

Studies on New Zealand Elasmobranchii.—Part IX.

Scymnodon plunketi (Waite, 1910), an Abundant Deep-water Shark of New Zealand Waters.*

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Abstract

Centrophorus plunketi Waite, 1910 is referred to *Scymnodon*. The lower teeth are centroscymnoid (oblique and without a symmetrical median tooth) but the upper teeth are scymnodoid (longer midway out along either side of jaw than at centre of mouth) as are the dermal denticles. Juvenile dermal denticles of *S. plunketi* have acutely trifid, concave, ridgeless blades; intermediates, concave with a shallow median longitudinal ridge; adult denticles, obtuse, trifid and strongly ridged. *Centroscymnus waitei* (Thompson, 1930) known only as juveniles, is recognised as *S. plunketi*. *S. plunketi* is abundant in New Zealand waters beyond 300 fathoms, and appears to be a bottom-dwelling, schooling species. Its liver has a high oil content (84 g. oil/100 g. fresh liver) but is low in Vitamin A (370 I.U./g. oil).

THE deep-water spiny dogfish described from New Zealand waters by Waite (1910) as *Centrophorus plunketi* has been variously placed in *Centrophorus*, *Scymnodon* and *Centroscymnus* by most later authors; while Fowler (1933, p. 239) proposes for it a new subgenus *Proscymnodon* which Whitley 1934, p. 199 regarded as a genus. These divergent opinions reflect the need for further examination of this species, which is now known to be abundant in New Zealand beyond 300 fathoms.

Consideration of recently collected adult material necessitates the transfer of the Plunket shark to the g. *Scymnodon*, and examination of juveniles and a half-grown specimen which were originally regarded as *Centroscymnus waitei* (Thompson, 1930) shows that Thompson's species is a synonym of *S. plunketi*. It is now definite that juvenile and adult dermal denticles of *S. plunketi* differ strongly in form. Denticle changes of this kind have not previously been reported in *Scymnodon*.

In their recent account of the Squaloidea, Bigelow and Schroeder (1957, p. 25) restate the generic criteria of *Centrophorus*, *Centroscymnus* and *Scymnodon* (the last including the *Proscymnodon* of Whitley which does not now warrant generic distinction), using as primary characteristics the shape of the posterior (inner) corner of the pectoral fin, and the size and shape of the teeth. *Centrophorus* is immediately distinct from *Scymnodon* and *Centroscymnus* in that the posterior pectoral corner is more or less extended (exceptionally it is angular in the juveniles of *C. squamosus*). The diagnosis for *Scymnodon* is that the posterior pectoral corner is rounded; the upper teeth midway along either side of jaw noticeably longer than those toward centre of the mouth; and the lower teeth erect and symmetrical along the median sector of the mouth, only weakly oblique towards the angles, and with a symmetrical median tooth. In *Centroscymnus* the posterior pectoral corner is rounded; the upper teeth midway along either side of the jaw scarcely longer than those at the centre of the mouth; and the lower teeth oblique and without a symmetrical median tooth.

The Plunket shark has a rounded posterior pectoral corner, and upper teeth like those of other species of *Scymnodon*; but its lower teeth are markedly oblique

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along the whole jaw, and there is no symmetrical median tooth (Text-fig. 2). In these lower teeth characters it corresponds with the condition in *Centroscymnus*. However, as has already been shown by Garrick (in press) the lower teeth are not always reliable criteria even in *Centroscymnus*, and where there is confusion from reference to the upper and lower teeth this can be resolved in all except the most juvenile specimens by examination of the dermal denticles. On the Plunket shark these are ovoid, tridentate, and have a median longitudinal ridge extending along the entire length of the blade (Text-fig. 3), leaving no doubt that the species is referable to *Scymnodon*. Such denticles contrast with those of *Centroscymnus* which are more circular in outline, have an uninterrupted circular concavity at the anterior end, and when a median longitudinal ridge is present, it is restricted to the posterior half or two-thirds of the blade, behind the concavity.

Although the obliqueness of the lower teeth of *S. plunketi* is without generic significance, it does set this species clearly apart from the three other species of *Scymnodon* currently recognised. In this respect it is as unusual a feature as the transverse ridging which occurs in addition to the usual longitudinal ridging on the dermal denticles of *S. obscurus* (Vaillant, 1888), but is not found on those of *S. ringens* Bocage and Capello, 1864, or *S. squamulosus* (Gunther, 1877), (or, for that matter, *S. plunketi*).

Compared with *S. ringens* (figured in Bigelow & Schroeder, 1957, Fig. 13, A-E) and *S. squamulosus* (in Gunther, 1887, Pl. 2, Fig. B), *S. plunketi* more resembles *S. ringens* in its overall heavy-bodied form and short snout. However, it differs from *S. ringens* in having a well-marked concavity in the lower posterior margin of the caudal fin; the posterior tip of the second dorsal fin reaching only as far back as the level of the hypural origin; shorter gill-openings; and in a much greater interspace between the tip of pectoral fin, when laid back, and the level of origin of the 1st dorsal spine (almost equal to the interspace between the eye and the first gill-opening in adult specimens, though much shorter than this in juveniles).

Differences between *S. plunketi* and *S. squamulosus* include a much blunter and shorter snout in the former (the preoral length noticeably less than the width of the mouth in *S. plunketi*, but much more than this width in *S. squamulosus*); and much larger first dorsal and pectoral fins in *S. plunketi* which by comparison make those of *S. squamulosus* appear markedly slender.

It was suggested by Thompson (1930, p. 278) that the species he described as *Centrophorus waitei* from a single juvenile specimen taken in deep water off Kaikoura might prove to be a growth stage of *S. plunketi*. This view has not been accepted completely by later authors mainly because the dermal denticles are markedly different. Waite (1914) had previously described late embryos of *S. plunketi*, which Thompson does not mention having available for comparison, and they cannot now be found in the Canterbury Museum. Direct comparison of Thompson's specimen with Waite's identified embryos of *S. plunketi* is therefore not possible, and no other embryos or juveniles of the latter species have been described. As a consequence Thompson's species has been retained, though Whitley (1940, p. 143) referred it to *Proscymnodon*, but later (1956, p. 398), following Garrick (1955) to *Centroscymnus*. Bigelow and Schroeder (1948, p. 451, footnote 8) considered it to be a *Scymnodon*, but later (1957, pp. 88-96) also referred it to *Centroscymnus* and reaffirm Thompson's suggestion that it may be a young stage of *S. plunketi*. Garrick (1955) gave a full description and illustration of the type of *C. waitei*, and, chiefly on the nature of the dermal denticles which have strongly concave blades and lack longitudinal ridges, regarded it as a *Centroscymnus*.

Since Garrick's (1955) study, further juvenile specimens seemingly *C. waitei*, have become available. These include two male embryos in the Dominion Museum collections, 336 and 348 mm long (Dom. Mus. No. 763) labelled "*C. plunketi*",

from Cook Strait, 1929; and one female 523 mm long (Dom. Mus. No. 2637) long-lined from 500 fathoms off Kaikoura by Mr. R. Baxter in November, 1955. These all agree closely with the type of *C. waitei* except that their caudal fins have a more or less truncate terminal lobe and a definite subterminal notch (Text-fig. 1, A). In this respect they resemble other species of *Centroscyrnus* and *Scymnodon*, and hence the unusually pointed caudal fin of the type of *C. waitei* can no longer be regarded as a distinctive feature of this species. The proportional dimensions of the 523 mm specimen are more or less intermediate between those of the type of *C. waitei* (318 mm) and those of two adult specimens of *C. plunketi* (1197 mm and 1417 mm), as in Table I, so that no specific distinction is apparent. Such variation as is present can be recognised as change with growth, the adults having proportionately longer bodies, and shorter heads and tails relative to the juveniles. Equivalent variation has been reported for species of *Centrophorus* and *Centroscymnus* (Garrick, 1959; in press).

TABLE I.—PROPORTIONAL DIMENSIONS IN PER CENT. OF TOTAL LENGTH.

| | <i>Scymnodon plunketi</i> | | <i>Centroscyrnus waitei</i> | |
|---|---------------------------|--------------------|-----------------------------|------------------|
| | 1,417 mm N.Z. ♀ | 1,197 mm N.Z. ♂ | 523 mm N.Z. ♀ | 318 mm Type ♂ |
| Trunk at pectoral origin: | | | | |
| Breadth | 14.4 | 13.3 | 12.2 | 12.9 |
| Height | 11.3 | 10.1 | 9.7 | 8.2 |
| Snout length in front of: | | | | |
| Outer nostrils | 1.1 | 0.8 | 0.8 | 1.6 |
| Mouth | 5.4 | 5.0 | 7.5 | 6.9 |
| Eye: horizontal diameter | 3.9 | 3.7 | 5.2 | 5.0 |
| Mouth: breadth | 6.7 | 6.5 | 6.7 | 8.2 |
| Nostrils: breadth between inner corners | 3.0 | 2.9 | 3.8 | 3.5 |
| Preoral clefts: breadth between inner corners | 5.1 | 4.2 | 5.0 | 4.7 |
| Gill-opening lengths: | | | | |
| 1st | 1.6 | 1.8 | 1.5 | 1.6 |
| 5th | 1.4 | 1.6 | 1.3 | 1.3 |
| 1st dorsal fin: | | | | |
| Vertical height | 3.6 | 3.2 | 3.1 | 2.5 |
| Length of base measured from origin of spine | 4.8 | 4.1 | 4.2 | 4.1 |
| 2nd dorsal fin: | | | | |
| Vertical height | 4.3 | 4.0 | 4.2 | 3.5 |
| Length of base measured from origin of spine | 5.6 | 5.2 | 5.3 | 5.3 |
| Caudal fin: | | | | |
| Upper margin | 17.2 | 18.4 | 23.8 | 23.8 |
| Lower ant. margin | 11.1 | 10.4 | 14.6 | 11.6 |
| Pectoral fin: | | | | |
| Ant. margin | 13.4 | 11.8 | 15.0 | 12.9 |
| Distal margin | 7.6 | — | 7.1 | 6.0 |
| Pelvic fin: ant. margin | 8.2 | 6.6 | 6.3 | 5.0 |
| Distance from snout to: | | | | |
| Eye | 3.5 | 3.2 | 4.2 | 4.1 |
| 1st gill opening | 14.8 | 13.1 | 15.9 | 16.0 |
| 5th gill opening | 17.8 | 16.7 | 18.9 | 19.8 |
| 1st dorsal spine | 36.8 | 36.7 | 37.0 | 34.3 |
| 2nd dorsal spine | 68.6 | 67.8 | 62.2 | 60.7 |
| Upper caudal | 82.0 | 81.5 | 76.5 | 75.0 |
| Pectoral | 17.9 | 16.8 | 19.0 | 20.1 |
| Pelvic | 60.7 | 60.0 | 54.5 | 52.0 |
| Interspace between: | | | | |
| 2nd dorsal and caudal | 8.0 | 8.5 | 9.6 | 8.5 |
| Pelvic and subcaudal | 10.6 | 12.2 | 10.1 | 13.2 |
| Distance from origin to origin: | | | | |
| Pectorals and pelvic | 43.3 | 42.8 | 36.8 | 31.7 |
| Pelvic and subcaudal | 17.6 | 19.6 | 15.8 | 18.8 |

The distinction between the dermal denticles of the juvenile *C. waitei* and those of adult *S. plunketi* is very misleading. The usual practice of examining denticles from the anterior half of the trunk when applied to the 523 mm specimen is equally misleading, for the majority of the denticles in this region are as in the type of *C. waitei*—i.e., they are well spaced, with strongly tridentate, concave, ridgeless blades rising steeply from the skin. But examination of the posterior half of the trunk shows in addition slightly larger denticles of another form which are newly erupted,* and have a shallow median longitudinal ridge extending along the whole length of the blade (Text-fig. 1, B). The presence of this complete median ridge means that the denticles cannot be those of a *Centroscymnus* but instead are referable to *Scymnodon*. Moreover, their shape and sculpture is such that they could reasonably be regarded as intermediate to the final form of the ovoid, tridentate, ridged blades of *S. plunketi* (Text-fig. 1, C-E).

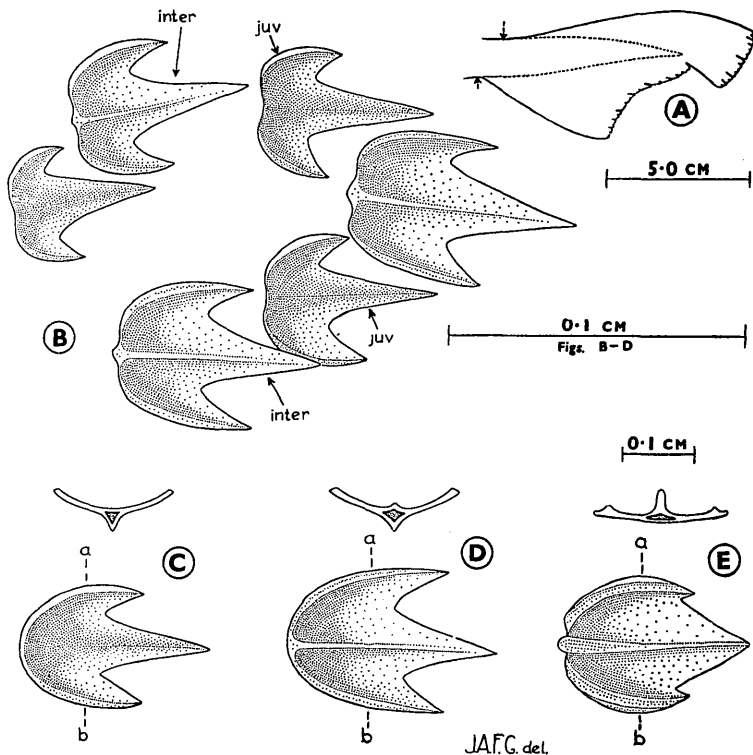
The above leaves no grounds on which to maintain *C. waitei* as separate from *S. plunketi*. If further confirmation is required, it is provided by the teeth. The upper teeth of *C. waitei* are like those of other species of *Scymnodon*, including *S. plunketi*, in that they are longest midway out along each side of the jaw; but the lower teeth series share with *S. plunketi* the peculiar feature of being oblique at the centre of the mouth and lacking a symmetrical median tooth.

The dermal denticle changes noted above (Text-fig. 1, C-E) are the first to be recorded from a species of *Scymnodon*, although equally remarkable changes are known from some species of *Centrophorus* and *Centroscymnus*. However the changes in *S. plunketi* are novel in that no other cases are known where ridgeless juvenile denticles are replaced by ridged intermediate and adult denticles. In *Centroscymnus coelelepis* and *C. owstonii* the reverse occurs, strongly ridged juvenile and intermediate denticles being replaced by adult denticles which lack ridges or at least have them greatly reduced.

All the known New Zealand catches of *S. plunketi* are from Cook Strait, Kaikoura and Banks Peninsula, but it is likely that line-fishing in deep-water elsewhere on our coasts would show that the species is not restricted to these areas. The depth range so far known is 120–780 fathoms and probably approximates the full range of the species, for it is rarely taken by commercial line-fishermen in 150 fathoms and shallower, and has not yet been caught on lines set deeper than 1,000 fathoms in Cook Strait. The south-eastern Australian records of the species (the only other region where it is known) give it an even narrower range of 260–450 fathoms, as shown by Cowper & Downie (1957, Fig. 12) who record 17 specimens from 7 stations, the greatest single catch of 7 specimens being long-lined in 360–400 fathoms. An indication of its abundance in 300–400 fathoms in New Zealand is shown by the catches of a commercial line-fisherman, Mr. R. Baxter, of Oaro, Kaikoura, who within a month caught sufficient specimens to yield 3,300lbs of liver. The livers average 8lb to 10lb per shark, so that some 300 to 400 specimens were taken within the period.

It now seems highly probable that *S. plunketi* is a schooling species of the deeper waters, at least on occasions, the schools segregating not only according to size but also to sex. This is shown by New Zealand catches of December, 1955, when 13 males, 1090 mm to 1198 mm long were taken in 450 fathoms, and July 1957, when 5 females 1,290 mm to 1,320 mm were caught in 600 fathoms. The Australian records also indicate that it is a bottom-dwelling species, for although it was taken there on seven occasions by the use of conventional long-lines, it was not caught at all during an extensive drop-lining programme in the same depths and region.

* This agrees with what has been described in *Centroscymnus owstonii*, where it has been shown by Garrick (in press) that replacement denticles which are of a new form, first appear on the caudal peduncle.



TEXT-FIG. 1.—Fig. A—*Centroscyrnus waitei*, tail of embryo male, 348 mm (Dom. Mus. No. 763). Fig. B—*C. waitei*, female, 523 mm (Dom. Mus. No. 2637), juvenile and intermediate dermal denticles from the flank of the caudal peduncle. Figs. C-E—*Scymnodon plunketi*, external views and cross-sections of the blades of juvenile, intermediate and adult denticles respectively (Figs. C and D from 523 mm female, E from 1,417 mm female), the cross-sections through a-b in each case.

The New Zealand catches (where information is available) have all been from long-lines, and on the few times when drop-lines have been used in depths of 300 fathoms or more, no *S. plunketi* have been taken.

To date there has been no commercial exploitation of *S. plunketi* other than isolated catches for liver such as mentioned above. The livers have a high oil content, as shown by the analysis of a New Zealand specimen taken in December, 1956, which had 84 g. oil/100 g. fresh liver; but the vitamin A content is low, being only 370 I.U./g. oil, compared with the common figure of 30,000 I.U./g. for the School shark, *Galeorhinus australis*. Similar figures are given by Cowper & Downie (1957, Table VI) for an Australian specimen of *S. plunketi*.

Cephalopod beaks and bony fish remains are the only stomach contents found in New Zealand specimens of these sharks. Of 18 specimens dissected, all of them long-lined, 12 had empty stomachs, presumably having vomited their contents. Four contained fish remains only; 1, cephalopod beaks only; and 1, both fish remains

and cephalopod beaks. Five of the same 18 specimens were infested with the large trematode *Otodistomum plunketi* Fyfe, 1953; mostly only 2 or 3 of these flukes were present, though one large female contained 29. The majority of the sharks also had larval tapeworms in the coelom, and a monogenetic trematode on the skin, the latter usually very numerous.

Little is known of the reproductive cycle or developmental stages other than the information in Waite (1914) and Phillipps (1946) on two gravid specimens. They show that the eggs are very large and numerous, up to 36 embryos being produced in one litter. In Waite's specimen, the 36 embryos were 165 mm long and attached to globular yolk-sacs 66 mm in diameter. Phillipps' specimen contained at least two embryos (Dom. Mus. No. 763) which are 336 mm and 348 mm long and evidently not far off birth, for their yolk sacs are almost completely resorbed. Thompson's (1930) specimen (as *C. waitei*) is the smallest free living one that has been recorded, and is 318 mm long; it was taken in August, 1928. The smallest mature male known is about 1,000 mm long. No mature female less than 1,290 mm is so far known; this and three others up to 1,320 mm taken in July, 1957, all contained numerous ova 7 mm to 20 mm diameter in each ovary. A 1,630 mm female caught in November, 1956, contained numerous ova of 5 mm diameter in each ovary (ovary length 230 mm), while a 1,700 mm female taken at the same time had only 8 ova of 20 mm diameter in each ovary (ovary length 100 mm). The small size of the ova in both of the above groups of females when compared with Waite's and Phillipps' records of gravid females taken in July and December respectively, and Thompson's recently-born juvenile taken in August, suggests that the breeding season is not well defined, or that *S. plunketi* breeds only every second year.

Scymnodon plunketi (Waite, 1910)

Centrophorus waitei Thompson, 1930

STUDY MATERIAL

(a) Adults

Female, 1,375 mm T. L., Canterbury Museum (no data, but possibly the parent of the embryos described in Waite, 1914); two females of 1,306 mm and 1,417 mm (Dom. Mus. Nos. 2635 and 2636 respectively) and one male of 1197 mm (Dom. Mus. No. 1846) lined from 7 miles south of Kaikoura by Mr. R. Baxter, in 200 fathoms (September, 1954) and 450 fathoms (December, 1955) respectively.

(b) Juveniles

Male of 318 mm T. L., Canterbury Museum (type of *Centrophorus waitei* Thompson, 1930); two males (late embryos) of 336 mm and 348 mm (Dominion Museum No. 763) from a gravid female taken in deep water in Cook Strait, December, 1929; and one female of 523 mm (Dominion Museum No. 2637) lined from 500 fathoms, 7 miles south of Kaikoura by Mr. R. Baxter, in November, 1955.

DESCRIPTION

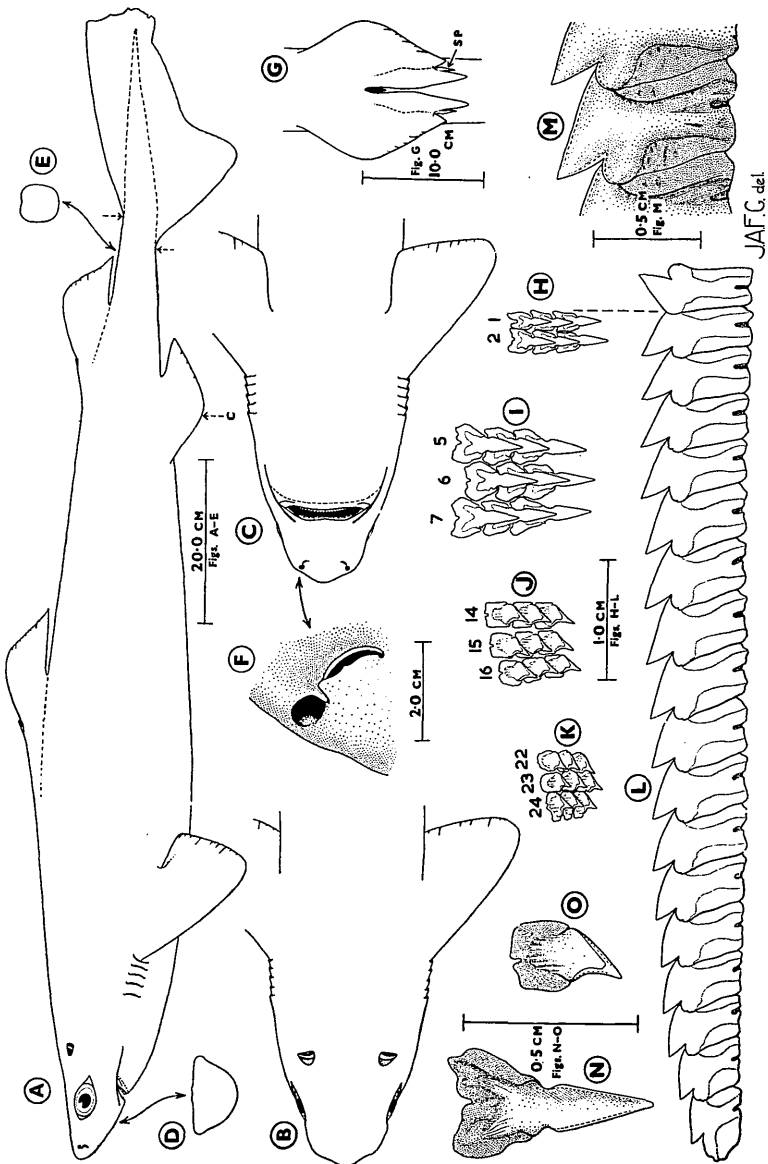
See Table I for proportional dimensions in per cent. of total length of both adults and juveniles (the latter as *C. waitei*).

(a) ADULTS. Text-fig. 1, E; Text-fig. 2, A-O; Text-fig. 3, A-H.

Based mainly on female 1,417 mm, and male 1,197 mm.

Head slightly depressed, short-snouted and large-eyed; snout bluntly pointed, its length in front of eye less than or equal to half the interspace between the eye and the 1st gill-opening; trunk moderately stout, subcircular in section anteriorly but slightly compressed posteriorly. Height of trunk at origin of pectorals $\frac{1}{4}$ th- $\frac{1}{3}$ th of its length to the origin of the caudal. Length of body measured to the cloaca 65% to 66% of the total length. Caudal peduncle without lateral keels or precaudal pits.

Dermal denticles large, close-set and overlapping so as to leave few and small interspaces, and covering the whole of the body with the exception of the axils of the fins and the margin of the lower lip. The pectoral and pelvic fins each with the naked axillary area extending



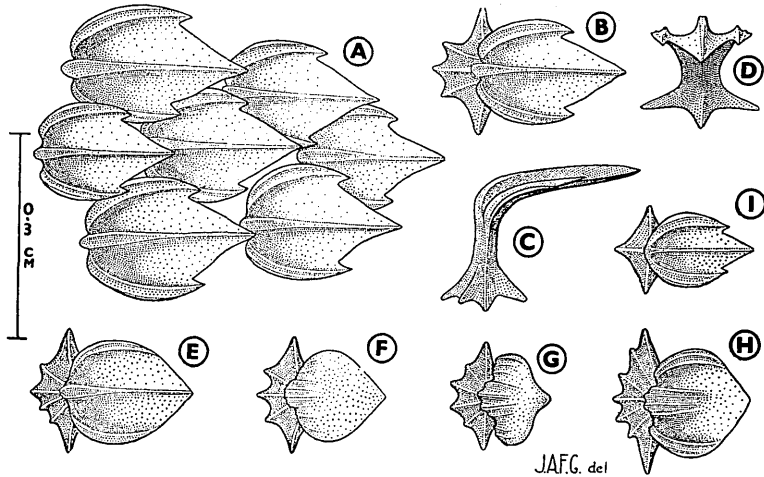
TEXT-FIG. 2.—*Scymnodon plunketi*, female, 1,417 mm (Dom. Mus. No. 2636). Fig. A—lateral view. Figs. B and C—Dorsal and ventral views of head. Fig. D—outline of transverse section of snout. Fig. E—Outline of transverse section of caudal peduncle. Fig. F—Left nostril (of male, 1,040 mm, Cant. Mus. No. 1). Fig. G—Ventral view of pelvic fins and claspers from same specimen as in Fig. F. Figs. H-K—Right upper teeth (row numbers indicated above figures). Fig. L—right lower teeth. Fig. M—4th right lower tooth. Fig. N—5th right upper tooth. Fig. O—16th right upper tooth. C = level of cloaca; SP = subterminal lateral spur.

J.A.F.C. det.

along the upper surface of the fin to its tip and parallel to its posterior margin, so as to embrace about one-fifth of the width of the fin. Each denticle of the trunk region with a broad, thin, near horizontal blade. The blades are directed posteriorly, and each is subovoidal in contour but with the posterior margin interrupted by three sharply pointed teeth, a long median tooth, and a short lateral tooth on each side, separated from each other by shallow, incised notches. The external surface of each blade with three major longitudinal ridges, including a median ridge extending the full length of the blade, and one lateral ridge on each side. The median ridge is steep-sided, and sharp-topped distally where it reaches to the tip of the median tooth, but round-topped at the basal end of the blade where it has a shallow, longitudinal groove along its crest. The lateral ridges are lower than the median ridge, broad-topped, and extend to the tip of the lateral teeth, and each is shallowly grooved longitudinally and may carry one and sometimes two minor ridges. The base of each denticle is essentially rhomboidal in outline, with a ridge arising from each of the four major angles on to a strap-shaped pedicle. However, the two anterior margins of the base each have one or two minor angles, which give them a scalloped appearance, and a minor ridge rises on to the pedicle from each of these angles between the major ridges. The denticles on the tail are similar to but smaller than those on the trunk, differing from them only in the lack of scalloping on the anterior margins of the bases, the latter being four-angled and carrying only the four major ridges. The denticles of the interorbital region are of about the same size as those of the trunk, and have the same features except that there are no lateral teeth, and the median tooth is less acutely pointed. The denticles on the margin of the upper lip have smaller, subcircular blades, each with a pointed, median, posterior tooth and lacking lateral teeth. The blades carry the same type of sculpture on their external surfaces as the trunk denticles, but the ridges are wider and heavier with several additional minor ridges on their crests, and are present only at the anterior end of each blade so that the greater portion of the blade is flat-topped and unornamented. The denticles on the lower lip are similar to those on the upper lip except that the blades are thicker and their sculpture extends further along them. At the extreme margin of the lower lip the denticles are squat and almost sessile, and in addition they have a short, thick, median ventral keel beneath the tip of the median tooth but not produced basally.

Head measured to 1st gill-opening 6.8-7.6 in the total length, and about twice the least fleshy interorbital distance. Head slightly depressed, flat above, and broad, with obtusely rounded lateral margins, except anterior to the eyes where there is a distinct dorsolateral edge extending to the tip of the snout. Contour of snout from above bluntly pointed at the snout tip which protrudes as a rounded prominence interrupting the anterior angle, but slightly concave at the level of the nostrils before widening out again anterior to the eyes. Posterior to the eyes the head widens smoothly to reach its maximum width at the level of the gill-openings. Snout short, its length anterior to the eyes just less than the horizontal diameter of the eyes and 2.0-2.2 in the interorbital. Eye large, elongate, and twice as long as high. Spiracle large and sited above and behind the eye so that its lower margin is level with the dorsal margin of the eye and its anterior margin separated from the eye by a distance equal to the spiracular length. Length of the spiracle 2.6-2.8 in the horizontal diameter of the eye. The lateral, anterior and median margins of the spiracle form a smooth, continuous arch, while the posterior margin is straight. Gill-openings small, almost vertical, their anterior margins straight or slightly convex, and forming a horizontal series anterior to and on the same level as the origin of the pectoral fin. Length of the gill-openings decreasing slightly from the 1st to the 5th, the former being 2.0-2.2 in the horizontal diameter of the eye. The interspace between the 1st and 2nd, and 2nd and 3rd gill-openings subequal, and slightly greater than that between the 3rd and 4th, which in turn is greater than that between the 4th and 5th. Nostrils oblique and placed close to the tip of the snout and to the lateral margin, where because of the thickness of the snout they open almost laterally. Distance between the inner corners of the nostrils 1.3-1.4 in the horizontal diameter of the eye. Each nasal aperture subdivided into a circular, anterolateral aperture and an elongate, subovoidal, posteromedial aperture by the posterior nasal flap, which extends anteriorly as a fleshy triangular process from the posterior nasal margin. The anterior nasal margin is produced as a long, low, free flap which almost entirely covers the posteromedial nasal aperture. Mouth broad and little arched. Width of mouth slightly greater than the preoral distance. The upper lip fimbriated and with a narrow, naked margin, the lower lip smooth but with a broad, naked margin. The preoral clefts deeply incised and reaching about half of the distance from the angles of the jaws to the upper symphysis. Posterior to the jaws they are continued by shallow furrows extending about halfway to the 1st gill-openings.

Teeth $\frac{48}{17-18}$ in the 1,417 mm female, and $\frac{23-24}{17-15}$ in the 1,197 mm male, dissimilar in the two jaws. The upper teeth each with a single, smooth-edged, sharply-pointed, lanceolate cusp borne on a subtriangular, bifid base, arranged in anteroposterior series, and with several rows functional. Counting from the symphysis, the teeth in the 1st and 2nd series are smaller than those in the 3rd to 10th series, which include the largest teeth in the upper jaw. The



TEXT-FIG. 3.—*Scymnodon plunketi*, female, 1,417 mm (Dom. Mus. No. 2636). Figs. A—D—Dermal denticles from high on side at level of 1st dorsal. Fig. A—External view of group of denticles. Fig. B—External view of one denticle showing underlying base. Fig. C—Lateral view. Fig. D—Apical view. Fig. E—Denticle from interorbital region. Fig. F—Denticle from upper lip. Fig. G—Denticle from margin of lower lip. Fig. H—Denticle from 0.5 cm behind lower lip. Fig. I—Denticle from caudal fin.

teeth in the 11th to 24th series become increasingly smaller, and instead of having the straight, clongate cusps of the more median teeth, they have short, slightly oblique cusps which are shallowly notched on their lateral margins. In all of the upper teeth, the proximal portion of each cusp which arises from the base, is sculptured with longitudinal ridges and may be bifid, as is the case in the teeth towards the centre of the jaw. These latter teeth may also have either a rounded prominence or a minute cusp-like structure on each side of the major cusp and just proximal in position to the constriction which gives the cusp its lanceolate form. Three or four rows of upper teeth functional at the centre of the upper jaw, two or three rows towards the angles. The lower teeth each with a single, smooth-edged, sharply-pointed, blade-like cusp borne on a rectangular base, and with one row functional. The bases are higher than broad, and those at the centre of the jaw are narrower than those towards the angles. The cusps are straight-edged, at least for the teeth in the median half of each side of the lower jaw, and recline laterally so that the median margin of each cusp forms the principal cutting edge, and the lateral margin is acutely notched. The teeth towards the angles of the jaws are smaller and have the cusps more oblique than those towards the symphysis so that the most lateral teeth have their median margins almost horizontal. There is no median lower tooth and the first tooth on the left side overlaps the first tooth on the right, while each adjacent tooth overlaps its lateral neighbour.

First dorsal originates by so shallow an angle from the dorsal profile that the actual point of origin cannot be precisely determined. Origin of 1st dorsal spine posterior to the tip of the adpressed pectoral by a distance equal to half the pectoral length. Base of the first dorsal, measured from the origin of the 1st dorsal spine 3.0–3.2 in the length of the head. 1st dorsal brush-shaped and rather elongate, the length of the free posterior margin one-quarter to one-third greater than the length of the base as measured above. Height of 1st dorsal 1.3 in the length of the base. The anterior margin convex, the distal margin straight and the apex smoothly and broadly rounded. The free posterior tip sharply pointed. The 1st dorsal spine short, laterally compressed, and barely interrupting the anterior margin. The 2nd dorsal larger than the 1st, triangular, and with a more acute apex. Origin of the 2nd dorsal above the middle of the pelvic base. Length of the 2nd dorsal base, measured from the origin of the 2nd dorsal spine, $1\frac{1}{2}$ that of the 1st dorsal. Height of the 2nd dorsal just less than the length of its free posterior margin, and 1.3 in its base as measured above. The posterior free tip sharply pointed and terminating just anterior to the hypural origin. Caudal

measured from the hypural origin 4.8–5.0 in the total length. The epiural lobe well developed, its height 4.1 to 4.5 in the length of its slightly convex anterior margin. The terminal lobe with an eroded margin in the female specimen of 1,417 mm, but complete and slightly convex in the 1,197 mm male. A shallow subterminal notch is present and divides the terminal margin from the hypural. The hypural deep and triangular, its height almost twice that of the epiural lobe. Origin of the hypural anterior to the epiural and close to the level of the posterior free tip of the 2nd dorsal. The anterior margin convex, the apex just less than a right angle and bluntly pointed, and the posterior margin shallowly concave. Pectorals originating just posterior to the 5th gill-opening, and about half way between the tip of the snout and the 1st dorsal spine. Pectorals large, broad, lobate, their greatest width 1.6–1.8 in the length of the anterior margin, and the latter 1.1 in the length of the head. All of the pectoral margins are weakly convex, the anterior angle is smoothly rounded, and the posterior angle is distinct but obtuse. Pelvics originating well anterior to the 2nd dorsal fin, the interspace between the pelvic origin and the 2nd dorsal spine equal to the distance from the snout tip to the hind edge of the eye. Pelvics similar in shape to the 2nd dorsal but larger. Claspers subcylindrical in section, tapered posteriorly, and each carrying a sharply pointed, subterminal, lateral spur. Length of the claspers measured from the anterior edge of the cloaca, $\frac{1}{4}$ th greater than the length of the posterior pelvic margin, and 1.8 in the head. The anterior two-thirds of the lateral margin of each clasper is fused to the posterior margin of the pelvic fin, so that the latter margin is free posteriorly for only one-fifth of its length.

COLOUR (in life): Dark greyish brown, except for the fringes of the paired fins and the caudal, which are almost black. Eye is a translucent yellow-green.

(b) JUVENILES. Text-fig. 1, A-D.

Description as in Garrick, 1955 (as *C. waitei*) except as noted below.

Origin of first dorsal spine level with or just posterior to the tip of the adpressed pectoral. Caudal fin with a slightly convex terminal margin and a distinct subterminal notch.

Dermal denticles in a 523 mm female mostly as described for the 318 mm male type of *C. waitei*, but with some larger, newly erupted denticles scattered throughout the others. These new denticles are more or less intermediate in shape and sculpture between the juvenile form of denticles of *C. waitei* and the adult form of denticles of *S. plunketi*. They have a shallow median longitudinal ridge extending the whole length of the blade, and rise less steeply from the skin than do the juvenile form. The median tooth on each blade is also relatively shorter, being about half the length of the blade. The intermediate denticles are most numerous on the sides of the caudal peduncle, where they are about equal in number to the juvenile denticles. Anteriorly on the trunk, at the level of the first dorsal fin, they are less numerous than the juvenile denticles.

SUMMARY

(i) *Centrophorus plunketi* Waite, 1910, has pectoral fins with rounded posterior corners; upper teeth which are noticeably longer midway out along each side of the jaw than at the centre of the mouth; and ovoid tridentate dermal denticles which carry strong median longitudinal ridges extending the full length of the blades. On these characters, the species is referred to *Scymnodon*.

(ii) The lower teeth of *S. plunketi* are like those of *Centroscymnus* spp.—i.e., all oblique and without a symmetrical median tooth; but they are not of generic significance. In *S. plunketi* they have specific value in that they separate it from all other species of *Scymnodon* (in which the lower teeth are erect at the centre of the mouth, and there is a symmetrical median tooth).

(iii) *Centroscymnus waitei* (Thompson, 1930), based on a juvenile specimen, is a young stage of *S. plunketi*. Juveniles of *S. plunketi* have dermal denticles with concave ridgeless blades which differ markedly from the strongly ridged blades of adult denticles. Intermediate form denticles have a shallow median longitudinal ridge, and first appear on the caudal peduncle of juveniles about 500 mm long. This is the first record of changes in dermal denticle form in *Scymnodon*, and is novel in that ridgeless denticles are replaced by ridged ones.

(iv) New Zealand catches of *S. plunketi* are from 120–780 fathoms, which approximates the full range of the species. It is abundant in 300 fathoms and deeper. It is probable that it is a schooling species, at least on occasions, segregating

according to sex and size, and living on the bottom. Food includes bony fish and cephalopods.

(v) *S. plunketi* is not exploited commercially. Its liver is high in oil content (84 g. oil/100 g. fresh liver) but low in vitamin A (370 I.U./g. oil).

(vi) Males of *S. plunketi* mature when 1,000 mm long, and possibly before this; females similarly are mature at least when they are 1,290 mm. Up to 36 young in one litter have been observed. The young are 300 mm long or more when born. Females containing well advanced embryos have been found in July and December; while other mature females taken at the same time of year have not been pregnant.

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