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TRIAKIS FEHLMANNI, A NEW SHARK FROM THE COAST OF SOMALIA

By Stewart Springer
Bureau of Commercial Fisheries Ichthyological Laboratory
U. S. National Museum, Washington, D. C.

A 46-cm adult female specimen of a remarkable new shark (Triakidae) collected off the coast of Somalia during the International Indian Ocean Expedition (I.I.O.E.) is described here and assigned to the genus *Triakis.*

Smith (1957) referred to species grouped by Bigelow and Schroeder (1948) in *Triakis* as an uneasy assemblage. This is an understatement in view of the remarkable diversity in the group noted by Smith (1957), Kato (1968), and L. J. V. Compagno (in correspondence). The addition of the new species places more strain on currently used definitions of genera and families of galeoid sharks and emphasizes the need for review of characters that are traditional for their recognition. For the purposes of this description, however, I follow Bigelow and Schroeder (1948) with some exceptions and make only those amendments required by the addition of the new species.

The family Triakidae and the genus *Triakis* as provisionally redefined here includes species with functional gill-rakers as well as species without them, and also includes species with as many as 7 cusps on lower jaw teeth toward the angles of the jaws. The gill-rakers of the new species are not homologous with denticle-derived structures in *Cetorhinus* and *Rhincodon* that Bigelow and Schroeder evidently had in mind as typical shark gill-rakers, but externally resemble those found in some squaloid species (see Daniel, 1934, p. 154, fig. 147). In the new species the structures are skin-covered, springy projections extending and interdigitating across the inner branchial apertures from both sides of the branchial bars. They are short but presumably serve to make the branchial basket more effective as a strainer of small food particles. Structures of this kind are present but developed to varying degrees in several small triakid and scyliorhinid species; in *Triakis barbouri* (Triakidae) and in *Halaelurus canescens* (Scyliorhinidae), for example, they are nearly as strong as in the new species, whereas, in *Cephalurus* (Scyliorhinidae) they appear as mere mounds of tissue or as short villi. These structures are absent from the various species of *Mustelus* and from *T. scyllia*, *T. semifasciata*, and *T. maculata*. Teeth toward the angles of the lower jaw of the new species have seven or more cusps, a condition that it shares with *T. attenuata*.

The new species is named in recognition of the important contributions of Dr. H. Adair Fehlmann in setting high standards for field treatment of shark specimens collected for study.

Triakis fehlmanni new species
(Figs. 1, 2, 3, 4, and 5C)

Holotype: A 46-cm sexually mature female, U.S.N.M. 202969, collected on I.I.O.E. cruise 9 of the R/V *Anton Bruun* at station 463, 17 December 1964, in a trawl dragged at a depth from 70 to 170 m at 11° 24′ North Latitude, 51° 35′ East Longitude, southwest of Cape Guardafui, Somalia.

Material examined: the holotype is the only specimen of the species known. It was compared with examples of *Triakis scyllia* Müller and Henle, 1841; *T. semifasciata* Girard, 1854; *T. maculata* Kner and Steindachner, 1867; *T. barbouri* Bigelow and Schroeder, 1943; *T. (Neotriakis) sinuans* J. L. B. Smith, 1957; *T. (Eridacnis) radcliffei* H. M. Smith, 1913; *T. venusta* (= *Calliscyllium venustum* Tanaka 1912, probably also = *Proscyllium habereri* Hilgendorf, 1904); *T. henlei* Gill, 1862; and several species of *Mustelus*. I did not see specimens of *T. attenuata* Garrick, 1954 or *T. acutipinna* Kato, 1968, but both were given thorough and modern descriptions and present no difficulty in diagnosis. Specimens of *Hemitriakis leucoperiptera* Herre, 1923, were not available for comparison. I agree, however, with L. J. V. Compagno (in correspondence) that it cannot be placed in *Triakis*.

Diagnosis: The distinctive color pattern of this species sets it apart from all other sharks. It is also unique among galeoid sharks in having

FIG. 1. *Triakis fehlmanni*, new species, 46-cm female holotype. Drawing by Mary H. Wagner.

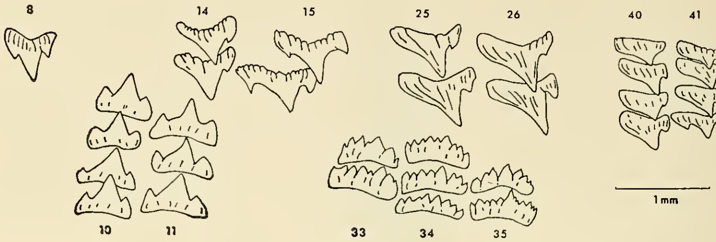

FIG. 2. Camera lucida outlines of teeth of *Triakis fehlmanni* new species. Upper row, teeth from upper left jaw (numbers below tooth groups indicate number of tooth row counting from symphysis). Lower row, teeth from lower left jaw.

large inner and outer nasal flaps that are irregularly scalloped along their posterior margins.

T. fehlmanni resembles *T. scyllia, T. semifasciata, T. maculata,* and *T. acutipinnis* in general body form, fin position, and fin shape as viewed laterally, although the lower caudal lobe is not produced to the extent that it is in adults of some of these species. It differs from them in that it has a wider and more flattened head, a wider mouth with smaller and more numerous teeth, very short labial furrows, short but functional interdigitating gill-rakers, and a comparatively shallow subocular gutter fully lined with denticles instead of a deep and incompletely denticle-lined subocular pouch.

The similarity of the new species to the various species of *Mustelus* in body form, and in fin shape and position is also striking. Furthermore, the large number of tooth rows in *T. fehlmanni* and their pattern of tooth arrangement in quincunx with more functional rows near the symphysis of the lower jaw are similar to that in species of *Mustelus*. *T. fehlmanni* differs from species of *Mustelus* in that it has multicuspid and sharp-pointed teeth, a wider head and mouth, shorter labial furrows, and functional interdigitating gill-rakers.

The gill-rakers of *T. fehlmanni* have slender, pointed tips but arise from wide bases, those of the anterior rim of one gill arch alternating in position with those of the posterior rim of the adjacent gill arch. Furthermore, they are as large and numerous around the anterior gill apertures as around the posterior ones and are also present around the spiracular pocket. In contrast, the gill-rakers of squaloid sharks, although proportionally higher, arise from slender bases chiefly on the posterior rims of gill arches and, if present, are usually larger on the posterior arches or are confined to posterior arches as in some species of *Centrophorus*. No observations were made on the comparative histology of the gill-rakers of galeoid and squaloid sharks.

Triakis barbouri, T. sinuans, T. radcliffei and *T. venusta* have the

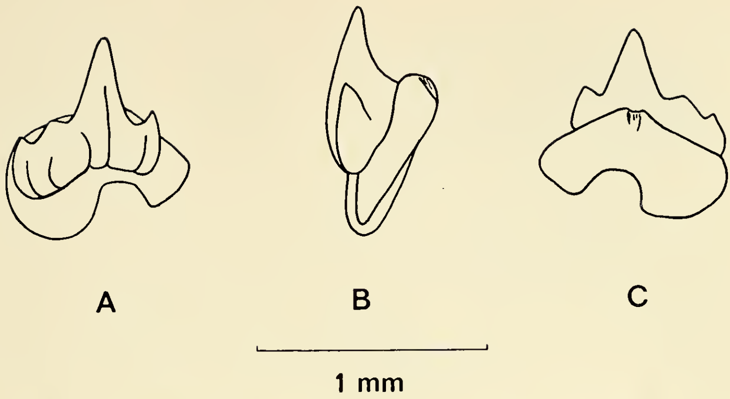

FIG. 3. Camera lucida outlines of 10th upper jaw tooth counting from symphysis. A—anterior face. B—lateral aspect. C—posterior aspect.

anal fin slightly in advance or nearly under the origin of the second dorsal fin, whereas in *T. fehlmanni* the anal origin is appreciably posterior to the origin of the second dorsal.

Triakis fehlmanni may be distinguished easily by its color and comparatively short body, from the plain-colored and elongate *T. attenuata*. *T. fehlmanni* and *T. attenuata* are similar in that both have broad, flattened heads, wide mouths with short labial furrows, and numerous small teeth of somewhat similar shape arranged in similar patterns. In both species the origin of the anal fin is posterior to the origin of the second dorsal.

Description: Proportional dimensions of holotype are in percentages of total length except as indicated. Measurements were made as outlined in Bigelow and Schroeder (1948).

Tip of snout to: front of mouth, 6.5; eye, 5.9; spiracle, 11.5; first gill opening, 18.3; fifth gill opening, 22.8; origin pectoral, 22.0; origin first dorsal, 33.7; origin pelvics, 43.0; origin second dorsal, 58.9; origin anal, 61.7; origin upper caudal lobe 76.5; anterior end cloacal opening, 45.9.

Greatest width of: head, 13.7; trunk at pectorals, 10.0; trunk at pelvics, 6.3; trunk at origin caudal 2.0.

Greatest height of: head at spiracles, 7.2; trunk at pectorals, 10.0; trunk at pelvics, 8.3; trunk at origin caudal 3.0.

Eyes: horizontal diameter, 4.3; vertical diameter 1.7; distance between supraorbital rims, 3.9.

Spiracles: greatest diameter, 0.9; least distance from eye, 1.2; distance between, 9.1.

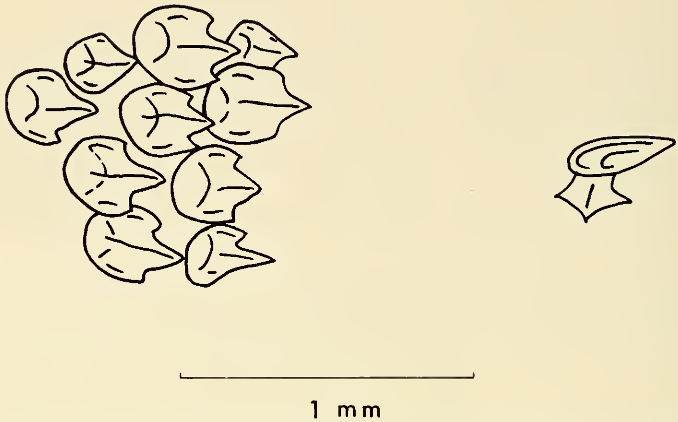

Fig. 4. Camera lucida outlines of dermal denticles from shoulder area of *Triakis fehlmanni* new species.

Mouth: width, 9.3; length, 3.9; length upper labial furrow, 0.2; length lower labial furrow, 1.1.

Nasal apertures: level of anterior ends to tip of snout, 3.7; level of posterior ends to front of mouth, 0.7; minimum distance between, 3.5; greatest length (diagonal), 3.3.

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

First dorsal fin: length base, 8.3; length posterior tip, 3.5; height, 7.2; length anterior margin, 9.8.

Second dorsal fin: length base, 9.3; length posterior tip, 2.8; height, 6.3; length anterior margin, 11.7.

Anal fin: length base, 7.0; length posterior tip, 2.6; height, 3.0; length anterior margin, 7.0.

Pectoral fins: width base, 5.0; length anterior margin, 13.9; greatest width, 10.4.

Pelvic fins: length (origin to rear tip), 9.8.

Caudal fin: upper margin, 23.0; anterior margin lower lobe, 8.9; tip to notch, 5.9.

Distance between fin bases: first to second dorsal, 17.8; pectoral to pelvic, 19.0; pelvic to anal, 11.7; anal to lower caudal, 6.5; second dorsal to upper caudal, 8.3.

Posterior tips of fins to fin origins: pectorals (appressed) to pelvics, 7.0; pelvics to anal, 8.3; anal to lower caudal, 4.1; second dorsal to upper caudal 5.4.

Teeth: upper, 86 rows; lower, 88 rows; width base, widest upper, 0.9 mm.; height, highest upper, 0.5 mm.; width, widest lower, 0.8 mm.; height, highest lower, 0.5 mm.

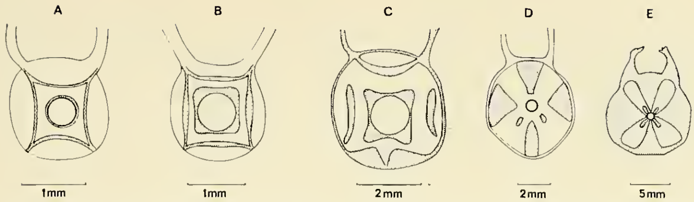

FIG. 5. Camera lucida outlines made from radiographs through the longitudinal axis of a single trunk vertebra to show calcification pattern. A—from *Eridacnis radcliffei,* a 25-cm female. B—from *Triakis barbouri,* a 29-cm female. C—from *T. fehlmanni* new species, type, a 46-cm female. D—from *T. semifasciata,* a 59-cm female. E—from *Mustelus canis,* an adult female about 150 cm (stippled and dark areas indicate calcification).

Vertebrae: total number, 137; number "monospondylous," 39; number precaudal, 90; number caudal, 47; A-value (see Springer and Garrick, 1964, p. 79), 128; B-value, 111; greatest diameter, 4.2 mm.

Gill-rakers: height of largest, 1.2 mm.; 6 or 7 on each side of ventral arms and 2 or 3 on each side of dorsal arms of gill bars 2, 3, and 4.

A small species; 46-cm holotype is sexually mature; head long, very wide, depressed; five gill slits, 4th over pectoral origin; abdominal body segment short, approximately circular in cross-section at pectoral level, trunk tapering toward tail, somewhat compressed posteriorly; no precaudal pits or keels; caudal axis slightly but definitely elevated; no nasal barbels or thickened areas on nasal flaps; nostrils not connected with mouth by groove; length caudal more than 2 times length first dorsal base; first dorsal base entirely in advance of origin pelvics.

Snout broadly rounded, slightly narrowed at nostrils, its length from front mouth about 0.7 times width mouth; large nasal apertures in posterior half snout, separated by about 0.5 times snout length; outer and inner nasal flaps large, their posterior borders in apposition and irregularly crenulate; pores of underside of snout moderately prominent, forming Y-shaped pattern in single row with base near front of mouth.

Eyes large, about 2 times as long as high, their lengths about half length of snout, situated well above rim of head, angle of view as much dorsal as lateral, with a strong but shallow and fully denticle-lined gutter below eye extending from anterior end of eye nearly to spiracle; supraocular crest present, not extended over orbit as a shelf; interorbital distance only about 55 percent of interocular distance; spiracle moderately large, its height about half height of eye, located immediately posterior to eye and separated from eye by a distance a little more than greatest diameter of spiracle.

Mouth very wide, its width more than 2 times its length, about equal to length of second dorsal base; lower jaw sharply arched at symphysis; labial furrows very short, length of lower labial furrow slightly less than greatest diameter of spiracle and about 5 times length of upper; inside of mouth light colored with one anterior row and 2 medial rows of low papillae; no oral denticles; branchial basket large, a series of springy, papilla-like gill rakers on both sides of each branchial bar interdigitating across internal branchial apertures; 6 or 7 gill rakers, some scarcely more than mounds of tissue, along each side of ventral section of complete gill bars, 3 along each side of each dorsal section, smaller numbers around spiracular pocket; branchial bars and internal surface of pharynx without denticles.

Teeth small, numerous (83/86 rows); those of central part of both jaws tricuspid, generally symmetrical, middle cusp much the longest, slender, erect, pointed; lateral cusps short, most teeth wider than high; series continuous across symphyses without marked change in tooth shape or size; anterior faces of central teeth of both jaws with a series of striations running from roots into enamel surfaces; the striations of upper laterals reaching nearly to tips, those of lower teeth short; central teeth of both jaws with posterior flange-like extension of roots (Fig. 3) surrounding nutrient canal. Upper teeth in 4 to 5 functional series; teeth tricuspid and nearly symmetrical in middle of jaw, generally lacking an accessory cusp on side toward symphysis and main cusp oblique from about 20th row (counting from symphysis) to jaw corners. Lower jaw teeth in 5 to 7 functional series; functional area broader at symphysis forming pavement-like occlusion surface of tricuspid symetrical teeth; teeth transitional at about 20th row to 5 to 7 or more cusped teeth, comb-like, cusps subequal, main cusp only slightly larger and higher than others and located asymmetrically as the 5th, 6th, or 7th cusp toward the jaw-corner side of each tooth.

Dermal denticles (Fig. 4) of shoulder area small, less than 0.5 mm, only a little longer than broad; closely imbricate with 3 posteriorly-directed short points, middle point longest; points little elevated, a moderately strong central ridge with a weaker ridge on each side; external surfaces uniformly covered, variation in denticle size and shape similar to that in lower galeoids—that is, ventral denticles generally without accessory points, ridges obsolete; denticle points somewhat longer toward tail; denticles of leading edges of fins and around apertures smaller, smoother, and rounder than on flanks. No caudal crest; skin relatively smooth to touch except when rubbed toward the head; color pattern produced by skin chromatophores; denticles uniformly semitransparent.

Pectorals broad, tips and inner corner broadly rounded, distal margins straight, distance from tips of appressed pectorals to origin pelvics about 1.5 times horizontal diameter of eye. Pelvics relatively small, their outer contours broadly rounded, posterior tips rounded and not attenuate; no apron connecting fins; origins slightly anterior to tip of first dorsal but posterior to end of first dorsal base. First dorsal origin about over free inner angle of pectorals, apex rounded, posterior point sharp but short; slightly higher but about equal to second dorsal in area. Distance between dorsal bases slightly less than distance from pectoral axilla to pelvic origin. A depression or trench in the skin extending between dorsal bases and continuing from second dorsal base to caudal origin. Shape of second dorsal similar to that of first but slightly lower, its base slightly longer; distance from its tip to origin upper caudal about 1.5 times horizontal diameter of eye; end of its base about over end of anal base; tip extending only slightly beyond anal tip. Anal about 0.5 times as high as dorsals, its base shorter, its origin posterior to second dorsal origin by distance about equal to vertical diameter of eye. Caudal slightly less than 0.25 times total length, strongly notched below near caudal tip; its lower anterior section not projecting as a definite lobe.

Vertebral column comparatively slender; greatest diameter of monospondylous vertebrae about 4.2 mm (about 6.7 mm in *T. semifasciata* of equal total length); transition from monospondyly to diplospondyly in pelvic region clearly marked, alternation of length of vertebrae not apparent. Pattern of vertebral calcification (see Fig. 5) intermediate in complexity between that of *Triakis barbouri* and *T. semifasciata*.

Visceral cavity short, its lining not pigmented; liver size moderate, 2 liver lobes well separated posteriorly, extending about 0.75 of distance to cloaca; intestinal valve a spiral with about 10 turns; one ovary and 2 oviducts functional; nidamental glands small as compared to those of most scyliorhinids such as *Galeus* of about equal total length. Holotype has, in each oviduct, one very thin-walled, transparent, 45-mm by 17 mm egg-case enclosing an amorphous mass of egg-yolk material (no embryos detected); single ovary appears to have much amorphous yolk material except for several spherical yolk masses about 7 mm in diameter. It is not clear from the condition of the specimen whether reproduction is oviparous or ovoviviparous.

The holotype observed a few months after formalin preservation was marked by a series of rich brown dorsal saddles interspersed by smaller brown markings of bars and round or ovoid spots of varying size on a ground color of light tan. Ventral surfaces were yellowish white with some indistinct spots on the lower sides of the pectorals and caudal trunk. Color changes after transfer to alcohol were not great.

Comments on natural history and relationships.

The stomach of the holotype contained only the partially digested cephalothorax of one unidentified crustacean. The upper portion of the valvular intestine contained some granular material (about 1 mm diameter), possibly incompletely digested invertebrate shells.

The combination of large mouth, small teeth, and a large branchial chamber with interdigitating gill-rakers suggests that this shark feeds on very small invertebrates. The presence or absence of gill-rakers has rarely been noted in descriptions of sharks except for the kinds of denticle-derived gill-rakers in the huge plankton-feeding whale sharks and basking sharks. To see gill-rakers in most sharks it is necessary to open the branchial chamber. This dissection is best accomplished by cutting preserved and well-hardened specimens through the angle of the jaws and gill arches on the right side back to the pelvic girdle. I recommend this procedure as standard, at least in first laboratory examination of a shark species. Even with unique specimens such as the type of *T. fehlmanni* no great harm is done and access is provided for the search for additional identification characters sorely needed by the shark taxonomist. A cut on the right side of the shark leaves intact the left side preferred by illustrators.

T. fehlmanni resembles various species of scyliorhinids in its basic color pattern, tooth shape, heterodonty, slender vertebral column, clear and abrupt transition from monospondyly to diplospondyly, prominent pore system on the ventral side of the snout, and degree of development of a subocular gutter, as well as in its size at maturity and in its scarcity from tropical continental shelf collections. All of these characters as represented in *T. fehlmanni* point up the difficulty in the separation of the families Scyliorhinidae and Triakidae. My own separation of the two families is arbitrary. In the Triakidae the first dorsal fin base is entirely in advance of the pelvic fins, whereas, in the Scyliorhinidae the first or in one species the only dorsal fin, has some part of its base over or posterior to the pelvic origin.

Tanaka (1915) reported that *Triakis venusta* (= *Calliscyllium venustum*; probably also = *Proscyllium habereri*) is oviparous and consequently should be placed in the Scyliorhinidae instead of in the Triakidae where it has been left by most authors. He evidently regarded the character of egg laying as of overriding importance. Cadenat (1959) reported, however, that of the two morphologically very similar species, *Galeus melastomus* and *G. polli*, one lays eggs and the other (*G. polli*) produces living young. By the arbitrary definition I have used, both *T. venusta* and *T. fehlmanni* definitely fall in the Triakidae as can easily be determined by external examination.

Several graded series of structural differences may be identified from the small, usually slope-dwelling and demersal scyliorhinids though the usually medium-size triakids that usually live in waters of the continental shelf to the generally large shallow-water or surface-dwelling carcharhinids. Among the differences are gradations from small to large size; increase in the amount of calcification and strength of the vertebral column; a shift from small multi-cusped teeth toward unicuspid teeth, blade-like in the upper jaw; a development of the nictitating lower eyelid through a series of stages accompanying loss of the spiracle; a change from egg-laying to the development of large young nourished in later stages of embryonic life by a pseudoplacenta;

a loss in the relative volume and perhaps also in complexity of the Ampullae of Lorenzini; and an increase in the length of the clasper-siphons accompanying a moderate lengthening of the claspers, a loss of clasper hooks or reduction of clasper spines; and a change in fin positions and shapes. Also, accompanying an adaptive radiation from the kind of demersal life that characterizes the scyliorhinids to the kind of life of the surface-dwelling carcharhinids, are improvements in locomotion through changes in fin shape and position and through the increased buoyancy provided by a relatively larger amount of liver oil.

Existing galeoid sharks provide a fine example of an evolutionary series from which general trends can be demonstrated. Unforunately, but as might be expected, the course of evolution of galeoids seems to have proceeded with shifts in direction and rate for different organ systems. The existing galeoids do not lend themselves to separation neatly into families either by groups of characters or by marked discontinuities in the degree of specialization of one particular character. Attempts to produce a phylogenetic classification through emphasis of one character over another breaks down as more species and specimens from the outer continental shelf and upper continental slopes become available. The vertebral calcification pattern as used by White (1937), for example, may be a better indicator of size at maturity or depth of habitat than of phylogeny.

T. fehlmanni has many characteristics in common with scyliorhinid species, perhaps more than with triakid species. My use of the position of the first dorsal fin as the primary character for the separation of members of the families Triakidae and the Scyliorhinidae has the practical advantage that fin position is easily determined on any specimen and that, among presently known species, variational overlaps are not known. So long as it is understood that galeoid families are grouped for convenience in discussion and are not separated by conspicuous gaps in character continuity no harm is done.

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