fin present . . . . . *Pentanchus profundicolus*

8a. Caudal crest of specialized denticles in three or many rows extending along the proximal half of upper edge of caudal fin, the crest denticles of some of them different in shape from denticles of the lateral surfaces of the caudal fin and separated from them by a narrow strip of naked skin 9

8b. No caudal crest of modified denticles 10

9a. Caudal crest nearly flat across its top, its marginal denticles strongly asymmetrical in young as well as in adults, small median denticles of crest usually in less than 5 rows; dorsal surfaces either marked with a variegated color pattern or dorsal surfaces darker than ventral surfaces; pectoral fins remarkably broad, their greatest widths measured straight across the fins near the convex distal margins usually greater than the width of the mouth . . . . . *Galeus* - 12 speci

9b. Caudal crest rounded across its top, its marginal denticles strongly asymmetrical only in adults or half-grown and symmetrical in juveniles, small median denticles of crest usually in more than five rows; dorsal surfaces not variegated and usually unmarked, color contrast between dorsal and ventral surfaces slight; pectoral fins not remarkably broad, their greatest widths usually less than or equal to the width of the mouth . . . . . *Parmaturus* - 6 speci

10a. Nasal flaps large, overlapping upper lip and hiding broad, shallow channels that connect nasal apertures with mouth . . . . . *Haploblepharus* - 3 speci

10b. Nasal flaps small or moderate in size, not overlapping upper lip; no depressed areas or channels across upper lip . . . . . .

11a. Labial furrows present along both upper and lower jaws and around mouth corners (except in some specimens of *Halaelurus buergeri*) . . . . . .

11b. No labial furrows . . . . . *Holohalaelurus* - 2 speci

12a. Adults tadpole-shaped as viewed from above, tapering from anterior part of head to origin of caudal fin; head length from tip of snout to fifth gill slit more than one-fourth total length . . . . . *Cephalurus cephalu*

12b. Adults not tadpole-shaped as viewed from above, not tapering regularly from anterior part of head to origin of caudal fin; head length from tip of snout to fifth gill slit less than one-fourth total length . . . . . .

13a. Throat with transverse wrinkles formed by rows of dermal denticles alternating with vary narrow bands of naked skin . . . . . *Parapristurus spongicep*

13b. Throat without transverse wrinkles . . . . . .

14a. Species with moderately firm bodies and thick skins covered by well-hardened denticles; color usually not uniform, most species with a pattern of darker spots, bars, or dorsal saddle blotches; angle of view of eyes more lateral than dorsal; snout not notably long or spatulate . . . . . .

14b. Soft-bodied species with thin skins and weakly stiffened dermal denticles; color usually uniform with markings absent except for darker areas around mouth, gill slits, and fin margins; angle of view of eyes more dorsal than lateral; snout typically flattened, elongate, and spatulate with sharply angled edges . . . . . *Apristurus* - 21 speci

15a. Basal half or third of pelvic fins of adult males united, forming an apron between the claspers and the pelvic trunk . . . . . .

15b. Adult males without an apron . . . . . *Halaelurus* - 9 speci

16a. Claspers of adult males notably long and slender, extending for at least half their lengths past pelvic fin tips . . . . . *Juncrus vincenti*

16b. Claspers of adult males not notably long and slender, extending less than half their lengths past pelvic fin tips . . . . . *Asymbolus analis*

APRISTURUS GARMAN

Apristurus Garman 1913:96 (type-species, *Scylliorhinus indicus* Brauer, by original designation).

Diagnosis. Species of *Apristurus* are somewhat compressed, soft-bodied scyliorhinids with two dorsal fins, much flattened heads, and long, spatulate snouts having conspicuous pores (ampullae of Lorenzini) above and below, the pores usually arranged in a pattern. The anterior and lateral edges of the snout are usually thin and sharp. The eyes are located dorsally so that the shark's angle of view is as much dorsal as lateral. *Apristurus* has prominent labial furrows that are continuous around the mouth corners. The nasal apertures are large and oblique and nasal flaps are reduced to narrow and usually short points that do not cover the posterior half of the nasal apertures and often do not extend across them.

All *Apristurus* lack a supraorbital crest (shelf) of the chondrocranium; they lack depressions or channels in the upper lip connecting the nasal apertures with the mouth; they lack a crest of modified denticles on the proximal half of the upper edge of the caudal fin; and they lack a series of transverse gular wrinkles that are formed by narrow bands of denticle-covered skin alternating with narrow bands of naked skin.

Most *Apristurus* are black, dark brown, or dark gray without markings except darker areas around the mouth, gill slits, and on the leading edges of fins. All species lack dark saddle blotches and darker or lighter spots or bars. The dorsal and ventral surfaces are either uniform in color or the ventral surface may be slightly darker. One species, *Apristurus sibogae*, known only from the immature holotype, was described as reddish-white.

The teeth of *Apristurus* species are small and numerous, usually similar in the upper and lower jaws, and with several transverse series functional. Symphyseal teeth are absent and considerable space may separate teeth on the right half from the left half of each jaw, but the amount of separation is variable and may be due only to the degree of relaxation of symphyseal ligaments. Typically the teeth are moderately flattened, multicuspid, the central cusp somewhat larger than the lateral cusps. The number of vertical rows of teeth is not easily counted and counts given in the literature may sometimes represent the number of diagonal rows instead of vertical rows. In one species, *A. riveri*, the teeth of adult males become enlarged and monocuspid through replacement (Fig. 7) but such sexual dimorphism has not been observed in other species of *Apristurus*.

The dermal denticles are small, usually with a three-pointed blade in adults. Young *Apristurus* may have slender, needlelike denticles which may be replaced by broad-bladed denticles as the shark grows larger. The denticles are sometimes rather flexible and the degree of flexibility may determine whether the skin feels rough or velvety to touch. The soft denticle points of some specimens may be an artifact of preservation.

The number of monospondylous vertebrae is comparatively small in *Apristurus* and these vertebrae are long, thin, and have weakly calcified centra. From X-ray examination it can be seen that vertebral centra are often broken, possibly during capture. The number of vertebrae in species of *Apristurus* shown in Table 1 may be useful in systematics as a character of secondary importance. For a discussion of vertebral numbers in the Scyliorhinidae see under *Galeus*.

Discussion. Twenty-one species of *Apristurus* have been named including the two new species described here. Although some of the nominal species are of doubtful validity it seems probable that some remain undiscovered. Such a view is supported, for example, by three specimens collected by the RV *Albatross* in 1888 near the Galapagos Islands. Each specimen, USNM 135363, 133206, and 133207, was given a manuscript name many years ago but no description was published. My own examination of the specimens indicated that *A. brunneus*, *A. nasutus*, and *A. kampae*, the three species hitherto described from the eastern Pacific, were not represented, but more specimens would have to be available to give an adequate basis for description of a new species.

Few museum specimens are available from many parts of the world. Some type-specimens are missing and some others are in very bad condition. To add to the difficulties of study, all of the species are undistinguished by prominent markings and outstanding structural differences. Members of the genus are all characterized by loose, thin skins and by weakly supported, soft bodies that preclude precise and reproduceable measurements, especially after long preservation.

Apristurus specimens hitherto reported from African coasts include the holotype of *A. atlanticus* from the vicinity of the Canary Islands, the three type-specimens of *A. indicus* from the coast of Somalia and the Gulf of Aden, the holotypes of *A. microps* and *A. saldanha* from South Africa, three specimens from the vicinity of Saldanha Bay, South Africa, referred to *A. saldanha* by Norman (1935) and tentatively by Bass et al. (1975), and finally, one specimen from Southwest Africa reported by Karrer (1973) as *Apristurus* sp. Eleven additional specimens not yet in published reports were taken by research vessels of the U.S.S.R. (Georgio Golovan, P. P. Shirshov Institute of Oceanology, Acad. Sci.

Table 1.—Numbers of monospondylous vertebrae in species of *Apristurus*.

Number of vertebrae (monospondylous)	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
A. herklotsi	1																		
A. riveri			2	9	5														
A. longicephalus[1]					1														
A. profundorum						1													
A. canutus						2	2	4	1										
A. kampae							1												
A. verweyi								1											
A. sibogae								1											
A. nasutus									3										
A. platyrhynchus									1										
A. parvipinnis										2	18	15	11						
A. macrorhynchus											2	1	3						
A. laurussonii											2	2	3	7	—	2			
A. indicus												1	1						
A. brunneus												1	2	2					
A. japonicus[1]																3	2	4	3

[1]Data from Nakaya (1975).

U.S.S.R., Moscow, pers. commun.). As provisionally identified by Golovan, four fit *A. profundorum,* three *A. micr* and the remaining four remain unidentified but are of great interest and may better establish the characters by wh *A. atlanticus* and *A. saldanha* may be recognized (see discussions under those species).

Apristurus species are not known from the Mediterranean and have not been taken from the eastern North Atla except peripherally from Iceland, Madeira, and Canary Island slopes.

A large number of *Apristurus* specimen records of capture were available to me from exploratory vessels of National Marine Fisheries Service (formerly Bureau of Commerical Fisheries). These indicate that for the Gul Mexico-Caribbean region, *Apristurus* is demersal and sparsely distributed on mud or soft-bottom localities at dep usually greater than 500 m. There, *Apristurus* was taken in the greatest numbers from 700 to 1,200 m but the dee limits of distribution were poorly defined. *Apristurus* was not taken in midwater in the Gulf of Mexico-Caribbean a but *Apristurus brunneus* was taken off central California (J. A. F. Compagno, pers. commun.) at several hundred met above the bottom. I suspect that the midwater occurrence is not really a rarity, especially in some localities, althou most records suggest strictly demersal habitats.

Publications by Chirichigno (1976) and Golovan (1976) which recorded *Apristurus* from the west coast of So America and from the west coast of Africa, respectively, were not seen until too late for adequate consideration for t paper.

The well-developed ampullae of Lorenzini that are so conspicuous on the snout of species of *Apristurus* undoubte play an important role in the location of prey for these sharks. The ampullae of Lorenzini detect electrical fi generated by animals in their proximity. The ability of some sharks to locate hidden prey through electrosensitivity been experimentally demonstrated for *Scyliorhinus canicula* (Kalmijn 1966, 1971). Such a means of locating food m be relatively more important for *Apristurus* because of its habitat in deep water where sunlight is nil and food is c paratively scarce. I may speculate further that the spatulate snout packed with canals of the ampullae system is adapted for food seeking in soft mud.

Key to Species of *Apristurus*

1a. Gill covers without a median pointed lobe, or if present, the lobe not projecting for a distance as great as 2× spiracle diameter . . . . . .

1b. Gill covers with a median pointed lobe projecting posteriorly for a distance about equal to 2× spiracle diameter . . . . . *A. maderen*

2a. Anal fin long, its rear tip separated from origin of lower caudal lobe by a distance less than half the length of the eye opening . . . . . .

2b. Anal fin shorter, its rear tip separated from origin of lower caudal lobe by a distance greater than half the length of the eye opening . . . . . *A. kamp*

3a. Distance between dorsal fin bases greater than length of base of second dorsal fin 4

3b. Distance between dorsal fin bases less than length of base of second dorsal fin . . . . . *A. microps*

4a. Origin of first dorsal fin over or in advance of rear end of pelvic fin base 9

4b. Origin of first dorsal fin posterior to rear end of pelvic fin base. 5

5a. Color black, brown, or gray, not white or reddish-white 6

5b. Color white or reddish-white . . . . . *A. sibogae*

6a. Distance between dorsal fin bases less than distance from tip of snout to eye 7

6b. Distance between dorsal fin bases greater than distance from tip of snout to eye . . . . . *A. platyrhynchus*

7a. Rear end of base of second dorsal fin in advance of rear end of base of anal fin 8

7b. Rear end of base of second dorsal fin over or behind rear end of base of anal fin . . . . . *A. verweyi*

8a. Distance between pectoral and pelvic fin bases short, 6.0 to 8.5% total length (TL); anal fin base long, 18.0 to 22.0% TL; monospondylous vertebrae 33-36 . . . . . *A. canutus*

8b. Distance between pectoral and pelvic fin bases long, 10.0 to 14.0% TL; anal fin base relatively shorter, 16.0 to 18.0% TL; monospondylous vertebrae 37-41 . . . . . *A. parvipinnis*

9a. Eye not very large, its horizontal diameter less than 4.2% TL 10

9b. Eye very large, its horizontal diameter more than 4.2% TL . . . . . *A. atlanticus*

10a. First dorsal fin much smaller than second dorsal fin, first dorsal area less than half area of second dorsal, length base first dorsal less than three-fourths length base second dorsal 11

10b. First dorsal fin equal to, or only a little smaller than second dorsal fin, first dorsal area more than half area of second dorsal, length base of first dorsal three-fourths or more than three-fourths length base of second dorsal 13

11a. Origin of first dorsal fin in advance of rear end of pelvic fin base 12

11b. Origin of first dorsal fin over rear end of pelvic fin base . . . . . *A. herklotsi*

12a. Length of anal fin base less than distance from tip of snout to spiracle . . . . . *A. riveri*

12b. Length of anal fin base greater than distance from tip of snout to spiracle . . . . . *A. investigatoris*

13a. Interdorsal space not very long, distance between first and second dorsal fin bases less than distance from tip of snout to spiracle 14

13b. Interdorsal space very long, distance between first and second dorsal fin bases about equal to distance from tip of snout to spiracle . . . . . *A. saldanha*

14a. Distance between bases of pectoral and pelvic fins less than distance from tip of snout to first gill slit 15

14b. Distance between bases of pectoral and pelvic fins greater than distance from tip of snout to first gill slit . . . . . *A. japonicus*

15a. Snout (in front of mouth) short or only moderately long, its length 6.6 to 10.5% TL; abdominal trunk moderately long, distance from base of pectoral fin (pectoral axilla) to base of pelvic fin (pelvic fin origin) usually more than 8.0% TL 16

15b. Snout very long, its length about 12% TL; abdominal trunk short, distance from base of pectoral fin to base of pelvic fin about 7% TL . . . . . *A. longicephalus*

16a. Distance between pectoral and pelvic fin bases greater than distance from tip of snout to spiracle 17

16b. Distance between pectoral and pelvic fin bases less than distance from tip of snout to spiracle . . . . . *A. laurussonii*

17a. Snout comparatively short, its length in front of mouth 6.6 to 8.2% TL 18

17b. Snout moderately long, its length in front of mouth 8.5 to 10.4% TL 19

18a. Distance between dorsal fin bases usually about equal to length of snout in front of mouth . . . . . *A. brunneus*

18b. Distance between dorsal fin bases usually greater than length of snout in front of mouth . . . . . *A. nasutus*

19a. Length of base of anal fin long, 15.7 to 19.1% TL 20

19b. Length of base of anal fin short, 13.9% TL . . . . . *A. profundorum*

20a. Origin of first dorsal fin over middle of base of pelvic fins . . . . . *A. indicus*

20b. Origin of first dorsal fin over posterior end of base of pelvic fins . . . . . *A. macrorhynchus*

Apristurus atlanticus (Kofoed)

Scylliorhinus atlanticus Kofoed 1927:18, pl. IV, No. 3 (from vicinity of eastern Canary Islands).

Not *Apristurus atlanticus:* Bigelow et al. 1953:217, fig. 1.

Material examined. Not seen, Kofoed's holotype, ZMO, is an immature male about 250 mm long, taken from 1,36 m at *Michael Sars* station no. 41,235 at lat. 28°08'N, long. 13°35'W, yellow mud bottom. Although I did not see the typ Alwyne Wheeler (in correspondence) gave me his recent measurements of the specimen. Western Atlantic specimen referred to this species by Bigelow and Schroeder (1948) and by Bigelow et al. (1953), are here regarded as specimens o *Apristurus laurussonii*.

Diagnosis. Kofoed's measurement of eye length, 4.9% TL, indicates a proportionally larger eye than in any othe species of *Apristurus*. His measurements show that the base of the anal fin, 14.4% TL, is slightly greater in proportio than that of the holotype of *A. profundorum*, 13.9% TL, and slightly less than that of two of the types of *A. indicus*, 15. and 16.2% TL.

Kofoed's figure for the holotype of *A. atlanticus* indicates that the two dorsal fins are nearly equal in size, the first do sal origin over the posterior end of the pelvic fin base; length of snout in front of mouth about equal to the distanc

between the dorsal fin bases and to the distance from the pectoral axilla to the pelvic fin origin; posterior tip of anal fin reaches origin of lower caudal fin and extends only a little posterior to the second dorsal fin base.

Discussion. Bigelow and Schroeder (1944:21-22) called attention to the strongly curved (concave) anterior edges of the gill slits in their account of *Apristurus* and noted that the curved gill slit margins were illustrated by Kofoed (1927, pl. 4) from the type of *atlanticus*. Bigelow and Schroeder believed that the genus might be divided on the basis of this character, with *atlanticus, riveri,* and others having curved gill slits and *brunneus* and other species having more or less straight ones. Examination of larger series, however, shows the character to be variable and unreliable. The larger specimens of some species often have gill slit edges straight or nearly so and young specimens have curved gill slit edges. The absence of denticles around the gill openings makes an oval patch of bare black skin. It appears to be frequent in immature examples but infrequent in adults of several species.

As with several species of *Apristurus* known from single specimens, the case for recognition of *A. atlanticus* is not strong but it is also not clear that it belongs in synonymy. Eastern Atlantic specimens of *Apristurus* are few in comparison with numbers taken in the western North Atlantic but whether this reflects a real scarcity or is due to differences in collecting effort is not clear.

Apristurus brunneus (Gilbert)
Figure 9

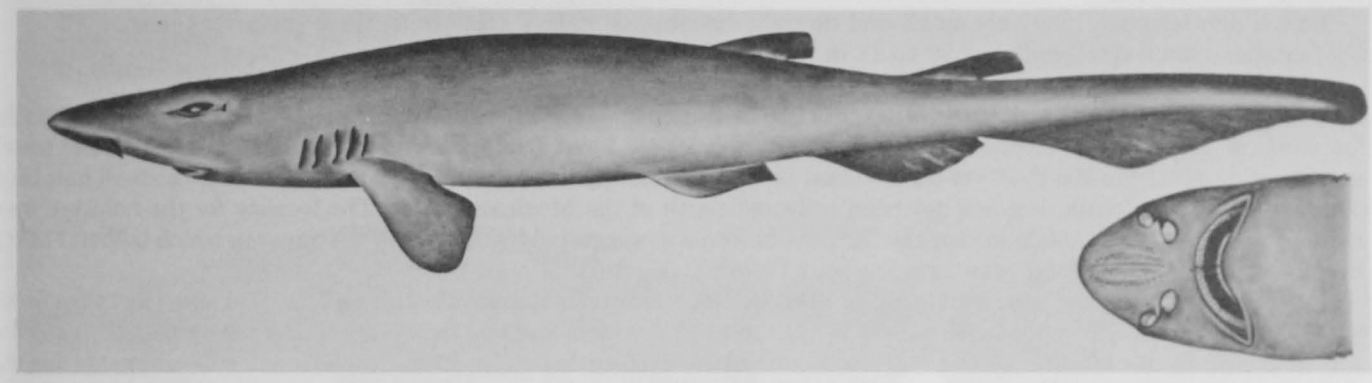


Figure 9.—*Apristurus brunneus,* 330-mm immature female from coast of Washington. Drawing by Mary Wagner.

Catulus brunneus Gilbert 1892 (from off La Jolla, Calif.).

Apristurus brunneus: Garman 1913:99; DeLacy and Chapman 1935:63; Roedel and Ripley 1950:49, fig. 33; Beebe and Tee-Van 1941:99; Clemens and Wilby 1961:78; Cox 1963:281, fig. 9.

Material examined. USNM 51708, holotype, adult (ad.) ♀, 50 cm *Albatross* stn. 2396, lat. 32°49′N, long. 117°29′W, in 556 m; ad. ♂, 655, 605 mm; imm. ♂, 545 mm; ♀, 567, 545, 355, 352, 265 mm, coast of Washington in 730-790 m; young ♂ 65 mm (probably taken from egg capsule before hatching), Santa Barbara Channel, Calif.

Diagnosis. In *A. brunneus* the area of the first dorsal fin is usually somewhat less than the area of the second dorsal although the size difference between the two fins is not great and is somewhat variable; the distance between dorsal fin bases is about equal to the snout length; the anal fin is long, the length of its base about equal to the distance from the snout tip to the spiracle, the anal fin tip reaching past the origin of the lower caudal lobe. *Apristurus brunneus* is brown in life and fades somewhat in preservative.

It is important to note for purposes of identification that *A. brunneus,* like all other *Apristurus,* lacks a caudal crest. The lack of a caudal crest distinguishes it from *Parmaturus xaniurus,* which may be found in the southern part of its range.

Two other *Apristurus* have thus far been described from the eastern Pacific. *Apristurus kampae* from the Gulf of California, here regarded as known only from the holotype, has a much shorter anal fin than *A. brunneus,* its posterior tip not reaching the lower lobe of the caudal fin. *Apristurus nasutus,* described from specimens taken off the coast of Chile, has a slightly shorter snout and a longer interspace between dorsal fin bases than *A. brunneus* from the coasts of Washington and British Columbia. The southward range of *A. brunneus* from southern California along the coast of Central America to Panama is suggested by some recent collections made in Panama Bay (C. E. Dawson, pers. commun.) which indicate the need to reexamine the status of *A. nasutus* (see discussion under that species).

Description. The following proportional measurements given as percentages of total length show something of th extent of variation with size in proportions. In each group of proportional measurements, the first is from a 655-mm adult male, the second from a 567-mm subadult female, the third from a 265-mm young female, and the last from a 65 mm hatchling male.

Tip of snout to: front of mouth, 6.0, 9.0, 9.4, 6.6; eye, 7.3, 9.7, 10.1, 6.5; first gill slit, 17.4, 19.8, 20.8, 20.6; origi pectoral fin, 21.7, 23.3, 26.4, 23.3; origin first dorsal fin, 51.1, 52.9, 46.0, 47.7; origin pelvic fins, 44.6, 45.9, 45.3, 45.3 origin anal fin, 53.4, 58.6, 52.8, 51.0; origin upper caudal fin lobe, 69.0, 70.5, 67.9, 72.4.

Orbit: horizontal diameter, 2.7, 3.5, 3.0, 4.0.

Mouth: width, 6.7, 7.9, 9.1, 9.9; length, 3.7, 4.2, 3.8, 5.4; length lower labial furrow, 2.6, 3.2, 2.6, 2.0; length uppe labial furrow, 3.1, 3.4, 2.6, 2.5

Nostrils: least distance between (= internasal), 2.4, 3.2, 3.4, 3.5.

Gill slits: height of first, 1.5, 2.1, 2.6, 2.6; height of fifth, 1.7, 1.6, 1.5, 1.7.

Length of fin bases: first dorsal, 5.8, 6.0, 6.8, 7.7; second dorsal, 6.7, 7.4, 7.5, 7.7; anal, 13.7, 12.0, 13.6, 13.9.

Distance between fin bases: first and second dorsal fins, 7.6, 7.1, 6.4, 3.9.

Anterior margin of fins: pectoral, 10.7, 10.4, 9.8, 10.5; first dorsal, 10.2, 7.9, 10.6, 9.2; second dorsal, 8.1, 10.2, 11.3 9.2; anal, 7.2, 9.2, 6.4, 7.2.

The teeth are mostly five-cusped, the middle cusp much the largest, upper and lower teeth are similar except that th lower jaw teeth may be somewhat more slender and less erect. Upper teeth are generally in 29 to 31 vertical rows, lowe teeth in 30 to 34 rows.

Dermal denticles are relatively small and densely distributed, nearly erect, with three posterior points.

Monospondylous vertebrae were 39 to 41 in five specimens.

Discussion. *Apristurus brunneus* is not uncommon at depths from 137 to 347 m off British Columbia and occurs a far north as the Strait of Georgia (Clemens and Wilby 1961). I saw moderately large numbers taken in some traw catches at depths from 455 to 790 m off the coast of Washington. *Apristurus brunneus* has been taken in small number off Oregon and California, but has not been collected south of the Mexican border. The locality for the holotype wa neither the Santa Barbara Islands nor the Gulf of California as suggested by the title of the paper in which Gilbert (1892 described *A. brunneus* (see Beebe and Tee-Van 1941:99).

Apristurus brunneus egg capsules were described by DeLacy and Chapman (1935) from four capsules, two taken from a 452-mm female caught in about 82 m in Washington coastal waters and two trawled from the same area. One capsul was attached by its tendrils to the stalk of a sea whip. The authors also gave proportional measurements for 2 specimens 368 to 500 mm long taken from Saratoga Passage, Wash. The egg capsule of *A. brunneus* is the smallest on produced by California scyliorhinids (Cox 1963). The capsules are usually described as brown, translucent o transparent, a little more than 50 mm long and a little less than 25 mm wide, slightly constricted at one end.

Apristurus canutus Springer and Heemstra, n. sp.
Figures 10, 11, 12, 13; Table 1

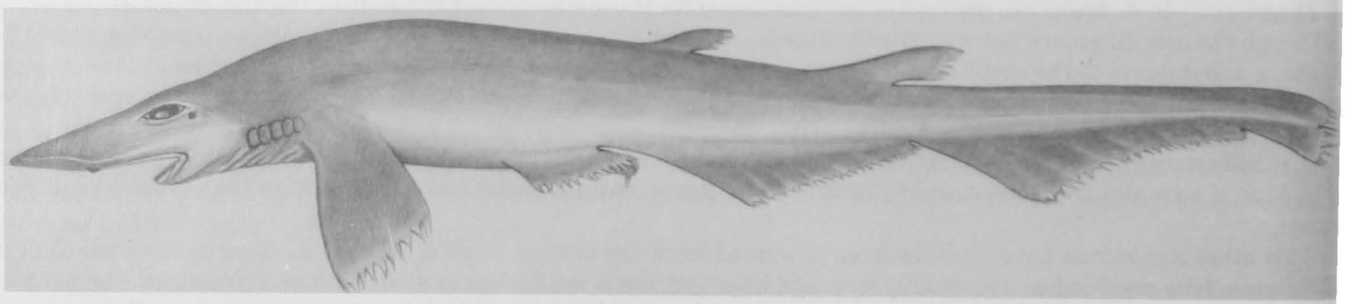


Figure 10.—*Apristurus canutus*, 428-mm adult male paratype, Leeward Islands. Wrinkles of skin that characterize most *Apristurus* specimen preserved in alcohol not shown. Drawing by Mildred Carrington.

Figure 11.—Ventral view of head of 455 mm female holotype of *Apristurus canutus* to show pattern of prominent pores.

Figure 12.—Dermal denticles from flank of *Apristurus canutus*, denticles about 0.5 mm long. Surface reflections partly obscure shingle-like structure of the denticle blades.

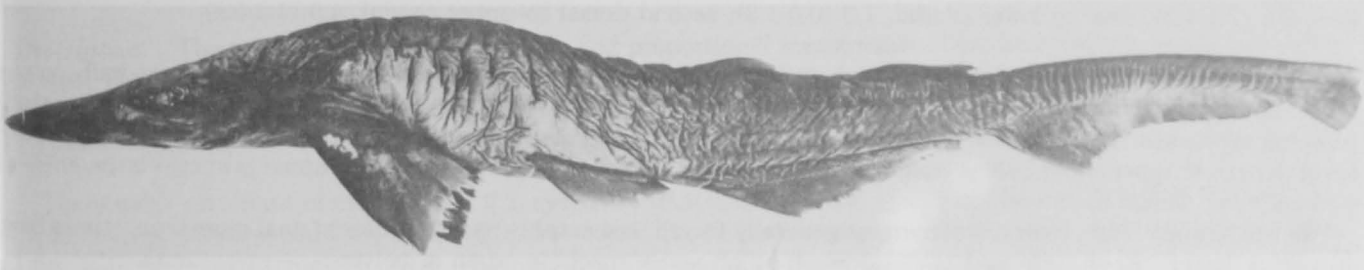


Figure 13.—Photograph of typical alcohol-preserved specimen of *Apristurus (A. canutus)* showing wrinkles usually following preservation of scyliorhinids with loose skins *(Apristurus, Parmaturus, Cephalurus, Parapristurus,* and *Pentanchus)*.

Holotype: USNM 206176, ad. ♀, 455 mm, RV *Oregon II* stn. 10834, Leeward Islands near Anguilla, lat. 18°18'N, long. 63°23'W, in 687 m.

Paratypes: USNM 206180, ad. ♂ 428, 395 mm, imm. ♂, 388 mm, ad. ♀, 395 mm, RV *Oregon I* stn. 6703, Leeward Islands near Antigua, lat. 16°53'N, long. 61°53'W, in 750-840 m.

Diagnosis. Second dorsal fin 2 to 3 times larger in area than first dorsal; origin of first dorsal at vertical between posterior end of pelvic fin bases and origin of anal fin; eye rather large, length of orbit (eye opening) about 2.9 to 3.5% TL, about equal to nostril length and three-fourths of least distance between nostrils; eye opening length contained 2.9 to 3.5 times in length of snout to front of mouth (edge of upper lip), 6.5 to 8 times in length of head to fifth gill opening; snout length 8.6 to 10.0% TL; distance between dorsal fin bases less than distance from tip of snout to level of anterior ends of orbits; width of snout at anterior ends of nostrils considerably greater than width of mouth; anal fin base long, 18 to 22% TL; distance between pectoral fin base and origin of pelvic fin small, 6.0 to 8.5% TL; monospondylous vertebrae 33 to 36.

Apristurus canutus belongs with the group of species *A. riveri* and *A. parvipinnis* in the Atlantic, having the second dorsal fin twice as large as the first dorsal. It differs from *A. riveri* in having the origin of the first dorsal fin posterior to the rear end of the pelvic fin base. The distance between the pectoral fin base and the pelvic fin base in *A. canutus* is 7.2 to 8.5% TL but in *A. parvipinnis* is 11.3 to 13.7% TL. The length of the anal fin base is 18.0 to 21.6% TL in *A. canutus* but in *A. parvipinnis* it is 16.4 to 17.9% TL.

Description. Proportional measurements as percentages of the total length are given below for the 455-mm holotyp with the range among the type series, holotype, and five paratypes, 319 to 455 mm, in parentheses.

Tip of snout to: front of mouth, 9.9 (8.6-9.9); eye, 11.0 (9.7-11.0); spiracle, 15.0 (13.9-15.0); first gill slit, 18.7 (17.7 18.7); fifth gill slit, 22.9 (21.8-22.9); origin pectoral fin, 21.1 (21.1-21.9); origin first dorsal fin, 49.1 (47.6-50.3); origi pelvic fins, 38.5 (36.0-38.5); origin second dorsal fin, 61.6 (61.6-63.5); origin upper caudal fin, 71.9 (69.6-71.9); anteric end cloacal opening, 43.3 (40.5-43.3).

Greatest width of trunk: at pectoral origin, 10.6 (7.7-11.1); at origin pelvics, 7.3 (4.4-9.6); at origin caudal fin, 1. (1.8-1.9).

Greatest depth of trunk: at pectoral origin, 8.1 (7.8-9.3); at origin pelvics, 10.1 (6.1-10.1); at origin caudal fin, 4. (2.0-4.6).

Orbit: horizontal diameter of opening, 3.3 (3.3-3.8); vertical diameter of opening, 1.1 (1.0-1.3).

Spiracles: greatest diameter, 0.4 (0.4-0.6); distance from eye, 0.7 (0.5-0.8).

Mouth: width, 6.4 (6.4-7.3); length, 3.1 (3.1-4.4); length upper labial furrow, 3.1 (3.1-3.5); length lower labia furrow, 2.0 (1.8-2.1).

Nostrils: least distance between, 4.4 (3.7-4.4).

Gill slits: height of first, 1.1 (1.0-1.8); height of fifth, 1.9 (1.0-1.9).

First dorsal fin: length base, 3.7 (3.2-3.8); length posterior tip, (free inner margin), 2.4 (2.0-2.8); height, 1.5 (1.5 2.6); length anterior margin, 6.4 (5.4-6.4).

Second dorsal fin: length base, 5.9 (5.0-6.1); length posterior tip, 2.4 (2.3-3.4); height, 2.4 (2.4-2.8); length anteric margin, 8.8 (7.5-9.3).

Anal fin: length base, 19.1 (18.0-21.6); length posterior tip, 0.9 (0.5-0.9); height, 3.7 (2.5-3.7); length anteric margin, 8.8 (7.8-9.4).

Pectoral fins: width base, 8.8 (7.2-8.8); anterior margin, 14.1 (11.2-14.1); greatest width, 10.3 (7.8-10.3).

Pelvic fins: overall length, origin to posterior tip, 12.3 (9.1-12.3).

Caudal fin: upper margin, 27.7; anterior margin lower lobe, 9.0 (8.9-9.8).

Distance between fin bases: first and second dorsal fins, 8.4 (7.7-9.8); pectoral and pelvic, 7.3 (7.2-8.5); pelvic an anal, 3.1 (3.1-4.2); anal to lower caudal, 1.3 (0.0-1.3); second dorsal to upper caudal, 4.8 (4.3-5.8).

Body moderately compressed; head and snout flattened; snout long with prominent pattern of pores medially on th lower side of the snout (Fig. 11), maxillary pores prominent; nasal apertures large, the upper nasal flap pointed reaching across nostril; labial grooves prominent along both upper and lower jaws, upper grooves somewhat longer tha lower, length of upper about half as great as distance from corner of mouth to symphysis of upper jaw; eyes large, angle o view as much dorsal as lateral.

Fins moderately large; their distal margins generally frayed, not notably rounded; base of anal more than 2 times bas of second dorsal; tip of appressed pectoral reaching or nearly reaching origin of pelvics.

Teeth generally with three to five cusps, in more than 50 vertical rows in both jaws; no difference in tooth shapes i males and females.

Dermal denticles of flanks, three-pointed, with a weak central ridge, surface of blades sculptured (Fig. 12).

Type series with 33 to 36 monospondylous vertebrae; holotype with 34 monospondylous vertebrae, 74 precaudal, an about 55 caudal vertebrae.

Color dark gray with minute white spots underneath denticles, ventral surfaces slightly darker than dorsal surface leading edges of fins, except pelvics and lower caudal, narrowly edged with black; narrow, denticle-free areas around lip and gill slits black; inside of mouth black.

Apristurus herklotsi (Fowler)

Pentanchus herklotsi Fowler 1934:238, fig. 3 (southern Philippines near Jolo).

Material examined. USNM 93134, holotype, ♀, 312 mm, RV *Albatross* stn. 5424.

Diagnosis. Apristurus herklotsi is one of the species having the first dorsal fin much smaller than the second dorsa the origin of the first dorsal is about over the rear end of the anal fin base. The caudal fin is long, its length from origin the lower caudal lobe more than one-third the total length. The eye is comparatively small, its length (length of openin less than the least distance between the nasal apertures. The anal fin is long, the length of its base much greater than t distance between dorsal fin bases and about equal to the distance from the tip of the snout to the first gill slit. In co bination, the preceding characters set off *herklotsi* reasonably well from all other species of *Apristurus*. The holotype *A. herklotsi* has 28 monospondylous vertebrae, fewer than any other specimen of *Apristurus* examined for this stu (Table 1).

Discussion. The holotype of *herklotsi* is not now in good condition, especially in the head region, and measurements cannot be made accurately for some of the structures. In my opinion, however, the original description and illustration are consistent with the type specimen and appear reliable in all details. I do not follow Fowler's (1934) emphasis on the presence or absence of nasal cirri as useful characters for the separation of *Apristurus* species. The structures are sometimes very small and easily damaged or distorted in preservation. Furthermore, I suspect they are variably developed within species.

Apristurus indicus (Brauer)
Table 1

Scylliorhinus indicus Brauer 1906:8, pl. 14, fig. 1 (Indian Ocean off Somalia and Gulf of Aden).
Pentanchus indicus: Fowler 1941:60.
Apristurus indicus: Garman 1913:97; Bigelow and Schroeder 1948:221.

Material examined. ZMB 22424, 336-mm, ♀, here designated the lectotype, *Valdivia* station 259, off coast of Somalia, lat. 02°59'N, long. 47°06'E, 1,289 m; ZMB 17411, 325-mm ♀, paralectotype, same station as lectotype. Brauer described the species from three specimens but the smallest, 132 mm, from the Gulf of Aden in 1,840 m probably was not preserved (Christine Karrer, pers. commun.).

Diagnosis. Second dorsal fin somewhat larger than the first dorsal fin in area; origin of first dorsal over middle of the pelvic fin bases; eye small, length of opening 2.4 to 2.8% TL, two-thirds nostril length, one-half to two-thirds internarial distance, contained about 3.8 to 4.2 times in length of snout; length of snout to front of mouth about 9.5 to 10.5% TL; distance between dorsal fin bases less than distance from tip of snout to eye opening; snout width at anterior ends of nostrils greater than width of mouth; teeth numerous, in about 60 to 62 vertical rows in upper jaw, most teeth with five cusps; color brown-black or black.

Description. The following descriptive account and proportional measurements are based solely on the two extant syntypes. The lectotype, a female, ZMB 22424, now measures about 345 mm TL and the smaller paralectotype, also a female ZMB 17411, 327 mm. The following measurements are in percentages of total length, the first figure in each pair is for the lectotype. Dashes indicate measurements were not made.

Tip of snout to: front of mouth, 10.1, 9.2; eye, 11.6, 10.4; spiracle, 15.7, 14.0; first gill slit, 20.9, 20.5; fifth gill slit, 24.1, 23.2; origin pectoral fin, 23.8, 22.9; origin first dorsal fin, 47.0, 49.8; origin pelvic fins, 40.6, 41.6; origin second dorsal fin, 58.0, 64.2; origin anal fin, 49.3, 54.1; origin upper caudal lobe, 69.6, 71.2; anus, 48.6, 47.8.

Greatest width of: trunk at pectorals, —, 11.9; trunk at pelvics, 6.4, 6.4; trunk at caudal fin origin, 2.0, 2.4.

Greatest height of: trunk at pectorals, —, 8.6; trunk at pelvics, 9.3, 9.5; trunk at origin caudal, 4.6, 4.9.

Orbit: horizontal diameter of opening, 2.8, 2.4; vertical diameter, 0.3, 0.7.

Spiracles: greatest diameter, 0.3, 0.8; least distance from eye opening, 1.0, 0.9.

Mouth: width, 9.0, 8.9; length, 4.3, 3.4; length upper labial furrow, 3.8, 3.4; length lower labial furrow, 2.9, 2.8.

Nostrils: least distance between, 4.6, 4.9.

Gill slits: height of first, 1.3, 1.5; height of fifth, 1.3, 1.2.

First dorsal fin: length base, 6.4, 7.0; length posterior tip along free inner margin, 3.2, 3.4; height, 3.5, 3.4; length anterior margin, 9.6, 9.2.

Pelvic fins: overall length, origin to posterior tip, 12.2, 13.8.

Second dorsal fin: length base, 7.2, 7.6; length posterior tip, 3.5, 1.5; height, 3.8, 3.4; length anterior margin, 10.7, 9.8.

Anal fin: length base, 15.7, 16.2; length posterior tip, 1.4, 0.9; height 5.2, 5.8; length anterior margin, 9.0, 7.6.

Caudal fin: upper margin, 29.9, 29.4; anterior margin lower lobe, 10.1, 10.1; tip caudal to notch, 4.3, 4.6.

Distance between fin bases: first and second dorsals, 9.0, 8.6; pectoral and pelvic, 8.1, 10.7; pelvic and anal, 1.4, 1.5; anal and lower caudal, 0.0, 0.3; second dorsal and upper caudal, 1.7, 1.5.

Teeth of upper jaw in both specimens in about 62 vertical rows, the lower jaw teeth in slightly fewer rows but more irregular. Most teeth with four or five cusps, the median cusp longest. Denticles with three posteriorly directed points, the middle point longest and with a weak ridge.

First dorsal fin origin in both specimens over the middle of the pelvic fin base. In the lectotype the second dorsal is only slightly larger in area than the first dorsal, but in the paralectotype the second dorsal is about 1½ times that of the first dorsal.

The two syntypes had 39 and 40 monospondylous vertebrae, respectively.

Discussion. The two larger of Brauer's (1906) three type-specimens were loaned to me by the Zoological Muse of Humbolt University of Berlin and are in remarkably good condition for *Apristurus* preserved for so long a ti Brauer's own measurements were obviously taken from the 132-mm juvenile specimen which was not preserved most of the differences between Brauer's descriptive account and mine can be attributed to differences between juveni and half-grown or adult specimens. Juveniles of *Apristurus* species may differ greatly in proportions from half-grow adult specimens. My own identification of Gulf of Mexico specimens of *A. parvipinnis* as *A. indicus* (Springer 19 followed my mistakes in understanding Brauer's account of the species. My error evidently was responsible for reference to *A. indicus* by Bass et al. (1975:7) as having the origin of the first dorsal behind the pelvic axil. In *A. indi* the origin of the first dorsal fin is well in advance of the posterior end of the bases of the pelvic fins.

Apristurus investigatoris (Misra)

Pentanchus (Parapristurus) investigatoris Misra 1962:636, pl. 1 (Andaman Sea).

Material examined. No specimens seen. The holotype and only specimen mentioned by Misra is ZSI F1, 62 collected at HMS *Investigator* station in the Andaman Sea, lat. 11°46′N, long. 93°10′E, from 1,040 m, bottom gr mud, globigerina ooze, bottom temperature 4.4°C. The holotype is a female 260 mm long.

Diagnosis. The illustration with Misra's description of *A. investigatoris* shows the first dorsal fin to be about half area of the second dorsal fin, the first dorsal origin about over the middle of the pelvic fin bases, and the dista between the dorsal fin bases about 75% of the length of the snout measured from the tip to the midpoint of the upper li

Misra's diagnosis separates *investigatoris* from *herklotsi* by several differences in proportional measurement. most striking difference, indicated by comparison of illustrations, is that the caudal fin in *investigatoris* is only 1.5 ti the head length but is 1.9 times the head length in *herklotsi*.

Apristurus japonicus Nakaya 1975

Apristurus japonicus Nakaya 1975:24, figs. 10, 11 (off Cape Daito, Japan).

Material examined. None.

Types. Holotype: HUMZ 40082, 697 mm ad. ♂, off Cape Daito Japan. Paratypes: HUMZ 40075, 626 mm ad HUMZ 39961, 690 mm ad. ♂; HUMZ 40076-40081, 654-711 mm ad. ♂; all paratypes from same locality as holoty

Diagnosis. Nakaya (1975:24) stated that *A. japonicus* differed from other *Apristurus* in having the distance betw the origins of the pectoral and pelvic fins greater than the distance from the snout tip to the origin of the pectoral fin, shorter than that from the snout tip to the end of the pectoral base. Nakaya noted that interbranchial septa sometim had slight prolongations.

Nakaya's measurements of *A. japonicus* indicate a very short snout in adults, shorter than the snouts of any of specimens of *Apristurus* that I have examined. Also, *A. japonicus* has a greater number of monospondylous vertebrae to 46, than any other *Apristurus*.

Description. Nakaya (1975:24) gave a comprehensive description which will not be repeated here. Points might be emphasized are that *A. japonicus* is a moderately large species of *Apristurus*, adults 626 to 711 mm. The dorsal is slightly smaller in area than the second dorsal and its origin is slightly in advance of the posterior end of pelvic fin bases. The interspace between dorsal fin bases is greater than the length of the snout.

Discussion. The description of *A. japonicus* should reduce the confusion over identification of *Apristurus* spe from Japan. The proportions, long trunk sector and short snout, may differ in young specimens but Nakaya's (19 descriptive account provides a good starting reference for comparisons of Japanese *Apristurus*.

Apristurus kampae Taylor

Apristurus kampae Taylor 1972:71, figs. 1, 3A, 4, 5 (from Gulf of California).

Material examined. None. The species is treated here as being known only from the holotype. Taylor's sec specimen may belong to this species but differs in several important features (see under discussion below). The holoty SIO 70-278, a 335-mm ♀ from lat. 27°22.4′N, long. 111°20.5′W to lat. 27°10.1′N, long. 111°29.6′W in 1,830 to 1,888 m the sole basis for the following diagnosis and description, here modified from Taylor (1972).

Diagnosis. *Apristurus kampae* is distinguished from all other species of the genus by its comparatively short anal fin, its base only about twice as long as the base of either the first or second dorsal, the posterior end of its base separated from the lower caudal lobe by a distance about as great as the length of the base of the second dorsal fin. The anal fin is also very high. Additional characters useful in comparison with characters noted in this paper for other species and practical for comparison with most original descriptions are: caudal fin moderately long, its length about equal to the distance from the tip of the snout to the origin of the pectoral; first dorsal fin origin in advance of posterior end of pelvic fin base, its area somewhat less than area of second dorsal but not as little as half the area of the second dorsal; length of snout in front of mouth and distance between dorsal fin bases about equal, and about three-fourths length of anal fin base; gill slits long, their length about 3.4 to 4.8% TL; eye moderately large, length of eye opening about 3.5% TL.

Description. Taylor's (1972) description of the holotype of *A. kampae* is comprehensive and details will not be repeated here except to note that the holotype has 34 monospondylous vertebrae and that it is 335 mm long, at which size it appears nearly mature.

Apristurus laurussonii (Saemundsson)
Figure 14

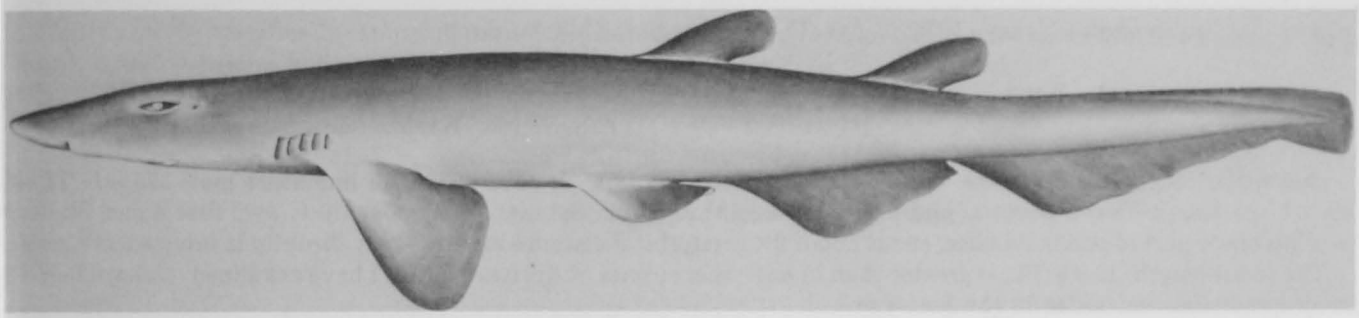


Figure 14.—*Apristurus laurussonii*, 540-mm female, MCZ 38406, collected off New England. Drawing by Mary Wagner.

Scyllium laurussonii Saemundsson 1922:73, pl. 4, fig. 2 and pl. 5, fig. 4, Saemundsson's text references to figures for *Scyllium laurussonii* and *Pristiurus jenseni* are reversed. (Near Vestmannaeyjar Island off southern Iceland.)
Apristurus profundorum: Bigelow et al. 1953:214-217, part; Bigelow and Schroeder 1954:40, part.
Apristurus laurussonii: Springer 1966:615, fig. 24B; in Monod and Hureau 1973:20.

Material examined: NHMR, holotype, ♀, 673 mm, from 560 m off southern Iceland; MCZ 38406, ♀, 540 mm, coast of New England; 2 ♂, 660-675 mm, from 1,024 m and 1,462 m off north coast of Hispaniola; 4 ♂, 466-550 mm, from 840 to 1,115 m off Alabama; 2 ♂, 4 ♀, 280-510 mm, from 1,097 m off Tamaulipas, Mexico; ♂, 536 mm, from 1,100 m, Gulf of Campeche.

Diagnosis. Dorsal fins nearly equal in area; origin of first dorsal fin over or slightly behind middle of pelvic fin base; body sector (tip snout to cloaca) slightly shorter than tail sector; anal fin long, extending from tips of pelvic fin nearly or completely to origin of lower caudal lobe, anal fin base equal to or greater than distance from tip of snout to first gill slit and greater than distance between dorsal fin bases; length of eye opening less than least distance between nostrils; snout relatively short, less than 8.0% TL; monospondylous vertebrae 38 to 43.

Description. Proportional measurements as percentages of total length are given below, first figure for 673 mm female holotype from Iceland, second figure for 675 mm adult male from Hispaniola.

Tip of snout to: front of mouth, 7.6, 6.9; eye, 8.5, 7.5; first gill slit, 17.2, 15.6; fifth gill slit, 20.4, 20.0; origin pectoral, 19.9, 18.8; origin first dorsal fin, 50.4, 49.6; origin pelvic fins, 42.3, 44.0; origin anal fin, 58.1, 55.8; origin second dorsal fin, 65.6, 65.1; origin upper caudal lobe, 72.3, 75.8; anterior margin cloaca, 49.3, 45.1.
Orbit: horizontal diameter of opening, 3.2, 2.5.
Spiracles: diameter, 0.6, 0.4; least distance from eye, 0.8, 1.2.
Mouth: width, 7.2, 7.0; length, 3.2, 3.1; length upper labial furrow, 2.7, 2.7; length lower labial furrow, 2.0, 2.4.
Nostrils: least distance between, 3.8, 3.7.
Gill slits: height of first, 1.5, 1.5; height of fifth, 1.4, 1.0.

First dorsal fin: length base, 7.0, 6.5; height, 2.1, 3.3; anterior margin, 10.3, 11.1.
Second dorsal fin: length base, 5.8, 5.8; height, 2.4, 3.4; anterior margin, 9.7, 10.8.
Anal fin: length base, 14.6, 16.9; height, 4.6, 5.0; anterior margin, 10.0, 8.6.
Pectoral fins: anterior margin, 11.9, 13.9; greatest width, 8.2, 8.9.
Caudal fins: length upper caudal lobe, 27.7, 24.2.
Distance between fin bases: first and second dorsals, 9.1, 10.5; pectoral to pelvic, 14.8, 17.6.
Teeth: mostly tricuspid, small, in about 40 to 50/38 to 44 diagonal rows; in about 70 to 90/54 to 64 vertical rows; indication of sexual dimorphism.
Dermal denticles: small, about 0.4 mm long and 0.3 mm wide, three-pointed, central ridge moderately stro lateral ridges weaker; denticles of male slightly larger.
Vertebrae: monospondylous, 43, 41, (range in 16 specimens, 38-43).

Discussion. *Apristurus laurussonii* was taken in 560 mm off Iceland, but specimens from the Gulf of Mex latitudes are apparently restricted to nearly twice that depth. Saemundsson's (1922) original description may have be overlooked because it was in Icelandic and the captions for *laurussonii* and *Pristiurus jenseni* were reversed. T holotype in the Museum at Reykjavik was in good condition when I examined it in 1964.

Apristurus longicephalus Nakaya

Apristurus longicephalus Nakaya 1975:32, figs. 15, 16 (Tosa Bay, Shikoku, Japan).

Material examined. None.

Diagnosis. Nakaya's diagnosis was based only on the holotype, HUMZ 42399, an immature male 375 mm TL. H stated: distance between pectoral and pelvic fin origins equal to distance from snout tip to eye; first dorsal fin orig over posterior part of pelvic fin base; snout about 2× interorbital distance and tapering abruptly in advance of nostril The snout length, 12.4% TL, is greater than in any other species of *Apristurus* that I have examined. Nakaya found monospondylous vertebrae in the holotype.

Discussion. Nakaya's account of *A. longicephalus* is thorough and details will not be repeated here. His descripti is, nevertheless, based on only one immature specimen which seems to be closely similar to *A. herklotsi* (Fowler 193 and to *A. investigatoris* (Misra 1962). These also are one-specimen species, each known only from an immature holotyp Fowler's holotype of *A. herklotsi*, USNM 93134, is in poor condition and not satisfactory now for detail measurements. I have not seen the holotype of *A. investigatoris*. All three species, *A. herklotsi*, *A. investigatoris*, and *longicephalus*, were illustrated and the illustrations suggest general similarity in body proportions. All three ha proportionally long tails, their lengths from the origin of the lower caudal lobe as measured on the illustrations are 38.9 TL for *A. herklotsi*, 35.6% TL for *A. longicephalus*, and 29.6% for *A. investigatoris*. Because proportional tail lengths a snout lengths in scyliorhinids may change during growth, the differences noted above do not set *A. longicephalus* ap from other *Apristurus* species in an entirely satisfactory way.
The small number of monospondylous vertebrae, 32, in the holotype of *A. longicephalus* confirms its distinction fr other species of *Apristurus* from Japanese waters. *Apristurus herklotsi* has 28 monospondylous vertebrae. I have vertebral count for *A. investigatoris*.

Apristurus macrorhynchus (Tanaka)

Scyliorhinus macrorhynchus Tanaka 1909:1 (neighborhood of Misaki, Japan), type, No. 2153, Imperial Univers Collection.
Apristurus macrorhynchus: Garman 1913:97; Nakaya 1975:36, figs. 17-19.
Pentanchus macrorhynchus: Fowler 1941:56, fig. 5. Note that fig. 5 is captioned *platyrhynchus* but depicts *macrorhynch*

Material examined. USNM 22623, ♀, 660 mm, Japan.

Diagnosis. In *A. macrorhynchus* the two dorsal fins are nearly equal in area; the snout is long and somewhat taper its length nearly equal to the distance between the dorsal fin bases; the origin of the first dorsal is slightly in advanc the posterior end of the pelvic fin base; and the posterior end of the second dorsal fin base is in advance of the poste end of the anal fin base by a distance nearly half as great as the horizontal diameter of the eye opening. In combinati these characters separate *macrorhynchus* from all other species of the genus.

Description. Tanaka's description of *macrorhynchus* designated a type, No. 2153 in the Imperial University collection, and included some measurements of the type specimen. The only specimen I have seen that agrees well with Tanaka's description of *macrorhynchus* is USNM 22623. The specimen was evidently the subject for an illustration (fig. 5) in Fowler's 1941 monograph but was mislabeled as *A. platyrhynchus*. I have included Tanaka's measurements of the type, a 470-mm young male, revised here as percentages of total length, with similar proportional measurements of the 660 mm female from the USNM. In the following series, the first figure in each pair refers to the type, the second to USNM 22623; dashes are used where data are not available, in this instance due to the poor condition of the USNM specimen.

Tip of snout to: front of mouth, 9.4, 9.7; eye, 10.6, —; first gill slit, 17.2, 16.7; fifth gill slit, —, 21.2; origin pectoral fin, 22.8, 20.0; origin first dorsal fin, 46.8, 48.5; origin pelvic fins, 38.3, 36.4; origin second dorsal fin, 61.7, 61.2; origin anal fin, —, 53.0; origin upper caudal fin, —, 70.9; origin lower caudal fin lobe, 69.2, —.
Orbit: horizontal diameter of opening, 3.2, —.
Nostrils: least distance between, 3.0, —.
First dorsal fin: length base, 4.7, 4.5.
Second dorsal fin: length base, 4.7, 5.3.
Anal fin: length base, 15.3, 16.9.
Distance between dorsal fin bases: 10.2, 10.2.

Tanaka (1909) specifically compared *macrorhynchus* and *platyrhynchus*. *Apristurus macrorhynchus* was said to have small dermal denticles but not as small as those of *A. playyrhynchus*.

Discussion. (See discussion under *A. platyrhynchus*.)

Apristurus maderensis Cadenat and Maul

Apristurus maderensis Cadenat and Maul 1966:769, figs. 1, 2, 3 (Madeira); Springer 1973:20.

Material examined. None. The holotype, an adult female, 668 mm, is No. 18750, Museu Municipal do Funchal, is the only known specimen.

Diagnosis. *Apristurus maderensis* is unique in the genus in having median, posteriorly projecting lobes extending from the gill covers (interbranchial septa) across the second to the fifth gill slits. It is one of the species having the second dorsal fin larger than the first dorsal in area and in having the origin of the first dorsal over or slightly in advance of the posterior end of the pelvic fin base.

Discussion. Cadenat and Maul's description and measurements of the holotype are comprehensive and will not be repeated here.

The holotype of *A. maderensis* had an egg capsule with more than 20 longitudinal striations. The illustration (Cadenat and Maul 1966, fig. 3) showed the striations appreciably higher than in other *Apristurus* egg capsules identified during the source of this study. *Apristurus riveri* and *A. parvipinnis* had egg capsules without prominent striations. Nakaya (1975) observed fine striations on egg capsules of *A. platyrhynchus* and *A. macrorhynchus*. The egg capsules of *A. brunneus* as illustrated by Cox (1963) appear smooth or very finely striated. The egg capsule of *A. maderensis* greatly resembles the egg capsule of *Halaelurus canescens*.

Apristurus microps (Gilchrist)

Scylliorhinus microps Gilchrist 1922:46, pl. VII, fig. 1 (coast of South Africa).
Pentanchus microps: Smith 1949:54, fig. 41, part.

Material examined. None. Gilchrist's holotype was not located.

Diagnosis. According to Gilchrist's brief description and figure, *A. microps* has the smallest eye of any species of the genus. The very short distance separating the dorsal fin bases, less than the length of the first dorsal fin base, is also unique among species of *Apristurus*. Gilchrist did not give the size of the only specimen he had, and the specimen was not seen by Barnard (1925) when he wrote his monograph on South African fishes. A specimen in the British Museum labeled *microps* does not fit Gilchrist's description.

Discussion. If Gilchrist's illustration showing a remarkably small distance between the dorsal fin bases is accurat this species must be recognized. No type has been found, however, and it is possible that Gilchrist's illustrations we not good representations of proportions of parts.

Three specimens, 325 to 465 mm, collected by research vessels of the U.S.S.R. between lat. 26°S and 33°S off We Africa in 800 to 1,000 m were identified as *Apristurus microps* (Georgio Golovan, Acad. Sci. U.S.S.R., Moscow, per commun.). Golovan had a larger collection of *Apristurus* from African coasts than hitherto reported and seems to ha been able to make identifications consistent with original descriptions.

Apristurus nasutus DeBuen

Apristurus nasutus DeBuen 1959:176 (vicinity of Valparaiso, Chile, in 400 m); Kato et al. 1967:25; Chirichigno 1974:3 fig. 17.

Material examined. ZMK - *Galathea* 739, ad. ♂, 503 mm, Gulf of Panama, lat. 07°22'N, long. 79°32'W, 915-925 m USNM, ♀, 465 mm, off Valparaiso, Chile, lat. 35°26'S, long. 73°01'W, 290-450 m; USNM ad. ♂, 520 mm, off Guay quil, Ecuador, lat. 03°57'S, long. 81°20'W, 600-750 m. DeBuen's holotype, ♂, 594 mm, EBMCh 10.184 was not see

Diagnosis. Apristurus nasutus is very much like *A. brunneus* but differs in having a greater interspace betwee dorsal fin bases and in being dark gray or gray-black instead of brown or brownish.

Adults of *A. nasutus, A. brunneus,* and *A. japonicus* usually have shorter snouts (measured from front of mouth) tha other species of *Apristurus.* In *A. nasutus* the length of the orbit (3.4-3.8) is greater than the length of the orbit in *A. japonicus* (2.4-3.0). *Apristurus nasutus* belongs to the group of *Apristurus* species having the first and second dorsal fi about equal in area, and this serves to separate it from the Pacific species *A. platyrhynchus, A. longicephalus, A. verweyi,* and *A. herklotsi.* The very long snout of *A. longicephalus* and the long snout of *A. macrorhynchus* set thos species off from *A. nasutus.*

Description. In the following proportional measurements expressed as percentages of total length, the first figure i each group refers to the adult male, 503 mm, the second figure to the 465-mm female, and the third to a second adu male, 520 mm long.

Tip of snout to: front of mouth, 6.6, 7.7, 6.7; eye, 8.0, 9.0, 7.1; spiracle, 12.1, 12.3, 10.9; first gill slit, 17.7, 18.1, 16. fifth gill slit, 24.4, 22.1, 24.2; origin pectoral fin, 23.9, 23.4, 22.3; origin first dorsal fin, 50.7, 51.6, 49.9; origin pelvic fin 43.4, 44.1, 45.7; origin second dorsal fin, 67.5, 66.7, 66.2; origin anal fin, 56.7, 59.1, 59.1; origin upper caudal lobe, 75. 77.4, 73.5; anterior end cloacal opening, 48.8, 51.6, 50.3.

Orbit: horizontal diameter of opening, 3.4, 3.4, 3.8; height opening, 1.0, 1.7, 1.2.

Spiracles: diameter, 0.3, 0.6, 1.0; least distance from eye, 1.0, 0.9, 1.0.

Mouth: width, 7.2, 6.7, 9.0; length, 5.2, 4.5, 4.6; length upper labial furrow, 2.8, 3.2, 5.0; lower labial furrow, 2. 1.7, 2.5.

Nostrils: least distance between, 3.4, 3.7, 2.9.

Gill slits: height of first, 1.8, 1.9, 1.7; height of fifth, 1.2, 1.5, 1.5.

First dorsal fin: length base, 5.8, 4.9, 6.0; length free inner margin, 3.2, 3.0, 3.3; height, 2.8, 2.8, 2.5; length anteri margin, 8.6, 8.6, 8.1.

Second dorsal fin: length base, 5.0, 5.2, 5.4; length free inner margin, 3.2, 3.2, 3.3; height, 4.2, 2.8, 4.4; leng anterior margin, 8.4, 9.5, 8.3.

Anal fin: length base, 13.7, 14.8, 12.1; length free inner margin, 1.4, 1.1, 1.3; height, 4.2, 4.7, 4.6; length anter margin, 8.0, 7.3, 7.7.

Pectoral fins: width base, 6.0, 8.0, 7.7; length anterior margin, 11.7, 11.8, 12.9; greatest width, 6.4, 8.0, 5.8.

Distance between fin bases: first to second dorsal, 11.9, 10.8, 9.8.

Teeth in all specimens mostly tridentate, but some with five cusps near angles of jaws. Upper and lower teeth simil small, about 75 vertical rows in both jaws. Monospondylous vertebrae 36 in three specimens.

Color dark-gray or gray-brown without prominent markings. DeBuen (1959) noted: color in Formalin uniform g with posterior borders of dorsal, pectoral, anal, and caudal tip colorless.

Discussion. The specimens of *Apristurus nasutus* examined for this study were from the coasts of Chile, Ecuad and Panama, and those specimens were compared with examples of *A. brunneus* from the coast of Washington. Sepa tion of the two species may be impossible on the basis of the dorsal interspace measurements. A larger collection specimens is needed to determine whether or not *A. nasutus* should be recognized as a valid species.

Apristurus parvipinnis Springer and Heemstra, n.sp.
Figure 15, Table 1

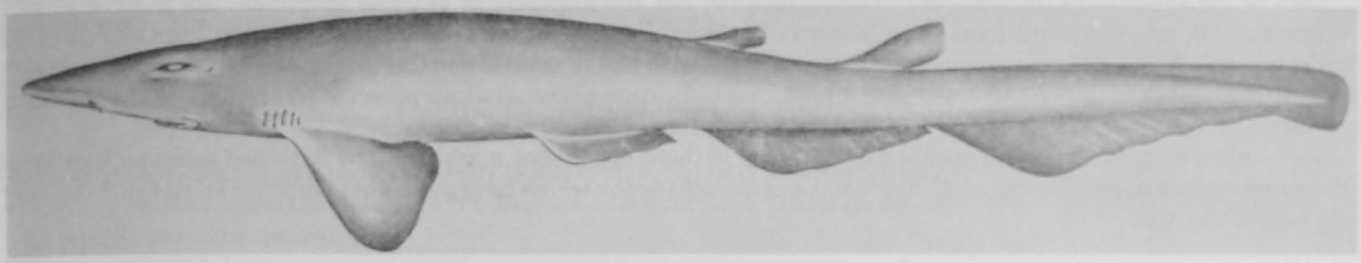


Figure 15.—*Apristurus parvipinnis*, 395-mm female, taken off Pensacola, Fla. Drawing by Mary Wagner.

Apristurus indicus: Springer 1966:613 part, and fig. 22B.

Holotype: USNM 206178, ♂, 476 mm, Gulf of Mexico off Pensacola, Fla., in 1,115 m.

Paratypes: USNM 206179, ♀, 465 mm, same locality as holotype. USNM, ♀, 395 mm, from MV *Oregon* stn. 3586, off the Caribbean coast of western Panama from 875 to 930 m; ♂, 268 mm, Gulf of Campeche from 895 m; ♀, 512 mm, Gulf of Campeche from 1,097 m; ♀, 485 mm, off west coast Florida from 722 m; 2 ♀, 386-521 mm off French Guiana, 636 m; ♀, 415 mm, off French Guiana, 676 m; ♂, 340 mm, ♀, 459 mm, off Pensacola, Fla., 914 m; 2 ♂, 425, 470 mm, off Caribbean coast of Colombia.

Diagnosis. Second dorsal fin 2 to 4 times larger than first dorsal; origin of first dorsal at a vertical between posterior end of pelvic fin base and origin of anal fin; orbit moderately long, 2.9 to 3.6% TL, its length about equal to nostril length and somewhat less than the least distance between nasal apertures; snout long, 8.5 to 10.7% TL, its length usually somewhat greater than distance between dorsal fin bases; anal fin base 16.1 to 18.6% TL; distance between pectoral fin base and pelvic fin base about 11 to 14% TL; monospondylous vertebrae 37 to 41.

Apristurus parvipinnis and *A. canutus* differ from other species of *Apristurus* in having, in combination, the second dorsal fin 2 to 4 times as large in area as the first dorsal fin and in having the first dorsal origin posterior to the end of the pelvic fin base. *Apristurus parvipinnis* has a long trunk segment, the distance between pectoral and pelvic fin bases about 11 to 14% TL as compared with 6.0 to 8.5% TL in *A. canutus*. The longer prepelvic trunk of *parvipinnis* is also reflected by its greater monospondylous vertebrae count, 37 to 40 as compared with 33 to 36 in *canutus*.

Description. Proportional measurements as percentages of total length of the holotype (first figure), paratype (second figure), and range in 12 specimens 268 to 512 mm long (third figures), are given as follows:

Tip of snout to: front of mouth, 8.8, 9.2, 8.6-10.4; eye, 10.1, 10.5, 9.6-11.2; spiracle, 14.5, 14.8, 13.7-15.7; first gill slit, 18.7, 18.9, 17.4-19.4; fifth gill slit, 22.5, 22.4, 20.9-23.5; origin pectoral fin, 21.4, 20.6, 20.0-22.5; origin first dorsal fin, 51.5, 51.6, 49.6-52.8; origin pelvic fins, 42.0, 41.1, 39.4-43.0; origin second dorsal fin, 63.0, 64.5, 60.4-65.0; origin anal fin, 54.6, 53.3, 51.3-54.7; origin upper caudal lobe, 72.2, 73.1, 69.4-73.8; anterior end cloacal opening, 48.3, 47.5, 45.1-48.3.

Greatest width of trunk at: pectoral fin origin, 9.5, 9.5, 8.9-10.4; pelvic fin origin, 5.9, 5.8, 4.7-6.9; caudal base, 2.1, 2.4, 1.6-2.4.

Greatest height of trunk at: pectoral fin origin, 9.0, 9.7, 5.1-9.8; pelvic fin origin, 10.9, 11.0, 7.8-11.0; caudal base, 4.6, 4.3, 4.0-4.9.

Orbit: horizontal diameter of opening, 3.1, 3.0, 2.9-3.5; vertical diameter opening, 1.2, 0.9, 0.7-1.4.

Spiracles: greatest diameter, 0.4, —, 0.4-0.6 in four specimens; least distance from eye opening, 1.1, 1.3, 0.7-1.3.

Mouth: width, 7.1, 7.5, 7.0-9.2; length, 3.6, 3.9, 2.8-3.9; length upper labial furrow, 2.9, 2.8, 2.6-3.4; length lower labial furrow, 1.7, 2.2, 1.7-2.2.

Nostrils: least distance between, 3.8, 3.8, 3.6-4.5.

Gill slits: first, 1.7, 1.9, 1.3-2.2; fifth, 1.5, 1.5, 1.0-1.7.

First dorsal fin: length base, 3.8, 4.1, 2.6-5.0; length posterior tip (inner posterior margin), 2.3, 2.2, 1.4-2.6; height, 3.4, 1.5, 1.3-3.4; length anterior margin, 6.1, 6.0, 5.5-7.6.

Second dorsal fin: length base, 5.7, 5.8, 5.3-7.3; posterior tip, 2.9, 2.4, 2.3-3.2; height, 2.5, 2.4, 2.0-3.2; anterior margin, 9.2, 9.0, 8.3-9.7.

Pectoral fins: width base, 8.0, 7.7, 7.1-9.8; length anterior margin, 11.6, 10.1, 10.1-14.6; greatest width, 8.2, 7.6, 7.2-8.5.

Pelvic fins: distance origin to posterior tip, 12.6, 11.0, 10.1-12.6.

Caudal fin: upper margin, 27.3, 26.2, 26.2-30.9.

Distance between fin bases: first to second dorsals, 8.0, 8.8, 6.7-9.4; pectoral to pelvic, 13.7, 13.5, 11.3-13.7; pelv to anal, 3.8, 2.4, 2.4-3.9; second dorsal to caudal, 4.0, 3.4, 2.2-5.2; anal to lower caudal origin, 0.0, 0.0, 0.0-1.0.

Both of the types have 37 monospondylous vertebrae but the numbers in 44 other specimens are from 38 to 40. Teeth small, crowded, with more than 50 somewhat irregular vertical rows in each jaw; teeth with three to six cusp but those with four cusps most numerous; tooth surfaces with one to several vertical ridges, the ridges extending near to tooth tips; teeth of upper and lower jaws similar; no indication of sexual dimorphism of tooth shape in the specime available.

Apristurus parvipinnis specimens are usually black without prominent markings. The flattened snout appears bro in comparison with species such as *A. riveri* and *A. macrorhynchus* which have somewhat narrower snouts slightly tape ing toward the tip.

Discussion. *Apristurus parvipinnis* is one of the more commonly collected *Apristurus* in the Gulf of Mexic Caribbean area along with *A. laurussonii*.

Apristurus platyrhynchus (Tanaka)

Scyliorhinus platyrhynchus Tanaka 1909:4 (from Japanese waters), holotype No. 2154, Imperial University Collectio
Apristurus platyrhynchus: Garman 1913:98; Nakaya 1975:28, figs. 12-14.
Pentanchus platyrhynchus: Fowler 1941, part, not fig. 5, see under *A. macrorhynchus*.

Material examined. FMNH 74130, imm. ♂, 525 mm (Sagami Sea) Owston collection No. 1019.

Diagnosis. First dorsal about half as large in area as second dorsal, the length of its base about two-thirds length second dorsal base, its origin posterior to posterior end of base of pelvics; snout moderately short, its length from tip snout to upper lip less than distance between dorsal fin bases; anal fin long, its base as long or longer than distance fro the tip of snout to first gill slit; eye moderately large, the length of its opening about equal to least distance betwee nasal openings; dermal denticles very small, smooth and velvety to touch; the holotype, an 800-mm male, presumab adult, is one of the largest *Apristurus* specimens recorded.

Description. Tanaka's measurements of the 800-mm male, here revised as percentages of total length, follo together with proportional measurements of a 525 mm, immature male, FMNH 74130. The first measurement in eac pair of figures represents Tanaka's holotype, the second represents the immature male. Dashes are used where data a absent.

Tip of snout to: upper lip, 7.1, 8.4; eye, 8.5, 8.8; spiracle, —, 11.8; first gill slit, 15.6, 15.2; fifth gill slit —, 20. origin pectoral fin, 20.0, 19.6; origin first dorsal fin, 50.0, 46.7; origin pelvic fins, 33.6, 37.5; origin second dorsal fin, 63. 61.5; origin anal fin, 50.0, 50.5; origin lower caudal lobe, 70.0, —; origin upper caudal fin, —, 69.2; anterior end of anu —, 41.9.

Orbit: horizontal diameter of opening, 3.0, 2.9.

Nostrils: least distance between, 2.9, 2.9; greatest distance between, —, 6.4.

Mouth: width, 6.5, 7.0; length, —, 3.0.

Spiracle: diameter, 0.5, 0.2; distance from eye, —, 0.6; distance between spiracles, 6.5, —.

First dorsal fin: length base, 2.8, 4.2; height, —, 1.9; length anterior margin, —, 6.7.

Second dorsal fin: length base, 4.3, 5.3; height, —, 2.5; length anterior margin, —, 7.8.

Anal fin: length base, 18.0, 15.0.

Pectoral fin: width base, 6.8, 7.4; length anterior margin, —, 12.4.

Distance between fin bases: first and second dorsals, 11.0, 11.0; pectoral and pelvic, —, 9.1; pelvic and anal, 4.8; anal and lower caudal, —, 0.0; second dorsal and upper caudal, —, 5.7.

Tanaka (1909) stated that the holotype had very small scales, much smaller than in *macrorhynchus*. The larger fla denticles of FMNH 74130 are about 0.4 mm long, with three points, the middle point longest. In the original descripti the teeth are described as tricuspid, the median cusp largest, set at wider intervals than in *macrorhynchus*. The long teeth in FMNH 74130 are only about 1.2 mm.

Discussion. Before Nakaya's (1975) work on Japanese catsharks appeared, I had examined 11 specimens *Apristurus* from Japanese waters but could identify with confidence only one as *A. platyrhynchus* and one as

macrorhynchus, before 1975 the only species of *Apristurus* known from Japan. It is true that many of the specimens I attempted to identify were immature but now with Nakaya's study it would be possible to do more. There may still be identification problems with young *Apristurus* from Japan as elsewhere either because species remain undescribed or because young specimens are not known or are poorly known.

Apristurus profundorum (Goode and Bean)

Scylliorhinus profundorum Goode and Bean 1896:17, pl. 5, fig. 16 (off Delaware Bay in 1,492 m).
Apristurus profundorum: Garman 1913:99; Bigelow and Schroeder 1948:222, fig. 38A; not of Springer 1966:612, figs. 22, 23 (see *Parmaturus manis*).

Material examined. Only specimen seen certainly identified as *A. profundorum* was the holotype, USNM 35646. The holotype is in very bad condition and the following descriptive account is based chiefly on the description and illustration of the holotype by Bigelow and Schroeder (1948:222-223, fig. 38, 38A).

Diagnosis. First dorsal fin not much smaller in area than second dorsal; origin of first dorsal fin somewhat in advance of the posterior end of the base of the pelvic fin; eye length (length of opening) about 2.7% TL, eye length contained about 10 times in head (tip of snout to fifth gill slit); anal fin base 13.9% TL, about equal to distance from tip of snout to spiracle; distance between dorsal fin bases 8.2% TL, only a little less than the width of the mouth; snout (in front of mouth) about 8.9% TL, abruptly narrowed in advance of nostrils, tapering, the tip broadly rounded; little if any interspace between the posterior end of the anal fin base and the origin of the lower caudal fin lobe; anal fin moderately high, 4.3% TL. The holotype has 33 monospondylous vertebrae.

Discussion. The holotype of *A. profundorum*, a male 510 mm long, USNM 35646, taken off Delaware Bay in 1,492 m, seems to have deteriorated greatly between 1948 and 1964. At present it is impossible to determine much about morphometrics from the specimen so the measurements made by Bigelow and Schroeder (1948:222) are assumed to apply.

In June and July 1952, collections of fishes were made under the direction of W. C. Schroeder at depths from 722 to 969 m off the coasts of Nova Scotia and New England. Several specimens identified as *Apristurus profundorum* were obtained and were reported with some detail in a series of publications (Bigelow et al. 1953; Bigelow and Schroeder 1954; Schroeder 1955; Springer 1966). I reexamined the same series of specimens for this study and found that I had misidentified the specimens and that the series contained no *A. profundorum*, but instead those described and figured in greatest detail (Springer 1966:612, figs. 22A, 23, and 25 left) were the forms described in later pages as *Parmaturus manis* and some others of the series were *Apristurus laurussonii*. *Parmaturus manis* has a well-defined caudal crest and does not belong in *Apristurus*.

Whether *A. laurussonii* should be considered a synonym of *A. profundorum* remains uncertain. The fact that the holotype of *laurussonii* has 10 more monospondylous vertebrae than the holotype of *profundorum* supports separation of the two forms.

Four specimens, 243-290 mm, taken off the west coast of Africa south of the Canary Islands at depths from 1,200 to 1,500 m were identified by Georgio Golovan as *A. profundorum* (pers. commun.). Clarification of the problems of identification of nominal *Apristurus* from the African coasts, *A. indicus*, *A. microps*, *A. atlanticus*, and a specimen recorded by Karrer (1973), will have to await comparisons of larger collections from the area than have been available to me.

Apristurus riveri Bigelow and Schroeder
Figures 7, 8, 16, 17, 18; Table 1

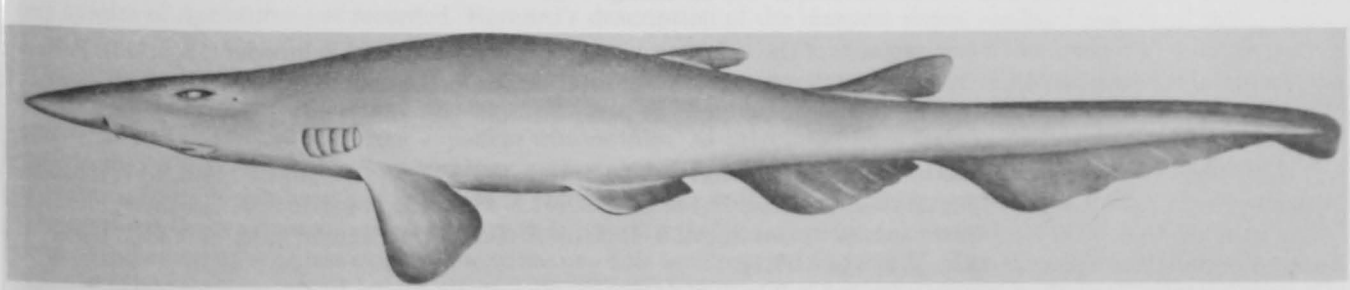


Figure 16.—*Apristurus riveri*, adult female, 400 mm, taken off Caribbean coast of Panama. Drawing by Mary Wagner.

Figure 17.—Mouth of adult male *Apristurus riveri*, 430 mm, showing comparatively large monocuspid teeth.

Figure 18.—*Apristurus riveri*, immature male, 350 mm, west Florida, showing tricuspid teeth found in all females and in imm ture males.

Apristurus riveri Bigelow and Schroeder 1944:23, pl. 7 (off north coast of Cuba, RV *Atlantis* stn. 2993, in 1,060 r Bigelow and Schroeder 1948:225, fig. 39; Springer 1966:613, figs. 4, 5, 7.

Material examined. MCZ 36092,♀, 407 mm, holotype, north coast of Cuba; ♂, 460 mm, ♀, 338 mm, west of D Tortugas, Florida, 914 m; ♀, 400 mm, ♂, 250 mm, off Mississippi coast, 622 m; ♂, 430 mm, 3 ♀, 400, 400, 405 mm, Caribbean coast of Panama, 860-914 m.

Diagnosis. *Apristurus riveri* is best recognized by its long narrow snout, narrower than in other species, with narrower pore pattern on the lower side of the snout, the number of longitudinal rows of prominent pores extending fr the level of the posterior end of the nasal aperture forward not more than four as compared with about eight or more most other species of *Apristurus*. The rows of pores are somewhat irregular but I have found the character reliable half-grown and adult *riveri*.

Sexual dimorphism in tooth size and shape is greater for *A. riveri* than for any other species examined for this stu Adult males have monocuspid, cone-shaped teeth that are much larger than the teeth of the adult females or of the i mature males (Fig. 7). The teeth of immature males have the same shape as the teeth of females.

Apristurus riveri belongs to the group of *Apristurus* species having the second dorsal fin much larger than the first d sal in area and in having the origin of the first dorsal well in advance of the posterior end of the pelvic fin base

Some *A. riveri* have denticle-free black skin around the gill slits and the gill filament tips may extend past the covers. I have noted this condition chiefly in young specimens of both *A. riveri* and *A. parvipinnis* and do not regard i reliable in diagnosis. The gill region of some *A. riveri* is well covered with denticles.

Counts of monospondylous vertebrae are 30 to 32 in 16 specimens of *A. riveri*, a somewhat smaller number th observed for other *Apristurus* (Table 1) except *A. herklotsi*.

Mature specimens examined were from 390 to 475 mm long.

Description. Proportional measurements of the holotype were given by Bigelow and Schroeder (1948:223). Follow are comparable measurements expressed as percentages of the total length for two adult males, 430 and 460 mm, w the range in three adult females, 400, 405, and 405 mm, in parentheses.

Tip of snout to: front of mouth, 8.1, 7.4, (9.4-10.0); eye, 10.7, 10.0, (10.4-11.5); first gill slit, 19.8, 18.7, (18.3-21 fifth gill slit, 25.3, 23.9, (22.2-24.5); origin first dorsal fin, 48.9, 48.9, (47.5-48.6); origin pelvic fins, 41.9, 40.9, (40.2-42 origin anal fin, 53.6, 52.4, (51.8-52.3); second dorsal fin, 62.8, 61.3, (59.3-60.2); upper caudal lobe, 71.6, 71.1, (68.3-70 anterior end cloacal opening, 45.3, 43.5, (44.9-47.7).

Orbit: horizontal diameter of opening, 3.5, 3.3, (3.3-3.5).

Nostrils: least distance between, 4.0, 3.9, (3.7-4.3).

Mouth: width, 5.3, 6.7, (6.9-7.3); length, 4.6, 5.2, (3.2-4.3); length upper labial furrow, 2.3, 2.2, (2.0-2.5); length lower labial furrow, 2.8, 2.2, (2.5-3.0).

First dorsal fin: length base, 4.0, 3.3, (4.2-4.3).

Second dorsal fin: length base, 6.3, 5.4, (6.1-6.5).

Anal fin: length base, 14.2, 13.0, (14.2-15.8).

Pectoral fin: length anterior margin, 11.2, 9.8, (10.0-11.6).

Distance between fin bases: pectorals and pelvics, 8.6, 9.8, (9.9-11.8); first and second dorsals, 7.6, 8.9, (6.9-7.4).

Tip of appressed pectoral to origin pelvic fin: 4.2, 5.4, (5.0-6.9).

In *A. riveri*, as in other species of *Apristurus*, it is difficult to count the number of vertical tooth rows because of a tendency to arrangement in diagonal files (Fig. 8). Counts of vertical rows in the specimens examined were from 24 to 29 rows on each half of the upper jaw and 19 to 22 rows on each half of the lower jaw.

Apristurus riveri is not as large as some of the other species. I estimate length of females at maturity as about 390 mm but males may be slightly larger. The longest specimen measured was 475 mm.

Egg capsules of *A. riveri* are about 50 to 60 mm long by 12 to 15 mm wide. The capsules are smooth-surfaced, greenish, somewhat translucent, and have some indistinct longitudinal bands of darker color.

Discussion. *Apristurus riveri* was taken less frequently by exploratory fishing vessels operating in the Gulf of Mexico-Caribbean area than *A. parvipinnis* and *A. laurussonii*. One possible explanation is that the depth range of *A. riveri* is in somewhat deeper water than other *Apristurus* of the region and fewer trawl hauls were made in deeper water. In an earlier paper (Springer 1966), *A. riveri* was the only species of the genus that was adequately and correctly defined but additional collections have confirmed earlier notes on *riveri* and add a little to the earlier account. New material shows that immature males have teeth similar to those in females, and it is evident that the transition from tricuspid to monocuspid teeth must be abrupt. Proof can only come with the capture of a male with both kinds of teeth, developing cone-shaped teeth near the germinal series and multicuspid teeth in the functional series.

Since no published explanation of shark tooth dimorphism has yet appeared, I offer the following hypothesis to account for it in *A. riveri*. In the few known observations of shark copulation, one species of the family Scyliorhinidae, *Scyliorhinus canicula*, has been observed. The essential preliminary is that the male seizes one of the female's pectoral fins with its jaws and then twists into position to permit copulation. Multicuspid teeth, especially those that are more or less flattened, tend to cut rather than pierce. Cone-shaped piercing teeth, as in the adult males of *A. riveri*, are less likely to cut through the thin pectoral fin of the female, and not only do less damage to the female, but also provide a firmer grip. This may be most important to the survival of the species in a sparsely distributed deepwater population.

It was previously reported (Springer 1966) that female *A. riveri* with egg capsules in the oviducts had a flattened ring of white tissue around the cloaca. Subsequent collections of both *A. riveri* and *A. parvipinnis* exhibited a similar condition but only when egg capsules were present in the oviducts and had capsule tendrils extending outside the oviducts. It is here postulated that the pad of white tissue, which is comparatively firm, is used to press and rub the tendrils against a relatively hard object. This may cause the tendril to bend and coil around the object so that the egg capsule can be pulled out of the oviduct. It is possible that some external pull is necessary for deepwater species such as *A. riveri* in which the abdominal walls are weak and perhaps too poorly muscled to expel egg capsules.

Apristurus saldanha (Barnard)

Scylliorhinus saldanha Barnard 1925:44 (off Saldanha Bay, South Africa in 914 m).

Pentanchus saldanha: Fowler 1941:59.

Apristurus saldanha: Bigelow and Schroeder 1948:221 (key only); not of Norman 1939:36; not of Bass et al. 1975:8, fig. 5.

Material examined. None. Barnard's holotype, now possibly lost, was an 810-mm male and the largest example of any species of *Apristurus* yet recorded. Barnard's description of the claspers shows the holotype to be an adult male.

Diagnosis. In *Apristurus saldanha* the distance between the two dorsal fin bases is about as great as the distance between the tip of the snout and the spiracle, greater than in any other species of *Apristurus* except *Apristurus platyrhynchus* (Tanaka 1909) from Japanese waters. Also, as calculated from Barnard's description, *A. saldanha* has: first dorsal fin slightly smaller (in area) than second dorsal fin; length of anal fin base almost equal to distance from tip of snout to first gill slit; length of body before vent about one-half total length; length of head to fifth gill slit about one-fifth total length; eye (there is some question as to how Barnard measured the eye because he states length of eye [not the orbit as indicated by scaleless skin]) three in snout—this is calculated as 2.6% TL; first dorsal fin origin about over midpoint of pelvic fin base; snout length about 7.2% TL; teeth tridentate; dermal denticles tridentate, lateral points much smaller than central point, obscure; claspers reaching anal fin origin.

Discussion. In 1969, I examined three specimens (BMNH 1935.5.2, 56-58) which appeared to be those identified Norman (1935, 1937) as *A. saldanha* and were taken off Saldanha, South Africa, in 735-1,000 m at RV *Discovery* Stati J. When I saw the specimens, two were labeled *A. saldanha* and one *A. microps*. All appeared to be immature, the t larger, a male 430 mm and a female 440 mm, differed from the smallest one in having somewhat larger eyes and a prop tionally longer trunk. None of the specimens had wide-bladed denticles that usually characterize most matu *Apristurus*. Bass et al. (1975:7, 8, figs. 5, 20A), tentatively and, I think, reluctantly, referred the specimens to *saldanha* and provided an important service by including a description and illustrations in their report. I do not agr that the specimens should be called *A. saldanha* chiefly because of their differences from Barnard's (1925) holotype the proportions of dorsal fin interspaces. The differences seem to me to be too great to attribute to differential growth cannot identify the specimens, however, as belonging either to an African species or to a species known from other area

Additional material may be reported soon for 1 of 11 *Apristurus* collected off the west coast of Africa. A 560-mm fema *Apristurus* taken off Saldanha Bay by a research vessel of the U.S.S.R. had an interdorsal distance nearly equal to t distance from the tip of the snout to the spiracle (Georgio Golovan, Acad. Sci. U.S.S.R., Moscow, pers. commun Although this specimen does not fit exactly Barnard's description, its differences may be attributable to its small siz

Apristurus sibogae (Weber)

Scyliorhinus sibogae Weber 1913:595 (Makassar Strait in 655 m).
Pentanchus sibogae: Fowler 1941:60.

Material examined. ZMA 111.076, imm. ♀, 210 mm, Indonesia, Makassar Strait, lat. 00°32'S; long. 119°39'E, in 6 m, the holotype and only specimen known.

Diagnosis. First dorsal fin about one-third the area of the second dorsal, its base about one-half the length of t second dorsal base, its origin posterior to the rear end of the pelvic fin base and over the anal fin origin; eye opening ve small, its length about one-half the least distance between nasal apertures and less than one-third the length of the sno to upper lip; length of snout about equal to distance between dorsal fin bases; color reddish-white.

Discussion. Apristurus specimens are usually black, dark gray, or dark brown but the holotype of *sibogae* is no pinkish-white and was described as reddish-white by Weber in 1913. Bright light or sunlight may cause the dark color *Apristurus* specimens to fade. One of Brauer's (1906) syntypes of *indicus* kept on exhibition for many years had faded grayish-white by 1970 (Christine Karrer, pers. commun.); but except for this syntype of *indicus* and the holotype *sibogae*, I have seen no light colored *Apristurus*. The holotype of *sibogae* was pinkish when examined by me in 1970 and do not believe that the color could have been the result of fading. The specimen was in good condition but very fragi and, although I handled it carefully, it broke in two pieces.

Apristurus verweyi (Fowler)

Pentanchus verweyi Fowler 1934:237, fig. 2 (vicinity of Sibuko Bay, Borneo).

Material examined. USNM 93135, imm. ♂, 295 mm, the holotype, Sibuko Bay, Borneo.

Diagnosis. In *Apristurus verweyi* the first dorsal fin is much smaller than the second dorsal and its origin is poster to the rear end of the pelvic fin base. It is thus similar to *A. platyrhynchus* but differs from that species in having the re end of the second dorsal fin base over or slightly behind the rear end of the anal fin base.

Discussion. The holotype and only known specimen of *A. verweyi* seen is not in good condition. The separation this species from *platyrhynchus* seems tenuous.

ASYMBOLUS WHITLEY

Asymbolus Whitley 1939:229 (type-species, *Scyllium anale* Ogilby, by monotypy).

Diagnosis. Asymbolus lacks a supraorbital crest that extends as a narrow shelf of the chondrocranium above t orbits, it lacks a crest of modified denticles along the upper edge of the caudal fin, it lacks barbels, and the poster margins of the nasal flaps do not reach the mouth and do not cover a depression or channel connecting the nasal cav with the mouth. *Asymbolus* has two dorsal fins. It has prominent but short labial furrows continuous around the mou corners and extending along the upper and lower jaws for a distance not greater than the least distance between the na apertures. The pelvic fins of males are not united directly by a union of their inner margins (as in *Juncrus*) but are c

nected by a membrane that forms a partial apron beneath the claspers. The eyes of *Asymbolus* are comparatively large with a prominent secondary lower eyelid which is separated from the primary lower eyelid and eye by a deep, but fully scaled, subocular gutter. The gutter extends from a little before the anterior corner of the eye, under the full length of the eye to the spiracle which is in the subocular gutter at its posterior end.

In *Asymbolus* the membrane connecting the pelvics originates from the dorsal side of one fin near, but not at, the inner margin and passes under the claspers to the other fin. This arrangement differs from that forming an apron or partial apron in *Scyliorhinus* and *Juncrus* which have proximal inner margins of pelvics directly united for varying lengths. It is not unique in the family, however, since an arrangement similar to that in *Asymbolus* is present in *Poroderma*.

Among scyliorhinid genera known to be represented in Australian waters, *Asymbolus* differs from *Aulohalaelurus*, *Atelomycterus*, and *Cephaloscyllium* in that *Asymbolus* lacks a supraorbital crest of the chondrocranium. In having a partial apron beneath the claspers, *Asymbolus* differs from all genera known from Australian waters except *Juncrus*, in which the partial apron is formed by the direct union of part of the inner margins of the pelvics as in *Scyliorhinus*. In *Halaelurus* membranes may be noted between the pelvic fins and claspers and between the two claspers at their bases but not extending under the claspers to connect the pelvics.

Asymbolus analis (Ogilby)

Scyllium anale Ogilby 1885:445 (type locality, Port Jackson Harbor, N.S.W., Australia).
Scyliorhinus analis: Regan 1908a:460.
Halaelurus analis: Garman 1913:85; McKay 1966:68.
Asymbolus analis: Whitley 1940:89, figs. 29, 78, 81.

Material examined. USNM 40016, ♀, 565 mm, Sydney, Australia; USNM 40027, imm. ♂, 475 mm, Port Jackson, Australia (these two specimens must have been incorrectly measured by Fowler who reported (1941:49) lengths of 612 and 515 mm; the difference from present lengths seems too great to be accounted for by shrinkage); BMNH 1890.9.23.273, imm. ♂, 470 mm, Australia; BMNH 1915.4.20.1-2, ad. ♂, 550 mm, New South Wales; BMNH 1937.9.21.1, stn. 113, lat. 42°40′S, long. 148°27.5′E, off Tasmania.

Type. Ogilby designated as a holotype an adult male 22.5 in (ca. 570 mm) long, giving the register number AMS B.8447. J. A. F. Garrick recently examined the holotype for me (pers. commun.) and noted that it was ca. 560 mm long. Based on comparison of original measurements with remeasurements made after many years of storage in alcohol a shrinkage in length of 1.75% as here, or 1 to 3%, is to be expected.

Diagnosis. *Asymbolus analis* should be readily recognized by the characters given in the diagnosis for *Asymbolus*. All of the specimens that I have seen (long in preservative) are light or dark brown above with scattered darker spots about the size of the dark-adapted pupil, and light tan or yellowish below without spots. Dorsal saddle blotches may also be present for these are indicated in Whitley's (1940, fig. 81) illustration and are mentioned in McKay's (1966) account. *Asymbolus analis* apparently never has white spots such as characterize *Juncrus vincenti*.

Description. Measurements expressed as percentages of the total length follow. In each series of figures the first refers to an immature male 475 mm long, from Port Jackson, Australia, USNM 40027; the second figure to a female, possibly mature, 560 mm long, from Sydney, Australia, USNM 40016; and the third to a 365-mm adult male from Tasmania, BMNH 1937.9.21.1. (see discussion of Tasmanian specimens as "island" forms of Australian scyliorhinids).

Tip of snout to: front of mouth, 3.6, 3.8, 5.0; eye, 3.8, 4.1, 5.2; spiracle, 7.8, 8.0, 9.6; first gill slit, 12.2, 12.5, 12.3; fifth gill slit, 17.1, 16.6, 17.0; origin pectoral fin, 15.4, 15.9, 16.0; origin first dorsal, 47.6, 47.3, 41.1; origin pelvics, 37.9, 40.7, 35.6; origin second dorsal, 70.7, 66.1, 63.0; origin anal, 66.9, 57.1, 56.2; origin upper caudal lobe, 77.7, 79.5, 76.7; anterior end anal opening, 42.1, 43.4, 39.5.

Eyes: horizontal diameter opening, 3.2, 3.2, 4.1; vertical diameter opening, 1.1, 0.7, 1.4.

Spiracles: greatest diameter, 1.1, 0.4, 0.3; distance eye to spiracle, 0.8, 0.9, 1.1.

Mouth: width, 5.5, 5.7, 7.1; length, 3.6, 3.4, 3.8; length upper labial furrow, 0.8, 0.8, 1.1; lower labial furrow, 1.3, 1.2, 1.6.

Nasal apertures: minimum distance between, 1.6, 1.8, 1.9.

Gill slits: height of first, 1.5, 2.0, 1.6; height of fifth, 1.1, 1.1, 0.8.

First dorsal fin: length base, 6.1, 6.3, 5.8; length free inner margin, 2.1, 2.1, 2.2; height, 3.6, 3.9, 4.7; length anterior margin, 8.4, 9.6, 7.9.

Second dorsal fin: length base, 6.9, 7.0, 6.3; length free inner margin, 2.3, 2.1, 2.2; height, 3.8, 3.9, 4.4; length anterior margin, 9.1, 9.6, 7.9.

Anal fin: length base, 10.9, 11.6, 12.3; height, 3.4, 3.2, 3.3; length anterior margin, 7.4, 8.2, 6.6.

Pectoral fin: width base, 4.4, 4.8, 5.5; length anterior margin, 10.1, 11.3, 9.9; greatest width, 8.0, 8.8, 9.6.
Pelvic fin: origin to rear tip, 11.8, 11.8, 11.5.
Caudal fin: upper margin, 22.3, 20.5, 24.7.
Distance between fin bases: first and second dorsals, 11.8, 12.0, 15.9; pectoral and pelvic, 18.1, —, —; pelvic a anal, 11.8, —, —; anal and caudal, 7.4, —, —; second dorsal and caudal, 5.9, —, —.

Asymbolus analis is slender and elongate, the head moderately flattened and the posterior trunk moderat compressed. The head is relatively short, less than one-fifth total length (less than three-sixteenths total length specimens examined) and the tail, measured from origin of upper caudal, is from one-fourth to one-fifth total leng The mouth is large with a high rounded arch, the length of the mouth nearly as long as the snout. Labial furrows a short but moderately prominent and continuous around the mouth corners, the lower longer than the upper. Eye lar its length a little less than length of snout; length of subocular gutter including spiracle is a little greater than sno length. The nasal apertures are large, separated from one another by a distance about one-half the snout length and ha broad outer nasal flaps entirely covering posterior nasal apertures but not reaching upper lips.

The second dorsal fin is slightly larger than the first and the interdorsal distance is about twice the length of base the second dorsal. The first dorsal originates behind the posterior end of the pelvic base and the second dorsal originat over the posterior third of the anal base. The lower caudal fin lobe originates considerably in advance of the origin of t upper lobe. The pectorals are moderate in length and wide with rounded corners.

The teeth are small, in about 60/62 rows, those in the central part of the upper jaw and in most of the lower jaw a tricuspid with middle cusps longest; lateral upper jaw teeth mostly have five cusps; upper and lower jaw teeth a generally similar except lateral lower jaw teeth which are much smaller, flattened, with low cusps. The modification the lateral lower jaw teeth appears to adapt them to a crushing function and the arrangement of teeth in a more or le shinglelike array is similar to the condition in lateral lower jaw teeth of some *Atelomycterus*.

The dermal denticles are tridentate, their blades imbricate. The blades have a wide, but low, and inconspicuous rid extending posteriorly from the central point. Pigment may be present within the denticles of those areas which ha darker brown spots. The denticles are similar in shape over most external body surfaces. Small denticles are present the anterior margin of the tongue and on the gill bars.

The specimens examined were all light brown above with the roundish darker spots about the size of the dark-adapt pupil somewhat irregularly distributed over dorsal and lateral surfaces. Lower surfaces were lighter and unmarke

In two specimens vertebral numbers were: monospondylous, 39, 39; precaudal, 86, 86; caudal, ca. 42, ca. 56; total, c 128, ca. 142.

Discussion. *Asymbolus analis* is recorded from New South Wales, Tasmania, and the southern coast of Austral west at least as far as Albany, Western Australia. It has been taken on the continental shelf and to depths of about 1 m. This species and other scyliorhinids of southern Australia and Tasmania are described by McKay (1966) as mostly i habiting shallow coastal waters, in contrast to scyliorhinids of the subtropical and tropical Atlantic species which i habit continental slopes at depths usually greater than 175 m.

Asymbolus is oviparous. Its egg cases are described and illustrated by Whitley (1940:40, fig. 29).

Three males, 470, 475, and 510 mm, are immature but a 550-mm male is mature. All of these specimens are from t Australian mainland shelf. The only Tasmanian *A. analis* seen was a 365-mm adult male. It seems possible that lar series would show differences between mainland and Tasmanian populations. In the Australian-Tasmanian gen *Juncrus*, however, the larger form seems to be the Tasmanian one.

ATELOMYCTERUS GARMAN

Atelomycterus Garman 1913:100 (type-species *Scyllium marmoratum* Bennett 1830, by monotypy).

Diagnosis. *Atelomycterus* has two dorsal fins nearly equal in area, the first originating over the middle of the pel base or over the posterior end of the pelvic base. It has a well-developed supraorbital crest on the chondrocranium p jecting as a narrow shelf above the orbits. The nasal flaps are long and usually extend to or past the edge of the upper l each covering a depressed segment in the upper lip forming channels in the upper lip connecting the mouth with t nasal cavities. Prominent and long labial furrows are continuous around the mouth corners, extending along the up jaw for a distance slightly less than length of the orbit and along the lower jaw for a somewhat greater distance.

Adults have the trunk vertebrae of adults calcified in a "Maltese-cross" pattern (White 1937). However, the type calcification has not been determined either in young *Atelomycterus* or in many of the less common scyliorhinid spec such as *Aulohalaelurus labiosus*.

Discussion. *Atelomycterus* has a slender, almost eellike form tapering from the posterior end of the jaws. A sli constriction in the area of the first gill slit gives *Atelomycterus* a somewhat reptilian appearance, but otherwise it rese

bles *Scyliorhinus canicula* in shape. According to White (1936b), *Atelomycterus* is found among coral reefs where its eel-like body is adapted to the sinuous movements needed for swimming into holes and around sharp corners. *Atelomycterus* probably gains some flexibility from its comparatively large number of vertebrae. It not only has a larger number than any other scyliorhinid, up to 172 in some males, but the trunk vertebrae are numerous with less abrupt and a less conspicuous transition from the longer monospondylous vertebrae to the shorter diplospondylous vertebrae than in other scyliorhinids.

White (1936a) included a family, the Atelomycteridae, in a brief synoptic list of families of galeoid sharks and later (1936b:19) gave a definition for the family, emphasizing the vertebral calcification pattern, in a paper entitled "Some transitional elasmobranchs connecting the Catuloidea with the Carcharinoidea." Although White treated only *A. marmoratus* and six other species in that paper, she specifically stated that *A. marmoratus* was not a transitional shark but one adapted to a restricted environment.

I provisionally recognize two species of *Atelomycterus, A. marmoratus* and *A. macleayi*. I am not certain, however, that *A. macleayi* warrants recognition or that *A. marmoratus* (as used here) represents a single species.

Atelomycterus macleayi Whitley

Atelomycterus macleayi Whitley 1939:230, fig. 3 (type-locality Melville Island, Northern Territory, Australia); Whitley 1940:92, figs. 86, 87; McKay 1966:67 (reference only); Taylor 1964:54.

Material examined. USNM 174070, ad. ♂, 475 mm, 6 mi NNW of Darwin, Northern Territory, depth about 0.5 m, 20 March 1948; USNM 174071, ad. ♀, 510 mm, 7 mi north of Darwin, depth about 3.5 m. The holotype, AMS I.5269, was not examined.

Diagnosis. Whitley's description of *A. macleayi* merely states that it differs from *A. marmoratus* in color, in relative position of the fins, and in the shape of the egg capsule which lacks tendrils at the anterior end.

I did not make direct comparisons of specimens of *A. marmoratus* with the two specimens of *Atelomycterus* in the U.S. National Museum collection and my notes are insufficient to show differences other than small differences in the relative positions of first dorsal and pelvic fins.

Atelomycterus needs further study and, as an aid to such a study, I have included a comprehensive description of *A. macleayi* based on one adult male and one adult female.

Description. Body elongate, subcylindrical; head short, less than one-fifth total length; tail from origin of upper caudal fin about one-fifth total length; distance from tip of snout to anterior end of cloaca slightly more than two-fifths total length.

Head and snout tapering from posterior end of jaw cartilages forward to a blunt, rounded point; head moderately flattened; snout in front of mouth short, its length a little more than one-half width of mouth; mouth moderately arched, its width somewhat less than half its length.

Nasal flaps large and long, entirely covering posterior openings of nasal apertures and extending past upper lip, covering depressed areas or channels in upper lip between nasal apertures and mouth; right and left nasal flaps confluent with upper lip and separated from one another by a distance about equal to length of fifth gill slit.

Eyes moderately large, lateral, not visible from below, openings elongate, length more than two-thirds snout length; a prominent subocular gutter fully lined with denticles originating somewhat in advance of anterior eye corner and extending under full length of eye to spiracle which is within the gutter at its posterior end; subocular gutter U-shaped in cross section and about as deep as wide; spiracles small, separated from eye opening by a distance slightly greater than spiracle diameter; gill slits moderate, the height of the first somewhat less than length of orbit, the first four subequal, the fifth somewhat shorter.

Pectoral fins short, their distal margins broadly rounded, origins under or slightly posterior to fourth gill slit; first and second dorsal fins about equal in area, the base of the first shorter than the base of the second, their bases separated from one another by about twice the length of first dorsal base, both dorsal fins broadly rounded at the apex, their distal margins concave and their inner posterior tips angular; first dorsal origin over the posterior end of the pelvic base; second dorsal origin over or slightly in advance of the midpoint of the anal base; anal fin much lower than either dorsal fin, its area little more than one-half area of either dorsal; caudal fin narrow, no salient extension near origin of lower caudal, notch very strong.

Proportional dimensions are given here as percentages of total length of the 475-mm adult male followed in parentheses by dimensions of the 510-mm female.

Tip of snout to: front of mouth, 3.4, (2.9); eye, 4.0, (4.1); spiracle, 7.6, (7.1); first gill opening, 12.6, (12.0); fifth gill opening, 17.9, (17.6); origin pectoral, 16.8, (16.7); origin first dorsal, 44.2, (45.1); origin pelvics, 38.3, (39.2); origin second dorsal, 64.2, (64.9); origin anal, 62.1, (63.3); origin upper caudal lobe, 80.0, (80.0); cloacal opening, 41.3, (41.2).

Greatest width of: head, 9.3, (9.8); trunk at pectorals, 8.2, (8.8); trunk at pelvics, 6.5, (6.7); caudal peduncle, 2 (2.5).

Greatest height of: head, 6.5, (6.5); trunk at pectorals, 6.9, (8.0); trunk at pelvics, 6.9, (8.2); caudal peduncle, 4 (3.9).

Eyes: horizontal diameter, 2.5, (2.5); vertical diameter, 0.9, (0.6).

Spiracles: greatest diameter, 0.4, (0.4); least distance from eye, 0.5, (0.5).

Mouth: width, 5.7, (5.7); length mouth, 2.9, (2.2); length upper labial furrow, 2.5, (2.5); length lower labial furr 3.4, (3.1).

Nasal apertures: distance between nasal flaps at inner posterior corner, 1.5, (1.5).

Gill slits: height of first, 2.1, (2.0); height of fifth, 1.5, (1.6).

First dorsal fin: length base, 6.7, (6.1); length inner posterior margin, 3.2, (2.7); height, 6.3, (2.9); note, dis margin of fin of female seems to have been nibbled away.

Second dorsal: length base, 8.4, (7.8); length inner posterior margin, 3.2, (2.7); height, 6.3, (6.7).

Anal fin: length base, 8.6, (7.8); length inner posterior margin, 2.5, (2.2); height, 3.2, (3.5).

Caudal fin: length upper margin, 20.0, (20.0).

Distance between fin bases: first and second dorsal, 13.7, (13.7); pectoral and pelvic, 18.7, (20.4); pelvic and an 18.1, (17.3); anal and lower caudal, 7.4, (7.3); second dorsal and upper caudal, 6.5, (7.5).

Teeth very small, in about 70/70 rows, no indication of sexual dimorphism; teeth similar in upper and lower ja tridentate, the middle cusps much the longest (crowns of largest teeth in 475 mm male about 0.7 mm high), basal rid of tooth crowns moderately strong; lateral 15 (more or less) rows on each side less than half size of central teeth

Dermal denticles close together, arranged almost in pavement, with thick denticle blades mostly with only posteriorly directed point (in adults), but a weak lateral point on one or both sides of central point present on some d ticles; points slightly elevated, rough to touch when rubbed toward head, smooth when rubbed toward tail; dorsal a lateral denticles with one to seven low ridges on anterior part of blade, ridges reduced or obsolete on ventral denticl blade surfaces of denticles of snout and leading fin edges smooth; inside of mouth, tongue, and gill bars covered w very small, nearly erect, cone-shaped denticles separated from one another by distances greater than the diameter their bases.

No gill rakers present.

Total number vertebrae, 172 in male, 167 in female; monospondylous 44 in both; precaudal 112 in both; caudal 60 male, 55 in female.

Claspers of 475-mm male (apparently an adult with well-calcified clasper cartilages) moderately robust, not notal long, extending 24 mm past tips of pelvic fins; no apron formed beneath claspers by partial union of inner margins pelvics or by membranous connection of pelvics.

Female of 510 mm with only right ovary functional, containing nine large eggs about 8 by 8 mm to 11 by 13 mm, eggs arranged linearly so that the ovary extends nearly the full length of the body cavity; two oviducts, the left ovid containing one egg capsule with enclosed egg; embryo, if present, not sufficiently developed to detect; the egg caps about 66 by 21 mm, a lateral constriction at both anterior and posterior ends of capsule [as shown in Whitley (1939, 3; 1940, fig. 87)]; anterior end of capsule without horny tendrils, posterior end with relatively short horny tendrils; li not large or oily, confined to anterior half of body cavity; valvular intestine with about 18 turns.

Color tan dorsally with numerous brown spots which coalesce dorsally to form short bars and posteriorly to fo saddles; spots in irregular longitudinal lines on sides and extend onto all fins of female and all fins, except anal and lo caudal, of male. Ventral surfaces of body unspotted.

Discussion. The adult male was collected where water depth was said to be 1½ ft (45 cm) and water temperat 95°F (35°C); the female was caught over a sand bottom with a few rocks from a depth not greater than 12 ft (3.7 m) a where the water temperature was 90°F (32.2°C). These records (Taylor 1964) are of much higher water temperatu than I have found for any other scyliorhinid and indicate that *Atelomycterus* must be adapted to an unusually warm a shallow-water environment. Apparently such environments are occupied by scyliorhinids only in the tropical In Pacific area.

One other scyliorhinid, *Aulohalaelurus*, of Western Australia and recorded from shallow water in the Arnhem La area, also lives in warm, shallow water. While *Aulohalaelurus* has a relatively small eye, usual in shallow water, diur sharks, the eye of *Atelomycterus* is not as small as might be expected. The upper eyelid in *Atelomycterus*, howe appears to be capable of shading the eye making it less exposed to strong light than the eye of *Aulohalaelurus*.

It seems likely that a study of the clasper structure might be useful in determining species of *Atelomycterus*. clasper of *Scyllium marmoratum* (*A. marmoratus*) illustrated by Leigh-Sharpe (1926, fig. 8) differs greatly from clasper of *A. macleayi* not only in length and shape but also in the number and distribution of component elemer

Atelomycterus marmoratus (Bennett)
Figure 19

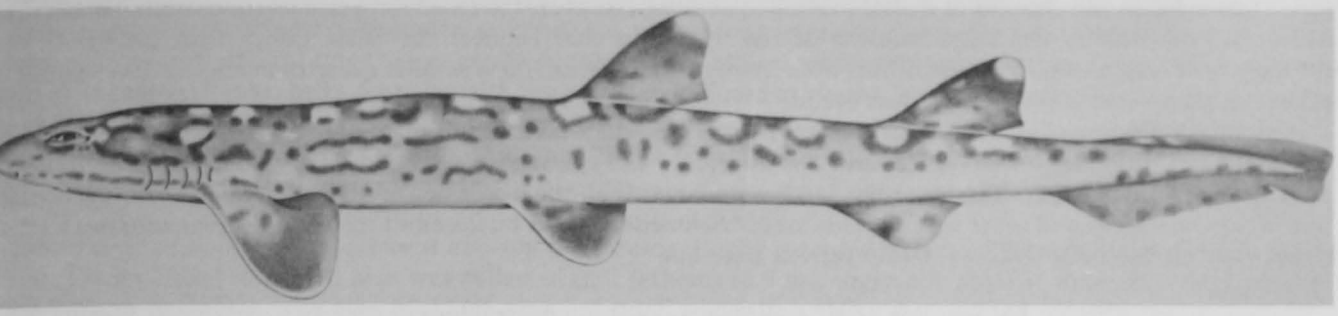


Figure 19.—*Atelomycterus marmoratus*, 437-mm female, Gulf of Thailand. Drawing by Mary Wagner.

cyllium marmoratum Bennett 1830:693 (type-locality, Sumatra); Günther 1870:401.
telomycterus marmoratus: Garman 1913:100; White 1936b:6; Fowler 1941:62, fig. 6; Teng 1962:53, Fig. 13; Chen 1963:32; McKay 1966:66, fig. 1; Besednov 1969:31, fig. 16.

Material examined. VFC 516, ♀, 437 mm, Gulf of Thailand, lat. 12°11'N, long. 100°19'E; SU 13562, ad. ♂, 615 mm, hilippines; SU 13659, ♂, 475 mm, Philippines; SU 13689, ♀, 466 mm, Philippines. Holotype not seen, presumed lost. ccording to Günther (1870) it is the skin of a half-grown specimen that was presented to BMNH by T. S. Raffles.

Diagnosis. *Atelomycterus marmoratus* is readily separable from scyliorhinids of other genera by the characters noted nder the generic diagnosis. The provisional distinction used here to separate *A. marmoratus* from *A. macleayi* is that in pecimens of *A. marmoratus* the origin of the first dorsal fin is over the middle of the pelvic fin base whereas in *A. nacleayi* it is over the posterior quarter of the pelvic fin base.

Description. Following are measurements expressed as percentages of the total length for a 437-mm female *A. narmoratus* from the Gulf of Thailand.

Tip of snout to: front of mouth, 3.2; eye, 4.6; spiracle, 7.8; first gill slit, 12.8; fifth gill slit, 18.1; origin pectoral fin, 5.6; origin first dorsal, 43.2; origin pelvics, 39.4; origin second dorsal, 66.4; origin anal, 62.2; origin upper caudal fin obe, 80.5; anterior end cloacal opening, 41.2.
Greatest width of trunk: at pectoral origin, 8.9.
Greatest height of trunk: at pectoral origin, 6.9.
Orbit: horizontal diameter, 3.0; vertical diameter, 0.7.
Mouth: width, 5.7; length upper labial furrow, 2.5; length lower labial furrow, 2.7.
Gill slits: height of first, 2.1; height of fifth, 1.6.
First dorsal fin: length base, 7.3; length free inner margin, 3.0; height, 6.9.
Second dorsal fin: length base, 8.2; length free inner margin, 2.3; height, 5.7.
Anal fin: length base, 7.6; length free inner margin, 1.6; height, 3.4.
Caudal fin: length upper margin, 20.6; anterior margin lower lobe, 7.3.
Distance between fin bases: first and second dorsals, 15.1; pectoral and pelvic, 17.6; second dorsal and caudal, 6.4; elvic and lower caudal, 34.8.

Teeth small, in about 74/74 rows, lateral 10 to 12 similar in upper and lower jaws, lateral 10 or 12 rows on each side ith very short cusps not readily counted or seen, remainder of teeth tridentate, the middle cusp much the longest. Vertebral numbers in four specimens examined were: monospondylous 44 to 47; total, 157-162.

Discussion. The color pattern in *A. marmoratus* is remarkably variable. The extent of variation in pattern can be en by comparing the drawing here (Fig. 19) of a specimen from the Gulf of Thailand; three specimens shown by Fowler 941, fig. 6), possibly from the Philippines; two specimens from Western Australia (McKay 1966, fig. 1); and a specimen lustrated by Besednov (1969, fig. 16), from the Gulf of Tonkin.

AULOHALAELURUS FOWLER, 1934

ulohalaelurus Fowler 1934:237 (type-species *Catulus labiosus* Waite, by original designation).

Diagnosis. *Aulohalaelurus* has a well-developed supraorbital crest of the chondrocranium that extends as a narro shelf above the orbit. It resembles *Atelomycterus* in this as well as in its elongate, somewhat cylindrical body form, in it fin positions, in its conspicuous, long, labial furrows, and in the absence of an apron formed by the partial union of th pelvic fins beneath the claspers of males. In *Aulohalaelurus*, however, the nasal flaps do not quite reach the mouth an *Aulohalaelurus* has no depressed sections of the upper lip that connect the nasal cavity with the mouth as i *Atelomycterus*. *Aulohalaelurus* also differs from *Atelomycterus* in having a smaller eye with much less development of subocular gutter and a secondary lower eyelid.

In direct comparison of an adult male *Aulohalaelurus labiosus* with an adult male *Atelomycterus macleayi* the follow ing additional differences were noted. In *Aulohalaelurus* the spiracle was proportionally larger and the teeth wer proportionally much larger. The lower jaw teeth were larger than the upper jaw teeth in *Aulohalaelurus*; the reverse true of *Atelomycterus* and other scyliorhinids except *Schroederichthys bivius* adult males. *Aulohalaelurus* has scattere black spots on the belly whereas *Atelomycterus* does not.

Aulohalaelurus labiosus (Waite 1905)

Catulus labiosus Waite 1905:57, fig. 23, Freemantle, Australia (holotype, a 620 mm ♂ WAM).
Halaelurus labiosus: Garman 1913:88; Fowler 1941:51; McKay 1966:68.
Aulohalaelurus labiosus: Whitley 1940:89, figs. 78, 80.

Material examined. WAM P.12020, ad. ♂, 540 mm, Point Peron, Freemantle, Western Australia, 3.7 m, 1 Marc 1965.

Diagnosis. *Aulohalaelurus labiosus* is most easily separated from other scyliorhinids by the characters given und the diagnosis of the genus.

Description. The following proportional measurements are in percentages of total length of a 540-mm adult male.

Tip of snout to: posterior end of nasal flap, 3.06; front of mouth, 3.14; eye, 5.1; spiracle, 8.0; first gill slit, 13.9; fif gill slit, 18.5; origin pectoral, 17.8; origin first dorsal, 49.3; origin pelvics, 43.5; origin second dorsal, 66.9; origin ana 63.2; origin upper caudal lobe, 79.6; anus, 46.3.

Eyes: horizontal diameter, 1.9; distance between rims of upper eyelids, 5.7.

Spiracles: greatest diameter, 0.7; least distance from eye, 1.0; distance between, 6.5.

Mouth: width, 7.4; length upper labial furrow, 3.3; length lower labial furrow, 3.7.

Nasal apertures: level of anterior opening to tip of snout, 2.0; level of posterior opening to tip of snout, 3.1; lea distance between, 2.3.

Gill slits: height of first, 2.2; height of fifth, 1.1.

First dorsal fin: length base, 6.9; inner posterior margin, 3.1; height, 5.6.

Second dorsal: length base, 8.3; inner posterior margin, 2.8; height, 5.2.

Anal: length base, 8.1; inner posterior margin, 2.0; height, 3.0.

Pectorals: width base, 4.3; anterior margin, 11.3; greatest width, 8.1.

Pelvics: length (origin to rear tip), 10.0.

Distance between bases: first and second dorsals, 10.4; pectoral and pelvic, 20.4; pelvic and anal, 13.5; anal a lower caudal origin, 6.9; second dorsal and upper caudal, 4.8.

Greatest width of: head, 11.5; trunk at pectorals, 10.0; trunk at pelvics, 7.6; trunk at caudal base, 2.6.

Greatest height of: head at spiracles, 6.9; trunk at pectorals, 9.4; trunk at pelvics, 8.7; trunk at caudal base, 3.9.

Aulohalaelurus labiosus is a species of moderate size, the holotype was 620 mm, the largest specimen recorded is a 6 mm female, WAM P.5690 (McKay 1966), and the specimen on which this description is based, a 540-mm mature ma Body elongate, subcylindrical; head somewhat flattened, its length less than one-fourth total length; snout short wit rounded point; nasal flaps large, completely covering posterior nasal openings, posterior edges nearly reaching upper l visceral cavity moderately long; pectorals short, their tips rounded; dorsal fins nearly equal in area, origin of the fi over posterior end of pelvic base, origin of second over middle of anal base; anal base about as long as second dorsal ba caudal fin short, its length from upper caudal fin origin about one-fifth total length, lower caudal fin low, with project lobe.

Mouth proportionally large with long and prominent labial furrows, their lengths more than 1 1/2 times the length the eye.

Color of 540-mm male brownish-gray on dorsal and lateral surfaces, yellowish-white below head and on belly, w roundish black spots 5 to 10 mm in diameter in generally random arrangement over all surfaces except the gular ar and with a few light-colored, small, and somewhat indistinct spots over dorsal surfaces, more notable posteriorly, sm white areas at tips of dorsal and caudal fins.

Teeth of upper and lower jaws generally similar in shape, mostly tricuspid in the central part of the jaws, the middle usp much the longest; teeth of the central part of the lower jaw about twice as high as corresponding teeth of the upper aw; extreme lateral teeth of both jaws very small, with five or more short cusps, and about five series functional; tooth ormula, about 50/45; highest tooth of lower jaw about 3.4 mm, highest tooth of upper jaw about 1.9 mm.

Dermal denticles over most dorsal surfaces imbricate, with three posteriorly directed points, the middle point largest; lades with a heavy central ridge, occasionally double, but no lateral ridges; denticles near midline of back somewhat nore erect than on flanks; belly denticles with lateral points reduced or absent; length of blades of larger denticles about .7 to 1.0 mm.

Claspers of mature male project less than half their length past the tips of the pelvic fins. The pelvic fins are not united o form an apron or partial apron beneath the claspers.

Discussion. *Aulohalaelurus labiosus* appears to be authentically recorded only from Western Australia (see McKay 966). The specimen described here was collected in 2 fathoms (3.6 m), unusually shallow water for a scyliorhinid in nost parts of the world. The eyes of *A. labiosus* are small suggesting also a well-lighted (shallow-water) habitat.

It has not been determined whether the species is oviparous, and egg capsules, if formed, are not known.

Aulohalaelurus labiosus was illustrated by Whitley (1940:78 and 80) and by Waite (1905, fig. 23).

CEPHALOSCYLLIUM GILL

Cephaloscyllium Gill 1862:407, 408 (type-species, *Scyllium laticeps* Duméril 1853, by original designation).

Diagnosis. The presence of a supraorbital crest of the chondrocranium in combination with the lack of either upper r lower labial furrows distinguishes *Cephaloscyllium* from all other scyliorhinid genera. Species of *Cephaloscyllium* are obust with wide heads and short snouts. They are unique among sharks in having the ability to inflate their stomachs vith water (or air) to give a balloonlike shape to the body.

Discussion. *Cephaloscyllium* changes greatly in body proportions during growth. For example, in a young specimen f *C. ventriosum* at hand, the distance from the tip of the snout to the cloaca is 45% TL, but in an adult the distance is 2% TL. Measurements given by Scott (1963) for *C. isabella laticeps* also indicate great proportional differences between oung and adults; eye length, for example, is 4.7 to 6.2% TL in six adults but 7.4% in a foetus 116 mm long. Jordan and owler (1903) characterized *C. umbratile* from Japan as having the space between the first and second dorsals much reater than the length of the first dorsal base. In eight immature *C. umbratile* that I examined, the interdorsal space is nly slightly longer than the length of the first dorsal base. Immature specimens reported by Chen (1963) and Besednov 1969) were also characterized in this way. Garman (1913) stated that the length of the first dorsal base is a little longer han the space between the dorsal fins in *C. umbratile*, but his key to the genus on a preceding page contradicts the tatement. The type of *C.umbratile* was noted by Jordan and Fowler (1903) to be a dried skin, SU 12693, and specific nention was not made of another *C. umbratile*. Their illustration of *C. umbratile* appears from the clasper length to be n adult and shows the interdorsal distance slightly less than the length of the first dorsal base. In summary, the receding details of measurement, and others from the literature not mentioned here, suggest that in immature exmples of all species of *Cephaloscyllium* the interdorsal distance is usually greater than length of the first dorsal base, ut that in adults the length of the first dorsal base is usually equal to or slightly longer than the interdorsal distance. In ddition, the small number of specimens that I have seen suggest that body proportions vary considerably even within a ingle size group.

The dermal denticles of *Cephaloscyllium* species also change in shape and number during growth. Typical flank denicles are erect and needlelike in young specimens but broader and not very erect in adults. Whitley's (1940) descriptive ccount and illustration of *C. laticeps* of Australia was obviously based on young specimens, "usually about one foot," nd his description of New Zealand *C. isabella* was based on adults.

The number of tooth rows in either upper or lower jaws of specimens that I have examined varied from about 55 to 70. I ave no explanation for Garman's (1913:81) count of 118/124 for *C. umbratile*.

The adults of various species of *Cephaloscyllium* appear to reach maturity at lengths of about 450 to 900 mm depending on both species and sex. New Zealand specimens, as already noted, are said to reach a length of 8 ft (2.45 m). I have ot been able to verify the existence of any specimen longer than about 1 ½ m.

I here recognize five species. One, *C. fasciatum*, is highly distinctive in color pattern and readily separable from the ther four species by other characters. The remaining four species are very near one another in body proportions and all ppear either to have been originally described because of geographic separation or on the basis of size or sex differences. n the basis of color differences and some other minor differences in the following key I recognize these five species as robably distinct. Adult specimens have not been available for my study in satisfactory numbers, and it is likely that I ave failed to find or observe some characters that would take *C. umbratile* out of the synonymy of *C. isabella* or to find me character that would better distinguish *C. laticeps* and *C. isabella* than the structure of the egg capsule.

The inflation of the body by swallowing great quantities of water probably enables *Cephaloscyllium* to wedge itself crevasses or small rocky caves and thus avoid some predators. When taken from the water, specimens may gulp air. T noise reported by fishermen to be like a barking dog (Whitley 1940), is the result of expulsion of air.

Key to Species of *Cephaloscyllium*

1a.	No definite color pattern of dorsal spots, lines, or blotches either in young or adults, but faintly indicated darker smudges with indefinite outlines occasionally visible in position of dorsal saddle blotches	*C. sufflan*
1b.	A definite color pattern present, usually more prominent or regular in young specimens	
2a.	A prominent pattern of dark lines outlining quadrilateral, dorsal, saddle areas; sometimes also a few irregularly scattered dark spots	*C. fasciatu*
2b.	A pattern of spots or blotches but no dark lines	
3a.	Posterior margins of nasal flaps extending to edge of upper lip	*C. ventriosu*
3b.	Posterior margins of nasal flaps not reaching edge of upper lips	
4a.	Egg capsules with strong transverse ridges	*C. laticep*
4b.	Egg capsules without transverse ridges	*C. isabell*

Cephaloscyllium fasciatum Chan
Figures 20, 21

Figure 20.—*Cephaloscyllium fasciatum*, newly hatched female about 128 mm, BMNH 1925.9.18, Philippines.

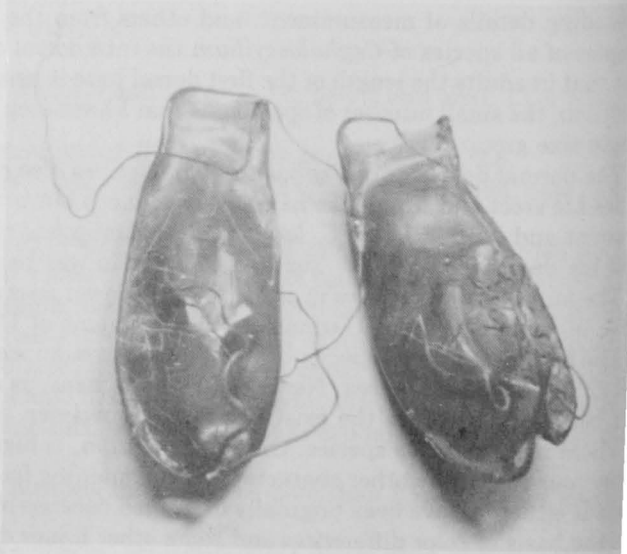


Figure 21.—*Cephaloscyllium fasciatum*, egg capsules about 83 m long by 33 mm wide, found attached to the Hong Kong-Manila ca in 310 m near Manila.

Cephaloscyllium fasciatum Chan 1966:232, figs. 6 and 7 (off Cape Bantagan, Vietnam).

Material examined. BMNH 1965.8.11.1, ♀ (maturing), 422 mm, holotype, 35 mi ESE of Cape Bantagan, Vietnam, in 219-314 m on soft mud bottom; 2 ♂, 235, 245 mm, paratypes, same locality as holotype; BMNH 1925.9.18.1, ♀, 128 mm (hatchling), lat. 14°24'N, long. 120°15'E, with two egg capsules, attached to Hong Kong-Manila cable in about 310 m, Figs. 20, 21.

Diagnosis. *Cephaloscyllium fasciatum* was distinguished in the original description by the presence of a lobelike extension of the nasal flap, its inner margin with a deep notch. That character may not always be sufficient since one *C. umbratile* of several specimens examined had a lobed nasal flap. The color pattern, however, is distinctive, and the presence of dark bordered saddle blotches or spots should readily distinguish *C. fasciatum* from all scyliorhinids except *Scyliorhinus retifer* of the western Atlantic. *Scyliorhinus retifer* has lower labial furrows and so differs from any species of *Cephaloscyllium*.

Discussion. Chan's (1966:232, table 1) comprehensive description of the species is accompanied by proportional measurements and details will not be repeated here. His account did not mention the presence of two rows of enlarged denticles on the backs of the smaller specimens of the type-series. The additional specimen that I examined, a hatchling 128 mm long, did not have the enlarged denticles so I assume they are not present on the young of this species. Such denticles are present, although perhaps only briefly, at hatching size on the young of *C. isabella*, *C. umbratile*, and *C. ventriosum*. I do not know whether young *C. sufflans* have these denticles. Possibly the absence of the enlarged denticles on *C. fasciatum* has a connection with a deeper habitat and the thinner walled egg capsules of *C. fasciatum*. For discussions of this see under *C. ventriosum* and also under *Halaelurus boesemani*.

Cephaloscyllium isabella (Bonnaterre)

Squalus isabella Bonnaterre 1788:6 (La mer du sud).
Cephaloscyllium umbratile Jordan and Fowler 1903:602, fig. 1 (Nagasaki, Japan); Garman 1913:80; Fowler 1941:32; Chen 1963:29, fig. 9; Lindberg and Legeza 1959:44, fig. 24; Chan 1966:229, figs. 4, 5, 7b, 7d; Besednov 1969:27, figs. 9, 10.
Cephaloscyllium laticeps (not of Dumeril): Waite 1909:136, pls. xiv - 1, xx - 1.
Cephaloscyllium isabellum: Garman 1913:79; Fowler 1941:31; 1967:358.
Cephaloscyllium formosanum Teng 1962:48, fig. 11.
Cephaloscyllium isabella nascione Whitley 1932:323, fig. 2, no. 2.
Cephaloscyllium isabella: Whitley 1940:91, fig. 84.

Material examined. USNM 176779, subad. ♂, 630 mm, Auckland, New Zealand; USNM 176795, ad. ♂, 690 mm, Cook Strait, N.Z.; USNM 176801, ad. ♀, 855 mm, Cook Strait, N.Z.; FMNH-Owston No. 1138, imm. ♀, imm. ♂, 465, 382, 335 mm, Boshu, Japan; FMNH-Owston No. 836, imm. ♀, 335 mm, Sagami Sea, Japan; FMNH-Owston No. 932, imm. ♂, 303 mm, imm. ♀, 268 mm, Idzu, Japan; FMNH-Owston 1351, imm. ♀, 365 mm, imm. ♂, 313, 326 mm, Yokahama Market, Japan.

Types. The holotype of *Squalus isabella* Bonnaterre was not located. The holotype of *Cephaloscyllium umbratile* Jordan and Fowler, SU 12693, a dried skin, was not found after search and is presumed lost. I did not see the holotype of *Cephaloscyllium formosanum* Teng, a 655-mm female, TFI 4339, taken off Tungkang, Formosa (Taiwan), in about 374 m, or the holotype of *Cephaloscyllium isabella nascione* Whitley, AMS - IA 2829.

Diagnosis. *Cephaloscyllium isabella* has a color pattern of irregularly arranged darker spots and saddle blotches, none of which have the black marginal lines characteristic of *C. fasciatum*. Also, *C. isabella* has broader and usually shorter nasal flaps than *C. fasciatum*, and egg capsules with thicker walls. Young *isabella* up to at least 226 mm long may have two rows of enlarged denticles on the back, but such denticles apparently do not appear on young *C. fasciatum*.

Separation of *C. isabella* from other species of *Cephaloscyllium* is much more difficult on the basis of characters observed in the few specimens that I examined. The South African *Cephaloscyllium sufflans* lacked the prominent color markings of *isabella* but I have not been able to find other differences. The length of the snout (in front of mouth) is somewhat shorter and the eye somewhat smaller in the adult *C. isabella* from New Zealand than in *C. sufflans*.

The eastern Pacific *C. ventriosum* is usually distinguished from *isabella* by nasal flaps that reach to or past the edge of the upper lip. Although nasal flaps in *isabella* were somewhat variable in shape, in the specimens I examined they were all short, and their edges did not reach the upper lip margin. *Cephaloscyllium isabella* lays smooth-surfaced egg capsules but otherwise differs little from *C. laticeps* which lays egg capsules with strong transverse ridges.

Description. Proportional dimensions as percentages of the total length are given following: first, for a 690-mm adu male, USNM 176795; second, for an adult female, USNM 176801; and third in each series of figures for an immatu female, FMNH-Owston 1138.

Tip of snout to: front of mouth, 3.5, 3.9, 3.4; eye, 6.4, 6.1, 5.6; spiracle, 11.0, 11.0, 9.7; first gill slit, 18.1, 17.3, 13.
last gill slit, 22.2, 21.3, 17.6; origin pectoral fin, 19.1, 18.0, 16.6; origin first dorsal, 50.7, 51.5, 49.5; origin pelvics, 44.
46.2, 45.2; origin second dorsal, 65.2, 66.7, 64.7; origin anal, 63.7, 64.3, 63.7; anterior end cloacal opening, 49.3, 51.5, 48.

Greatest width of: trunk at pectoral origin, 16.5, 18.1, 14.6; trunk at pelvic origin, 9.1, 9.8, 6.5; trunk at caud origin, 2.2, 2.2, 2.4.

Greatest height of: trunk at pectoral origin, 9.9, 14.0, 10.8; trunk at pelvic origin, 9.9, 9.4, 7.7; trunk at caud base, 3.3, 2.8, 3.0.

Eyes: horizontal diameter of opening, 3.5, 3.4, 3.2; height of opening, 8.4, 0.6, 0.9.

Spiracles: greatest diameter, 0.9, 0.7, 0.2; least distance from eye opening, 1.2, 1.1, 1.3.

Mouth: width, 11.7, 11.8, 10.5; length, 6.8, 4.8, 4.5.

Nasal apertures: level of anterior ends to tip of snout, 2.5, 2.6, 1.9; level of posterior ends to front of mouth, 0.3, 0.
0.2; minimum distance between, 3.2, 3.5, 2.4.

Gill slits: height of first, 2.2, 2.5, 1.7; height of fifth, 1.7, 2.0, 0.5.

First dorsal fin: length base, 8.7, 9.6, 8.0; length posterior tip, 2.6, 2.3, 2.6; height, 5.5, 5.8, 4.5; length anteri margin, 10.1, 11.8, 9.0.

Second dorsal fin: length base, 6.1, 6.4, 4.3; length posterior tip, 2.5, 2.3, 2.6; height, 3.3, 3.2, 4.5.

Anal fin: length base, 7.0, 7.4, 6.7; length posterior tip, 2.9, 2.5, 2.6; height, 4.3, 4.1, 3.0; length anterior margi 9.0, 8.3, 6.5.

Pectoral fins: width base, 10.1, 11.2, 6.9; length anterior margin, 15.8, 17.7, 13.3; greatest width, 14.1, 13.6, 10.5.

Pelvic fins: origin to rear tip, 14.2, 12.3, 9.7.

Caudal fin: length upper margin, 22.0, 21.3, 22.4.

Distance between fin bases: first and second dorsals, 7.8, 7.5, 8.6; pectorals and pelvics, 14.8, 17.4, —; pelvics a anal, 11.4, 9.2, —; anal and lower caudal, 4.6, 4.6, —; second dorsal and upper caudal, 6.5, 5.4, —.

Teeth are small, highest tooth in 465 mm female 1.2 mm, similar in upper and lower jaws, some teeth near the midd of each jaw three-cusped but most lateral teeth four- or five-cusped, their bases with ridges with a few having ridges e tending nearly to tooth tips. Number of tooth rows (rows perpendicular to jaw axis) about 50 to 70 in the upper jaw a about 45 to 65 in the lower jaw.

Dermal denticles erect and narrow in young becoming wider with blades heavy and parallel to skin surface in adult Hatchlings with two rows of enlarged denticles on back probably similar in structure and function to those described u der *C. ventriosum*.

Vertebral numbers counted by X-ray were: USNM 176795, total 120, monospondylous 47, precaudal 79, caudal 4 USNM 176801, total about 116, monospondylous 45, precaudal 76, caudal about 40; USNM 176779, total about 11 monospondylous 48, precaudal 78, caudal about 40.

The egg capsule of *C. isabella* from New Zealand illustrated by Waite (1909, pl. xxi, fig. 1) has a smooth surface and similar in shape to the egg capsule of *C. ventriosum* (Fig. 26).

Discussion. Except for *C. fasciatum*, which has highly distinctive color markings, the species of *Cephaloscyllu* appear similar and are consequently distinguished by minor differences. These differences have not been checked w large numbers of specimens, however, and the treatment here should be regarded as tentative. In earlier accounts species of *Cephaloscyllium* it seems that insufficient attention was given to changes in body and fin proportions and changes in dermal denticle structure during growth. Earlier keys generally separate *isabella, laticeps,* and *umbrat* from one another by attributing juvenile characters to some and adult characters to others. This should be easily c rected but will require a greater amount of data than have been available to me.

I can find no confirmation of the existence of very large New Zealand specimens of *Cephaloscyllium* and assume th lengths to 8 ft attributed to the genus are based on misidentifications. Waite (1909:136) and McCulloch (1911:6) refer to *Cephaloscyllium* as a "carpet shark," a common name often applied to larger species of the shark family Or tolobidae in Australia. It seems obvious that Whitley's account and illustration of *C. isabella* (1940:91, fig. 84) are bas on large specimens, mature or nearly so, whereas his description and illustration of *C. laticeps* (1940:92, fig. 85) are tak from small and immature specimens. Whitley (1932:323) seems to have been first to note that egg cases of *Cephalosc lium* from southeastern coasts of Australia were "flanged, not smooth" but other characters he used to characterize t species were based on juvenile specimens. It appears from Whitley's account (1932:323) that both *C. isabella* and *laticeps* may occur in Australian waters with *C. laticeps* restricted to the southeastern coast and being more common Tasmania.

Cephaloscyllium laticeps (Duméril)
Figure 22

Figure 22.—*Cephaloscyllium laticeps*, BMNH 1849.11.2.8-9, Georgetown, Tasmania. The function of the transverse ridges is unknown but a possible explanation for heavy-walled egg capsules is discussed under *C. ventriosum*.

cyllium laticeps Duméril 1853:84 (coasts of New Holland = Tasmania); Günther 1870:404 (Tasmania).
ephaloscyllium laticeps: Whitley 1940, part 92, fig. 85, no. 1a (Tasmanian form), also fig. 30, no. 14.
ephaloscyllium isabella laticeps: Whitley 1932:323, fig. 2, no. 1; Scott 1963:3, fig. 1 (Tasmania).

Material examined. None except dried egg capsules: BMNH 1849.11.2.8,9, Georgetown (probably Georgetown, asmania); similar egg capsules in BMNH marked unknown locality.

Diagnosis. I am unable to find differences in accounts of *Cephaloscyllium* morphology between *C. laticeps* and *C. abella* that are consistent with all of the material and data that are available to me. The two forms are separated here olely upon the differences in egg capsule form (Fig. 22). *Cephaloscyllium laticeps* produces egg capsules that are flanged Whitley 1932:323) or having about 31 to 33 strong transverse ridges in Tasmanian waters (Scott 1963:5). Egg capsules om Tasmania in the British Museum have about 25 to 28 transverse ridges and no doubt the number of ridges varies onsiderably. Whitley (1940:43, fig. 30, no. 14) illustrated a similar "laminated" egg capsule from Victoria and referred several from the Bass Strait area without species identification. What is known of the distribution of egg capsules sug-ests that *C. laticeps* is restricted to Tasmanian waters and to the nearby Australian shores. *Cephaloscyllium isabella*, *. ventriosum*, and *C. fasciatum* all have smooth-surfaced egg capsules. I have not found a description of egg capsules of *. sufflans*.

Discussion. Egg capsules of *Cephaloscyllium* species are discussed in more detail under *C. ventriosum*. Several uthors have indicated that New Zealand *Cephaloscyllium* grow to a larger size than do Tasmanian *Cephaloscyllium*. I m not able to verify this and suspect that the larger size attributed to some New Zealand specimens is in error. Scott (1963) included a table of measurements of seven *Cephaloscyllium* 885 to 961 mm and a 116-mm foetus from asmania. His illustration of the young one before hatching shows the two rows of enlarged denticles on the back as in atchlings of other species of *Cephaloscyllium* except *C. fasciatum*.

Cephaloscyllium sufflans (Regan)

cyliorhinus sufflans Regan 1921:413 (coast of Natal in 219 to 238 m).
cylliorhinus sufflans: Barnard 1925:41.
ephaloscyllium sufflans: Smith 1949:52, fig. 34; Bass et al. 1975:9, fig. 6.

Material examined. USNM 201910, imm. ♂, 345 mm, off Tugels River, South Africa; USNM SS 610, imm. ♂, 200 m, off Kenya, east Africa, lat. 02°50'S, long. 40°31'E, in 290 m, 8 November 1964.

Diagnosis. The lack of dark markings may serve to separate *C. sufflans* from other species of *Cephaloscyllium* at sizes. The two small specimens of *C. sufflans* examined show no trace of markings and small specimens of other spec have prominent markings.

Regan's (1921) description of the 750-mm holotype of *C. sufflans* includes the statement, "pectoral . . . , extending quite half the distance from its origin to that of the pelvics." In the New Zealand *C. isabella*, 630 to 855 mm, at hand pectoral extends considerably more than half the distance.

Description. Regan's (1921:413) description of *C. sufflans*, based on his only specimen, the 750-mm holoty includes no information that I find useful to separate it from other species except that he stated the specimen w without distinct spots or markings. All other *Cephaloscyllium* species have markings or spots although they sometim may be diffuse.

Both *C. sufflans* specimens that I examined were immature without distinct markings. Both had slender and more less erect denticles that gave the specimens a somewhat shaggy appearance.

Vertebral numbers in the 345-mm male, USNM 201910, as shown by X-ray were: total number about 125; monospo dylous 49; precaudal 85; caudal about 40.

Bass et al. (1975:9, table 2) provided a thorough analysis of variation in proportional dimensions of *C. sufflans* bas on measurements of 41 males and 61 females following methods proposed by Bass (1973). Comparisons of these measur ments of *C. sufflans* with measurements, similarly treated, of large series of *C. isabella* subspecies and regional popul tions of *C. isabella* should reveal morphometric and growth characters to separate these forms if any such characters e ist.

Cephaloscyllium ventriosum (Garman)
Figures 23, 24, 25

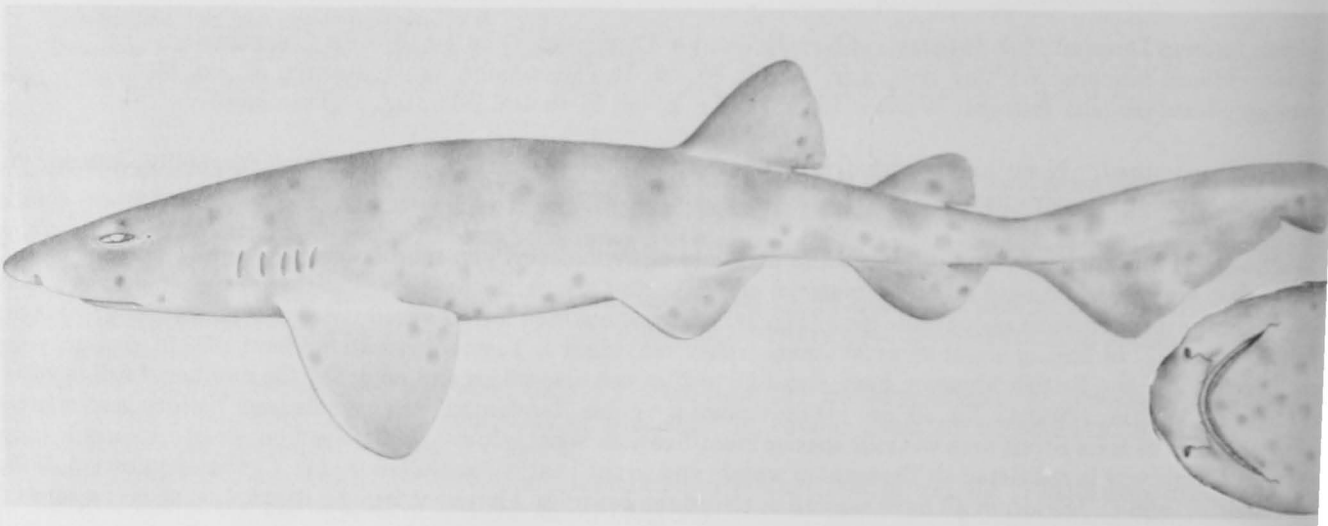


Figure 23.—*Cephaloscyllium ventriosum*, 400-mm male, California, SU 19090. Drawing by Mary Wagner.

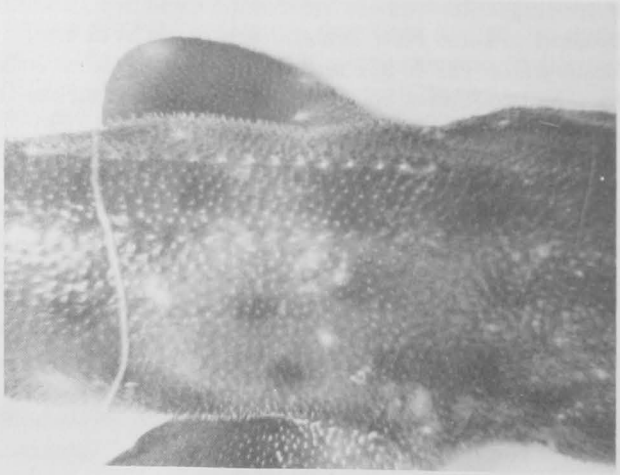


Figure 24.—*Cephaloscyllium ventriosum*, newly hatched male, mm, Monterey, Calif.

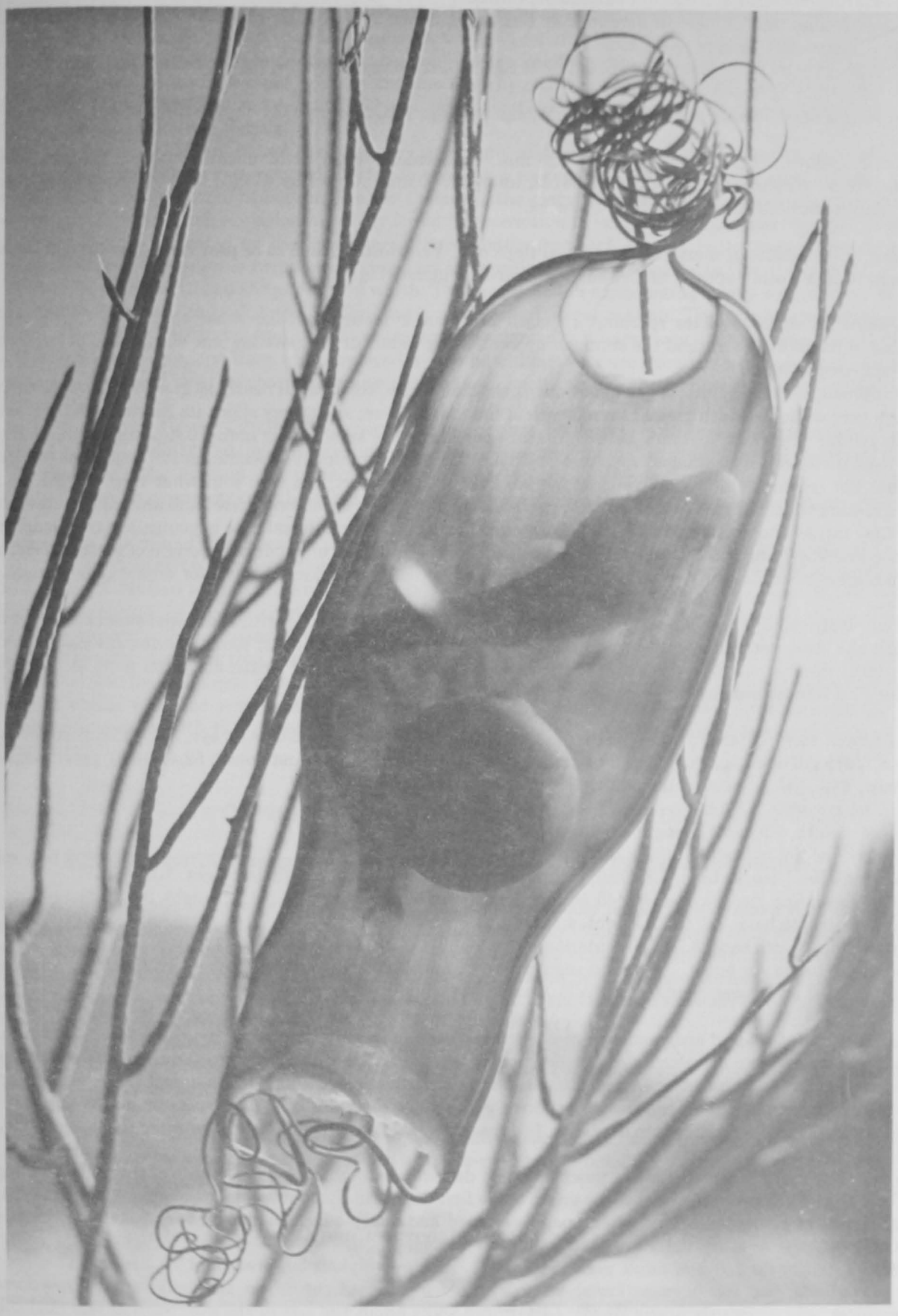


Figure 25.—Egg capsule of *Cephaloscyllium ventriosum*, with embryo. Photograph courtesy of Marineland of the Pacific, Palos Verdes, Calif.

Scyllium ventriosum Garman 1880:167 (Valparaiso, Chile).
Catulus uter Jordan and Gilbert in Jordan and Evermann 1896:25, pl. 3, fig. 12 (Santa Barbara Channel, Calif.
Scyliorhinus ventriosus. Regan 1908a:458.
Cephaloscyllium ventriosum: Garman 1913:80, pl. 9, figs. 6-9; Kato et al. 1967:24, fig. 36; Nelson and Johnson 1970:73
Grover 1972a:191; 1974:359, figs. 1-3.
Cephaloscyllium uter: Roedel and Ripley 1950:50, fig. 34; Cox 1963:283, fig. 11.

Material examined. USNM 52853, ad. ♂, 820 mm, California, 1895; USNM uncat., imm. ♂, 158 mm, Montere Bay, Calif., 46 m, 4 February 1964; USNM 196142, imm. ♂, 550 mm, Avila Bay, Calif.; USNM 25084, 26866, ad. ♂, c 850 mm, Santa Barbara, Calif. Holotype not seen.

Diagnosis. The posterior margins of the nasal flaps of *C. ventriosum* reach to or past the upper lip and the speci thus differs from all other species of *Cephaloscyllium* (see insert, Fig. 23).

Description. A robust species reaching a length of about a meter and like other species of *Cephaloscyllium* remarkable in its ability to distend the stomach by swallowing water (or air), swelling the elastic skin of the trunk int a nearly spherical shape.

Head flattened, very broad, its length about one-fifth total length, its breadth nearly as great as its length to first gi slit; mouth very wide, its width greater than length of first dorsal base; snout very short, its length from front of mout not much greater than least distance between nasal apertures; eyes small, their horizontal diameter in adults abou equal to least distance between nasal apertures, with a moderately prominent subocular gutter under the full length the eye but not reaching small spiracle close behind eye; gill slits short, the fifth somewhat shorter than the first.

Fins increasing relatively in size with growth; pectorals much larger than second dorsal and anal fins in area; distanc between first and second dorsal fin bases slightly greater than length of first dorsal base in young, less than length of fir dorsal base in adults; origin of first dorsal over or in advance of midpoint of pelvic base; origin of second dorsal over slightly posterior to anal origin; lower caudal fin moderately broad but lacking an anterior salient point; caudal notc prominent.

Teeth relatively small, numerous in about 55/55 to 60/60 rows, tricuspid, a few with additional small cusps, the midd cusp much the strongest, similar in upper and lower jaws, no great reduction in tooth size toward jaw angles.

Proportional dimensions of an 820-mm adult male in percentages of total length are given here, each followed i parentheses by similar dimensions for a newly hatched 158-mm male.

Tip of snout to: posterior margin nasal flap, 3.2, (3.2); front of mouth, 3.0 (3.2); eye, 5.0, (5.7); first gill openin 16.3, (15.8); fifth gill opening, 22.2, (20.3); origin pectoral, 21.0, (20.3); origin first dorsal, 52.4, (46.2); pelvic origin, 57. (41.5); anus, 61.6, (45.3); second dorsal origin upper caudal fin, 78.7, (72.2).

Eye: length orbit, 2.8, (4.1).

Mouth: width, 9.9, (10.1); length 4.9, (4.1).

Gill slits: height of first, 1.7, (2.2); height of fifth, 1.5, (1.9).

First dorsal fin: length base, 8.8, (7.0); length posterior inner margin, 3.8, (3.2); height, 7.1, (5.7).

Second dorsal fin: length base, 5.9, (5.7); length posterior inner margin, 2.8, (2.2); height, 3.4, (3.2).

Anal fin: length base, 7.8, (8.2); height, 4.5, (3.2).

Pectoral fin: width base, 8.7, (7.6); anterior margin, 17.1, (13.3); greatest width, 12.2, (9.8).

Distance between fin bases: first and second dorsal, 8.0, (7.6); pectoral and pelvic, 17.9, (15.5); pelvic and a 11.8, (9.5); anal and lower caudal, 5.1, (5.1); second dorsal and upper caudal, 5.4, (4.4).

Dermal denticles of sides of body and over most surfaces erect and needle-shaped with no lateral expansion of a bla in juveniles; denticles of adults with a stout blade, more or less triangular with a single posterior point; denticle blades adults nearly parallel to skin surface in ventral areas, more erect to angle of about 45° in dorsal areas; ventral denticl with smooth surfaces without ridges, dorsal denticles with one or several ridges; dark spots on adults apparently d chiefly to pigment incorporated within denticles. (Forms of dermal denticles of adults illustrated in Garman 1913, pl. fig. 9.)

Newly hatched young have two rows of much enlarged denticles extending along each side of the middorsal line fr the level of the first gill slit to the level of the origin of the first dorsal fin. Each row consists of about 28 uniformly spac denticles. These large denticles have stout, paddle-shaped and sharp-edged blades on very heavy and broad-bas pedicles. Apparently these denticles are shed soon after hatching.

Vertebral numbers for 820 mm adult male: total 111, monospondylous 39, precaudal 70, caudal 41.

Color in newly hatched specimen, yellowish-white with seven or eight light-brown, saddlelike areas across dorsal a lateral surfaces, and numerous nearly round, dark-brown spots about the size of the eye, more or less randomly d tributed over body surfaces and fins. Color in adults similar but saddles and spots less well defined, and all surfa darker.

Discussion. All of the specimens of *C. ventriosum* I have seen were from California where the species is regularly aken. The type-locality of *C. ventriosum* is Valparaiso, Chile, suggesting that the species has either an antitropical dis-ribution or that the absence of records from the tropical eastern Pacific is due to lack of collecting effort in that area. If *. ventriosum* usually spends daylight hours in crevices of rocky reefs as indicated by Grover (1972a) and moves about eding mostly at night (Nelson and Johnson 1970), it can easily have been missed in collections depending on daylight awling or daytime handline fishing.

Nelson and Johnson (1970) observed *C. ventriosum* commonly at depths from 9 to 30 m around Santa Catalina Island, alif., but noted that others had reported California specimens to depths of 300 m. In their observations, Nelson and ohnson found *C. ventriosum* to be bottom dwellers preferring the rocky, algae-covered slopes of kelp-bed communities, nd active only at night. Their experimental study found *C. ventriosum* to exhibit an endogenous rhythm compared with n exogenous rhythm indicated for the horn shark, *Heterodontus francisci*, studied in the same experimental series.

Cephaloscyllium ventriosum is oviparous laying eggs in capsules which, according to Cox (1963:283, fig. 11), range m 90 to 125 mm in length and 28 to 55 mm in width. The capsules have a moderately heavy wall (Fig. 26) with smooth faces but with some thickening for reinforcement along each lateral margin. The young are 140 to 150 mm at tching (Grover 1974:360) and at that time have two rows of enlarged denticles along the back. These denticles, accord-g to Grover's detailed observations, are employed by the hatchling to escape from the relatively stiff-walled egg cap-le using a ratchet and pawl mechanical arrangement to pull itself through the compressing walls of the egg capsule ee Grover 1974, fig. 3).

In an earlier paper, Grover (1972b:871) reported evidence that predators, both mollusks and teleosts, might cut rough egg capsule walls to destroy eggs or young of *C. ventriosum* and noted that this supported the view that egg cap-les in elasmobranchs evolved for protection rather than for more effective osmoregulation. My overview of *ephaloscyllium* species and other scyliorhinids seems to support the idea that protection is the primary function of egg apsules.

Grover (1972a:191) found differences in the egg capsule, tendril length, the size of egg capsules, and the relative fin zes between the *C. ventriosum* population surrounding Santa Catalina Island and the population inhabiting shores of earby California. He had sufficient material to show that these differences were significant. While my data are inade-uate to be conclusive, the separation of the largely Tasmanian form, *C. laticeps*, from the more extensively distributed *. isabella* is similar in being based on egg capsule differences.

The *Cephaloscyllium* species that are known to me to have egg capsules with thick walls, *C. isabella*, *C. laticeps*, and *. ventriosum*, also have enlarged dorsal denticles during the hatching stage, presumably in each instance to assist the atchling to escape from the somewhat inflexible walls of the egg capsule. *Cephaloscyllium fasciatum*, on the other and, has egg capsules with thin, weak walls and apparently does not develop enlarged dorsal denticles during the atching stage.

CEPHALURUS BIGELOW AND SCHROEDER

igelow and Schroeder 1941:73 (type-species, *Catulus cephalus* Gilbert 1892, by original designation).

Diagnosis. *Cephalurus* has a wide, flattened head with a short, broadly rounded snout and a very wide mouth. The nchial region is especially long and wide, with widely spaced gill slits. *Cephalurus* has a short abdominal trunk which ers to a slender and moderately long tail. As viewed from above, the shark has a tadpolelike outline that readily dis-guishes it from all other scyliorhinids. It is also the only genus of the Scyliorhinidae with the first dorsal fin origin in vance of the origin of the pelvic fins. The skin is loosely adherent to the body and the body is soft as in many sharks in-biting moderately deep continental slope waters.

Juvenile *Cephalurus* have denticles of the upper edge of the caudal fin near its origin arranged much as in juvenile *rmaturus xaniurus*, but development of a prominent caudal crest of somewhat enlarged and modified denticles does not occur in *Cephalurus* as it does in *Parmaturus*.

Discussion. The young of *Cephalurus* develop in very thin-walled egg capsules within the oviducts of the mother. robably the egg capsules are ruptured or absorbed and free-swimming young are born at a length somewhat less than 0 mm. Adults reach a length of about 300 mm.

Cephalurus cephalus (Gilbert)
Figure 26

atulus cephalus Gilbert 1892:541 (from vicinity of Clarion Island, Revillagigedo Islands); Jordan and Evermann 1896: 24; Garman 1913:78.

cyliorhinus cephalus: Regan 1908a:460.

ephalurus cephalus: Bigelow and Schroeder 1941:73; Kato et al. 1967:23; Mathews and Ruiz 1974:556.

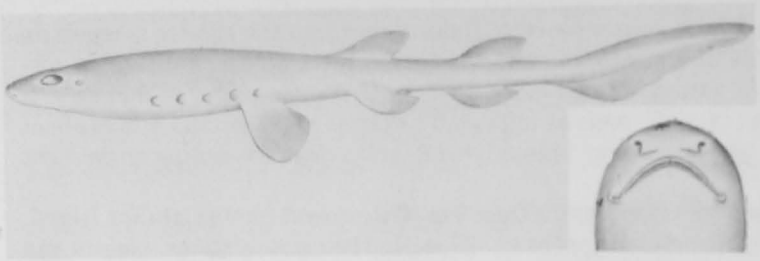


Figure 26.—*Cephalurus cephalus*, immature male, 195 mm, SU 293, Gulf of California. Drawing by Mary Wagner.

Material examined. USNM 125094, ad. ♂, 240 mm, holotype, *Albatross* stn. 2992, lat. 18°17′30″N, long. 114°43′15″W, 841 m, near Clarion I.; SU293, imm. ♂ 195 mm, *Albatross* stn. 3007, lat. 25°27′30″N, long. 110°50′30″W, 662 m, near Santa Catalina I., Gulf of California; USNM, 3 juv. ♂, 82-89 mm, *Albatross* stn. 3007; USNM 87557, marked *Albatross* but no other data, probably stn. 3007; UA 67-63-1, gravid ♀, 235 mm, 40 mm, embryos, *Te Vega* cruise 16, lat. 28°27′N, long. 112°34.5′W, 600-800 m, south of Tiburon I., Gulf of California, 9 October 1967; USNM, imm. ♂, 224 mm; imm. ♀, 200 mm; 11 ad. ♀, 260-320 mm, *Anton Bruun* cruise 18A, lat. 15°4.5′S, long. 75°45′W, 275 m, off Peru; USNM, 5 imm. ♀, 160-190 mm, lat. 11°24.5′S, long. 78°05′W, 380 m, off Peru; USNM 201525, ♀, 180 mm, lat. 07°48′S, long. 80°23′W, 365 m off Peru; USNM 3 juv. ♂, 92-96 mm; juv. ♀, 96 mm, lat. 23°41′S, long. 70°34′W, 250-400 m, off Chile.

Diagnosis. As only one species of *Cephalurus* has been described, the generic diagnosis adequately distinguishes *C. cephalus* from other species.

Description of adults. Head very wide and flattened with a very long branchial region; abdominal sector short, wider than high at pectoral, higher than wide at pelvic origin; tail sector moderately compressed, its length to caudal tip from midpoint of cloacal opening about one-half total length; caudal fin a little more than one-fifth total length; caudal axis not elevated; caudal peduncle higher than wide.

Snout short, its length from front of mouth less than one-half mouth width; snout tip broadly rounded; pores of midsection on upper and lower sides of snout usually not conspicuous, arranged in single file lines, those of lower side of snout forming goblet-shaped pattern.

Nasal apertures very large, oblique, nearer mouth than snout tip, not connected with mouth by a groove, least distance between nasal apertures much less than horizontal diameter of eye; posterior inner opening of each aperture partly or completely covered by a short, broad flap, the outer corner of flap projecting to partly separate anterior and posterior openings.

Mouth very wide and broadly arched, its width greater than the length of head in front of spiracles; short labial furrows present, continuous around mouth corners, lower furrow slightly longer, its length less than least distance between nasal apertures; inside of mouth with numerous short papillae on roof and tongue; gill rakers represented only by low mounds of tissue.

Eyes moderately large; openings elongate, notched at both ends; eyes not visible from below but their angle of view more lateral than dorsal; no distinct secondary lower eyelid or subocular gutter; spiracles moderately small, diameter less than one-fifth eye length, behind and slightly below eye, separated from eye by distance slightly more than spiracle diameter.

Gill slits large and very far apart, the fourth slightly in advance of the pectoral origin.

Teeth small, generally somewhat similar in upper and lower jaws, those of central part of jaws generally tricuspid with the middle cusp much the longest; away from symphyses teeth become progressively slightly smaller toward the jaw angles, have proportionally shorter central cusps, and a greater number of cusps per tooth to about seven; teeth of central part of upper jaw of adult male holotype about 1½ times as high as teeth of gravid female of same total length; three to five series of teeth functional, their arrangement alternate; 28+27/27+27 rows in adult male holotype, 33+33/34+34 in adult female from Gulf of California, 37+36/36+36 in one adult female from Peru; no symphyseal teeth, varying space separates right and left halves of each jaw, from no space to space enough for 5 rows of teeth suggesting considerable elasticity of symphyseal ligaments.

Dermal denticles over most of body surfaces widely spaced, somewhat needlelike, with only slight if any lateral expansion to form blades; most denticles nearly erect with moderate curve to direct points posteriorly, secondary points weak if developed at all on blades; denticles more closely spaced and broader near snout, around mouth, as a patch at the origin of the upper caudal fin, and, in some specimens along midline of back; denticles absent from roof of mouth, tongue, and gill bars.

Two dorsal fins about equal in area; the first dorsal origin slightly in advance of pelvic origin; anal fin slightly larger than either dorsal fin and approximately under the second dorsal; pectoral fin origins under fourth gill slit or very slightly posterior to it; fin positions and sizes unusually variable in the available material except origin of first dorsal slightly in advance of pelvic origins in all specimens.

Skeletal elements not greatly mineralized; vertebrae, except for a few terminal, caudal vertebrae of smaller specimens, ell defined on radiographs; radiographs made for vertebral counts show jaw cartilage outlines but do not show girdle nd fin elements or chondrocranium outline; total number of vertebrae about 100 (95 to 106 in 18 specimens, mean 00.2); number of monospondylous vertebrae about 30 (28 to 35 in 27 specimens, mean 30.1); supraorbital crest of chon-rocranium absent.

Color somewhat variable perhaps due to different preservation times and methods; generally dark gray, dark brown, r blackish above and somewhat lighter below, without prominent markings.

Proportional dimensions in percentages of total length for the 237-mm adult male holotype from near Clarion Island, or a 235-mm adult female from the Gulf of California, and for a 290-mm adult female from Peru are as follows.

Tip of snout to: front of mouth, 5.5, 5.1, 5.2; eye, 5.5, 5.5, 5.2; spiracle, 11.0, 9.9, 9.5; first gill opening, 21.9, 17.9, 0.4; fifth gill opening, 31.7, 30.6, 29.7; origin pectoral, 30.4, 27.2, 28.3; origin first dorsal, 44.7, 44.7, 45.5; origin pelvics, 3.0, 46.4, 46.6; origin second dorsal, 60.3, 62.6, 62.1; origin anal, 59.6, 61.7, 61.1; origin upper caudal lobe, 73.0, 76.6, 4.2; anterior end cloacal opening, 47.7, 47.2, 49.0.

Orbit: horizontal diameter, 5.1, 4.9, 3.3; vertical diameter, 1.9, 1.7, 1.0.

Spiracle: greatest diameter, 1.3, 0.9, 0.7; least distance from eye, 1.5, 0.9, 1.4.

Mouth: width, 13.1, 12.8, 11.0; length, 6.3, 6.0, 4.1; length upper labial furrow, 0.8, 1.1, 0.7; lower labial furrow, .7, 1.4, 1.4.

Nostrils: least distance between openings, 1.7, 2.9, 2.6.

Gill slits: height of first, 3.8, 3.8, 2.8; height of fifth, 3.4, 3.8, 3.3.

First dorsal fin: length base, 9.5, 9.2, 7.9; length posterior tip, 3.4, 1.9, 3.8; height, 3.4, 3.8, 3.8; length anterior argin, 10.1, 7.7, 7.9.

Second dorsal fin: length base, 8.4, 7.0, 8.3; length posterior tip, 3.0, 2.1, 4.0; height, 4.2, 3.8, 3.5; length anterior argin, 10.1, 6.8, 7.9.

Anal fin: length base, 9.3, 8.1, 10.2; length posterior tip, 3.0, 1.3, 3.6; height, 4.6, 4.0, 4.1; length anterior margin, .3, 8.1, 8.3.

Pectoral fin: width base, 5.5, 5.1, 6.6; length anterior margin, 10.6, 8.9, 10.4.

Caudal fin: upper margin, 27.0, 23.4, 25.9; anterior margin lower caudal lobe, 11.0, 10.2, 9.0; tip caudal to notch, .5, 6.4, 4.3.

Distance between fin bases: first and second dorsal, 6.8, 9.5, 7.2; pectoral to pelvic, 10.6, 12.3, 13.1; pelvic and nal, 8.0, 7.4, 5.2; anal and lower caudal lobe origin, 5.5, 4.7, 3.5; second dorsal and origin upper caudal, 5.1, 6.4, 3.8.

Claspers of male holotype project well beyond pelvic fin tip and are stiffened by clasper cartilage calcification; laspers have small fleshy projections at tip much as in some species of *Parmaturus* and *Galeus*; no clasper apron present ither by union of inner margins of pelvic fins or membranous connection between pelvic fins.

Three large females collected 25 August 1966 from lat. 15°04.5'S off Peru were partially dissected. All three specimens ad large livers with the posterior tips of both right and left lobes extending beyond the cloaca; valvular intestine with ve or six turns.

Discussion. Only one species of *Cephalurus* is recognized here but additional material and further study may show at specimens taken off Peru and Chile represent a species distinct from those of the Lower California area. The darker olor and the somewhat smaller eye notable in most of the specimens from Peru and Chile are regarded here as due either circumstances of preservation or to intraspecific variation. The inside of the mouth of the specimens from Peru and hile is dusky with numerous melanophores. The inside of the mouth in the Lower California specimens is white or ellowish.

Cephalurus has been taken from nearly lat. 29°N to nearly lat. 24°S by trawling in depths from 250 to 841 m. The bot-m temperature for *Albatross* station 2992 was 5.4°C and at station 3007, 7.0°C (Townsend 1901).

Cephalurus cephalus is ovoviviparous retaining egg capsules with developing embryos within the oviducts. The 235-m female from the Gulf of California contained embryos about 40 mm long. The three large females from Peru that ere dissected each had one egg capsule in each oviduct. The egg capsules were transparent, very thin-walled, and agile. Each capsule contained one large egg yolk about 15 by 30 mm, but embryos, if present, were not found. The egg apsules were shaped like egg capsules of oviparous scyliorhinids at the lower end but tendrils were represented only by ort hooks and the upper (inner) end of the capsule was formless.

Only the right ovaries were developed. The nidamental glands were small and each thin-walled oviduct was about 45 m long.

GALEUS RAFINESQUE

aleus Rafinesque 1810:13 (type-species, *Galeus melastomus* Rafinesque, designated by Fowler 1908:53).

Pristiurus Bonaparte 1834, fasc. VII (type-species, *Galeus melastomus* Rafinesque, by monotypy).
Figaro Whitley 1929:238 (type-species, *Pristiurus* (*Figaro*) *boardmani* Whitley, by monotypy).

Diagnosis. *Galeus* species lack supraorbital crests of the chondrocranium that extend as narrow shelves above t orbits; they lack depressions in the upper lip or channels connecting the nasal apertures with the mouth; and they la barbels. *Galeus* species have prominent labial furrows that are continuous around the mouth corners and extend f short distances along both upper and lower jaws; they have well-developed nasal flaps that cross or cover the posteri nasal openings; they have moderately long snouts broadly rounded at the tips and not greatly flattened; they ha shallow subocular gutters that extend under the eyes for nearly their full lengths.

Galeus differs from other scyliorhinid genera (except *Parmaturus*) in having a caudal crest of dermal denticles alo the upper edge of the proximal half (or more) of the caudal fin.

The caudal crest in *Galeus* consists of several rows of denticles, the central ones not much larger than denticles of bo surfaces, but the marginal row of denticles on each side are much larger than other denticles and are strong asymmetrical (Fig. 27). The top of the crest in *Galeus* is flattened and the marginal denticles project on the sides almo hiding a narrow band of naked skin that separates the caudal crest from denticles of the lateral surfaces. Furthermore, species of *Galeus* known from juveniles as well as adults, the crest is well differentiated from the time of birth hatching. In some species of *Parmaturus*, notably *P. xaniurus*, the crest is not fully differentiated in juveniles and later denticles of the crest are not asymmetrical as they are in adult *P. xaniurus*. *Parmaturus* species of all sizes have the to of the crest rounded, not flat as in *Galeus*, and in comparable sizes have more longitudinal rows of denticles in the cre than *Galeus* species.

Dermal denticles of dorsolateral surfaces of juvenile *Galeus* are sparsely distributed, nearly erect, and without later blade points. Replacement denticles are progressively wider and less erect. Dorsolateral surfaces of adults have in bricate denticles.

Galeus has large and broad pectoral fins, their greatest width usually greater than the width of the mouth (about equ in *G. piperatus*) whereas *Parmaturus* has narrower pectorals, their greatest width about equal to or less than the mout width (see discussion).

Species of *Galeus* are either oviparous (as in *G. melastomus*) or ovoviviparous (as in *G. polli*). Claspers of adult mal are moderately long and slender or very long and slender (in *G. nipponensis*) with remarkably complex terminal stru tures but no hooks. Aprons are partially developed in some species.

All species of *Galeus* are darker above than below and several species have elaborate patterns of markings on the do sal surfaces that diverge considerably from the pattern of saddle blotches present on many scyliorhinid species. *Pa maturus* species have few color markings and both the ventral and dorsal surfaces are uniformly dark.

Discussion. The livers of *Galeus* are small and short in the species that I have examined and have low oil conte with little or no squalene. The broad pectorals of *Galeus* may be an adaptation to assist in providing the lift needed offset a high sinking factor. The other genus with a caudal crest, *Parmaturus*, is presumably aided in moving more oft into midwater by greater liver oil buoyancy and does not require such a large pectoral fin as *Galeus*.

Species of *Galeus* occur in the eastern Atlantic from the coasts of Iceland and Norway nearly to Angola. They are pre ent in the Mediterranean. They are found in the tropical and subtropical western North Atlantic. They are present the Gulf of California and elsewhere in the Pacific in waters around Japan, Formosa, the Philippines, and Australi

Figure 27.—Enlarged denticles of the caudal crest of *Galeus arae arae*. Drawing by Mary Wagner.

Galeus has not been taken off the coasts of South Africa, an area having more species of scyliorhinids than any other, and is unknown from the Indian Ocean. In some regions where *Galeus* is unknown, the lack of records may merely reflect the lack of deepwater trawling. On the Atlantic and Caribbean coasts of the Americas, however, the known geographical range of *Galeus* ends abruptly at its southern end off the coast of Colombia and at its northern end off the coast of Georgia. *Galeus* is absent from the Gulf of Mexico west of the Mississippi River mouth and from the Gulf of Campeche.

Variation is great in color pattern and in morphometrics even among adults within a single species. In the following key, two species, *G. piperatus* and *G. schultzi*, key out in three places and *G. arae antillensis* keys out in two places. Vertebral numbers are given for most of the species (Table 2) and these may be of some assistance in identification.

Hatchlings and the smaller postjuvenile specimens of *Galeus* may not be identifiable to species and their identifications are unlikely to be helped by the following key. Known hatchlings or newborn *Galeus* have the seven or eight dorsal saddle blotches that occur among juveniles of several scyliorhinid genera.

Twelve forms of *Galeus* are recognized, two of them described as new. Three of the 12 are regarded as subspecies, a category that I consider useful in this genus. I have been unable to make an entirely satisfactory classification for some West Indian populations, here grouped as *Galeus arae antillensis* and the few available specimens suggest the possibility that slopes of each island may have populations distinct from others (see Fig. 31).

Juveniles are poorly known and are remarkably rare in collections. I am unable to suggest a reason other than probable loss through the large meshes of nets commonly used in deepwater trawling. Species of *Galeus* are oviparous and some are ovoviviparous. Substantial evidence shows that *G. melastomus melastomus* is oviparous and that *G. polli* is ovoviviparous. Observations indicate that *G. arae arae* is probably ovoviviparous and that *G. arae antillensis* and *G. piperatus* are probably oviparous. Gross anatomical differences between the oviparous species and the ovoviviparous species have not been observed.

I have placed *Figaro* Whitley (1929) in the synonymy of *Galeus*. Whitley's *Figaro boardmani* is one of the few catsharks that I have not seen. It is described (Whitley 1940) as differing from *Galeus* in having modified denticles similar to those of the caudal crest at the base of the lower caudal fin lobe. Other species of *Galeus* do not have modified denticles at the base and on the leading edge of the lower caudal lobe but such denticles are present on some large specimens of *Parmaturus pilosus*.

Table 2.—Numbers of monospondylous vertebrae in species of *Galeus*.

Species of *Galeus*	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
G. arae arae						12	43	23	8						
G. arae antillensis					1	8	21	7	3	5	5				
G. arae cadenati					6	8	2	1							
G. melastomus melastomus (Norway)												1	—	—	1
G. melastomus melastomus (Mediterranean)									1	5	17	5			
G. polli				2	16	33	18								
G. nipponensis[1]										3	7	2			
G. eastmani[1]					1	4	7	2							
G. sauteri[1]			2	7	6	3									
G. schultzi				1	3										
G. piperatus[2]		2	3	1	3										

[1]Data added from Nakaya (1975).
[2]Data added from Hubbs and Taylor (1969).

Key to Adult *Galeus*

a. Denticle arrangement similar to caudal crest present on lower side of caudal peduncle, continuing on to leading edge of lower caudal fin lobe . . . . . *G. boardmani*

b. Denticle arrangement similar to caudal crest not present on lower side of caudal peduncle and not on leading edge of lower caudal fin lobe 2

2a. Dorsolateral body surfaces brown or gray-black, either uniform in color or with weakly contrasting saddle blotches or spots darker than the ground color but with poorly defined margins; not variegated 3

2b. Dorsolateral body surfaces brown or gray-black variegated with saddle blotches, spots, or lines of darker or lighter color, the markings usually with sharply defined margins; variegated 10

3a. Dorsal and lateral body surfaces with poorly defined darker markings, their margins indefinite sometimes recognizable as saddle blotches 4

3b. Dorsal and lateral body surfaces uniformly colored, without markings 8

4a. Lining of mouth white 5

4b. Lining of mouth black 6

5a. Distance from tip of snout to nearest rim of nasal opening less than horizontal diameter of eye . . *G. eastmani*

5b. Distance from tip of snout to nearest rim of nasal opening greater than horizontal diameter of eye . . *G. nipponensis*

6a. Length of snout in front of mouth comparatively short, 5.4 to 5.9% TL . . . . . some *G. schultzi*

6b. Length of snout in front of mouth comparatively long, 5.8 to 6.6% TL 7

7a. Length of base of anal fin comparatively short, usually less than 11% TL . . . . . some *G. arae antillensis*

7b. Length of base of anal fin comparatively long, usually more than 11% TL . . . . . some *G. piperatus*

8a. Both dorsal fins and sometimes upper and lower caudal fin lobes with a dark spot or dark smudge near their upper terminal margins (or lower tip on lower lobe of caudal fin) and usually not narrowly edged with black . . . . . *G. sauteri*

8b. Both dorsal fins and caudal fins not spotted or smudged, fins either uniformly colored, or edged with black, or marked with a narrow terminal colorless band that contrast with the color of the rest of the fin 9

9a. Adults 500 mm or more TL . . . . . *G. melastomus murinus*

9b. Adults less than 400 mm TL . . . . . *G. piperatus*

10a. Highly variable color pattern on dorsolateral surfaces, usually made up of dark markings with white borders or white areas over or near the dorsal midline, markings often in longitudinal series or forming stripes . . . . . *G. arae antillensis*

10b. Color pattern or dorsolateral surfaces made up of series of dark spots or saddle blotches or both 11

11a. Distance between bases of dorsal fins greater than length of base of anal fin; Pacific species 12

11b. Distance between bases of dorsal fins less than length of base of anal fin; Atlantic species 13

12a. Mouth width comparatively small, 6.5 to 6.7% TL; mouth arch comparatively high . . . . . *G. schultz*

12b. Mouth width comparatively great, 8.3 to 13.2% TL; mouth arch comparatively low and broad . . . . . some *G. piperatu*

3a. Base of anal fin comparatively short, 10.3 to 13.6% TL; its length usually less than the distance between bases of the two dorsal fins . . . . . *G. arae arae*

3b. Base of anal fin comparatively long, 13.2 to 17.0% TL, its length greater than the distance between bases of the two dorsal fins 14

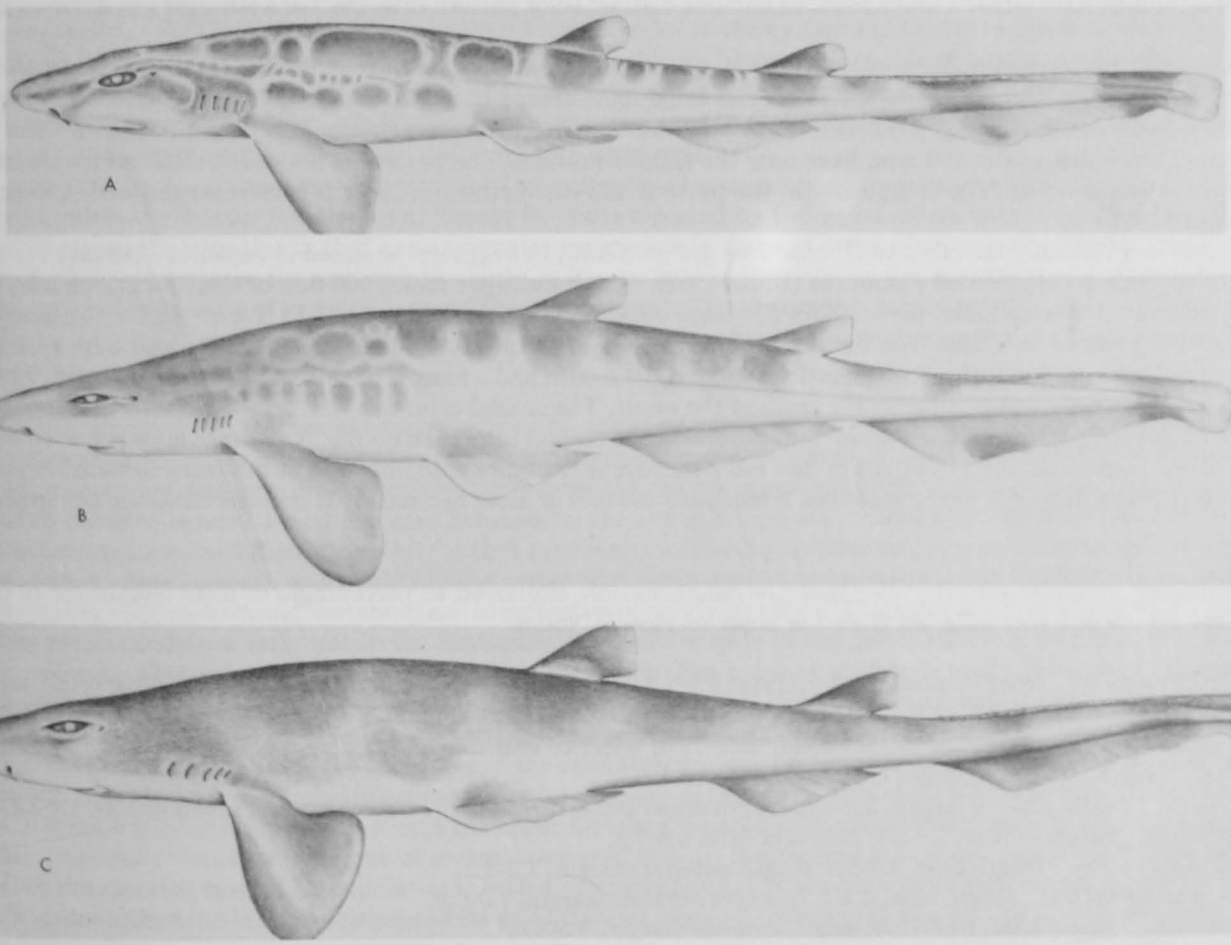
4a. Dorsal ground color and markings in shades of gray or gray-black (before storage in alcohol that may release brown-staining pigments from livers); length of snout in front of mouth comparatively great, 7.4 to 8.5% TL . . . . . *G. polli*

4b. Dorsal ground color and markings in shades of brown; length of snout in front of mouth 6.0 to 7.8% TL 15

5a. Tip of anal fin reaching a little past the origin of lower caudal fin lobe . . . . . *G. melastomus melastomus*

5b. Tip of anal fin not reaching origin of lower caudal fin lobe . . . . . *G. arae cadenati*

Galeus arae arae (Nichols)
Figures 27, 28A, 29, 30



ure 28.—A. *Galeus arae arae*, 290-mm female, coast of Florida. B. *Galeus arae cadenati*, 300-mm female, Caribbean coast of Panama. C. *Galeus arae antillensis*, 320-mm female, coast of Puerto Rico (see Fig. 32 for other color patterns of *G. a. antillensis*).

Pristiurus arae Nichols 1927:1 (off Miami Beach, Fla.).
Galeus arae: Bigelow and Schroeder 1948:216, figs. 36, 37; Springer 1966:608, figs. 20A, 21A, 27F; Bullis 1967:14 figs. 8-3 to 8-6.

Material examined. USNM, 3 ad. ♂, 272-290 mm, 1 imm. ♂, 190 mm, 1 imm. ♂, 125 mm, 1 juv. ♂, 90 mm, ad. ♀, 255-331 mm, 3 imm. ♀, 196-228 mm, all from the coast of Florida. Examined by X-ray: 48 males, 37 femal coast of Florida; 72 males, 38 females, Caribbean coasts of Nicaragua, Honduras, and Costa Rica; 86 other specime from Florida and Honduras coasts. A print-out from data cards on file at the National Marine Fisheries Service Lab ratory at Pascagoula, Miss., on 213 trawling stations where *G. arae arae* were taken in the Gulf of Mexico, the Caribbe Sea, and adjacent waters by exploratory fishing vessels.

Diagnosis. *Galeus arae arae* is the smallest *Galeus* of the Atlantic, females rarely reaching 360 mm and males 3 mm. *Galeus arae cadenati* may be only a little larger but is not well enough known for a reliable size estimate. *Gale arae antillensis* is larger, some specimens reaching more than 400 mm. The *Galeus* of the eastern Atlantic all may rea a length of more than 400 mm.

Galeus arae arae is readily separable by its complex color pattern (Fig. 28A) from the plain colored or weakly mark species of the western Pacific: *G. sauteri, G. eastmani,* and *G. nipponensis.* It has a shorter snout than *G. polli,* its leng in front of mouth 5.3 to 7.1% TL for *G. arae arae* and 7.4 to 8.5% TL for *G. polli.*

Galeus arae arae is similar to *G. schultzi* of Philippine seas in morphometrics, but has a more strongly marked col pattern with more spots on the top of the head and anterior trunk than *G. schultzi. Galeus arae arae* and *G. melastom melastomus* both have complex color patterns but *G. arae arae* is not only a smaller form but also has a shorter anal f base, 10.3 to 13.6% TL compared with about 15.0 to 16.0% TL for *G. melastomus melastomus.* Also in adult *G. arae ar* the posterior tip of the anal fin falls appreciably short of the origin of the lower lobe of the caudal fin, but reaches it both *G. melastomus melastomus* and *G. polli.* In *G. arae arae* the length of the snout in front of the mouth is 5.3 to 7.1 TL but in *G. piperatus* it is 6.3 to 7.8% TL; in *G. arae arae* the distance between bases of the two dorsal fins is 10.5 12.2% TL, but in *G. piperatus* it is 15.2 to 17.3% TL. *Galeus arae antillensis* may differ from *G. arae arae* in any of t following ways: it may reach a larger size at maturity; it may have a shorter anal fin; it may have more monospondylo vertebrae; it may have either a much reduced and less distinct color pattern (Fig. 28C) or a stronger but different patte (Fig. 31).

Throughout its range as defined below, *G. arae arae* of half-grown to adult size have a distinctive and complex col pattern with little variation (Fig. 28A). Small and large spots among the usual saddle blotches of brown or tan are in bilaterally symmetrical arrangement over dorsal and lateral surfaces. Ventral surfaces are light colored without spot Very small examples, under 150 mm, have only the saddle blotches. The pattern is not much different from that of *melastomus melastomus.* The complexity of the pattern and distinctness of spots is somewhat reduced in some oth species of *Galeus.*

Egg capsules certainly referable to *G. arae arae* are unknown, but eggs not enclosed in capsules were taken from ov ducts of specimens collected off Honduras (Bullis 1967). Very small specimens, 100 mm or less, are known from only few specimens. A 90-mm male, presumably newborn, collected 9 November 1960 off Ft. Lauderdale, Fla., from 376 had indistinct saddle blotches. The denticles were needlelike, as in many young scyliorhinids, and were arranged longitudinal rows on the flanks. Some denticles around the mouth had a narrow blade and were three-pointed. The tee were similar in shape and number to the teeth of the adult. The caudal crest was well organized with the lateral sca asymmetrical as in adults. The crest had fewer scales in the central rows than adults. A 125-mm male collected 30 Ap 1961, off St. Augustine, Fla., from 302 m had more numerous denticles with only a faint tendency to form longitudi rows. Most of the denticles were needlelike. Specimens 150 mm or more had mostly tridentate denticles not arranged rows.

Description (morphometrics). The range of measurements expressed as percentages of total lengths for 10 *Gal arae arae* 190 to 321 mm long, all from the coast of Florida, follow.

Tip of snout to: front of mouth, 5.3-7.1; eye, 5.9-7.8; first gill slit, 13.8-16.0; fifth gill slit, 16.3-19.8; origin pecto 15.3-19.3; origin first dorsal, 42.4-47.3; origin pelvics, 37.2-42.0; origin anal, 50.9-56.9; origin second dorsal, 59.0-67 upper caudal fin from origin of caudal crest, 65.5-72.0; anterior end cloacal opening, 39.8-46.3.

Eye: length, 3.4-3.9; distance eye to spiracle, 0.8-1.5.

Mouth: width, 6.2-7.5; length, 3.2-4.3; length upper labial furrow, 1.0-1.5; length lower labial furrow, 1.4-2.2.

Gill slits: height of first, 1.3-2.1; height of fifth, 0.6-1.3.

First dorsal fin: length base, 4.2-5.9; length anterior margin, 7.2-8.3.

Second dorsal fin: length base, 4.4-5.7; length anterior margin, 7.0-8.0.

Anal fin: length base, 10.3-13.6; length anterior margin, 5.5-8.0.

Distance between: first and second dorsal fin bases, 10.3-13.6; posterior inner ends of nostril, 2.5-3.3.

Pectoral fin: length anterior margin, 10.5-12.2.

Discussion (Geographical and Vertical Ranges). *Galeus arae arae* is found from the coast of Georgia southward on the continental slope around the Dry Tortugas and northward in the Gulf of Mexico as far as the Mississippi River delta. It is rare west of Pensacola and absent from the western Gulf of Mexico and Gulf of Campeche. It occurs off Honduras, Nicaragua, and Costa Rica on the continental slope and also off neighboring islands and oceanic banks including Pedro Bank south of Jamaica. It is replaced along the Caribbean coastal slope of Panama and Colombia by *G. arae cadenati*. The very sparse population of *Galeus* on the northeastern coast of Cuba, the Santaren Channel, and Mona Passage seems to be made up of intergrades of *G. arae arae* and *G. arae antillensis*.

The geographical range of *G. arae arae* is restricted to a narrow band along the slopes well below the edge of the continental shelf. The species was recorded from several hundred stations of research vessels of the National Marine Fisheries Service at depths from 292 to 732 m (160 to 400 fathoms). The water temperature taken at the bottom by reversing thermometer was recorded from 56 stations where *G. arae arae* was taken and ranged from 5.6° to 11.1°C. The mean temperature at 44 stations off the Florida coast was 9.2°C and at 12 stations off Central America it was 8.75°C. We have too few records of depth or temperature to make firm conclusions but it is interesting that the only temperature record at the point of capture of *G. arae cadenati* was 4.6°C and the shallowest record for a *Galeus* in the western Atlantic was for *G. arae antillensis* taken from 146 m.

Although *G. arae arae* must be common within most of its range, it seems to be irregularly distributed. The largest trawl haul contained 180 specimens and more than 10 were frequently taken in single hauls. Nevertheless, many hauls made in areas expected to have *G. arae arae* produced no specimens. The object of the trawling was chiefly to define areas of occurrence of red shrimp, *Hymenopeneus robustus* Smith, a commercially valuable species on which *Galeus* sometimes feeds. Stomach examinations showed that small *Hymenopeneus* and a smaller shrimp, *Penaeopsis megalops* (Smith) made up the greatest bulk of the food of the *G. arae arae* examined.

Bullis (1967) found adults but very few immature specimens in depths of more than 450 m. Although immature examples were most common in less than 450 m, adults of both sexes were also common there. In view of the large numbers of trawling stations providing records of the presence or absence of *G. arae arae*, the limits of the geographical and depth ranges would be well established except for the unexplained paucity of data on very small specimens (under 150 mm) and on gravid females.

Reproduction. Bullis (1967) found eggs without egg capsules in the oviducts posterior to the shell glands in *G. arae arae* taken off Honduras. This constitutes the only direct evidence about the site of embryonic development of *G. arae arae*. Springer (1966) had assumed the species to be ovoviviparous but only because of failure to find egg capsules. The smallest young example seen was the 90-mm specimen mentioned in the foregoing description and a few, probably not more than a dozen specimens, less than 150 mm long were seen.

If, as seems certain, *G. arae arae* gives birth to fully developed young, gravid females should have been found among the large number of mature females seen. Except for those reported by Bullis, no others have been observed. The only plausible explanation for this is that gravid females congregate in nursery areas of very rough bottom that precludes trawling. One nursery area for scyliorhinid sharks is known for *Scyliorhinus retifer*, an egg laying species.

The unsatisfactory state of knowledge about the development of *G. arae arae* is accentuated by the fact that in *G. arae antillensis*, for which relatively few specimens are available, one has been found with encapsulated eggs, one egg in each oviduct.

Vertebral numbers. The comprehensive survey of vertebral numbers in sharks by Springer and Garrick (1964) outlined some of the tendencies toward special family characteristics in vertebral number. They discussed differences between monospondylous and diplospondylous vertebrae but did not report numbers of each in their tabular summary. The Scyliorhinidae represent a special case because, on the average, they are smaller than sharks of other families and their vertebrae are more difficult to count for that reason alone. The Scyliorhinidae, also on the average, are species of deeper waters where strength and rigidity of the vertebral column are not so important as in shallow waters, hence it is not surprising that scyliorhinid vertebrae are comparatively poorly calcified. There are few exceptions to the rule that the long monospondylous vertebrae in the Scyliorhinidae end abruptly in the pelvic region to be replaced in the postpelvic region by obviously shorter diplospondylous vertebrae. The point of change is easily recognized. The point at which caudal vertebrae begin in the Scyliorhinidae is not easily established. The caudal axis is either little or not at all elevated and there is no visible difference in vertebrae in the part of the vertebral column near the base of the tail. In two genera, *Galeus* and *Parmaturus*, the beginning of the caudal sector may be determined as opposite the point of origin of the caudal crest. In other scyliorhinid genera the point of origin of the upper caudal fin lobe may be used as a reference point. It is not a good one, however, because the upper fin lobe rises gradually and its exact point of origin is subjective.

From some early counts of vertebrae of several species of *Galeus*, it appeared that males might have more vertebrae than females and that species (or populations) with a northerly habitat might have more vertebrae compared with those from a more southerly habitat. A test procedure was arranged using all *Galeus arae arae* and all *G. polli* available at that time. The specimens were all radiographed and vertebrae were counted by a student technician, John Asarian, following a uniform procedure. The *G. arae arae* were divided into two groups: one group of 85 from the coast of Florida north of lat. 23°30'N, and the other group of 110 from the Caribbean coasts of Honduras-Nicaragua-Costa Rica south of lat.

17°40′N. The sharks of the two groups could not be distinguished from each other by color pattern or extern morphological features that separate the species and subspecies now described in the genus *Galeus*. The test series w further subdivided by sex and also by size into three length categories: small specimens 150-227 mm, mediu specimens 228-253 mm, and large specimens over 253 mm. The *G. polli* were grouped only by sex and area of origi northern specimens from lat. 5° to 8°N off Sierra Leone and Liberia, and southern specimens from lat. 3° to 4°S Gabon.

The results of examinations are summarized here in two Hubbs-Perlmutter graphs as modified by Hubbs and Hub (1953) and show our data for monospondylous vertebrae (Fig. 29) and for total vertebral numbers (Fig. 30). The grap permit a rough estimate of significance in that the lack of overlap between any two dark bars indicates a significa difference. The length of the line underneath the dark and light bars shows the range of variation in the sample. Thus f *G. arae arae* it can be seen at a glance that differences in total length within sex and area groupings are not significan that differences between northern females and southern males are not significant, and that differences betwe monospondylous vertebral numbers between northern and southern females are not significant.

It is evident that the great range of variation in total numbers of vertebrae, 130 to 142 in the sample of *G. arae arae* ar 126 to 137 in the *G. polli* sample, makes the use of these counts of little use in identification. The variation is less monospondylous vertebrae, in the samples used here, 34 to 38 for *G. arae arae* and 32 to 35 for *G. polli*. The analys shows only that, in *Galeus arae arae*, a small but significant difference in numbers of vertebrae exists between males ar females and that both males and females may have a significantly greater number of vertebrae in one geographical are than in another.

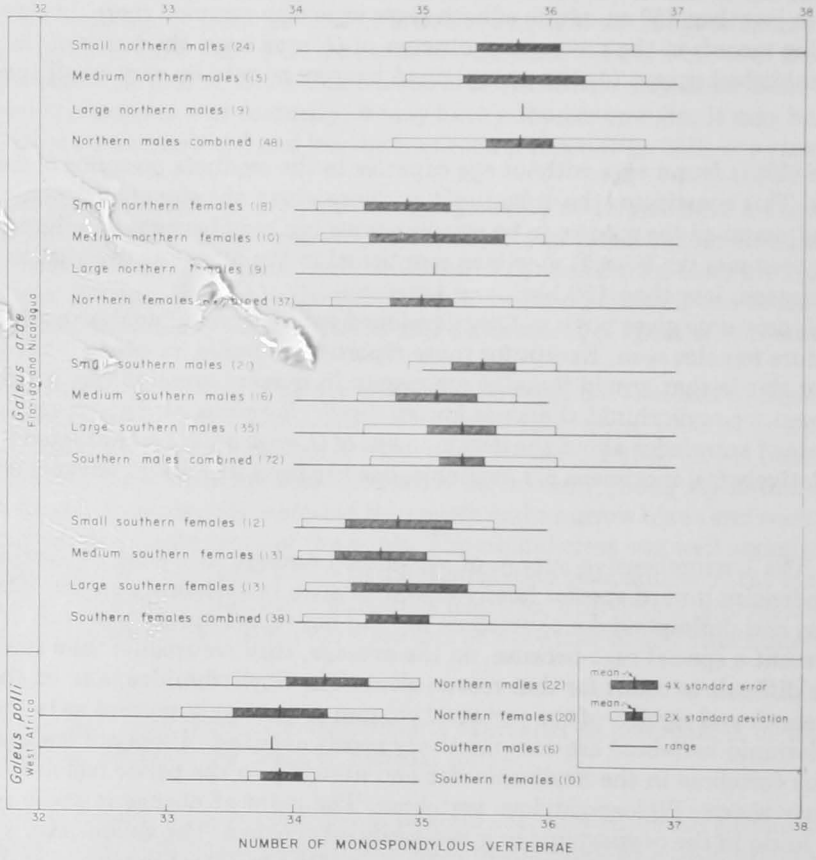


Figure 29.—Number of monospondylous vertebrae in samples of *Galeus arae arae* and *G. polli* shown in a Hubbs-Perlmutter graph. The samples of the northern population of *G. a. arae* were taken between lat. 23° and 29°N and the samples of the southern population between lat. 9° and 18°N. The northern samples of *G. polli* were taken between lat. 3° and 8°N and the southern samples between lat. 3° and 4°S. From the same data, *t* values were calculated for *G. a. arae* as follows: between northern males and northern females $t = 3.6205$ (difference significant at 99.9% level); between southern males and southern females $t = 4.4010$ (significant at 99.9%); between northern males and southern males $t = 2.9149$ (significant at 99.5%); between northern females and southern females $t = 1.0822$ (not significant at 80% level).

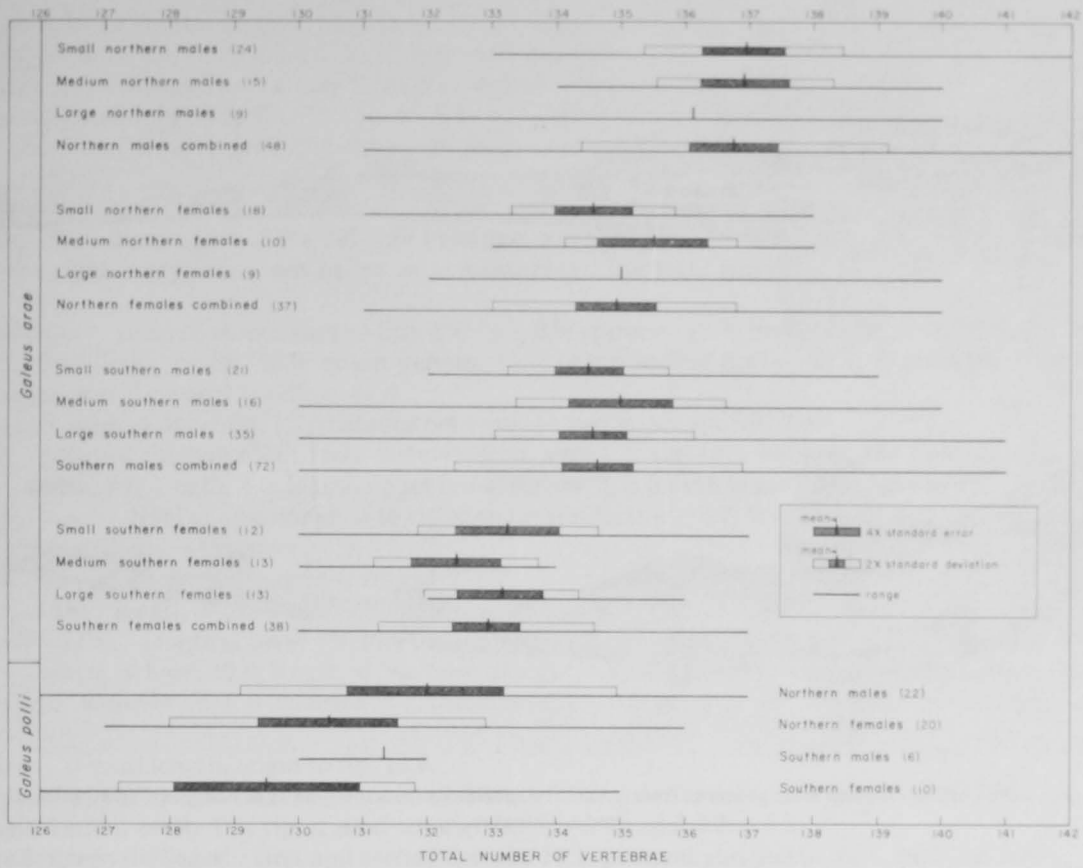


Figure 30.—Total number of vertebrae in same samples (as in Fig. 29) of *Galeus arae arae* and *G. polli*. The *t* values calculated for *G. a. arae* are as follows: between northern males and northern females $t = 3.1687$ (difference significant at the 99.5% level); between southern males and southern females $t = 4.0844$ (significant at 99.9%); between northern and southern males $t = 4.8680$ (significant at 99.9%); between northern and southern females $t = 4.7338$ (significant at 99.9%).

Galeus arae antillensis New Subspecies
Figures 28C, 31, 32

Holotype: USNM 214178, a 347-mm ♀, near St. Kitts, Leeward Islands, W.I., from 550 to 585 m, 18 May 1967, RV *Pregon* stn. 6695, water temperature at point of capture 8.9°C.

Other material examined. USNM-ORE 5417, 2 imm. ♂, 270, 255 mm, near La Tortue Island, Windward Passage, W.I., 658 m; USNM-ORE 6701, 3 ♀, 325, 328, 345 mm, Leeward Islands, W.I., 640-676 m; USNM-ORE 6722, 2 imm. ♀, Leeward Islands, 612-698 m; USNM-ORE 2646, imm. ♂, 160 mm, Leeward Islands, 384 m; USNM-ORE 10862, 2 ♀, 430 mm, Cal Sal Bank, Santaren Channel, 457 m; USNM-SB5181, imm. ♂, 270 mm, ♀, 240 mm, Mona Passage, W.I., 548 m; USNM-ORE 10840, 2 ♀, 237, 410 mm, Leeward Islands, 642 m; USNM-ORE 10841, ♀, 200 mm, Leeward Islands, 643 m; USNM-ORE 10842, imm. ♂, 260 mm, 4 ♀, 130, 235, 350, 370 mm, Leeward Islands, 579 m; USNM-ORE 9343, imm. ♂, 320 mm, 3 ♀, 290, 320, 435 mm, Leeward Islands, 589 m; USNM-ORE 10207, imm. ♂, 200 mm, 2 ♀, 190-200 mm, Leeward Islands, 658 m; USNM-ORE 5427, ad. ♂, 310 mm, off Hispaniola, 512-576 m; USNM-ORE 7221, ♀, 340 mm, Leeward Islands, 622-695 m; USNM-ORE 6695, ad. ♂, 335 mm, 3 ♀, 345, 355, 425 mm, all nongravid adults, Leeward Islands, 550-585 m.

Diagnosis. *Galeus arae antillensis* can usually be recognized by the characters used in the foregoing key to species but it is remarkably variable. It reaches a length of 435 mm or more, but some specimens, the holotype, for example, are mature at less than 350 mm. It is a larger form, however, than the other western Atlantic *Galeus*.

The color pattern diverges only slightly from *G. arae arae* on the eastern and southern sides of the Straits of Florida, but specimens taken off Hispaniola and Puerto Rico have obscure (Fig. 28C) and dull markings. In the vicinity of the Leeward Islands, patterns appear to vary greatly from obscure markings to vivid patterns of brown, black, and white (Fig. 31). The color patterns differ from the pattern of the continental form in being either stronger, weaker, or only slightly different in general arrangement.

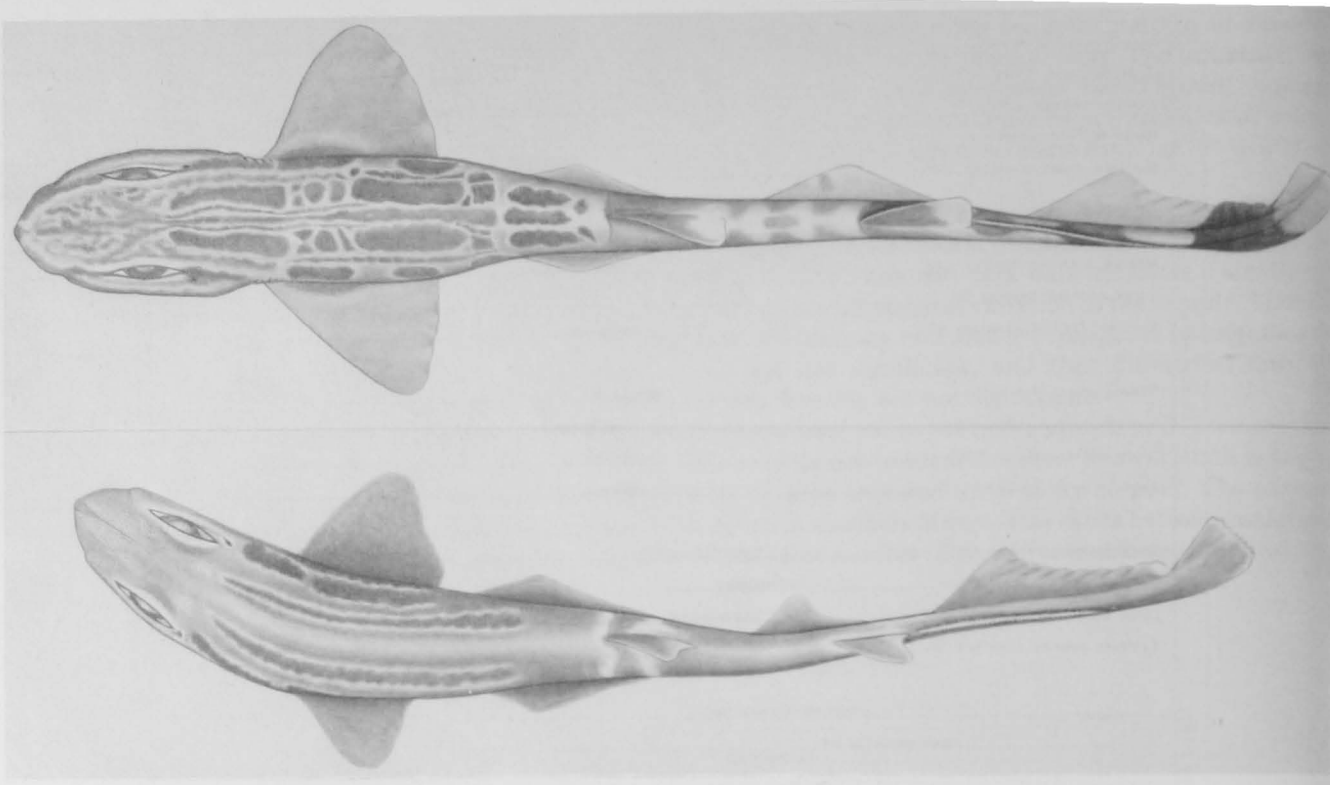


Figure 31.—*Galeus arae antillensis.* Two color patterns from immature specimens from the vicinity of Antigua, West Indies. Drawings by M
dred Carrington.

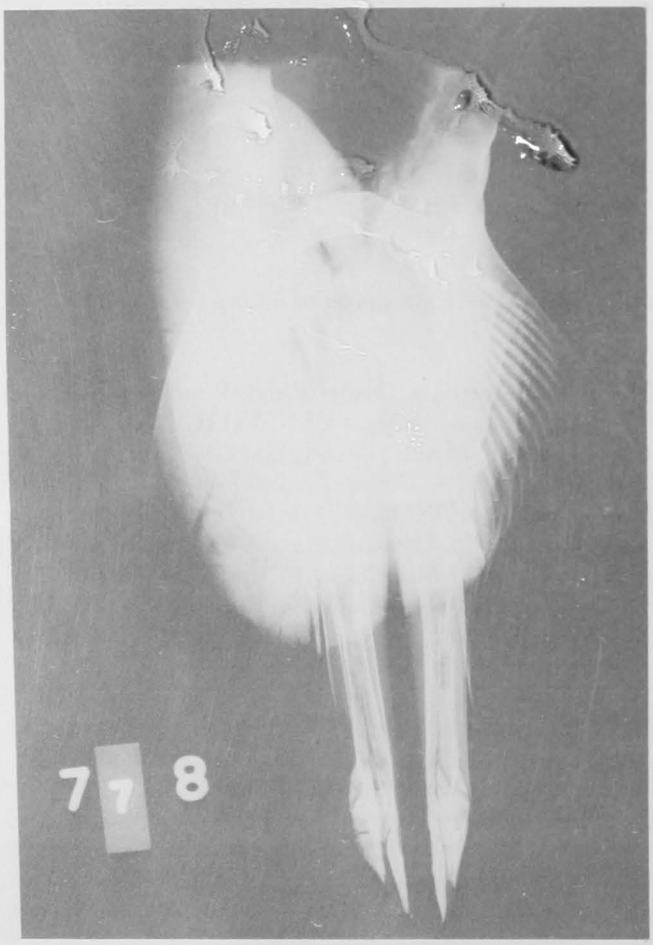


Figure 32.—X-ray of pelvic area and claspers of adult male *Ga*
arae antillensis, slope off northwestern Peninsula of Haiti. T
shows a thin layer of mineral that is deposited at the surface of
principal clasper cartilage (stem) immediately following matura
of the testes. Appreciable growth in length of all male sharks s
abruptly or becomes negligible at the time of clasper calcifica
(stiffening). The heavily calcified terminal cartilages are more c
plex in *Galeus* than in most other scyliorhinids.

The subspecies has a shorter anal fin base and a longer distance between the two dorsal fin bases than other Atlantic pecies except possibly the little known *G. melastomus murinus*.

Too few specimens scattered over a very large geographical area were available to use for a statistical study. The mean umber of monospondylous vertebrae in *Galeus arae antillensis* was not much different than the mean number for a uch larger sample of *G. arae arae* but the range in *G. arae antillensis* was twice as great.

Description. The dimensions of the 347-mm holotype, a sexually mature female with ovarian eggs about 10 mm in iameter in the right ovary, are given below as percentages of the total length.

Tip of snout to: front of mouth (upper lip), 6.6; eye, 6.9; spiracle, 12.7; first gill slit, 17.0; fifth gill slit, 20.7; origin ctoral, 20.1; first dorsal origin, 46.9; origin pelvics, 41.7; origin second dorsal, 64.4; origin anal, 57.5; origin caudal est, 73.9; anterior end cloacal opening, 44.0.

Eye: length orbit, 4.3; height, 1.7; distance between the two upper eyelids, 7.8.

Spiracle: greatest diameter 0.6; least distance from eye, 1.2; distance between the two spiracles, 8.3.

Mouth: width, 7.5; length, 4.0; length upper labial furrow, 1.7; length lower labial furrow, 2.0.

Nasal apertures: level of anterior ends to tip of snout (projection), 3.7; level of posterior ends to level of middle of pper lip, 0.8; least distance between, 2.9.

Gill slits: height of first, 2.0; height of fifth, 1.2.

First dorsal fin: length of base, 5.2; length of free inner margin, 2.6; height, 4.0; length of anterior margin, 6.9.

Second dorsal fin: length of base, 4.9; length of free inner margin, 2.9; height, 2.9; length of anterior margin, 6.6.

Anal fin: length of base, 10.9; length of free inner margin, 1.4; height, 2.2; length of anterior margin, 6.3.

Pectoral fin: width of base, 6.3; length of anterior margin, 10.9; greatest width of fin, 8.3; distance between the two ectoral axils, 6.3.

Pelvic fins: overall length, origin to tip, 13.5.

Caudal fin: upper margin from origin of caudal crest, 28.2; anterior margin of lower caudal lobe, 7.8; tip of second orsal to origin caudal crest, 1.7; tip of anal to origin of lower caudal lobe, 5.2.

Distance between fin bases: first and second dorsals, 14.1; pectoral and pelvic, 15.5; pelvic and anal, 7.5; anal and ower caudal origin, 6.0; second dorsal and origin of crest, 5.2.

Body dimensions: greatest width head, 11.2; trunk width at pectoral origin, 10.1; trunk width at pelvic origin, 6.3; idth at origin caudal crest, 2.0; trunk height at pectoral origins, 7.5; trunk height at pelvic origin, 9.5; caudal peduncle eight at origin caudal crest, 3.5.

Teeth small and crowded, estimated number of vertical tooth rows 28+28/26+26; the largest about 0.7 mm high above he enamel line; about 3 or 4 rows nearest symphysis with three cusps, the central cusp much the longest, most of the eeth with four, five, or six cusps, number of cusps increasing laterally but irregularly. Lateral 8 to 10 rows of teeth in ower jaw with 5 to 7 low subequal-length cusps forming a comblike structure, otherwise teeth of upper and lower jaws imilar.

Dermal denticles of dorsolateral surfaces small, imbricate, with three lateral points, the middle one much the longest, he larger flank denticles about 0.2 to 0.3 mm long, transparent. Caudal crest of holotype about 64 mm long, the longest symmetrical marginal denticles about 1.2 mm long, number of longitudinal rows of small, median, symmetrical den- icles increasing from zero at origin to about four near posterior terminus.

Inside of mouth with moderate numbers of denticles on anterior mouth roof, estimated about 0.05 mm long, denticles ot detectable elsewhere in mouth or on gill bars. Gill bars with one to three low and broad tubercles but no gill rakers.

Color of inside of mouth dusky, probably black in life, ground color after about 8 yr in preservative light yellowish hite, dorsolateral surfaces with tan markings; top of head and dorsal trunk with somewhat irregular large tan saddle otches, one at first dorsal, one at second dorsal, and two across tail.

Liver short, its lobes reaching less than halfway toward posterior end of body cavity, no oil detected by touch after long reservation. Peritoneum black. Right ovary with 3+ yolks about 10 mm in diameter.

Discussion. *Galeus arae antillensis*, as defined here, represents the island form of *Galeus arae*. The geographical ange of *G. arae antillensis* extends from the eastern and southern slopes of the Straits of Florida east-southeastward long the slopes off the northern coasts of Cuba, Hispaniola, and Puerto Rico through slopes off many of the Leeward lands. Specimens have not been seen from slopes off the southern coasts of Cuba, Hispaniola, or Puerto Rico, or off amaica or southward from Martinique but the absences could be due to lack of fishing effort there. With respect to color attern, *G. arae antillensis* is nearest to *G. arae arae* in the adjacent parts of the ranges of the two, but diverges greatly in he Leeward Islands area.

The average number of monospondylous vertebrae in 50 *G. arae antillensis* was about the same (35.76) as from a com- osite sample of 86 continental slope *G. arae arae* (35.31), but the range of variation was greater (33 to 39) in *G. arae an- illensis* as compared with that (34 to 37) in *G. arae arae*.

One 345-mm female from the Leeward Islands near Antigua had one egg capsule in each oviduct. The capsule measured approximately 38 by 16.5 by 10 mm. The evidence for oviparity in *G. arae antillensis* is scant as is the evidence for ovoviviparity in *G. arae arae*. It is not apparent why as much material as is available does not give much more information about prenatal development.

The holotype was trawled where the water temperature within a meter of the bottom was 8.9°C and within the temperature range at which *G. arae arae* has been taken. As with *G. arae arae*, the specimens of *antillensis* were taken mostly from 300 to 700 m, but a few *antillensis* were recorded in RV *Oregon* notes as being collected at lesser depths near Puerto Rico.

Galeus arae cadenati Springer
Figure 28B

Galeus cadenati Springer 1966:609, fig 20 (Caribbean coast of Panama).

Material examined. USNM 260468-Fl, ♀, 303 mm, holotype, Caribbean coast of Panama, 439 m, 30 May 1962; USNM-ORE 3600, ♀, 314 mm, Caribbean coast of Panama, 548 m; USNM-ORE 5722, imm. ♂, 290 mm, 2 ♀, 270, 300 mm, Caribbean coast of Panama, 512 m.

Diagnosis. *Galeus arae cadenati* has a longer anal fin base than the other western Atlantic subspecies of *Galeus arae*; the anal fin base length in *G. arae cadenati* being about as long or longer than the distance between dorsal fin bases. The few specimens of *G. arae cadenati* seen indicate a somewhat greater size than *G. arae arae*.

Discussion. *Galeus cadenati* was described (Springer 1966) from a small series of female specimens from the Caribbean coast of Panama. Only a few additional specimens were collected and these included some from the coast of Colombia (Harvey R. Bullis, Jr., pers. commun.). The separation of the large population of typical *Galeus arae arae* of the Caribbean coast northward from Panama from *cadenati* is not clear and abrupt. Provisionally all the specimens seen from the coasts of Panama and Colombia are regarded here as *Galeus arae cadenati*.

Galeus boardmani (Whitley)

Pristiurus (*Figaro*) *boardmani* Whitley 1928, pl. 18, fig. 3 (Montague Island, New South Wales, 128-146 m).
Figaro boardmani socius Whitley 1939:230 (Great Australian Bight off western South Australia, and eastern Western Australia).
Figaro boardmani: Whitley 1940:90, fig. 83.
Galeus boardmani: Fowler 1941:28.

Material examined. None

Diagnosis. *Galeus boardmani* differs from other species of the genus as here defined in having a caudal crest structure on the lower side of the caudal peduncle and extending for some distance on the leading edge of the lower caudal fin lobe. *Galeus boardmani* shares this character with some individuals of *Parmaturus pilosus* and juveniles of *P. melanobranchus* and *P. campechiensis*. It may be distinguished, however, from species of *Parmaturus* by its wider and larger pectoral fins; the maximum width of the pectoral is greater than the mouth width in *Galeus* but less than mouth width in *Parmaturus*. Whitley's (1940, fig. 83) illustration of *G. boardmani* shows a shark with the typical *Galeus*-like seven or eight saddle blotches with an additional eight or more slightly smaller blotches interspersed.

Discussion. The holotype of *Galeus* (*Figaro*) *boardmani* is a 540-mm male, AMS IA 2483, trawled from the vicinity of Montague Island, southern New South Wales in July 1925 from 70-80 fathoms (128-146 m). Whitley's (1928) description mentioned paratypes trawled from slightly deeper water nearby in September. Whitley (1928) placed his new species *boardmani* in a new subgenus, *Figaro*, on the basis of the presence of modified scales on the ventral edge of the caudal peduncle and later (1939, 1941) treated *Figaro* as a genus. According to Whitley's accounts (1928:238; 1939:230) many specimens were in the *Endeavor* collections trawled from the eastern edge of Bass Strait in 100-200 fathoms. He also reported the collection of specimens from the Great Australian Bight (off South Australia and Western Australia) in depths of 70 to 450 fathoms (128-823 m). He noted that all were males less than 16 in (about 400 mm) long. Specimens from the Bight were described as having fainter color bands (dorsal saddles) by Whitley and given subspecific rank as *Figaro boardmani socius*.

Although I have not recognized *Figaro* here, I should point out that Whitley's (1940, fig. 83) figure of the holotype shows a shark with a larger spiracle than I would expect in *Galeus* and a pointed clasper. If the holotype is a mature male, the figure suggests that *Figaro* might be separated from *Galeus* by clasper characters.

I suspect that the hump in the back mentioned by Whitley as a *G. boardmani* character is the result of fixation with trong preservative which, for deepwater scyliorhinids with weak vertebrae, tends to distort the trunk and often produces hump.

Galeus eastmani (Jordan and Snyder)

ristiurus eastmani Jordan and Snyder 1904:230, pl. 60 (off Izu, Japan); Garman 1913:93.
aleus eastmani: Fowler 1941:26; Besednov 1969:28, fig. 11; Nakaya 1975:23-25, 46.

Material examined. SU 7740, ♀, 337 mm, holotype (originally measured 345 mm), off Izu, Japan; FMNH, Owston 78, ad. ♂, 347 mm, Japan (Misaki); FMNH, Owston 705, subad. ♂, 315 mm, Sagami Sea, Japan.

Diagnosis. In the original description (Jordan and Snyder 1904:230) it was stated, "Teeth each with seven acutely inted cusps . . ." and was repeated by Garman (1913) and Fowler (1941). My examination of the holotype revealed at only the extreme lateral teeth have seven cusps. The majority of the teeth have four or five cusps as shown in akaya's illustration (1975, fig. 24) and are very small, those in the holotype reach at most about 1 mm high from the amel line. The teeth of *G. eastmani* are smaller than the teeth of *G. sauteri*. They are crowded with more than one ries in function. The dermal denticles are small; typical three-pointed flank denticles of the 347-mm male are 0.3 to 0.4 m long compared with 0.7 for flank denticles of a male *G. sauteri* of similar size. *Galeus eastmani* is a slender species of edium length, smaller than *G. nipponensis* but larger than *G. schultzi*. One *G. eastmani* that I examined had been in reservative for more than 50 yr and its color was uniform brownish without markings. Nakaya (1975) found fresh pecimens gray or brownish-gray on dorsolateral surfaces and gray on the upper surfaces of the pectoral fins and vertical ins with saddles and blotches of darker color without definite edging.

In the three *G. eastmani* examined, the distance between bases of the dorsal fins was 15.3 to 16.2% TL compared with 3.2 to 14.5% TL for two specimens of *G. nipponensis*, 12.7 to 13.7% TL for six *G. sauteri*, and 11.0 to 14.2% TL for four pecimens of *G. schultzi*. For larger series of fresher specimens, Nakaya (1975) found (for the distance between dorsal fin ases) in *G. eastmani* 14.2 to 15.9% TL, for *G. nipponensis* 13.5 to 15.6% TL, and for *G. sauteri* 11.7 to 13.8% TL.

Description. The following description is of the 347-mm adult male, FMNH-Owston 678. Body slender; fins latively small; pectorals broad but short, distal margins nearly straight, greatest width (along distal margin) much reater than mouth width, tips of appressed pectorals not reaching more than halfway to the origin of the pelvics; origin f first dorsal fin over posterior part of pelvic base; distance between first and second dorsal fin bases somewhat greater han length of head to first gill slit; first and second dorsals about equal in area but the length of base of first dorsal omewhat longer; anal fin long and moderately low, its base somewhat longer than lengths of first and second dorsals ombined; basal half of pelvics united to form an apron beneath the fully calcified claspers.

Head narrow with moderately pointed tapering snout; mouth moderately large and regularly arched, its width about qual to the length of the snout in front of mouth; distance between inner posterior ends of nostrils about half the ngitudinal diameter of the eye opening; nasal flap triangular without an extended point.

Teeth very small, the largest about 1 mm high; teeth of upper and lower jaws similar in shape, the upper jaw teeth ghtly larger; teeth near symphysis tricuspid, but laterally the teeth have more cusps, to five or seven cusps in extreme teral teeth; teeth crowded and difficult to count, 20-25 rows in each half of upper jaw, 20-22 rows in each half of lower w.

Dermal denticles small, the largest flank denticles about 0.3 to 0.4 mm long, imbricate, with three posterior points, the ntral one much the longest. Caudal crest denticles extending along upper edge of tail for about 65% of its length. udal crest near its origin consists of three central rows of symmetrical denticles between the two marginal rows of ger asymmetrical denticles.

Except for a trace of lighter color near the tips of the two dorsal fins the specimen has no markings.

Measurements of series. The following measurements are expressed as percentages of the total length. The first easurement in each set of three refers to the 337-mm holotype, the second to the 347-mm adult male, and the third to a 5-mm immature male.

Tip of snout to: front of mouth, 6.2, 5.5, 5.4; eye, 5.6, 5.8, 5.7; spiracle, 11.6, 11.2, 10.2; first gill slit, 14.8, 13.8, 14.0; th gill slit, 18.4, 17.9, 18.1; origin pectoral, 17.5, 17.3, 17.1; first dorsal fin, 42.1, 43.2, 43.2; origin pelvics, 35.6, 37.2, 3; origin second dorsal fin, 62.3, 61.9, 63.2; anal fin, 50.7, 53.9, 52.4; origin caudal crest, 71.2, 70.6, 71.4; anterior end bacal opening, 38.0, 38.9, 38.1.

Greatest width of: trunk at pectorals, 7.4, 7.8, 7.6; trunk at pelvics, 4.5, 4.0, 4.4; caudal base, 1.8, 2.2, 2.3.

Greatest height of: trunk at pectorals, 8.6, 7.5, 7.0; trunk at pelvics, 7.4, 7.5, 6.6; caudal base, 3.6, 3.2, 3.5.

Eyes: horizontal diameter of opening, 4.2, 3.7, 4.4; vertical diameter, 1.2, 1.2, 1.0.

Spiracles: greatest diameter, 0.6, 0.4, 0.5; least distance from eye, 0.6, 0.9, 0.7.

Mouth: width, 6.2, 5.8, 6.4; length mouth, 3.7, 4.0, 3.2; length upper labial furrow, 1.2, 1.4, 1.1; lower labial furr
1.5, 1.4, 1.3.

Nasal apertures: minimum distance between, 2.1, 1.9, 1.9.

Gill slits: height of first, 1.5, 1.4, 1.3; height of fifth, 0.9, 0.9, 0.6.

First dorsal fin: length base, 4.7, 4.6, 4.1; length posterior tip, 2.4, 1.7, 1.7; height, 3.9, 3.2, 3.2; length ante
margin, 7.4, 6.6, 6.4.

Second dorsal fin: length base, 5.6, 5.0, 5.1; length posterior tip, 2.1, 1.8, 1.9; height, 3.9, 3.3, 3.2; anterior mar
7.4, 6.9, 6.9.

Anal fin: length base, 11.9, 11.5, 12.4; length posterior tip, 1.5, 1.7, 1.3; height, 3.0, 2.3, 2.9; length anterior mar
5.9, 5.8, 6.7.

Pelvic fins: overall length, 11.0, 11.2, 9.8.

Claspers: reach past pelvic fin tips, 0.0, 3.5, 2.5.

Pectoral fins: width base, 4.5, 4.6, 5.1; anterior margin, 9.5, 10.0, 9.5; greatest width, 8.0, 8.3, 7.3.

Distance between fin bases: first and second dorsals, 15.4, 15.3, 16.2.

Discussion. Nakaya (1975:50, fig. 25) found yellow, smooth-surfaced egg capsules about 60 mm long and 16 mm w
in *G. eastmani*; mode of reproduction single oviparity, that is, egg capsules not retained in the oviducts for more tha
very short part of the development period; no evidence of sexual dimorphism in teeth; females mature at about 36
370 mm.

Galeus melastomus melastomus Rafinesque

Galeus melastomus Rafinesque 1810:13 (occurrence in Sicilian waters implied).

Pristiurus melanostomus Bonaparte 1834, fasc. VII; Müller and Henle 1841:15; Collett 1905:95; Regan 1908a:
Lozano Rey 1928:315; Nobre 1935:418; Andriashev 1954:35; Albuquerque 1954-1956:95; Azouz and Capapé 1971:
Quignard and Capapé 1971a:132, 1971b:160.

Pristiurus atlanticus: Vaillant 1888:59, pl. 1.

Pristiurus melastomus: Garman 1913:92; Maurin and Bonnet 1970:130, fig. 4.

Galeus melastomus: Bigelow and Schroeder 1948:215; Dollfus 1955:82; Tortonese 1956:133, figs. 70-71; Cadenat 19
figs. 5, 6; Bini 1967:61; Krefft 1968:40; Wheeler 1969:46; Springer 1973:11.3.1.

Material examined. USNM 23029, ♀, 635 mm, Norway; Bergen Museum, ad. ♂, 612 mm, Norway; USNM 17
imm. ♂, 407 mm; USNM 48275, imm. ♂, 337 mm; USNM 48276, imm. ♀, 313 mm; SU 20604, imm. ♀, 377 mm, Nap
ZMK *Thor* stn. 92, juv. ♂, 149 mm, west coast of Scotland from 550 m; about 100 specimens, coasts of Tunisia, Alge
Morocco; BMNH 1934, 8.8. 3a, 4a, egg capsules off S.W. Ireland; BMNH 1928, 9.18. 13, 16, egg capsules off S
Ireland, 292 m. Holotype not found.

Diagnosis. Galeus melastomus melastomus occurs along continental slopes from the vicinity of Trondheim, Norw
southward around the British Isles and into the Mediterranean and Adriatic Seas. Its range overlaps that of *Galeus p*
in the vicinity of Tangier and off the Atlantic coast of Morocco. Two characters by which *G. m. melastomus* may be
tinguished, size at maturity and number of vertebrae, are greater in the northern part of its range than in the south
sector.

Galeus m. melastomus differs from *G. m. murinus* in having a longer anal fin and in having much more promin
dorsolateral markings. A juvenile *G. m. melastomus* from the coast of Scotland has the base of the anal fin 18.1% T
compared with the juvenile holotype of *G. m. murinus* which has the base of the anal fin 11.8% TL.

Galeus m. melastomus differs from *G. polli* in producing its eggs in leathery capsules. It is a larger species reach
more than 600 mm as compared with *G. polli* which reaches a length of about 450 mm. It has smaller and more numer
dorsolateral markings than *G. polli*. Its anal fin base length is more than 15.0% TL as compared with less than 14.0%
for *G. arae arae*. Its strongly marked dorsolateral surfaces serve to mark it off from plain colored species such a
sauteri or from species with diffuse markings such as *G. nipponensis*.

Krefft (1968:40) noted additionally that the tip of the second dorsal fin extended rearward past the origin of the ca
crest and posterior tip of the anal fin in *melastomus* but not in *polli*. He also noted greater numbers of vertebrae in N
Sea specimens of *melastomus* than in African coast specimens of *polli* and observed that *melastomus* usually had 1
18 saddle blotches as compared with 9 or 10 for *polli*.

Maurin and Bonnet (1970, fig. 4) illustrated for comparison a 410-mm male *melastomus* and a 410-mm male *p*
presumably both from the northwest coast of Africa. The illustration shows a larger and wider band for *melastomu*
less arched mouth; a longer pectoral; a greater distance between the nostrils; and a somewhat lesser distance betw
the axis of the pectorals.

Description. Galeus melastomus melastomus reaches a length of 900 mm (Krefft 1968) but that length ma
unusual. Among specimens examined for this study a male 612 mm long from Norway was certainly an adult a

male 635 mm long, also from Norway, probably was an adult. Individual variation in proportional measurements is bstantial in *G. m. melastomus* as it is for many scyliorhinid species. Variation in vertebral number is great but, in rt, appears to be geographical.

Following are measurements expressed as percentages of the total length. The first figure in each series represents a 2-mm adult male from Norway; the second represents a 635-mm female from Norway; the paired figures in rentheses give the range in four half-grown specimens, two males and two females 313 to 407 mm long from Naples; e final figure in each series represents a juvenile male 149 mm long from the west coast of Scotland.

Tip of snout to: front of mouth, 7.8, 6.3, (6.4-8.6), 8.2; eye, 7.2, 6.3, (6.4-8.3), 7.2; spiracle, —, 10.6, (— - —), 13.4; st gill slit, 15.0, 12.6, (15.4-17.5), 17.4; last gill slit, 21.2, 17.2, (18.8-23.0), 21.2; origin pectoral, 21.6, 16.7, (18.1-22.1), 3; origin first dorsal, 48.5, 46.1, (44.9-48.2), 40.9; origin pelvics, 41.5, 39.1, (36.9-39.6), 34.9; origin second dorsal, 66.7, 9, (61.5-63.5), 55.7; origin anal, 58.0, 53.9, (52.1-53.6), 46.3; origin upper caudal lobe (= origin caudal crest), 76.0, 1, (70.0-72.5), 65.1; anterior end anal opening, 43.0, 41.9, (40.3-43.1), 39.6.

Eyes: length eye opening, 4.2, 3.6, (4.2-4.5), 5.4.

Spiracles: greatest diameter, 0.7, —, (— - —), 0.4; least distance from eye, 0.8, 0.8, (0.7-1.3), 0.4.

Mouth: width, 7.8, 7.9, (6.2-7.9), 6.7; length, 3.9, 3.3, (3.4-5.4), 4.0; length upper labial furrow, 1.5, 1.4, (1.0-1.6), ; lower labial furrow, 1.6, 1.6, (1.3-1.9), 2.0.

Nasal apertures: least distance between, 2.5, 2.4, (2.9-3.5), 2.7.

Gill slits: height of first, 2.1, 2.8, (2.0-2.7), 1.3; height of fifth, 1.1, 1.4, (0.9-1.3), 0.8.

First dorsal fin: length base, 5.7, 4.9, (4.4-5.1), 6.0; length anterior margin, 8.7, 7.9, (7.7-7.9), —.

Second dorsal fin: length base, 5.4, 4.6, (4.8-5.4), 6.7; length anterior margin, 8.3, 7.6, (8.0-8.6), —.

Anal fin: length base, 15.4, 15.3, (12.8-15.5), 18.1; length anterior margin, 8.2, 7.2, (6.4-8.1), —.

Pectoral fins: greatest width, 11.4, —, (— - —), 8.7; length anterior margin, 11.4, 13.2, (11.9-12.8), 11.4.

Pelvic fins: overall length, origin to posterior tip, 11.4, —, (— - —), 10.7; reach of claspers posterior to pelvic fin , 6.0, —, (— - —), −4.0.

Distance between fin bases: first and second dorsals, 13.2, 14.0, (10.9-12.3), 9.4; pectoral and pelvic, 11.8, 15.3, 6-11.7), —.

Galeus melastomus melastomus has high numbers of vertebrae compared with other species of *Galeus* for which rtebral counts were made. The two specimens from Norway had 40 and 43 monospondylous vertebrae and 28 Mediter- nean specimens, mostly from the vicinity of Tangier, had 37 to 40 vertebrae. Quignard and Capapé (1971b) reported 39 d 40 monospondylous vertebrae from specimens taken off Tunis.

Galeus m. melanostomus is strongly marked with a pattern of dark saddle blotches over the dorsolateral surfaces. ntral surface is uniformly light colored. Juveniles have 7 or 8 saddle blotches, but the number increases during growth as many as 19 in very large specimens.

Discussion. Egg capsules about 58 by 21 by 14 mm, not including horns or tentacles, taken off the southwest coast of and from about 290 m presumably belong to *G. m. melastomus*.

Azouz and Capapé (1971) reported partially digested crustaceans and cephalopods from the stomachs of the species en off Tunis.

The name *melastomus* refers to the black color of the inside of the mouth. Black mouths seem to be usual among cies of *Galeus* although the color is rather quickly lost after preservation.

Galeus melastomus murinus (Collett)

tiurus murinus Collett 1904:4 (Faröe Channel from 1,200 m).

tiurus jenseni Saemundsson 1922:169, pl. 4, fig. 2, pl. 5, fig. 4; not pl. 4, fig. 1 and pl. 5, fig. 3 as indicated by Saemundsson. (Vestmannaeyjar off southern coast of Iceland.)

tiurus murinus: Regan 1908a:463; Garman 1913:93.

leus murinus: Wheeler (1x, in list of species); Springer 1973:11.3.2.

Material examined. ZMO, *Michael Sars* stn. 76, imm. ♀, 222 mm, holotype (specimen examined at Zoological seum, Bergen).

Diagnosis. In the juvenile 222-mm female holotype of *Galeus marinus*, the length of the base of the anal fin is 11.8% but in a 149-mm juvenile of *Galeus melastomus* from the west coast of Scotland the length of the base of the anal fin 18.1% TL. *Galeus murinus* was originally described as being uniformly brown above, lighter below without the riegated pattern that characterizes *G. melastomus*. Saemundsson's holotype of *Pristiurus jenseni*, a 630-mm male, as easured by Saemundsson (1922:171) differs only moderately in proportional dimensions from the holotype of *murinus*.

For example, its eye length is 3.4% TL and the length of its anal fin base is 13.5% TL, dimensions that set it off somew from *murinus* but in the direction of *melastomus* characteristics.

Description. After describing *murinus* in 1904, Collett (1905) prepared a more thorough description of the species again referred to only one specimen. Following are proportional measurements I made in 1969 when the total lengt Collett's holotype was 222 mm. Figures are percentages of total length.

Tip of snout to: front of mouth, 8.1; eye, 8.6; spiracle, 13.6; first gill slit, 16.8; fifth gill slit, 20.5; origin pecto 19.5; origin first dorsal, 44.1; origin pelvics, 36.8; origin second dorsal, 55.9; origin anal, 48.6; origin caudal crest, 6 anterior end cloacal opening, 42.7.

Eyes: horizontal diameter, 4.1; vertical diameter, 1.4.

Spiracles: greatest diameter, 0.6; least distance from eye, 0.8.

Mouth: width, 7.7; length, 3.6; length upper labial furrow, 1.7; length lower labial furrow, 2.1.

Gill slits: height of first, 1.1; height of fifth, 0.9.

First dorsal fin: length base, 5.2; length free inner margin, 2.5; height, 2.5; length anterior margin, 8.0.

Second dorsal fin: length base, 5.9; length free inner margin, 3.2; height, 2.5; length anterior margin, 9.1.

Anal fin: length base, 11.8; length free inner margin, 0.9; height, 4.1; length anterior margin, 9.5.

Pectoral fin: width pectoral base, 5.9; length anterior margin, 11.4; greatest width, 7.7.

Pelvic fins: origin to rear tip, 10.5.

Caudal fin: length from origin caudal crest, 32.3.

Distance between fin bases: first and second dorsals, 8.6; anal to lower caudal lobe, 0.9.

Discussion. As pointed out by Blacker (1962:269), most "rare" fish are common somewhere. Blacker was referrin occasional, surprisingly large catches of *Galeus melastomus* made by research trawlers although that species had b considered uncommon in commercial trawler catches. In conversation with a group of Grimsby, England, trawlerme learned that *Galeus* was indeed taken in large numbers although not regularly by "distant water" trawlers fishing in direction of Iceland. Also, I learned that the black-mouths (*Galeus*) were variable in color, not so spotted and graye color toward Iceland.

Galeus nipponensis Nakaya
Figures 33, 34

Galeus nipponensis Nakaya 1975:51, figs. 26-28 (Tamase, Kochi Prefecture, Japan).

Material examined. SU 13887, ♀, 592 mm, Japan; BMNH 1937.7.7.7, subad. ♂, 550 mm, Sagami Channel, Japan.

Diagnosis. Nakaya's diagnosis, directed chiefly toward separating *G. nipponensis* from other *Galeus* of Japan waters is as follows: body with dark blotches; origin of anal fin below middle or posterior half of interdorsals; inside mouth white; snout in front of anterior nasal aperture longer than horizontal diameter of eye.

Additionally I note that *G. nipponensis* has remarkably wide and short pectoral fins, their greatest widths, measu parallel to distal fin margin, considerably greater than the width of the mouth or length of the snout in front of mou and equal to or slightly greater than the length of the base of the anal fin; the pectoral fins short, their lengths equal t not much greater than their widths. The first dorsal fin in *G. nipponensis* is slightly larger than the second dorsal fi

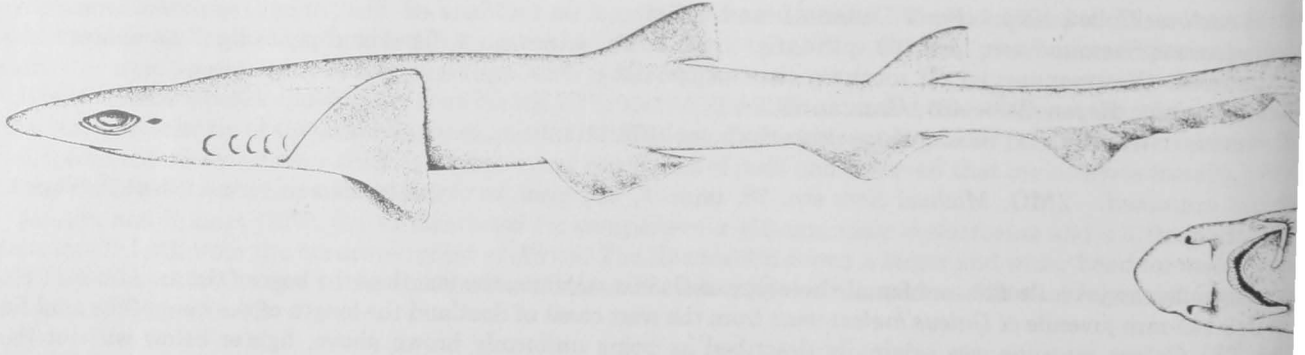


Figure 33.—*Galeus nipponensis*, female, 592 mm. Lower jaw damaged and absence of lower labial furrow probably due to injury. Drawin Mildred Carrington.

Figure 34.—*Galeus nipponensis*, subadult male, 550 mm, ventral side of head, from BMNH 1937.7.7.

ll dimensions and this differentiates it from many *Galeus* species. The snout in front of mouth is tapering and about as ong as the width of the mouth.

Description. The specimens that I examined had been in preservative for 30 yr or more and no markings were visible n their uniform brown dorsal surfaces or somewhat lighter ventral surfaces. The male had a darker smudge on the upper art of each dorsal fin.

The 550-mm male has very long but uncalcified claspers, their tips reaching the origin of the anal fin and extending ast the tips of the pelvic fins for a distance greater than the length of the snout. In this specimen the extension of the laspers past the tips of the pelvic fins is 6.9% TL. Only *Galeus schultzi* and *Juncrus vincenti*, among adult male cyliorhinids, have proportionally longer claspers. The claspers of adult male *G. sauteri* reach nearly to the base of the nal fin, but in the series of five adult male *G. sauteri* examined for this study the claspers extend beyond the tips of the elvic fins by only 2.8 to 3.6% TL. The claspers of the 347-mm adult male *G. eastmani* examined extended past the elvic tips only about halfway to the anal fin origin, 3.5% TL.

Dermal denticles of the flank of the 592-mm female are imbricate, tridentate, and about 0.3 to 0.4 mm long. Thus, the enticles are about the same size as those on *G. eastmani* but smaller than the flank denticles of the 0.7-mm denticles at appear typical of *G. sauteri*.

Following are measurements expressed as percentages of the total length. Measurements for the 592-mm female are epresented by the first figure in each pair; the 550-mm male's proportions are shown by the second figure.

Tip of snout to: front of mouth, 6.4, 6.9; eye, 6.4, 7.3; spiracle, 11.1, 10.7; first gill slit, 15.5, 15.3; fifth gill slit, 19.9, .1; origin pectoral fin, 19.4, 18.4; origin first dorsal, 43.1, 43.6; origin pelvic fins, 38.5, 37.8; origin second dorsal, 62.7, .4; origin anal fin, 57.6, 60.0; origin caudal crest, 71.6, 71.8; anterior end cloacal opening, 40.7, 40.9.

Eyes: horizontal diameter, 3.9, 3.5; vertical diameter, 1.5, 1.1.

Spiracles: greatest diameter, 1.0, 0.9; least distance from eye opening, 0.8, 0.5.

Mouth: width, 6.4, 6.9; length, 3.9, 3.5; length upper labial furrow, 2.0, 1.6; length lower labial furrow, —, 2.0.

Nasal apertures: minimum distance between, 2.1, 2.0.

Gill slits: height of first, 1.5, 1.5; height of fifth, 0.9, 1.0.

First dorsal fin: length base, 6.1, 6.2; length lower posterior margin, 2.2, 2.2; height, 4.4, 4.5; length anterior argin, 8.8, 8.0.

Second dorsal fin: length base, 5.9, 5.8; length lower posterior margin, 2.0, 1.8; height, 3.9, 3.5; anterior margin, 6, 7.6.

Anal fin: length base, 8.8, 7.9; length lower posterior margin, 1.5, 1.8; height, 3.5, 3.3; anterior margin, 5.6, 6.4.

Pectoral fins: width base, 5.2, 6.0; anterior margin, 10.1, 9.6; greatest width, 11.3, 9.1.

Pelvic fins: Overall length, 11.0, 14.5.

Claspers: reach past pelvic fin tips, —, 6.9.

Distance between fin bases: first and second dorsals, 13.2, 14.5.

Discussion. Both the specimens that I examined had previously been identified variously as *G. eastmani* or *G.*

hertwigi. *Galeus nipponensis* is nearly as large as *Parmaturus pilosus* (= *G. hertwigi*) but has a sharper, more tapered and shorter snout as well as much wider pectoral fins.

Nakaya, (1975) reported that *G. nipponensis* attains sexual maturity at about 530 to 550 mm; sexual dimorphism in teeth of adults is minor; the egg capsule is finely striated longitudinally, 89 by 20 mm, rather thick-walled and strong brown, opaque; and a hatched embryo is 133 mm TL.

Galeus piperatus Springer and Wagner
Figure 35

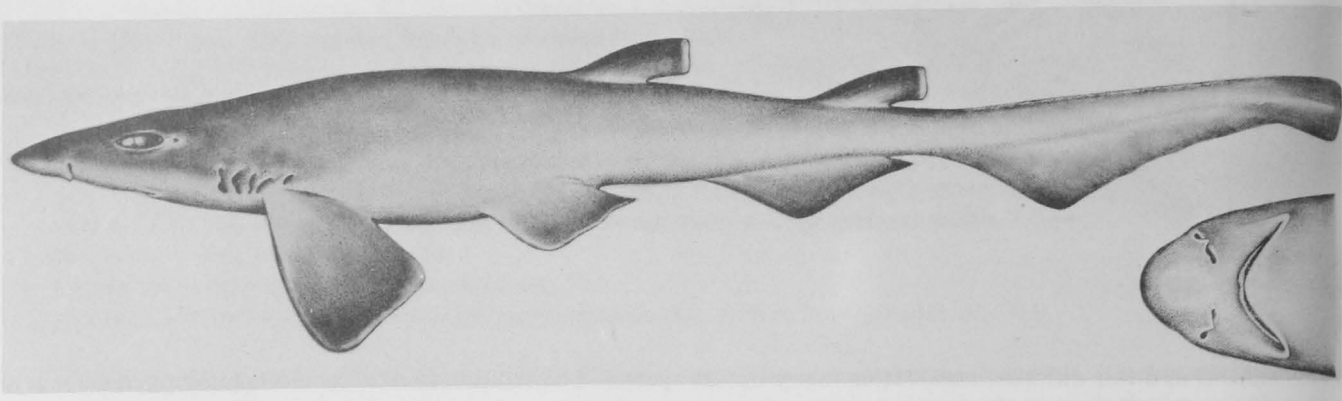


Figure 35.—*Galeus piperatus*, female, 302 mm, holotype, Gulf of California. The plain color of this specimen may be unusual. The few other specimens now available have a color patttern approaching that of *G. arae arae*. Drawing by Mary Wagner.

Galeus piperatus Springer and Wagner 1966:1, figs. 1, 2 (Gulf of California); Hubbs and Taylor 1969:310, figs. 1-7; Brewer 1973:5.

Galeus sp. Lavenberg and Fitch 1966:96, 98.

Material examined. LACM 7552, ad. ♀, 302 mm, holotype; LACM 8818, imm. ♀, 256 mm, paratype; USNM 200413, ad. ♀, 296 mm, paratype. All types from RV *Alaska* stn. 64A2-16, lat. 28°55'N, long. 112°50.5'W, south of Isla de la Guardia in 402-412 m, Gulf of California.

Diagnosis. When described from the type-material listed above, *Galeus piperatus* was stated to lack well-defined dorsal blotches as in the holotype or to have indistinct mottling as in the other two specimens. Hubbs and Taylor (1969) examined six additional specimens and found moderately conspicuous markings set off by a light subhexagonal reticulum approaching that figured by Springer (1966, fig. 20) for a specimen of *G. arae* of comparable size. The lack of markings on the holotype (as in Fig. 35) may have been due in part to the method of preservation as suggested by Hubbs and Taylor. I have not seen a preserved *Galeus arae arae* nearly or entirely lacking markings, however, among hundreds that I have examined and I suspect that *G. piperatus* is a more variable species than *G. arae arae*. The separation of *G. piperatus* from *G. arae arae* seems a lesser problem than its separation from *G. arae cadenati*, and I doubt that such separations can be made with confidence except on the basis of large series of both populations.

Some confirmation that *G. piperatus* differs from *G. arae arae* and *G. arae cadenati* lies in the vertebral count (Table 2) but overlap is present for both subspecies.

Description. Measurements of the three type-specimens are given by Springer and Wagner (1966) and also by Hubbs and Taylor (1969) for the same specimens with an additional five specimens. These measurements are not repeated here.

As noted several times in the present study, scyliorhinid sharks shrink, swell, and twist in a variety of ways depending on the manner of their death and preservation. Furthermore, during storage in alcohol they show a fairly consistent tendency to shrink in total length but such shrinkage does not appear to be uniform for all dimensions.

In addition, small differences in method of measurement make small differences in results, and differences in definition of whatever is measured may produce some remarkably divergent figures.

It is instructive to compare the measurements made by Springer and Wagner with those made by Hubbs and Taylor. The agreement is only approximate for many measurements. For one measurement it is obvious that different things were being measured and reported under similar but confusing names. Springer and Wagner referred (1966:3) to "interspace between first and second dorsal" and (in table 1) to "distance between dorsal fins." In both instances the space being measured was the distance between the posterior end of the first dorsal fin base and the origin of the second dorsal fin base. Hubbs and Taylor (1969) referred to (table 2) "interdorsal space" and the measurement reported was the distance from the appressed posterior tip of the first dorsal fin to the anterior end of the base of the second dorsal.

Hubbs and Taylor (1969) reported a scyliorhinid egg capsule 35 mm long believed to belong to *G. piperatus* for eral reasons that seem valid. They also found one juvenile, 85 mm in life but 80 mm when preserved. Their illustra- n (1969, fig. 2) shows the usual color of juveniles of several *Galeus* species.

Galeus polli Cadenat

leus polli Cadenat 1959:395, 18 figs. (coast of Senegal); Krefft 1968:40.
leus melastomus: Fowler 1936:40; Poll 1951:22, figs. 6, 7, pl. XII, fig. 1.
stiurus polli: Maurin and Bonnet 1970:131, fig. 4.

Material examined. USNM, 58 uncatalogued specimens, west coast of Africa between lat. 10°N and 5°S; USNM, 17 catalogued specimens, Liberia to Angola; USNM, 2 ♂, 360-385 mm, 1 ♀, 320 mm, from 420 to 450 m at lat. 35°41′N, g. 04°55′W, near Ceuta, Spanish Morocco; Guinean Trawling Survey, lat. 09°32′N to 05°17′N, 10 ♀, 210 to 299 mm, , 205 to 228 mm, west coast of Africa.

Diagnosis. *Galeus polli* has a longer anal fin than *G. arae arae*, *G. arae antillensis*, and probably longer than some *G. e cadenati*, *G. melastomus murinus*, and some *G. melastomus melastomus*. Its longer snout (in front of mouth) arates it from western Atlantic species. Its color pattern distinguishes it from *G. melastomus murinus* and from the narked or weakly marked Pacific species.

Galeus polli and *G. melastomus melastomus* have overlapping ranges off the coast of Spanish Morocco and probably some distance southward off the Atlantic coast of Morocco and off Senegal. Distinguishing *G. polli* and *G. m. lastomus* is not always possible in the area of overlap on the basis of single morphometric characters.

Adult *G. polli* reach lengths up to 430 mm, but *G. m. melastomus* grows to a much larger size, especially in the north- part of its range (Cadenat 1959; Krefft 1968; Maurin and Bonnet 1970). *Galeus polli* adults have from 9 to 11 dorsal dle blotches as compared with 15 to 18 for *G. m. melastomus*; *G. polli* has smaller denticles in the caudal crest than *m. melastomus*; the tip of the anal fin overlaps the origin of the lower caudal fin lobe in *G. m. melastomus* but barely ches it in *G. polli* (Krefft 1968). The least distance between nostrils in *G. polli* is half or less than half the distance ween the pectoral axils in *G. polli* but about equal to that distance in *G. m. melastomus* (Maurin and Bonnet 1970, 4).

Krefft (1968) noted differences between the number of trunk vertebrae, 33 to 35 for *polli* and 40-41 for *melastomus* n the northern part of its range. The difference decreases somewhat toward the area of overlap. Quignard and Capapé 71b) found 39 and 40 monospondylous vertebrae (= trunk vertebrae) for *melastomus* from the coast of Tunis. The ee *polli* noted in the material examined section above from Spanish Morocco had 33, 34, and 34 monospondylous tebrae.

Among specimens that I have seen, *G. polli* has stronger markings than other species of *Galeus* and the dorsolateral or and saddle blotches were gray and gray-black rather than brown.

Description. The following dimensions expressed as percentages of total length were taken from Cadenat (1959:396); series of figures for each dimension refer first to a 390-mm male, second to a 350-mm male, third to a 410-mm female, last to a 415-mm female.

Tip of snout to: front of mouth, 8.2, 7.4, 8.5, 7.4; origin first dorsal, 46.1, 44.2, 45.1, 43.3; origin second dorsal, 62.8, 3, 62.1, 57.8; origin anal, 53.8; 54.2, 51.2, 48.0; pectoral, 19.2, 20.0, 19.5, 19.2; pelvic, 38.4, 38.5, 37.8, 34.9.
First dorsal fin: length of base, 5.1, 6.5, 7.3, 4.8; height, 2.8, 2.8, 3.1, 2.4.
Second dorsal fin: length of base, 5.1, 5.6, 6.0, 6.0; height, 3.0, 3.1, 3.4, 2.8.
Anal fin: length of base, 14.0, 15.1, 17.0, 15.6; height, 3.8, 4.2, 4.2, 4.3.
Length upper caudal border: 28.2, 28.5, 28.0, 25.3.
Greatest length pectoral fin: 14.6, 12.8, 13.4, 43.3.
Width of mouth: 7.2, 7.4, 7.8, 7.4.
Distance between fin bases: first and second dorsals, 11.5, 12.0, 9.7, 9.6; second dorsal to upper caudal, 3.8, 2.8, 3.6.
Distance between fin origins: pectoral and pelvic, 19.2, 18.5, 18.2, 18.0; pelvic and anal, 15.3, 14.2, 13.4, 13.2.

Body comparatively slender; length of snout in front of mouth about 2½ in head; head about 20% TL; tail from origin caudal crest about 25 to 30% TL; orbit about 3.0 to 4.0% TL. Origin of first dorsal over posterior part of base of vic fin; dorsal fins not greatly different in size, the second slightly larger; anal fin long, much longer than distance ween bases of dorsal fins, its tip barely reaching origin of lower lobe of caudal fin.

Dermal denticles and teeth similar to those of other species of *Galeus*.

Discussion. *Galeus polli* eggs, as found in the oviducts before appreciable embryonic development (Cadenat 195 figs. 8-10), have transparent and apparently very thin shells which soon disappear.

Galeus polli gives birth to living, fully formed young. Egg capsules are not heavy-walled, substantial structures an appear to be absorbed in early stages of development of the embryos in the oviducts. Cadenat reported that the female produce from 4 to 10 young at a time, the sexes in nearly equal numbers among 51 foetuses counted. Young apparentl are born at a length of about 115 mm.

Poll (1951) had already reported on the capture of 77 specimens taken between lat. 6°08′S and 19°52′S on the wes coast of Africa and had noted that the species was ovoviviparous "contrairement ā l'opinion generale adnaise que le Scyliorhinidae sont ovipares." That Poll used the name *Galeus melastomus* for these sharks is not so surprising to me a is Poll's apparent willingness to discard opinions of dozens of zoologists that *G. melastomus* lays eggs in leathery cases. I is nevertheless true that the literature on the development of *G. melastomus* is scanty and some of its conclusions ma be based on assumptions.

Cadenat (1959:398) included a table with lengths and weights of males and females more than 300 mm long. The tabl shows that females 355 to 415 mm long weigh from 128 to 220 g and that males 305 to 390 mm long weigh from 70 to 140 g Cadenat (1959:400) determined the liver weight in a series of 16 adult *G. polli* to be from 3.6 to 8.1% of total weigh (average 5.47% total weight). I do not know of another report on the weights of scyliorhinid sharks.

Galeus sauteri (Jordan and Richardson)

Pristiurus sauteri Jordan and Richardson 1909:160, pl. 63, fig. 1 (Takao, Formosa).
Galeus sauteri: Fowler 1941:28; Teng 1962:43, fig. 9; Chen 1963:27, fig. 8; Nakaya 1975:41, figs. 20-22.

Material examined. SU 21261, 4 ad. ♂, 360-365 mm, syntypes, Takao, Formosa, coll. Hans Sauter, 1906; USNM 191185, ad. ♂, 380 mm, 2 ad. ♀, 415-430 mm, Tamshui, Taipei, Taiwan; USNM, juv. ♂, 138 mm, Ta-chi, Taiwan 23 November 1969.

Diagnosis. *Galeus sauteri* is distinctively marked with the upper edges of the first and second dorsal fins and cauda fin with a black spot near the tips; the pectorals and pelvics are unmarked except for a moderately distinct band o lighter color along the distal margins; the dorsal and lateral surfaces are plain gray or brown; ventral surfaces are whit or yellowish, the light color extends somewhat on the lateral surfaces, especially posterior to the pelvics; the color of the juvenile specimen examined is similar to color of adults except the apex of the anal fin and the apex of the lower cauda lobe are black tipped and the dark and light areas are in stronger contrast.

Galeus sauteri adult males, at about 360 to 380 mm TL, are in contrast to *G. schultzi* in which the adult male holotyp is about 260 mm.

Galeus sauteri is smaller than *nipponensis*. In the latter, a 550-mm male is not quite sexually mature.

The claspers of mature male *G. sauteri* are proportionally about as long as those of other species of *Galeus* except *nip ponensis* and *schultzi*. In *G. sauteri*, the tips of the claspers reach approximately to origin of the anal fin but reach pas the tips of the pelvics for a distance a little more than half the length of the snout. In *nipponensis*, the claspers reach pas the pelvic fin tips by a distance about equal to the snout length.

In the study series of *G. sauteri*, the anal fin base is longer at 11.7 to 15.0% TL than *nipponensis* for which the propo tion is 8.2 to 8.8% TL. The proportion of the distance between dorsal fin bases in *sauteri* is less than that of *eastmani* an *nipponensis* and about equal to that of *schultzi*.

Description. Although the dermal denticles are imbricate they are somewhat rough to touch. Flank denticles a about 0.7 mm long with three points and one strong central ridge. The caudal crest denticles of the central rows a about 1.0 mm long and the lateral crest denticles about 2.0 mm long.

The jaws are strongly arched. The teeth are small, crowded, each tooth with 3 to 5 points. Several symphyseal teet are present.

The claspers reach past the tips of the pelvic fins in the mature males for a distance about equal to the length of th eye. The pelvic fins are united beneath the claspers for about half their length forming a partial apron.

Measurements expressed as percentages of the total length follow. The first pair of figures under each category giv the range in the four syntypes, all mature males, 360 to 365 mm long. The second pair of figures represents the range two females 420 and 440 mm long. The final single figure represents a 385-mm adult male.

Tip of snout to: front of mouth, 6.1-6.7, 6.4-6.6, 6.2; eye, 6.3-7.2, 6.7-6.8, 6.8; first gill slit, 15.6-16.7, 15.7-16.0, 15. fifth gill slit, 18.6-19.7, 19.8-20.7, 20.0; origin pectoral, 17.5-18.4; 19.0-20.0, 19.5; origin first dorsal, 44.5-45.9, 43.3-43. 44.1; origin pelvic fins, 36.1-39.5, 38.4-39.8, 37.4; origin second dorsal, 63.3-63.9, 62.4-62.5, 60.3; origin anal, 53.9-54. 52.3-53.6, 53.2; origin caudal crest, 72.2-75.1, 68.9-73.8, 71.2; anterior end cloacal opening, 40.6-43.6, 40.0-42.9, 39.

Eyes: horizontal length, 3.6-4.2, 3.8-4.1, 3.9.

Spiracles: greatest diameter, 0.8-0.8, 0.7-0.9, 0.8; distance from eye, 0.8-0.8, 0.7-1.1, 0.8.
Mouth: width, 6.0-7.0, 6.6-6.7, 6.0.
Nasal apertures: least distance between, 2.2-3.0, 2.4-2.5, 2.3.
Gill slits: height of first, 1.1-1.4, 1.6-1.7, 1.3; height of fifth, 0.8-0.8, 1.0-1.1, 0.8.
First dorsal fin: length of base, 4.2-5.3, 5.2-5.9, 4.7; length anterior margin, 6.7-7.5, 7.6-8.2, 6.0.
Second dorsal fin: 4.2-5.0, 4.3-4.5, 4.2; length anterior margin, 5.5-6.7, 6.4-6.7, 6.0.
Anal fin: length base, 11.7-13.9, 15.0-15.0, 12.5; length anterior margin, 5.3-6.4, 4.5-6.7, 5.7.
Pectoral fin: length anterior margin, 10.1-11.1, 10.0-10.4, 8.8; greatest width, 8.5-8.9, 10.2-10.2, 8.6.
Caudal fin: length from origin caudal crest, 26.7-29.5, 26.0-28.2, 28.6.
Distance between fin bases: first and second dorsals, 13.1-13.7, 12.7-12.9, 12.7.

iscussion. *Galeus sauteri* is common around Taiwan (Formosa) and according to Nakaya (1975:46) may occur ınd the southernmost islands of Japan. A specimen from the Philippines in the California Academy of Sciences ection may belong to this species (L. J. V. Compagno, pers. commun.).
lakaya (1975) described the egg capsules of *G. sauteri* as transparent, yellow, and about 35.5 mm long by 15 mm e. The egg capsule surfaces were smooth without longitudinal streaks and had long tendrils.

Galeus schultzi New Species

lolotype: USNM 122312 (*Albatross* Stn. 4693), ad. ♀, 297 mm, Balayan Bay, Luzon, Philippines, from 329 m, February 1909.
aratypes: USNM 122307, ad. ♂, 254 mm, China Sea off southern Luzon from 431 m, 16 January 1908; USNM 311, ad. ♀, 268 mm, Balayan Bay, Luzon, from 391 m, 22 February 1909.

)ther material examined: USNM, imm. ♂, 220 mm, Philippines.

)iagnosis. *Galeus schultzi* is one of the smallest species of *Galeus*. It is sexually mature at less than 300 mm. The otype is the largest specimen of those available, only 297 mm TL. The specimens had been in preservative for more n 50 yr before I saw them and presumably had faded somewhat and had assumed the light tan color common to served sharks. Four saddle blotches were visible on the holotype, one at the first dorsal, one at the second dorsal, and on the tail. The first and second dorsal fins are nearly equal in area. The anal fin base length is greater than that of *ipponensis*, but is variable and overlaps anal base lengths of *G. eastmani* and *G. sauteri*. The claspers of the 254-mm lt male are longer proportionally than other *Galeus* except possibly *G. nipponensis*. The small size (length at sexual turity) is probably the most reliable character for the separation of *G. schultzi* from other *Galeus* now known from the ific.
Galeus schultzi resembles *G. piperatus* in more ways than any other *Galeus* species. Following is a direct comparison he 297-mm holotype of *G. schultzi* with a 293-mm paratype of *G. piperatus*. The head of *G. schultzi* is narrower, the slightly smaller, the nasal apertures somewhat less oblique, the mouth smaller with a higher arch, gill slits only ut half as long, posterior tip of pelvics to origin of anal longer, caudal crest much stronger, outer rows of crest den- es larger, fewer middle crest denticles, and caudal crest flatter in *schultzi* than in *piperatus*.

)escription. The measurements of the type-series made 50 yr after preservation are given below expressed as centages of the total length. The first figure in each series represents the 297-mm female holotype, the second the 268- female, and the third the 254-mm mature male.

Tip of snout to: front of mouth, 5.9, 5.4, 5.5; eye, 6.1, 5.2, 6.3; spiracle, 10.8, 10.4, 10.4; first gill slit, 16.5, 15.7, 14.6; gill opening, 21.2, 19.4, 19.7; origin pectoral fin, 20.2, 17.9, 18.5; origin first dorsal, 45.4, 44.7, 46.3; origin pelvics, , 38.0, 37.0; origin second dorsal, 62.6, 61.9, 64.6; origin anal, 55.6, 54.1, 57.9; origin caudal crest, 70.7, 70.9, 74.4; erior end cloacal opening, 41.1, 43.3, 41.9.
Eyes: length of opening, 3.7, 2.4, 4.1.
Spiracles: greatest diameter, 0.7, 1.0, 0.9; least distance from eye, 1.3, 1.1, 1.2.
Mouth: width, 6.6, 6.5, 6.7; length, 4.0, 3.7, 4.7; length upper labial furrow, 0.7, 0.4, 0.6; length lower labial furrow, 1.1, 1.2.
Nasal apertures: least distance between, 2.4, 2.4, 2.8.
Gill slits: height of first, 1.5, 1.0, 0.9; height of fifth, 1.0, 0.7, 0.6.
First dorsal fin: length base, 5.1, 6.3, 4.7; length free inner margin, 2.7, 2.6, 1.6; height, 4.0, 3.4, 3.5; length anterior gin, 8.4, 9.7, 5.9.
Second dorsal fin: length base, 5.6, 6.2, 4.7; length free inner margin, 2.8, 2.8, 1.9; height, 3.0, 3.4, 3.0; length erior margin, 8.1, 8.6, 4.7.

Anal fin: length base, 11.8, 11.2, 11.8; length free inner margin, 1.7, 1.7, 1.4; height, 3.7, 3.7, 2.6; length anteri margin, 6.7, 6.3, 4.7.

Pectoral fins: width base, 4.7, 4.5, 5.1; anterior margin, 12.6, 12.3, 12.6; greatest width, 9.4, 10.2, 9.1.

Pelvic fins: overall length, 12.1, 11.9, 9.5; reach of claspers past posterior tips of pelvics, —, —, 8.3.

Distance between fin bases: first and second dorsals, 12.1, 11.6, 14.2; pectoral and pelvic, 13.8, 14.5, 12.6; pelv and anal, 8.8, 7.1, 11.8; anal and lower caudal lobe, 5.4, 4.1, 4.3; second dorsal and origin caudal crest, 2.7, 3.0, 3.

Teeth of the holotype, small, crowded, in about 24+24 rows in the upper jaw, probably not quite so many in the low jaw but number of rows not readily counted. About three rows near the symphyses in each jaw tricuspid, other teeth wit five cusps or a few with six or seven cusps near corners in lower jaw.

Dermal denticles moderately small, largest flank denticles about 0.4 to 0.5 mm long, with three points, the central or much the longest.Asymmetrical marginal caudal crest denticles 1.0 to 1.2 mm long.

The specimens had been in preservative for about 60 yr when examined and it seems probable that most of the obscu markings may once have been moderately strong saddle blotches. Those at the first and second dorsal fins and two ov the caudal appeared most definite.

The inside of the mouth was dusky and some scattered small denticles could be felt on the roof of the mouth.

Discussion. As in some other *Galeus* species, individual variation may account for the differences in measuremen in the type-series.

The specimens were first recognized and set aside in the USNM collection by Henry W. Fowler but evidently we forgotten in the press of other work. Fowler had labeled the specimens *Galeus schultzi*, the specific name given to hon Leonard P. Schultz, long Curator of Fishes at the National Museum. I am pleased to follow Fowler in this as in many his actions in shark classification.

HALAELURUS GILL

Halaelurus Gill 1862:407 (type-species, *Scyllium bürgeri* Müller and Henle, by monotypy).

Diagnosis. Species of *Halaelurus* lack a supraorbital crest or shelf above the orbits. Labial furrows are present ar extend as a continuous groove around the mouth corners, except that in *Halaelurus buergeri* the furrows may be weal very short, incomplete, or even absent on one side. Probably in exceptional examples of *H. buergeri* labial furrows ma not be detected at all but in all the specimens I have examined furrows were present. Nasal flaps are present in varyin size but do not project posteriorly past the upper lip. Species of *Halaelurus* have no groove or depression in the upper l connecting the nasal apertures with the mouth. They lack a caudal crest of modified dermal denticles. The pelvic fins males may be united near their bases but the condition is notable only in juveniles, the fins do not unite to form an apr beneath the claspers as in some other genera. The claspers of males are not notably long at sexual maturity and do n extend for more than half their length past the pelvic fin tips. The angle of view of the eyes is more lateral than dors and the snout in *Halaelurus* is not notably flattened and spatulate.

Discussion. At one time or another 17 or more species have been placed in the genus *Halaelurus*. In the treatme here, the genus includes only nine species. Because none of the other species have been assigned to the synonymy with *Halaelurus*, it may reduce reader confusion to know where they went.

Halaelurus garmani Fowler (1934) has earlier been regarded as a species of *Scyliorhinus* (Springer and Garrick 196 and is so considered here not only because the holotype has the overlapping upper lip corner found in *Scyliorhinus* b also because it has a supraorbital crest.

Scyllium bivium A. Smith (1837) and *Scyllium chilense* Guichenot (1848) are also excluded from *Halaelurus* becau they have supraorbital crests and are placed in *Schroederichthys* because of their development characteristics and oth features.

The distinctive *Catulus labiosus* Waite (1905) has a supraorbital crest and too many other notable features to go any other scyliorhinid genus than *Aulohalaelurus*.

Two Australian species, *Scyllium vincenti* Zietz (1908) and *Scyllium anale* Ogilby (1885), like *Halaelurus*, do not ha supraorbital crests but for other reasons are referred here to *Juncrus* and *Asymbolus*, respectively.

Two South African species, *Scylliorhinus regani* Gilchrist (1922) and *Scylliorhinus punctatus* Gilchrist (1914), la supraorbital crests but have no trace of labial furrows. They are referred to *Holohalaelurus*.

One specimen identified by Alcock (1899) as *Scyllium canescens* Günther (1878) and later described as *Halaelur alcockii* Garman (1913), I have not seen and am unable to identify from descriptive accounts. It had Indian Museu Calcutta, number 68/1. Alcock's description does not fit clearly the description of any scyliorhinid that I know an prefer to leave it in limbo.

The nine species of *Halaelurus* that I recognize fall readily into two groups (Table 3). One group includes *buergeri*, *semani*, *quagga*, *lineatus*, and *natalensis*. They are all relatively firm-bodied, strongly marked, small sharks of the er continental shelves and island terraces occuring from the Sea of Japan through waters off China, the East Indies, stralia, the Indian subcontinent, and the eastern coast of Africa and perhaps rarely to Saldanha Bay north and west of Cape of Good Hope. The other group, *canescens*, *dawsoni*, *hispidus*, and *lutarius*, consists of relatively soft-bodied, bly and weakly marked species, often in deeper water of the upper continental and island slopes off the west coast of th America, New Zealand, the Andaman Islands, the Gulf of Mannar, the Gulf of Aden, and Mozambique. *Halaelurus boesemani* has the most extensive geographical range among species of the genus occurring from the Gulf Tonkin to the coast of Somalia. It is present in the East Indies and also on the coast of Western Australia.

Table 3.—Numbers of monospondylous vertebrae in species of *Halaelurus*.

Species of *Halaelurus*	31	32	33	34	35	36	37	38	39	40	41	42	43
H. buergeri			4	2									
H. boesemani			1	6	1								
H. quagga	2	1											
H. lineatus			1	6									
H. natalensis	1	3	2										
H. hispidus					1	4	5	1					
H. dawsoni						2	4	2					
H. lutarius								1	6	8	1	1	
H. canescens									2	11	3	2	1

Key to Adult and Half-grown *Halaelurus*

Body relatively firm, skin tightly adherent and well covered by imbricate denticles, its surface moderately hard and smooth. A color pattern of darker saddle blotches, transverse bars, and spots or some combination of these 2

Body usually somewhat soft, skin either somewhat loose or at least not hard and smooth, flank denticles not closely imbricate, prickly or velvety to touch. No strong color pattern, appearance usually drab, sometimes with rather poorly defined saddle blotches, white spots, or white patches 6

Snout obtusely pointed, its tip knoblike and turned upward 3

Snout not pointed, its tip rounded and not turned upward 4

Tan dorsally with about 26 narrow dark bars across back and extending on sides; numerous brown spots and vermiculate marks between bars; the darkest bars show tendency to occur in pairs with a single and somewhat lighter colored bar between each pair; mouth relatively small, its width about 7% or less of total length, its length 2.1 to 2.6% TL . . . . . *H. lineatus*

Tan dorsally with about 10 darker saddle blotches, each blotch made up of a pair of dark bars enclosing a somewhat lighter colored area; definite spots or vermiculations between saddle blotches absent or rare; mouth relatively large, its width 7.3 to 8.1% TL, its length 2.8 to 3.5% TL . . . . . *H. natalensis*

Color pattern made up primarily of transverse dark bars with few spots; the spots, if present, usually arranged in one or more transverse rows between bars . . . . . *H. quagga*

Color pattern made up primarily of spots; transverse markings or saddle blotches, if present, usually weak and without definite margins 5

5a. Dark spots not remarkably numerous and usually moderately large, usually much larger than the spiracle, often 4 to 5 mm in diameter in adults, sometimes arranged along borders of barely visible saddle blotches or sometimes arranged in clusters of two to five spots; labial furrows very short and weak, longest in adult specimens seen 2 mm, sometimes visible only on one side of mouth . . . . . *H. buerger*

5b. Dark spots very numerous and small, usually not appreciably larger than spiracle, usually less than 2 mm in diameter in adults, often arranged in clusters of two to five spots and usually distributed over and between weakly evident saddle blotches; labial furrows moderately strong, the lower limb extending usually 5 mm or more along lower jaw in adults . . . . . *H. boesemar*

6a. Length of base of anal fin as long or longer than the distance between dorsal fin bases; nasal flaps lobelike, not triangular, sides of lobe nearly parallel . . . . . *H. dawson*

6b. Length of base of anal fin shorter than the distance between the dorsal fin bases; nasal flaps essentially triangular . . . . .

7a. Length of anal fin base less than 1.3 times the length of the second dorsal fin base; adults 440 to 690 mm long; color uniform dark above and from uniform dark or somewhat lighter below; usually no markings of any kind but sometimes with white fin tips, especially on young specimens . . . . . *H. canescen*

7b. Length of anal fin base 1.5 or more times the length of the second dorsal fin base; adults less than 400 mm long; color uniform gray or brown in adults or with darker saddle blotches often poorly defined or limited to the region of the first dorsal fin and posterior to it; young may have white markings . . . . .

8a. Roof of mouth with numerous small papillae; eye length in adults less than 14 times in distance from tip of snout to first dorsal origin; adults 240 to 285 mm . . . . . *H. hispidu*

8b. Roof of mouth without papillae; eye length in adults 14 or more than 14 times in distance from tip of snout to first dorsal origin; adults 270 to 345 mm . . . . . *H. lutariu*

Halaelurus boesemani Springer and D'Aubrey
Figures 36, 37

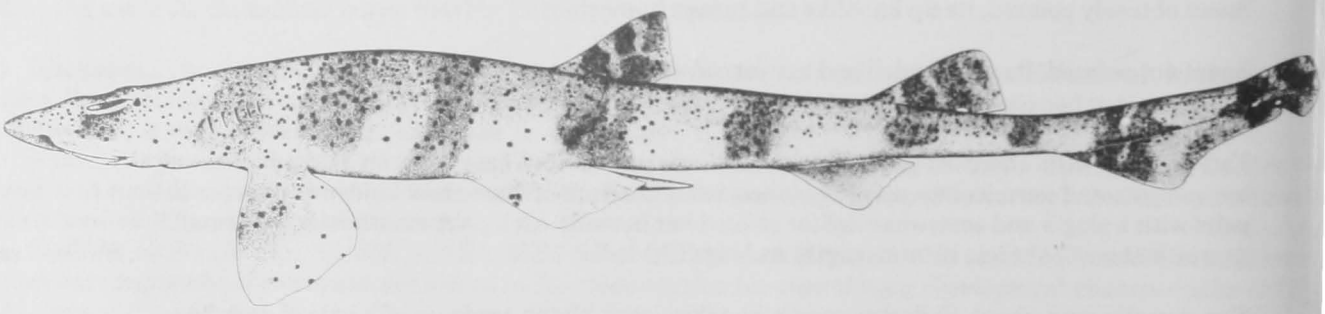


Figure 36.—*Halaelurus boesemani,* adult male 447 mm, from coast of Somalia. The arrangement of spots varies; in some specimens the spots ar clustered to a greater extent. Drawing by Mildred Carrington.

Scyllium bürgeri (not of Müller and Henle 1841), Bleeker 1856:69, one specimen, Amboina; Günther 1870:404, par adult from Amboina only.

Halaelurus bürgeri (not of Müller and Henle 1841), McKay 1966:68, Western Australia, Besednov 1969:30, Gulf Tonkin.

Scyliorhinus quagga (not of Alcock 1899), Norman 1939:8, Gulf of Aden.

Halaelurus boesemani Springer and D'Aubrey 1972:11, coast of Somalia.

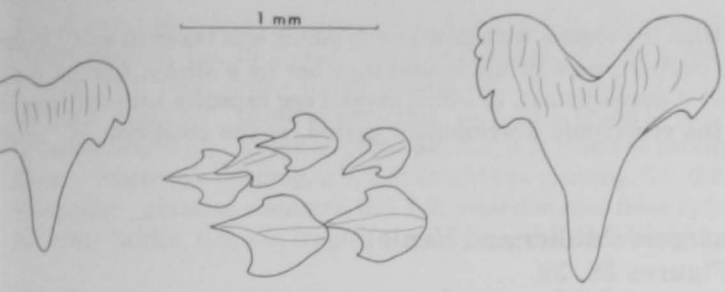


Figure 37.—*Halaelurus boesemani*, upper jaw teeth and dermal denticles. Left, tooth from 436-mm female, 4th row from symphysis. Center, dermal denticles from flank below first dorsal fin. Right, tooth from 432-mm adult male, 4th row from symphysis.

Material examined. USNM 205136, ad. ♂, 430 mm, holotype, coast of Somalia, 67-72 m; 3 ad. ♂, 416-447 mm, 3 ♀, 432-467 mm, damaged but identifiable female with four egg capsules, 1 juv. ♀, 72 mm, all from same locality as otype; BMNH 1939.5.24.1, ad. ♂, 460 mm, Gulf of Aden; BMNH 1858.4.128, marked Frank's collection, ad. ♂, 477 n, Amboina; WAM-P14836, ad. ♂, 430 mm, Western Australia.

Diagnosis. *Halaelurus boesemani* has moderately small but readily visible labial furrows extending for a distance of r more times the greatest diameter of the spiracle along the lower jaws and continuous around the mouth corner for a rter distance along the upper jaw. *Halaelurus boesemani* is a firm-bodied species with imbricate denticles, smooth to ch when rubbed in the head to tail direction. It has a strong pattern of very small dark nearly round spots, the spots ally not much larger than the spiracle and sometimes, although not always, arranged in irregular clusters of from two five spots. The spots usually overlie weakly defined saddle blotches.

Halaelurus boesemani differs from *H. buergeri* in having smaller spots and in having much stronger labial furrows. It fers from *H. quagga* in not having transverse and narrow dark bars or in not having spots arranged in transverse series.

Description. The teeth are small in adults, the largest about 1 mm high. The upper and lower jaw teeth are similar. e middle cusp is by far the longest and accessory cusps, usually one or two on each side of the principal cusp, are so all as to be barely visible. As in most scyliorhinids, the middle cusps are somewhat shorter toward the angles of the s. Vertical striations are present near the tooth bases. There are usually one to three rows of small symphyseal teeth. *H. boesemani* the teeth of an adult male were larger than the teeth of a female of about the same length (Fig. 37). The dermal denticles (Fig. 37) are small, about 0.5 mm long, with a strong median ridge. The denticles are imbricate that the skin is smooth to touch when rubbed in a head to tail direction.

In eight specimens the numbers of monospondylous vertebrae were 33 to 35, the total number of vertebrae 135 to 139. Proportional measurements as percentages of the total length follow, the first figure in each pair refers to the 430-mm ult male holotype, the second to a 467-mm adult female, both from the coast of Somalia. The range of some of the asurements are given in Springer and D'Aubrey (1972, table 3) for nine specimens including one from Western stralia and one from Amboina.

Tip of snout to: front of mouth, 4.0, 4.1; eye, 4.9, 4.4; spiracle, 8.6, 7.9; first gill slit, 13.3, 13.7; fifth gill slit, 17.9, 9; origin first dorsal, 41.9, 43.7; origin pelvic fins, 36.3, 38.8; second dorsal, 67.0, 66.2; origin anal, 59.3, 58.4; upper dal fin, 81.4, 80.3; anterior end cloacal opening, 38.6, 41.3.

Greatest width of: trunk at pectorals, 12.1, 11.8; trunk at pelvics, 7.2, 7.9; trunk at caudal origin (origin of upper dal lobe), 2.1, 1.7.

Greatest height of: trunk at pectoral, 8.1, 9.0; trunk at pelvics, 7.9, 9.0; trunk at caudal origin, 2.8, 3.0.

Eyes: length of eye opening, 3.3, 3.0; height of opening 0.9, 0.9.

Spiracles: greatest diameter, 0.7, 0.6; least distance from eye, 0.5, 0.4.

Mouth: width, 7.9, 5.9; length, 3.5, 3.2; length upper labial furrow, 0.5, 0.4; lower labial furrow, 1.5, 1.0.

Nasal apertures: least distance between, 1.9, 1.9.

Gill slits: height of first, 1.9, 1.3; height of fifth, 0.9, 0.6.

First dorsal fin: length of base, 7.0, 6.0; length free inner margin, 1.6, 1.9; height, 5.1, 4.7; length anterior margin, 7.9.

Second dorsal fin: length of base, 8.1, 6.4; length free inner margin, 1.9, 1.7; height, 4.0, 4.5; length anterior rgin, 8.6, 7.5.

Anal fin: length of base, 8.4, 8.0; length free inner margin, 1.9, 1.7; height, 3.0, 3.0; length anterior margin, 7.2, 8.1.

Pectoral fin: width base, 5.3, 5.4; anterior margin, 10.5, 10.9; greatest width, 8.8, 8.6.

Caudal fin: length upper margin, 18.6, 19.7.

Distance between fin bases: first and second dorsals, 17.1, 15.7; pectoral and pelvic, 14.0, 13.3; pelvic and anal, 5, 13.3; anal and lower caudal lobe, 12.3, 14.3; second dorsal and upper caudal lobe, 7.9, 8.1.

Discussion. *Halaelurus boesemani* on the coast of Somalia retains egg capsules in the oviducts for at least long ugh for embryos to reach 49 to 54 mm and to reach the external gill filament stage of development. A 72-mm juvenile

with yolk stalk attached was collected at about the time the female with developing young was taken in mid-Decembe 1964. Several egg capsules, as many as four in one oviduct, were firmly bound together by a sticky, fibrous materia (Springer and D'Aubrey 1972:15, fig. 4). This method of development, in which several egg capsules with leathery shell are retained in each oviduct for a part or all of the embryonic development period, is the condition of "multipl oviparity" described by Nakaya (1975:83).

Halaelurus buergeri (Müller and Henle)
Figures 38, 39

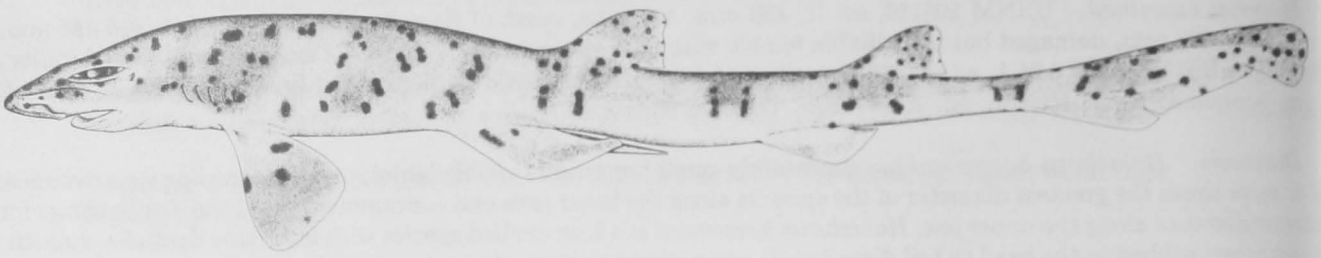


Figure 38.—*Halaelurus buergeri*, 442-mm adult male, Nagasaki, Japan, SU 26791. Drawing by Mildred Carrington.

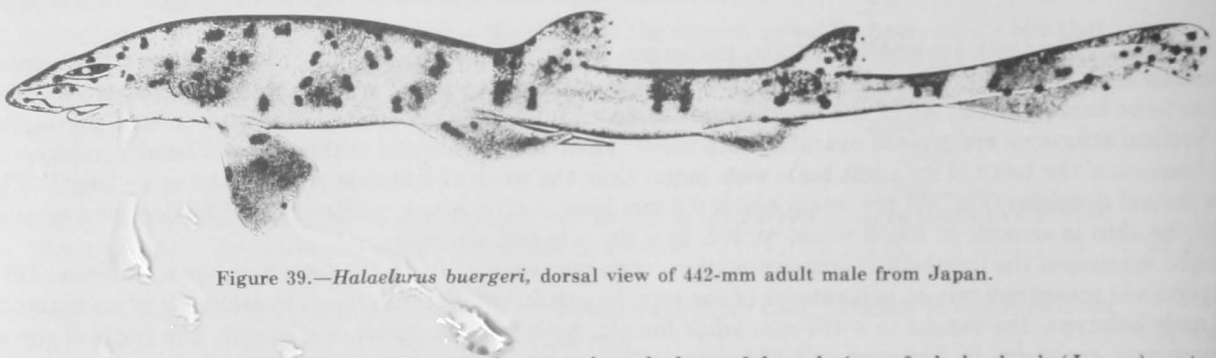


Figure 39.—*Halaelurus buergeri*, dorsal view of 442-mm adult male from Japan.

Scyllium bürgeri Müller and Henle 1841:8, second unnumbered plate of dorsal view of whole shark (Japan), not ventr view of head; Temminck and Schlegel 1850:301; Günther 1870:404 a, b, and c, Japan and Formosa, not d and *Halaelurus bürgeri*: Gill 1862:407 (name only); Jordan and Fowler 1903:601 (part); White 1936b, fig. 1C; Garman 1913: (part); Teng 1962:51, fig. 12; Chen 1963:31, fig. 10; Nakaya 1975:61, figs. 30-32.
Scyliorhinus buergeri: Regan 1908a:461 (part).
Halaelurus buergeri: Springer and D'Aubrey 1972:10, fig. 1C, tables 1-3.

Material examined. SU 26791, 2 ad. ♂, 442, 428 mm, Nagasaki, Japan; BMNH 1862.11.1.38, ad. ♀, 485 m Japan; BMNH 1862.12.26, subad. ♂, 404 mm, ♀, 430 mm, Swintoe's collection, Formosa; BMNH 1869.11.28, purchased of Bleeker (locality not stated but believed to be Japan); ZMK 16.2.1918 (1), imm. ♂, 325 mm, Nagasak Japan; ZMK 16.2.1918 (2), imm. ♀, Nagasaki, Japan, 1911 coll. Jordan.

Diagnosis. *Halaelurus buergeri* has extremely short labial furrows or perhaps none at all in some individuals. It m have perceptible labial furrows at one corner of the mouth but not at the other. In some of the specimens examined t lower labial furrow, when present, was the longer but a turn around the mouth corner into an upper labial furrow cou be seen in most instances. When visible, the lower labial furrow was 2 mm or less and the upper labial continuation the furrow only a fraction of a millimeter long.

Identification of *H. buergeri* should not be made from the labial furrow character alone. *Halaelurus buergeri* does n have a supraorbital shelf and so is easily distinguished from *Scyliorhinus torazame* and *Cephaloscyllium isabell* species that occur in the same geographical areas as *H. buergeri* and have occasionally been confused with it.

Halaelurus buergeri is evidently related closely to *H. boesemani* and the few specimens examined of each species not show overlapping geographical ranges. In specimens examined, the labial furrows of *H. buergeri* were much short and weaker than those of *H. boesemani* and the rounded dark spots in the color pattern of *H. buergeri* were much larger

Description. Proportional measurements of two adult males, SU 26791, from Nagasaki, Japan, are given here percentages of total length, the first figure refers to the 442-mm male, the second to the 428-mm male.

Tip of snout to: front of mouth, 4.1, 4.0; eye, 5.0, 4.9; spiracle, 8.1, 8.6; first gill slit, 13.1, 13.1; fifth gill slit, 16.7, 3; origin pectoral fin, 16.1, 16.1; origin first dorsal, 42.5, 40.2; origin pelvics, 34.2, 33.6; origin second dorsal, 63.8, 64.7; in anal, 58.1, 56.5; origin upper caudal fin lobe, 79.6, 77.8; anterior end cloacal opening, 37.3, 37.1.
Greatest width of: trunk at pectorals, 10.2, 10.3; trunk at pelvics, 6.3, 5.6; trunk at caudal origin, 2.3, 2.1.
Greatest height of: trunk at pectorals, 8.1, 8.2; trunk at pelvics, 7.5, 6.8; trunk at caudal origin, 2.7, 2.8.
Eyes: length eye opening, 2.9, 2.8; height eye opening, 0.9, 0.9.
Spiracles: greatest diameter, 0.8, 1.2; least distance from eye, 0.9, 0.5.
Mouth: width, 6.6, 7.0; length, 4.1, 3.0; length upper labial furrow, barely visible, 0.05; lower labial furrow, absent,

Nasal apertures: minimum distance between, 2.0, 2.1.
Gill slits: height of first, 1.1, 1.2; height of fifth, 0.7, 0.7.
First dorsal fin: length base, 6.3, 6.8; length free inner margin, 2.3, 4.2; height, 3.6, 4.9; length anterior margin, 8.1,

Second dorsal fin: length base, 6.1, 7.2; length free inner margin, 2.0, 1.9; height, 3.6, 3.5; length anterior margin, 8.2.
Anal fin: length base, 6.8, 7.5; length free inner margin, 1.8, 1.9; height, 2.7, 2.3; length anterior margin, 6.3, 6.7.
Pelvic fins: overall length, 11.8, 11.7; claspers reach past tip of pelvic fins, 3.6, 4.9.
Caudal fin: length from origin upper caudal lobe, 20.4, 21.7.
Distance between fin bases: first and second dorsals, 15.2, 16.4; pectoral and pelvic, 13.8, 13.3; pelvic and anal, , 15.7; anal and lower caudal lobe origin, 12.0, 13.2; second dorsal and upper caudal lobe origin, 8.8, 7.2.

he teeth are tricuspid but the lateral cusps of teeth near the middle of the jaws are much smaller than the central p. The teeth of the upper and lower jaws are similar, those of the lower jaw slightly smaller; teeth in about 24 to 28 + 2 4 to 28 rows in the upper jaw, but somewhat fewer in the lower jaw. The largest teeth are about 1 mm high.
ermal denticles of the dorsolateral surfaces of the trunk have three points, the central one much the longest, the den- es about 0.5 to 0.6 mm long. Typical denticles have one strong median ridge, wide or double near the anterior end of blade.
n four specimens of *H. buergeri* the number of monospondylous vertebrae was 33 to 34, total number of vertebrae 132 134.
he adult males examined had no apron formed by union of the inner margins of the pelvic fins but the mature male, mm, had a partial apron, the pelvic fins being united about halfway from base to tips.

iscussion. Springer and D'Aubrey (1972:10, 11) included Hong Kong in the geographical range of *H. buergeri* but ed no specimens from that area. A possible source of the reference to Hong Kong may be a 446-mm gravid female now he California Academy of Sciences collection which is definitely *H. buergeri*, not *H. boesemani* (L. J. V. Compagno, s. commun.). It is VFC, HK98 and was from Shan Island about 160 km southwest of Hong Kong. Specimen records ilable to me indicate that *H. buergeri* is replaced by *H. boesemani* southward from Hong Kong although possibly h some overlap.
oeseman (1947:215) designated as lectotype a specimen collected by Bürger in Japan. It is a stuffed specimen, No. 93 in the Rijksmuseum van Natuurlijke Historie, Leiden. Müller and Henle's (1841) description was based on a cimen in the Leiden Museum. Their description included the statement that there are almost no labial furrows ast Keine Mundwinkelfalten"), but their illustration insert depicting the lower side of the head shows longer and nger labial furrows than I have seen. Their illustration of the whole shark (dorsal view) shows the color pattern of lerately large spots that characterize the eight specimens of *H. buergeri* that I have seen.
vidently *H. buergeri* is rarely caught and preserved. I have seen only eight specimens, all taken more than 60 yr ago. lan and Fowler's treatment (1903) was based on a dried skin from Nagasaki. Garman's (1913) brief description seems ave been based only on the literature. The only correctly labeled specimens in United States collections are the two n the Stanford University collection noted above, and one in the Vanderbilt Foundation Collection (VFC), all three at the California Academy of Sciences.
erhaps because of its rarity or perhaps from reluctance by ichthyologists to accept color pattern as an important racter of a species, *H. buergeri* has sometimes been confused with the common scyliorhinid *Scyliorhinus torazame* of anese waters. Fowler's (1941:45) account of *H. buergeri* was obviously drawn from specimens of *S. torazame*. midt (1930a) found that specimens collected in Tokyo in 1885 and placed in the Zoological Museum, Academy of nce, U.S.S.R., conformed to descriptions of *Scyliorhinus torazame*. Schmidt assumed incorrectly that the species he should be called *Halaelurus torazame* instead of *Scyliorhinus torazame*. In *torazame*, as in other species of *liorhinus*, the upper lip has a very small tab that extends down and over the lower lip when the mouth is closed, so t without close examination it may appear that a labial furrow is continuous around the mouth corner (see under *liorhinus torazame*).
akaya (1975:66, fig. 32) reported that *H. buergeri* has translucent, yellow, and smooth-surfaced egg capsules about nm long and 21 mm wide with long, weak tentacles extending from each end. Several of the egg capsules may be

retained in each oviduct for at least a part of the embryo's development period. This method of development was called multiple oviparity by Nakaya (1975:83). It occurs also in *H. boesemani* (Springer and D'Aubrey 1972:14, fig. 4) and in both *H. lineatus* and *H. natalensis* (Bass et al. 1975:14, 15).

Halaelurus canescens (Günther, 1878)
Figures 40, 41

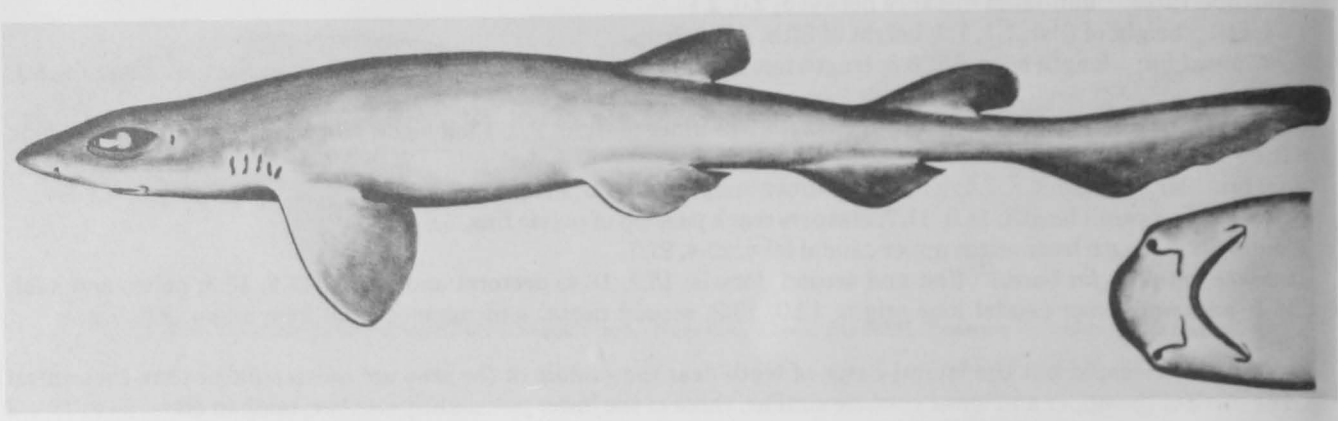


Figure 40.—*Halaelurus canescens*, immature female, 242 mm, coast of Chile, SU 22689.

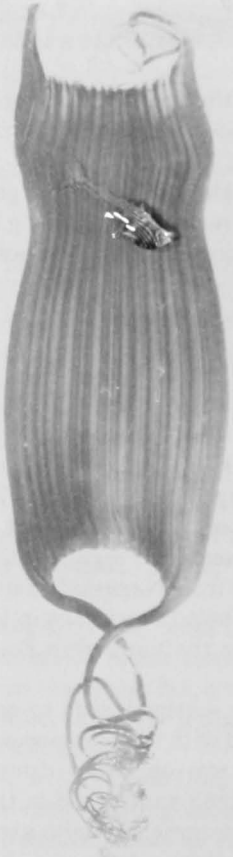


Figure 41.—*Halaelurus canescens*, egg capsule from oviduct of 660-mm specimen from vicinity of Corral, Chile (lat. 39°57'S) in 250-300 m.

Scyllium canescens Günther 1878:18 (Pacific coast of South America); type not seen but according to Garman a female about 275 mm. Probably in British Museum. Not of Alcock 1891:310.
Scyliorhinus canescens: Garman 1899:26; Regan 1908a:461.
Halaelurus canescens: Garman 1913:87; DeBuen 1959:175; Kato et al. 1967:25, fig. 38; Chirichigno 1974:30.

Material examined. SU 22689, imm. ♀, 220 mm, off Chile, *Albatross* stn. 2780; USNM, 2 ♀, gravid, 645, 660 mm, ear Corral, lat. 39°57'S, in 250-300 m, longline, mud and rock bottom, egg capsules from same area; 3 ad. ♂, 550, 630, 0 mm, coast of Chile, lat. 35°26'S, in 290-450 m; 1 ad. ♀, 600 mm, coast of Chile, lat. 33°22'S, in 260-280 m; 1 ad. ♀, 0 mm, coast of Chile, lat. 32°08'S, in 960 m; 7 imm. ♂, 280-435 mm, off Chile, lat. 32°22'S, to lat. 18°10'S off Peru, 0-280 m; 3 imm. ♀, 197-390 mm, off Chile, lat. 33°22'S, in 260-280 m; 1 imm. ♀, 340 mm, lat. 03°57'S, off Ecuador nd northern Peru in 600-700 m.

Diagnosis. *Halaelurus canescens* is one of the drab soft-bodied species of *Halaelurus*. It has no spots, stripes, or ddle blotches. The dorsal surfaces are blackish and the ventral surfaces are variously dusky white to blackish. The dorsal fins of some but not all immature specimens have whitish tips in moderate contrast to the generally dark color. It is e largest species of the genus with adults 450 to 660 mm long.

Halaelurus canescens may be most closely allied to *H. dawsoni* of New Zealand waters but differs in having triangular sal flaps instead of the lobelike flaps that characterize *H. dawsoni*.

Halaelurus canescens is also different from *H. dawsoni* in having the anal fin base length shorter than the distance tween dorsal fin bases in all but juvenile specimens. In *H. canescens* the length of the anal fin base in adults is less an 1.3 times the length of the base of the second dorsal fin whereas it is more than 1.5 times that length in *H. hispidus* nd *H. lutarius*.

Of scyliorhinids from the Pacific coast of South America, *H. canescens* may be confused occasionally with *chroederichthys chilensis*, but among other differences *H. canescens* lacks the supraorbital crest that is prominent in ecies of *Schroederichthys*.

There are superficial resemblances between *H. canescens* and *Parmaturus xaniurus*, a species that may in the future reported from the equatorial eastern Pacific. In *H. canescens* the posterior tip of the second dorsal fin extends far past e anal tip but little, if any, past it in *P. xaniurus*.

Description. *Halaelurus canescens* is a robust scyliorhinid when full grown. It has a wide head with comparatively rge nostrils and a wide mouth that is only moderately arched. The snout is moderately long, that is appreciably longer an the snout in *Cephaloscyllium*, but definitely shorter than the snout in *Apristurus*. The tip of the snout varies in ape from bluntly pointed to broadly rounded. The series of specimens examined shows *H. canescens* to be a variable ecies in many respects but without indication of consistent sex or age differences in tooth form or in morphometrics.

The teeth are small, numerous, and difficult to count because of crowding and because they form both vertical and agonal rows. The largest tooth in a 660-mm specimen was 1.6 mm high above the enamel line. Upper and lower jaw eth are similar in size and shape in immature specimens, but in adults the teeth of the lower jaw appear to be slightly naller than upper jaw teeth and teeth of females slightly smaller than teeth of males. Midjaw teeth are tricuspid but teral teeth may have up to seven points.

Dermal denticles of juveniles are needlelike and nearly erect as in many other scyliorhinids and show little development of lateral points. Denticles of dorsolateral surfaces of adults are wider, usually less erect, and sometimes have ints on their lateral blade expansions. Denticles of dorsolateral surfaces of a 660-mm female were 0.8 to 1.0 mm long thout lateral points; denticles from fin surfaces were 0.4 to 0.5 and were tridentate.

Gill rakers about 3 mm high, three to six somewhat irregularly placed on both sides of gill bars.

Liver large, posterior tips extending to or past cloaca; one functional ovary (right); one female 660 mm had one egg psule with strong longitudinal ridges (see Fig. 41) in each oviduct. Each egg capsule contained one egg about 22 mm in ameter. The egg capsules were about 66 by 32 mm. These and several other egg capsules from the coast of Chile had m 12 to 18 longitudinal ridges, the ridges about 2 mm high.

Valvular intestines in several specimens dissected had seven turns.

Proportional measurements expressed as percentages of the total length follow. The first figure in each measurement tegory refers to an adult male 640 mm long, the second figure to a 660-mm adult female, and the third to a 197-mm venile female.

Tip of snout to: front of mouth, 4.5, 5.1, 5.8; eye, 5.1, 5.5, 5.8; spiracle, 10.0, 11.5, 11.2; first gill slit, 16.4, 16.1, 17.3; h gill slit, 21.1, 20.3, 20.8; origin pectoral, 20.3, 18.6, 20.3; origin first dorsal fin, 46.9, 48,0, 41.6; pelvic fins, 43.8, 46.1, 1; origin second dorsal fin, 64.1, 64.2, 56.9; origin anal fin, 59.4, 58.3, 49.2; upper caudal lobe, 77.3, 76.8, 72.1.

Greatest width of: trunk at pectoral origin, 11.1, 15.0, 10.7; trunk at pelvic origin, 5.8, 7.9, 4.1; trunk at caudal gin, 1.6, 1.9, 1.8.

Greatest height of: trunk at pectoral origin, 8.4, 10.5, 7.6; trunk at pelvic origin, 7.7, 9.1, 6.1; trunk at caudal gin, 3.1, 3.0, 3.0.

Eyes: horizontal diameter, 3.9, 5.0, 5.3; vertical diameter, 1.1, 1.5, 1.5.

Spiracles: greatest diameter, 0.8, 1.1, 0.6; least distance from eye, 0.9, 0.8, 0.7.

Mouth: width, 8.4, 10.3, 7.6; length, 4.5, 4.8, 4.3; length upper labial furrow, 0.8, 0.8, 0.5; length lower labial row, 1.5, 2.0, 1.5.

Nostrils: least distance between, 1.9, 2.0, 2.3.

Gill slits: height of first, 2.7, 3.3, 1.8; height of fifth, 2.0, 2.3, 0.8.

First dorsal fin: length base, 5.6, 6.1, 6.3; length posterior tip (= free inner margin), 3.0, 4.2, 2.3; height, 5.0, 5.2 4.6; length anterior margin, 8.9, 10.8, 9.1.

Second dorsal fin: length base, 6.9, 7.3, 8.1; length posterior tip, 2.3, 3.6, 2.5; height, 4.2, 5.0, 4.1.

Anal fin: length base, 7.5, 9.2, 10.2; height, 3.4, 5.2, 2.5.

Pectoral fins: width base, 5.6, 6.8, 4.3; anterior margin, 10.9, 13.5, 10.7; greatest width, 10.5, 11.7, 8.4.

Pelvic fins: overall length, 10.8, 13.3, 9.4; projection of clasper past posterior fin tips, 5.0, —, —.

Distance between fin bases: first and second dorsal, 9.1, 9.5, 11.6; pectoral to pelvic, 13.5, 21.2, 17.2; pelvic to ana 6.1, 6.2, 8.9.

The vertebral numbers in 19 specimens that were collected over a great range in latitude 3° to 35°S were 39 to 4 monospondylous and 117 to 131 in total number.

Discussion. *Halaelurus canescens* is an egg-laying and highly variable species, rather common south of the Equato to about lat. 35°S.

The stomach contents of a few specimens that were dissected were empty or contained remains that were not iden tifiable but appeared to be mostly invertebrates. Most of the specimens seen were trawled from mud bottom, but a fe were collected from rock and mud areas on bottom longlines.

Halaelurus dawsoni Springer, 1971
Figure 42

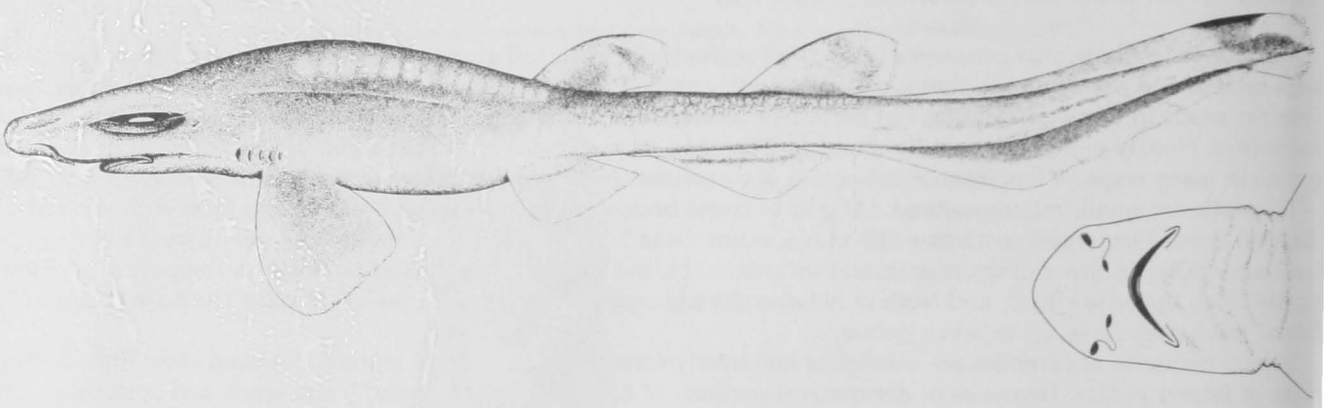


Figure 42.—*Halaelurus dawsoni*, immature female, 186 mm, from 371-375 m near Auckland Islands, New Zealand. The row of light-colored spots on the dorsolateral surface is not present on the few other known specimens, all of which are larger. Drawing by Mildred Carrington

Halaelurus dowsoni Springer 1971:235, fig. 1 (west of southern South Island, New Zealand).

Material examined. DMW 5188.1, subad. ♂, 349 mm, holotype, trawled from 389-420 m west of southern Sout Island, New Zealand, lat. 44°32.5′S, long. 166°41′E, 20 November 1970; DMW 5523, 3 ♀, 2 imm. ♂, 241 to 250 mm fro same haul as holotype; USNM 206096, 1 imm. ♂, 324 mm, same haul as holotype, paratypes; USNM 205537, 1 imm. 186 mm, trawled from 371-375 m near Auckland Islands, N.Z., lat. 50°01′S, long. 167°49′E; N.Z. Oceanographic Ins Stn. F89, P.187, 1 ♀, 242 mm, from Auckland Islands location.

Diagnosis. *Halaelurus dawsoni* belongs with *H. canescens*, *H. Lutarius*, and *H. hispidus*, that is, with the dra colored and more or less soft-bodied species of the genus. The specimen shown in the accompanying illustration (Fig. 4 was the only one of the type-series with the rows of white dorsal spots but all had broad bands or areas of white at the f tips.

Halaelurus dawsoni probably reaches 350 to 450 mm as suggested by the 349-mm subadult male holotype which h large but flexible claspers. It is thus a larger species than *H. hispidus* but a smaller species than *H. canescens*. The nas flaps in *H. dawsoni* are lobelike and have nearly parallel lateral margins. The nasal flaps of other *Halaelurus* speci are triangular or nearly so.

The length of the base of the anal fin in *H. dawsoni* is about as great or greater than the distance between dorsal f bases. In all other *Halaelurus*, except *H. hispidus* and *H. canescens*, the distance between dorsal bases is much t greater. In *H. hispidus* and *H. canescens* the interdorsal distance usually is greater.

Description. *Halaelurus dawsoni* has moderately large fins, the dorsals lobelike, the second somewhat greater in area ıan the first. The pectorals are broad and short and the anal fin is low on a long base, the ends of its base separated espectively from the base of the pelvics and the origin of the lower caudal lobe by distances less than the horizontal iameter of the eye.

The origin of the first dorsal is over or in advance of the middle of the pelvic base and the second dorsal originates ove the middle of the pelvic base.

The body is relatively soft with somewhat loose skin. The gill slits in the specimens seen are short and the spiracle nall, its greatest diameter about equal to its least distance from the eye.

The teeth are small and crowded, and most of them have five cusps, the central cusp longest in the midsections of the ws, the largest about 1 mm high in the 349-mm specimen, in about 64/70 rows.

The dermal denticles of specimens under 300 mm long were somewhat needlelike and erect, mostly with a single osterior point and only slight lateral expansions of the blades, the expansions with or without points. In the largest ecimen, the 349-mm male, the denticle blades were wider with lateral points more or less strongly developed.

Vertebral numbers: monospondylous vertebrae in holotype 36 (range in eight others 36 to 38); precaudal vertebrae 67 ange 67-73), caudal vertebrae about 57 (range about 55 to 62); total number 124 (range 124 to 129).

Measurements of three specimens are given below as percentages of their total lengths. The first figure in each series efers to the 349-mm subadult male holotype, the second to a 334-mm female, and the third to a 186-mm female.

Tip of snout to: front of mouth, 5.4, 5.4, 6.7; eye, 5.4, 5.7, 7.0; spiracle, 10.9, 11.1, 12.6; first gill slit, 14.6, 14.4, 17.2; fth gill slit, 18.9, 17.7, 19.9; origin first dorsal, 45.8, 44.9, 41.9; origin second dorsal, 60.5, 60.8, 57.5; origin pelvics, 39.5, 1.9, 40.3; origin anal fin, 54.7, 54.2, 50.5; origin upper caudal fin, 71.6, 71.3, 68.8; anterior end cloacal opening, 45.3, 4.9, 42.5.

Greatest width of: trunk at pectoral origin, 12.3, 12.0, 10.8; trunk at pelvic origin, 7.2, 6.0, 5.4; caudal peduncle, 3, 2.1, 1.9.

Greatest height of: trunk at pectoral origin, 7.2, 8.1, 8.6; trunk at origin pelvics, 8.3, 6.6, 7.5; caudal peduncle, 3.7, 6, 3.2.

Eyes: horizontal diameter, 4.9, 4.0, 3.8; vertical diameter, 0.6, 0.7, 1.1.

Spiracles: greatest diameter, 1.1, 0.9, 0.4; least distance from eye, 1.1, 0.9, 0.8.

Mouth: width, 8.0, 7.5, 7.5; length, 3.4, 3.3, 3.3; length upper labial furrow, 0.9, 0.7, 0.4; length lower labial furrow, 0, 1.8, 1.8.

Nasal openings: minimum distance between, 2.9, 2.4, 2.7.

Gill slits: height of first, 1.6, 2.4, 1.2; height of fifth, 0.9, 0.9, 1.1.

First dorsal fin: length base, 6.9, 6.9, 7.2; length free inner margin, 2.6, 2.1, 2.7; height, 5.4, 4.8, 3.2; anterior argin, 10.3, 10.2, 9.7.

Second dorsal fin: length base, 7.7, 8.1, 8.6; length free inner margin, 2.9, 2.1, 2.7; height, 5.2, 5.1, 3.2; anterior argin, 11.5, 11.4, 11.3.

Anal fin: length base, 11.5, 10.8, 11.6; length free inner margin, 2.0, 2.4, 2.7; height, 4.3, 4.5, 4.3; length anterior argin, 8.3, 8.1, 8.6.

Pectoral fins: width base, 6.3, 6.6, 5.8; length anterior margin, 12.9, 14.4, 12.4; greatest width, 9.2, 10.2, 9.7.

Pelvic fins: overall length, 11.2, 12.3, 8.6; inner margin claspers, 9.7, —, —,; reach claspers past fin tip, 2.9, —, —.

Distance between fin bases: first and second dorsal, 9.5, 9.6, 10.2; pectoral and pelvic, 17.2, 20.1, 13.4; pelvic and al, 6.6, 5.1, 4.3; anal and origin lower caudal lobe, 4.0, 2.4, 3.8; second dorsal and origin upper caudal lobe, 2.6, 2.7, 1.9.

Discussion. The four soft-bodied, drab-colored species of *Halaelurus* now known are from widely separated areas: *tarius* from the east coast of Africa, *hispidus* from India and the Andaman Islands, *dawsoni* from New Zealand waters, d *canescens* from the west coast of South America. It seems likely that more exploration of moderately deep water on ntinental or island slopes between these areas would reveal more species. *Halaelurus dawsoni* ranges farther south an the other species insofar as ranges are known.

No information on reproductive habits of *H. dawsoni* is now available.

Halelurus hispidus (Alcock)
Figure 43

yllium hispidum Alcock 1891:21 (Andaman Sea, *Investigator* stn. 115, 344-402 m); Alcock 1899:15 (Andaman Sea, 344-766 m); Alcock 1900, figs. 3, 3a, pl. 8 (pl. 8 dated 1894).

yliorhinus hispidus: Regan 1908a:460 (Andaman Sea).

laelurus hispidus: Garman 1913:85 (Andaman Sea); Springer and D'Aubrey 1972:8, figs. 1B and 2B (Andaman Sea); Nair and Lal Mohan 1973:71, fig. 1 (Gulf of Mannar).

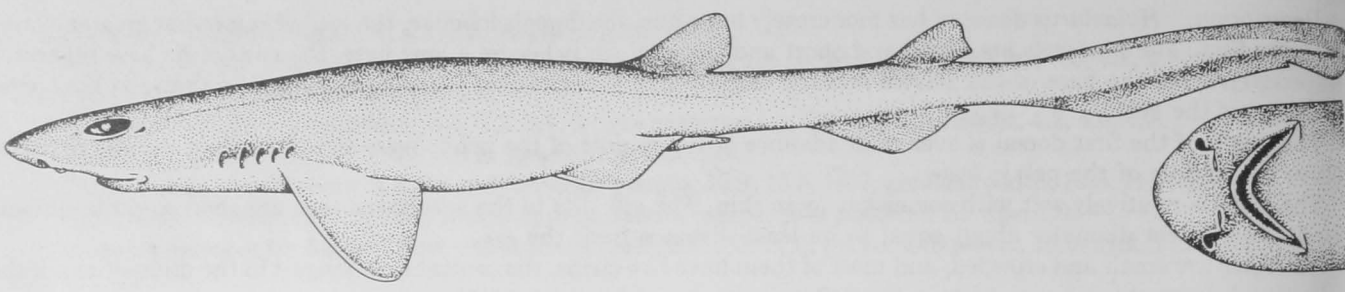


Figure 43.—*Halaelurus hispidus*, a 245-mm adult male from Andaman Sea.

Material examined. BMNH 98.7.13.21 (227/1), ad. ♂, about 237 mm, Andaman Sea, 344-402 m, holotype; USNM, (imm. ♂, 195 to 220 mm, 3 ad. ♂, 240 to 260 mm, 1 ad. ♀, 285 m, all from Andaman Sea, in 293 m at lat. 10°39'N long. 97°06'E.

Diagnosis. *Halaelurus hispidus* is the smallest species of the genus. Alcock's largest specimen in a series of six wa 280 mm; the largest USNM specimen was 285 mm; and of more than 100 reported by Nair and Lal Mohan from the Gul of Mannar the largest was 265 mm.

Halaelurus hispidus belongs with *canescens*, *dawsoni*, and *lutarius*, species of *Halaelurus* without a characteristi pattern of dark spots, bars, or saddle blotches as adults. Nair and Lal Mohan (1973) described the first *hispidus* take outside the Andaman Sea and also reported on smaller specimens than had previously been collected. They observe great variation in color among 130 Gulf of Mannar specimens, mostly immature, from a single haul. Some were pal brown with gray crossbands, some had white markings, and a few were almost white with scattered patches of darke pigmentation.

Alcock's first description (1891) of *H. hispidus* noted that the walls of the buccal cavity and the surface of the tongu are covered with small papillae. These papillae were not mentioned in Alcock's second account of the species (1899) no did Nair and Lal Mohan (1973) mention their presence. Papillae were present on the tongue and over most of the mouth lining in the specimens I examined but were absent in *lutarius*; *dawsoni* has only a few papillae anteriorly on the roof o the mouth and on the tongue; *canescens* has numerous and rather large mouth papillae.

Halaelurus hispidus has nearly triangular and moderately large nasal flaps, quite different from the lobelike nasa flaps of *dawsoni*.

Halaelurus hispidus is nearest to *H. lutarius* but is a little smaller and has proportionally a somewhat larger eye than *lutarius*.

Description. Following are measurements expressed as percentages of the total length. All three specimens are from the Andaman Sea. The first figure in each series represents a 255-mm adult male, the second a 285-mm adult female and the third an immature male 193 mm long.

Tip snout to: front of mouth, 5.3, 5.3, 5.9; eye, 5.3, 5.6, 6.7; spiracle, 10.4, 10.0, 10.6; first gill slit, 16.1, 15.4, 16.6 fifth gill slit, 20.6, 21.4, 22.8; origin pectoral fin, 19.6, 20.7, 21.8; origin first dorsal, 46.3, 47.7, 44.6; origin pelvic fins, 42.0 43.5, 40.9; origin second dorsal, 65.1, 65.3, 62.2; origin anal fin, 60.4, 60.7, 57.0; origin upper caudal fin lobe, 75.3, 77.6 74.1; anterior end cloacal opening, 44.3, 46.0, 42.5.

Greatest width at: origin pectorals, 10.2, 10.5, 10.4; origin pelvics, 5.1, 5.3, 5.7; caudal base, 1.2, 1.4, 2.1.

Greatest height at: origin pectorals, 6.7, 6.7, 8.3; origin pelvics, 5.9, 6.7, 6.5; caudal base, 2.7, 2.8, 2.9.

Eyes: horizontal diameter, 3.9, 3.7, 3.4; vertical diameter, 1.6, 0.7, 1.3.

Spiracles: greatest diameter, 0.6, 0.7, 0.5; least distance from eye, 0.8, 0.8, 0.8.

Mouth: width, 8.8, 8.4, 9.8; length, 4.3, 5.3, 3.6; length upper labial furrow, 0.8, 1.0, 0.8; lower labial furrow, 1.6 1.8, 1.3.

Nasal openings: least distance between, 2.7, 2.8, 2.6.

Gill slits: height of first, 1.6, 1.1, 1.3; height of fifth, 1.2, 0.9, 0.9.

First dorsal fin: length base, 5.5, 6.0, 4.9; length free inner margin, 1.6, 1.9, 1.6; height, 4.7, 3.9, 4.4; anteri margin, 7.8, 7.7, 7.8.

Second dorsal fin: length base, 5.5, 6.7, 6.2; length free inner margin, 1.8, 1.8, 1.8; height, 2.5, 2.5, 3.4; lengt anterior margin, 6.7, 7.4, 7.2.

Anal fin: length base, 9.8, 10.5, 10.4; length free inner margin, 1.6, 1.4, 1.3; height, 3.1, 2.1, 3.1; length anteri margin, 7.1, 6.3, 5.7.

Pectoral fins: width base, 5.1, 4.9, 5.2; greatest width fin, 9.0, 8.4, 7.8; length anterior margin, 11.8, 12.3, 10.4.

Pelvic fins: overall length exclusive of claspers, 9.8, 10.5, 8.8; length inner margin claspers, 8.6, —, 4.4; exter claspers beyond posterior pelvic fin tip, 3.1, —, 1.0.

Least distance between fin bases: first and second dorsals, 10.6, 11.2, 11.4; pectoral and pelvic, 15.7, 17.6, 14.5; elvics and anal, 9.4, 11.9, 9.6.

In 11 *H. hispidus* the number of monospondylous vertebrae ranged from 35 to 38 and the total number of vertebrae om 123 to 131.

The teeth of upper and lower jaws similar, those in the central part of the upper jaw with a high central cusp and a low ateral cusp on each side; some teeth near the corners of the mouth with four or more cusps, the cusp lengths nearly qual; teeth numerous and crowded with number of vertical rows difficult to count. In one adult male I counted 4+36/42+41 vertical rows.

Dermal denticles spikelike in juveniles and tridentate in large specimens, the blades rather wide in adults.

Inside of mouth with numerous papillae; gill rakers present only as low humps on gill bars, intermediate in relative ze between those of *H. lutarius* and *H. canescens*.

Liver of moderate size, not notably oil-filled, valvular intestine with 8.5 to 9.0 turns.

A 216-mm female had many small eggs 2 to 4 mm in diameter in its functional right ovary, but was considered im- ature because its oviducts were very slender and appeared underdeveloped for an adult. A 285-mm female had only ne egg, 15 by 21 mm in diameter, in its ovary. The oviducts were empty but well developed. Relative to the size of the other the ovarian egg was remarkably large.

Discussion. Both *Halaelurus hispidus* and *H. lutarius* are variable but are generally similar in many characters. As resently known, however, I believe their separation as distinct species is justified.

The known geographical range of *H. hispidus* extends only from the Gulf of Mannar at the southern tip of India partly cross the Bay of Bengal to the Andaman Sea. It is thus separated by very large distances from the geographical areas of s relatives, *H. lutarius* on the east coast of Africa and *H. dawsoni* near New Zealand. Presumably additional continen- al and island slope collecting would extend the range of *H. hispidus*.

The name *hispidus* presumably comes from the hairlike papillae in the mouth of the Andaman Sea specimens. It ould be useful to know whether Gulf of Mannar specimens also have papillose mouths. The separation of *hispidus* and *tarius* depends strongly on the presence or absence of papillae, especially because morphometric differences and ifferences in vertebral number in scyliorhinids may often reflect only differing conditions at different latitudes.

Halaelurus lineatus Bass, D'Aubrey, and Kistnasamy
Figures 44, 45, 46

Figure 44.—*Halaelurus lineatus*, 330-mm immature female taken off Durban, South Africa, in 68-70 m.

laelurus lineatus Bass, D'Aubrey, and Kistnasamy 1975:12, fig. 8A (Durban, Natal, South Africa, from shore).

Material examined. USNM 214224, imm. ♂, 340 mm, cruise 8, IIOE stn. 1948, from shrimp trawl haul in 68-70 m off rban, South Africa, lat. 29°27'S, long. 31°31'E, 25 September 1964; USNM, 2 imm. ♂, 313, 357 mm, 3 imm. ♀, 313, 3, 351 mm, from same haul as preceding; USNM, ad. ♂, 475 mm, off Durban; SAM 10556, ad. ♀, 457 mm, off Natal.

Diagnosis. *Halaelurus lineatus* is similar to *H. natalensis* in many respects and both differ from other *Halaelurus* ecies and from all other scyliorhinids also in having a pointed and upturned snout tip. This character had not been ted in accounts earlier than the 1972 report of Springer and D'Aubrey even as a feature of *H. natalensis* probably cause small sharks preserved in glass containers often have snouts deformed by being pushed into a too small space. ne turned up snout tip of *H. lineatus* and *H. natalensis*, is easily seen when the sharks are alive. It is a little ore prominent in *H. natalensis* than in *H. lineatus*.

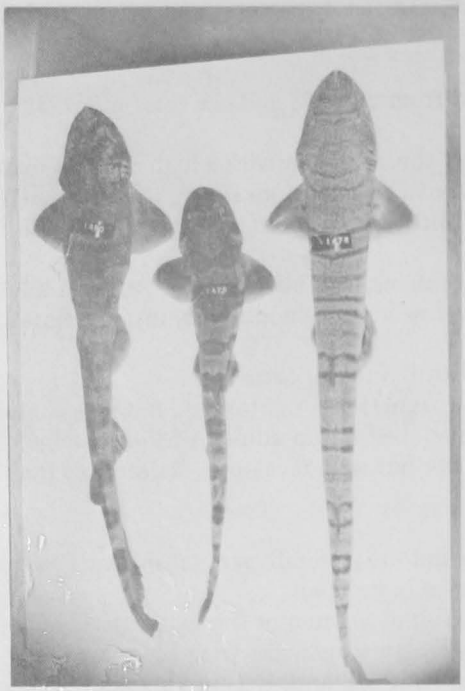


Figure 45.—Left, two *Halaelurus natalensis*, Algoa Bay, South Africa. Right, 475-mm female *H. lineatus* taken off Durban.

Figure 46.—*Halaelurus lineatus*, 457-mm female, Natal, South Africa, SAM 10556.

Halaelurus lineatus is easily distinguished from *H. natalensis* by its color pattern (see Figs. 44 and 45). Characteristically *H. lineatus* has many small dark spots, as small or smaller than the spiracle, between transverse dark bars that cross the dorsal surface. *Halaelurus natalensis* has no such spots. In *H. lineatus* some specimens have a single transverse row of spots between some of the bars as does *H. quagga*. *Halaelurus quagga* does not have an upturned snout tip. Some *H. lineatus* have small spots on the two dorsal fins and near the caudal fin tip, but one specimen, SAM 10556, has no fin spots. Small spots were not seen on any of the specimens of *H. natalensis* that were examined.

Few differences in body and fin proportions seen among specimens of *H. lineatus* and *H. natalensis* were sufficiently great to appear significant. The fins of *H. lineatus* were slightly smaller. The distances between dorsal fin bases in all specimens of *H. lineatus* seen were more than 75% TL but were less than 15% TL in specimens of *H. natalensis*

Skin surfaces of *H. lineatus* feel appreciably smoother than those of *H. natalensis* apparently because *H. natalensis* nticles have their points directed upward as well as posteriorly.

Description. A medium sized but slender cat shark, males 337 and 357 mm not mature, a male 475 mm and a female 7 mm probably mature; whether young hatch from egg capsules or carried in oviducts until birth is not known. Abdominal trunk short as in other *Halaelurus* with firm bodies, distance from tip of snout to anterior end of cloacal ening about 40% TL or less, both abdominal and caudal sections of trunk more or less cylindrical; head moderately ort and flattened; snout pointed but not long, its length to front of mouth considerably less than width of mouth, tip of out a rounded point slightly turned upward, somewhat knoblike, dermal denticles of snout tip whitish; lateral margins snout with moderately acute edges.

Mouth rather wide, its arch low; labial furrows continuous around the mouth corners, upper furrow about one-fourth long as lower furrow, lower furrow about half as long as eye; inner posterior ends of nasal apertures close together, parated by a distance about equal to half of eye length; nasal flaps broadly triangular, their sides meeting at about 90° form flap tips; flaps entirely covering posterior inner part of nasal aperture, their posterior margins close to anterior per lip, separated from it by a distance less than diameter of spiracle.

Eyes moderate, a little more than 5% TL in half-grown or adult individuals; no supraocular shelf of cranium but angle view of eyes more lateral than dorsal; subocular gutter fully scaled, well developed, about as long as length of eye; iracle moderately large, opening elongate, its length about half eye length, its position very near posterior eye corner, her near, in, or continuous with, subocular gutter, its distance from eye less than half its greatest diameter.

Gill slits short, progressively shorter from first to fifth, the last two over the pectoral base.

Fins rather small; pectorals short and broad, their greatest widths only a little less than their greatest lengths, pressed pectoral tips to origin of pelvics only a little more than snouth length, distance from pectoral base (axil) to igin pelvics 12 to 15% TL in specimens examined, probably greatest in mature females; pelvic fins rather long th moderate lateral projection; claspers not notably large or long, clasper tips of adult males not reaching origin anal fin; dorsal fins of nearly equal size, the first usually a little greater in area, the distance between dorsal fin ses 16 to 18% TL in specimens examined, first dorsal origin a little posterior to midpoint of pelvic fin base, second rsal origin a little anterior to posterior end of anal fin base; anal fin relatively smaller in area than other fins, lower an dorsal fins, the length of its base only a little greater than length of either dorsal fin base.

Teeth small, crowded, tricuspid near middle of jaws, five to seven cusps at angles, in about 60 vertical rows in upper w, 55 in lower, the longest in the holotype about 0.5 mm, symphyseals not well defined, upper teeth very slightly larger an lower but not greatly different in shape.

Dermal denticles imbricate and small posterior blades of dorsolateral denticles with three points, the points posterior- at angle not greater than 40° above body surface, all surfaces when rubbed from head toward tail smooth and firm. In- de of mouth covered generally with very small denticles; papillae in mouth confined to fringe of jaw area; no gill rakers, cept a lump less than 1 mm high on each gill bar.

Ventral surfaces whitish without spots or markings on body or fins; dorsolateral surfaces brown with a pattern of rker transverse bars and between bars small darker brown spots, the small spots generally as small or smaller than iracle but tending to coalesce to form irregular vermiculations. Inside of mouth whitish.

Following are measurements expressed as percentages of total length. The first figure in each series represents the 340- m subadult male holotype, the second a 330-mm immature female, and the third the 457-mm adult female.

Tip of snout to: front of mouth, 5.3, 5.3, 5.3; eye, 5.6, 5.8, 5.3; spiracle, 9.1, 8.9, 7.9; first gill slit, 13.6, 13.6, 12.5; th gill slit, 17.7, 17.9, 16.0; origin pectoral, 16.2, 17.3, 15.5; origin first dorsal, 41.6, 41.2, 42.0; origin pelvics, 35.4, 35.1, .6; origin second dorsal, 64.9, 63.3, 64.5; origin anal fin, 54.6, 56.4, 56.2; origin upper caudal fin lobe, 79.1, 80.3, 81.0; terior end cloacal opening, 39.2, 38.8, 38.9.

Greatest width of: trunk at pectoral origin, 11.5, 9.7, 10.5; trunk at pelvic origin, 6.5, 6.7, 7.7; caudal peduncle, 2.4, , 2.6.

Greatest height of: trunk at pectoral origin, 8.5, 9.1, 7.7; trunk at origin pelvic fins, 7.9, 8.2, 8.6; caudal peduncle, , 3.0, 3.3.

Eyes: horizontal diameter, 3.5, 3.0, 2.8; vertical diameter, 1.2, 0.9, 0.7.

Spiracles: greatest diameter, 1.5, 1.5, 1.3; least distance from eye, 0.9, 0.9, 0.4.

Mouth: width, 7.7, 7.0, 5.9; length, 3.0, 2.1, 2.2; length upper labial furrow, 0.9, 0.6, 0.7; lower labial furrow, 1.8, , 1.3.

Nasal apertures: least distance apart, 1.9, 1.7, 2.2.

Gill slits: height of first, 1.8, 2.0, 1.8; height of fifth, 0.9, 0.8, 0.9.

First dorsal fin: length base, 5.3, 6.5, 5.9; length posterior inner margin, 2.7, 2.1, 1.8; height, 5.0, 4.5, 5.0; length terior margin, 8.0, 7.6, 7.2.

Second dorsal fin: length base, 5.0, 6.5, 5.7; length posterior inner margin, 2.1, 2.1, 1.8; height, 4.1, 3.9, 3.9; length terior margin, 6.8, 7.6, 7.2.

Anal fin: length base, 7.4, 7.0, 7.0; length posterior inner margin, 3.0, 2.6, 2.2; height, 3.5, 2.9, 2.8; length anterior margin, 6.5, 6.4, 6.3.

Pectoral fin: width base, 4.7, 4.8, 4.6; length anterior margin, 11.21, 10.6, 10.9; greatest width, 8.9, 9.1, 9.0.

Pelvic fin: overall length, 12.9, 12.1, 12.0; inner margin clasper, 11.2, —, —; reach clasper past posterior tip pelvic fin, 1.8, —, —.

Least distance between fin bases: first and second dorsals, 16.8, 17.3, 17.1; pectoral and pelvic, 15.3, 12.1, 13.8; pelvic and anal, 13.2, —, 13.8; anal and origin lower caudal lobe, 13.2, —, 14.7; second dorsal and origin upper caudal lobe, 9.1, 11.2, 9.8.

Vertebrae numbers in 457-mm adult female were, monospondylous 34, percaudal 92, caudal 47, total vertebra 139.

Discussion. *Halaelurus lineatus* probably shares more characters in common with *H. natalensis* than with other species of the genus and seems to be in some ways intermediate between *H. quagga* and *H. natalensis*. The turned up snout tip is absent on *H. quagga*, present but weak on *H. lineatus*, and strong on *H. natalensis*. The pattern of transverse bars with transverse rows of dots or small spots is present on *H. quagga*; it is present but confused by additional markings on *H. lineatus*; and it is transformed to a pattern of dorsal saddles on *H. natalensis*.

Bass et al. (1975:13, 14) described *H. lineatus* partly from the 500-mm holotype that was caught on a hook and line from shore at Durban. The capture of a scyliorhinid by hook and line from shore underlines the littoral to upper continental slope distribution of many of the scyliorhinids of the southeastern coast of Africa in contrast to the restricted slope distribution of scyliorhinids on the eastern continental slope of North America. One of the *H. lineatus* paratypes was trawled from 290 m off Durban. The known range of *H. lineatus* extends from the Natal coast to the vicinity of Beira, Mozambique.

Bass et al. (1975:13, 14) summarized breeding data for *H. lineatus* in the following statement. "Pregnant females of this oviparous species are caught in the surf in Natal during late winter (July to September). The egg-cases measure about 40 by 20mm and have long but very thin weak tendrils. They are covered with a coating of short sticky hairs which help them to adhere to the substrate. The embryos are fairly advanced, measuring 30 to 40 cm in length, when the egg-cases are laid. Females carry up to eight egg-cases in each uterus simultaneously. A series of egg-cases laid in tanks at the Durban Aquarium hatched out between 23 and 36 days after deposition (at a water temperature averaging between 19 and 20°C)."

Halaelurus lutarius Springer and D'Aubrey
Figure 47

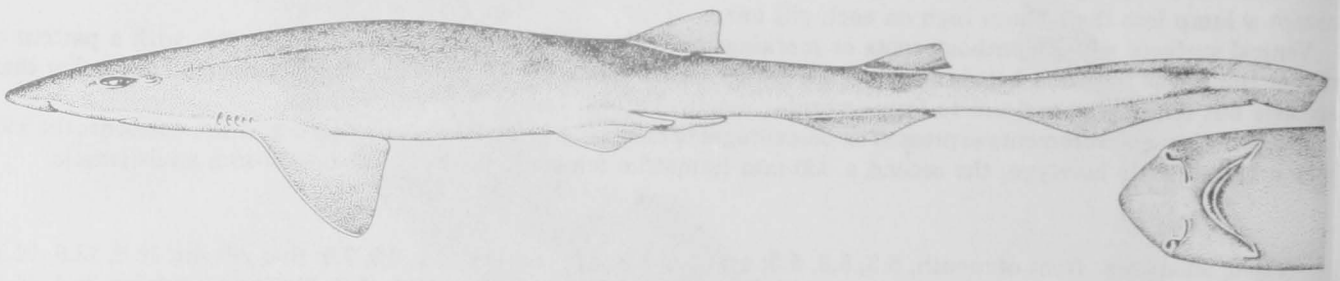


Figure 47.—*Halaelurus lutarius*, 313-mm adult male, Delagoa Bay, Mozambique.

Halaelurus lutarius Springer and D'Aubrey 1972:6, figs. 1A, 2A (off Delgoa Bay, Mozambique); Smith 1975:13.
Scylliorhinus hispidus (not of Alcock 1891) Brauer 1906:7 (coast of Somalia).

Material examined. USNM 205135, ad. ♂, 326 mm, the holotype, trawled from 450-455 m off Delgoa Bay, East Africa, lat. 25°32'S, long. 33°24'E, 2 ad. ♂, 310, 317 mm and 14 ad. ♀, 310 to 367 mm, same haul as holotype.

Diagnosis. *Halaelurus lutarius* differs from others of the genus except *H. canescens*, *H. dawsoni*, and *H. hispidus* by its lack of prominent dorsal spots or crossbands of lighter or darker color.

Halaelurus lutarius may be distinguished from the larger and more robust *H. canescens* (adults 500 to 650 mm) by its relatively longer anal fin base, 1.5 times the length of the second dorsal base in *lutarius* but less than 1.3 times the length in *canescens*. *Halaelurus lutarius* lacks papillae on the roof of the mouth such as characterize *H. hispidus*. The nasal flap of *lutarius* is roughly triangular, quite unlike the lobelike nasal flap in *H. dawsoni*.

Halaelurus lutarius and *H. hispidus* resemble each other in general appearance. *Halaelurus lutarius* is larger, adults 310 to 367 mm for *lutarius* and about 230 to 285 mm for *hispidus*. *Halaelurus lutarius* lacks the small papillae that are

distributed in moderate density over the roof of the mouth and tongue of *hispidus*. In adult specimens examined the eye length in *lutarius* is less relative to total length than the eye length in *hispidus*.

Description. Following are measurements expressed as percentages of the total length. The first number in each series refers to the 323-mm adult male holotype, the second to a 367-mm adult female, and the third to a 310-mm adult female.

Tip of snout to: front of mouth, 5.1, 6.3, 6.1; eye, 6.2, 6.5, 6.8; spiracle, 10.8, 10.6, 11.9; first gill slit, 16.1, 16.4, 16.1; fifth gill slit, 20.7, 20.7, 20.1; origin pectoral fin, 20.4, 19.6, 19.7; origin first dorsal fin, 48.0, 50.1, 49.7; origin pelvic fins, 40.9, 44.1, 45.2; origin second dorsal fin, 65.6, 68.4, 69.0; origin anal fin, 60.4, 64.6, 61.6; origin upper caudal fin lobe, 74.6, 77.9, 78.1; anterior end cloacal opening, 45.2, 46.3, 46.1.

Greatest width of: trunk at pectoral origin, 9.3, 10.9, 10.3; trunk at pelvic origin, 5.0, 6.5, 5.5; caudal base, 1.5, 1.9, 1.9.

Greatest height of: trunk at pectoral origin, 6.2, 8.2, 8.7; trunk at pelvic origin, 7.1, 8.2, 9.4; caudal base, 3.1, 3.3, 3.2.

Eyes: horizontal diameter, 2.8, 3.3, 3.2; vertical diameter, 0.9, 1.1, 1.0.

Spiracles: greatest diameter, 0.3, 0.5, 0.5; least distance from eye, 0.9, 0.7, 0.8.

Mouth: width, 6.2, 8.4, 7.1; length, 4.0, 3.8, 3.9; length upper labial furrow, 1.2, 1.1, 1.5; length lower labial furrow, 1.5, 2.0, 1.6.

Nasal apertures: least distance between, 2.5, 3.0, 3.2.

Gill slits: height of first, 1.1, 1.4, 1.2; height of fifth, 0.9, 1.1, 0.6.

First dorsal fin: length of base, 5.3, 4.8, 5.8; length free inner margin, 2.5, 3.0, 2.3; height, 3.1, 4.1, 3.5; anterior margin, 7.1, 7.6, 7.4.

Second dorsal fin: length base, 5.3, 5.0, 5.3; length free inner margin, 1.9, 2.5, 2.3; height, 2.2, 2.5, 2.4; length anterior margin, 6.2, 6.4, 6.4.

Anal fin: length base, 11.1, 10.2, 10.3; length free inner margin, 1.5, 1.4, 1.5; length anterior margin, 7.1, 5.7, 6.5.

Pectoral fins: width base, 5.0, 5.5, 4.5; greatest width fin, 7.1, 8.2, 7.7; length anterior margin, 10.8, 12.5, 11.0.

Pelvic fins: overall length without claspers, 9.6, 11.0, 10.0; length inner margin clasper, 9.6, —, —; extent clasper past posterior tip pelvic fin, 3.4, —, —.

Distance between fin bases: first and second dorsals, 12.7, 12.0, 13.2; pectorals and pelvics, 17.0, 16.6, 17.1; pelvics and anal, 13.3, 12.5, 11.0.

Of the 17 *H. lutarius* examined, the number of monospondylous vertebrae varied from 38 to 42 and the total number of vertebrae from 129 to 139.

The teeth of *H. lutarius* are tricuspid near the jaw symphyses; the central cusp of each tooth is much the longest. The teeth in the 12 to 15 rows near the mouth corners have lower cusps than those of the midjaw area and usually have about five cusps to each tooth. The teeth of the upper and lower jaws are similar, only slightly smaller and lower in the lower jaw. The larger teeth are coarsely marked with vertical striations at their bases. The teeth are crowded into about 76/86 vertical rows.

The dermal denticles are tridentate over the dorsolateral surfaces, their blades slightly elevated posteriorly.

Mouth papillae generally absent, no distinct gill rakers.

The liver is comparatively small and is confined to the anterior third of the body cavity. The valvular intestine has about 10 turns.

The specimens examined (all adults) were gray-brown above and lighter below without well-defined or prominent spots or bands. Some of the specimens have ill-defined saddle blotch areas, strongest in the second dorsal fin region.

Discussion. *Halaelurus lutarius* is known to occur off the east coast of Africa from the southern coast of Mozambique to the coast of Somalia in 338 to 766 m.

The species is ovoviviparous. The young are retained in the oviducts until they are a little more than 100 mm long. Egg capsules in *H. lutarius* are thin-walled and very fragile bags. Such a capsule or bag would not furnish appreciable protection outside an oviduct to an incompletely formed embryo or to an embryo made somewhat inactive by attachment to a large yolk sac. Bass et al. (1975:12) described an egg capsule of *H. lutarius* as a thin, fragile bag about 50 by 15 mm.

Halaelurus lutarius adults are about 310 to 390 mm long.

Halaelurus natalensis (Regan)
Figures 48, 49, 50

Scyllium natalense Regan 1904:128 (coast of Natal).

Scyliorhinus natalensis: Regan 1908a:461 (Natal and Cape Colony).

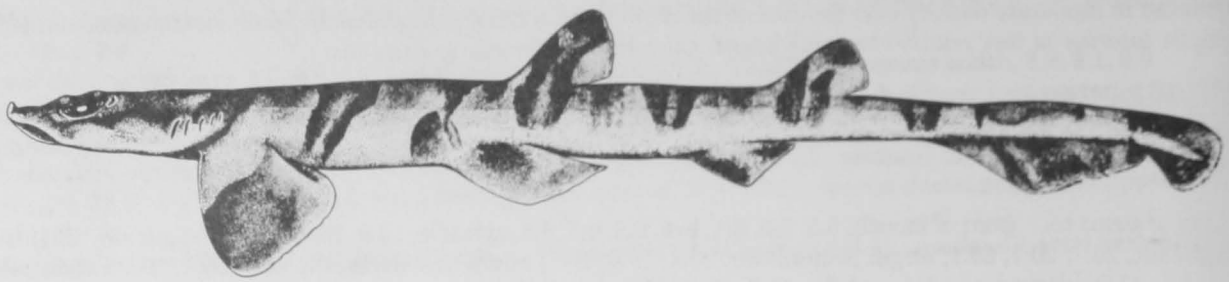


Figure 48.—*Halaelurus natalensis,* 334-mm immature female, Algoa Bay, South Africa.

Figure 49.—*Halaelurus natalensis,* 425-mm adult male, Saldanha Bay, South Africa.

Figure 50.—*Halaelurus natalensis,* head region of holotype or paratype, 425-mm specimen, BMNH.

Scylliorhinus natalensis: Barnard 1925:43 (Algoa Bay to Natal).
Halaelurus natalensis: Garman 1913:84 (coast of Natal); Smith 1949:50, pl. 2, no. 40 (Knysna to Natal).

Material examined. BMNH 1904.6.28.29, ad. ♂, 425 mm, holotype or paratype, see discussion, one of two specimens received from J. F. Quekett, coast of Natal only locality given; BMNH 1905.6.8.34, 2 ad. ♂, 416, 430 mm, 16 mi northeast Bird Island in 40 fathoms, Algoa Bay; USNM 119224, 3 imm. ♀, 233, 317, 322 mm, Algoa Bay, South Africa; USNM, imm. ♀, 334 mm, Algoa Bay; SAM 22992, 1 ad. ♂, 425 mm, Saldanha Bay, South Africa.

Diagnosis. The most important character to set off *Halaelurus natalensis* from all other sharks, except the newly described *H. lineatus*, is its upturned snout tip. Regan (1904) called the snout "elliptical with obtusely pointed tip." I suppose he meant that the cross section of the snout was elliptical. The tip of the snout, in all the specimens noted above and several more that I examined but did not record, had a very small knoblike tip, denticle covered, usually colorless, and having a somewhat worn appearance. The knob is present on specimens of both *natalensis* and *lineatus* but is more prominent on *natalensis*. Regan's (1904) original description of *natalensis* noted that it was allied to *H. quagga*. There are general similarities but only *natalensis* and *lineatus* have obtusely pointed snouts. *Halaelurus quagga* has a broadly rounded snout without a trace of a knoblike tip.

The difference in color pattern between *H. natalensis* and *H. lineatus* can be seen best by comparison of illustrations (*H. natalensis* Figs. 48, 49, 50, with *H. lineatus* Figs. 44, 46). In *natalensis*, the darkest bars partly surround areas of lighter brown forming discrete saddle blotches of two shades of brown or brownish-black. The dorsolateral surfaces of *H. natalensis* thus have three shades of brown in a complex pattern. Within this pattern additional fainter markings may be present to varying degrees. In Figure 50 showing the head region of the holotype or paratype the pattern described in Regan's (1904) species description is clearly evident. "The second band is represented by two oval patches at the level of the gill openings, nearly meeting in the middle line." Figure 49 shows another pattern arrangement of the second saddle blotch in which the two "oval patches" noted by Regan have merged.

The specimens of *H. natalensis* examined have no single body proportion that clearly separates them from specimens of *H. lineatus*. It is possible that differences could be found by comparison of a larger series of both species. Both species are presumably variable but in a general way the material available shows that *H. natalensis* has a more robust form, has slightly larger fins, has a slightly shorter but more pointed snout with a more prominent knoblike tip, has lesser distances between fin bases, and feels somewhat rougher to touch than *H. lineatus*.

Description. For an account of proportional measurements I have chosen a 425-mm adult male from Saldanha Bay and a 334-mm immature female from Algoa Bay. Measurements are given as percentages of total length and in the following the first figure in each pair represents the adult male, the second figure the immature female.

Tip of snout to: front of mouth, 4.5, 4.5; eye, 5.9, 5.1; spiracle, 9.2, 9.0; first gill slit, 13.6, 13.2; fifth gill slit, 17.9, 17.4; origin pectoral fin, 16.2, 15.6; origin first dorsal fin, 42.8, 41.0; origin pelvic fins, 36.0, 35.6; origin second dorsal fin, 63.8, 62.6; origin anal fin, 56.5, 54.5; origin upper caudal fin lobe, 80.0, 78.8; anterior end cloacal opening, 41.9, 40.4.

Greatest width of: trunk at pectoral origin, 11.3, 12.0; trunk at pelvic origin, 6.8, 8.1; caudal base, 2.1, 2.4.

Greatest height of: trunk at pectoral origin, 7.3, 6.0; trunk at pelvic origin, 8.2, 7.2; caudal base, 3.1, 3.0.

Eyes: horizontal diameter, 3.1, 3.6; vertical diameter, 0.5, 0.9.

Spiracles: greatest diameter, 0.9, 1.2; least distance from eye, 0.3, 0.6.

Mouth: width, 7.3, 7.5; length, 3.5, 3.0; length upper labial furrow, 1.1, 1.5; length lower labial furrow, 1.8, 1.8.

Nasal apertures: least distance between, 2.1, 1.8.

Gill slits: height of first, 2.1, 1.9; height of fifth, 0.9, 1.0.

First dorsal fin: length base, 6.1, 6.3; length free inner margin, 2.4, 2.1; height, 4.5, 5.7; length anterior margin, 8.7, 8.7.

Second dorsal fin: length base, 7.3, 6.4; length free inner margin, 2.1, 2.1; height, 4.0, 7.2; length anterior margin, 8.4, 7.5.

Anal fin: length base, 9.4, 7.5; length free inner margin, 2.4, 2.4; height, 3.5, 3.9; anterior margin, 7.1, 6.6.

Pectoral fins: width base, 5.4, 5.4; greatest width fin, 9.4, 10.2; anterior margin, 11.8, 11.7.

Pelvic fins: overall length not including clasper, 12.7, 12.6; inner margin claspers, 12.7, —; extent clasper past fin tips, 4.2, —.

Distance between fin bases: first and second dorsals, 14.1, 14.7; pectorals and pelvics, 15.3, —; pelvics and anal, 12.5, —; anal and lower caudal lobe, 11.5, —; second dorsal and upper caudal lobe, 8.7, —.

The 425-mm male from Saldanha Bay had 34 monospondylous vertebrae, 85 precaudal vertebrae, and 45 caudal vertebrae. The total number was 130.

An interesting summary of proportional dimensions of 21 males and 20 females of *Halaelurus natalensis* compared with series of *H. lutarius* is given by Bass et al. (1975:43).

The dentition was similar to that in most other species of *Halaelurus*, that is, small, crowded teeth, tridentate in the middle of the jaws with some increase in the number of cusps near the mouth corners. In the 322-mm female from Algoa Bay the highest teeth reached from 0.6 to 0.7 mm above the enamel line; the number of vertical rows of teeth was 26+1+27/20+1+20; and the lateral cusps of many of the larger teeth of the middle part of the jaws were scarcely visible.

The dermal denticles of dorsolateral surfaces were tridentate, the denticle points more inclined upward than in *H. lineatus*.

The inside of the mouths of most of the specimens had some papillae anteriorly and some scattered denticles of very small size on the tongue and gill bars.

The snout of all the specimens seen had the terminal knob turned upward.

Discussion. The locality given by Regan (1904) for two specimens on which he based his description was "coast of Natal." All of the specimens, except the type that I have seen, have been taken between Algoa Bay and Saldanha Bay south and west of the coast of Natal. All the specimens of *H. lineatus* that I have seen have been labeled either as from the coast of Natal or more specifically from the vicinity of Durban which is centrally located on the coast of Natal according to current maps. My material therefore does not clearly indiate that the geographical ranges of *natalensis* and *lineatus* overlap.

The British Museum (Natural History) has only one of the specimens remaining of the two on which Regan based his description. Regan mentioned only one dimension, 325 mm. The present measurement of the single remaining specimen is 420 mm TL.

Bass et al. (1975:15) reported that *H. natalensis* is oviparous and has egg cases about 40 by 15 mm, the egg cases with fairly thick, robust tendrils in contrast with those of *H. lineatus* which are thin and weak. They stated that female *H. natalensis* may carry up to 11, but usually 6 to 9, egg cases in each oviduct at a time.

Halaelurus quagga (Alcock)
Figures 51, 52

Figure 51.—*Halaelurus quagga*, 354-mm adult male, coast of Somalia in 59-61 m. Drawing by Mildred Carrington.

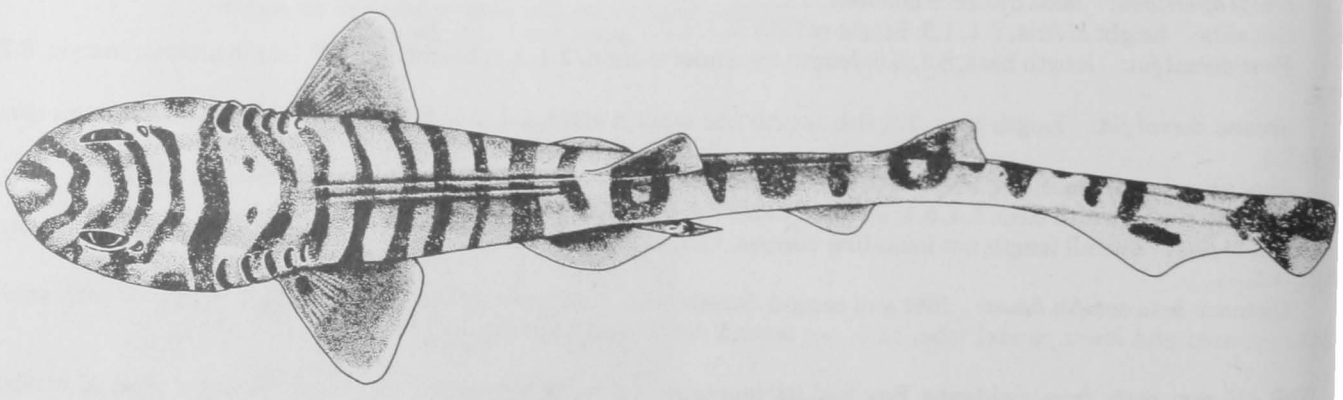


Figure 52.—*Halaelurus quagga*. Redrawn by Mildred Carrington from Alcock's (1899) illustration of the holotype, an adult male, 280 mm, from Malabar Coast.

Scyllium quagga Alcock 1899:17 (off Malabar coast, India, in 186 m).
Scyliorhinus quagga: Regan 1908a:461 (compiled).
Halaelurus quagga: Garman 1913:84 (compiled); Springer and D'Aubrey 1972:15, fig. 1E (coast of Somalia).
Scyliorhinus (*Halaelurus*) *silasi* Talwar 1972:779, fig. 1 (off Quilon, southwest coast of India, Malabar coast, in 300 m).

Material examined. ZSI, ad. ♂, 333 mm, lat. 10°00'N, long. 51°15'E, coast of Somalia, presented to Indian Museum for comparison with holotype; USNM, 2 ad. ♂, 342, 354 mm, same locality as preceding; USNM, juv. ♂, 79.5 mm, lat. 09°41'N, long. 51°15'E. All specimens in 59-61 m.

Diagnosis. The holotype, ZSI 751/1, is an adult male about 280 mm TL. The specimens listed above are the only specimens that I have seen. They were almost identical in appearance with a pattern of transverse bars as shown in Figure 51. One of these was sent to the Indian Museum and was reported to be similar in all essential features to the holotype (A. G. K. Menon, pers. commun.). The illustration, Figure 52, redrawn from Alcock's plate, may be a better representation of some specimens from the coast of India than of specimens from the coast of Somalia, Figure 51.

The status of *H. quagga* and of *Scyliorhinus* (*Halaelurus*) *silasi* Talwar remains uncertain because it has not been determined whether the holotypes of either lack supraorbital crests. The reported absence of labial furrows in *silasi* brings to mind past difficulties in the determination of distinctions between *Halaelurus buergeri* and *Scyliorhinus torazame* without reference to other characteristics such as the presence or absence of a supraorbital crest.

None of the specimens of *H. quagga* have the knoblike structure at the tip of the snout such as is present on *H. lineatus* and *H. natalensis*.

The adult males of *H. quagga* lack the numerous small black spots irregularly scattered between transverse dark bars or saddle blotches as in *H. boesemani*. When spots are present on *H. quagga* they tend to be arranged in transverse rows. The reticular marbling that is faintly present between transverse bars of *H. lineatus* is absent from specimens of *H. quagga*.

Description. Proportional measurements expressed as percentages of the total length follow. The first figure refers to a 354-mm adult male, the second to a 342-mm adult male, and the third to a juvenile male 79.5 mm long that is probably newly hatched or born. The proportions of juveniles differs considerably from proportions of adults in most shark species.

Tip of snout to: front of mouth, 4.5, 4.7, 5.9; eye, 5.1, 5.3, 5.3; spiracle, 8.8, 9.4, 10.0; first gill slit, 13.6, 14.0, 16.4; fifth gill slit, 19.2, 18.7, 19.5; origin pectoral fin, 18.1, 17.5, 19.9; origin first dorsal fin, 42.9, 43.6, 38.4; pelvic fins, 37.3, 36.3, 33.5; origin second dorsal fin, 65.0, 64.0, 57.9; origin anal fin, 56.5, 56.7, 48.4; origin upper caudal fin lobe, 78.5, 80.1, 75.0; anterior end cloacal opening, 39.3, 40.9, 37.2.

Eyes: horizontal diameter, 3.7, 3.5, 4.4; vertical diameter, 0.8, 1.2, 0.8.

Spiracles: greatest diameter, 0.7, 0.6, 1.4; least distance from eye, 0.6, 0.6, 0.5.

Mouth: width, 6.2, 6.4, 8.7; length, 3.7, 3.5, 3.5; length upper labial furrow, 0.4, 0.5, —; length lower labial furrow, 1.1, 1.5, undeveloped ? .

Nasal apertures: least distance between, 2.0, 2.0, 2.0.

Gill slits: height first, 1.6, 1.2, 1.5; height fifth, 1.4, 1.0, 0.8.

First dorsal fin: length base, 5.1, 6.4, 6.5; length free inner margin, 1.8, 1.5, 2.9; height, 4.0, 4.1, 4.0; length anterior margin, 7.6, 7.9, 9.4.

Second dorsal fin: length base, 6.2, 6.4, 7.5; length free inner margin, 1.8, 1.5, 2.3; length anterior margin, 7.1, 7.3, 10.3.

Anal fin: length base, 7.5, 7.3, 10.1; length free inner margin, 2.3, 2.9, 2.5; length anterior margin, 5.1, 5.6, 7.5.

Pectoral fins: width base, 4.5, 5.0, 6.3; greatest width fin, 7.6, 7.9, 7.5; length anterior margin, 9.6, 9.4, 10.3.

Pelvic fins: overall length exclusive of claspers, 10.4, 11.1, 11.6; length inner margin claspers, 11.0, 11.1, 2.9; reach claspers past pelvic fin tip, 3.7, 3.2, (-3.3).

Distance between fin bases: first and second dorsals, 16.9, 14.6, 11.3; pectorals and pelvics, 13.8, 15.2, 8.9; pelvics and anal, 13.3, 10.8, 6.5; anal and lower caudal fin lobe, 12.1, 14.3, 11.3; second dorsal and upper caudal lobe, 9.3, 10.2, 8.2.

In the three adult males from the coast of Somalia the number of monospondylous vertebrae was 31 to 32; the total number of vertebrae from 123 to 125.

The teeth in adult *H. quagga* were tridentate and similar in upper and lower jaws, the longest about 0.8 to 0.9 mm above the enamel line. The number of vertical rows of teeth were 26+3+26/27+27 and 28+3+28/27+1+27 in two of the adult males.

Dermal denticles of the dorsolateral surfaces were tridentate from 0.3 to 0.6 mm long, with a double central ridge.

The inside of the mouth had no prominent papillae, and denticles of very small size were scattered over the anterior mouth roof and on the tongue and gill bars.

Discussion. *Halaelurus quagga* and *H. boesemani* were taken in trawl hauls made only a few miles apart on the continental shelf of Somalia at depths of 60 to 70 m. No indications that the two forms occupied different habitats were observed.

HAPLOBLEPHARUS GARMAN

Haploblepharus Garman 1913:101 (type-species, *Scyllium edwardsii* Cuvier 1817; by monotypy).

Diagnosis. *Haploblepharus* lacks a supraorbital crest or narrow shelf of cartilage above the eye and thus differs from *Atelomycterus*. Of the genera without a supraorbital crest, *Haploblepharus* differs in having in combination, large confluent nasal flaps that reach past the edge of the upper lip, prominent labial furrows that extend around the mouth corners as a continuous groove, and depressed areas of the upper lip that make a connection between the nostrils and the mouth. It also lacks a caudal crest of modified and enlarged denticles.

The three species recognized here are robust sharks with wide and moderately depressed heads, short snouts, and wide mouths. They have moderately small eyes with poorly developed subocular gutters below the eyes, the gutters not reaching the spiracles which are very close to the posterior eye corners.

Color and markings vary and the significance of color differences for systematics in this genus has not been established.

Discussion. Specimens of *Haploblepharus* are not comonly available in systematic collections outside of South Africa and, until the recent publication by Bass et al. (1975), the species were poorly known. I have examined only four specimens divided among three species. As a consequence, much of my treatment of the genus is based on data from Bass et al. (1975) who examined 44 specimens. Since their morphometric data are presented only as a summary of an analysis of variation in proportional dimensions (see also Bass 1973), I have included here proportional dimensions of specific specimens of two of the species.

The three species of *Haploblepharus* are not easily distinguished from one another but seem more reliably separated by color characters than by morphometric differences. All three are known from shore waters of continental shelf waters of the coasts of southern Africa and have somewhat different but probably overlapping geographical ranges.

Two leathery egg capsules 60 by 30 mm were laid by a female identified as *Haploblepharus edwardsii* by Bonde (1945). One of these hatched in 104 days. Bass et al. (1975) regard it as likely that the species was *H. pictus*. All three species are probably oviparous.

Haplobleparus has moderate sexual dimorphism in the teeth, the upper jaw teeth of adult males having somewhat longer middle cusps than the teeth of females or immature males. This difference appears greater in *H. fuscus* than in the other two species.

Key to Adults of Species of *Haploblepharus*

1a. Origin of first dorsal fin in advance of posterior end of base of pelvic fin; dorsolateral surfaces generally dark with a few large saddle blotches extending onto paired fins, dorsolateral surfaces also with scattered spots of lighter color, the spots generally larger than the spiracle but smaller than the eye. . . . . *H. pictus*

1b. Origin of first dorsal fin over or posterior to posterior end of base of pelvic fin; dorsolateral surfaces either dark or light, sometimes tan, reddish, or brown, with or without scattered spots of lighter color, the light colored spots, if present, generally smaller than the eye 2

2a. Dorsolateral surfaces of adults with distinct saddle blotches, sometimes bordered at front and back with noticeably darker margins; many small pale spots not much larger than spiracles . *H. edwardsii*

2b. Dorsolateral surfaces of adults either plain colored or with indistinct bands or narrow saddle blotches; small pale spots either absent or present . . . . . *H. fuscus*

Haploblepharus edwardsii (Müller and Henle)
Figure 53

Scyllium edwardsii Müller and Henle 1841:4, first unnumbered plate (Cape of Good Hope).
Haploblepharus edwardsii: Garman 1913:102; Smith 1950:879, fig. 1; Bass et al. 1975:17, fig. 11.

Figure 53.—*Haploblepharus edwardsi*, adult male, estimated length 450 mm (part of tail missing), taken off Simontown, South Africa, in 18 m, SAM 22021.

Material examined. SAM 22021, ♂, estimated length 450 mm, part of tail missing, Simontown, South Africa, 18 m; USNM 201809, ♀, 470 mm, Algoa Bay, South Africa.

Diagnosis. In *Haploblepharus edwardsii* the origin of the first dorsal fin is over or posterior to the rear end of the base of the pelvic fin, not in advance of it as in *H. pictus*. The separation of *H. edwardsii* and *H. fuscus* is based on color pattern as described in the key. The color pattern appears to be variable, especially in *H. fuscus*, and separation on color alone may be tenuous. Although the accompanying illustration of *H. edwardsii* (Fig. 53) shows a strong pattern of saddle blotches that in one form or another is usually present on *H. edwardsii*, the illustration of *H. fuscus* here (Fig. 54) shows just one of several patterns for that species. Another color phase of *H. fuscus* was illustrated by Bass et al. (1975, fig. 12).

Discussion. Bass et al. (1975:16) observed a separate cartilage in *Haploblepharus* between the two halves of the lower jaw. That structure was illustrated for *H. edwardsii* (1975, fig. 10). I made no observations of *Haploblepharus* jaw structures but have seen somewhat similar intermediate or symphyseal cartilages in some *Heptranchias perlo* (Family Heptranchidae). Unlike *Haploblepharus* which has a remarkably wide mouth with a low arch, *Heptranchias* has a very narrow mouth with a very high arch.

Haploblepharus fuscus Smith
Figure 54

Haploblepharus fuscus Smith 1950:883, fig. 2 (East London and Knysna coast of South Africa); Bass et al. 1975:19, fig. 12.

Material examined. SAM 24545, ad. ♂, 692 mm, Bredasdorp coast, South Africa.

Diagnosis. *Haploblepharus fuscus* has the first dorsal origin over or posterior to the rear end of the base of the pelvic fins and thus differs from *H. pictus* in which the first dorsal origin is in advance of the rear end of the pelvic fin base. *Haploblepharus fuscus* may be distinguished from *H. edwardsii* by its color pattern as outlined in the key.

The adult male and only specimen of *H. fuscus* that I examined was slightly longer than any *Haploblepharus* measured by Bass et al. (1975:20) and was much darker (Fig. 54) than the specimens they examined. My measurements show some slightly different proportional dimensions than given for the species by Bass et al. (1975, table 4) but probably only differences of a degree to be expected in a larger specimen. The teeth of the large male were tricuspid and notably high and narrow with slender cusps. Judging from the few *Haploblepharus* that I have seen and the teeth illustrated by Bass et al. (1975, fig. 20G, H, I), *H. fuscus* may be separated from other *Haploblepharus* by its narrower and higher tooth form with mostly three rather than five cusps.

Figure 34.—*Haploblepharus fuscus*, 692-mm adult male, Bredasdorp, South Africa, SAM 24345.

Description. The 692-mm male *H. fuscus* was brown dorsally, paler ventrally, with faint darker dorsal crossbands (
or 6) and numerous white spots about spiracle size on dorsolateral surfaces.

Following are proportional measurements of the 692-mm adult male expressed as percentages of the total lengt

Tip of snout to: front of mouth, 3.9; eye, 4.6; spiracle, 7.8; first gill slit, 14.5; fifth gill slit, 18.4; origin pectoral fi
17.5; origin first dorsal fin, 43.7; origin pelvic fins, 37.9; origin second dorsal fin, 65.1; origin anal fin, 56.4; origin upp
caudal fin lobe, 81.8; anterior end cloacal opening, 42.5.

Greatest width of trunk: at pectoral origin, 12.9; at pelvic origin, 8.1; at origin caudal fin, 3.0.

Greatest height of trunk: at pectoral origin, 9.5; at pelvic origin, 8.8; at caudal origin, 3.6.

Eyes: length of eye opening, 2.5.

Spiracles: greatest diameter, 0.7; least distance from eye, 0.3.

Mouth: width, 7.4; length, 2.0; length upper labial furrow, 1.7; length lower labial furrow, 2.2.

Gill slits: height of first, 2.7; height of fifth, 1.2.

First dorsal fin: length base, 7.4; length free inner margin, 2.6; height, 5.6; length anterior margin, 9.3.

Second dorsal fin: length base, 8.7; length free inner margin, 2.6; height, 5.5; length anterior margin, 9.7.

Anal fin: length base, 11.9; length free inner margin, 2.5; height, 5.1; length anterior margin, 9.7.

Pectoral fins: width base, 5.9; greatest width of fin, 10.4; length anterior margin, 12.7.

Pelvic fins: overall length exclusive of claspers, 11.6; inner margin claspers, 12.0; reach of claspers past tip
pelvic fins, 3.8.

Distance between fin bases: first and second dorsals, 12.7; pectorals and pelvics, 14.5; pelvics and anal, 12.1; an
and lower caudal origin, 10.7; second dorsal and upper caudal origin, 8.1.

Vertebral numbers for the 692-mm adult male are: total 134, monospondylous 36, precaudal 90, caudal 40.

Discussion. Comparative examinations of larger series of specimens are needed to test the validity of the speci
The illustration of the clasper of *H. edwardsii* in Bonde's (1945) account of external development and my sketches of t
clasper of the 692-mm *H. fuscus* do not differ appreciably.

Haploblepharus pictus (Müller and Henle)
Figure 55

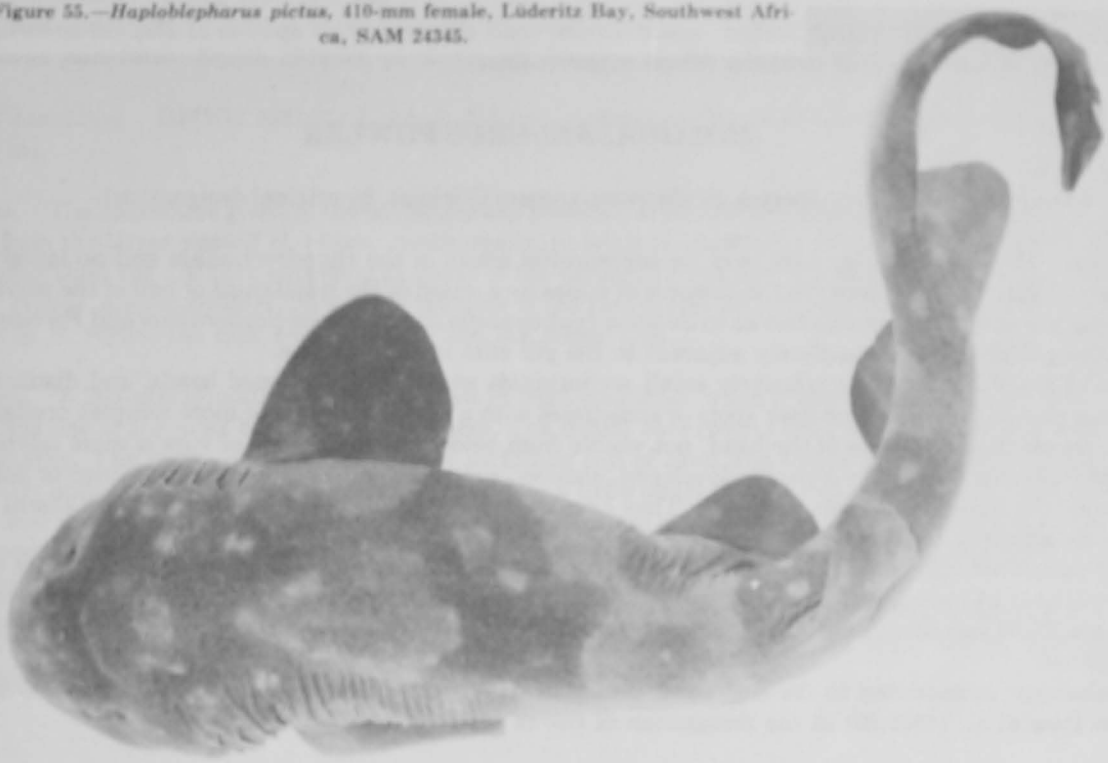


Figure 55.—*Haploblepharus pictus*, 410-mm female, Lüderitz Bay, Southwest Africa, SAM 24345.

Haploblepharus pictus Müller and Henle 1841:4 (Cape of Good Hope); Smith 1975:13; Bass et al. 1975:21, fig. 13.

Material examined. SAM 24345, ♀, 410 mm, Lüderitzbucht, Southwest Africa.

Diagnosis. The more anterior position of the origin of the first dorsal fin, its origin in advance of the posterior end of the pelvic base (over or posterior to it in *H. edwardsii* and *H. fuscus*) should distinguish *H. pictus* at all ages. Differential growth usually affects relative position of fins near the midpoint in the shark's length less than the extremes. The larger spots noted by Müller and Henle (1841) and present in SAM 24345 may be a practical way to identify *H. pictus* if it turns out to be a reasonably constant character.

Description. The color pattern of the 410-mm female is best shown in Figure 55.

Following are measurements of the 410-mm female expressed as percentages of the total length.

Tip of snout to: front of mouth, 3.7; eye, 5.1; spiracle, 8.3; first gill slit, 14.9; fifth gill slit, 20.0; origin pectoral fin, 17.1; origin first dorsal, 44.7; origin pelvic fins, 39.0; origin second dorsal fin, 63.7; origin anal fin, 56.9; origin upper caudal fin, 80.0; anterior end cloacal opening, 41.5.

Greatest width at: pectoral origin, 14.9; pelvic fin origin, 9.8; caudal base, 3.2.

Greatest height at: pectoral origin, 11.2; pelvic fin origin, 10.5; caudal base, 3.7.

Eyes: length, 2.4; height opening, 0.7.

Spiracles: greatest diameter, 1.1; least distance from eye, 0.7.

Mouth: width, 9.8; length, 2.4; length upper labial furrow, 2.0; length lower labial furrow, 2.9.

Gill slits: height of first, 3.2; height of fifth, 1.5.

First dorsal fin: length base, 7.8; length free inner margin, 3.2; height, 5.9; length anterior margin, 10.7.

Second dorsal fin: length base, 8.8; length free inner margin, 2.9; height, 5.9; length anterior margin, 10.7.

Anal fin: length base, 10.7; length free inner margin, 2.9; height, 4.6; length anterior margin, 8.5.

Pectoral fins: width base, 6.6; greatest fin width, 11.5; length anterior margin, 11.5.

Pelvic fins: overall length, 12.4.

Distance between fin bases: first and second dorsals, 12.7; pectorals and pelvics, 15.6; pelvics and anal, 8.8; anal and lower caudal fin, 9.3; second dorsal and upper caudal fin, 7.1.

In the female examined the teeth were tricuspid in the middle part of the jaws and the lateral cusps were more tha half as long as the central cusps.

Vertebral numbers for the 410-mm female are: total 129, monospondylous 35, precaudal 82, caudal 47.

Discussion. Possibly *H. pictus* prefers cooler waters than the other two species of *Haploblepharus*; at least i presence on the Atlantic side of southern Africa suggests this.

HOLOHALAELURUS FOWLER

Holohalaelurus Fowler 1934 (type-species, *Scylliorhinus regani* Gilchrist, by original designation).

Diagnosis. *Holohalaelurus* species have no supraorbital crests of the chondrocranium and no labial furrows; th have a partial apron formed beneath the claspers of males by a union of the basal third or half of the pelvic fins, but t skin uniting the pelvics is denticle free as in *Juncrus* (not denticle covered as in *Scyliorhinus* and *Poroderma*); the sk between the gill slits and immediately adjacent to the gill slits is denticle free.

Species of *Holohalaelurus* are relatively small scyliorhinids with broad, flattened heads, and distinctively mark with a color pattern of variegated dark spots or sometimes with a few white spots or more complex ocellalike marking The eyes are on the dorsal side of the head, not visible from below but their angle of view is more lateral than dorsa Species of *Holohalaelurus* have a poorly developed, shallow, subocular gutter either denticle lined or naked extendi below the eye for about two-thirds its length. They have denticle-free gill covers and denticles are absent from the ski immediately adjacent to the gill slits.

In *Holohalaelurus* substantial changes in body proportions accompany growth. Also, the adult color pattern diffe greatly from that of juveniles (Bass et al. 1975, fig. 15). Even the color patterns of adults vary considerably and sho some geographical variation. Adult males are larger than adult females whereas the reverse is the more general conditi among sharks.

Holohalaelurus is restricted to the east coast waters of Africa and is known from about 200 to 740 m.

I follow Bass et al. (1975:23) in the recognition of two of the four nominal species.

Key to Species of *Holohalaelurus* from Bass et al. (1975:23)

1a. Anal base equal to or less than 3½ times anal height; denticles on back and top of head uniform in size . . . . . *H. punctatu*

1b. Anal base more than 3½ times anal height; a series of relatively large denticles on back and top of head . . . . . *H. rega*

Holohalaelurus punctatus (Gilchrist)
Figure 56

Figure 56.—*Holohalaelurus punctatus*, ventral view of head, 315-m adult male showing shape of mouth characteristic of adult males genus.

Scyliorhinus punctatus Gilchrist 1914:129 (off Cape Point, South Africa); Barnard 1925:43.
Scyliorhinus polystigma Regan 1921:413 (15 to 22 mi off Umvoti River, Natal); Norman 1939:10 (as synonym of *S. punctatus* Gilchrist).
Halaelurus punctatus: Fowler 1935:361, fig. 1.
Scyliorhinus melanostigma Norman 1939: 9 (part), fig. 2A (Zanzibar; syntype BMNH 1939.5.24.5 only).
Holohalaelurus punctatus: Smith 1949:55, pl. 2, fig. 42; Bass et al. 1975:23, fig. 14.

Material examined. BMNH 1921:3.1.1, ad. ♂, 315 mm, holotype of *Scyliorhinus polystigma* Regan 1921 (Natal in 219 to 238 m).

Diagnosis. The characters given in the preceding key probably are sufficient to separate both adult and immature *H. punctatus* from the larger sizes of *H. regani*. Additionally, in adult *H. punctatus* the length of the base of the anal fin is usually shorter than the distance between the bases of the dorsal fins but nearly or quite as long as the interdorsal distance in *H. regani*. Also in adult *H. punctatus* the area of the first dorsal fin is nearly the same as the area of the second dorsal, but in *H. regani* the first dorsal usually has the larger area.

Discussion. A 205-mm immature male that I saw in fresh condition, when it was hauled up in a trawl off the coast of Tanzania, was one of the most beautiful of all sharks. The dorsal background color was orange-brown becoming cream colored ventrally. The entire dorsolateral surface including top of head and upper side of pectorals and pelvics was covered rather uniformly with dark brown spots, each spot a little larger than the spiracles. Each dorsal fin was marked by a small and short brown bar bordered by bright yellow. A white spot about pupil size was present on each side just above the pectoral axilla. The only marks on the cream colored ventral surface were brown spots on the distal halves of the pectoral and pelvic fins.

Holohalaelurus punctatus is somewhat variable in color as shown by the description of Bass et al. (1975:23). According to those authors, *H. punctatus* is oviparous forming egg capsules about 17 by 10 mm, much smaller than any shark egg capsule that I have seen.

Holohalaelurus regani (Gilchrist)
Figures 57, 58

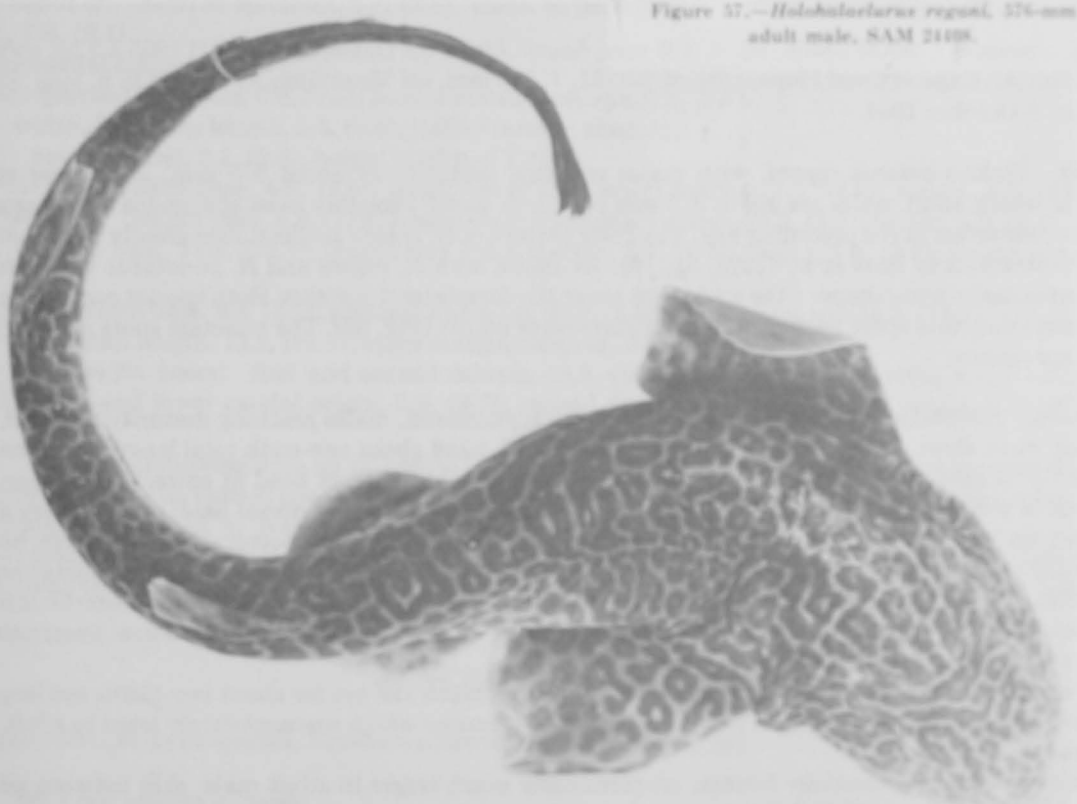


Figure 57.—*Holohalaelurus regani*, 576-mm adult male, SAM 24498.

Figure 58.—*Holohalaelurus regani*, 576-mm adult male, ventral view to show markings. Similar markings are present on *Raja laevis*, the barndoor skate.

Scyliorhinus regani Gilchrist 1922:45 (Cape Seas, 174-320 m).
Holohalaelurus regani: Smith 1949:55, fig. 43; Bass et al. 1975:25, fig. 15.

Material examined. SAM 24408, ad. ♂, 576 mm, South Africa off Dassen I.; BMNH 1935.5.2.55, subad. ♂, 540 mm, *Discovery* Stn. A., Cape of Good Hope; USNM 201751, ♀, 360 mm, off Mozambique, lat. 22°25'S, long. 35°54'E, trawled from 740 m, 1 October 1964.

Diagnosis. *Holohalaelurus regani*, with males reaching maturity at about 575 mm, is a larger species than *H. punctatus* in which adult males are about 315 mm or a little more. Probably most specimens of *H. regani* can be identified by the characters in the preceding key. The color pattern of *H. regani* adults differs greatly from that of juveniles as shown in illustrations in Bass et al. (1975, fig. 15). As adults both *H. regani* and *H. punctatus* vary somewhat in color pattern, particularly in the shape of the spots that cover the dorsolateral surfaces. Both species occur usually in shades of brown. Ventral punctate spots appear on ventral surfaces of adults (Fig. 58). The punctate spots may be absent on some immature specimens.

Description. *Holohalaelurus regani* is a medium size scyliorhinid, males reaching maturity at about 575 mm; head and anterior trunk short, flattened, and wide tapering to tail, head about one-sixth total length; body cavity short, distance from tip of snout to cloaca less than two-fifths total length; depth of head at spiracles less than one-half head width; snout in front of mouth short, its length about equal to length of first dorsal base; gill slits very small, length of longest less than horizontal diameter of orbit which is less than length of snout; pectoral fins very large, broad, the length of the anterior margin about equal to distance from tip of snout to first gill slit; first dorsal fin somewhat smaller than second, its origin slightly in advance of posterior end of pelvic base; second dorsal origin over posterior third of anal base; anal long and low, the length of its base twice as long or nearly twice as long as second dorsal base; caudal fin narrow without a salient point on anterior lower lobe.

Eyes of medium size; a shallow subocular gutter extending below the eye for about two-thirds eye length, its deepest part not covered with denticles; gutter not reaching small spiracles which are moderately large in adult male and very close to posterior eye corner.

Gill slits very small in immature female, proportionally much larger in adult male, skin between gill slits and immediately adjacent area denticle free.

Nasal apertures long, oblique, the inner posterior nasal opening covered by a broad triangular flap without salient point; posterior margin of nasal flap not reaching upper lip.

Inside of mouth without denticles except for padlike groups of denticles at upper end of each gill bar; papillalike gill rakers irregularly distributed on gill bars, heights not greater than width of bases.

Basal half of inner margins of pelvics united by denticle-free skin forming an apron beneath the claspers; tips of claspers of mature male just reaching tips of pelvic fins, clasper tips slender, flexible.

Teeth in immature female small, in about 60/66 rows, mostly with five cusps, teeth of central parts of jaws with longer middle cusps, difference in cusp length less notable in lateral parts of jaws; teeth of upper and lower jaws generally similar; lateral teeth small, low, with all five cusps low.

Teeth of adult male with about seven rows on each side of symphysis of lower jaw, larger than opposite upper jaw teeth and lacking accessory cusps; rest of teeth of adult male generally similar to teeth of immature female but with somewhat higher central cusps.

Dorsal and lateral dermal denticles nearly erect with narrow blades; ventral dermal denticles somewhat less erect with broader blades; denticles generally with a strong high central ridge, usually double, leading to a posterior point, no lateral ridges and lateral points weak if present; dermal denticles of a broad dorsal area extending from the level of the eyes to the level of the second dorsal fin of two sizes, the larger denticles widely spaced in several irregular longitudinal series among the much more numerous smaller denticles; large denticles about twice the height of the small denticles.

Color in the specimens I examined was light gray, dark gray, and black but probably this was due to changes after preservation. According to Bass et al. (1975:25, 26) the overall color is brown, except in juveniles in which the ground color is black.

Punctate black spots on the ventral surface were regarded by Bass et al. (1975:24) as characteristic of the genus and are shown in accompanying Figure 58.

Vertebral numbers of adult male with numbers for immature female following in parentheses are: total number 130 (124), monospondylous 31 (29), precaudal 80 (79), caudal 50 (45).

Proportional dimensions as percentages of total length are given below for the 576-mm adult male followed in parentheses for dimensions of 360-mm immature female.

Tip of snout to: front of mouth, 3.8, (4.7); eye, 5.0, (6.3); spiracle, 8.7, (10.0); first gill slit, 13.4, (14.7); fifth gill slit, 17.0, (17.2); origin first dorsal, 42.6, (40.3); pelvics, 32.7, (34.2); second dorsal, 60.8, (59.2); anal, 51.2, (50.0); origin upper caudal fin, 76.4, (76.5); anterior end cloacal opening, 36.0, (35.6).

Greatest width of: head, 12.7, (12.2); trunk at pectorals, 13.0, (12.2); trunk at pelvics, 7.6, (7.5); trunk at caudal origin, 1.9, (2.4).

Greatest depth of: head at spiracles, 6.1, (5.6); trunk at pectorals, 6.9, (6.1); trunk at pelvics, 7.5, (5.8); trunk at caudal origin, 2.8, (3.1).

Eyes: horizontal diameter, 3.3, (3.5).

Spiracles: greatest diameter, 0.8, (0.6); least distance from eye, 0.5, (0.7).

Mouth: width, 7.5, (8.3); length, 3.5, (4.4), (labial furrows absent).

Gill slits: height of first, 2.1, (0.6); height of fifth, 0.7, (0.4).

First dorsal fin: length base, 4.9, (4.6); length inner (posterior) margin, 2.8, (2.5); height, 4.2, (3.9).

Second dorsal fin: length base, 6.8, (7.0); length inner (posterior) margin, 3.3, (3.3); height, 5.0, (4.4).

Anal fin: length base, 13.2, (13.1); length free inner margin, 2.3, (1.7); height, 3.6, (2.8); length anterior margin, 6.8, (6.7).

Pectoral fins: width base, 8.9, (7.2); greatest width fin, 10.9, (8.9); anterior margin 14.2, (14.2).

Pelvic fins: overall length, 13.9, (11.7); inner margin claspers, 10.1, (—).

Distance between fin bases: first and second dorsals, 15.5, (15.0); pectorals and pelvics, 8.7, (10.8); pelvics and anal, 9.2, (9.7); anal and lower caudal origin, 9.9, (9.7); second dorsal and upper caudal origin, 9.2, (9.7).

Discussion. All of the following data on *H. reguni* is from Bass et al. (1975:26). Egg capsules measured 35 by 15 mm and all of 14 pregnant females carried one egg capsule in each oviduct. This is taken to mean that the species is oviparous and in the condition described by Nakaya (1975:82) as single oviparity.

The smallest specimen recorded was 130 mm long. Off the Natal coast males were mature at 500 to 550 mm, but 570 mm in males from the Cape region. Mature females were smaller—380 to 440 mm—on the coast of Natal.

JUNCRUS WHITLEY

Juncrus Whitley 1939:229 (type-species, *Scyllium vincenti* Zietz, by monotypy).

Diagnosis. Only one species is known.

Juncrus lacks a supraorbital crest or narrow shelf extending from the chondrocranium above each orbit. It lacks a caudal crest of modified dermal denticles, and does not have nasal flaps extending posterior to or past the edge of the upper lip. *Juncrus* has labial furrows of moderate length extending around the mouth corners but less than half the distance toward the jaw symphyses. *Juncrus* has a partial apron beneath the claspers in males formed by the union of the denticle covered pelvic fins near their bases and by this character is separable from *Halaelurus*. In *Juncrus* the partial apron beneath the claspers (between the claspers and the caudal part of the trunk) is formed by the direct union of the denticle-covered inner margins of the pelvic fins near their bases, whereas in *Asymbolus* the connection between the pelvic fins is made by a denticle-free membrane that is attached to each pelvic fin near its inner margin on the dorsal side of the fin.

The claspers of adult male *Juncrus* are remarkably long and slender and extend past the tips of the pelvic fins for half the total clasper length. In this respect *Juncrus* differs from all other scyliorhinids except *Atelomycterus* and the two species of *Galeus*, *G. nipponensis* and *G. schultzi*.

Juncrus vincenti (Zietz)

Scyllium vincenti Zietz 1908:287 (type-locality, Kangaroo Island, South Australia).
Scyliorhinus vincenti: McCulloch 1911:4, pl. 2.
Halaelurus vincenti: Fowler 1941:50; McKay 1966:68.
Juncrus vincenti: Whitley 1940:90, fig. 82.

Study material. WAM P.3777, subad. ♂, about 350 mm, Esperance, Western Australia; BCIF 56-406, ad. ♂, about 365 mm, Adelaide area, South Australia; USNM, 2 ad. ♂, 490, 505 mm, 4♀, 455, 458, 458, 520 mm, Tamar River mouth, Tasmania. Type not seen, type-series in South Australian Museum (McCulloch 1911:4).

Diagnosis. *Juncrus vincenti* is distinguishable from other scyliorhinids by characters used in the key to genera and in the diagnosis for *Juncrus*. *Juncrus vincenti* has a color pattern including many light colored, small spots (generally smaller than the dark adapted pupil) and in this differs from other Australian scyliorhinids.

Description. *Juncrus vincenti* is a slender, elongate scyliorhinid with the head and trunk only moderately higher than wide, and the postpelvic trunk only moderately wider than high; head blunt, snout rounded, its length in front of mouth a little more than 2 times the horizontal diameter of the orbit; eyes moderate, length of orbit as great or greater than least distance between nasal apertures; secondary lower eyelid prominent, extending below eye for its entire length, subocular gutter deep, fully covered by denticles, spiracle moderately small, very near posterior corner of orbit; mouth with a high arch, labial furrows continous around each mouth corner, lower somewhat longer than upper, both shorter than least distance between nasal apertures; nasal flaps entirely covering posterior nasal openings, posterior margins somewhat sinuous or slightly notched, not reaching upper lip; gill slits short, the first usually longest, its length less than least distance between nasal apertures; pectoral fins small, their corners rounded, their origins under fourth gill slits, dorsal fins nearly equal in area, the second usually with a somewhat longer base, the origin of the first over or posterior to the end of the pelvic base; anal fin usually long, length of its base greater than base length of either dorsal; caudal fin about one-fifth total length, caudal axis not elevated, the lower caudal fin without a projecting lobe.

Teeth numerous in about 60/56 rows, with three to five cusps, the middle one longest, similar in upper and lower jaws, crown bases with vertical ridges not extended on cusps, no indication of sexual dimorphism in teeth.

Dermal denticles with tridentate blades on high, slender pedicles; blades imbricate, all three blade points strong, the central one longest; blades with a central ridge and a lateral ridge on each side but ridges not prominent and obsolete on denticles of some parts of body; denticles mostly transparent, microstructure visible but not prominent; some denticles of specimens from Tasmania with some diffuse pigment and small dark pigment spots (pigment not evident in two specimens, WAM P.3777 and BCIF 56-406, both of which have been in preservative for a comparatively long time); very small denticles in a patch anteriorly on roof of mouth, denticles also present on gill bars. No gill rakers.

Generally mottled with darker color (gray or brown) on dorsal surfaces with numerous light-colored spots randomly distributed, the spots not larger than the dark-adapted pupil and separated from one another by a distance about equal to or more than spot diameter; seven or eight ill-defined saddle blotches of darker color; ventral surfaces whitish with some diffused darker color on some specimens.

Total number of vertebrae 130 to 139 in seven specimens (caudal vertebrae in one specimen partly fused and could not be counted); monospondylous vertebrae, one specimen with 34, five with 35, one with 36, one with 37; precaudal vertebrae 80 to 85.

Following are proportional measurements expressed as percentages of total length. The first figure in each series refers to a 505-mm adult male from Tasmania, the second figure to a 520-mm adult female from Tasmania, and the third figure to a 350-mm adult male from Esperance, Western Australia.

Tip of snout to: front of mouth, 4.4, 4.6, 3.4; eye, 4.8, 5.2, 5.0; spiracle, 8.1, 8.5, 8.3; first gill slit, 11.9, 13.1, 12.9; fifth gill slit, 17.0, 17.7, 15.7; origin pectoral, 16.2, 17.3, 14.9; origin first dorsal fin, 48.5, 50.0, 42.9; origin pelvics, 37.0, 37.5, 34.3; second dorsal fin, 67.5, 69.6, 65.7; origin anal fin, 61.4, 59.2, 54.3; origin upper caudal fin, 79.2, 78.8, 80.0; anterior end cloacal opening, 41.0, 40.8, 40.0.

Greatest width of: trunk at pectoral origin, 7.5, 10.3, 8.3; trunk at pelvic origin, 6.9, 8.4, 2.6; at caudal origin, 2.8, 3.3, 2.6.

Height of trunk at: pectoral origin, 6.7, 8.4, —; pelvic origin, 7.9, 8.6, 7.1; caudal origin, 3.8, 4.4, 4.3.

Eyes: length, 2.4, 2.5, 2.9; height, 0.6, 1.1, 0.7.

Spiracles: greatest diameter, 0.3, 1.0, 0.9; least distance from eye, 0.5, 0.6, 0.6.

Mouth: width, 5.9, 6.0, 6.0; length, 3.8, 3.1, 2.7; length upper labial furrow, 1.2, 1.0, 1.0; lower labial furrow, 1.6, 1.3, 1.6.

Nasal apertures: least distance between, 1.8, 2.0, 2.3.

Gill slits: height of first, 1.0, 1.7, 1.7; height of fifth, 0.8, 0.8, 0.6.

First dorsal fin: length base, 6.3, 6.2, 8.0; length free inner margin, 2.6, 2.9, 2.3; height, 4.4, 4.0, 3.7; length anterior margin, 8.7, 7.9, 10.0.

Second dorsal fin: length base, 7.1, 7.7, 8.6; length free inner margin, 2.8, 2.5, 2.6; height, 3.8, 4.2, 3.7; length anterior margin, 9.1, 9.6, 10.0.

Anal fin: length base, 10.5, 11.5, 9.1; length free inner margin, 2.0, 1.9, 1.7; height, 3.8, 3.8, 3.4; length anterior margin, 7.7, 8.1, 7.1.

Pectoral fins: width base, 4.3, 4.6, 4.9; greatest fin width, 7.5, 7.9, 7.4; length anterior margin, 10.5, 11.2, 10.0.

Pelvic fins: overall length exclusive of claspers, 12.1, 13.1, 14.3; inner margin claspers, 15.8, —, 16.6; extent claspers past pelvic fin tips, 9.5, —, 8.0.

Distance between fin bases: first and second dorsals, 13.9, 14.0, 13.4; pectorals and pelvics, 16.2, 15.9, 15.7; pelvics and anal, 15.6, 13.5, 10.9; anal and lower caudal, 6.1, 5.2, 6.6; second dorsal and upper caudal, 5.3, 4.2, 7.4.

Discussion. McCulloch (1911) compared a specimen taken by the research vessel *Endeavour* from 37 m off the mouth of the Murray River, South Australia, with one of Zietz's (1908) specimens that he called a co-type and noted several differences in body proportions and fin positions between the two. Similar variations were found in the eight specimens that I examined. Differences among specimens examined found in accounts by others are random and I can only conclude that *J. vincenti* is variable in color, relative positions and size of fins, and in size at maturity.

In the series at hand the distance from the tip of snout to the origin of the first dorsal fin varies from 42.9 to 50.0% TL. The first dorsal origin is either over the end of the pelvic base or considerably posterior to it. The length of the anal fin base varies from 9.0 to 13.2% TL. In one specimen the anal fin base length is approximately 2 times the first dorsal base length but in another it is only 1 1/3 times the first dorsal base. The distance between dorsal fin bases varies from 11.8 to 16.4% TL.

The USNM specimens from Tasmania resemble Whitley's (1940, fig. 82) illustration of the species in color pattern more closely than the other two specimens in the present study series. More specimens are needed to determine whether the treatment here of all specimens as one variable species is correct.

Juncrus vincenti is oviparous. The following descriptive account of the egg capsules is taken from Hale (1935). The egg capsule is quadrangular in shape, somewhat flattened, 52 mm long by 21 mm wide by 10.5 mm in greatest thickness. At the posterior end of the capsule each corner is produced, tapering to form a single filament which is about 250 mm long. When the capsule was removed from the oviduct and placed in saline solution (seawater?) the posterior filaments (tendrils) "corkscrewed." Along the lateral margins of the egg capsule, silky filaments emerge and extend to 30 or 40 mm. At the anterior corners much longer filaments composed of fine threads are 350 mm long.

Hale speculated that when the egg capsule was extruded the posterior tendrils twisted rapidly around some weed or other support and that the anterior threads tend to cling to any object touched.

PARAPRISTURUS FOWLER, 1934

Parapristurus Fowler 1934:237 (type-species, *Catulus spongiceps* Gilbert, by original designation).

Diagnosis. *Parapristurus* has a series of transverse folds or wrinkles in a denticle-free patch of skin extending across the throat between the ends of the anterior gill slits. Such a patch of wrinkles is not present in other scyliorhinid sharks but is present in some species of the squaloid sharks of the genera *Centrophorus* and *Deania*. In *Parapristurus* the wrinkle patch is associated with basihyals that are comparatively large and heavy for a scyliorhinid shark and may function to permit sudden expansion of the branchial cavity to draw in prey.

Parapristurus is similar to *Apristurus* in having a somewhat flattened and spatulate snout, strong labial furrows extending around the mouth corners, lobe-shaped fins, generally uniform dark color on all surfaces without notable markings, and is like most *Apristurus* species in having a long anal fin with a much larger area than the two dorsal fins combined. Like *Apristurus*, *Parapristurus* has a domelike tectum (roof) of the chondrocranium and no supraorbital

crests but differs somewhat from *Apristurus* in having postorbital processes extending across the posterior corners of t orbits.

In *Parapristurus* the eyes are more lateral than dorsal with thick upper lids that project slightly above the eye and wi a definite pouch under the anterior half of the eye. In *Apristurus* the eyes are more dorsal than lateral with thin upp lids and at most a shallow and inconspicuous gutter below the eye.

Discussion. Only one species of *Parapristurus* has been described; *P. spongiceps* is known only from the 500-m adult female holotype from the vicinity of Hawaii and a 105-mm juvenile reported by Weber (1913) from the Banda Se

Parapristurus spongiceps (Gilbert)

Catulus spongiceps Gilbert 1905:579.
Scyliorhinus spongiceps: Regan 1908a:459.
Pristiurus spongiceps: Garman 1913:94.
Pentanchus spongiceps: Fowler 1941:53, fig. 2.
Apristurus spongiceps: Bigelow and Schroeder 1948:220.

Material examined. USNM 51590, ad. ♀, 500 mm, near Bird Island, WNW of Hawaii in 572-1,462 m, holotype.

Diagnosis. The generic characters, especially the presence of a patch of transverse small folds or wrinkles across t throat, serve to distinguish *Parapristurus spongiceps* from all other scyliorhinid sharks.

Description. The following proportional measurements of the holotype in percentages of total length, except indicated, do not differ greatly from measurements included in the original description (Gilbert 1905) but are more cor prehensive. The holotype is in moderately good condition but undoubtedly has been somewhat distorted during storag

Tip of snout to: front of mouth, 8.6; eye, 8.9; first gill slit, 20.4; fifth gill slit, 25.6; origin pectoral, 24.8; origin fir dorsal, 49.0; pelvics, 43.6; second dorsal, 63.4; anal, 55.2; upper caudal lobe origin, 74.0; anus, 49.0.

Greatest width of: head, 12.7; trunk at pectorals, 10.6; trunk at pelvics, 9.0; trunk at caudal origin, 2.0.

Greatest height of: head at spiracles, 10.4; trunk at pectorals, 15.0; trunk at pelvics, 15.0; trunk at caudal origi 4.4.

Eyes: horizontal diameter, 3.2; vertical diameter, 1.2; distance between upper eyelid rims, 9.6.

Spiracles: greatest diameter, 0.5; least distance from eye, 1.2; distance between, 10.4.

Mouth: width, 9.0; length, 4.8; length upper labial furrow, 2.8; length lower labial furrow, 3.6.

Nasal apertures: level of anterior ends to tip of snout, 3.8; level of posterior ends to tip of snout, 7.0; minimu distance between, 4.2; greatest length (diagonal), 3.2.

Gill slits: height of first, 1.4; height of fifth, 1.0.

First dorsal fin: length base, 6.8; inner posterior margin, 2.4; height, 4.0.

Second dorsal fin: length base, 6.6; inner posterior margin, 2.0; height, 4.0.

Anal fin: length base, 13.0; inner posterior margin, 1.8; height, 5.0.

Pelvic fins: length (origin to rear tip), 11.2.

Caudal fin: upper margin, 26.0; tip to notch, 5.6; anterior margin lower lobe, 10.0.

Distance between fin bases: first and second dorsal, 8.6; pectoral and pelvic, 10.6; pelvic and anal, 2.2; anal a lower caudal, 0.0; second dorsal and upper caudal, 5.0.

Teeth: arrangement alternate; separation at symphyses, 2 mm; number of tooth rows, counted as numb perpendicular to line of occlusion of jaws 25/22, counted as oblique rows 18/18.

Vertebrae: total number about 106; monospondylous 34, precaudal 61, caudal about 45.

Body moderately compressed, deep, stout, visceral cavity short, head about one-fourth total length, tail about or fourth total length; fins lobelike, dorsal fins nearly equal in area, the origin of the first over midpoint of pelvic base, t origin of the second slightly in advance of midpoint of anal base; anal fin origin slightly in advance of pelvic tips; pos rior end anal base separated from lower caudal lobe only by a complete notch.

Snout broadly rounded (collapsed in holotype); two double rows of prominent pores on lower side of snout, about 12 longitudinal series; nasal openings large, oblique, nasal flaps developed only as points, not covering either anterior posterior openings; mouth moderately arched, large, with conspicuous labial furrows around corners; gular area denti free, with 10-25 transverse small folds; denticles not detected inside mouth, no gill rakers, a few scattered small papill present.

Teeth similar in upper and lower jaws, mostly with five cusps, the central cusp much the longest.

Dermal denticles generally similar over all surfaces, spikelike, nearly erect, slightly curved posteriorly.

Color of preserved holotype uniform brown.

Parapristurus spongiceps was illustrated by Fowler (1941, fig. 2).

Discussion. The holotype has a fully formed egg capsule in the right oviduct, length not including tentacles 52 mm, width 23 mm. The surface has fine longitudinal striations, but otherwise is unmarked. The egg capsule is firm as would be expected in an oviparous species.

PARMATURUS GARMAN

Parmaturus Garman 1906:203 (type-species, *Parmaturus pilosus* Garman, designated by Jordan 1917-1920:518).

Diagnosis. *Parmaturus* lacks a supraorbital crest (a narrow shelf of the chondrocranium that extends over the orbits). The nasal flaps do not reach as far back as the upper lip. The nostrils are not connected to the mouth by a groove or a depression of the upper lip near each nostril. The gular area in most species is covered with denticles and the area has no conspicuous transverse wrinkles. Species of *Parmaturus* lack the color pattern of darker saddle blotches or spots that characterize many scyliorhinid species including most *Galeus* species.

Parmaturus has two dorsal fins, labial furrows of moderate length that extend around the mouth corners, and a caudal crest, the crest made up of modified and sometimes enlarged dermal denticles on the proximal half or more of the upper edge of the caudal fin, the crest separated from the denticles of the lateral surfaces of the caudal fin by a narrow strip of naked skin on each side. *Parmaturus* and *Galeus* are distinguished from all other scyliorhinids by the presence of the caudal crest.

Parmaturus differs from *Galeus* in the following respects: *Parmaturus* lacks saddle blotches whereas *Galeus* usually has them; the pectoral fins of *Parmaturus* are not notably large or broad, their greatest width (measured parallel to the distal margin of the pectoral) less than the width of the mouth, whereas in *Galeus* the pectorals are broad, usually as wide or wider than the width of the mouth; *Parmaturus* species are comparatively soft-bodied scyliorhinids, their dermal denticles not closely imbricate and their denticle points not notably stiff so that *Parmaturus* feels more velvety than prickly to touch whereas *Galeus* species are moderately hard-bodied, their dermal denticles imbricate in adults, and their denticle points rather stiff so that *Galeus* feels more prickly than velvety to touch.

Discussion. Species of *Parmaturus* may have different and less complex clasper structures than *Galeus* species. *Parmaturus xaniurus* has striking external differences in clasper structure from *G. arae*, *G. sauteri*, and *G. eastmani* (L. J. V. Compagno, pers. commun.). I have not used clasper structure in the classification of scyliorhinids to the extent that may be warranted. For *Parmaturus* at least, there is the obvious excuse that I have seen an adult male of only one of the six species.

As defined here, *Parmaturus* includes six somewhat diverse species, four of which are known only from immature specimens. One of the species here placed in *Parmaturus* was originally described by Chan (1966) as *Dichichthys melanobranchus* based only on the immature holotype from the South China Sea. Chan regarded his species as transitional between the *Galeus-Parmaturus* "complex" and *Apristurus*. I now add three new species no better known than *melanobranchus* and each is transitional in one way or another within the *Galeus-Parmaturus-Apristurus* group of genera. Furthermore, I have found that juveniles of both *Cephalurus cephalus* and *Halaelurus canescens* have incipient caudal crests that disappear in later growth stages.

One *Parmaturus pilosus* that I examined had a short section of the ventral edge of the caudal peduncle with denticles modified in about the same way as caudal crest denticles are modified. *Parmaturus melanobranchus* was also described as having a crest of enlarged denticles on the ventral edge of the caudal peduncle and on the front portion of the lower caudal lobe (Chan 1966:223).

Although the species of *Parmaturus* are loosely tied together by the presence of a caudal crest on the upper edge of the caudal fin, I suspect that an equally important similarity, but hypothetical for most species, is their ability to live in midwater without excessive energy expenditure. *Parmaturus pilosus* and *P. xaniurus* are the only scyliorhinid species known to have an abundant supply of liver oil that is chiefly squalene (see discussion under *P. xaniurus*).

My solution to the treatment of the diverse group is to make subgeneric distinctions which reflect my present opinion on relationships.

Key to Species of *Parmaturus*

1a. Nasal flaps either triangular and large enough to nearly cover posterior nasal apertures or lobe-like and long enough to reach across nasal apertures 2

1b. Nasal flaps very small, pointed, and neither large enough to cover the posterior nasal apertures nor long enough to reach across nasal apertures 3

2a. Nasal flaps triangular; origin of second dorsal fin nearly over origin of anal fin; posterior end of base of second dorsal fin well in advance of posterior end of base of anal fin . . . *P. (Parmaturus) xaniuru*

2b. Nasal flaps lobelike; origin of second dorsal fin over or slightly in advance of midpoint of base of anal fin; posterior end of base of second dorsal fin about over posterior end of base of anal fin . . . . . *P. (Parmaturus) pilosu*

3a. Eye relatively large, its length less than 2 times in length of snout in front of mouth . . . . . .

3b. Eye relatively small, its length more than 2 times in length of snout in front of mouth . . . . . .

4a. Origin of first dorsal fin over or slightly in advance of origin of pelvic fins *P. (Dichichthys) campechiens*

4b. Origin of first dorsal fin over posterior end of base of pelvic fins . . . . . *P. (Dichichthys) melanobranchu*

5a. Snout tapering, somewhat cone-shaped, its tip a blunt point . . . . . *P. (Campagnoia) stense*

5b. Snout moderately flattened, its tip broadly rounded . . . . . *P. (Campagnoia) man*

Subgenus *Dichichthys* Chan

First dorsal fin smaller than second dorsal fin; eyes large, their lengths less than 2 times in length of snout in front mouth; eyes more lateral than dorsal; adults not known.

Parmaturus campechiensis n. sp.
Figure 59

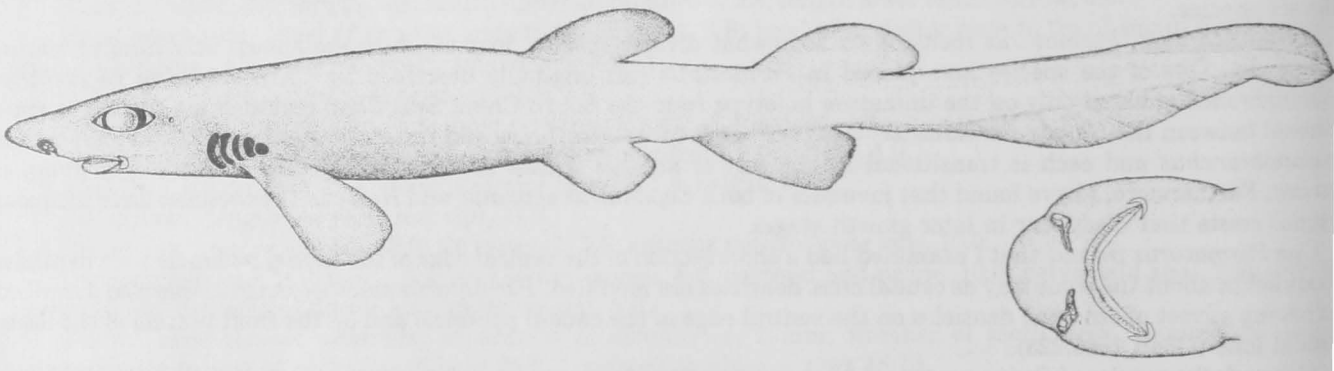


Figure 59.—*Parmaturus campechiensis*, 157-mm female holotype from Gulf of Campeche in 1,097 m. Drawing by Keiko Hiratsuka Moore.

Holotype. USNM 206184, juv. ♀, 157 mm, northwestern Bay of Campeche, Gulf of Mexico, lat. 21°33'N, lon 96°48'W, 1,097 m, trawled by RV *Oregon II*, stn. 10956, 3 June 1970. Only specimen known.

Diagnosis. *Parmaturus campechiensis* differs from other species of the genus in having the first dorsal fin origin ov or slightly in advance of the pelvic origin, whereas it is slightly behind the pelvic origin in *P. pilosus* and *P. xaniurus* ar farther back in other species. *Parmaturus campechiensis* has many characters in common with *P. melanobranchus* the South China Sea and *P. pilosus* of Japanese waters.

In *P. campechiensis*, the first dorsal is appreciably smaller than the second as in *P. melanobranchus*; the two fins a nearly equal in *P. pilosus*. In both *P. campechiensis* and *P. melanobranchus*, the gill slits are small and especially clo together but are well separated in *P. pilosus*. The forward position of the first dorsal fin in *P. campechiensis* sets it c distinctly from *P. melanobranchus* which has the first dorsal origin over the posterior fourth of the pelvic base.

In direct comparison with specimens of *P. xaniurus* 135, 170, and 183 mm long, the 157-mm holotype has a smaller, narrower head with a smaller mouth, shorter gill slits spaced much closer together, a small eye, the first dorsal fin smaller than the second, the posterior tip of the second dorsal fin extending well past the tip of the anal fin (tips about opposite in *P. xaniurus*), and much smaller nasal flaps.

The more anterior position of the first dorsal sets *P. campechiensis* apart from the two other new species *P. stenseni* and *P. manis* described here. In addition, the eyes in the two latter species are more dorsal in position with their angle of view more dorsal than lateral, and both have longer snouts, somewhat pointed in *P. stenseni*, rounded in *P. manis*. Also, in those species the anal fins are comparatively long.

Description. A species of *Parmaturus* with a caudal crest of modified denticles; color grayish, somewhat darker on belly, around gill slits, and on outer parts of fins; first dorsal fin somewhat smaller than second, its origin very slightly in advance of origin of pelvics; second dorsal fin origin a little in advance of midpoint of anal base, posterior end of second dorsal base posterior to end of anal base, tip of second dorsal overlapping origin of caudal crest; areas of second dorsal and anal nearly equal; anal base longer than second dorsal base and longer than distance between dorsal fin bases; pectoral fins short, not broad; caudal fin not wide, its lower extension narrow.

Caudal crest present with crest denticles larger and different in shape from denticles of lateral surface of tail but marginal denticles of crest not asymmetrical as in *P. melanobranchus*.

Snout rounded, its length in front of mouth less than width of mouth; nasal apertures oblique, the nasal flap little developed, not covering posterior opening; eyes small, their lengths nearly equal to the least distance between nasal apertures; spiracles small, distance from eye about four times spiracle diameter; gill slits short, the fifth less than half the length of the first, close together.

Teeth mostly tridentate, only a few with four cusps, not differing greatly in upper and lower jaws, in somewhat more than 60 vertical rows.

Dermal denticles over most of body needlelike, somewhat curved toward the tips; denticles of anterior part of head with narrow tridentate blades; caudal crest denticles in only about three to five irregular rows well separated from denticles of the lateral surface of the tail by a band of naked skin, the caudal crest denticles with a high central ridge reaching a slender point, blades moderately widened basally with a weak posteriorly directed point on each side; caudal crest originates in advance of tip of second dorsal and continues along proximal half of caudal fin edge; a similar arrangement of modified denticles begins ventrally under the anal fin tip but remains differentiated and separated from lateral surface denticles by a band of naked skin only to origin of the lower caudal fin lobe, a distance about equal to length of base of second dorsal fin.

Following are dimensions in percentages of total length for the 157-mm juvenile holotype. The proportions in larger specimens may be expected to be somewhat different. Furthermore the figures should be considered as approximations because they were made from a soft-bodied species.

Tip of snout to: front of mouth, 5.7; eye, 7.0; first gill slit, 15.6; fifth gill slit, 18.5; origin first dorsal, 38.5; pelvics, 39.2; origin second dorsal, 54.8; anal, 51.0; origin caudal crest, 65.9; anus, 42.7.

Eye: horizontal diameter, 3.2; vertical diameter, 2.5.

Spiracle: diameter, 0.5; least distance from eye, 2.0.

Mouth: width, 7.3; length, 3.8; length upper labial furrow, 1.4; lower labial furrow, 1.3.

Gill slits: height first, 2.9; height fifth, 1.0.

First dorsal fin: length base, 7.0; length posterior inner margin, 3.5; height, 3.2.

Second dorsal fin: length base, 8.6; length posterior inner margin, 3.5; height, 4.5.

Anal fin: length base, 10.8; length posterior inner margin, 1.3; height, 3.8.

Pectoral fin: width base, 6.4; anterior margin, 8.9; greatest width, 5.7.

Distance between fin bases: first and second dorsal, 8.9; pectoral and pelvic, 17.2; pelvic and anal, 5.1; anal lower caudal, 3.2; second dorsal and lower caudal, 0.0.

Vertebral numbers are: monospondylous 39, precaudal 75, caudal 36, total 111.

Discussion. The juvenile holotype of *Parmaturus campechiensis* and the immature specimens forming the type-series of *P. manis* are the first *Parmaturus* reported from the Atlantic. If these species are restricted to midwater at depths usually greater than 200 m they would be taken only accidentally by trawls or dredges designed to operate at the sea bottom. Such trawls do occasionally catch fishes during travel to and from fishing depths but are not efficient then and probably are easily avoided by all but the smallest sharks.

Parmaturus melanobranchus (Chan)

Dichichthys melanobranchus Chan 1966:226, figs. 2, 3 (South China Sea).

Material examined. BMNH 1965.8.11.6, 235 mm ♀, RV *Cape St. Mary*, cruise 4/64, stn. 119, SSE of Hong Kong, lat. 20°05'N, long. 115°03'E, trawled from 548 m, 22 August 1964, the holotype and only specimen known.

Diagnosis. *Parmaturus melanobranchus* is readily separable from all other species here allocated to the genus by the posterior position of its first dorsal fin, its origin over the posterior one-fourth of the base of the pelvics.

Parmaturus melanobranchus is obviously close to *P. campechiensis*. In addition to the difference in the position of the first dorsal fin, however, *P. melanobranchus* differs in a number of proportional measurements from *P. campechiensis* and also in having a somewhat more highly differentiated caudal crest. The total number of vertebrae, 140 for *P. melanobranchus* as compared with 111 for *P. campechiensis*, shows a far greater difference than can be accounted for by species variation.

Discussion. Chan's description, illustrations, and measurements of the species are comprehensive and accurately cover the essential features of this shark and will not be repeated here.

Parmaturus melanobranchus has modified denticles (as in the caudal crest) on the ventral side of the caudal peduncle and along the leading edge of the lower caudal fin lobe.

Subgenus *Campagnoia* New Subgenus

Type-species, *Parmaturus* (*Campagnoia*) *manis*.

Eyes more dorsal than lateral; eyes of juveniles and young small, the horizontal diameter of orbit more than two in snout length; adults not known.

Parmaturus manis n. sp.
Figures 60, 61, 62, 63

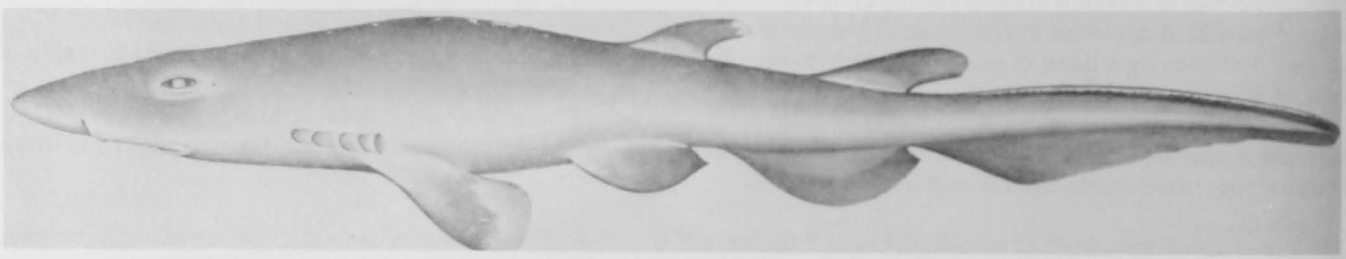


Figure 60.—*Parmaturus manis*, 328-mm female holotype from lat. 39°52'N, long. 70°50'W, (off Nantucket, Mass.) in 731-841 m. Drawing by Mary Wagner.

Figure 61.—*Parmaturus manis*, holotype, lateral view of upper lobe of tail showing caudal crest of denticles at top.

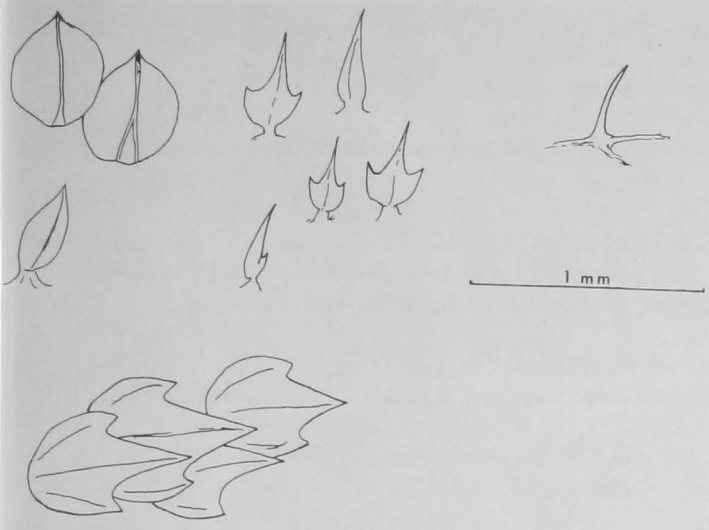


Figure 62.—*Parmaturus manis*, Upper left, denticles from top of head in advance of eyes. Upper middle, flank denticles from below first dorsal fin. Upper right, denticle from lateral surface of tail. Lower, caudal crest denticles.

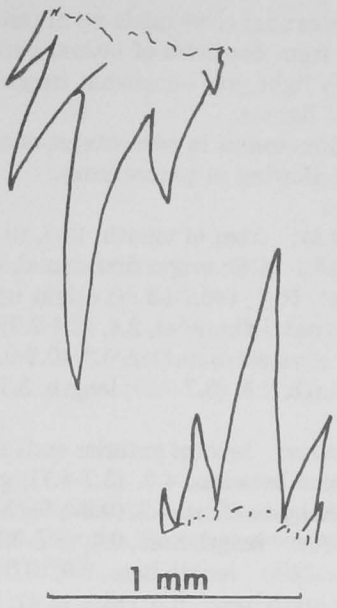


Figure 63.—*Parmaturus manis*, holotype, teeth from upper and lower jaws taken from 4th vertical rows, counting from symphyses.

Apristurus profundorum (not of Goode and Bean 1896). Springer 1966:612, figs. 22A, 23 (part, except holotype of *profundorum*).

Holotype. MCZ 38299, imm. ♀, 328 mm, southwest of Nantucket, Mass., lat. 39°52′N, long. 70°50′W, 731-841 m, W. C. Schroeder, stn. 24, 23 June 1952.

Paratypes. MCZ 37512, imm. ♂, from same haul as holotype; MCZ 37535, imm. ♀, 225 mm, lat. 39°52′N, long. 69°38′W, 658-768 m; MCZ 37416, 2 imm. ♂, 240, 245 mm, lat. 39°52′N, long. 70°43′W, 759-804 m.

Material examined. Known only from the type-series.

Etymology. From Latin *manis*, ghost or shade of the departed, in reference to its grayish-white color.

Diagnosis. *Parmaturus manis* most closely resembles species of *Apristurus* except for the presence of a well-defined caudal crest of modified denticles. *Parmaturus manis* has a long, flattened snout with a broadly rounded tip as in *Apristurus* and its eyes are nearly dorsal so that the shark's angle of view is more dorsal than lateral, also as in *Apristurus*. Of the species here placed in *Parmaturus*, *P. manis* most closely resembles *P. stenseni* but differs from it in having a broadly rounded snout instead of a snout tapering to a blunt point. *Parmaturus manis* not only has a longer snout than *P. campechiensis*, *P. melanobranchus*, *P. pilosus*, and *P. xaniurus*, about 10% TL in *P. manis*, but also lacks an appreciable interspace between the posterior end of the base of its long anal fin and the origin of the lower caudal lobe.

Description. *Parmaturus manis* is a soft-bodied scyliorhinid with a flattened head and a long flattened snout, the snout about 10% TL; snout spatulate, its tip broadly rounded; nasal apertures large, oblique; nasal flaps reduced to small pointed projections; no depressed area of upper lip forming a channel between nasal apertures and mouth; labial furrows prominent, upper and lower continuous around mouth corners; eyes small, dorsal, making shark's angle of view more dorsal than lateral; no supraorbital crest; gill slits short; spiracle small; fins lobelike, their corners rounded except posterior tips of pelvics and anal; first dorsal origin over middle of pelvic base; second dorsal larger than first, its origin over middle of anal base; anal fin long, length of its base more than 2 times length of first dorsal base.

Teeth small, mostly with three or five cusps, the middle cusp much the longest; arrangement alternate, a small space at the symphysis of each jaw; teeth in about 29+30/26+26 vertical rows.

Dermal denticles of lateral surfaces of tail sparsely and randomly distributed, needlelike, nearly erect, the point slightly curved posteriorly; forward from the tail the denticles become tridentate except on the top of the head where they are leaf-shaped with only one apical point and with a single very high central ridge; proximal half of upper edge of

caudal fin with a caudal crest made up of imbricate, tridentate denticles, their blades about as wide as long; crest denticles separated from denticles of lateral surfaces of tail by a band of naked skin (Fig. 61).

Color generally light gray somewhat irregularly suffused with darker gray but not definitely lighter above or below, tips of some fins lighter.

Proportional dimensions in percentages of total length are given here for the holotype with the range in dimensions for four paratypes following in parentheses.

Tip of snout to: front of mouth, 10.7, (9.3-10.7); first gill slit, 22.7, (19.6-22.7); fifth gill slit, 27.7, (23.6-27.7); origin pectoral, 26.4, (23.1-26.4); origin first dorsal, 46.7, (40.4-46.9); pelvic, 40.0, (36.4-42.9); origin second dorsal, 58.7, (52.2-58.7); origin anal, 50.7, (46.7-53.8); origin upper caudal crest, 69.3, (64.5-70.8); anus, 44.0, (40.9-45.7).

Eyes: horizontal diameter, 2.4, (2.4-2.7).

Spiracles: greatest diameter, 0.3, (0.3-0.6); least distance from eye, 1.1, (1.1-1.3).

Mouth: width, 7.5, (5.7-7.5); length, 3.7, (3.7-4.9); upper labial furrow, 3.2, (2.2-3.3); lower labial furrow, 2.7, (1.3-2.7).

Nasal apertures: level of anterior ends to snout tip, 6.9, (5.8-6.9); level of posterior ends to snout tip, 8.5, (8.3-9.4); minimum distance between, 4.3, (3.7-4.7); greatest length, diagonal, 3.5, (3.1-3.7).

Gill slits: height of first, 1.3, (0.9-1.6); height of fifth, 1.3, (0.7-1.5).

First dorsal fin: length base, 6.1, (5.8-6.5); length inner posterior margin, 4.0, (3.7-4.4); height, 3.2, (2.2-3.2).

Second dorsal fin: length base, 8.0, (6.0-8.0); length inner posterior margin, 4.5, (3.8-4.5); height, 2.7, (2.7-3.1).

Anal fin: length base, 15.5, (13.3-15.5); height, 5.1, (2.9-5.1).

Pectoral fin: width base, —, (5.3-6.7); length outer margin, 10.7, (8.4-10.7).

Pelvic fins: length, origin to rear tip, 10.9, (8.9-10.9).

Distance between fin bases: first and second dorsal, 7.5, (5.3-8.9).

Vertebral numbers: monospondylous 35, (34-35); precaudal 64, (62-65); caudal about 56, (about 48-57); total vertebrae about 120, (about 110-121).

Gill rakers not present; mouth denticles not present; inside of mouth with small papillae.

Color light gray with irregular darker areas; distal parts of some fins white.

Discussion. In an earlier paper (Springer 1966:612, figs. 22A, 23) I incorrectly based my account of *Apristurus profundorum* chiefly on the specimens here made the type-series of *Parmaturus manis*. The series was originally part of a collection of 16 *Apristurus*-like specimens caught by the RV *Caryn* and the fishing vessel *Cap'n Bill II* in the summers of 1952 and 1953. Eleven of the specimens were in fact *Apristurus* and rather nice-looking specimens. The other five were smaller and looked very much like sick, damaged, or long-dead *Apristurus*. These five are the specimens here described as *Parmaturus manis*. The entire collection of 16 specimens was reported as *Apristurus profundorum* at various times (Bigelow et al. 1953; Bigelow and Schroeder 1954; Schroeder 1955).

Parmaturus stenseni n. sp.
Figures 64, 65, 66

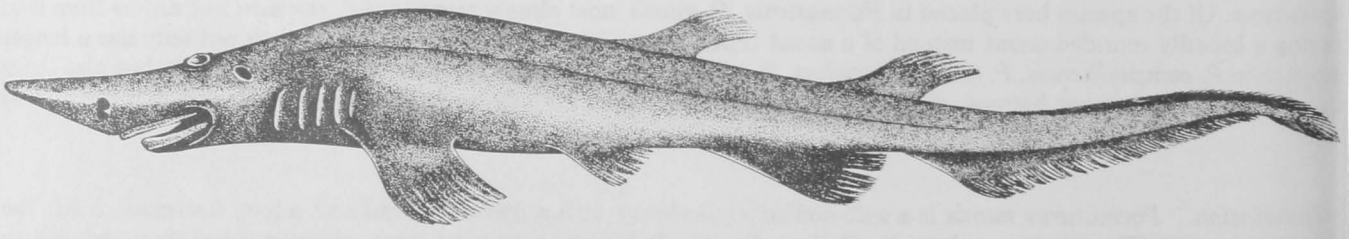


Figure 64.—*Parmaturus stenseni*, immature male holotype, 185 mm, from 915 to 975 m, Gulf of Panama. Drawing by Mildred Carrington.

Holotype. ZMK-*Galathea* 739-1, imm. ♂, 185 mm, Gulf of Panama, lat. 07°22'N, long. 79°32'W, 915-975 m, herring otter trawl, 15 May 1952.

Paratypes. ZMK-*Galathea* 739-2 to 41, 40 specimens, 94 to 230 mm, same haul as holotype except one specimen, which one not known, from *Galathea* station number 745, Panama Bay.

Condition of material examined. The only specimens known are those of the type-series. They are delicate sharks all damaged during capture in one way or another but all are complete enough for identification as belonging in the species

Figure 65.—*Parmaturus stenseni,* upper jaw teeth, longest tooth about 0.2 mm. Scanning electron photomicrograph by U.S. National Museum staff.

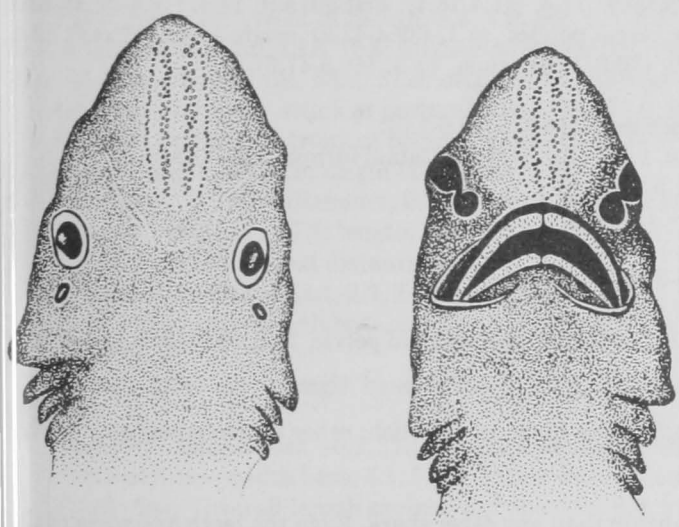


Figure 66.—*Parmaturus stenseni,* dorsal and ventral views of head of 203 mm female. Drawing by Mildred Carrington.

escribed here. The internal structures are generally in better condition than external ones. The series was fixed in Formalin and preserved in alcohol. Two specimens were cleared and stained, and are preserved in glycerin.

Etymology. *Parmaturus stenseni* is named in honor of Niels Stensen (Steno), 1638-84, in recognition of his important studies of elasmobranch anatomy, which, because of their scientific accuracy, were influential in the beginnings of elasmobranch systematics in the pre-Linnaean period and later, even to the time of the appearance of Müller and Henle's "Plagiostomia" in 1841.

Diagnosis. *Parmaturus stenseni* is a soft-bodied scyliorhinid shark with a caudal crest of modified denticles. *Parmaturus stenseni* and *P. manis* differ from other species of the genus in having longer, flattened, or somewhat conical snouts with eyes set in a dorsal position (Fig. 66) such that the shark's angle of view is more dorsal than lateral. Both species have large nasal apertures with nasal flaps reduced to small points. *Parmaturus stenseni* differs from *P. manis* in having the flattened snout tapering to a blunt point, its tip not broadly rounded as in *P. manis.*

Description. The description is based primarily upon two males and three females, the 185-mm holotype and four others, 203 to 230 mm, all immature.

Soft-bodied sharks with thin skins, head flattened, one-fifth to one-fourth total length; body moderately compressed tail from origin of caudal crest about three-tenths TL, its axis not elevated, upper and lower caudal lobes narrow, poorly developed, caudal notch present but inconspicuous; body cavity short; eyes small, orbit length less than one-half snout length; nasal apertures moderately large, nearer mouth than tip of snout, with small, short, and pointed nasal flaps; mouth with a moderately high arch, about twice as wide as high; labial furrows moderately prominent and continuous around mouth corners; fins not large, pectorals and anal largest; first dorsal origin about over middle of pelvic base; separated from second dorsal by a distance less than length of anal base; second dorsal slightly larger than first, its origin over posterior part of anal base, posterior end of its base posterior to rear tip of anal; anal base long, its origin under end of base of first dorsal fin.

Teeth not proportionally very small or numerous, in about 28 to 32 rows in each jaw, delicate and easily broken (see Fig. 65), with three or more cusps, the middle cusp longest, cusps somewhat lanceolate in type-series (all immature).

Dermal denticles over entire body surface except caudal crest needlelike on four-pronged bases; denticles very widely spaced; dermal denticles of caudal crest with three slender points, denticle blades nearly as wide as long, imbricate or nearly imbricate; a naked band of skin separating caudal crest from denticles of lateral surfaces of tail prominent in some specimens but very narrow in others; denticles inside of mouth not observed except on gill bars, gill bar denticles more or less erect with paddle-shaped denticle blades.

Livers not notably large but posterior tips reach level of cloaca in some specimens; valvular intestine with 10 or more turns.

Vertebral calcification moderately strong in trunk sector; monospondylous vertebrae in 10 specimens; 33 in three, 34 in six, 35 in one; estimated total number from radiographs 100 to 110.

Claspers of largest male, 208 mm, bent strongly outward, claspers moderately stiff but calcification not evident.

Dimensions as percentages of total length are given below for the 185-mm holotype and in parentheses the range in the holotype and four other larger specimens.

Tip of snout to: level of anterior ends nasal apertures, 4.3, (2.9-5.8); level of posterior ends nasal apertures, 5.9, (3.8-8.0); front of mouth, 6.5, (5.3-8.7); eye, 8.6, (8.6-12.2); spiracle, 11.4, (11.4-16.4); first gill slit, 18.4, (18.4-20.4); fifth gill slit, 23.2, (20.0-27.6); origin first dorsal, 47.0, (42.3-48.9); origin pelvics, 41.1, (39.4-42.2); origin second dorsal, 59.5, (59.1-62.2); anal, 54.1, (49.8-54.3); origin caudal crest, 70.0, (70.0-75.6); anus, 44.3, (41.8-47.6).

Eyes: horizontal diameter, 2.7, (2.4-2.7).

Spiracles: greatest diameter, 1.1, (0.7-1.1); least distance from eye, 0.6, (0.6-1.0).

Mouth: width, 7.0, (7.0-8.9); length upper labial furrow, 1.6, (1.6-3.6); lower labial furrow, 2.2, (2.2-4.4).

Gill slits: height first, 3.0, (1.9-3.6); height fifth, 2.7, (1.5-2.7).

First dorsal fin: length of base, 4.9, (3.9-5.1); height, —, (2.4-3.5).

Second dorsal fin: length of base, 5.4, (5.3-6.7); height, —, (3.0-4.4).

Anal fin: length base, 10.8, (10.3-14.8); height, —, (2.5-3.6).

Pectoral fins: width base, 5.9, (3.4-5.9); length anterior margin, —, (5.8-13.3).

Distance between fin bases: first and second dorsal, 7.8, (7.8-10.1); pectoral and pelvic, 13.0, (8.9-13.0); pelvic and anal, 7.0, (3.0-7.0).

Color, belly, lower snout, branchial region, and distal half of fins black or blackish; other external surfaces brown; inside of mouth, black; peritoneum black.

Discussion. *Parmaturus stenseni* seems to be far more delicate than any other shark. Even the teeth and some of the long slender denticles are somewhat flexible but were very easily broken or displaced.

In the largest male (208 mm), claspers were strongly bent laterally outward but I could not determine whether there was any calcification. In the largest female (230 mm), the ovary could be seen but no distinct ovarian eggs were recognized.

The peritoneum was black ventrally and laterally but not on the dorsal side of the body cavity. The inside of the mouth was black.

Subgenus *Parmaturus* Garman

First and second dorsal fins subequal or the first slightly larger than the second; eyes large, the horizontal diameter of orbits of adults and juveniles less than 1½ in snout; eyes more lateral than dorsal; adults with high proportions of squalene in liver oil.

Parmaturus pilosus Garman

Parmaturus pilosus Garman 1906:204 (Sagami Bay, Japan, 786 m); Garman 1913:89, pl. 8, figs. 7-10.
Pristiurus hertwigi Engelhardt 1912:643.

Material examined. MCZ 1107, imm. ♂, ca. 544 mm, holotype, Sagami Bay, Japan, lat. 34°59'N, long. 139°31'E, 786 m, Owston; SU 13899, imm. ♂, 563 mm, Sagami Bay, Owston; FMNH 74133, ♀, 640 mm, Sagami Sea, Owston; FMNH 74132, ♀, 590 mm, Boshu, Japan, Owston; SU 35478, ♀, 460 mm, probably Sagami Bay, Owston; FMNH 74168, ♀, 300 mm, Sagami Sea, Owston; FMNH 74134, imm. ♂, 293 mm, Okinose, Japan, Owston.

Diagnosis. *Parmaturus pilosus* should be identifiable readily by use of the foregoing key. As already noted, the distinctions between *Galeus* and *Parmaturus* adults are not very sharp and *Galeus eastmani* is similar to *P. pilosus* in many respects. *Parmaturus pilosus*, however, has smaller and narrower pectoral fins and a somewhat longer body cavity than *G. eastmani* so that the distance from the appressed pectoral tip to the origin of the pelvics in *P. pilosus* is greater than the length of the anterior margin of the pectoral. In *G. eastmani* the reverse applies.

All of the specimens of *P. pilosus* that I have seen have long been in preservative and the color has become more or less uniform brown. In three of the large specimens a series of small light-colored dots can still be seen along the lateral line. The presence of a series of white dots was emphasized by Englehardt (1912) as one of the ways to distinguish his species, *Pristiurus hertwigi*, from *eastmani*. He further separated the two by noting that *hertwigi* has a shorter snout and short pectoral fins, characters that apply to *P. pilosus*. Evidently Englehardt overlooked Garman's (1906) earlier description of *P. pilosus*. The type-series of Englehardt's *Pristiurus hertwigi* was lost by bomb damage in World War II and I cannot find differences other than color in Englehardt's description to separate *hertwigi* from *pilosus*.

A 563-mm male was found to be immature and none of the other specimens seen gave any indication of the size at maturity. Nothing is known of the reproductive pattern. *Parmaturus pilosus* is larger than *P. xaniurus* which seems to be mature at about 450 mm.

Description. The illustration of an immature male, its teeth and denticles, in Garman's Plagiostomia (1913, pl. 8, figs. 7-10) is excellent and should be consulted for additional details.

Following are measurements expressed as percentages of total length for a 563-mm immature male, first figure in each pair, and a 590-mm female, second figure in each pair.

Tip of snout to: front of mouth, 5.3, 4.6; eye, 5.7, 4.4; spiracle, 10.7, 9.8; first gill slit, 15.1, 13.6; fifth gill slit, 19.4, 18.3; origin pectoral fin, 18.6, 18.0; origin first dorsal fin, 45.5, 45.4; origin pelvic fins, 44.8, 44.1; origin second dorsal fin, 63.6, 63.4; origin anal fin, 58.6, 57.6; origin upper caudal fin, 71.0, 71.2; anterior end cloacal opening, 47.4, 46.1.

Greatest width of: trunk at pectoral origin, 9.1, 11.0; trunk at pelvic origin, 6.2, 5.6; caudal peduncle, 1.8, 1.9.

Greatest height of: trunk at pectoral origin, 11.1, 11.0; trunk at pelvic origin, 10.1, 8.8; caudal peduncle, 3.9, 3.9.

Eyes: length, 4.4, 3.9; height of opening, 1.2, 1.4.

Spiracles: greatest diameter, 0.7, 0.7; least distance from eye, 1.1, 1.0.

Mouth: width, 7.8, 7.6; length, 4.8, 3.7; length upper labial furrow, 1.1, 1.2; length lower labial furrow, 1.7, 1.5.

Nasal apertures: least distance between, 2.1, 2.2.

Gill slits: height of first, 2.3, 2.0; height of fifth, 1.1, 1.2.

First dorsal fin: length base, 6.6, 6.4; length free inner margin, 2.1, 1.9; height, 5.9, 5.4; length anterior margin, 9.8, 9.8.

Second dorsal fin: length base, 6.7, 6.4; length free inner margin, 1.4, 2.4; height, 4.6, 4.6; length anterior margin, 9.8, 9.7.

Anal fin: length base, 10.1, 11.5; length free inner margin, 1.1, 1.0; height, 4.3, 4.7; length anterior margin, 7.1, 8.0.

Pectoral fins: width base, 4.1, 5.1; greatest width of fin, 7.3, 7.0; length anterior margin, 8.0, 7.6.

Pelvic fins: overall length exclusive of claspers, 8.9, 9.8; length inner margin claspers, 7.6, —; extent claspers past pelvic fin tips, 3.0, —.

Distance between fin bases: first and second dorsals, 13.0, 12.2.

Among the specimens examined the smaller ones had narrow, nearly erect, and needlelike dermal denticles, the larger examples had tridentate denticles more or less erect.

The teeth, however, had more cusps in the smaller specimens, usually five or more cusps whereas the larger specimens had only three cusps on the larger teeth of the middle parts of the jaws.

The snout shape was more pointed or conical in the larger specimens than in the smaller ones.

If specimens referred to *P. pilosus* represent only one species it appears that marked changes in tooth and denticle form are to be expected.

The number of monospondylous vertebrae was 42 in each of three specimens, the total number of vertebrae 130 to 135.

Discussion. The 590-mm female *P. pilosus* had a short (about 15 mm) section on the ventral edge of the caudal peduncle with denticles modified in the same way as in caudal crests.

Parmaturus pilosus has a high concentration of squalene in its liver oil (Tsujimoto 1920). Since squalene is a low density hydrocarbon, it seems probable that its function is to give near neutral buoyancy to the shark and to eliminate much

of the energy requirement for a midwater habitat. I find no records of either depth of capture or of habitat observations for *P. pilosus* and implications of midwater habitat are all assumed and extrapolated from observations on *P. xaniurus*.

According to Tsujimoto (1920) one of the Japanese names for *P. pilosus* is imori-zame, another shusu-zame, implying that *P. pilosus* was a reasonably well-known shark to some Japanese fishermen. Tsujimoto found no squalene in any other scyliorhinid that he examined. I have great confidence in Tsujimoto's determination not only because of his excellent reputation as a chemist but also because he apparently had his sharks identified by Shigeho Tanaka whose work with Japanese sharks was outstanding in accuracy.

The range of *Parmaturus pilosus* has to be given here as moderately deep waters of the coasts of Japan. It should be pointed out however, that 60 to 300 yr ago, deepwater sharks were caught by Japanese and Portuguese fishermen and no others except a few on elaborately and expensively equipped expeditions. Thus, the known ranges of deepwater sharks and especially of those sharks with midwater habitats may be determined by the distribution of highly skilled fishermen whose art is now lost because of economic pressures.

Parmaturus xaniurus (Gilbert)
Figure 67

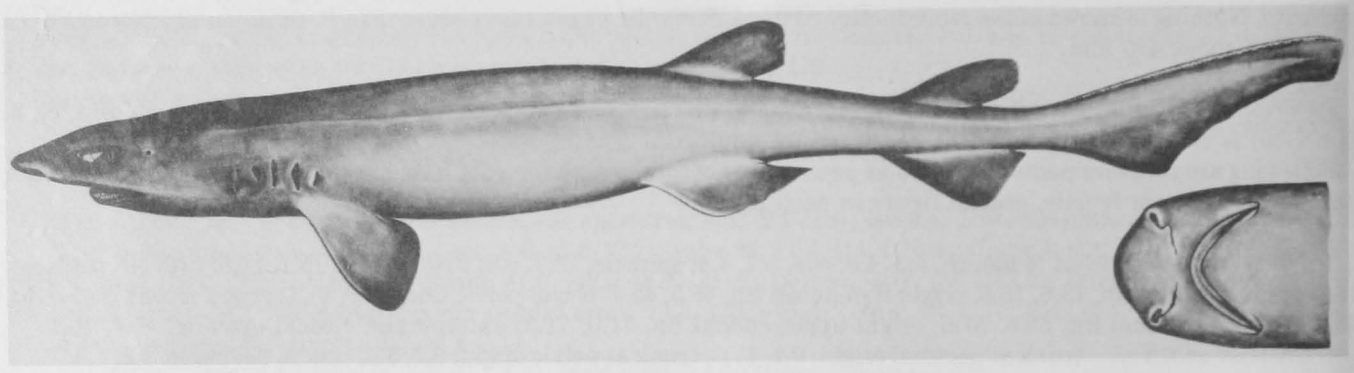


Figure 67.—*Parmaturus xaniurus*, 480-mm adult female filetail shark from 448 m off San Pedro, Calif. Drawing by Mary Wagner.

Catulus xaniurus Gilbert 1892:540 (coast of southern California).
Parmaturus xaniurus: Garman 1913:90, pl. 9; Roedel and Ripley 1950:48, fig. 32.

Material examined. USNM 46719, ♀, 550 mm, here designated lectotype, off southern California, lat. 33°55.5'N, long. 128°28'W, in 687 m, January 1889; USNM 46718, 4 ♂, 141-184 mm, 3 ♀, 140-163 mm, off southern California, paralectotypes; USNM 12059, 6♂, 146-224 mm, 7 ♀, 125-191 mm; USNM, imm. ♂, 410 mm, 2 ♀, 428, 499 mm, off San Pedro, Calif., lat. 34°16'N, long. 120°30'W, 448 m; USNM, juv. ♂, 135 mm, 2 juv. ♀, 170-185 mm, off southern California, lat. 34°12.5'N, long. 130°03.4'W, 91 m.

Diagnosis. *Parmaturus xaniurus* has a comparatively short snout and large eye. In specimens near adult size the length of the snout in front of the mouth is about equal to the horizontal diameter of the orbit. In *P. manis* and *P. stenseni* the snout is more than 2 times the length of the eye. In *P. xaniurus* the origin of the second dorsal fin is nearly opposite the origin of the anal fin, and the posterior tip of the second dorsal and anal fins are about opposite whereas in *P. pilosus*, *P. melanobranchus*, and *P. campechiensis* the tip of the second dorsal extends well past the anal tip.

Parmaturus xaniurus has comparatively small pectoral fins as do others of the genus but the proportional size is appreciably greater in large adults than in young.

Description. *Parmaturus xaniurus* is a soft-bodied shark without conspicuous markings. It is grayish-black, not much lighter below. The fins of some individuals may have darker spots, darker tips, or darker edges but these are not consistently present.

The origin of the first dorsal fin is usually in advance of the midpoint of the pelvic fin base, the first dorsal is slightly larger than the second dorsal and the distance between their bases is about equal to the length of the base of the anal fin.

Following are measurements of an adult female 467 mm long, first figure in each pair, and an immature male 135 mm long, second figure of each pair.

Tip of snout to: front of mouth, 4.3, 4.1; eye, 4.9, 3.7; spiracle, 11.1, 8.5; first gill slit, 16.1, 17.8; fifth gill slit, 22.7 23.7; origin pectoral fin, 21.0, 22.2; origin first dorsal fin, 46.7, 43.7; origin pelvic fins, 45.0, 41.1; origin second dorsal fin 61.7, 59.7; origin anal fin, 61.7, 58.3; origin upper caudal fin, 71.1, 67.1; anterior end cloacal opening, 47.1, 44.5.

Greatest width of trunk at: pectoral origin, 13.3, 11.1; pelvic fin origin, 5.6, 6.4; caudal origin, 1.7, 2.2.
Greatest height of trunk at: pectoral fin origin, 9.6, 9.0; pelvic fin origin, 7.4, 10.7; caudal fin origin, 3.7, 3.2.
Eyes: length, 4.3, 4.3; height of opening, 1.1, 1.7.
Spiracles: greatest diameter, 0.6, 0.6; least distance from eye, 1.1, 1.2.
Mouth: width, 9.0, 11.9; length, 5.1, 4.1; length upper labial furrow, 0.9, 1.3; length lower labial furrow, 1.7, 2.1.
Gill slits: height of first, 2.4, 3.7; height of fifth, 2.6, 2.2.
First dorsal fin: length base, 7.3, 7.4; length free inner margin, 3.4, 2.6; height, 4.3, 3.2; length anterior margin, 0.7, 9.6.
Second dorsal fin: length base, 6.4, 6.7; length free inner margin, 3.2, 3.0; height, 3.4, 3.0; length anterior margin, 0, 8.9.
Anal fin: length base, 9.4, 8.9; length free inner margin, 1.9, 1.3; height, 4.3, 2.4; length anterior margin, 8.1, 4.8.
Pectoral fins: width base, 5.1, 4.4; greatest width fin, 8.1, 4.6; length anterior margin, 10.7, 7.4.
Pelvic fins: overall length, 12.4, 10.7.
Distance between fin bases: first and second dorsals, 9.6, 8.9; pectoral and pelvic, 18.0, —; pelvic and anal, 8.4, —; nal and lower caudal, 2.1, —; second dorsal and upper caudal, 4.3, —.

The teeth of the 467-mm female *P. xaniurus* were in approximately 41+45/42+42 vertical rows, the upper and lowers milar in shape, the longest upper tooth about 0.8 mm from the enamel line, the longest lower tooth only about 0.4 mm igh. A few of the central rows of upper jaw teeth with three cusps, most of the uppers with four cusps, and a few near outh corners with five cusps. Most of the lower jaw teeth with four cusps.

Dermal denticles needlelike in young, dermal denticles of adults with three points, much as in other scyliorhinids.

Ovary (only right ovary developed) of 467-mm female with 10 large eggs 8 to 13 mm in diameter. Oviducts mature tretched about 7 mm in diameter); liver large reaching level of cloaca; spiral valve with seven turns.

Number of monospondylous vertebrae 38 in two specimens, 39 in five specimens examined. Total number of vertebrae in seven specimens 109 to 121.

Discussion. *Parmaturus xaniurus* is the only species of the genus known from more than a dozen specimens and is robably the only scyliorhinid to have been observed in moderately deep water. In California, *P. xaniurus* is well-known ichthyologists and to a few deepwater trawl fishermen as the filetail shark. Walford (1935) noted that it occurred from outhern California southward to about Port San Bartholome but was rarely taken by fishermen. Roedel (1951) reported ne capture of 15 specimens taken off Santa Barbara as noteworthy. Kato et al. (1967) gave the range as central Califoria southward to the Gulf of California. Mathews and Ruiz (1974) recorded the species as probably collected, but not rtainly identified, from the northern part of the Gulf of California.

The best clue to the distribution of *Parmaturus xaniurus*, and by inference to all other species of *Parmaturus* as well, as furnished by collections made by the General Motors research vessel *Swan* in the Santa Barbara and Santa Cruz asins. Hauls with an Isaacs-Kidd self-closing midwater trawl caught *P. xaniurus* in 43 hauls made from 10 to 490 m bove the bottom where water depths in the Santa Barbara basin were 500 m or more (Lee 1969). No other small sharks ere collected although *Apristurus brunneus* and *Cephaloscyllium venustum* are known from the region that includes ne Santa Barbara basin.

On a dive in the research submarine *Dowb* several small sharks were seen at the bottom in the deepest part of the anta Barbara basin (William Aron, pers. commun.). The sharks were estimated to be less than 600 mm long and were oted especially by Aron because the water there is known to be low in oxygen (Emery 1960). With the exception of the harks, Aron observed no benthic vertebrates except some apparently moribund myctophid fishes. Several myctophids ere seen lying on the bottom or motionless a short distance above the bottom. One shark, observed briefly, had a myctophid in its mouth. The general impression was that the sharks were feeding on myctophids that had accidentally moved into water too low in oxygen to support their activity.

Although the kinds of sharks most often seen in aquariums seem to need moderate to high levels of dissolved oxygen or survival, some others are known to thrive in regions of low oxygen such as in the deeper parts of the Red Sea Marshall and Bourne 1964) or to be taken in situations of very low oxygen (Compagno and Springer 1971). A question of pecies identity for the Santa Barbara sharks remained so Phillip Heemstra, who was well acquainted with the lhouettes of small sharks, made a later dive aboard the *Dowb*. Sharks were again observed and Heemstra identified nem positively as *Parmaturus xaniurus*. Feeding was not observed.

Livers and fresh liver oil from three immature female *P. xaniurus* were obtained from Santa Barbara fishermen by . S. Lee and examined by Mary H. Thompson, National Marine Fisheries Service, Miami. The liver oil was 54 to 59% qualene and the whole oil had a specific gravity of 0.886 to 0.891 at 20°C. Except for *P. pilosus* and *P. xaniurus*, liver oil qualene has not been found in any other scyliorhinid shark although it is found in some squaloid sharks, in *'hlamydoselachus*, in *Cetorhinus maximus*, and in some odontaspids of oceanic habitats. One squaloid, *Squalus canthias*, the spiny dogfish, has been shown experimentally to be able to adjust its sinking factor by shifts in the ratios f concentrations of diacyl glyceryl ethers to triglycerides in the liver (Malins and Barone 1970). It seems, therefore, not

unlikely that many sharks can make some minor or fine adjustments of hydrostatic balance by metabolic means. Suc changes presumably would take hours or minutes to become effective.

Large livers, with their content of light-weight oil, greatly reduce the energy requirements for slow swimming and a important as hydrostatic organs (Baldridge 1970, 1972) in many shark species. This seems always to be only a coarse ad justment. The substitution of the lower specific gravity squalene for other liver oils, such as is the condition in mos midwater sharks, may still be only a coarse adjustment to full hydrostatic balance.

The method of fine adjustment or the attainment of neutral buoyancy that is presumed here as necessary for th shark's mastery of the midwater environment, is still largely unknown but metabolic changes of liver components, suc as found by Malins and Barone (1970), may indicate one general method.

Cox (1963) described the egg capsule of *Parmaturus xaniurus* as being 74 to 110 mm by 28.5 to 36 mm, as bein relatively slender, and as having a smooth surface. His illustration (fig. 10) showed wide lateral flanges which in the te were noted to be T-shaped in cross-section. This is sufficiently unusual to distinguish *P. xaniurus* egg capsules fro others known from the California coast.

One egg capsule collected on 29 September 1966 in about 450 m had been attached to a black coral "tree" (*Antipathes* along with about 184 other capsules (Bill Bradley, pers. commun.). Bradley's log noted that the water temperature wa 6°C and that no filetail sharks were seen there on the day the egg capsule was recovered but that filetails had been see among large rocks in the locality (lat. 32°38.8′N, long. 117°29.3′W) on the previous day. The recovered egg capsule wa placed in a home refrigerator and apparently was alive with an active embryo about "half developed" when it died abou a year later.

PENTANCHUS SMITH AND RADCLIFFE

Pentanchus Smith and Radcliffe in Smith 1912:490 (type-species, *Pentanchus profundicolus* Smith and Radcliffe by original designation).

Diagnosis. A scyliorhinid shark with only one dorsal fin, its origin over the middle of a long anal fin; body strongl compressed, head moderately flattened with a long, somewhat spatulate snout abruptly narrowed in advance of th nostrils and tapering to a rounded point; nasal apertures large, oblique; nasal flaps represented only by small points, no large enough to cover outer nasal opening; no crest of modified denticles along upper edge of caudal fin; eyes more dorsa than lateral; five gill slits.

Discussion. Pentanchus is known only from the holotype of *P. profundicolus*. It was first described as a notidanoi shark in a new family, the Pentanchidae, because of its single dorsal fin.

Pentanchus is similar to *Apristurus* species in so many respects that Fowler (1941) regarded the name *Pentanchus* a superceding *Apristurus*. I follow Garman (1913) and Bigelow and Schroeder (1948), however, in retaining *Apristurus* a distinct from *Pentanchus* at the generic level.

Pentanchus profundicolus Smith and Radcliffe

Pentanchus profundicolus Smith and Radcliffe in Smith 1912:490, pl. 42; Garman 1913:95; Bigelow and Schroede 1948:196.

Material examined. USNM 70260, ad. ♂, 495 mm, *Albatross* Stn. 5486, lat. 10°02′N, long. 125°19′20″E, Sea Mindanao, Philippines, 1,069 m, 31 July 1909, holotype and only known specimen.

Condition of the holotype. The holotype (USNM 70260) is in fair condition. The original description gave the lengt as 508 mm and it now measures 495 mm, but the difference is undoubtedly due to normal shrinkage of scyliorhini specimens that have been preserved in alcohol for long periods. At some time in the past, possibly when the specime was first examined, the skin of the top of the head was peeled back and the upper part of the chondrocranium was remo ed and evidently discarded. It is consequently impossible to determine whether or not cranial crests projected above th orbits. Also cuts were made at a short distance away from the dorsal midline and a few trunk vertebrae and a fe vertebrae at the base of the caudal fin were removed and evidently discarded. The cuts did not damage the midlin where a dorsal fin might be expected and the specimen now shows no indication at all of fin components or of scar tissu from accidental damage. The trunk section of the specimen is still firm and the number of trunk vertebrae removed ca be estimated (7½ removed) with confidence. The number of tail vertebrae removed can be determined from the rem nants of the neural arches still apparent in radiographs.

X-ray examination of the specimen revealed one interesting and unexpected condition for which no explanation offered. The degree of calcification is as great as or greater than in any other scyliorhinid, not only in the vertebrae b also in fin radials, components of visceral arches, and even in rostral cartilages.

Diagnosis. *Pentanchus profundicolus* may be distinguished from other scyliorhinids by the presence of only one dorsal fin but otherwise has most of the characteristics of *Apristurus*. In addition, however, *P. profundicolus* differs from species of *Apristurus* in having a very short visceral cavity with broad and long pectoral fins so that the tips of the appressed pectorals nearly reach the origin of the pelvic fins. Perhaps the body cavity is somewhat longer in adult female *P. profundicolus*, but it seems more likely that the body cavity in both sexes of *P. profundicolus* will be found to be unusually short.

In *P. profundicolus* the snout is more strongly narrowed in advance of the nasal apertures and tapers to a rounded point rather than being broadly rounded as in species of *Apristurus*. The base of the anal fin in *P. profundicolus* is somewhat longer than in specimens of *Apristurus* that I have measured.

Jordan and Hubbs (1925) reported on a stuffed scyliorhinid shark with only one dorsal fin observed in a Japanese museum. They did not identify the shark as to species or genus but their account of it, noting small pectoral fins, large pelvic fins, and a short caudal fin, would not apply to *P. profundicolus*. The stuffed specimen seems to have been lost (Nakaya 1975).

Description. Proportional measurements as percentages of the total length in the 495-mm holotype of *P. profundicolus* follow.

Tip of snout to: level of anterior end of nasal apertures, 6.7; level of posterior end of nasal apertures, 8.9; front of mouth, 10.0; eye, 10.7; first gill slit, 20.6; last gill slit, 25.3; origin pectoral, 23.8; origin dorsal fin, 60.6; origin pelvics, 38.2; origin anal, 49.5; upper caudal fin origin, 71.7; anus, 41.0.

Greatest width of: head, 11.5; trunk at pectoral origin, 9.3; trunk at pelvics, 5.1; tail at caudal origin, 1.6.

Greatest height of: head at spiracles, 6.9; trunk at pectoral origin, 8.9; trunk at pelvics, 8.9; tail at caudal origin, 5.1.

Eyes: horizontal diameter, 3.2.

Spiracles: greatest diameter, 0.4; least distance from eye, 0.8; distance between, 6.5.

Mouth: width, 6.9; length, 2.6; length upper labial furrow, 3.4; length lower labial furrow, 2.6.

Nasal apertures: minimum distance between, 3.2; greatest diagonal length, 3.6.

Gill slits: height of first, 0.6; height of fifth, 1.1.

Dorsal fin: length base, 7.3; length free inner margin, 2.8; height, 3.0.

Anal fin: length base, 20.2; height, 3.4.

Pectoral fins: width base, 7.5; length anterior margin, 14.6; greatest width, 10.5.

Pelvic fins: length (origin to rear tip), 9.5.

Distance between fin bases: pectoral and pelvic, 5.9; pelvic and anal, 2.6; anal and origin lower caudal, 0.0; dorsal and origin upper caudal, 3.8.

The teeth are generally similar in the upper and lower jaws but the upper teeth have slightly higher cusps. Upper teeth in the central part of the jaw may have only three cusps, the central cusp much the longest, but most of the teeth have five cusps and the central cusps are lower toward the angles of the jaws. The teeth have striations near their bases. Smith and Radcliffe in Smith (1912, pl. 42) showed the main tooth cusps somewhat lanceolate, constricted at the bases. This seems to be an error. I have found the lanceolate form of tooth cusps in some juvenile *Apristurus* and in some juveniles of related genera, but cusps of the teeth of the holotype taper regularly from their bases to near their tips. The largest teeth are about 1.5 mm high. The teeth are numerous, alternate in both jaws, and those in the lower jaw form diagonal rows. I did not attempt to count the number of rows since counting would have required cutting one jaw corner.

Whether or not gill rakers are present was not determined.

The dermal denticles are tridentate, small, the blades of the largest about 0.5 to 0.7 mm long, imbricate, with a single median ridge. Denticles are similar in shape over most of the body surfaces but lateral and ventral denticles have reduced lateral points somewhat less prominent than those shown in Smith and Radcliffe's figure (in Smith 1912, pl. 42). No caudal crest of modified denticles is present.

The general appearance of *P. profundicolus* in its lateral aspect is well shown in Smith and Radcliffe's illustration. The first gill slit is shorter than the fifth as in the illustration. It appears that the angle of view of the eyes may be less dorsal than in species of *Apristurus* but the condition of the head of the specimen does not allow any assurance on that question.

Another difference is that the patch of pores on the under side of the snout is not divided along the midline as it is in *Apristurus*.

The viscera of the holotype are not at present in good condition but it does appear that the liver is unusually small in comparison with species of *Apristurus*, its lobes not reaching posteriorly for more than half the length of the short body cavity.

The color of the holotype is now as described by Smith and Radcliffe, uniform dark brown.

Springer and Garrick (1964:86) estimated the number of vertebrae (because of several centra missing) as 74 precaudal, 54 caudal.

PORODERMA A. SMITH

Poroderma A. Smith 1837:85 (type-species, *Squalus africanus* Gmelin, 1789:1494, designated by Fowler 1908:53).
Conoporoderma Fowler 1934:234 (type-species, *Scyllium pantherinum* Müller and Henle, by original designation).

Diagnosis. Species of *Poroderma* are the only scyliorhinid sharks with cone-shaped barbels that extend from the nasal flaps for a distance at least as great as the diameter of the barbel base. Adult *Poroderma* are conspicuously marked either by dark longitudinal stripes, by round solid spots, by crescent-shaped markings that may be arranged in pairs to form interrupted circles, or by short bars.

Poroderma closely resembles *Scyliorhinus* in many respects. In both genera the supraorbital crests of the chondrocranium extend above the orbits as narrow shelves, lower labial furrows are present but labial furrows are not continuous around the mouth corners and a true upper labial furrow is not present, the upper lip is very slightly expanded or enlarged at each mouth corner and more or less overlaps the lower lip as an inconspicuous lobe. The margin of the mouth corner lobe of the upper lip curves laterally and then anteriorly, especially in *Poroderma* and may then look superficially like an upper labial furrow. It can be seen easily, however, that the upper lip margin is entirely distinct from the lower labial furrow and is not connected with it. A subocular gutter appears to be somewhat less distinct in *Poroderma* than in *Scyliorhinus* and an apron formed beneath the claspers by union of the basal section of the inner margins of the pelvic fins is less developed in *Poroderma* than in *Scyliorhinus*.

Discussion. Bigelow and Schroeder (1948:197) rejected the name *Poroderma* for the genus because its type-species, *Squalus africanus* Gmelin, designated by Fowler, "lacks barbels." It is true that Gmelin's (1789:1494) description of *Squalus africanus* includes no reference to barbels but it does not specifically indicate their absence. Gmelin's description does state that *Squalus africanus* has seven parallel longitudinal lines of darker color, a striking color pattern that is found on only one described species of shark, a species with barbels.

Andrew Smith (1837) listed four species, all from the Cape of Good Hope region, as belonging to *Poroderma: P. africanum, P. pantherinum, P. variegatum,* and *P. submaculatum.* Johannus Müller was present at the session of the Zoological Society of London at which Smith "demonstrated" his species. Müller and Henle (1841) published accounts of the first three species, crediting Smith. Subsequent authors have recognized variously one to three species. Regan (1908a), Garman (1913), and Barnard (1925) included only *africanum* and *pantherinum* in their accounts of *Poroderma.* Fowler (1934) added a species, *P. marleyi*, based on a 225-mm specimen from the coast of Natal. Fowler's (1941) later treatment of *Poroderma* and Smith's (1949) account have keys to the three species *africanum, pantherinum,* and *marleyi.*

I have had only five specimens for study (see under material examined, *P. africanum* and *P. pantherinum*). Although my treatment of *Poroderma* here is based on my own observations and on literature references from 1949 and earlier, it is not essentially in conflict with the much more comprehensive account of Bass et al. (1975:27-32).

Key to *Poroderma,* Adapted from J. L. B. Smith (1949)

1a. Three to seven black longitudinal stripes on body; adults large, more than 700 mm . . . . . *P. africanum*

1b. Black spots on body, either randomly distributed or organized into longitudinal rows 2

2a. Spots most often with light colored centers, arranged as pairs of crescent shaped marks, or irregularly formed into various shaped marks, sometimes arranged in longitudinal bands; adults mature at somewhat smaller size than *africanum* . . . . . *P. pantherinum*

2b. Spots of solid color and random distribution; a small species reaching about 450 mm . . . . . *marleyi*

Poroderma africanum (Gmelin)
Figure 68

Squalus africanus Gmelin 1789:1494 (African seas).
Scyllium africanum: Müller and Henle 1841:12; Gunther 1870:405 (part).
Scyliorhinus africanus: Regan 1908a:456.
Poroderma africanum: Garman 1913:70; Fowler 1941:39; Bonde 1948:465, pls. 13-16; Smith 1949:53, fig. 37; Bass et al. 1975:28, table 5, fig. 16.

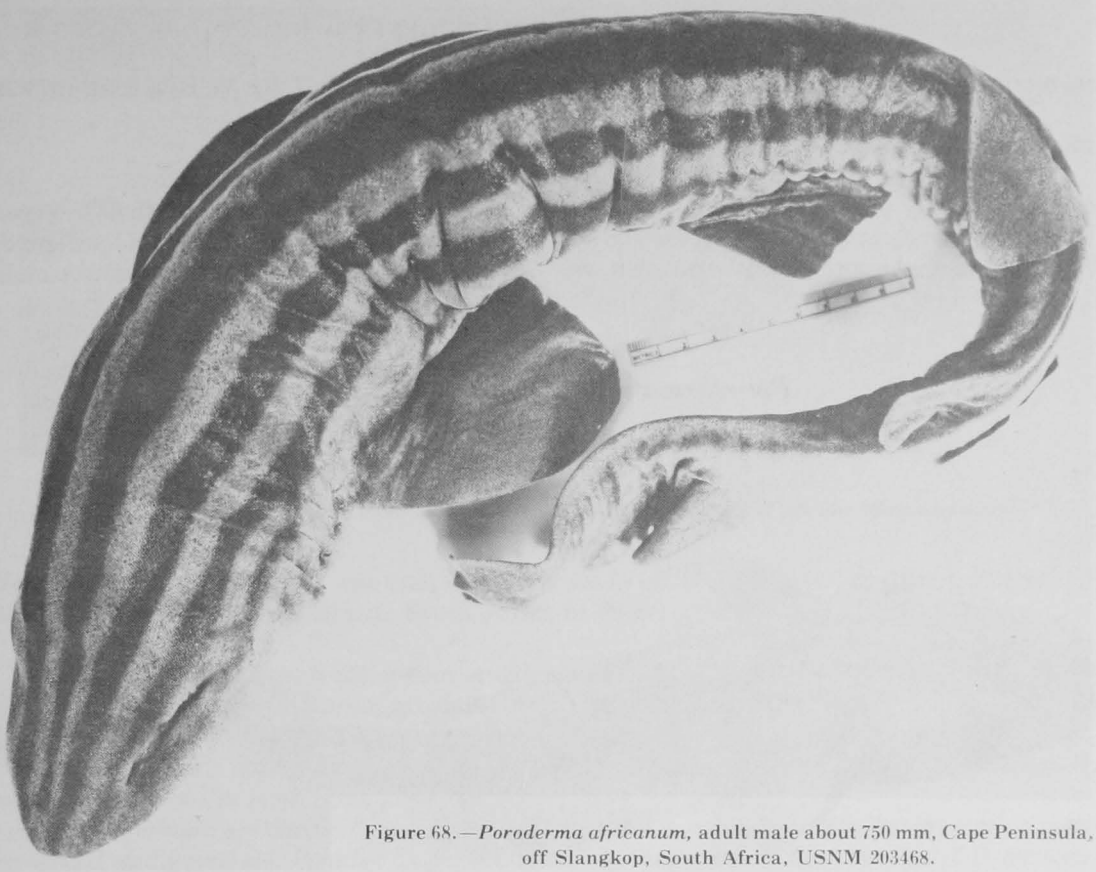


Figure 68.—*Poroderma africanum*, adult male about 750 mm, Cape Peninsula, off Slangkop, South Africa, USNM 203468.

Material examined. USNM 203468, ad. ♂, about 750 mm, Cape Peninsula, off Slangkop, South Africa; USNM, imm. ♂, 570 mm, same locality.

Diagnosis. *Poroderma africanum* differs from *P. pantherinum* and *P. marleyi* as well as from all other scyliorhinids in having three to seven dark stripes (most often five) extending from the head longitudinally along the back toward the tail. The middle three or five dark stripes are usually continuous, not broken into spots anterior to the first dorsal fin. The background between dark stripes and the ventral surface is cream colored.

The fins of *P. africanum* are unspotted whereas in *P. pantherinum* and *P. marleyi* all fins are spotted with darker color.

Description. *Poroderma africanum* is one of the larger catsharks, reaching a length of 950 mm (Barnard 1925). Bass et al. (1975) reported that specimens were sexually mature between 580 and 760 mm for males and between 650 and 720 mm for females; they observed no indication of sexual dimorphism in tooth shape.

The specimens I examined were strongly curved in preservation and not suitable for measurement, but Bass et al. (1975, table 5) provided an analytical summary of measurements of nine males and seven females.

Vertebral counts in the two specimens I examined were: total 117, 120; monospondylous 44, 45; precaudal 82, 85; caudal 35, 35.

Discussion. According to Bonde's account (1948), *Poroderma africanum* is an oviparous species and lays egg capsules about 103 by 50 mm, the capsules with long tendrils at each corner. Of two egg capsules laid at the Sea Point Aquarium by an 850-mm *P. africanum*, one was not viable, but the other hatched a young one 145 mm long on the 164th day. The egg capsule was transparent and smooth-surfaced, although barely visible striations indicated the structure of the capsule walls.

Bass et al. (1975) reported that *P. africanum* is abundant in shallow waters off the southwestern Cape; that its range off the east coast of Africa does not reach Natal; and that the extent of its range off the southwestern coast of Africa is undetermined. They observed *P. africanum* lying among the rocks and in caves at depths of about 10 m in Flase Bay and quoted a report that it is nocturnal in captivity.

Poroderma marleyi Fowler

Poroderma marleyi Fowler 1934:234 (Natal coast in 37 m); Smith 1949:53, pl. II, fig. 35; Bass et al. 1975:29, fig. 17.

Material examined. None.

Diagnosis. Randomly distributed round, dark spots of solid color, none much larger than the eye, distinguish *marleyi* from other *Poroderma*. The holotype of the species, ANSP 53427, was about 225 mm long and Smith's illust tion (1949, fig. 35) showed a specimen of about that size. Bass et al. (1975:29) had a 580-mm mature male from the co of Natal.

Poroderma pantherinum (Müller and Henle)
Figures 69, 70, 71

Figure 69.—*Poroderma pantherinum*, 610 mm female, Cape Blaize, South Africa.

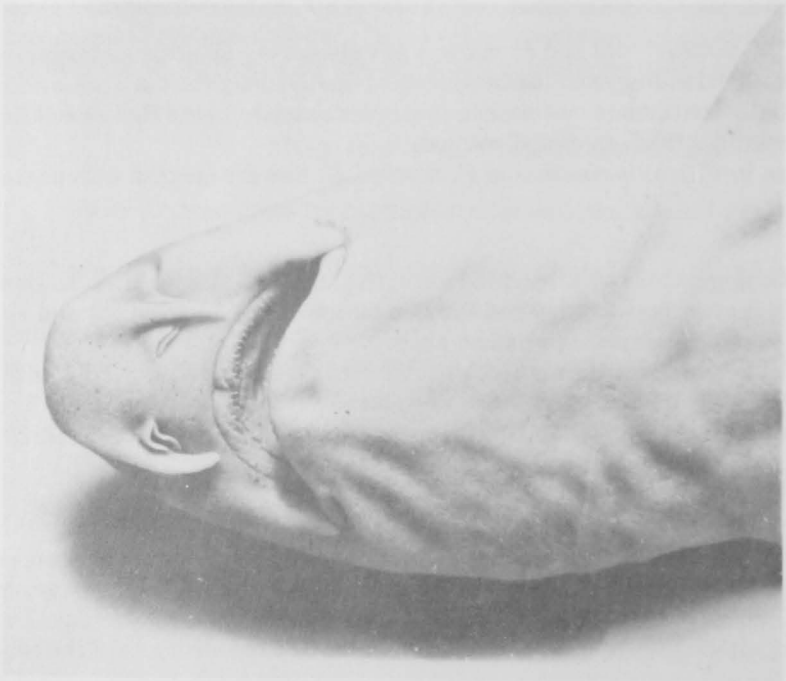


Figure 70.—*Poroderma pantherinum*, ventral side of he of 610 mm female.

Scyllium pantherinum Müller and Henle 1841:13 (Cape of Good Hope).
Scyllium africanum Var. γ. *pantherina:* Günther 1870:406.
Poroderma pantherinum: Fowler 1941:37; Smith 1949:53, fig. 36; Bass et al. 1975:30, fig. 18.

Figure 71.—*Poroderma pantherinum*. Color pattern of dorsal side of tail of 397-mm immature male.

Material examined. USNM, imm. ♂, 430 mm, Cape Peninsula off Slangkop, South Africa; BMNH 1900.11.6.19, imm. ♂, 397 mm, ♀, 610 mm, off Cape Blaize, South Africa in 69 m.

Diagnosis. Some earlier authors cited the greater length of the barbels, barbels reaching mouth, as a way to distinguish the present species from *P. africanum* in which the barbels are said not to reach the mouth. In my material, however, the barbels are somewhat slenderer and proportionally longer than those of *P. africanum*, but do not reach the mouth in a position that appears normal, and, conversely, barbels of *P. africanum* may reach as far back as the mouth if pushed toward the middle of the jaws.

Specimens of *P. pantherinum* are clearly distinct from *P. africanum* in color pattern in having a color pattern of spots in various shapes and configurations. *Poroderma pantherinum* also has spots on fins, but fins of *P. africanum* are free from dark markings.

Description. An analytical summary of measurements of five males and five females was included in the treatment of *Poroderma pantherinum* by Bass et al. (1975, table 5). The color pattern and its variation in *P. pantherinum* is best understood by reference to illustrations (see Bass et al. 1975, fig. 18; Smith 1949, fig. 36; and Figs. 69 and 71 in this study).

Vertebral numbers in a 430-mm male are: total 114, monospondylous 41, precaudal 80, caudal 34.

Discussion. According to Günther (1870) the type of *Scyllium pantherinum* is an Algoa Bay, stuffed specimen, 27 in long, from the collection of A. Smith. In the original description, Müller and Henle (1841) mentioned such a specimen among several others as belonging to this species and gave Cape of Good Hope as the locality for all.

Bass et al. (1975:31) recorded lengths from 540 to 740 mm for mature males and 580 to 710 mm for mature females. They did not have data on hatching size or on egg capsules.

SCHROEDERICHTHYS SPRINGER

Schroederichthys Springer 1966:604 (type-species, *Schroederichthys maculatus* Springer, by original designation).

Diagnosis. The tail section of *Schroederichthys* is longer than the head-trunk section, the distance from the anterior end of the cloacal opening to the tail tip about three-fifths or more than three-fifths the total length in adults and as much as two-thirds the total length of juveniles of some species.

Members of the genus have supraorbital crests extending as narrow shelves above the orbits; they have labial furrows continuous around the mouth corners along both upper and lower jaws. They lack a crest of modified denticles on the upper edge of the caudal fin and the pelvic fins of males are not united along their inner margins to form an apron above the claspers.

Discussion. Schroederichthys belongs with the group of genera including *Scyliorhinus, Poroderma, Cephaloscyllium, Atelomycterus,* and *Aulohalaelurus,* all having supraorbital crests. The four species of *Schroederichthys* are known only from Central American or South American coasts. The type-locality of one, *S. bivius,* I believe to have been recorded originally in error as the Cape of Good Hope, South Africa (see discussion under *S. bivius*).

Key to Species of *Schroederichthys*

1a. Nasal flaps nearly triangular, their margins far from parallel, tip or sides of broadly based triangular flaps sometimes with a very short lobelike extension at the apex of the triangle . . . . . .

1b. Nasal flaps lobelike, the lobes narrow and usually long, their lateral margins parallel or nearly so . . . . .

2a. Dorsal and lateral surfaces tan or brown with numerous randomly distributed, nearly round, light-colored spots about the size of the expanded pupil or larger, usually also with six to nine saddle blotches slightly darker than ground color, indistinct or absent on head and trunk in most adults; small sharks, maximum length about 350 mm . . . . . *S. maculati*

2b. Dorsal and lateral surfaces variously light brown to dark gray or brownish-black and profusely marked with black; markings include many black spots, a few round black spots sometimes present on ventral surfaces; six to nine saddle blotches, sometimes including black spots, sometimes all black, and in some specimens with a few white spots; moderately large scyliorhinids, largest seen an adult male 630 mm . . . . . *S. chilens*

3a. Dorsal surfaces typically gray-brown usually with about seven or eight saddle blotches somewhat poorly defined; usually also some irregularly scattered spots of white, smaller than dark-adapted pupil but usually highly contrasted with ground color; juveniles (three specimens seen) with large black saddle blotches of solid color and contrasting white patches between blotches; a large scyliorhinid, adults to 700 mm . . . . . *S. biviu*

3b. Dorsal surfaces (of two immature type-specimens) brown with numerous small darker brown spots, mostly somewhat smaller than expanded pupil and some arranged in rows outlining saddle blotches; no white spots; a large scyliorhinid reaching 700 mm or more . . . . . *S. tenu*

Schroederichthys bivius (Müller and Henle)
Figures 72, 73

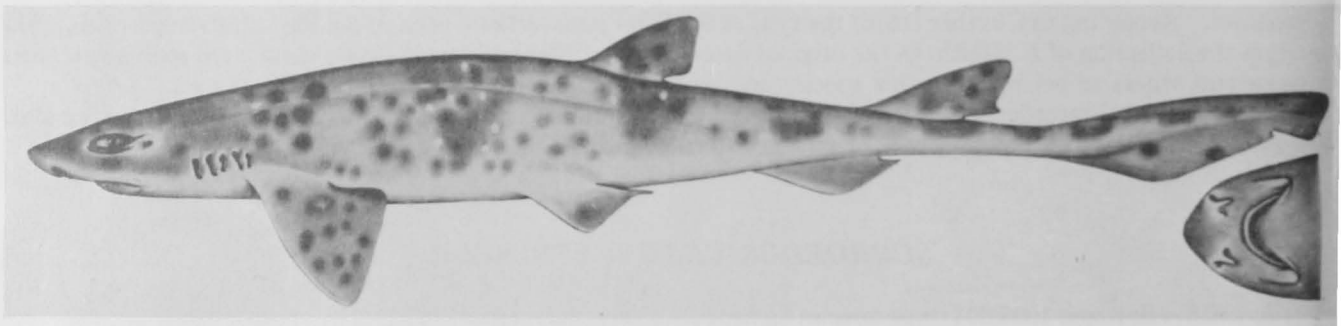


Figure 72.—*Schroederichthys bivius*, female, 440 mm, southern Chile, USNM 114725. Drawing by Mary Wagner.

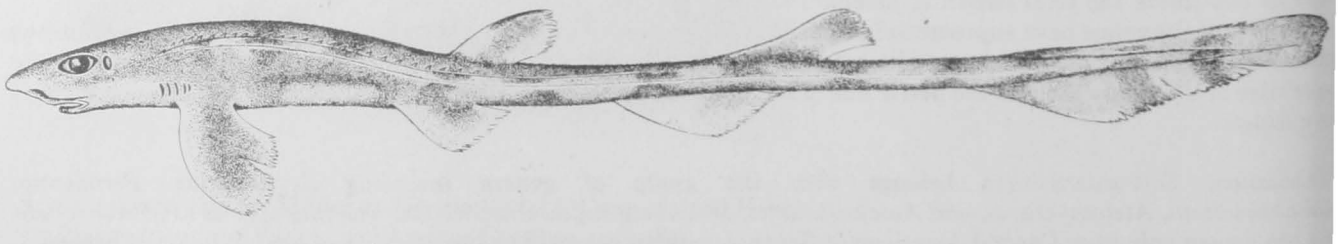


Figure 73.—*Schroederichthys bivius*, juvenile male about 110 mm long, Straits of Magellan. Drawing by Mildred Carrington.

Scyllium bivium A. Smith 1837:85 (name only).
Scyllium bivium: Müller and Henle 1841:8 (Cape of Good Hope, probably in error); Günther 1870:405.
Scyliorhinus bivius: Regan 1908a:462; Norman 1937:8; Petit and Budker 1937:120.
Scylium bivium: Lahille 1929:302, figs. 3, 4, 5.
Halaelurus bivius: Garman 1913:86; Springer 1966:618, fig. 26; Kato et al. 1967:26, fig. 39; Gosztonyi 1973:317, pl. 1 and fig. 1.

Material examined. BMNH 1936.8.26.12.14, 2 juv. ♂, about 110 mm, juv. ♀, about 155 mm, near Punta Arenas, Chile, lat. 53°39′S, long. 70°54′W; USNM 114731, 5 ♂, 552-625 mm, Lin Bay, Chile, lat. 41°54′S, long. 73°06′W; USNM 114725, ♀, 436 mm, Castro, Chile, lat. 42°29′S, long. 72°46′W; USNM 114727, 2 ♀, 437-447 mm, Puerto Montt, Chile; USNM 42061, ad. ♂, 700 mm, Straits of Magellan; BMNH 1879.5.14. 406, 2 egg capsules with well developed embryos, Straits of Magellan, January 1876; BMNH 1849.11.2.2, egg capsule.

Diagnosis. *Schroederichthys bivius* and *S. chilensis* both vary considerably in color pattern and in the proportions that are often used in the diagnosis of scyliorhinids. I recommend that first attention in identification be given to the shape of the nasal flap. It does not vary greatly in shape in either species. In *S. bivius* it is moderately long and slender and definitely not broadly triangular as it is in *S. chilensis.*

Identification of specimens from the region south of lat. 50°S is made difficult because both *S. bivius* and *S. chilensis* may be found there and exhibit secondary sexual dimorphism in mouth and tooth shape. In *S. bivius*, and possibly also in *S. chilensis*, proportional differences between young and adults are great. Possible differences in total length at sexual maturity in individuals taken from areas far apart should also be taken into account in future comparative studies of the two species.

In side by side comparison of an adult male 625 mm *S. bivius* with an adult male 620 mm *S. chilensis*, it was noted that *S. bivius* has a somewhat more pointed snout, a narrower head, a longer and narrower mouth, somewhat larger eyes, much smaller spiracles, and smaller dermal denticles with less variety in denticle shape on the head region. Most important, however, the nasal flaps were narrow and long lobes on *S. bivius* but broad-based and relatively short on *S. chilensis*. The lobelike, narrow and long nasal flaps of half-grown *S. bivius* among specimens I have seen distinguished that species from *S. chilensis*. I have not myself, seen either adult female *S. bivius* or newly hatched *S. chilensis.*

Description. Newly hatched *S. bivius* (Fig. 73) from the Straits of Magellan have very long tail sectors, their lengths from the anterior end of the cloacal opening to the tip of the tail two-thirds or more of total length. The tail section was shorter in the large specimens that I examined but was near three-fifths or more than three-fifths of total length. The *S. bivius*, that appeared from yolk scars to be newly hatched, were about 110 mm long.

Norman (1937:8) said of *S. bivius* that no enlarged tubercles were present on the back. On the newly hatched *S. bivius* two rows of much enlarged denticles are present on the back but are represented partly by scars on the 155-mm specimen and are entirely absent on the half-grown specimens seen. The enlarged denticles on *S. chilensis* are of a different shape and apparently persist for a longer period but are frequently absent even on half-grown individuals.

The series of enlarged denticles noted as present on juvenile *S. bivius* are the "dents cutanées jumelées" discussed in detail by Petit and Budker (1937). Petit and Budker pointed out the structural differences between the "twin denticles" of juvenile *S. bivius* and the dorsal tubercles with surrounding rosettes of smaller denticles on *S. chilensis*. The dorsal tubercles of *S. chilensis* evidently persist longer (or appear later) than the enlarged denticles of *S. bivius*. I found the *S. bivius* and *S. chilensis* material available for examination incomplete and somewhat baffling as did most earlier authors. This difficulty is now partly removed by the account of Gosztonyi (1973) on a series of *S. bivius* including adults of both sexes and egg capsules.

Gosztonyi (1973) described for *S. bivius* the secondary sexual dimorphism in both mouth and tooth morphology from a study of a series of late embryos, juveniles, and adults of both sexes collected in an estuary of the Desado River (about lat. 48°S), Argentina. In adult male *S. bivius*, the lower jaw teeth are definitely larger than the upper and the teeth lack accessory cusps in both jaws. The adult male's teeth are at least twice as high as the teeth of females of comparable size. The teeth of females and young are multicuspid, mostly tricuspid near the middle of the jaw but with five or more cusps near the jaw corners. The mouth of the male at maturity develops a higher arch that becomes V-shaped with the midportion of the jaws occluding approximately on a transverse line; the arch of the jaws not evenly rounded in a V-shape as in females and immature males. In Gosztonyi's series, males were mature at 530 mm. Some records of lengths show *S. bivius* may reach a length of 700 mm in the Straits of Magellan. This disparity in lengths of adults seems unusual but it should be noted that the geographical range of *S. bivius* extends as a narrow strip over a great distance and presumably has a large range of temperature differences.

The following measurements are based entirely on notes that I made years ago on two adult males collected in Lin Bay, coast of Chile, at lat. 41°54′S, long. 73°06′W, 20 January 1945. Measurements are expressed as percentages of the total length, the first figure in each pair refers to a 625-mm adult male and the second to a 555-mm adult male.

Tip of snout to: front of mouth, 3.5, 3.8; first gill opening, 16.0, 15.1; fifth gill opening, 20.5, 18.4; origin pectora fin, 19.2, 18.0; origin first dorsal fin, 43.8, 40.5; anterior end cloacal opening, 40.0, 37.9; origin upper lobe caudal fin, 81.4 78.0.

Eye: horizontal diameter orbit, 2.7, 2.9; vertical diameter, 1.0, 0.7.

Nasal apertures: least distance between, 2.7, 2.3.

Mouth: width, 6.4, 5.8; length, 5.6, 5.0; length upper labial furrow, 3.2, 2.7; length lower labial furrow, 2.7, 2.2.

Gill slits: height of first, 1.6, 1.4; height of fifth, 1.0, 0.7.

First dorsal fin: length base, 6.2, 5.6; length inner posterior margin, 3.2, 2.9; anterior margin, 10.2, 9.0.

Second dorsal fin: length base, 6.7, 8.3; length inner posterior margin, 3.2, 2.9; length anterior margin, 10.9, 12.6.

Anal fin: length base, 9.9, 9.4; length inner posterior margin, 2.4, 2.2; length anterior margin, 7.5, 7.4.

Pectoral fins: length anterior margin, 12.2, 11.7; greatest width, 10.4, 8.6.

Distance between fin bases: first and second dorsals, 16.0, 16.2.

Length claspers: inner margin, 9.6, 9.4; extent past pelvic fin tips, 6.4, 4.9.

Pectoral fins: width base, 4.8, 4.5; length anterior margin, 12.2, 11.7; greatest width, 10.4, 8.6.

Distance between fin bases: first and second dorsals, 16.0, 16.2.

Greatest length clasper: inner margin, 9.6, 9.4; extent past tip of pelvic fins, 6.4, 4.9.

No notably enlarged dorsolateral denticles are present except on juveniles. The dorsolateral denticles are moderatel heavy with three points, the middle one strongest. The denticles of ventral surfaces generally with only one point and im bricate.

Dorsal surfaces grayish, with darker gray or black saddle blotches of irregular shapes. Some small white spots about mm in diameter among some darker spots of same size.

First dorsal fin origin about over posterior end of pelvic fin base; distance between dorsal fin bases about equal to dis tance from tip of snout to first gill slit.

Discussion. Müller and Henle (1841) credited their description of *Scyllium bivium* to Andrew Smith and indicate that it was based on a dry specimen from the Cape of Good Hope. In a footnote, Müller and Henle (1841:8) indicate that the species was established by Smith in the South African Quarterly Journal, Oct. 1831, No. 5, and in the Govern ment Journal of the Cape, 1 November 1828, but stated that they did not see these references. P. A. Hulley of the South African Museum looked for the articles in the South African Public Library and the Library of the Houses of Parliamen (South Africa). He found (pers. commun.) no publication under the title "Government Journal of the Cape," and found no mention of a fish by Smith in issues of the "Government Gazette of the Colony of Cape of Good Hope" for 27 Octobe 1828 and 7 November 1828; there was no entry for 1 November. The 1831 article by Smith in the South African Quarterl Journal had no reference to a shark, only to three percid fishes.

Both Andrew Smith and Johannes Müller were present at the 1837 meeting of the Zoological Society of London a which Smith gave an untitled paper which was published as a part of the Proceedings for 1837 and also, under the titl "On the necessity for a revision of the groups included in the Linnaean genus *Squalus*," in the Annals and Magazine o Natural History in its first (1838) volume. These published accounts included *Scyllium bivium* only by name. Data fo the Müller and Henle description were probably obtained at this time from Smith's specimen and apparently their de scription in 1841 was the first and was based entirely on a single stuffed specimen that can be considered the holotype

The 27-in stuffed specimen later came to the British Museum (Natural History) and is noted by Günther (1870:405) a the type of *Scyllium bivium*. I suspect that Günther did not know that Müller had already seen the specimen and ma have taken detailed notes with descriptive data for he stated in a footnote (1870:405) that, "I do not understand hov Müller and Henle obtained their notes on the coloration, as they had only one example for examination, the same fron which I have made the diagnosis, and the only one known to exist in collections." Victor G. Springer examined th specimen and sent me photographs of it. The specimen is now catalogued as BMNH 1857.10.20. I have no doubts tha this specimen is the holotype of *Scyllium bivium*.

I do have strong doubts about the type-locality given by Müller and Henle as "Am Cap" (Cape of Good Hope). In viev of the great interest in stuffed natural history objects during the 19th century it seems possible at least, that Smit bought a specimen in South Africa that had been collected near Cape Horn by a sailor and stuffed for sale by the sailo by the time the sailor reached South Africa. I am indebted to G. S. Myers for this suggestion.

Another possibility is that some specimens or labels were mixed since it was customary then to exhibit specimens o new species at scientific meetings, evidently before they were catalogued or formally deposited in a museum. In this in stance the holotype, as shown by its number, was catalogued in 1857, long after Müller and Henle described it and eve longer after it was obtained and exhibited by Andrew Smith.

Schroederichthys chilensis (Guichenot)
Figure 74

Scyllium chilense Guichenot 1848:362 (Chile); Günther 1870:405.

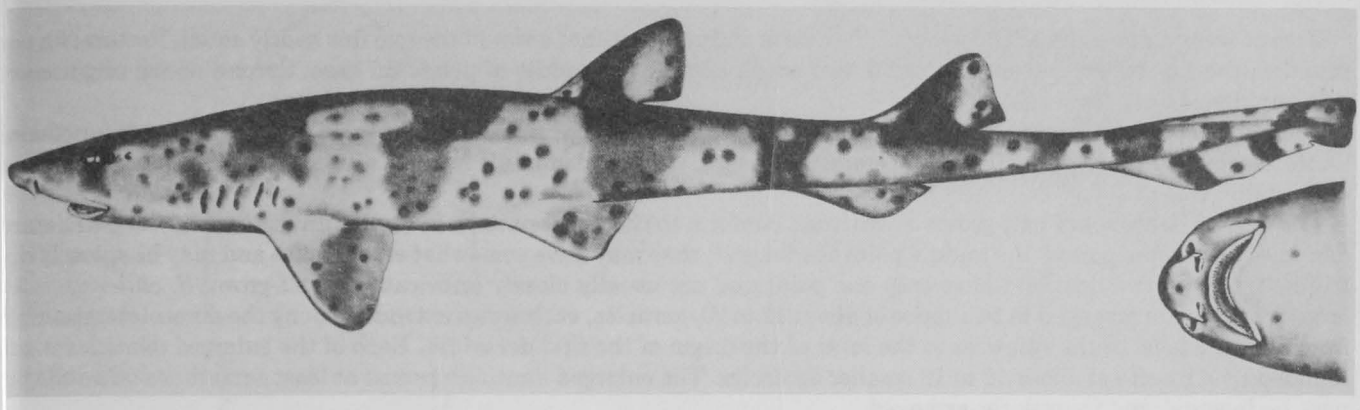


Figure 74.—*Schroederichthys chilensis*, immature female, 390 mm, coast of Peru. Drawing by Mary Wagner.

Scyliorhinus chilensis: Regan 1908a:462.
Halaelurus chilensis: Garman 1913:83; Springer 1966:618, fig. 26; Kato et al. 1967:26, fig. 40.
Schroederichthys chilensis: Chirichigno 1974:29, fig. 21.

Material examined. USNM, ad. ♂, 620 mm, ♀, 530 mm, Corral, Chile, lat. 39°42'S, long. 73°27'W, 36-45 mm; USNM 77305, ad. ♂, 565 mm, Tome, Chile; USNM, ad. ♂, 555 mm, Valparaiso, Chile; USNM 127764, ♀, 480 mm, Independencia Bay, Peru; USNM 77738, ad. ♂, Mollenco, Peru; USNM 114728, 2 imm. ♂, 400-410 mm, Coquimbo Bay, Chile; USNM 103770, imm. ♂, 325 mm, I. of Quiriquina, Chile; USNM, imm. ♀, 385 mm, imm. ♂, 400 mm, Valparaiso, Chile; USNM, imm. ♀, 255 mm, San Juan, Peru.

Diagnosis. The characters in the key should separate *S. chilensis* from *S. bivius* in most instances. Additional differences between the two forms were noted above under *S. bivius*. It has never been stated clearly and comprehensively how to distinguish all *S. chilensis* from all *S. bivius*. Certainly this diagnosis is not complete and may not be free from error. Such a situation probably arises because both species are highly variable, both undergo great changes during growth, and both have sexually dimorphic adults. Furthermore, if convergence in diagnostic characters occurs in the areas of geographical range overlap as it seems to do, a full diagnostic account would become remarkably long. I believe, however, that in most instances *S. chilensis* can be distinguished by its broadly triangular nasal flap. Some caution should be observed because both *S. chilensis* and *Halaelurus canescens* may occur in the same locality, and both have triangular nasal flaps. Large, melanistic *S. chilensis* may thus superficially resemble *H. canescens*.

Description. The measurements I have for *Schroederichthys chilensis* are for two immature males from the coast of Chile at about lat. 30°S and two immature females from the coast of Peru at about lat. 15°S. The following proportional measurements are expressed as percentages of the total length, the first pair of figures in each group refer to 365 and 392 mm males from Chile and the second pair in parentheses to 460 and 455 mm females from Peru.

Tip of snout to: front of mouth, 3.3, 3.3, (3.3, 3.3); first gill slit, 15.2, 16.6, (16.1, 15.4) fifth gill slit, 18.3, 21.4, (22.2, 20.2); origin first dorsal fin, 38.4, 38.6, (42.4, 42.6); anterior end cloacal opening, 37.0, 38.2, (39.1, 41.1); upper caudal fin, 80.3, 74.7, (81.6, 81.4).

Eye: horizontal length, 2.7, 2.8, (2.6, 2.6).

Nostrils: least distance between, 2.2, 2.0, (2.1, 2.2).

Mouth: width, 7.4, 7.7, (8.7, 7.7); length upper labial furrow, 2.2, 2.6, (2.4, 2.4); lower labial furrow, 2.2, 2.6, (2.6, 2.4).

Least distance between bases: first and second dorsal fins, 16.4, 16.6, (13.7, 15.6).

Gill slits: height of first, 1.6-2.0, (2.1, 2.0); height of fifth, 1.1, 1.3, (1.5, 1.5).

First dorsal fin: length base, 7.4, 7.7, (7.3, 8.4); length free inner margin, 3.6, 3.1, (3.7, 2.9); length anterior margin, 11.0, 10.4, (11.5, 12.3).

Second dorsal fin: length base, 8.8, 9.2, (9.3, 9.2); length free inner margin, 4.1, 3.1, (3.7, 3.1); length anterior margin, 12.3, 12.0, (13.0, 11.7).

Anal fin: length base, 8.9, 8.9, (7.6, 7.7); length free inner margin, 2.7, 2.8, (3.3, 2.9); length anterior margin, 7.4, 8.2, (7.6, 7.7).

Pectoral fins: width base, 5.2, 5.1, (4.6, 4.8); length anterior margin, 12.3, 12.0, (11.1, 11.2).

Pelvic fins: length anterior margin, 8.2, 7.1, (7.8, 7.5); length inner posterior margin, 8.7, 7.5, (5.2, 5.4); length outer posterior margin, 7.3, 7.0, (5.8, 6.4).

Base of second dorsal fin slightly longer than base of first dorsal but areas of the two fins nearly equal. Pectoral fin tip rounded, the fins broad and short. First dorsal origin about over middle of pelvic fin base. Second dorsal origin abou over middle of anal fin base.

Teeth in specimens examined varying from 23 to 33/22 to 33 vertical rows with four to six series apparently functional Tooth arrangement alternate. Teeth of immature of both sexes and of adult females multicuspid. Teeth of adult male unicuspid.

The dermal denticles of half-grown *S. chilensis* conform to the usual pattern in scyliorhinids, that is, the dorsolatera denticles have three points, the middle point the longest, they may have somewhat erect blades and may be sparsely dis tributed; the ventral denticles have only one point and are usually closely imbricate. In half-grown *S. chilensis*, a fe large denticles are arranged in two series of about 12 to 20 denticles, each series extending along the dorosolateral surfac from near the level of the spiracles to the level of the origin of the first dorsal fin. Each of the enlarged denticles is sur rounded by a rosette of about 12 to 18 smaller denticles. The enlarged denticles persist at least sometimes on adults bu may be unequal and irregularly arranged.

The various descriptions in the literature suggest that juvenile *S. chilensis* have enlarged denticles but I am uncertai that newly hatched specimens have been examined and doubt that comparisons of young *S. chilensis* with young *S bivius* have yet been made. Structural differences between enlarged denticles of young *S. bivius* and *S. chilensis* of un specified age or size have been described by Petit and Budker (1937). They use the term tubercle to describe the enlarge denticles of *S. chilensis*.

Between half-grown and adult stages in *S. chilensis* there appears to be a trend toward occurrence of proportionall larger denticles on dorsolateral surfaces especially on the head and anterior trunk. These denticles also tend to los points or any specific shape or surface sculpturing. The head becomes well armored with a pavementlike assortment o smooth denticles and is presumably well adapted to probing among rocks, corals, or armed invertebrates.

Schroederichthys chilensis has a color pattern of seven or eight distinct and often dark gray or black saddle blotche with a few nearly round dark gray or black spots between the saddles, these spots somewhat larger in diameter than th spiracles. Some specimens have few such spots on the ventral surfaces. Some individuals have a few small white spots The ground color of some specimens is light gray dorsally and white below but more or less general melanism may occur Some of the pigment occurs in the skin, but in the darker individuals it is also incorporated within denticles.

Discussion. *Schroederichthys chilensis* frequents shallow water, at least in the southern part of its range, as might b inferred by its small eye (smaller than eyes of *Halaelurus canescens*) and large denticles, somewhat smooth surfaced i the head region. It is known only from the west coast of South America. Its range overlaps that of *S. bivius* in southern Chile and extends northward to Peru. I have not verified a record of its occurrence south of lat. 39°42'S.

I have not seen an egg capsule of *S. chilensis* or any reference to one.

Schroederichthys maculatus Springer
Figures 75, 76

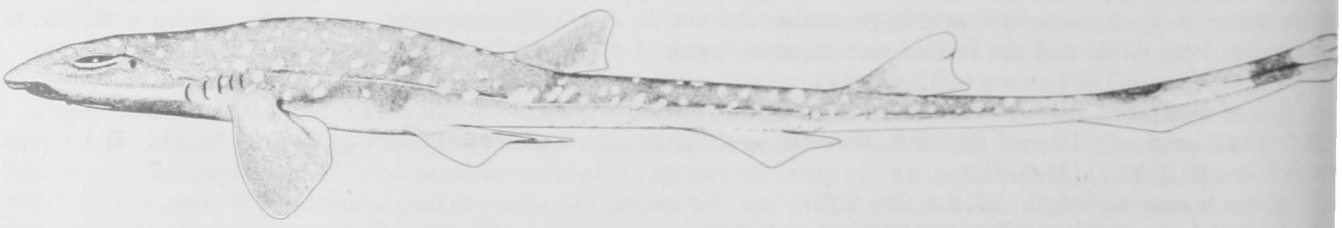


Figure 75.—*Schroederichthys maculatus*, adult male holotype, 330 mm, USNM 185556. Dorsal saddle blotches in this drawing are somewhat more prominent than is usual for the species. Drawing by Mildred Carrington.

Schroederichthys maculatus Springer 1966:605, fig. 4A (Caribbean Sea, NNW Cape Gracias a Dios, Honduras).

Material examined. USNM 185556, ad. ♂, 328 mm, holotype, off Honduras, 410 m, 21 August 1957; USNM 185557 ad. ♀, 335 mm, paratype, from same haul as holotype; USNM 187684, about 35 specimens, off Rosalind Bank, western Caribbean Sea, 274 m; USNM 187687, 4 specimens, off Rosalind Bank; USNM 187690, 7 specimens, off Quita Suen Bank, western Caribbean; USNM, 2 specimens, off western Colombia, 274 m.

Diagnosis. *Schroederichthys maculatus* is a small scyliorhinid, the maximum length about 342 mm. It has a shor trunk and a very long caudal section, the caudal section in adults about two-thirds total length, proportionally longe than in adults of any other scyliorhinid except possibly *S. tenuis*. Caudal fin is only about one-fifth total length

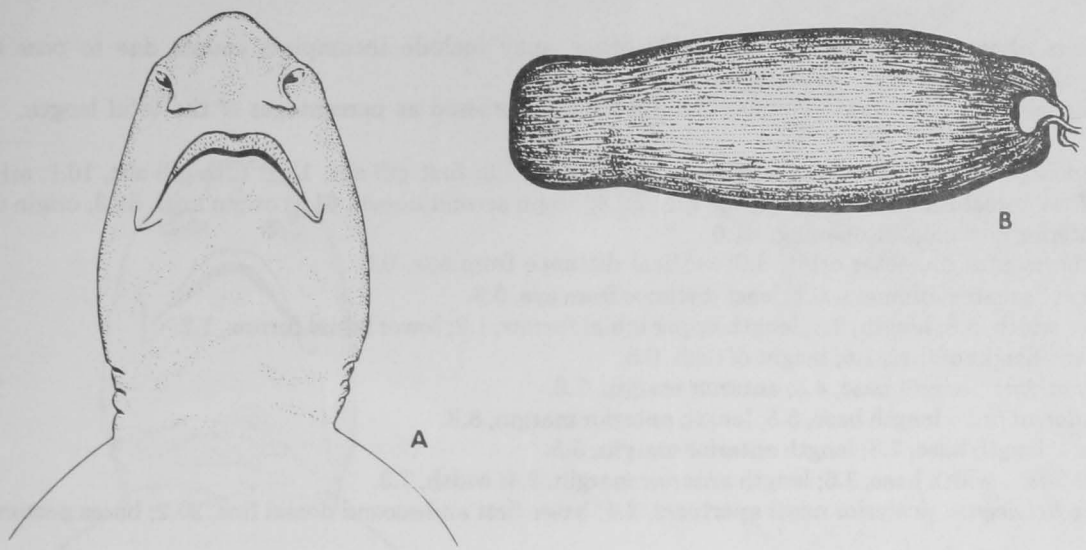


Figure 76.—*Schroederichthys maculatus*. A. Ventral side of head of 328-mm adult male holotype, USNM 185556. B. Egg capsule taken from oviduct of 342-mm female, midline length of capsule 39 mm, anterior end of capsule (without horns and tendrils) probably incomplete.

chroederichthys maculatus is not sexually dimorphic in tooth shape. It has broadly triangular nasal flaps unlike the arrow lobelike flaps in *S. tenuis* and *S. bivius*. It has no enlarged dorsal denticles such as are to be found on *S. chilensis*.

Schroederichthys maculatus is tan or light brown dorsally with randomly distributed, approximately round, ellowish or white spots, the spots about the size of the pupil. Young or half-grown *S. maculatus* have seven to nine sadle blotches which may faintly persist on adults or may be absent.

In color and pattern *Schroederichthys maculatus* and *Scyliorhinus torrei* are identical and they may be expected to occur in some of the same localities although available material does not show overlapping ranges. Of course, *maculatus* ay be recognized by its much longer tail section and also by the characters that distinguish *Schroederichthys* from *cyliorhinus*. *Schroederichthys* has labial furrows continuous around the mouth corners. *Scyliorhinus* does not and lacks urrows along the upper jaw. *Schroederichthys* also lacks the inconspicuous tabs of the upper lip that overlap the lower ip at the mouth corners in all species of *Scyliorhinus*. The pelvic fins of *Schroederichthys* males are not united along heir inner margins as they are in *Scyliorhinus*.

Description. In the series of *Schroederichthys maculatus* examined, 40 males ranged from 145 to 330 mm long and all f those longer than 280 mm were sexually mature. Nine females ranged from 220 to 342 mm. The 342-mm specimen was avid with one fully formed, opaque, greenish, egg capsule. The egg capsule was striated longitudinally and was 44 by 4 mm with threadlike tendrils 225 mm long.

Head broad and somewhat flattened; trunk short postpelvic section very long, about two-thirds total length, but udal fin short, about one-fifth length; trunk rather slender; snout with a rounded point.

Nasal flaps triangular, their points crossing or covering posterior part of nasal apertures; mouth with a moderately gh arch, somewhat higher and more V-shaped in the adult male; labial furrows extending around the mouth corners, t long, the upper and lower furrows about equal; eye moderately large, its length more than one-half length of snout, bocular gutter extends under full length of eye but does not include spiracle, subocular gutter lined with denticles; racle somewhat larger than in most scyliorhinids; gill slits not long, the last two above the pectoral base.

Origin of first dorsal fin over posterior end of pelvic fin base, origin of second dorsal fin over or slightly posterior to sterior end of anal fin base; second dorsal fin slightly greater in area than first dorsal, the distance between their bases eater than the head length; anal fin low, its base only a little longer than the second dorsal fin base; lower caudal fin w, without an anterior lobelike projection; pectoral fin very wide, its distal margin nearly straight; pelvic fins rather ng and narrow (not projecting much laterally), not united along their inner margins.

The teeth are in about 48 to 53 vertical rows in the upper jaw, 36 to 42 in the lower. Symphyseal teeth are not always ell-differentiated from other teeth. About two to four series are functional. Most of the teeth have long central cusps ith one or two much smaller cusps on each side of the main cusp. The largest upper jaw tooth in a 330-mm male was 0.9 m high.

Denticles of dorsolateral surfaces of adults are three-pointed but the middle point of each blade is much longer than e lateral points. The long denticle points overlap other denticles to some extent but skin is visible between most denicles. The largest on a 330-mm male were a little less than 0.5 mm long.

Radiographs show 29 to 32 monospondylous vertebrae in 23 specimens except one count of 36 that apparently was due the presence of 4 short (diplospondylous) vertebrae in the trunk where monospondylous vertebrae usually are present.

Total numbers of vertebrae, 132 to 145 in this series, may include incomplete counts due to poor resolution radiographs of terminal caudal vertebrae.

Measurements for the 328-mm holotype are given here expressed as percentages of the total length.

Tip of snout to: front of mouth, 4.2; eye, 4.6; spiracle, 7.2; first gill slit, 13.1; fifth gill slit, 16.1; origin pecto 15.2; origin first dorsal fin, 38.3; origin pelvic fins, 30.4; origin second dorsal, 61.1; origin anal, 52.3; origin upper cau fin, 80.5; anterior end cloacal opening, 31.0.

Eyes: horizontal diameter orbit, 3.0; vertical distance from eye, 0.9.

Spiracles: greatest diameter 0.7; least distance from eye, 0.9.

Mouth: width, 5.8; length, 3.3; length upper labial furrow, 1.2; lower labial furrow, 1.2.

Gill slits: height of first, 1.5; height of fifth, 0.5.

First dorsal fin: length base, 4.3; anterior margin, 7.0.

Second dorsal fin: length base, 5.5; length anterior margin, 8.8.

Anal fin: length base, 7.3; length anterior margin, 5.5.

Pectoral fins: width base, 3.6; length anterior margin, 9.4; width, 7.3.

Distance between: posterior nasal apertures, 2.4; bases first and second dorsal fins, 20.2; bases pectoral and pel fins, 10.7.

Clasper: length inner margin, 8.5; reach past pelvic fin tips, 2.5.

Discussion. *Schroederichthys maculatus* is known only from the western Caribbean Sea at depths from 190 to 410 but the series available for study includes a better representation of medium and adult specimens of both sexes tha available for most scyliorhinids. Catch data suggest a habitat preference of sea bottom of fine, white, calcare material. This is supported by radiographs of specimens showing nasal rosettes packed with mineral material and sections show the valvular intestines contain much of the white, finely granular material. One stomach examined c tained a 60-mm length of teleost vertebrae, one small squid or octopus beak, four eye lenses from an unidentified sou several pieces of algae, and several fish scales about 10 mm in diameter.

Schroederichthys maculatus shows very little difference in body proportions between immature individuals 145 to mm long and 280 to 342 mm adults.

Schroederichthys tenuis Springer
Figures 77, 78

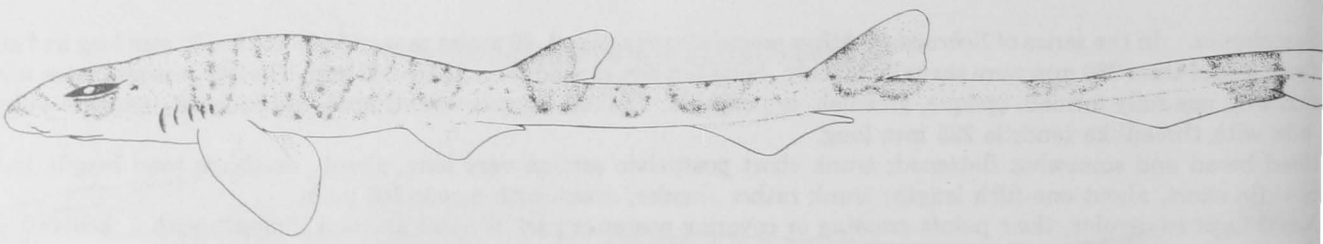


Figure 77.—*Schroederichthys tenuis*, 230-mm immature male holotype, coast of Brazil, USNM 188052. Drawing by Mildred Carrington

Schroederichthys tenuis Springer 1966:606, figs. 16B, 18 (off mouth of Amazon River).

Material examined. USNM 188052, imm. ♂, 230 mm, holotype, off mouth of Amazon River, lat. 01°49'N, lo 46°48'W, 410 m; USNM 188053, imm. ♂, 180 mm, paratype, from same locality as holotype.

Diagnosis. The narrow nasal flaps of *S. tenuis* (Fig. 78A) separate it from *S. maculatus* which has broadly triangu nasal flaps (Fig. 76A). The color pattern of *S. tenuis* (see Fig. 77) in the two immature specimens of the type-series tinguishes it from the three other species of the genus as indicated in the preceding key.

Gerhard Krefft has informed me (pers. commun.) of the capture of a 70-cm specimen of this species off the coas Brazil. Evidently *S. tenuis* is a much larger species than *S. maculatus*, equal to or larger than *S. bivius*. Separatio the small *S. tenuis*, 180 mm, from small *S. bivius*, 155 mm, seems adequate on the basis of color pattern. In *S. tenu* pattern of small spots outlines saddle blotches whereas in *S. bivius* the saddle blotches are made up of solid color with bordering spots.

Description. Comparison of measurements of the 220 and 180 mm *S. tenuis* with measurements of *S. maculatu* equal length shows no significant differences.

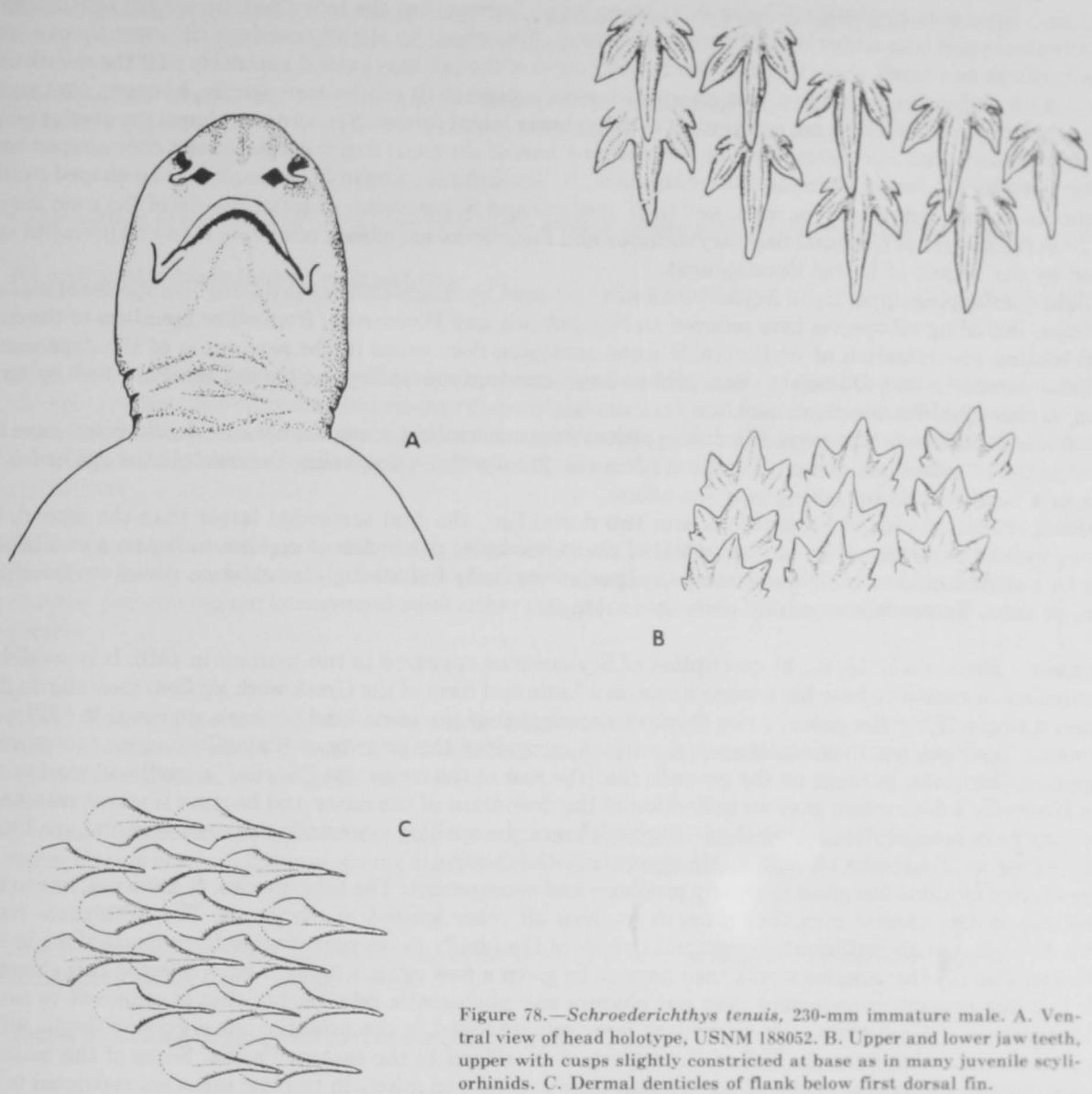


Figure 78.—*Schroederichthys tenuis*, 230-mm immature male. A. Ventral view of head holotype, USNM 188052. B. Upper and lower jaw teeth, upper with cusps slightly constricted at base as in many juvenile scyliorhinids. C. Dermal denticles of flank below first dorsal fin.

The two specimens of *S. tenuis* had 32 and 34 monospondylous vertebrae and both had counts of 107 diplospondylous vertebrae.

The teeth in *S. tenuis* were similar to those of *S. maculatus*, but the long central cusps were slightly constricted at their bases, a condition often seen in very young scyliorhinids. The dermal denticles in the 220-mm *S. tenuis* lacked the lateral points found on adult *S. maculatus* denticles. The denticles on the 180-mm *S. tenuis* were more erect than on adults of *S. maculatus* and had very narrow almost needlelike blades. Dermal denticles in juvenile scyliorhinids are often more erect, narrower, and more sparsely distributed than denticles of adults of the same species.

Discussion. The general color pattern of *S. tenuis* is remarkably similar in the two types to that of *Scyliorhinus haeckelii*, a species that also occurs off the coast of Brazil.

SCYLIORHINUS BLAINVILLE

Catulus (not of Kniphof 1759, for insects) Valmont 1769:114 (type-species, *Catulus vulgaris* Valmont = *Squalus canicula* Linnaeus, by monotypy), inadmissible.

Scyliorhinus Blainville 1816a:121 (type-species, *Squalus canicula* Linnaeus 1758 by subsequent designation of Gill 1862:407).

Scyllium Cuvier 1817:124 (type-species, *Squalus canicula* Linnaeus 1758 by subsequent designation of Jordan 1917:97).

Catulus A. Smith 1837:85 (type-species, *Squalus canicula* Linnaeus 1758 by subsequent designation of Fowler 1908:53).

Diagnosis. Species of *Scyliorhinus* have short lower labial furrows, but the labial furrows are not continuous aroun the mouth corners and true upper labial furrows are absent. The upper lip slightly overlaps the lower lip at each mout corner, sometimes as a small projecting tab, the outer margin of the tab may extend anteriorly past the mouth corner fo a short distance giving the impression that an upper furrow is present. It can be seen readily, however, that such an ex tension of the upper lip margin is not continuous with the lower labial furrow. *Scyliorhinus* shares the overlapping corne of the upper lip only with *Poroderma*, but in *Poroderma* a part of the nasal flap is extended as a cone-shaped barbel th free portion of which is longer than the base of the cone. In *Scyliorhinus*, except *S. canicula*, a cone-shaped swelling of part of the nasal flap can usually be seen, and in *S. stellaris* and *S. cervigoni*, at least, the tip of the cone may projec slightly from the margin of the nasal flap. *Scyliorhinus* and *Poroderma* are closely related in many respects but are easil separated by the degree of barbel development.

The slight overlapping upper lip in *Scyliorhinus* was first used by Regan (1908a) to distinguish species of his subgenu *Scyliorhinus*, including all species here referred to *Scyliorhinus* and *Poroderma*, from other members of the family. I practical routine identification of scyliorhinids some confusion does occur in the separation of the Japanese specie *Scyliorhinus torazame* and *Halaelurus buergeri* and museum specimens frequently are misidentified by too casua attention to the labial furrow characters.

Scyliorhinus and *Halaelurus* are readily distinguished from one another, however, because *Scyliorhinus* has a supraor bital crest of the chondrocranium and *Halaelurus* does not. Even without dissection, the cranial crest can be felt throug the skin as a narrow shelf projecting over the orbits.

Additional characteristics of *Scyliorhinus* are: two dorsal fins, the first somewhat larger than the second, the firs originating over or posterior to the posterior half of the pelvic base; pelvic fins of males forming an apron beneath th claspers by partial union of their inner margins; species variously but strongly marked on dorsal surfaces by spots blotches, or lines, lighter below usually without markings.

Discussion. Blainville's (1816a, b) description of *Scyliorhinus* appeared in two journals in 1816. It is possible that i was Blainville's intention to base his generic name on a Latinized form of the Greek work *skylion*, meaning dogfish, and so he used a single "l" in the name. After Cuvier's description of the same kind of shark appeared in 1817 under the generic name *Scyllium*, publications of several authors recognized the priority of Blainville's name but emended the spelling to *Scylliorhinus*, perhaps on the grounds that the root of the name was "Scylla," a mythical marine monster. Because Blainville's description gave no indication of the derivation of the name and because it seems reasonable that the root may have been *skylion* rather than "Skylla," I regard a spelling emendation unnecessary and use Blainville's original spelling as did Regan (1908a) in his synopsis of the family.

The genus *Scyliorhinus* has given me many problems and some persist. The type-species, *S. canicula*, has some structural features in the nasoral area that separate it from all other species of the genus. The differences (see under diagnosis, *S. canicula*) are sufficiently great and unique in the family to warrant placing *S. canicula* alone in its genus *Scyliorhinus*. The 12 other species would then have to be given a new generic home. I have rejected this change on the grounds that the present arrangement does not obscure any phylogentic relationship that is apparent to me.

Thirteen species of *Scyliorhinus* are recognized here: ten are found in the Atlantic; one occurs off South Africa with its range barely extending into the Indian Ocean; two are confined to the eastern Pacific. Some of the better known species are demersal inhabitants of cool continental shelf waters, and others in tropical areas are restricted to the cool upper continental and island slopes.

All species of *Scyliorhinus*, so far as known, are oviparous and lay eggs at very early stages of development in smooth-surfaced egg capsules that have tendrils at their four corners for attachment to objects on the sea bottom.

The identification of some species of *Scyliorhinus* by differences in color pattern seems more feasible than identification by differences in proportional measurements or other features. Color pattern differences are emphasized in the following key. *Scyliorhinus canicula* is easily distinguished from all other species of the genus by its large nasal flaps which extend over the upper lip and conceal, on each side of the upper lip, a broad and shallow depressed area on the outer side of which is a deep groove connecting the mouth with one of the nostrils. None of the 12 other species have structures so arranged. Color pattern variation as well as variation in body proportions is great, however, and some specimens of the Caribbean-West Indian region may not be identifiable even as adults.

I have changed an earlier opinion (Springer and Sadowsky 1970) that I held on subspecies of *Scyliorhinus retifer* because of the availability of new material and because of my earlier misidentification of some specimens from the coast of Honduras as typical *S. retifer*. *Scyliorhinus meadi* and *S. hesperius* now appear to me to be fully differentiated species. I consider *S. boa* as the typical island form of the Lesser Antilles, Hispaniola, and the offshore islands of the coast of Venezuela, with the continental slope population of Venezuela and northwestern Colombia considered to be *S. haeckelli*.

Key to Species of *Scyliorhinus*
(Not all immature specimens will be identifiable with this key.)

1a. A depressed area of the upper lip on each side of the jaw symphysis forming broad, shallow chan-

nels underneath the nasal flaps connecting the nasal cavities with the mouth; a deep groove along the outer margin of each broad, shallow channel ..... *S. canicula*

1b. No depressed areas of the upper lip and no deep grooves connecting the nasal cavities with the mouth 2

2a. Color pattern of reticulating black lines or of black lines outlining areas of dorsal saddle blotches ... *S. retifer*

2b. No reticulating black lines in color pattern 3

3a. Round or nearly round white or yellow spots about the size of the dark-adapted pupil or larger, the spots rather uniformly distributed over dorsolateral surfaces and forming the dominant feature of the color pattern; background color brown, tan, or gray dorsally and white or yellowish ventrally; saddle blotches either present or absent, often not prominent in adults; black spots few or none 4

3b. Either no round or nearly round white or yellow spots, or, if spots present, spots not uniformly distributed over dorsolateral surfaces but confined to particular areas such as top of head and anterior pectoral region; background color either grayish or brownish; black spots present or not present 5

4a. One of the larger species of *Scyliorhinus*, males mature at 660 to 780 mm and may reach 950 mm, females mature at about 680 to 700 mm and may reach 850 mm; juveniles 300 to 310 mm long with umbilical scars; hatching size not known ..... *S. capensis*

4b. The smallest species of *Scyliorhinus*, males mature at about 240 mm and may reach 292 mm, females mature at about 250 mm; young observed at about 130 mm; hatching size unknown ..... *S. torrei*

5a. Saddle blotches generally inconspicuous, either weak or absent in adults or masked by large or small spots, either black, white, or both 6

5b. Saddle blotches a conspicuous part of the color pattern 8

6a. Spots numerous, mostly smaller than eye, either black, brown, or white or in combinations of colors, usually in dense array over dorsolateral surfaces ..... *S. stellaris*

6b. Spots, mostly as large as or larger than dark-adapted pupil, brown or black, not in dense array but generally distributed over dorsolateral surfaces 7

7a. Dark brown spots on lighter brown background, the spots generally round, uniform in size, not closely spaced, and generally distributed over dorsolateral surfaces ..... *S. garmani*

7b. Blackish spots on gray background, spots not uniform in size but many about size of dark-adapted pupil, some spots with light-colored centers, spots somewhat sparsely distributed over dorsolateral surfaces ..... *S. besnardi*

8a. Round, white or whitish spots as large as or larger than the dark-adapted pupil confined for the most part to the area within the dark saddle blotches ..... *S. hesperius*

8b. Usually no white or whitish spots, but if white spots are present then the spots not round and not confined to areas within saddle blotches 9

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1b. No depressed areas of the upper lip and no deep grooves connecting the nasal cavities with the mouth 2

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2b. No reticulating black lines in color pattern 3

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3b. Either no round or nearly round white or yellow spots, or, if spots present, spots not uniformly distributed over dorsolateral surfaces but confined to particular areas such as top of head and anterior pectoral region; background color either grayish or brownish; black spots present or not present 5

4a. One of the larger species of *Scyliorhinus*, males mature at 660 to 780 mm and may reach 950 mm, females mature at about 680 to 700 mm and may reach 850 mm; juveniles 300 to 310 mm long with umbilical scars; hatching size not known ..... *S. capensis*

4b. The smallest species of *Scyliorhinus*, males mature at about 240 mm and may reach 292 mm, females mature at about 250 mm; young observed at about 130 mm; hatching size unknown ..... *S. torrei*

5a. Saddle blotches generally inconspicuous, either weak or absent in adults or masked by large or small spots, either black, white, or both 6

5b. Saddle blotches a conspicuous part of the color pattern 8

6a. Spots numerous, mostly smaller than eye, either black, brown, or white or in combinations of colors, usually in dense array over dorsolateral surfaces ..... *S. stellaris*

6b. Spots, mostly as large as or larger than dark-adapted pupil, brown or black, not in dense array but generally distributed over dorsolateral surfaces 7

7a. Dark brown spots on lighter brown background, the spots generally round, uniform in size, not closely spaced, and generally distributed over dorsolateral surfaces ..... *S. garmani*

7b. Blackish spots on gray background, spots not uniform in size but many about size of dark-adapted pupil, some spots with light-colored centers, spots somewhat sparsely distributed over dorsolateral surfaces ..... *S. besnardi*

8a. Round, white or whitish spots as large as or larger than the dark-adapted pupil confined for the most part to the area within the dark saddle blotches ..... *S. hesperius*

8b. Usually no white or whitish spots, but if white spots are present then the spots not round and not confined to areas within saddle blotches 9

9a. Color of saddle blotches not contrasting strongly with background color but made conspicuous by borders of black spots or broken lines, most of the spots smaller than the dark-adapted pupil . . . . *S. boa*

9b. Saddle blotches not bordered by black spots or broken lines 10

10a. Dorsolateral color dark gray or brown with saddle blotches of darker color, the blotches sometimes with poorly defined margins so that dorsolateral surface appears irregularly mottled; spots of either white or black rarely present 11

10b. Dorsolateral color medium or light gray or tan with darker but weakly contrasting saddle blotches; no white spots but black spots variously from size of spiracle to size of eye present 12

11a. Head broad, its greatest width nearly equal to its length as measured from the tip of the snout to the level of the fifth gill slit; typical dermal denticles of upper dorsolateral surfaces have a strong central ridge which is expanded and bulbous at its anterior end, the denticles of large specimens with only one point, the point not notably elevated; skin not remarkably rough to touch . . . . . *S. meadi*

11b. Head not especially broad, its greatest width about three-fourths head length; dermal denticles of upper dorsolateral surfaces with a strong central ridge which is not bulbous at its anterior end; dorsolateral denticles of large specimens with three points, the points notably elevated; skin remarkably rough to touch . . . . . *S. torazame*

12a. Length of base of anal fin as long as or longer than the distance between the bases of the two dorsal fins . . . . . *S. cervigoni*

12b. Length of base of anal fin less than the distance between the bases of the two dorsal fins . . . . . *S. haeckelii*

Scyliorhinus besnardi Springer and Sadowsky
Figures 79, 80

Figure 79.—*Scyliorhinus besnardi*, 366-mm immature male paratype from 190 m off northern Uruguay, USNM 204377. Drawing by Mildred Carrington.

Scyliorhinus retifer besnardi Springer and Sadowsky 1970:95, fig. 2 (continental shelf off northern Uruguay).

Material examined. USNM 204376, ♀, 385 mm, holotype, off Uruguay, lat. 33°26′S, long. 51°21′W, 190 m, 2 November 1968; USNM 204377, imm. ♂, 366 mm, same haul as holotype.

Diagnosis. Adults and subadults of *S. besnardi* are distinguished from other species of *Scyliorhinus* by the presence of nearly round black spots on the dorsolateral surfaces, the spots varying in size, many of the spots as large as the dark-adapted pupil or larger and separated from one another by a distance as great as or greater than the diameter of the smaller spots except for obviously paired spots. Some spots may have lighter colored centers. Spot arrangements are somewhat irregular but with a tendency to occur in longitudinal rows.

Figure 80.—*Scyliorhinus besnardi*. Upper, 385-mm holotype. Lower, 470-mm paratype.

The black spots that characterize *S. besnardi* are much larger than the spots of *S. haeckelii* and are much less numerous. The spots on *S. besnardi* do not outline the saddle blotches or the areas where saddle blotches occur as they do on *C. boa*.

Scyliorhinus besnardi has a series (on some specimens) of prominent black spots along the middorsal line between the tip of the snout and the origin of the first dorsal fin. The spots are smaller than the middorsal spots on *S. cervigoni* of the opposite side of the south Atlantic. The series of middorsal spots is absent from *S. boa* but may be present on some *S. haeckelii*, although on *S. haeckelii* the spots are smaller and do not appear at all on most *S. haeckelii*.

Except for color pattern I do not find significant differences between *S. besnardi* and other species of the group that includes *S. haeckelii, S. boa, S. hesperius,* and *S. retifer*. Juveniles of these species agree well in color pattern with adults so it is assumed that juveniles of *S. besnardi* would be recognized by color pattern.

Scyliorhinus besnardi apparently becomes sexually mature at about 470 mm.

Description. The teeth are mostly tridentate but additional small cusps may be present on teeth toward the jaw angles. The upper and lower teeth are similar in shape, the largest about 1 by 1 mm in the 385-mm female holotype. The teeth are in 48 to 49/42 to 45 rows.

The dermal denticles are similar to those of *S. retifer* (see Fig. 8G).

Vertebrae in five specimens 37-38 monospondylous, 122-129 total.

Proportional measurements as percentages of the total length follow. The first figure in each set is for the 385-mm holotype, the figures in parentheses give the range in the 385-mm female holotype, a 338-mm female, and a 366-mm immature male.

Tip of snout to: front of mouth, 4.2, (4.1-5.4); eye, 4.2 (4.2-5.5); spiracle, 10.1 (9.6-10.6); first gill slit, 14.5 (14.5-15.6); fifth gill slit, 19.0 (18.9-19.2); origin pectoral fin, 18.2, (17.8-18.5); origin first dorsal, 48.1, (48.1-49.7); origin pelvics, 39.5, (39.5-41.6); origin second dorsal, 66.0, (66.0-67.2); origin anal, 58.5, (58.5-60.9); origin upper caudal fin lobe, 79.2, (77.5-79.3); anterior end cloacal opening, 41.8, (41.8-45.2).

Greatest width of: head, 11.2 (11.2-11.5); trunk at pectorals, 8.6 (8.6-11.0); trunk at pelvics, 6.2, (6.0-6.4); trunk at caudal origin, 2.1, (2.1-2.8).

Greatest height of: head at spiracles, 7.3, (6.1-7.3); trunk at pectorals, 9.9, (9.8-9.9); trunk at pelvics, 8.6, (8.4-8.7); trunk at caudal origin, 3.4, (3.3-3.6).

Eyes: horizontal diameter, 3.6, (2.9-3.6); distance between edges of supraorbital crest of chondrocranium, 3.5, (3.5-3.8); distance between upper eyelids, 6.2, (6.2-6.3).

Spiracles: greatest diameter, 0.5, (0.5-0.7); least distance from eye, 0.8, (0.8-1.2); distance between, 7.5, (7.5-7.9).

Mouth: width, 6.5, (6.5-7.9); length, 3.9, (3.6-4.2); upper labial furrow, absent; lower labial furrow, 1.2, (1.2-1.7).

Nasal apertures: level of anterior ends to tip of snout, 2.5, (2.5-3.2); level of posterior ends to front of mouth, 0.6, (0.5-1.0).

Gill slits: height of first, 1.8, (1.5-1.9); height of fifth, 1.0, (1.0-1.2).

First dorsal fin: length base, 5.7, (5.7-6.9); length free inner margin, 2.6, (2.6-3.1); height 4.4, (4.4-5.1); length anterior margin, 9.1, (9.1-10.7).

Second dorsal fin: length base, 5.2, (5.2-5.7); length free inner margin, 2.6, (2.6-2.8); height, 2.9, (2.7-3.8); length anterior margin, 7.5, (7.5-8.2).

Pelvic fins: origin to posterior tip, 9.9, (7.4-10.2).

Caudal fin: upper margin, 20.8, (20.8-22.5); anterior margin lower lobe, 9.6, (9.6-10.4).

Distance between fin bases: first and second dorsal, 12.5, (10.4-12.5); pectoral and pelvic, 16.4, (16.1-18.2); pelvic and anal, 11.7, (11.7-13.7); anal and lower caudal, 9.9, (7.9-9.9); second dorsal and upper caudal, 9.1, (4.8-9.1).

Discussion. The geographical range of *Scyliorhinus besnardi* probably overlaps that of *Schroederichthys bivius* off the coast of Argentina and may coincide with that of *Schroederichthys tenuis* off Brazil.

Scyliorhinus boa Goode and Bean
Figures 81, 82

Figure 81.—*Scyliorhinus boa*, 420-mm female from 384 m off Bonaire, W.I.

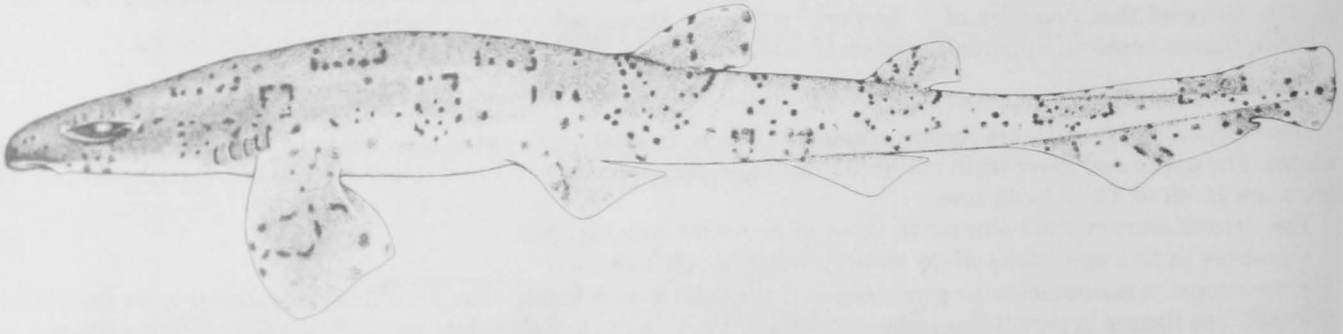

Figure 82.—*Scyliorhinus boa*, 348-mm immature female from 347 m off Isla Los Testigos, southeastern Caribbean. Drawing by Mildred Carrington.

Scyliorhinus boa Goode and Bean 1896:17, fig. 6 (Barbados).

Catulus boa: Garman 1913:77 (only that part referring to the type-specimen).

Scyliohinus boa: Bigelow and Schroeder 1948:204 (only that part referring to the type-specimen); Springer 1966:601 (only that part referring to the type-specimen).

Scyliorhinus retifer boa: Springer and Sadowsky 1970:90 (only referring to the type-specimen and to island slope specimens from Bonaire to Hispaniola).

Material examined. MCZ 1335, juv. ♂, about 150 mm, Barbados, 366 m, holotype; *Fregata* stn. 181, ad. ♂, 540 mm, lat. 12°58'N, long. 59°37'W, off Barbados; USNM, ♀, 420 mm, near Bonaire, 384 m, *Oregon* stn. 4840; USNM, imm. ♂, 420 mm, off Dominica in 369 m, *Oregon* stn. 5943; 12 other USNM specimens, Lesser Antilles, 274 to 676 m.

Diagnosis. *Scyliorhinus boa* has rows of small black spots that outline seven or eight dorsal saddles and may extend into a somewhat reticulating pattern over most of the dorsolateral surfaces (Fig. 82). In some specimens fewer and larger spots indicate saddle corners (Fig. 81). Except for spots, the saddles contrast little with the background color. In addition to the spots that delineate saddle blotches or make up reticulating rows of spots, a few black spots and a few white spots may be distributed over dorsolateral surfaces.

Scyliorhinus boa differs from *S. retifer* in having rows of spots instead of solid black lines and from *S. haeckelii* in having no spots or few spots within the saddle margins.

Description. *Scyliorhinus boa* apparently is mature at about 550 mm, but the number of adults seen is too small to estimate maximum length. Newly hatched specimens were not obtained but presumably hatching occurs when young are about 100 mm long.

The dermal denticles, teeth, and morphometrics do not set off *S. boa* sharply from any other western Atlantic *Scyliorhinus* except the much smaller *S. torrei*.

Vertebral numbers in *S. boa* are not now available and the numbers reported by Springer and Sadowsky (1970, table 1) may in part refer to specimens now identified as *S. hesperius*.

Following are measurements expressed as percentages of the total length for a 540-mm adult male from near Barbados, first figure of each pair, and a 420-mm immature female from near Bonaire, second figure of each pair.

Tip of snout to: front of mouth, 4.3, 4.3; eye, 5.2, 4.3; spiracle, 9.8, 9.5; first gill slit, 15.2, 15.0; fifth gill slit, 20.4, 21.2; origin pectoral, 18.3, 17.4; origin first dorsal, 50.7, 48.8; origin pelvics, 39.6, 40.5; origin second dorsal, 64.8, 67.8; origin anal, 59.2, 59.0; origin upper caudal fin lobe, 75.9, 77.8; anterior end cloacal opening, 43.8, 42.8.

Eyes: length opening, 3.5, 3.8; height, 0.9, 1.4.

Spiracles: greatest diameter, 0.7, 0.6; least distance from eye, 1.1, 0.5.

Mouth: width, 6.8, 6.9; length, 4.6, 4.3; length upper labial furrow, not present; length lower labial furrow, 0.9, 1.4.

Nasal apertures: least distance between, 1.9, 1.9.

Gill slits: height of first, 1.5, 1.9; height of fifth, 0.9, 1.0.

First dorsal fin: length base, 7.0, 6.4; length free inner margin, 2.6, 3.0; height, 5.9, 5.2; length anterior margin, 9.6, 10.2.

Second dorsal fin: length base, 5.7, 5.5; length free inner margin, 2.6, 2.1; height, 3.7, 3.3; length anterior margin, 7.6, 7.9.

Anal fin: length base, 8.3, 7.1; length free inner margin, 2.6, 2.4; height, 3.7, 3.3; length anterior margin, 7.4, 6.2.

Pectoral fins: width base, 5.6, 6.0; length anterior margin, 13.3, 15.0; greatest width, 9.4, 10.9.

Pelvic fins: overall length, 11.8, 10.0; length inner margin claspers, 5.9, —; distance clasper tip posteriorly to pelvic fin tips, 0.6, —.

Caudal fin: length upper margin, 24.1, 22.1.

Distance between fin bases: first and second dorsal, 10.2, 12.4; pectoral and pelvic, 14.4, 15.7; pelvic and anal, 10.0, 12.1; anal and lower caudal, 8.0, 9.0; second dorsal and upper caudal, 7.0, 5.5.

Discussion. Available material indicates that *S. boa* is restricted to island terraces at depths of 329 to 658 m from Hispaniola through the Lesser Antilles and around islands off Venezuela as far west as Bonaire.

Scyliorhinus canicula (Linnaeus)
Figure 83

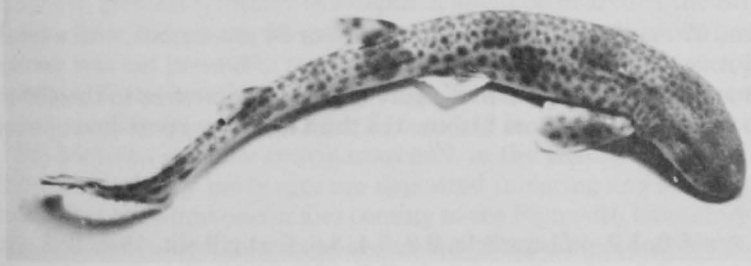

Figure 83.—*Scyliorhinus canicula*, immature female about 290 mm, North Sea. The saddle blotches shown prominently for this specimen are not consistently present in *S. canicula*.

Squalus canicula Linnaeus 1758:234 (habitat in oceans Europae).
Scyllium canicula: Cuvier 1817:124; Bonaparte 1834, fasc. 7; 1846:81.
Catulus caniculus: Garman 1913:72.
Catulus duhamelii Garman 1913:73.
Scylliorhinus canicula: Collett 1905:94; Lozano Rey 1928:306, pl. 2, fig. 1, figs. 86-87; Maurin and Bonnet 1970:129.
Scyliorhinus caniculus: Bigelow and Schroeder 1948:203; Wheeler 1969:45, figs. 13-14.
Scyliorhinus canicula: Regan 1908a:458; Tortonese 1956:127, figs. 62-65; Bini 1967:57, figs; Springer 1973:19.

Material examined. USNM 195851, ♀, 385 mm, Bay of Genoa; USNM, seven specimens, Mediterranean; Mediterranean Sorting Center, Tunis, 51 specimens, Ceuta, Morocco; BMNH 60.4.122.13654, ad. ♂, 510 mm, Lisbon; BMNH 1902.6.9.2, 4 ♂, 82-208 mm, Gulf of Genoa; BMNH 1961.10.10, juv. ♀, 197 mm, ♀, 290 mm, North Sea; BMNH 1962.7.30.1, juv. ♂, 125 mm, NNW of Isle of Man, 68-73 m.

Diagnosis. *Scyliorhinus canicula* differs from all other species of the genus in having a depressed area of the upper lip on both sides of the jaw symphysis that forms a channel from the nasal aperture to the mouth, the channel hidden by long nasal flaps that extend just over the edge of the upper lip and are nearly confluent along their posterior margins, separated only by a narrow attachment to the upper lip. In having covered channels from the nasal apertures to the mouth, *S. canicula* is like species of *Haploblepharus* and *Atelomycterus* as well as sharks of the family Orectolobidae. *Scyliorhinus canicula* differs from species of *Haploblepharus* and *Atelomycterus* in lacking upper labial furrows. It differs also from *Haploblepharus* in having a cranial crest and from *Atelomycterus* in not having vertebral calcification of the "Maltese cross" type.

Scyliorhinus canicula has a slender nearly cylindrical form with less taper than most scyliorhinids except *Atelomycterus*. Its dorsal surfaces are covered with small dark spots about the size of the pupil in a somewhat random arrangement and usually without groups of spots or darker areas forming saddle blotches. Ventral surfaces are unmarked.

Garman (1913) described *C. duhamelii* from two specimens: one from Nice, thought by Garman to be a mature male about 345 mm, and the other a female from the Adriatic about 430 mm (MCZ 60 and 63). I compared these types with a series of *S. canicula* but did not find significant differences, and the size at maturity difference did not seem to me to be well established although it is possible that a size difference for the Mediterranean-Adriatic populations distinguish them from Atlantic populations.

Description. *Scyliorhinus canicula* is a variable species with an extensive geographical range possibly including several somewhat different populations. It may reach a length of 760 mm (Wheeler 1969:45) in British waters and both males and females become mature usually between 570 and 600 mm (Ford 1921:486) in the English Channel. A study by Leloup and Olivereau (1951) indicated an average of 30% less length for Mediterranean *S. canicula*. Among specimens that I have measured, a sexually mature male from off Lisbon was 510 mm long and a mature male from near Ceuta, Morocco, was 460 mm long. Young are about 90 to 100 mm long at hatching (Ford 1921).

The color pattern of small spots rather densely and uniformly distributed over dorsolateral surfaces is illustrated by Lozano Rey (1928, pl. II, fig. 1), Tortonese (1956, fig. 63), and Bini (1967:57). The spots generally are about the size of the pupil, most of them dark or black but some white spots may be present. Most *S. canicula* do not have dark colored dorsal saddles but some do as shown in the accompanying illustration (Fig. 83). Usually *S. canicula* changes its color pattern very little during growth, but a juvenile illustrated by Tortonese (1956, fig. 95) does have a smaller number of spots than might be expected and the spots roughly indicate the boundaries of saddle blotches as in typical *S. boa*.

The pelvic fins of males are united along their inner margins to form an apron dorsal to the claspers. This apron is more or less developed in all *Scyliorhinus* as well as in some other scyliorhinid genera. The clasper tips do not quite reach the pelvic fin tips in *S. canicula* and the pelvic fins may be united all the way to their tips. Also a fold in the ventral surface of each pelvic fin serves to cover and almost conceal the claspers.

The teeth of *S. canicula* are small with one main central cusp and one or two very small cusps on each side of it. The teeth counted in a few specimens were in (21-23) + (1-2) + (21-23)/(18-22) +(1-3) + (18-22) vertical rows. In the 460-mm adult male from Ceuta, the longest teeth near the middle of the lower jaw about two rows from the symphysis are about 1.2 mm high from the enamel line. The teeth of *S. canicula* are illustrated by Lozano Rey (1928, fig. 86). The dermal denticles are also shown in Lozano Rey's figure 87.

Three *S. canicula* from the coast of Tunis each had 37 monospondylous vertebrae, 83 or 84 precaudals, and a total of 126 or 127 vertebrae (Quignard and Capapé 1971b).

Measurements as percentages of the total length are given below; the first figure in each group refers to the 460-mm adult male from Ceuta; the second refers to the 510-mm adult male from Lisbon; the third figure to a post-juvenile male from the southern part of the North Sea.

Tip of snout to: front of mouth, 3.5, 3.3, 4.6; eye, 5.0, 3.9, 4.6; spiracle, 9.2, 8.4, 8.6; first gill slit, 13.0, 12.7, 12.7; fifth gill slit, 17.0, 17.8, 17.3; origin pectoral, 16.3, 16.9, 15.7; origin first dorsal, 48.7, 50.0, 44.2; pelvic fins, 37.0, 39.2, 36.5; origin second dorsal, 65.7, 68.6, 61.9; origin anal, 56.5, 56.8, 52.8; origin upper caudal fin lobe, 77.6, 78.4, 74.6; anterior end cloacal opening, 41.3, 45.1, 39.1.

Greatest width of: trunk at pectoral origin, 9.3, 9.6, 8.1; trunk at pelvic origin, 6.1, 5.9, 5.1; caudal base, 2.0, 2.4, 2.4.

Greatest height of: trunk at pectoral origin, 8.3, 8.8, 8.1; trunk at pelvic origin, 9.1, 9.8, 7.1; caudal base, 3.7, 3.5, 3.3.

Eyes: length orbit (opening), 2.8, 2.9, 2.0.

Spiracles: greatest diameter, 0.9, 0.3, 0.1; least distance from eye, 0.4, 0.8, 0.5.

Mouth: width, 4.8, 5.9, 6.0; length, 3.5, 3.9, 3.6; length lower labial furrow, 1.9, 2.5, 1.6.

Gill slits: height of first, 2.2, 2.0, 2.0; height of fifth, 1.0, 1.2, 0.8.

First dorsal fin: length base, 5.9, 6.1, 5.8; length free inner margin, 2.8, 3.1, 3.0; height, 4.3, 5.1, 5.1; length anterior margin, 8.7, 10.0, 9.6.

Second dorsal fin: length base, 5.7, 5.5, 5.1; length free inner margin, 2.8, 2.9, 2.5; height, 3.0, 4.1, 4.1; length anterior margin, 6.1, 7.8, 8.6.

Anal fin: length base, 8.3, 9.4, 11.9; length free inner margin, 2.8, 2.5, 2.0; height, 2.2, 3.7, 3.6; length anterior margin, 3.0, 7.3, 8.1.

Pectoral fins: width base, 5.0, 5.7, 5.6; length anterior margin, 10.4, 14.3, 12.7; greatest width, 8.7, 10.4, 10.2.

Distance between fin bases: pectoral and pelvic, 15.9, —, —; pelvic and anal, 11.3, —, —; anal and lower caudal, 10.2, —, —; second dorsal and upper caudal lobe, 6.3, —, —.

Ford (1921) found much variation in overall length of *S. canicula* egg capsules taken from females landed at Plymouth, 55 capsules measuring from 53 to 64 mm. One capsule from Naples that I measured was 49 mm long overall or 42.5 mm center length.

Discussion. *Scyliorhinus canicula* is the best known of all scyliorhinid sharks. Its small size and adaptability to tank conditions have made it an important experimental animal. Writing of the species around the British Isles Wheeler (1969:45-46) said: "The dogfish has considerable commercial value; along with several other small sharks it is sold as rock eel or rock salmon. Many thousands are used annually for dissection in educational establishments. It is a popular angling species, although perhaps too small, too easy to catch and too relatively inedible to possess the value of other marine species."

Scyliorhinus canicula is not typical of the family Scyliorhinidae in many ways. No other scyliorhinid shark in the world is captured in sufficient numbers to warrant commercial exploitation. Only a few species come into nearshore waters; *Schroederichthys bivius*, and perhaps its near relative *S. chilensis*, may be in shore waters in the Straits of Magellan and nearby cool water areas; *Atelomycterus* is taken in very small numbers in relatively shallow water by Thai fishermen; several species have been taken in inshore waters of South Africa but apparently in small numbers; my sample of one specimen of *Aulohalaelurus* came from shore waters of Western Australia; *Cephaloscyllium* on the coast of southern California comes within reach of skin divers but is normally nocturnal (Nelson and Johnson 1970). *Scyliorhinus canicula* is much more abundant and lives in shallower water than its larger neighbor *S. stellaris*. Its frequent appearance in publications on the fauna of Tunis attests to its relative abundance there (Quignard and Capapé 1971a). It is so well known in the Mediterranean that Bini (1967) listed 15 non-Italian vernacular names for it and more than 25 dialect variants in Italian.

Scyliorhinus canicula is found from Senegal northward along African and European coasts to southern Norway. It is a well-known species throughout the Mediterranean but does not enter the Black Sea (Bănărescu 1969) or the Red Sea (Gohar and Mazhar 1964). As a general rule, it inhabits deeper water in the southern parts of its range or, at least may move into deeper water there. It is considered very common off the coast of Tunis, chiefly within the 0 to 100 m depth range (Quignard and Capapé 1971a). Tortonese (1956) noted a depth range for the Bay of Naples area out to 400 m but the deeper part indicated may be based on a few unusual records. In the northern sector of the species range, off the British Isles, the usual figures for depth range are 0 to 100 m.

Wheeler (1969:45) suggested that the species is found particularly over sandy, gravelly, or muddy bottoms and is caught in greatest numbers at a depth of about 55 m around the British Isles. For the little that it is worth, negative data do not show in general the presence of *S. canicula* in northern waters at depths greater than 100 m; for example, the species was not present in trawl hauls, mostly from 100 m or more, made on fishing banks west of Ireland (Blacker 1962) although *S. stellaris* was taken. Because trawls do not operate successfully over sea bottom covered with large boulders it is not possible to conclude that *S. canicula* is usually absent from such areas.

Scyliorhinus canicula is oviparous and, in the vicinity of Plymouth England, egg laying goes on throughout the year although probably more eggs are deposited in spring and summer than in autumn and winter (Ford 1921). Ford also noted that the number of males coming to the Plymouth laboratory exceeded the number of females in winter with landings of females more numerous in summer. Ford did not include fishing and water temperature data, however, and correctly noted that the significance of the difference in the number of one sex over the other was not clear. The developing young of *S. canicula* and *S. stellaris* have interesting similarities to be discussed under *S. stellaris*.

The food of *S. canicula*, as shown by stomach contents, consists of a mixture of bottom dwelling invertebrates and small fishes (Ford 1921; Eales 1949; Azouz and Capapé 1971). Both Ford and Eales noted the presence of the whelk, *Buccinium*. With reference to the whelk, Eales had the following comment: "Molluscs, except for *Buccinium*, are not well represented. How does the dogfish tackle a whelk? Does it swallow it whole and dissolve the shell? I have found lamellibranch shells and even cuttlebone undigested, but have never seen a trace of a whelk shell, though opercula are frequently found. Are the opercula scooped up from dead material on the sea bottom? Similarly, does the dogfish swallow the shell containing the hermit crab—for again, no trace of the shell remains, though the crab itself forms a large proportion of the food in some fish?"

I have an explanation that appears to me to be a partial answer to the question. It is based on somewhat parallel observations that I made on stomach contents of the tiger shark, *Galeocerdo cuvieri*, while commercial shark fishing in the vicinity of the Dry Tortugas and the Florida Keys. A large proportion of the tiger sharks (which were up to 4 m long) had

marine snail opercula, as many as a double handful, in the pyloric end of the stomach, some of the opercula as much as 100 mm long. I also caught at least two large tiger sharks with stomachs full of large edible conchs, *Strombus gigas*, large whelks, *Busycon* sp., and a few horse conchs, *Fasciolaria gigantea*, all of them complete with shell and in fine condition although my notes do not specify whether the conchs were alive. I have examined many tiger shark stomachs that held partially digested conchs with no trace of shell. I caught one tiger shark with a stomach full of undigested conchs, the conchs complete with their livers intact but no shell at all in the shark's stomach.

At first I thought that the shells might have been dissolved, but after some tests with shells in hydrochloric acid and some calculations, I concluded that the chemical digestion of up to 30 kg of shell in a full stomach was beyond the capacity of even a half-ton tiger shark. The procedure that I assume must be used is that the tiger shark swallows a number of the big gastropods which, after a time, leave their shells. Next the shark regurgitates the lot, both shells and animals, and then swallows the conchs again but this time without the shells. On a smaller scale I assume the procedure would work with *S. canicula*.

The ampullae of Lorenzini, which constitute an extensive organ in the snout of all sharks of the family Scyliorhinidae and are present in other elasmobranch families, function as electroreceptors in elasmobranchs (Dijkgraaf and Kalmijn 1962; Kalmijn 1966). Experimental studies reported by Kalmijn (1971) were carried out with *S. canicula* as one of the experimental subjects and suggest an important role of the electrical sense for locating otherwise hidden prey. Of course, the electrical sense is not exclusively a property of *S. canicula* and may even be better developed in other species.

Scyliorhinus capensis (Müller and Henle)
Figure 84

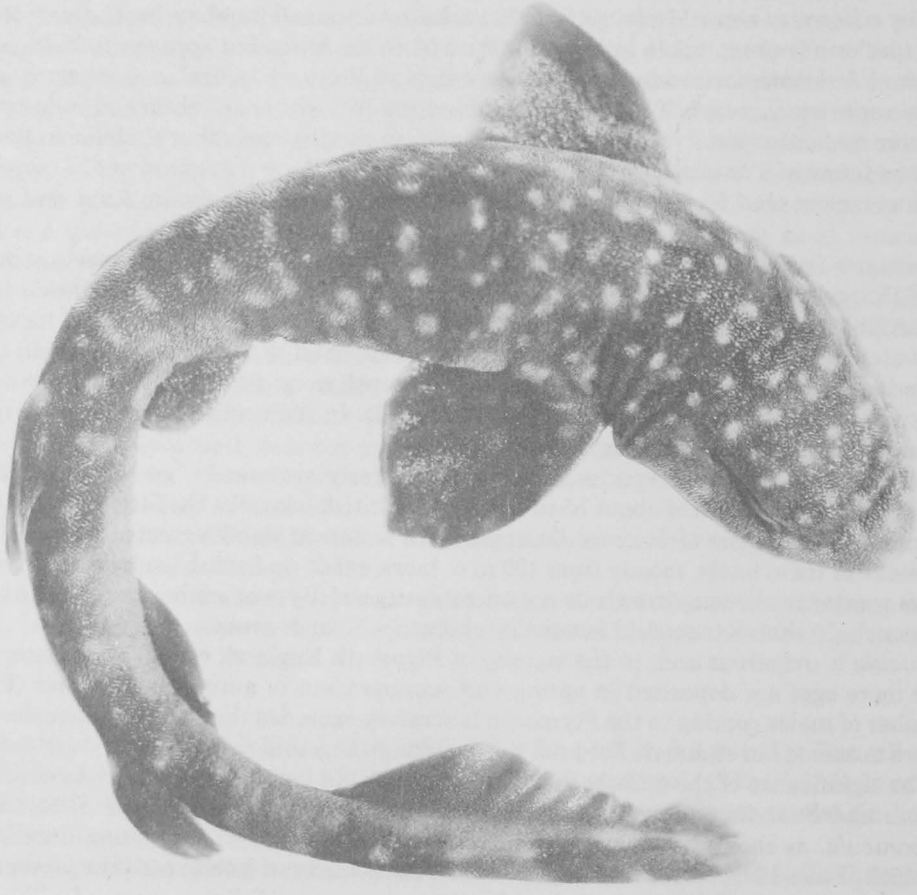

Figure 84.—*Scyliorhinus capensis*, 400-mm immature male, False Bay, South Africa, SAM 22626.

Scyllium capense—name only, A. Smith 1837:85.
Scyllium capense Müller and Henle 1841:11 (Cape of Good Hope).
Scyliorhinus capensis: Regan 1908a:458; Smith 1949:54, fig. 38; Bass et al. 1975:32, fig. 19.

Material examined. BMNH 1935.5.2.54, ♀, 560 mm, Cape of Good Hope; SAM 22626, imm. ♂, 400 mm, False Bay, South Africa, 91 m.

Diagnosis. Light-colored spots, more or less the size of the pupil, randomly distributed over the dorsolateral surfaces distinguish *S. capensis* from all other *Scyliorhinus* except *S. torrei*. The spots in *S. capensis* are pale yellow and often appear so bright as to seem luminescent (Bass et al. 1975). *Scyliorhinus capensis* reaches a length of over 1,220 mm according to Smith (1949) and by size alone should be readily distinguishable from *S. torrei* which does not exceed 320 mm. In addition to the light-colored spots, *S. capensis* has seven to nine indistinctly outlined saddle blotches which may be faintly contrasting in older specimens and may be obsolete in very large ones.

Description. The following brief description is based on one specimen, a 400-mm immature male. Distance from tip of snout to anterior end of cloacal opening slightly more than two-fifths total length; head and anterior trunk wider than deep, tapering to tail which is subcylindrical in cross section; head short, somewhat less than one-fifth total length, and caudal fin a little more than one-fifth total length; snout tapering, its tip rounded; nasal flaps not reaching upper lip, separated from one another by a distance about equal to length of moderately prominent lower labial furrows; labial furrows overlapped slightly by upper lip at mouth corners; pectoral fins moderately large, their corners rounded; pelvic fins united for about nine-tenths the length of their inner margins; first dorsal fin slightly larger than second, its origin over or slightly posterior to pelvic base; origin of second dorsal over posterior third of anal base; base of anal longer than either dorsal base.

Teeth numerous, small, the uppers somewhat larger than lowers, mostly with five cusps but the outer cusp on each side very small.

Dermal denticles characteristic of immature *Scyliorhinus*, but somewhat more erect than other *Scyliorhinus* of similar size, making skin rough to touch.

Color tan dorsally with numerous pale spots and seven to nine indistinct saddle blotches; ventral surface pale without markings.

Dimensions as percentages of total length (400 mm) are given below.

Tip of snout to level of: anterior end nasal aperture, 3.0; posterior end nasal aperture, 4.3; front of mouth, 5.0; eye, 5.3; spiracle, 9.5; first gill opening, 14.3; last gill opening, 19.5; origin pectoral, 17.0; origin first dorsal, 47.0; origin pelvics, 40.0; origin second dorsal, 64.5; origin anal, 57.5; origin upper caudal fin, 77.0; anus, 42.5.

Greatest width of: trunk at pectorals, 11.3; trunk at pelvics, 6.3; caudal peduncle, 2.3.

Greatest depth of: trunk at pectorals, 9.0; trunk at pelvics, 8.5; caudal peduncle, 3.8.

Eyes: horizontal diameter, 3.0.

Spiracles: greatest diameter, 0.5; distance from eye, 1.3.

Mouth: width, 7.3; length, 3.5; length lower labial furrow, 1.8.

Gill slits: height of first, 1.8; height of fifth, 1.3.

First dorsal fin: length base, 6.0; inner margin, 3.3; height, 6.0.

Second dorsal fin: length base, 6.0; inner margin, 3.0; height 4.3.

Anal fin: length base, 9.3; inner margin, 2.5; height, 3.5.

Pectoral fins: outer margin, 14.5; width base, 6.3; greatest width, 10.5.

Pelvic fins: origin to rear tip, 11.5.

Distance between fin bases: first and second dorsals, 11.3; pectoral and pelvic, 15.8; pelvic and anal, 10.5; anal and origin lower caudal lobe, 7.5; second dorsal and upper caudal origin, 7.5.

Vertebral numbers in SAM 22626 are: total about 130, monospondylous 48, precaudal 90, caudal about 40.

Discussion. *Scyliorhinus capensis* was recorded from India by Day (1889) and was included in the Indian marine fauna by Misra (1947), probably on the basis of Day's reference. Day's statement that the only reason for recording it from India was due to a stuffed specimen in the British Museum being so labelled indicates some skepticism on his part. Other known specimens are all from the Cape region of South Africa and it seems likely that the species occurs only in South African waters.

The account of *Scyliorhinus capensis* by Bass et al. (1975) is based on a large number of specimens and the following notes are adapted from their account.

The species was reported to range from the southwestern Cape of Good Hope area to the coast of Natal but to be rare off Natal. Depths of capture were from 26 to 290 m off the Cape area and from a single specimen from the Natal coast 420 m.

Egg capsules taken from three females were about 80 by 30 mm. Males were found to be mature from 660 to 780 mm and females from 680 to 700 mm, the largest male seen was 950 mm and the largest female 850 mm long.

Scyliorhinus cervigoni Maurin and Bonnet
Figure 85

Scylliorhinus stellaris: Cadenat 1950:87.

Figure 85.—*Scyliorhinus cervigoni*, 665-mm adult male, from 70 m off Senegal. Drawing by Mildred Carrington.

Scyliorhinus stellaris: Poll 1951:21, fig. 4, pl. 13, fig. 3.
Scylliorhinus cervigoni Maurin and Bonnet 1970:129, fig. 3 (off Senegal).

Material examined. USNM, ad. ♂, 665 mm, off Senegal, lat. 12°03'N, long. 17°14'W, 70 m; USNM, imm. ♂, 325 mm, juv. ♀, 122 mm, off Portuguese Guinea, lat. 11°25'N, long. 17°21'W, 200 m, 10 December 1963; USNM, imm. ♀, 335 mm, off Liberia, lat. 06°31'N, long. 11°29'W, 350-500 m, 12 November 1963; USNM, 2 ♂, 210-220 mm, 2 ♀, 220-240 mm, off Liberia, 260 m; USNM, imm. ♂, 580 mm, off Angola, lat. 12°36'S, long. 13°12'E, 45 m.

Diagnosis. *Scyliorhinus cervigoni* lacks a depressed area on either side of the upper lip (groove of some authors) connecting the nasal opening with the mouth such as is present in *S. canicula*. *Scyliorhinus cervigoni*, as other species of *Scyliorhinus*, does have a slightly overlapping upper lip at the mouth corners. It has a lower labial furrow but no upper furrow. *Scyliorhinus cervigoni* is very close to *S. stellaris* but differs strongly and consistently in color pattern. It has fewer spots than *S. stellaris* and regularly has a series of spots of darker color along the dorsal midline in the position of the six to nine saddle blotches present on scyliorhinids of many genera. The spots on *S. cervigoni* are more or less round, with indefinite edges, and do not extend far on the sides. In addition to the dorsal spots, *S. cervigoni* has a variable number of smaller dark spots on the lateral surfaces but far fewer than *S. stellaris*, and the white spots that are usually present on *S. stellaris* are absent. The specimens of *S. cervigoni* from the coast of Angola have fewer spots than shown in illustrations of Maurin and Bonnet (1970) and Poll (1951).

Description. One male that I noted under material examined was sexually mature at 665 mm, but I have found no records of other specimens of *S. cervigoni* said to be adult. Poll (1951:21) considered females 510 and 670 mm long immature.

Measurements as percentages of total length are given below for a 343-mm immature female from the coast of Angola, first figure in each series; a 265-postjuvenile male from Senegal, second figure; in parentheses I have given percentages for the 380-mm immature female type calculated from measurements by Maurin and Bonnet.

Tip of snout to: front of mouth, 5.2, 4.9; eye, 7.0, 5.7, (6.6); spiracle, 11.1, 11.3; first gill slit, 17.5, 17.0, (17.4); fifth gill slit, 22.4, 21.9; origin pectoral fin, 20.7, 20.0, (21.3); origin first dorsal, 50.1, 49.1, (52.6); origin pelvics, 44.0, 42.3, (45.1); origin second dorsal, 66.5, 64.9, (68.4); origin anal fin, 61.2, 58.1, (61.1); origin upper caudal fin lobe, 77.2, 76.6; anterior end cloacal opening, 47.5, 44.5.

Greatest width of: trunk at pectoral, 11.1, 12.5; trunk at origin pelvics, 7.3, 6.8; caudal peduncle, 2.9, 3.4.

Greatest height of: trunk at pectoral origin, 10.8, 11.3; trunk at origin pelvics, 8.5, 9.8; caudal peduncle, 3.8, 4.5.

Eyes: length opening, 3.2, 4.0; height of opening, 0.9, 1.1.

Spiracles: greatest diameter, 0.6, 0.8; least distance from eye, 1.2, 0.8.

Mouth: width, 8.7, 8.3; length, 4.4, 4.5; length lower labial furrow, 1.7, 1.1.

Nasal apertures: least distance apart, 1.7, 1.5.

Gill slits: height of first, 2.3, 1.9; height of fifth, 1.0, 1.1.

First dorsal fin: length base, 6.4, 7.2; length free inner margin, 3.5, 3.4; height, 4.7, 4.2; length anterior margin, 10.2, 10.9; overall length, (9.7).

Second dorsal fin: length base, 5.8, 6.4; length free inner margin, 2.6, 3.4; height, 2.9, 3.4; length anterior margin, 7.6, 9.1; overall length, (7.9).

Anal fin: length base, 8.7, 10.2; length free inner margin, 2.6, 2.3; height, 3.2, 3.4; length anterior margin, 7.6, 9.1; overall length, (9.2).

Pectoral fins: width base, 6.7, 6.4; length anterior margin, 13.7, 15.1, (14.7); greatest width, 9.0, 11.7.

Pelvic fins: overall length, 9.3, 10.2.

Distance between fin bases: first and second dorsal, 8.5, 9.8; pectoral and pelvic, 17.2, 14.0; pelvic and anal, 11.1, 11.3; anal and lower caudal origin, 7.3, 6.8; second dorsal and upper caudal fin, 6.7, 6.0.

Discussion. *Scyliorhinus cervigoni* occurs along the west coast of Africa from Senegal to Angola at depths from 45 to 430 m.

The few specimens available suggest that specimens from the southern part of the range have fewer small dark spots.

Scyliorhinus garmani (Fowler)

Halaelurus garmani Fowler 1934:235, fig. 1 (East Indies); Fowler 1941:49, fig. 1.
Scyliorhinus garmani: Springer and Garrick 1964:86.

Material examined. USNM 43749, ♀, 240 mm, holotype, East Indies. The only specimen known.

Diagnosis. Fowler's illustrations of *Halaelurus garmani* (1934, fig. 1; 1941, fig. 1) indicate the presence of an upper labial furrow, but his text description stated (1934, 1941), "short labial furrow only at angle of lower jaw." Examination of the holotype shows the text description of labial furrows to be correct. The specimen has a slight overlapping upper lip at the mouth corners, characteristic of *Scyliorhinus*. It also has a well-developed supraorbital crest or shelf so there seems to be no question but that an assignment to *Scyliorhinus* is in order. Although the specimen is probably faded, the spots appear much as shown in Fowler's illustrations and serve to distinguish it from other *Scyliorhinus*.

Description. A species with the characters of *Scyliorhinus*, having broad outer nasal flaps, the middle part somewhat swollen and extended slightly beyond the posterior margin of the flap as a very short, barbellike lobe, its tip nearly reaching mouth; mouth strongly arched; teeth tridentate, similar in upper and lower jaws, the middle cusp much the longest, tooth bases with grooves; horizontal diameter of eye about equal to length of snout in front of mouth.

Proportional measurements of the holotype as percentages of the total length are given below.

Tip of snout to: front of mouth, 3.8; origin pectoral fin, 16.7; origin first dorsal, 48.3; origin second dorsal, 63.3; origin pelvics, 40.4; origin anal fin, 58.3; origin upper caudal lobe, 77.1.

Distance between fin bases: first and second dorsal, 10.0; pectoral and pelvic, 19.2; pelvic and anal, 9.2; anal and lower caudal, 6.3; second dorsal and upper caudal, 5.0.

First dorsal fin: length base, 6.3; height, 4.2.

Second dorsal fin: length base, 6.3; height, 3.5.

Anal fin: length base, 10.4; height, 3.8.

Pectoral fin: width base, 4.2; length anterior margin, 12.5; greatest width, 7.5.

Eye: horizontal diameter, 3.8.

Nasal aperture: least distance between, 1.3.

Spiracle: diameter, 0.4; least distance from eye, 1.5.

Gill slits: height of first, 2.1; height of fifth, 0.8.

Color light tan with darker brown spots about as large as eye pupil (2-3 mm in diameter), the spots generally distributed over the dorsolateral surfaces of the body and on the upper or lateral surfaces of all fins; seven dorsal saddle blotches are indistinctly recognizeable.

Vertebrae, from Springer and Garrick (1964), precaudal 92, caudal 40.

Dermal denticles of dorsolateral surfaces rather erect, not closely imbricate; surface of skin rather rough to touch; denticles with one strong central ridge, three-pointed; one row on each side of the dorsal midline extending from the level of the pectoral origin to the level of the first dorsal origin, each row made up of about 25 denticles which are only a little larger than adjacent denticles but which are smooth with no included pigment; color of spots primarily within denticles rather than skin.

Discussion. *Scyliorhinus garmani* is sufficiently distinctive in its color pattern and in the shape of its nasal flaps for recognition as a valid species. I could not find a more precisely indicated origin than type-locality "East Indies."

Scyliorhinus haeckelii (Miranda-Ribeiro)
Figure 86

Catulus haeckelii Miranda-Ribeiro 1907:163, pl. 8 (25 to 30 mi off Ilha Rasa, Brazil).

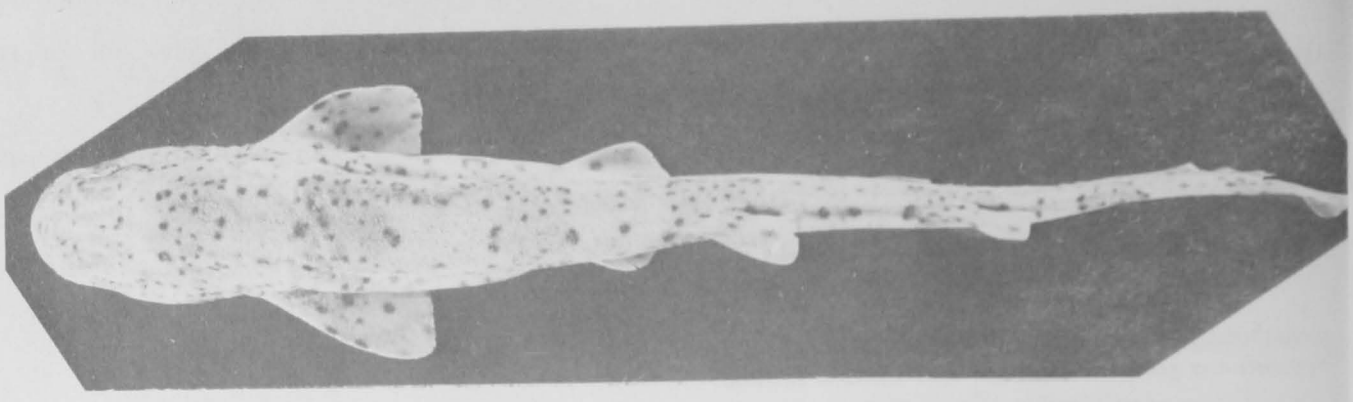

Figure 86.—*Scyliorhinus haeckelii*, immature male holotype about 316 mm from vicinity of Rio de Janeiro. Specimen in Museo Nacional Rio de Janeiro, photograph by University São Paulo Oceanographic Research Institute staff.

Scyliorhinus boa: not of Goode and Bean; Bigelow and Schroeder 1948:204, fig. 32 (except reference to holotype of *S. boa*); Springer 1966:601 (except reference to island slope specimens and fig. 15A).
Scyliorhinus fernandezi Weibezahn 1953:3, fig. 1 (off La Guaira, Venezuela in 37 m).

Material examined. USNM 186195, ad. ♂, 345 mm, imm. ♂, 312 mm, imm. ♀, 278 mm, off French Guiana, 200-220 m; USNM 188061, imm. ♂, 143 mm, off Brazil, north of Amazon River mouth, 329 m; RV *Calamar* stn. 413, juv. ♂, 99 mm, juv. ♀, 103 mm, juv. ♀, 106 mm, off Surinam, 250 m; 9 egg capsules taken in same haul as preceding juvenile specimens.

Holotype. Not seen: MNB 494, imm. ♂, 316 mm, off Ilha Rasa, near Rio de Janeiro, Brazil, 80 m; holotype illustrated, Miranda-Ribeiro (1907, pl. 8), Bigelow and Schroeder (1948, fig. 32), and in this study (Fig. 86).

Diagnosis. *Scyliorhinus haeckelii* has well-defined saddle blotches contrasting well with the lighter colored background. It also has numerous small black spots generally distributed over the dorsolateral surfaces, the spots generally smaller than the dark-adapted pupil. It differs from *S. boa* in having more strongly contrasting saddle blotches and in having more black spots, the spots not forming borders to the saddle blotches. It differs from *S. besnardi* in having spots smaller and more numerous and in having saddle blotches that are much more distinct (saddle blotches weak or absent in *S. besnardi*).

Scyliorhinus haeckelii seems somewhat more variable than other western Atlantic *Scyliorhinus* and seems to have many characters intermediate between *S. boa* and *S. besnardi*. Its geographical range is intermediate and also touches that of *S. hesperius* off the coast of Colombia where melanistic specimens with white spots, here regarded as atypical *S. hesperius*, were taken.

The separation of *S. haeckelii* from *S. besnardi* is supported, although only weakly, by vertebral counts (see Table 4).

Table 4.—Number of monospondylous vertebrae in western Atlantic species of *Scyliorhinus*.

Species	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
S. torrei	1	3	2	3	2															
S. besnardi								1	4											
S. haeckelii									1	1	7	1	1	1						
S. hesperius										2	3	2	1							
S. boa										2	4	2	—	1	1					
S. retifer										2	5	8	7	1						
S. meadi														1	—	—	1	—	2	1

Description. Measurements, expressed as percentages of total length, follow for a 345-mm adult male, first figure in each pair, and for a 99-mm juvenile male, second figure of each pair.

Tip of snout to: front of mouth, 4.5, 6.2; eye, 6.1, 7.0; spiracle, 10.2, 13.0; first gill slit, 15.1, 18.0; fifth gill slit, 20.3, 22.5; origin pectoral, 18.3, 21.0; origin first dorsal fin, 51.0, 48.0; origin pelvics, 42.3, 39.0; origin second dorsal, 67.6, 65.0; origin anal, 61.8, 56.0; origin upper caudal fin lobe, 78.3, 78.0; anterior end cloacal opening, 45.0, 42.0.

Eyes: length orbit, 3.8, 5.0; height, 1.2, 1.4.

Spiracles: greatest diameter, 0.6, 0.6; distance from eye, 0.9, 0.4.

Mouth: width, 7.3, 7.5; length, 4.6, 2.5; length lower labial furrow, 1.5, 1.0.

Nostrils: least distance between, 2.2, 2.0.

Gill slits: height of first, 1.3, 2.9; height of fifth, 0.7, 1.2.

First dorsal fin: length base, 5.8, 6.0; length free inner margin, 2.5, 3.0; height, 4.6, 5.0; length anterior margin, 9.6, 10.0.

Second dorsal fin: length base, 4.9, 4.5; length free inner margin, 2.6, 3.5; height, 2.9, 3.5; length anterior margin, 7.3, 8.0.

Anal fin: length base, 8.1, 9.0; length free inner margin, 2.9, 3.0; height, 3.2, 4.5; length anterior margin, 6.7, 8.0.

Pectoral fins: width base, 5.2, 6.0; anterior margin, 13.9, 13.0; greatest width, 9.3, 8.0.

Pelvic fins: overall length, 10.2, 11.0; length inner margin claspers, 7.8, 4.0; reach claspers past pelvic fin tips, 1.5, (-3.0).

Distance between fin bases: first and second dorsal, 10.7, 11.0; pectoral and pelvic, 17.1, 13.0; pelvic and anal, 12.8, 12.0; anal and lower caudal fin lobe, 8.1, 7.0; second dorsal and upper caudal fin lobe, 5.8, 7.0.

Teeth in about 23+24/22+22 vertical rows; most of teeth in 345 mm adult male with five cusps, the lateral cusps very short, similar in upper and lower jaws.

Dermal denticles of dorsolateral surfaces of adults mostly three-pointed, the central point much the strongest, blades with three or five ridges, the central ridge strong and somewhat projecting anteriorly.

Vertebral numbers mostly 40, but varying from 38 to 43.

Discussion. As with other species of the genus, *Scyliorhinus haeckelii* is oviparous. The largest of nine egg capsules taken in a haul with three juvenile specimens off Surinam was 66 mm long, exclusive of tendrils, and 24 mm wide. The cases were smooth, transparent, amber-colored, and six contained eggs with embryos in very early stages of development. The largest egg yolk was about 22 to 30 mm in diameter. The egg capsules were rather thick-walled with moderately thickened lateral margins. The tendrils were estimated to be about 150 mm long or more and were attached from each of the four corners of the egg capsule to pieces of coral.

Scyliorhinus haeckelii occurs on the outer parts of the continental shelf from the Venezuela-Colombia border to southern Brazil where it is probably replaced by *S. besnardi*.

Scyliorhinus hesperius Springer
Figures 87, 88, 89

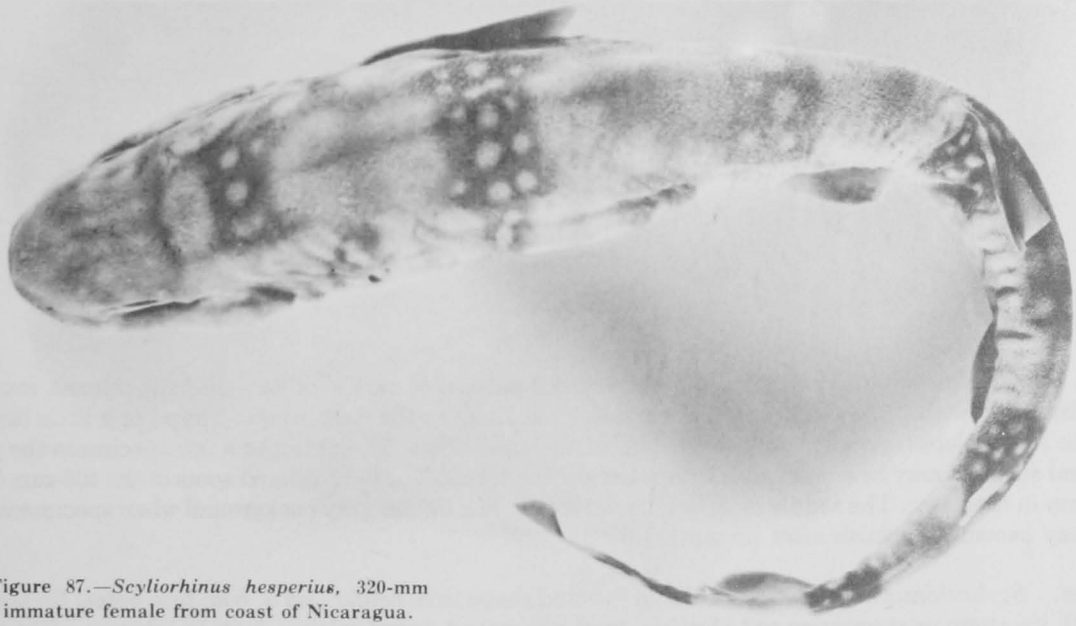

Figure 87.—*Scyliorhinus hesperius*, 320-mm immature female from coast of Nicaragua.

Scyliorhinus hesperius Springer 1966:603, fig. 15B (Caribbean coast of Panama).

Material examined. USNM 187732, imm. ♀, 405 mm, lat. 09°03'N, long. 81°22'W, Caribbean coast of Panama, Golfo de los Mosquitos, 366 to 402 m, holotype; USNM 187730, ad. ♀, 466 mm, near Pedro Bank, Jamaica, 530 m; USNM 187728, imm. ♀, 333 mm, off Nicaragua, in 439 to 457 m; USNM 187688, 2 imm. ♀, 267, 317 mm, off Honduras, 274 m; USNM 187729, imm. ♀, 260 mm, off Rosalind Bank, 366 m; USNM 187731, 2 imm. ♂, 305, 355 mm, off Panama; 5 other USNM specimens, western Caribbean in 366 to 457 m.

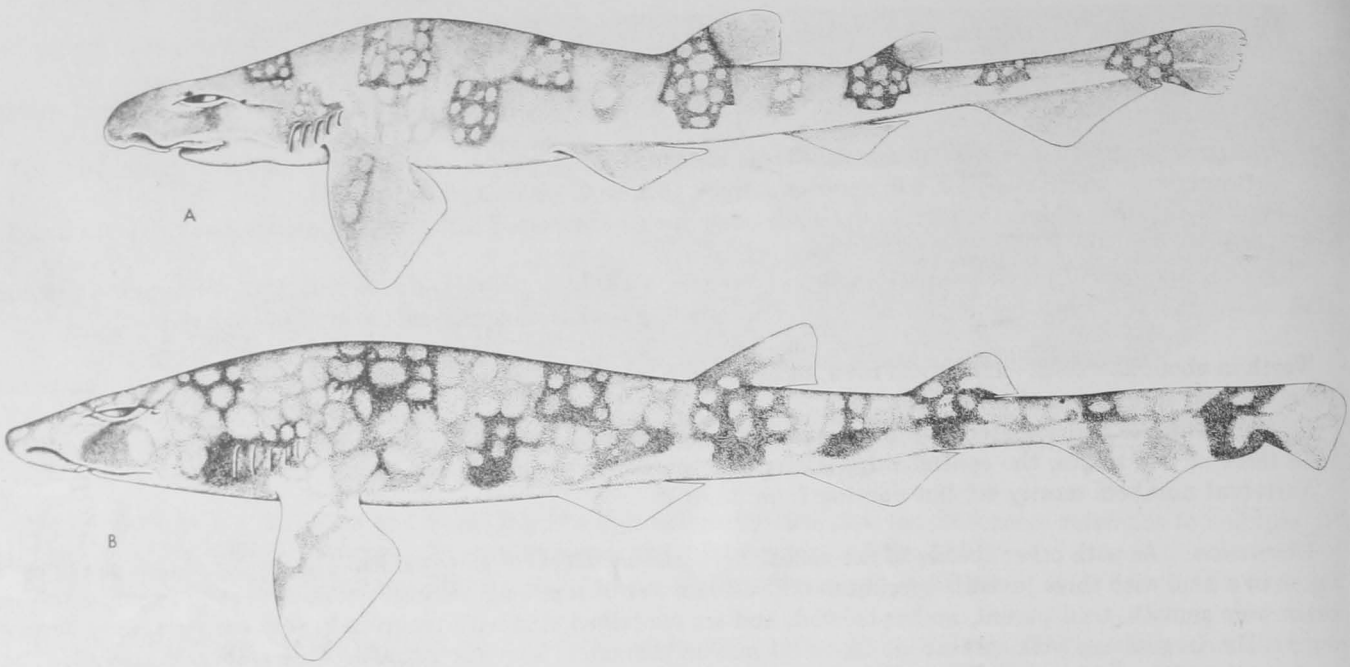

Figure 88.—*Scyliorhinus hesperius*. A. 260-mm immature female from 366 m off northwestern Rosalind Bank, Western Caribbean, *Oregon* stn. 1883. B. Vicinity of Baranquilla Island off the coast of Venezuela, USNM 187688. Drawings by Mildred Carrington.

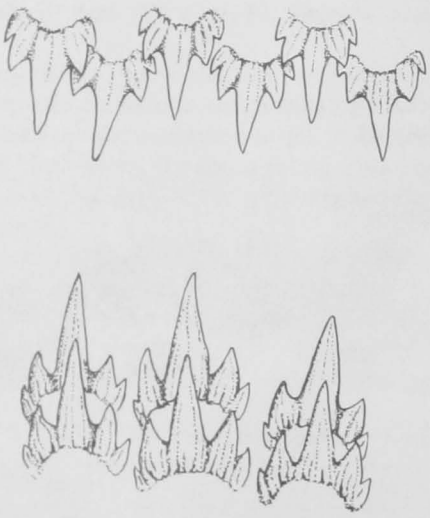

Figure 89.—*Scyliorhinus hesperius*, teeth from upper and lower jaws of immature female about 260 mm from slope of Rosalind Bank, Western Caribbean. Longest upper jaw tooth about 0.8 mm. Drawing by Mildred Carrington.

Diagnosis. *Scyliorhinus hesperius* has a distinctive color pattern of dark saddles with light colored, round or nearly round spots included within the saddles, the spots usually as large as the dark-adapted pupil or a little larger. In most specimens the light colored spots are only within the saddle areas (Figs. 87, 88) but in a few specimens the pattern over all dorsolateral surfaces may be similar to the dappled gray of horses. The light colored spots of the 405-mm holotype are from 2 to 5 mm in diameter. The saddle blotches are dark gray on a lighter gray background when specimens are caught, but colors may become brownish after preservation.

Description. *Scyliorhinus hesperius* is similar in size and shape to *S. retifer* and *S. boa*; first dorsal fin larger than the second dorsal, its origin over anterior end of pelvic fin base; second dorsal origin a little in advance of posterior end of anal fin base; length of anal fin base a little less than the distance between dorsal fin bases; pectoral fin origin under third gill slit, its greatest width equal to or a little less than, length of its anterior margin; fifth gill slit half or less than half length of first gill slit.

Teeth in about 26+26/21+4+21 vertical rows, mostly with five cusps in females and immature specimens (Fig. 89).

Dermal denticles much as in *S. retifer* (see Fig. 8G); some of the color pattern from melanophores in the skin but major dark areas produced by pigments within dermal denticles.

Following are measurements given as percentages of total length. The first figure of each pair refers to a 466-mm adult female and the second figure to a 355-mm immature male.

Tip of snout to: front of mouth, 4.7, 4.8; eye, 4.9, 5.3; first gill slit, 14.6, 14.6; fifth gill slit, 18.9, 18.9; origin pectoral fin, 18.2, 17.7; origin first dorsal fin, 50.9, 47.9; pelvic fins, 44.4, 39.4; origin second dorsal, 66.5, 64.7; origin anal fin, 59.2, 58.5; origin upper caudal fin lobe, 77.3, 75.5; anterior end cloacal opening, 46.8, 41.7.

Eye: length opening, 3.4, 3.3; least distance from spiracle, 0.8, 0.8.

Mouth: width, 7.5, 7.0; length 4.0, 3.7; length lower labial furrow, 1.5, 1.7.

First dorsal fin: length base, 6.4, 6.2; length anterior margin, 10.1, 10.1.

Second dorsal fin: length base, 5.2, 4.8; length anterior margin, 8.2, 7.0.

Anal fin: length base, 7.7, 8.2; length anterior margin, 9.2, 7.9.

Pectoral fin: anterior margin (= length), 13.3, 13.3.

Distance between: base first dorsal and base second dorsal fin, 9.2, 10.7; nasal openings, 1.8, 2.0; axil pectorals and origin pelvics, 20.0, 17.5.

Discussion. No adult males were seen but a female 466 mm long was found to have four large, 20-mm diameter, eggs in the single developed ovary. No eggs were present in the oviducts.

Scyliorhinus hesperius appears to be restricted to the slopes of offshore banks of the western Caribbean and the continental slopes from Honduras to Colombia. The absence of adults from trawl catches suggests that *S. hesperius*, like *S. retifer*, either lives largely on types of sea bottom unfavorable to trawling, or that adults are too large to catch easily in the trawling equipment used.

Radiographs of eight *S. hesperius* show the number of monospondylous vertebrae to be from 39 to 42 (Springer 1966, table 1). These counts do not differ appreciably from counts for *S. retifer, S. boa*, and *S. haeckelii*.

Scyliorhinus meadi Springer
Figures 90, 91, 92

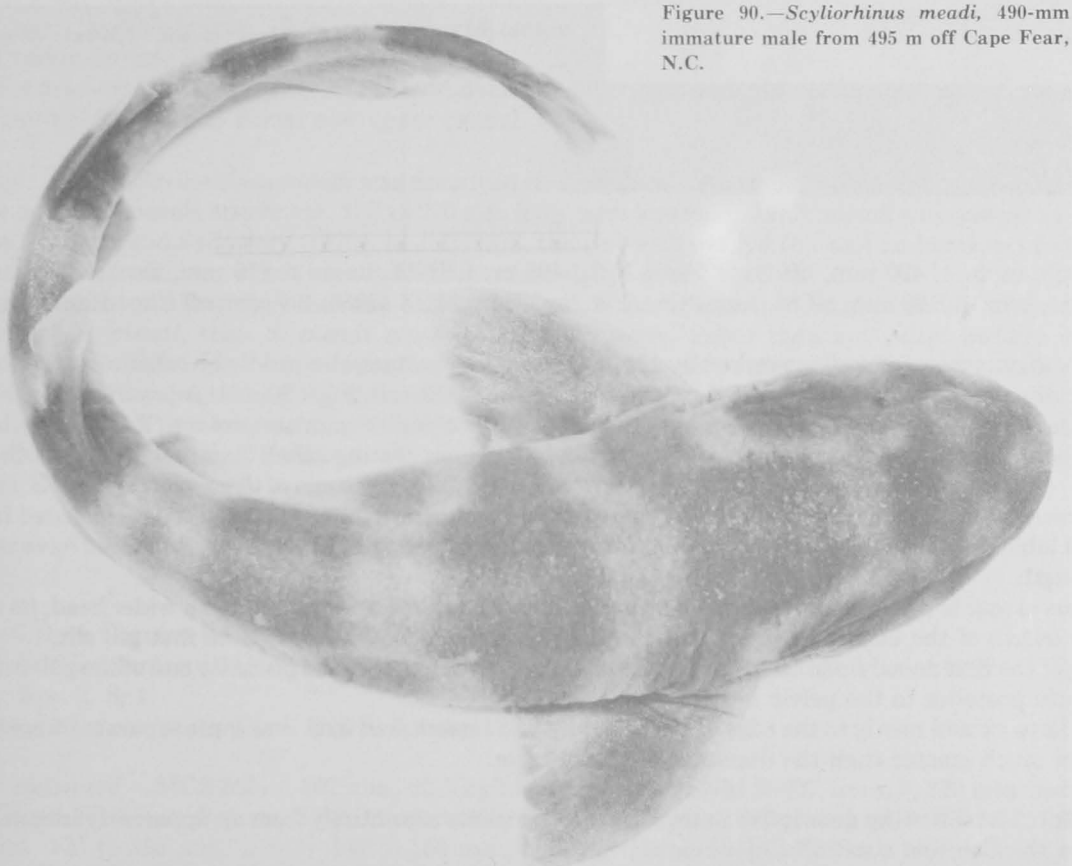

Figure 90.—*Scyliorhinus meadi*, 490-mm immature male from 495 m off Cape Fear, N.C.

Scyliorhinus meadi Springer 1966:600, fig. 14B (off Cape Kennedy, Fla.).
Scyliorhinus retifer meadi: Springer and Sadowsky 1970:92.

Material examined. USNM 188049, imm. ♂, 247 mm, off Cape Kennedy, Fla., 329 m holotype; USNM 188050, imm. ♂, 183 mm, imm. ♀, 235 mm, same locality as holotype; USNM, 2 imm. ♂, 186-212 mm, off Daytona, Fla., 402-548 m;

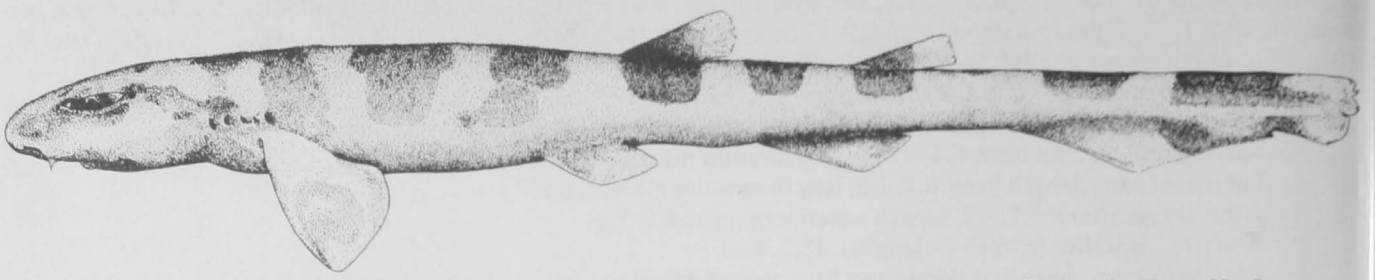

Figure 91.—*Scyliorhinus meadi*, 190 mm from 338 m off St. Augustine, Fla., *Combat* stn. 51. Drawing by Nancy Mead.

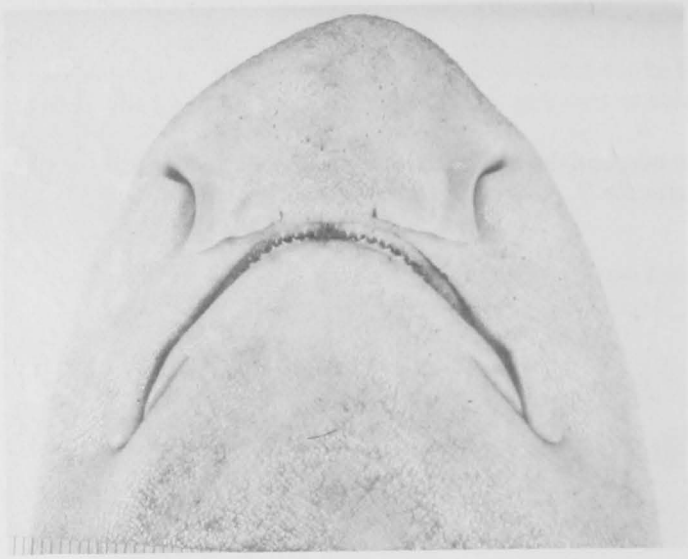

Figure 92.—*Scyliorhinus meadi*, ventral view of head of 490-mm male.

UNCIMS 4958, imm. ♂, 490 mm, off Cape Fear, N.C., 495 m; USNM, imm. ♂, 270 mm, Santaren Channel, 548 m; USNM 188051, imm. ♂, 180 mm, off St. Augustine, Fla., in 338 m; MCZ 42986, 190 mm, off Cape Kennedy, Fla., 329 m.

Diagnosis. *Scyliorhinus meadi* is marked by about seven nearly rectangular saddle blotches of darker color crossing the dorsal midline of the head and body and by two more crossing the tail (Figs. 90, 91). A few indistinct blotches present on the lateral surfaces, but no definite smaller spots of lighter or darker color are present. The color pattern of saddle blotches without additional light or dark spots or reticulating lines distinguishes *S. meadi* from all other species of *Scyliorhinus*, except some *S. torazame* of Japanese waters and possibly only some of those specimens of *S. torazame* that have been preserved for a long time in alcohol. The available specimens of *S. meadi* have tails (measured from origin of upper caudal lobe) very near one-fourth total length whereas the specimens of *S. torazame* examined have tails near one-fifth total length.

Scyliorhinus meadi is a somewhat more robust species than other *Scyliorhinus* and has a wider head, its width nearly equal to the length of the head measured from the tip of the snout to the level of the first gill slit.

The origin of the first dorsal fin in *S. meadi* is over or slightly in advance of the posterior end of the pelvic fin base; it is usually slightly posterior to the pelvic base in *S. retifer*.

The nasal flaps extend nearly to the edge of the upper lip in *S. meadi*, but in *S. retifer* are separated from the upper lip by a distance much greater than the diameter of the spiracle.

Description. The following descriptive notes and measurements are entirely from an apparently immature male 490 mm TL from the Carolina coast off Cape Fear.

Body robust; head wide, its length to fifth gill slit about one-fifth total length; body width at pectoral origin one-seventh total length; body depth at pectoral origin one-eighth total length; caudal sector posterior to cloacal opening about one-half total length; upper caudal fin lobe length about one-fourth total length; snout short, broadly rounded; mouth wide with low arch; eye rather small; gill slits very short, height of longest about equal to one-half length of eye opening.

Teeth small, in about 28+28/23+23 vertical rows, the teeth near the middle of the upper jaw with five cusps but mostly with three cusps laterally.

Dorsolateral dermal denticles with three ridges on blade, the central ridge expanded and bulbous at the anterior end as in adults of *S. retifer*, the lateral ridges not terminating posteriorly in points as in smaller *S. meadi* and in adults of *S. retifer*.

Monospondylous vertebrae 47, precaudal 90, and caudal 37; total number of vertebrae 127.

Dorsolateral surfaces gray with strongly contrasting darker, gray-black saddle blotches with some alternating lateral blotches; no blotches outlined by solid dark lines or spots; no small dark or light spots within blotches or in spaces between blotches; ventral surfaces grayish-white, without markings; pigments producing darker color of saddles mostly carried within dermal denticles.

The following measurements are given as percentages of the total length, 490 mm.

Tip of snout to: front of mouth, 4.2; eye, 5.3; spiracle, 10.6; first gill slit, 15.3; fifth gill opening, 19.6; origin pectoral fin, 18.4; origin first dorsal fin, 49.0; origin pelvic fins, 42.5; origin second dorsal, 65.9; origin anal, 60.2; origin upper caudal fin lobe, 75.5; anterior end cloacal opening, 46.9.

Greatest width of: head, 14.3; trunk at pectoral origin, 14.3; trunk at pelvic origin, 7.1; trunk at caudal peduncle, 2.4.

Greatest height of: head, 12.7; trunk at pectoral origin, 12.7; trunk at pelvic origin, 9.4; caudal peduncle, 3.7.

Eyes: horizontal diameter, 3.1; vertical diameter, 0.8.

Spiracles: greatest diameter, 0.7; least distance from eye, 1.0.

Nasal apertures: least distance apart, 2.0; least distance nasal flap to upper lip, 0.4.

Mouth: width, 8.0; length, 4.5; length lower labial furrow, 2.4.

Gill slits: height of first, 1.6; height of fifth, 1.0.

First dorsal fin: length base, 6.9; length free inner margin, 3.1; height, 6.1; length anterior margin, 11.2.

Second dorsal fin: length base, 5.5; length free inner margin, 3.3; height, 3.7; length of anterior margin, 8.6.

Anal fin: length base, 8.6; length free inner margin, 2.4; height, 3.9; length anterior margin, 8.6.

Pectoral fins: width base, 6.5; length anterior margin, 14.9; greatest width, 10.8.

Pelvic fins: overall length, 12.0; inner margin clasper, 4.7; outer margin clasper, 1.7; distance tip of clasper anterior to pelvic fin tip, 3.1.

Distance between fin bases: first and second dorsal fins, 9.7; pectoral and pelvic, 18.8; pelvic and anal, 10.0; anal and lower caudal, 7.6; second dorsal and upper caudal, 4.9.

Discussion. When *Scyliorhinus meadi* was described in 1966 there were some doubts about its validity because only six juvenile and postjuvenile specimens, 183 to 270 mm long, were known. Later *S. meadi* was treated as a subspecies of *S. retifer* by Springer and Sadowsky (1970). In July 1970, the University of North Carolina Institute of Marine Sciences collected a 490-mm specimen which greatly increases knowledge of the species.

The claspers of the 490-mm specimen are very small, and if this specimen is representative of normal growth and development of *S. meadi*, then *S. meadi* must be a large species, larger than any other western North Atlantic scyliorhinid. It is possible that the specimen may be an adult female although the condition of a female having partly developed claspers (Compagno and Springer 1971:624) is not known to be common.

Scyliorhinus meadi is now known from 329 to 548 m and from Cape Fear, N.C., southward to the Santaren Channel between Cuba and the Bahama Bank.

Scyliorhinus retifer (Garman)
Figure 93

Scyllium retiferum Garman 1880:223 (off Delaware Bay in 163 m).

Scyliorhinus retifer: Jordan and Evermann 1896:25; Regan 1908a:457; Bigelow and Schroeder 1948:207, fig. 33; Springer 1966:602, figs. 2, 6, 7.

Scyliorhinus retifer retifer: Springer and Sadowsky 1970:88.

Material examined. MCZ 825, ♂, 307 mm, off Virginia, holotype; USNM 33499, imm. ♂, 320 mm, south of Martha's Vineyard Island; RV *Silver Bay* stn. 2173, 11 ad. ♂, 365 to 410 mm, imm. ♂, 385 mm, 5 ad. ♀, 350 to 420 mm, more than 500 juveniles, 100 to 225 mm, mostly 100 to 150 mm, off Nags Head, N.C., in 183 m, 19 July 1960; more than 100 specimens, USNM, from Gulf of Mexico, mostly off Pensacola, Fla.

Diagnosis. Scyliorhinus retifer differs from all other species of the family, except *Cephaloscyllium fasciatum* from the South China Sea, in having a color pattern of black lines that outline dorsal saddles and sometimes extend over the lateral surfaces as a reticulum (Fig. 93). The nasal flaps in *S. retifer* do not reach as far as the edge of the upper lip as they do in all specimens of *S. canicula* and in some specimens of *S. stellaris, S. cervigoni,* and *S. meadi*. The color pattern in *S. retifer* is distinctive in juveniles of 100 mm, about hatching size, to the largest adults.

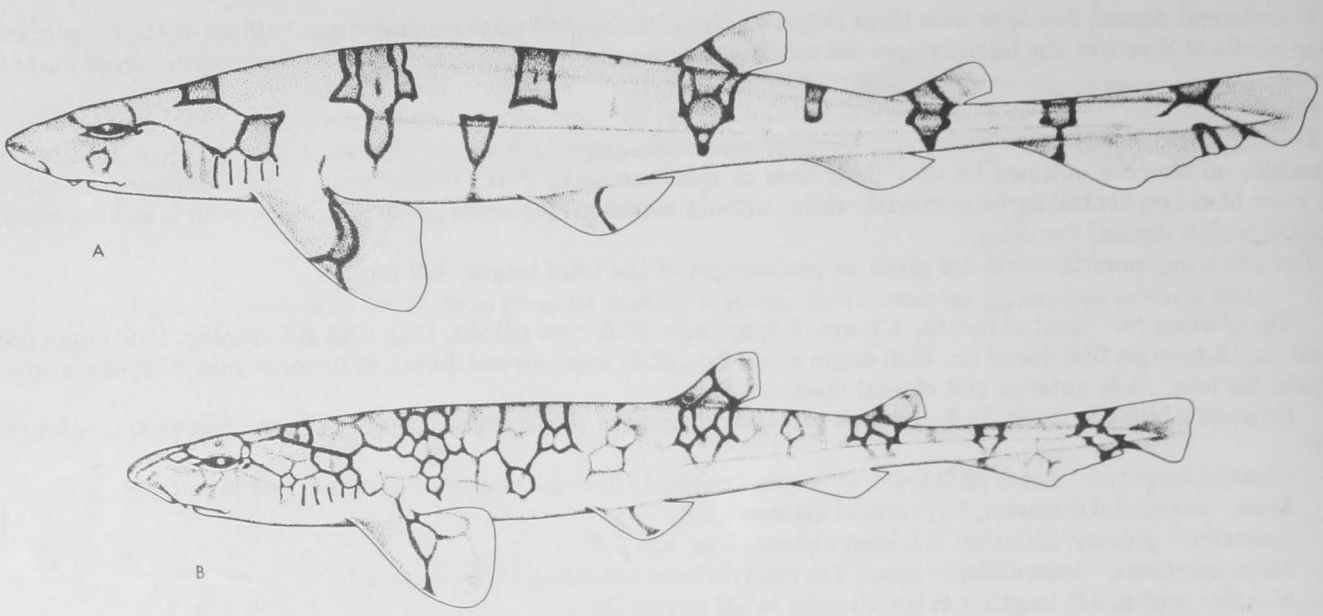

Figure 93.—*Scyliorhinus retifer*. A. Drawn from 455-mm female. B. Drawn from 380-mm female. Both specimens from 365 to 385 m off Pensacola, Fla. Drawings by Mary Wagner.

Description. Bigelow and Schroeder (1948:210) measured specimens up to 430 mm. The largest specimen I have seen was 465 mm long. The number of tooth rows varies independently from the size of the shark from about 21+0+21/20+0+20 to 26+2+26/22+4+22. Denticle size, shape, and spacing changes with growth of the shark with small denticles replaced by larger ones that tend to fill in spaces (see Springer 1966, fig. 6). Monospondylous vertebrae in counts from radiographs ranged from 39 to 43, mean 41, in 45 specimens. The total number counted was 122 to 134, mean 128.

Measurements for the largest female *S. retifer*, 465 mm, are given here as percentages of the total length, first figure of each pair. The second figure is for a juvenile female 173 mm.

Tip of snout to: front of mouth, 4.5, 5.8; eye, 4.5, 5.8; first gill slit, 15.9, 14.4; fifth gill slit, 20.4, 18.5; origin pectoral fin, 18.3, 17.3; origin first dorsal fin, 51.0, 46.2; pelvic fins, 41.7, 40.4; second dorsal, 62.5, 63.0; anal, 60.7, 57.8; origin upper caudal fin lobe, 76.1, 76.8; anterior end cloacal opening, 43.6, 41.0.

Eyes: length orbit, 4.3, 4.0; height, 1.2, 1.4.

Nasal apertures: least distance between, 1.5, 2.3.

Mouth: width, 7.2, 8.1; length, 4.3, 4.0; length lower labial furrow, 1.9, 1.7.

Gill slits: height of first, 1.9, 1.7; height of fifth, 0.9, 0.9.

First dorsal fin: length base, 6.0, 6.4; length anterior margin, 9.7, 8.1.

Second dorsal fin: length base, 5.2, 4.6; length anterior margin, 7.2, 6.4.

Anal fin: length base, 6.5, 6.9; length anterior margin, 6.5, 6.9.

Outer margin pectoral: 15.0, 11.6.

Distance between first and second dorsal fin bases: 11.2, 11.0.

Discussion. *Scyliorhinus retifer* is not uncommon from George's Bank off Massachusetts southward along the continental slopes to Nicaragua. At the northern end of its range, it is occasionally taken on the continental shelf but inhabits deeper water southward to depths more than 450 m. Its distribution appears to be irregularly interrupted by areas where it is very uncommon and adults of the species are rarely taken in trawls. Springer and Sadowsky (1970) suggested that *S. retifer* adults prefer rough bottom areas generally considered by fishermen as not suited to trawling. One trawl haul off Cape Hatteras produced a huge number of newly hatched and very small *S. retifer* suggesting that egg laying may be concentrated in specifically limited nursery areas.

The stomachs of 16 adults and a sample of a dozen young taken in one haul off Nags Head, N.C., were examined. All stomachs were empty except for small pebbles about 3 to 8 mm in diameter which were present in about half the stomachs. One possibility is that the stones were taken on as ballast.

Scyliorhinus retifer inhabits water that is near 10°C. The extremes recorded for bottom water temperatures where *S. retifer* were caught ranged from 8.5° to 11.3°C off the Carolinas and also off Pensacola, Fla.

Scyliorhinus stellaris (Linnaeus)
Figures 3, 94

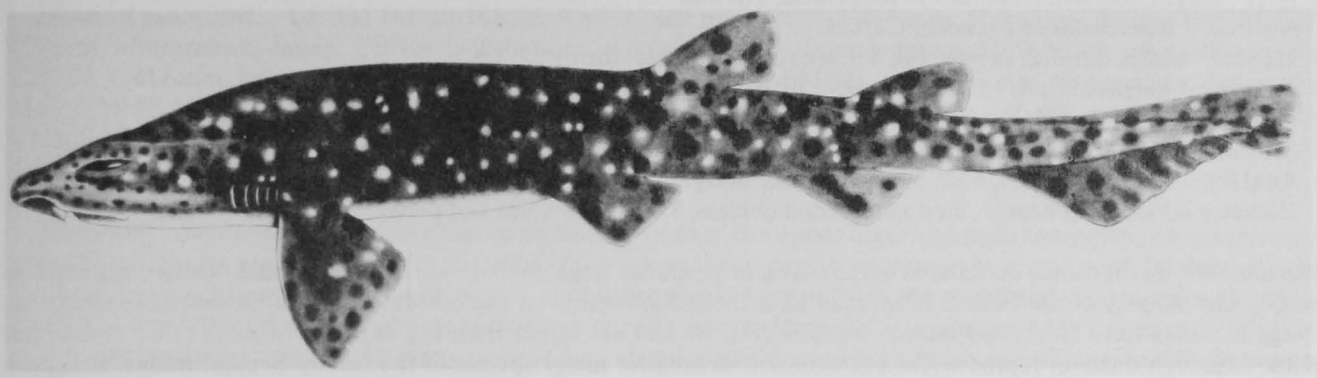

Figure 94.—*Scyliorhinus stellaris*, a typical dark phase, immature female, 325 mm, Adriatic Sea. For more common color pattern see Bini (1967:59) and Lozano Rey (1928, fig. 2).

Squalus stellaris Linnaeus 1758:235 (Habitat in Mari Europae).
Scyllium catulus: Müller and Henle 1841:9.
Scyliorhinus stellaris: Regan 1908a:457; Tortonese 1956:130, figs. 66-69; Bini 1967:59, figs; Wheeler 1969:44, fig. 15; Springer 1973:19.
Catulus stellaris: Garman 1913:75.

Material examined. USNM 28461, imm. ♂, 320 mm, Livorno; USNM, 6 imm., Europe; USNM, 2 imm., Adriatic; BMNH, 6 imm., egg cases, European waters; USNM 34352, imm. ♂, 370 mm, Venice; USNM 163354, juv. ♂, 167 mm, Straits of Messina, Italy.

Diagnosis. *Scyliorhinus stellaris* has no depressed areas of the upper lip with grooves or channels connecting the nasal apertures with the mouth and by this lack can be distinguished from *S. canicula.* Postjuvenile *S. stellaris* are profusely spotted with small dark spots, often with some white spots, and sometimes with distinct dorsal saddle blotches. It is thus easily separated from *S. cervigoni* which has relatively few dark spots, no white spots, and often no trace of saddle blotches.

Description. *Scyliorhinus stellaris* is one of the larger species of the family, reputed to reach a length of 1,500 mm (Poll 1951; Wheeler 1969) in the northern part of its range but only about 750 mm in the Mediterranean (Tortonese 1956; Bini 1967).

The color pattern of *S. stellaris* is variable but, as a general rule, many of the darker spots are larger than the dark-adapted pupil and some may have light-colored centers. Some may be crescent-shaped, similar to spots of *S. besnardi.* The illustration used here (Fig. 94) was drawn from an unusually dark specimen. The color pattern shown in the illustration accompanying Bini's (1967:59) account of the species is more representative of the species.

In *S. stellaris* the origin of the first dorsal fin is usually over or slightly in advance of the posterior end of the pelvic fin base.

The nasal flaps are moderately large and fully cover the posterior openings of the nostrils but usually do not quite reach the edge of the upper lip. As in all *Scyliorhinus*, except *S. canicula, S. stellaris* has, within the nasal flap, a conical swollen area, the tip of which, in *S. stellaris* but usually not in other species, may extend slightly past the edge of the flap. Garman (1913:75) called this a rudimentary cirrus. For Garman the cirrus was the structure here called a barbel.

The dermal denticles, at least in immature *S. stellaris*, are moderately erect with the central posterior points of the tridentate blades very long, lateral points short, and with the blades directed upward to some extent. I have not seen adults but assume that change in denticle form during development is similar to that described by Ford (1921, figs. 10 to 15) for *S. canicula* and by Springer (1966, fig. 6) for *S. retifer.*

Two rows of enlarged denticles, one row on each side of the dorsal midline, extending from the level of the spiracles to the level of the first dorsal fin, are present on newly hatched *S. stellaris* (Ford 1921, figs. 5, 6) but disappear during post-juvenile development.

The teeth are comparatively small, mostly tricuspid, with the central cusp much the longest.

Following are measurements of a 370-mm immature male and a 167-mm juvenile male from Italy expressed as percentages of the total length, the first figure in each pair refers to the 370-mm specimen.

Tip of snout to: front of mouth, 3.8, 4.2; eye, 4.1, 4.8; first gill slit, 14.1, 12.6; fifth gill slit, 19.2, 18.6; origin pectoral fin, 17.3, 17.4; first dorsal fin, 50.0, 47.3; pelvic fins, 43.2, 39.5; second dorsal fin, 65.4, 62.3; anal fin, 59.5, 53.9; origin upper caudal fin lobe, 77.0, 73.7; anterior end cloacal opening, 46.0, 43.7.

Eye: length, 3.5, 3.0; distance eye to spiracle, 1.1, 0.9.

Nostrils: least distance between, 1.4, 0.9.

Mouth: width, 6.8, 7.2; length, 4.3, 3.0; length lower labial furrow, 2.2, 1.8.

Gill slits: height of first, 1.6, 1.8; height of fifth, 0.9, 0.6.

First dorsal fin: length base, 7.0, 6.6; length anterior margin, 10.5, 8.4.

Second dorsal fin: length base, 6.5, 6.6; length anterior margin, 9.2, 6.6.

Anal fin: length base, 9.7, 10.2; length anterior margin, 7.8, 7.8.

Distance between fin bases: first and second dorsals, 8.6, 9.0; pectoral and pelvic, 20.5, 17.4.

Discussion. *Scyliorhinus stellaris* is oviparous and produces large, smooth-surfaced and thick-walled, egg capsules which, in the vicinity of the British Isles, may be attached to objects on the bottom in favorable nearshore situations. The egg capsules have thickened lateral margins (Fig. 3) and are larger than egg capsules of most other scyliorhinid species. Although data on reproductive patterns are lacking for many species of the family Scyliorhinidae, it appears that species producing heavy-walled capsules, such as does *S. stellaris*, have rows of enlarged denticles during the hatching period. Presumably these denticles may function to assist the fully developed young to escape from the capsule as observed by Grover (1974) for *Cephaloscyllium ventriosum*.

Ford (1921) found stomachs of *S. stellaris* to contain mostly small fishes, crustaceans, and squids. In Ford's series of 18 stomachs, 3 contained *Scyliorhinus canicula*.

Scyliorhinus torazame (Tanaka)
Figures 95, 96

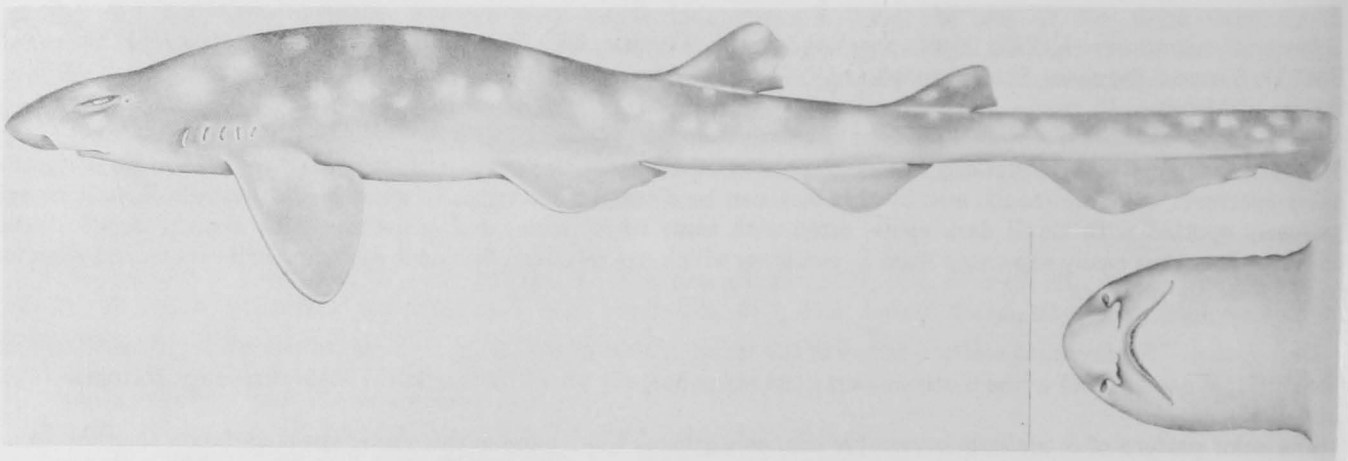

Figure 95.—*Scyliorhinus torazame*, 333-mm female from Japan, SU 53386. Drawing by Mary Wagner.

Figure 96.—*Scyliorhinus torazame*, ventral view of pelvic area of a 440-mm adult male from Japan to show claspers and surrounding pelvic fins.

Catulus torazame Tanaka 1908:6, pl. 2, figs. 2A, 2B (Misaki, Japan); Garman 1913:77; Kamohara 1952:5.
Scyliorhinus rudis Pietschmann 1908a:133; 1908b:699, pl. 1, fig. 3; Regan 1908a:457.
Halaelurus rudis: Tanaka 1911:13, pl. 3, fig. 12.

Halaelurus torazame: Schmidt 1930a:225; 1930b:48.
Scyliorhinus torazame: Fowler 1941:16; Nakaya 1975:15, figs. 4-9.
Scylliorhinus torazame: Mori 1952:5.

Material examined. USNM 161523-161526, 2 ad. ♂, 460 mm, 2♀, 430, 410 mm, Hakodate, Japan; USNM 22558, ♀, 350 mm, Miuramisak, Japan; USNM 104945, imm. ♀, 233 mm, Cape Tsiuka, Japan; MCZ 35309, ad. ♂, 465 mm, Japan; FMNH, ♀, 417 mm, between Oshima and Idzu, Japan, Owston 934; FMNH, ad. ♂, 440 mm, Sagami Sea, Japan, Owston 1218; UMMZ 179027, juv., 115 mm, Nagasaki, Japan; UMMZ 179037, 5 specimens, 205-490 mm, Mutsu Bay, Japan; UMMZ 179029, 8 specimens, 240-350 mm, Fusan, Korea; BMNH 1936.7.29, 3 ad. ♂, 410 to 440 mm, Sagami Channel, Japan.

Diagnosis. *Scyliorhinus torazame* has no depressed areas of the upper lip or channels connecting the nasal apertures with the mouth. Its nasal flaps do not extend as far back as the upper lip as they do in *S. garmani*. Its dermal denticles are large and erect in comparison with denticles of other sharks especially in the middorsal region and make the shark rougher to touch than any other species of *Scyliorhinus*. Its color pattern consists of a series of six to nine saddle blotches in addition to which there may be many more or less irregular markings of both black and white (Fig. 95). In most of the smaller specimens in collections, however, only the saddle blotches show. I do not know whether the loss is from preservation or whether some of the markings only appear after growth.

As with other species of *Scyliorhinus, S. torazame* has no upper labial furrow. It does have a small tab from the upper lip overhanging the lower lip but the structure is inconspicuous and *S. torazame* has often been confused with *Halaelurus buergeri. Halaelurus buergeri* has very small or short labial furrows that sometimes are very inconspicuous or even absent. The two species can easily be distinguished because *S. torazame* has a supraorbital crest whereas *H. buergeri* has none.

The only other *Scyliorhinus* of the Pacific, *S. garmani,* is known from only one specimen which differs from *S. torazame* in having broad and long nasal flaps reaching the edge of the upper lip and in having a color pattern including randomly distributed brown spots about the size of the eye.

Description. *Scyliorhinus torazame* is a rather small species; males are mature at about 400 mm and may reach a length of nearly 500 mm. The skin is rough to touch due to comparatively large and hard denticles which are nearly erect on the dorsal surfaces.

The pelvic fins of adult males are united along their inner margins to form an apron, as in other species of *Scyliorhinus*, and they envelop the relatively large claspers for their entire length to the origin of the anal fin (Fig. 96). The pelvic fins of adult females are united along most of their inner margins but are only a little more than half the overall length of pelvic fins of the adult male. I assume that with the onset of sexual maturity the pelvic fins grow rapidly as do the claspers of most or perhaps all sharks. I have not seen specimens of other sharks for which the apron has grown to keep pace with comparatively large claspers. The claspers are provided with a long row of hooks along the margin of the exorhipidion (for illustration see Schmidt 1930b).

The smaller specimens I have seen had moderately well-defined saddle blotches but most of the adults were mottled with saddles obscure. Most specimens have small light-colored spots about the size of the eye variously distributed over the dorsolateral surfaces both inside and outside of the saddle blotches. Tanaka's (1908, pl. 2) illustration of the species shows white spots in a somewhat regular pattern outlining borders between dark and light areas, but the number of light spots on the specimens I have seen varies from many to none at all.

The teeth are mostly tridentate but a few have additional small marginal cusps.

Following are measurements expressed as percentages of total length of a 480-mm adult male (first figure in each pair), and of a 417-mm female (second figure).

Tip of snout to: front of mouth, 3.5, 3.6; eye, 4.0, 3.8; spiracles, 7.1, 7.9; first gill slit, 12.9, 12.5; fifth gill slit, 18.1, 18.5; origin pectoral fin, 17.3, 16.5; origin first dorsal, 49.0, 50.4; pelvic fins, 36.5, 40.8; origin second dorsal, 66.2, 66.4; origin anal, 60.4, 60.0; origin upper caudal fin lobe, 77.0, 76.0; anterior end cloacal opening, 43.3, 43.6.

Greatest width of trunk at: pectoral origin, 10.4, 11.0; pelvic origin, 6.2, 7.4; caudal origin, 2.1, 2.4.

Greatest height of trunk at: pectoral origin, 10.4, 9.4; pelvic origin, 8.5, 8.6; caudal origin, 2.9, 3.1.

Eyes: length, 3.1, 3.4; height, 1.0, 0.7.

Spiracles: greatest diameter, 0.8, 0.5; least distance from eye, 0.8, 0.7.

Mouth: width, 7.9, 7.7; length, 3.3, 3.1; length lower labial furrow, 0.8, 0.5.

Nasal apertures: least distance apart, 1.9, 1.4.

Gill slits: height of first, 1.5, 1.2; height of fifth, 0.6, 0.6.

First dorsal fin: length base, 6.9, 6.5; length free inner margin, 2.1, 2.2; height, 3.1, 3.1; length anterior margin, 8.7, 10.5.

Second dorsal fin: length base, 5.6, 5.5; length free inner margin, 2.1, 2.2; height, 3.1, 3.1; length anterior margin, 6.5, 7.0.

Anal fin: length base, 7.9, 7.7; length free inner margin, 2.3, 1.9; height, 3.3, 3.1; length anterior margin, 6.0, 7.0.

Pectoral fins: width base, 6.2, 5.8; length anterior margin, 11.2, 8.1; greatest width, 8.7, 8.2.

Pelvic fins: overall length, 19.6, 11.5; outer margin claspers, 9.8, —; inner margin claspers, 13.3, —; extent fin tips past tips of claspers, 1.7, —.

Distance between fins: base first dorsal to base second dorsal, 9.8, 9.8; tip of pelvics to origin anal, 2.3, 7.4; tip of second dorsal to origin upper caudal lobe, 5.0, 3.1.

Nakaya (1975, table 3) reported 33 to 38, mode 35, monospondylous vertebrae in 99 *Scyliorhinus torazame*.

Discussion. Tanaka stated (1908:8) that the "tiger shark," *S. torazame*, was very common at Misaki, Sagami, Japan. Kamohara (1952:5) noted that it was very rare off Shikoku Island, southern Japan. Mori (1952:18) recorded the species from Pusan, Korea, and from Quelpart Island. Nakaya's (1975:21) comprehensive account of distribution gave the geographical range as also including Shantung and Shanghai, China, and Negros Oriental Province, Philippines. Nakaya's Philippine record should not be accepted without verification, and its great distance from other recorded captures suggests that the Philippine record may have been based on another species, possibly *Scyliorhinus garmani*. It appears from the literature that the species may be locally common in suitable habitats off the northern Japanese islands, Korea, and the northern coast of China, somewhat less common or rare around the southern islands of Japan, and doubtfully occuring south of lat. 30'N.

White (1937:107) reported two specimens from Japan including a female with "egg cases in oviduct." Nakaya's (1975:18-22, 83) description of the development of *S. torazame* shows the species to be oviparous (single oviparity), hatching at a length somewhat greater than 79 mm from a translucent, yellow, and smooth-surfaced egg capsule about 55 by 19 mm. Nakaya found both sexes of Hakodate specimens under 360 mm to be immature and most of those over 390 mm to be mature.

Scyliorhinus torrei Howell-Rivero
Figure 97

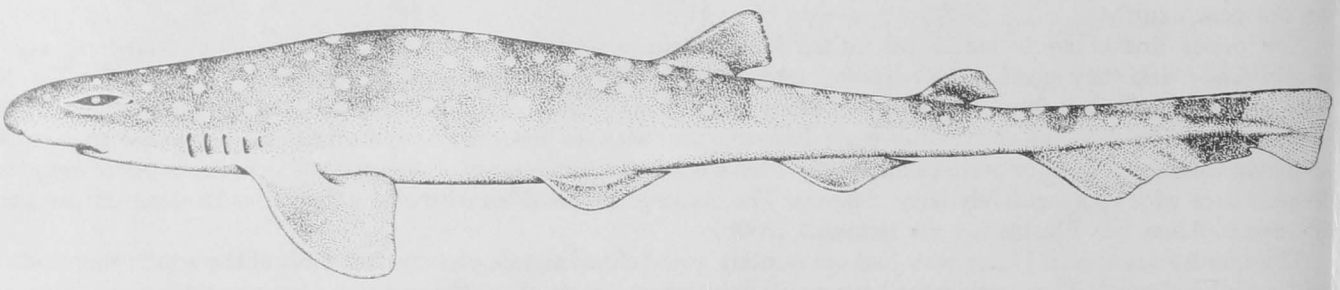

Figure 97.—*Scyliorhinus torrei*, 258-mm adult female from 457 m in Santaren Channel between Great Bahama Bank and Cay Sal Bank. Drawing by Mary Wagner.

Scylliorhinus torrei Howell-Rivero 1936:43, pl. 9 (off Havana, Cuba).

Scyliorhinus torrei: Bigelow and Schroeder 1948:211, figs. 34, 35; Springer and Bullis 1956:40; Bullis and Thompson 1965:17; Springer 1966:598, fig. 14A; Springer and Sadowsky 1970:85.

Material examined. USNM 157845, ad. ♂, 254 mm, ♀, 252 mm, Santaren Channel off north coast of Cuba, 457 m, 16 July 1955; USNM, about 20 additional specimens.

Diagnosis. Dorsal surfaces tan or brown with many randomly distributed light-colored round spots as large as or larger than the diameter of the pupil. Dorsal saddle blotches of slightly darker brown are faintly visible in large specimens but more prominent in smaller individuals. *Scyliorhinus torrei* is the smallest species of *Scyliorhinus*, lengths not exceeding 320 mm.

In combination the light brown color, randomly distributed small spots of lighter color, and the small size at maturity distinguish this species from all other *Scyliorhinus*.

The first dorsal fin is larger than the second dorsal, the first dorsal origin over the posterior end of the pelvic base and the second dorsal origin over the posterior end of the anal fin base. In comparison with adults of other species of *Scyliorhinus*, *S. torrei* has somewhat smaller fins and a shorter snout. In adult male *S. torrei* the extent of union of the pelvic fins to form an apron varies as do the lengths of the calcified claspers (Springer 1966:599). Within the genus

Scyliorhinus, apron development is most complete in *S. torazame* and least complete in *S. torrei*. Clasper hooks are most extensively developed in *S. torazame* but are poorly developed in *S. torrei*.

Description. Adult males of *Scyliorhinus torrei* are immature at 220 mm but may be sexually mature at 240 mm. The teeth are in 20+20/19+19 to 23+23/20+2+20 vertical rows. Shapes of teeth and dermal denticles do not differ much from those in other species of *Scyliorhinus*.

Following are measurements expressed as percentages of total length. The first figure of each series is for a 256-mm adult male, the second figure for a 256-mm adult female, and the third for a 129-mm young male.

Tip of snout to: front of mouth, 3.5, 3.9, 4.7; eye, 4.3, 4.7, 5.4; first gill slit, 14.5, 14.1, 14.7; fifth gill slit, 18.0, 18.0, 17.0; origin pectoral fin, 16.8, 17.2, 16.3; origin first dorsal fin, 48.4, 49.2, 45.7; origin pelvic fins, 38.3, 39.5, 37.2; second dorsal, 65.6, 67.6, 63.6; anal, 57.0, 57.4, 56.6; origin upper caudal, 77.3, 78.9, 75.2; anterior end cloacal opening, 41.4, 41.0, 39.5.

Eye: horizontal diameter, 3.1, 3.5, 3.1; least distance from spiracle, 0.8, 1.2, 0.8.

Mouth: width, 6.6, 6.6, 7.8; length, 5.5, 3.5, 4.7; length lower labial furrow, 1.6, 2.0, 3.1.

Gill slits: height of first, 1.6, 1.6, 1.6; height of fifth, 0.8, 0.8, 0.2.

Distance apart: nostrils, 2.0, 1.6, 2.3; bases of first and second dorsal fins, 11.3, 14.5, 10.9; bases pectoral and pelvic, 27.0, 28.1, 25.6.

First dorsal fin: length base, 5.9, 6.2, 7.0; length anterior margin, 8.2, 8.6, 7.8.

Second dorsal fin: length base, 4.3, 4.3, 4.7; length anterior margin, 5.1, 5.1, 4.7.

Anal fin: length base, 9.4, 8.2, 8.5; length anterior margin, 5.9, 5.5, 6.2.

Pectoral fins: length anterior margin, 10.9, 11.3, 8.5.

The number of monospondylous vertebrae in the three specimens for which measurements were given was 31 and 33. A series of 11 had from 30 to 34 monospondylous vertebrae.

Discussion. Neither egg capsules nor newly hatched young have been identified.

Specimens have been collected only from depths of 229 to 550 m off the north coast of Cuba, Jupiter Inlet, Fla., and the Virgin Islands.

In having a color pattern of light-colored spots on a light tan background, adults of *S. torrei* and *Schroederichthys maculatus* are identical. These two species are known only from small geographical ranges in the West Indian region.

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