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A SYNOPSIS OF THE HAMMERHEAD SHARKS (*SPHYRNA*), WITH DESCRIPTION OF A NEW SPECIES.

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(Figures 1–3.)

While working upon material obtained recently in the Gulf of Aden I found it necessary to examine the collection of Hammerhead Sharks in the British Museum (Nat. Hist.). The results of this study were somewhat surprising and have necessitated the publication of this paper.

During my work in the field I distinguished three species which I named *Sphyrna zygaena*, *S. mokarran* and *S. tudes*, in accordance with the previously accepted definitions of these forms, but it now appears that not one of these names was correctly applied. The position can best be made clear by discussing briefly each of these in turn.

(*a*) *Sphyrna zygaena*.—It has been shown by Springer that under this name two quite different species have been confused, and he has proposed the name *S. diplana* for the one having a median indentation in the snout, short narial grooves, and other characters. More recently Bigelow and Schroeder, in their fine monograph of the Sharks of the western North Atlantic, have presented a large amount of data upon both species which leaves no doubt as to their distinctness and makes comparative work simple.

The bulk of the material labelled "*S. zygaena*" in our collection proved to agree with the description of "*S. diplana*" and so far from being simply an Atlantic species, as the American authors seem to have supposed, it appears to be circumtropical. We have specimens from Panama, West Indies, Rio Grande, Mediterranean, West Africa, Nigeria, Zanzibar, Seychelles, Aden, Canara, Moluccas, Japan, Formosa, China and Honolulu, none of which differs in any important respect from those described by Bigelow and Schroeder.

In one way this is very unfortunate, because the species occurs off Australia, whence it was described in 1822 by Griffith as *Zygaena lewini*. The original description is almost worthless, but the illustration leaves no doubt that it represents the shark later described and figured more accurately by Whitley. Comparison of the latter with our material and the American descriptions reveals no essential difference between the two forms.

When describing his *S. diplana*, Springer applied the name *S. lewini* to a specimen taken off California in order to show differences between the two. It must be pointed out, however, that some of the minute differences noted may well be due to error. For example, in his best description of the species Whitley (1934) makes no mention of serrated teeth, and in fact shows them in his illustration as entire. His remark in a later work that "the teeth which are entire in the young become finely denticulated" is evidently based on observation of larger specimens for the identity of which we have no evidence. In fact, the photograph which accompanies his comments shows what appears to be a large *S. tudes*, in which the teeth would be serrated. His statement is accompanied also by remarks concerning the alleged lengthening of the narial grooves with age, and proportional differences, which further suggest confusion with other species.

The Californian specimen discussed by Springer had "heavy, serrated teeth" and lacked a median fenestra in the rostral cartilage. This, in my view, rules out the possibility that it could have been *S. lewini*, for all our specimens have smooth-edged teeth and the rostral fenestra is discernible by holding the specimens to the light. Incidentally, as far as our material shows, only those species in which the snout has no median emargination lack the fenestra (*S. tiburo*, *zygaena* and *media*).

Whatever the Californian specimen may have been, therefore, it seems necessary to regard *S. diplana* as a synonym of *S. lewini*.

Of the true *S. zygaena* all our material is from the Atlantic, except for one specimen from Japan, and it is very likely that it does not occur in the Indian Ocean.

(*b*) *Sphyrna mokarran*.—It would seem that no separate species to which the name *S. mokarran* is applicable can be recognized. Reference to the original description and figure and subsequent literature, together with my notes and sketches made in the Gulf of Aden, lead me to the conclusion that *S. mokarran* should be considered a synonym of *S. tudes* as defined by Bigelow and Schroeder. In the Gulf of Aden, as in the Atlantic, this grows larger than the other species and is well named the Great Hammerhead.

(*c*) *Sphyrna tudes*.—The specimens which I noted under this name in the field, and some of the material labelled thus in the British Museum, prove to be very different from *S. tudes* as recognized above. Among the specimens originally described by Valenciennes were two from the Atlantic and one from Coromandel; it is clear that the latter (the head of which he figured) represented the species now under consideration, which cannot bear the name *tudes* because this has been taken, by common agreement, to apply to the Atlantic specimens. It appears, therefore, that Valenciennes' Coromandel example, some of our Old World material and a number of records in the literature should be associated with *S. oceanica* Garman.

To sum up this discussion:

(*a*) *Sphyrna diplana* Springer, 1940 = *S. lewini* (Griffith, 1834).

(*b*) *Sphyrna mokarran* (Rüppell, 1835) = *S. tudes* (Valenciennes, 1822, *part*).

(*c*) *Sphyrna tudes* (Valenciennes, 1822, *part*) = *S. oceanica* (Garman, 1913).

One more point needs to be elucidated before giving a synopsis of the whole genus. The specimen described by Fowler, 1941, from Richmond River, New South Wales, as *S. lewini* certainly is not that species. Springer seems to have thought it to be *S. mokarran*, which is considered here to be a synonym of *S. tudes*, but although it is admittedly closely related it seems to be a different species. This opinion I base partly on Fowler's description and figure (which unfortunately are not in complete agreement), but more especially on a specimen in our collection from Clarence River, New South Wales, which can be identified with reasonable certainty with Fowler's example. This species requires a new name and is now described.

Sphyrna ligo, sp. nov. (Figure 1.)

Head moderately expanded laterally, the posterior margin of the expansion much shorter than the width behind the nostril. Length of snout contained three and one-eighth times in greatest width of head. Front margin of snout doubly convex, a distinct median indentation; no distinct notch before nostril. Hind edge of lateral expansion of head roughly parallel with front edge, the outer angles posterior to corners of mouth. Outer narial groove scarcely developed, inner groove not at all. Eye moderate, its diameter equal to its distance from nostril. Length of head, measured to upper end of last gill-opening, contained three times in length of shark measured to caudal pit. Pectoral fin commencing a little anterior to fourth gill-slit, the length of its base four and a quarter in length of head, its front margin more than twice as long as its base, four times as long as its hind margin, one and three-quarter times as long as its distal margin, which is concave.

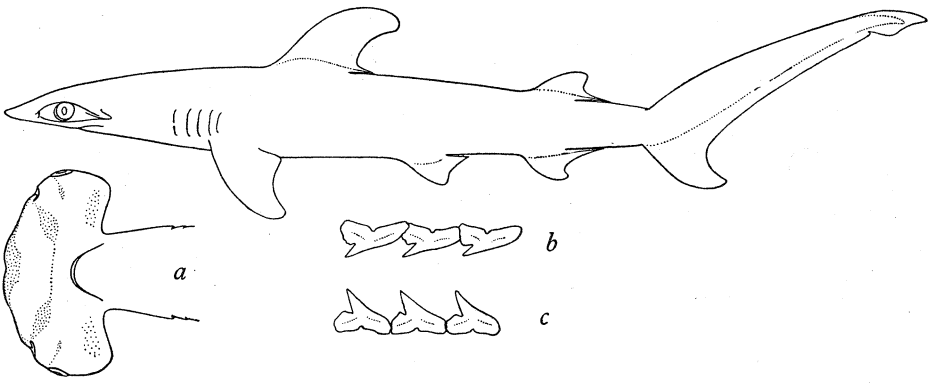

Figure 1. *Sphyrna ligo*, sp. nov. Holotype. *a*, ventral view of head; *b*, upper, and *c*, lower teeth.

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First dorsal fin commencing well behind axil of pectoral, but not as far back as hind angle. Base of dorsal fin contained three and a quarter times in length of head, one and a third times as long as pectoral base; front margin of fin curved, about one and a quarter times as long as that of the pectoral, its tip broadly rounded, its distal margin deeply concave, forming pointed hind lobe with hind margin, which is one-third length of base of the fin. Distance from axil of pectoral to axil of pelvic somewhat less than distance from tip of snout to origin of pectoral. Base of pelvic about equal to that of pectoral, shorter than its front margin and twice as long as its hind margin; distal margin slightly concave. Distance from axil of pelvic to origin of anal twice length of anal fin, which is a little shorter than that of the pectoral. Front margin of anal fin a little longer, hind margin a little shorter, than the base; distal margin concave; posterior pointed lobe reaching half-way from base of fin to caudal pit. Base of second dorsal fin a little longer than that of anal, commencing somewhat farther back; its front margin much longer than its hind margin; distal margin deeply concave; posterior pointed lobe reaching half-way from base of fin to caudal pit.

Caudal fin (measured from caudal pit to tip) equal to distance from tip of snout to posterior angle of pectoral, or two and a third times in length of body; lower lobe shorter than pectoral.

Teeth at sides of both jaws oblique, outer edges forming deep notch; lower cusps somewhat larger and more erect; four or five smaller erect teeth in middle of each jaw.

Underside of head with mucous pores arranged in patches as shown in the figure.

Described from the holotype, a specimen 325 mm. from tip of snout to caudal pit, from Clarence River, New South Wales.

Closely related to *S. tudes*, from which it differs in having the eyes somewhat farther from the nostrils, the mouth farther forward, first dorsal fin more posterior, and the relationship of the second dorsal and anal different.

The head is reminiscent of a Dutch hoe rather than a hammer, hence the name (Lat. *ligo*, a hoe).

The Sphyrnidae seem to differ from the Carcharhinidae mainly in the lateral expansion of the head, and the evolution of this curious development is illustrated quite well among the known species, as will be seen by reference to Figure 2 and the key.

The least aberrant form is *S. tiburo*, having the head comparatively little expanded, the snout evenly rounded and no extended narial grooves; related to this is *S. media*, in which the head is much wider. From this point we must recognize a divergence. On one hand is *S. zygaena*, in which the head is more greatly expanded, with a consequent drawing out of the narial apparatus, as it were. On the inner side

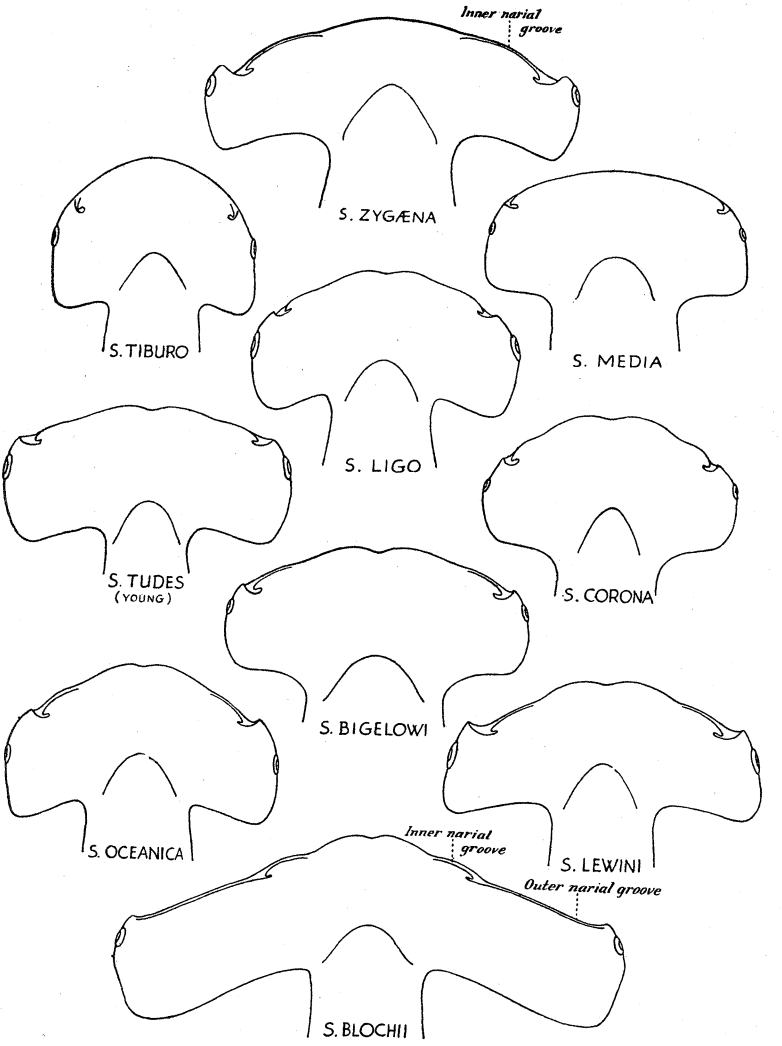

Figure 2. Lower view of heads of Hammerhead Sharks. Where narial grooves are present they are shown, for clarity, a little more ventral than they actually are.

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of the nostril, extending towards the middle of the snout, is the "inner narial groove", longer in this than in any other species. On the outer side a slight extension of the nasal opening shows the beginning of an "outer narial groove". But in this form the profile of the snout retains its original rounded form.

Along another line from *S. tiburo* we find a more gradual widening of the head, at first without extended inner grooves (*S. ligo, tudes, corona*), then with the grooves distinct (*bigelowi, oceanica, lewini*), and in all these there is a distinct emargination in the middle of the profile of the snout.

In *S. lewini* there is the beginning of an external narial groove, and from this form we can derive, by a rather sudden jump, the extraordinary *S. blochii*, in which the lateral expansion carries the eye far from the nostril, with a consequent extension of the outer narial groove that is far greater than that of the inner one. It will be

obvious by a comparison of the figures given that without the extension of the outer narial region the head of *S. blochii* would be almost exactly like that of *lewini*; the two also resemble each other in the proportions of the fins, and especially in the second dorsal point reaching farther back than in the rest.

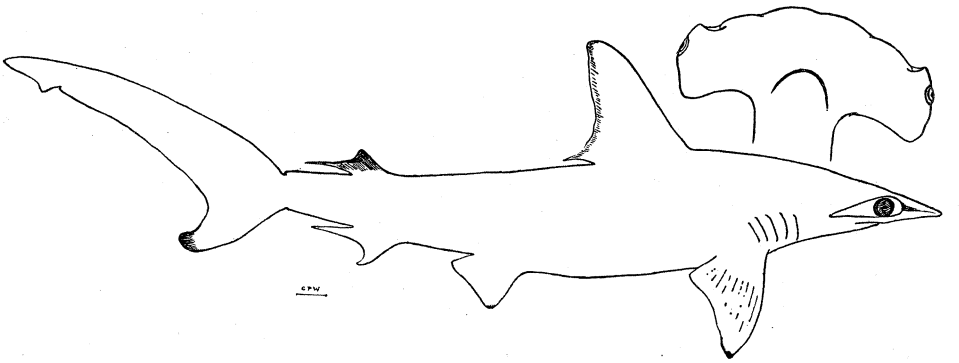

Figure 3. *Sphyrna lewini* (Griffith). Immature female, 55 cm. from snout to caudal pit, from Menapi, Goodenough Bay, Papua.

G. P. Whitley del.

If subgenera are to be recognized in this group, they can best express the relationship if applied to *S. zygaena* (*Sphyrna*), to the *tiburo-media* group (*Reniceps*), to the *ligo-lewini* complex (*Platysqualus*), and to *S. blochii* (*Eusphyra*).

Key to the Species of Sphyrna.

I. Outer narial grooves not extensive; eye not more than twice its diameter from the nostril.
  A. Inner narial groove extending more than half-way to middle of snout (total narial length contained one and a half times or less in internarial width). Front of snout, viewed from above, convex, without median indentation; no median fenestra in rostral cartilage. Base of anal fin much shorter than that of pectoral, about equal to base of second dorsal (*Sphyrna* Rafinesque, 1810).
    Anterior edge of second dorsal shorter than its posterior pointed lobe, which reaches half-way from base of fin to caudal pit. First dorsal and pectoral fins subequal ..... 1. *zygaena.*
  B. Inner narial grooves, when present, extending less than half-way to middle of snout (total narial length contained twice or more in internarial space). Base of anal fin at least as long as that of pectoral.
    1. Inward extension of narial groove inconspicuous or absent.
      a. Front margin of snout convex, without median indentation; rostral cartilage without median fenestra. Origin of first dorsal fin above hind angle of pectoral. First dorsal and pectoral fins subequal. Base of second dorsal much shorter than that of anal (*Reniceps* Gill, 1862).
        i. Head shovel-shaped, the length of snout contained much less than three times in greatest width of head. Hind angles of lateral expansion of head posterior to corners of mouth. Anterior edge of second dorsal longer than hind lobe, which reaches two-thirds distance from base of fin to caudal pit .... 2. *tiburo.*
        ii. Head broader, length of snout contained three times or more in width of head. Front and hind margins of lateral expansions of head converging, the hind angles anterior to corners of mouth. Anterior edge of second dorsal fin about as long as the hind lobe ..... 3. *media.*
      b. Front margin of snout double-convex, a distinct median indentation; rostral cartilage with median fenestra.* First dorsal fin much larger than pectoral, its origin anterior to hind angle of pectoral (*Platysqualus* Swainson, 1839).
        i. Hind angle of lateral expansion of head posterior to corners of mouth. Eye distant from nostril by at least its own diameter. First dorsal fin commencing well behind axil of pectoral. Base of second dorsal a little longer than that of anal, but somewhat behind it. Base of anal a little shorter than that of pectoral. Pointed hind lobe of second dorsal reaching half-way from base of fin to caudal pit ..... 4. *ligo.*

* Not verified in *S. corona.*

ii. Hind angle of lateral expansion of head anterior to corners of mouth.

a. Front and hind margins of lateral expansions of head roughly parallel. Eye distant from nostril by less than its own diameter. First dorsal fin commencing above axil of pectoral. Base of second dorsal a little shorter than that of anal, ending above it. Base of anal somewhat longer than that of pectoral ..... 5. *tudes.*

β. Front and hind margins of lateral expansions of head converging, head roughly oval. Eye distant from nostril by more than its own diameter. Base of second dorsal less than half length of that of anal. Base of anal twice length of that of pectoral ..... 6. *corona.*

2. Inward extension of narial groove distinct, deep, extending less than half-way to middle of snout. Front profile of snout double-convex, a distinct median indentation present.

a. Front and hind margins of lateral expansions of head converging, the hind angles far in advance of corners of mouth. Eye small, distant from nostril by about its own diameter. First dorsal originating somewhat behind axil of pectoral; these fins subequal. Base of second dorsal fin half (or less) length of that of anal, ending above it. Base of anal fin much longer than that of pectoral. Anterior edge of second dorsal as long as, or longer than, hind lobe, the point of which reaches two-thirds of the way from fin base to caudal pit ..... 7. *bigelowi.*

b. Front and hind margins of lateral expansions of head roughly parallel, the hind angles posterior to corners of mouth. First dorsal fin much larger than pectoral. Base of second dorsal fin much shorter than that of anal, which equals pectoral base.

i. Eye small, distant from nostril by twice its diameter or more. Length of snout contained three times in greatest width of head. First dorsal origin above axil of pectoral. Front edge of second dorsal shorter than the posterior lobe, the point of which reaches two-thirds of the distance from fin base to caudal pit ..... 8. *oceanica.*

ii. Eye larger, distant from nostril by its own diameter or less. Length of snout contained about four times in width of head. First dorsal origin somewhat behind axil of pectoral. Front edge of second dorsal fin shorter than hind lobe, the point of which reaches nearly to caudal pit ..... 9. *lewini.*

II. Outer narial grooves greatly extended along much produced lateral expansions of head, the eye distant from the nostril by many times its diameter (*Eusphyra* Gill, 1862). Head otherwise much like that of *S. lewini.* First dorsal fin much larger than pectoral, its origin somewhat behind axil of pectoral. Base of second dorsal much shorter than that of anal, ending behind it; front margin of fin about equal to hind lobe, point of which reaches nearly to caudal pit. Base of anal equal to that of pectoral ..... 10. *blochii.*

The species thus defined are listed below, with such references to literature as will help to clarify their status; but it has not proved possible for me to determine the true identity of many of the Old World records, a task which must be left for a later occasion.

1. *Sphyrna zygaena* (Linnaeus, 1758).

For synonymy and references see Bigelow and Schroeder, 1948, Mem. Sears Found. Mar. Res. no. 1, pt. 1, p. 436, fig. 85.

Hab.—Coasts of Atlantic Ocean; Mediterranean; eastern Pacific Ocean; Japan.

2. *Sphyrna tiburo* (Linnaeus, 1758).

For synonymy and references see Bigelow and Schroeder, 1948, *loc. cit.*

Hab.—Coasts of Atlantic Ocean; eastern Pacific Ocean.

3. *Sphyrna media* Springer, 1940.

Sphyrna media Springer, 1940, Stanford Ichth. Bull. i, no. 5, p. 162, fig. 3.

Hab.—Pacific coast of Mexico and Panama.

4. *Sphyrna ligo*, sp. nov. (p. 214).

Sphyrna lewini Fowler, 1941, Bull. U.S. Nat. Mus., 100, xiii, p. 215, fig. 9 (not of Griffith).

Hab.—New South Wales.

5. *Sphyrna tudes* (Valenciennes, 1822).

Zygaena tudes Valenciennes, 1822, Mem. Mus. Hist. nat. Paris, p. 225 (*part.*).
Zygaena mokarran Rüppell, 1835, Neue Wirbelth. Fische, p. 66, pl. xvii, fig. 3.
Zygaena dissimilis Murray, 1887, Journ. Bomb. Soc., ii, p. 103 and pl.
Sphyrna mokarran Fowler, 1941, Bull. U.S. Nat. Mus., 100, xiii, p. 214 (Indo-Pacific references).
Sphyrna tudes Fowler, 1941, *loc. cit.*, p. 213 (Indo-Pacific references); Bigelow and Schroeder, 1948, Mem. Sears Found. Mar. Res., no. 1, pt. 1, p. 428, figs. 83–84.
Hab.—Circumtropical.

6. *Sphyrna corona* Springer, 1940.

Sphyrna corona Springer, 1940, Stanford Ichth. Bull., i, no. 5, p. 163, fig. 4.
Hab.—Panama.

7. *Sphyrna bigelowi* Springer, 1944.

Sphyrna bigelowi Springer, 1944, J. Wash. Acad. Sci., xxxiv, p. 274, ill.; Bigelow and Schroeder, 1948, Mem. Sears Found. Mar. Res., 1, pt. 1, p. 410, figs. 79–80.
Hab.—Atlantic coasts of South America (specimens from British Guiana in Brit. Mus.).

8. *Sphyrna oceanica* Garman, 1913.

Zygaena tudes Valenciennes 1822, Mem. Mus. Hist. nat. Paris, p. 225 (*part.*), pl. 12, fig. 1; Günther, 1870, Cat. Fish. Brit. Mus., viii, p. 382 (*part.*); Day, 1878, Fishes of India, pt. 4, p. 720, pl. 188, fig. 4; and later authors (*part.*).
Cestracion oceanica Garman, 1913, Mem. Mus. Comp. Zool., xxxvi, p. 158.
Sphyrna tudes Fowler, 1941, Bull. U.S. Nat. Mus., 100, xiii, p. 213 (Indo-Pacific references *part.*).
Hab.—Indo-Pacific (specimens from Gulf of Aden, Sumatra and Marquesas Is. in Brit. Mus.).

9. *Sphyrna lewini* (Griffith, 1834).

Zygaena lewini Griffith, 1834, Animal Kingdom Cuv., x, p. 640, pl. 50.
Sphyrna lewini Whitley, 1934, Mem. Queensl. Mus., x, pt. 4, p. 192, pl. xxviii.
Sphyrna zygaena Fowler, 1941, Bull. U.S. Nat. Mus., 100, xiii, p. 217 (Indo-Pacific references).
Sphyrna diplana Springer, 1940, Proc. Florida Acad. Sci., v, p. 46, figs. 1, 2; Bigelow and Schroeder, 1948, Mem. Sears Found. Mar. Res., 1, pt. 1, p. 415, fig. 81 (Atlantic references).
Sphyrna lewini Whitley, 1948, Austr. Zool., xi, p. 262, pl. xxiv, and figs. 3-4; 1949, Austr. Mus. Mag., ix, p. 345.
Hab.—Circumtropical.

10. *Sphyrna blochii* (Cuvier, 1817).

Zygaena blochii Cuvier, 1817, Regne Anim., ii, p. 127.
Zygaena platycephalus Van Hasselt, 1823, Algem. Konst. Letterb.
Zygaena laticeps Cantor, 1837, Quart. Med. J. Calcutta, p. 315, pls. 1–3.
Sphyrna blochii Fowler, 1941, Bull. U.S. Nat. Mus., 100, xiii, p. 221 (full references).
Hab.—Indo-Pacific.