OBSERVATIONS ON SOME TASMANIAN FISHES: PART XXVII

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(with six tables, one text-figure and one plate)

ABSTRACT

One new species is added to the Tasmanian list; *Amnotretis elongatus* McCulloch, 1914, from Goose Island, Furneaux Group, Bass Strait.

A detailed account, with table of dimensions, is given for two examples of *Trygonorrhina fasciata* Muller & Henle, 1841 (Rhinobatidae). It has hitherto been assumed the Tasmanian fiddler ray is the typical subspecies; however, the present material is determined as *T. f. guanerius* Whitley, 1932.

Other species noted are: *Dinolestes lewini* (Griffith, 1834) (Apogonidae), *Beryx decadactylus* Cuvier, 1829, *B. decadactylus* (Gunther, 1859) (Berycidae), *Paratrachichthys tralli* (Batten, 1875) (Trachichthyidae), the treatment of the last three species including detailed morphometry and various aspects of body form, with some comparison between them.

INTRODUCTION

This paper follows the general plan of others in the series. Linear measurements are given throughout unless otherwise specified in millimetres, the name of the unit commonly being omitted. The symbols *Ls, Lt, TLs, TLt* denote standard length, total length, thousandths (permillages) of standard length, thousandths of total length, respectively. Registration numbers denoted by Q.V.M. are those of the Queen Victoria Museum and Art Gallery, Launceston. Certain other conventions are noted in earlier contributions.

Family RHINOBATIDAE

The Handbook (Munro 1956) recognized three genera with Australian representatives, *Rhinobatos* Linck, 1790 (2 species, the Check-List (McCulloch 1929) recording 5), *Aptychotrema* Norman, 1926 (3 species) and *Trygonorrhina* Muller & Henle, 1838 (rendered *Trygonorhina*) with 2 subspecies, the typical subspecies (type locality New Holland) in Queensland, New South Wales, Victoria, Tasmania and *Trygonorrhina fasciata guanerius* Whitley, 1932 from South Australia (type locality) and southern Western Australia (the Check-List includes a fourth genus, *Rhynchobatus* Muller & Henle, 1837, with 1 species). Of these only *Trygonorrhina fasciata* was listed for Tasmania. While no investigation appears to have been made as to the subspecific nature of the local fiddler ray — which is included in the earliest State list (the MS catalogue of Morton Allport) — it has been assumed since the recognition by Whitley of the existence of 2 subspecies that it is the eastern form categorized by him, and this is the position adopted in the Handbook, in Scott (1962), and in Scott et al. (1974). However, material from the estuary of the Tamar, northern Tasmania, observations on which are presented below, proves to be assignable to *T. f. guanerius*.
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Genus **TRYGONORRHINA** Müller & Henle, 1838


Type-species, **Trygonorrhina fasciata** Müller & Henle. (Spelt **Trygonorhina** in PLAGUÉZ., 1841 on p.124 but **Trygonorhina** on p.143).

**Trygonorrhina fasciata guanericus** Whiteley, 1932

Trygonorrhina fasciata guanericus Whiteley, 1932, p.317; cites figure 39 in Waite, 1921.

Type locality: Kangaroo Island.

**Trygonorrhina fasciata** Whiteley, 1948, p.9.

**Trygonorrhina fasciata guanericus** Whiteley, 1940, p.174, fig.200 and 1964, p.34: Scott, 1954, p.106 and 1962, p.53, unnumbered fig.: Scott, Glover & Southcott, 1974, unnumbered fig.

**Trygonorrhina fasciata guanericus**: Munro, 1956, p.15, fig.105.


**Trygonorrhina fasciata**: Johnston, 1883, p.40 and 1891, p.39.

Accounts Without Subspecific Differentiation

In the course of an excellent description, with figure, of a young specimen of **Trygonorrhina fasciata** from Sandon Bluff, New South Wales, McCulloch (1921b, p.460, pl.38, figs 1,2) noted, in addition to sources cited above in synonymy as dealing with material from South Australia, Western Australia or Tasmania (and thus presumably relating to **T. f. guanericus**), some treatments of **T. fasciata** without subspecific differentiation but in view of the localities involved presumably relating to the typical subspecies. The more important Australian texts cited include Castelnau (1872), Macleay (1881), Haswell (1884), Ogilby (1886), Lucas (1890), Hill (1895), Waite (1899, 1904): to these the following other texts may usefully be added McCulloch (1921a), Tindale (1926), Griffith (1936). Among basic extralimital references those of Muller & Henle (1838, 1841), Duméril (1865), Günther (1870) and Garman (1913) may be mentioned. Of these accounts some adopt **Trygonorrhina**, others, including McCulloch’s own, **Trygonorhina**.

Subspecific Differentiation

The brief passage in which Whiteley (1932) proposed his subspecies comprises only three sentences and may profitably be quoted verbatim. “The South Australian Fiddler Ray, which has been figured by Waite differs markedly from the New South Wales form in the disposition and nature of its colour-markings. The difference may be better appreciated by comparing Waite’s figure with that of McCulloch than conveyed by written description.” The only other available account of **T. f. guanericus** is that of Scott (1954). As noted above, the Tasmanian form has hitherto been assumed to be **T. f. fasciata**, but on the basis of the figures by Waite and McCulloch, subsequently reproduced side by side by Whiteley (1940), our specimens are identifiable as **T. f. guanericus**. After preservation of the rays in formalin for several months the pattern, originally well defined, became indistinct. On available information no morphometric distinction between subspecies can be drawn.

Other Species

For upwards of a hundred years **Trygonorrhina** had been cited as a monotypic genus; however, a second species, **T. melaleuca** Scott, 1954, also from South Australia, has now been described. It differs at sight from **T. fasciata** in colouration, having a diffuse bluish-black pattern covering back and upper part of tail to caudal fin and 4 grey bars on the hinder part of the disc.

Material

Two examples collected in the Tamar estuary in the vicinity of Ilfracombe, 3 March 1980: (a) female, total length 1046 mm standard length (to origin of caudal) 803 maximum disc width 474, J. Sutcliffe (Q.V.M. Reg.No. 1980/5/26), (b) female, total length 1139 mm standard length 994 maximum disc width 490, R. Hunt (Q.V.M., Reg.No. 1980/5/57).
Dimensions; Methods of Determination
Hubbs and Ishiyama (1968), extending the recommendations of the methods for the study of bony fishes by Hubbs and Lagler (1958, 1964) and in part those previously proposed and followed by Ishiyama (1958) for rays, set out a series of measurements and defined the conventions in accordance with which it is recommended they be made. A basic proposition is the following: "Each determination is taken point-to-point, as this procedure is far more objective and precise than measuring projections onto an imaginary line supposedly parallel with some axis." This procedure represents a radical departure from the general practice long observed in Australian and in the majority of overseas texts in respect of those measurements that can appropriately be made between parallels, e.g. directly between normals to the general anteroposterior axis of the fish — see, for instance, "the set of standard measurements for comparative and biometric studies of Australian sharks" devised by Whitley (1943 p.114) and extensively employed in his papers. In offering their recommendations Hubbs and Lagler observe "We hope that these methods will meet with the acceptance afforded the methods proposed by Hubbs and Lagler (1958, 1964) for the systematic study of bony fishes"; and this hope has found general fulfillment. It is here suggested such acceptance of the proposals (in particular the general point-to-point specification) may perhaps have been somewhat uncritical one; some considerations regarding the appropriateness of the two methods of measuring and reporting the magnitude of some morphological features are here noted. The relative merits of measurements made point-to-point and those made between parallels may conveniently be examined in respect of two criteria, (a) the ease of operation and the precision, objectivity and reliability of specification, (b) the general biological significance of the magnitudes recorded.

Consider first ease, precision and objectivity. It is evidence that for the majority of measurements the point-to-point technique is indeed simpler and easier to perform and is calculated to yield an objective and precise result. It may be questioned whether in the case of the dozen or so measurements listed by Hubbs and Ishiyama that include the specification "from snout tip" point-to-point measurements made with dividers are likely to be as truly objective as those taken between parallels with the aid of a measuring board (the tip of the snout being objectively determined in the latter method by direct contact with the anterior board, the former involving some subjective decision as to the precise point to be treated as the tip of a part of the body commonly rounded in two planes). In respect, however, of reliability in the sense of uniformity of magnitude (i.e., as with reported measurements in general, relative magnitude; reported values conventionally being given as proportions, usually as percentages or millesimals of a standard magnitude such as maximum disc width - adopted by Hubbs and Ishiyama - or standard length) among members of a sample, hence as a systematic index, the point-to-point method is open to theoretical objection. Consider the listed measurement No.33, "Prenarial length: from tip of snout to nearest point on outer rim of nostril". If taken between parallels this involves only one axis that is the subject of variation, namely, the general anteroposterior axis of the ray. If taken point-to-point two axes subject to variation are involved, namely, the general anteroposterior axis and the transverse axis. With a large series of specimens at hand it would be instructive to compare the coefficients of variation of prenarial length yielded by point-to-point and between-parallel measurements. (Experience indicates that in species with a markedly sinuous outline in the anterior half of the disc individual variation in disc width here may be not inconsiderable; with this internarial distance may be correlated.) Further, in a measurement such as No.31, precocial length, there is introduced, at least as a formal component, a third plane of variation, that of depth.

The significance of certain dimensions and their mode of determination may next be considered. In the course of these contributions it has repeatedly been found for a variety of species among teleosts, selachians and (less extensively investigated) batoids that with measurements taken between parallels normal to the general anteroposterior axis
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dimensions such as length of head, length to vent, lengths to origins and terminations of vertical fins, calculated as relative to standard length, exhibit the exponential relation \( L = b t^k \), where \( L \) = length to point, \( k \) = a natural number. It is difficult to believe that such formulations do not point to the existence of certain basic nodes of growth disposed linearly along the primary antero-posterior axis of the fish (e.g.). The location of such nodes so disposed would clearly be less precisely specified by point-to-point measurements involving the additional component of depth. Among rays, sharks and bony fishes the first, in view of their depressed form, would in general be least subject to such extra variation, while in deep-bodied forms the differences between the two types of measurement may be considerable. In a specimen of the moderately deep Centroberyx affinis (Günther, 1859) at hand the point-to-point measurements of length to dorsal origin, length to anal origin are 1.27 and 1.07 those taken between parallels. A more pertinent example is provided by a ray with an elevated dorsal profile such as Myliobatis atratulus MacLeay, 1821, in a specimen of which with a total length of 1225 mm and a disc width of 990 mm the precaudal length measured between parallels was found to be 65 mm, measured point-to-point 128, or virtually twice as much. The considerable difference between the figures just noted directs attention to a further significant point of difference between the two methods of measurement when the results are considered as applicable to a series of dimensions, namely, the relative divergence between the two data will not be constant for all items but will be subject to variation determined by the body form.

Where it has seemed expedient dimensions of the present specimens are recorded by both methods of measurement, thus making them directly comparable with those noted in accounts already published of this (and in general other Australian) species and with those specified in accordance with the more recent system.

Dimensions; Present Material

Published accounts of the typical subspecies provide no good series of measurements, but more than a dozen dimensions of a female Trygonorrhina f. guarnierii from St Vincents Gulf, South Australia have been recorded by Scott (1954). Two sets of measurements are here presented. Apart from a couple of omissions the first represents the schedule of measurements of external features proposed by Hubbs and Ishiyama, absolute dimensions (mm) being recorded only for the first two entries, total length disc width, the remainder being given as millesimals of maximum disc width. The second set covers some additional morphological features not noticed in the Hubbs-Ishiyama schedule, in particular those here investigated in the section Aspects of form. In order to permit direct comparison of proportional relations here specified with comparable formulations for other species previously reported in these contributions, dimensions continue here to be expressed as millesimals of standard length, i.e., length to origin of more anterior caudal lobe ((a) 893 mm (b) 994 mm), rather than as millesimals of maximum disc width ((a) 474 mm (b) 490 mm) as in the preceding set. In the case of exponential relations of the form \( Y = b t^k \), with \( k \) the serial number of a metameric or otherwise repetitive structure, here regularly rectified as \( \log Y = a \log t + \log b \), conversion from a standard length to a disc width metric is obtained thus: the slope \( (k) \) is constant, the intercept \( (a) \) is transformed by multiplying its antilogarithm by absolute standard length, dividing by absolute disc width and taking the antilogarithm. The statistical significance as measured by \( t \) of course remains unaltered.

Hubbs-Ishiyama schedule, dimensions from No.3 onward as millesimals of maximum disc width.

1 Total length 1046 mm, 1139 mm

Disc measurements

- Disc width 474 mm, 490 mm; 3 disc length 1014, 1020; 4 anterior projection 608, 571; 5 trunk length 647, 646; 6 mouth to tail 1215, 1238; 7 precaudal length 992, 1087.

Tail measurements

- 8 Tail length 1018, 1097; 9 tail width, end \( P_2 \) 179, 179; 10 tail depth, end \( P_2 \) 116, 122; 11 tail width, origin \( P_1 \) 174, 173; 12 tail depth, origin \( P_1 \) 105, 107; 15 predorsal length 100, 168; 14 \( D_1 \) origin to tail tip 918, 929.
Fin measurements
15 $D_1$ basal length 124, 120; 16 between $D$ bases 211, 241; 17 $D_2$ basal length 122, 118; 18 postdorsal length 939, 989; 19 $C_1$ vertical height 173, 180; 20 $D_2$ vertical height 174, 176; 21 $C$ vertical height 86, 84; 22 lateral fold length 960, 929; 23 lateral fold width 19, 15; 24 behind lateral fold 127, 122; 25 between front tips, $F_1$, 970, 980; 26 $P_1$ width 222, 235; 27 $P_2$ length 396, 367 (mean of left and right); 28 anterior $P$ lobe 141, 125 (mean of left and right); 29 clasper lengths (not here applicable) —.

Head measurements
  30 Head length 543, 582; 31 preocular length 264, 255; 32 preoral length 253, 245; 33 prenarial length 190, 194; 34 internarial distance 179, 184; 35 nasal curtain length 92, 86; 36 nasal curtain width 194, 196; 37 between nasal fimbriae 179, 178; 38 between rostral pores 146, 148; 39 mouth width 148, 159; 40 eye length 36, 35; 41 between orbits 110, 112; 42 between spiracles 156, 155; 43 spiracle length 82, 86; 44 over 1st gill slits 418, 451; 45 prefontanellar length 385, 374; 46 anterior concavity 44, 39; 47 anterior convexity 143, 86; 48 posterior concavity 127, 78; 49 posterior convexity 137, 61. Between disc spines
  50 left-right scapulars 158, 168; 51 spines, one side 316, 337; 52 over precapulars 59, 61; 53 pre- to mediiscapular 76, 87; 54 behind last scapular 46, 47; 55 over lumbar spines 548, 408.

Some additional dimensions, all measured between parallels and recorded as millisemicals of standard length, smaller specimen cited first. Lengths to gill slits 1-5 (mean length on right and left sides as measured, the two values agreeing within 1.4% or less) 183 198 234 229 242, 191 209 226 243 258. Intervals between gill slits (inner ends) 181 172 150 145 138, 171 159 148 134 128. Lengths of gill slits (direct from tip to tip) 19.6 22.0 25.0 24.6 18.2, 23.1 24.8 25.7 26.1 17.8. Length to vent (middle) 489 512, length of vent 26 28. Length to origin of first dorsal 660 674, of second dorsal 839 849. Width of disc at 12 equal intervals along anteroposterior axis from tip of snout to and including posterior border 172 291 370 430 490 520 531 521 496 461 396 274, 160 258 337 400 456 486 493 479 458 425 372 241. (in view of the general inability of the disc in the region the last measurement of each set cannot be regarded as having a high degree of reliability). Preocular length 112 106 (cf. point-to-point 150 123).

South Australian Female Specimen
A description of a female of this subspecies of total length 864 mm, disc width 374, disc length 357, from St Vincent's Gulf, South Australia (Scott 1954, p.108) contains a dozen other dimensions (recorded in mm, here rendered as thousandths of disc width): tail 502, its width at posterior insertion of ventrals 86, eye 28, interorbital 71, preocular length 108, preoral length 116, width of mouth 91, width of internarial valve 96, length of ventral 86, first dorsal height 102, its distance from origin of tail 76, second dorsal height 89, its distance from origin of tail 211. The method of measurement is not specified but it may be presumed distances are measured between parallels.

General Features
The following account is based primarily on the larger individual, La 994 mm, entries relating to the smaller, La 893 mm, being in parentheses; all dimensions are here recorded as thousandths of standard length (TLs). As far as is relevant and expedient it follows, with some extensions, the description (with figures of dorsal aspect and oral region) by McCulloch (1921b) of a young specimen of T. fasciata fasciata 580 mm long from off Sandon Bluff, New South Wales.

Skin of upper surface of disc and tail more or less velvety, that of lower surface in general hard, smooth, glossy. On most of lower surface minute subcircular denticles occur in regularly arranged rows, some 50-60 cm, their interspaces modally less than their diameters; on most of upper surface they are of two or more sizes, less regular in form, less evenly disposed. On dorsal surface of disc from immediately behind scapular arch at 1.8 (1.8) of disc length to origin of second dorsal (first dorsal, McCulloch) a band of small but clearly visible tubercles, set rather thickly, 15-20 cm, width at origin 125 226 (100) at insertion of first dorsal 50 (56) of second dorsal 25 (20).
Disc well rounded, anterior half rather less pointed than in figures by McCulloch and Waite; differing markedly in the snout region in our two specimens in (b) outline here sloping evenly forward and very obtusely pointed (much as in illustrations cited), in (a) at round about one-third of preocular length the width of the outline decreasing abruptly with formation of a -marked median lobe, its length almost one-third its margin of a circle (see below, Aspects of Form). Width of disc just less than, 0.996 its length (just greater than, 1.03) ("a very little narrower than long", McCulloch; 1.05 length, Scott). Width-length equations of both discs are given below. Ventrals wholly anterior segment of approaching linear, its broadly rounded, segment convex length to anterior, tip acute, inner bisinuous, its length 100 greatest width a little more than twice in that between 150 (135).

Preocular length from snout tip to eyeball between parallels 9.57 (9.70) or point-to-point 8.17 (9.08) in length of disc, and, parallels 2.95 (3.70), point-to-point 2.52 (3.08) width of disc at level of eyes. Eyes fairly well elevated above level of snout tip, with strong supraorbital ridges, the space between them flat but sloping somewhat down and forward longitudinally, very concave transversely. Eyeball 2.5 (3.0) (McCulloch, 3.5; 2.5, Scott) in interorbital, 4.5 (4.3) in preocular length, here measured between parallels (McCulloch, 5; 3.9, Scott). Spiracle large, about one-sixth longer than eye, extending forward to just in advance of middle of eye, pointed in front sinusously rounded behind; from its posteroexternal border there projects a stout fleshy structure; viewed from above it constitutes an upwardly convex subtriangular process, its basal width one-fifth length of spiracle, its length half as great again; viewed laterally it is seen to be subextended lengthwise along the middle by a subtriangular fold, the basal (posterior, attached) border of which is subequal to the width of the external base of the structure.

Mouth cleft almost straight at most slightly proconvex, its width, here measured across tooth band of upper jaw, 0.55 (0.60) preoral length ("almost three-fifths of", McCulloch; 0.84, Scott), or 4.47 (5.06) in disc width here. In the larger individual a simple groove, its length about one-seventh width of mouth, curves back from either end
of hind lip; in the smaller individual the groove on the left side, but not that on the right, continues round and back to trace out a blunt recurved process, which, however, achieves no independent existence as a three-dimensional structure, remaining merely outlined on the general plane here by the continuous groove. This dermoglyph is evidently one of the prominent and decidedly larger paired features shown in McCulloch's figure, of which that on the right of the illustration could perhaps be mistakenly interpreted as a process of the nasal curtain. External to the mouth cleft and, except very briefly below the dermoglyph, to these grooves a continuous or subcontinuous groove curves back from about the level of the rictus on either side, then turning inward and running subparallel to the mouth, but being slightly proconcave, thus forming a large transversely elongate loop; width of groove 1.1 that of mouth, greatest distance behind lower lip 0.5 its own length. Within this loop, subparallel to its hind border, from which it is distant about half as far as from mouth, a more or less straight groove, its length approximately equal to half mouth width.

The narial region differs considerably in general appearance from that in the figure by McCulloch, the differences, however, being in part only a question of proportion. Thus: distance from level of outer border of upper rim of narial opening to level of hind border of nasal curtain (nasoral valve, internarial valve) much shorter relative to width of curtain, about 2.5 in latter, in our material 2.1 (2.1); length of opening together with its associated fringing fold much greater, about 0.7 (cf. about 0.4) curtain length, its greater length being largely accounted for by the great width of the fringing fold, about two-thirds (cf. about one-third) its width; anterior border of naris, broadly rounded in the Tasmanian specimens, figured as bluntly pointed; hind border of curtain, virtually coextensive with mouth, shown slightly and evenly proconvex, is slightly sinuous in (a) with approximately the same degree of overall curvature but almost linear in (b). Some distance below the general surface a fold crosses the upper half of the bordering it externally undercut), its lower border continuing inward behind the curtain to constitute the forwardly convex anterior wall of the olfactory sac, the outer half of the posterior wall being formed by an elongate curved process representing a continuation of the external fold flanking the opening behind, the inner half by a separate proconcave fold; distance between hidden pointed inner ends of the right and left sacs about one-fourth greatest width of curtain, which at this level is broadly attached by a transverse base; within the sac, the large fusiform olfactory organ with the usual system of complex folds extends outwards beyond the external outer margin of the nasal opening.

Tooth complement in upper jaw a whitish band about one-tenth as wide as long, surface moderately convex fore and aft curving down most rapidly behind; extending across virtually whole extent of mouth cleft, anterior border rather strongly posterior slightly proconvex; teeth very small, lozenge-shaped, contiguous forming a smooth pavement with round about 70, rows from left to right, up to about 16 from back to front. In lower jaw extending on to external surface in a band, anterior border slightly proconvex posterior more decidedly proconcave, about one-tenth as wide as long, visible length 0.7 that of band of upper jaw; up to about 10 teeth in an oblique anteroposterior row.

Gill slits of moderate size, modally presenting a simple curve or briefly recurved at inner end, 5th sigmoid; length to ist 0.39 (0.40) to 5th 0.52 (0.53) length of disc ("well behind middle of pectoral disc", McCulloch; slightly behind, Scott); antero-posterior extension of series subequal to direct (oblique) distance of 1st from angle of mouth; widths between ist pair 2.88 (2.73) between last pair 3.82 (3.72) in disc widths at respective levels. (For further specifications of gill slits see section, Aspects of Form.)

Tail as measured between parallels from middle of vent to origin of caudal fin slightly shorter than body, 448 Tls (a little longer than, 502 Tls) ("a little longer", McCulloch; 1.01, Scott: tail in Scott includes, and in McCulloch probably includes, caudal fin); stout, its greatest depth two-thirds its greatest width or somewhat greater than (McCulloch, equal to) interocular width or 1.3 (1.1) width of mouth, lower surface flat, lateral strongly dorsal moderately convex, trenchantly divided in respect both of
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character of surface and colour into upper and lower elements by the well-developed lateral fold, originating not far behind commencement of free tail at SS (45) in front of first dorsal origin, traceable back, gradually lapsing to extinction on caudal fin, right to level of end of vertebral column, located in advance of tip of fin by SS (62) ("lost at the base of the caudal", McCulloch).

Dorsal fins located in middle one-third of the total free tail with caudal fin, set rather close together, the interval between them 1.2 (1.1) height of the taller; fins much similar in size and form, first a trifile taller; in the first dorsal the slightly convex anterior border is 1.4 (1.4) the almost straight distal border and 4.6 (4.6) the slightly concave posterior, in second dorsal 1.4 (1.5) and 5.1 (5.4); bases subequal; in first dorsal height 1.8 (1.5) base, in second 1.1 (1.2). Caudal well developed, its length between parallels being 12.7 (14.6) in total length, or 1.3 (1.6) vertical height of first (tailor) dorsal, paddle-shaped, upper border only very slightly convex, distal and ventral borders not sharply differentiated, together presented more or less a single sweep, 2.3 (2.1) as long as wide, wider lobe inserted shortly in advance of upper.

A feature noted by McCulloch, Whitty or Scott and not observed in any other Tasmanian rajids at hand is a pair of grooves on the ventral surface, one on either side of the median longitudinal line, lying behind the gill slits by about one-tenth of the interval between the last pair of these. Each groove comprises a sinuous transverse segment, its length about five-sevenths of mouth width, and an outwardly convex segment the oblique arc of which slopes backward and outward, its length about half as great again as that of the transverse segment; at their anterior ends the grooves approach each other to within 3-4 mm, while the distance between their posterior extremities is 170 (190) TLs or 0.6 of disc width here. Each groove is divided into cells, longer than wide, about 5 in 20 mm, the partitions between which do not in general extend quite up to the level of the general external surface. From its structure this feature would seem probably to be of a sensory or secretory nature.

Aspects of Form

1. Shape of disc. In both individuals the disc overall is broadly rounded attaining its greatest width at seven-twelfths of its length from the tip, the front half being in the larger noticeably, in the smaller somewhat, less convex than the hind half. In the larger disc the tip is quite evenly and rather bluntly rounded, the whole outline presenting a flowing curve, closely approximating those found in the figures of this subspecies by Waite (1921 unnumbered on p.27) of Trigonyrhina fasciata Muller & Henle, 1841, by McCulloch (1921, pl.38 fig.1) and of the South Australian T. melaleuca Scott, 1954 by its author (1954, fig.1); this may well be the modal configuration. In the smaller disc the outline in the anterior one-twelfth is more complex: at the hind boundary of this segment, 39 mm (44 TLs) behind the tip, the width is 172 TLs units; after continuing forward in the same general sense as the curve behind it for a distance of some 15 mm, representing a direct advance of some 10 mm, the disc rim on either side abruptly approaches a direction normal to the general anteroposterior axis, the least width now being only about 105 TLs; arising from the short right and left platforms thus established the remainder of the anterior outline takes the form of a clearly differentiated evenly rounded arc, its chord about three and a half times its length. It may be observed that in rays in general variability of outline tends to be more pronounced, at both the specific level (where it may be diagnostic) and the individual level, in the anterior than in the posterior moiety of the disc, the latter commonly being or approximating a simple conic curve.

With eleven measurements of width taken at equal intervals between the tip and the level of the hindmost point on the posterior border the disc outline is very satisfactorily specified in each case by a second degree polynomial. The data below are for widths as thousandths of 'standard length' (to base of caudal fin), the larger individual noted first. Initially twelve measurements were made. However, that representing the distance between the most posterior points of the disc on either side was in the event rejected—an accurate determination being found to present some difficulty in view of the general lability of the disc in this region; further, calculation with twelve variates...
demonstrated the inability of a second degree or even a third degree polynomial to cope satisfactorily with the sharp decrease in magnitude of the width here (thus for the smaller specimen predicted values for the eleventh and twelfth widths were 379, 387, measured 396, 374; a striking contrast to the accurate predictions of equations for eleven variates). The grid of measurements at twelve equal intervals between anterior and posterior boundaries of the disc here adopted misses the pronounced local variation in outline just behind the tip in the smaller ray.

\[ W = 44.75 + 124.11 N - 8.015N^2 \]

Calculated (measured) widths: 160(160), 258(258), 340(337), 403(400), 450(456), 479(486), 491(493), 486(479), 464(458), 424(425), 367(372). \( R = 0.9978 \). \( W = 34.15 + 153.12 N - 9.282N^2 \), 178(172), 283(291), 370(370), 438(436), 488(490), 519(520), 531(531), 325(321), 500(496), 457(461), 385(390). \( R = 0.9994 \).

The addition of a term in \( N^2 \) yields only a marginally better fit (\( F = 0.496 \) 0.092).

In addition to some obvious difference of form already noted some other features distinguish the discs. With dimensions made directly comparable by being expressed as millesimals of standard length it is found that of the smaller example is longer relative to general length (524 v. 495) and also is relatively wider (1 mean 424.9, 160-493 mean 392.9). Without examination of further material it cannot be determined whether these variations are size-determined or are merely individual.

Not only do the specimens differ in overall relative length and relative width, they exhibit also variation in the proportional widths of their anterior and posterior sections, as is apparent from the subjoined equations for, first the outline from the tip to the maximum width, secondly, that from (and including) the maximum width to the posterior border (dimensions as \( TLs \), larger individual first).

Front half:

\[ W = 43.14 + 124.71 N - 8.503N^2 \]

(Percentage variation of predicted from measured widths 0.0-1.4 mean 0.46).

\[ W = 49.43 + 136.16 N - 9.631N^2 \]

(Percentage variation 0.0-2.7 mean 0.92).

Hind half:

\[ W = 489.28 + 8.71 N - 6.428N^2 \]

(Percentage variation 0.0-0.7 mean 0.16).

\[ W = 520.00 + 18.43 N - 8.571N^2 \]

(Percentage variation 0.2-0.9 mean 0.47).

Hence while the sample widths both in the anterior halves of the two discs and in their posterior halves are strongly correlated, specimen with specimen (\( r = 0.9991 \) 0.9986, \( n = 5.835 \) 3.645) the parameters of the regression of one individual on the other differ noticeably when front and hind sections are compared. With the data for specimen (b) of \( La 994 \) mm plotted against those for (a) of \( La 893 \) mm the best straight lines are as below:

\[ W_A = 0.886W + 20.35, t = 33.14** \]

\[ W_A = 0.955W - 10.62, t = 51.71*** \]

\[ W_B = 0.9429 \log N + 2.4237, t = 23.20** \]

\[ W_B = 0.9722 \log N + 2.4153, t = 21.81** \]

2. Head, length to vent, standard length (head is here taken as length to 5th gill slit, standard length as length to origin of anterior (lower) caudal lobe). In a loglog plot these three dimensions are significantly linear on integral 1 2 4. With lengths as \( TLs \) the best straight lines are as below (here, as customarily in these studies, minimization of the sum of the squares of deviations is performed for the logarithmic, not the arithmetic, deviations — in general it is found the two solutions do not lead to a significant difference in the formulation).

\[ \log L = 0.9429 \log N + 2.4237, t = 23.20** \]

\[ \log L = 0.9722 \log N + 2.4153, t = 21.81** \]

3. Origins of first dorsal, second dorsal, caudal fins. These dimensions are linear on a loglog plot on 9 10.

\[ \log L = 1.7115 \log N + 1.2320, t = 15.06** \]

\[ \log L = 1.9349 \log N + 1.1347, t = 17.41** \]
4. Transverse distance between gill slits. It has been found in some unpublished investigations on sharks and rays that, in a loglog context, certain measurements involving gill slits, comprising length to length of and transverse distance between slits, are specifiable in terms of the sequential numbers of the slits. However, it would appear that in general one or other of the terminal slits (1st or 5th) stands outside the pattern presented by the remainder. In the case of the present material, when the transverse intervals (I) between slit pairs 1 2 3 4 5 are plotted on loglog paper on their respective serial numbers, it is seen that for variant 2, 3, 4 5 intervals are effectively similar while slit 1 on 5 lies outside the series. For the relevant variants the best straight lines are:

\[
\log I = 0.2593 \log N^5 + 2.0905; \quad t = 33.754**; \quad \text{calculated intervals, } TL\alpha, 145\,160\,172\,181.
\]

\[
\log I = 0.2618 \log N^5 + 2.0473; \quad t = 29.478**; \quad 154\,140\,160\,170.
\]

5. Lengths to gill slits. With lengths (between parameles) from tip of snout as measured on right and left sides averaged (lengths for the two sides differing by a maximum of 1.4\% mean - 1\%) it is found that in a loglog plot the lengths to slits 2-5 on their serial numbers are linear; with length to slit 1 outside the line.

\[
\log L = 0.2151 \log N + 2.2798; \quad t = 3.994 \text{ (just short of significance at } P = 0.05; 4.503; \text{ calculated lengths, } TL\alpha, 221\,242\,257\,269.
\]

\[
\log L = 0.2358 \log N + 2.2484; \quad t = 15.181**; \quad 209\,230\,246\,259.
\]

6. Lengths of gill slits. In a loglog plot the lengths of slits 1-4 are linear on their serial numbers; with length of slit 5 well outside (below) the line of positive slope.

\[
\log L = 0.1579 \log N + 1.2921; \quad t = 9.908*; \quad \text{calculated lengths, } TL\alpha, 19.6\,21.9\,23.3\,24.4.
\]

\[
\log L = 0.08908 \log N + 1.3661; \quad t = 12.822**; \quad 23.2\,24.7\,25.6\,26.2.
\]

7. Overall curves for gill slit variates. In formulations above it has been shown that the transverse interval between, the lengths to and the lengths of the gill slits are functions in a loglog plot of the serial numbers of the slits, with one of the terminal members of the series (1st or 5th slit) lying outside the specification. In view of their very wide occurrence such simple magnitude-number relations are clearly worthy of record even in a curtailed series. However, the question of the overall curves for the complete populations is itself a matter of separate interest, and polynomials of the third degree are to precise of the data. All slits, the relevant arithmetic (logarithmic) magnitude, expressed as millesimals of standard length, here being associated with their ordinal numbers. The relevant equations, together with values predicted by them and an indication of goodness of fit, are presented in table 1.

Coloration

The ground color of the upper surface is reported as varying "from sandy to light brown, yellowish, dark brown, even greyish at times, according to the immediate environment" (Stead 1963).

In both our specimens as preserved the ground color of the upper surface of the disc and tail is almost uniform dark somewhat greenish brown approaching black; pelvics a little lighter distally; dorsals dark elephant, a trifle lighter along distal margin, caudal concolorous with dorsals except area occupied by vertebral column which is concolorous with general dorsal surface. When first examined both individuals presented an elaborate pattern of bands of a light color approximating lilac, bordered along each margin by a narrower band of very dark brown, disposed along and symmetrically on either side of the median line — somewhat suggestive of the scroll-like holes and purlings in the belly of a violin, whence the vernacular name "fiddler ray" — the general arrangement being in close agreement with that shown in the figure (Waite 1921) of T. faaioata guanerius, departing clearly from that in the standard figure (McCulloch 1921a) of the typical subspecies. The markings have almost disappeared in (b) but most are still traceable in (a), main band greyish, modally some 10 mm wide, bordering lines usually of even width throughout (modally about 4 mm) dark brown.

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Measurements involving gill slits defined by \( Y = A + BN + DN^3 \), where \( N \) = serial number of slit; dimensions as millesimals of standard length. Two specimens from the estuary of the Tamar River, northern Tasmania, (a) standard length 893 mm (b) 994 mm.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Transverse interval</th>
<th>Length to slit</th>
<th>Length of slit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specimen</td>
<td>(a)</td>
<td>(b)</td>
<td>(a)</td>
</tr>
<tr>
<td>( A )</td>
<td>179.00</td>
<td>176.00</td>
<td>170.20</td>
</tr>
<tr>
<td>( B )</td>
<td>9.05</td>
<td>-1.19</td>
<td>11.15</td>
</tr>
<tr>
<td>( C )</td>
<td>-8.037</td>
<td>-4.607</td>
<td>1.892</td>
</tr>
<tr>
<td>( D )</td>
<td>0.91677</td>
<td>0.58333</td>
<td>0.24990</td>
</tr>
<tr>
<td>( R )</td>
<td>0.9999</td>
<td>0.9987</td>
<td>1.0000</td>
</tr>
<tr>
<td>Calculated (measured)</td>
<td>181(181)</td>
<td>170(171)</td>
<td>183(183)</td>
</tr>
<tr>
<td>values</td>
<td>172(172)</td>
<td>160(159)</td>
<td>198(198)</td>
</tr>
<tr>
<td>145(145)</td>
<td>135(134)</td>
<td>229(229)</td>
<td>243(243)</td>
</tr>
<tr>
<td>138(138)</td>
<td>128(128)</td>
<td>242(242)</td>
<td>258(258)</td>
</tr>
</tbody>
</table>

The overall color of the ventral surface is ivory. In both individuals the disc is bordered in its hind half by a dark brown strip, regularly widening backward, up to about 60 in (a); the color in each case lightening inward; in (a) more or less continuously to end in a scalloped line of light grey, in (b) in two more or less distinct bands; in (b) this lateral darkening becomes apparent behind level of mouth, in (a) it is traceable forward virtually to tip of snout, here only 2-3 mm wide. Both examples present some dusky smudging, in (b) in scattered and quite irregular lines and patches on hind half of disc and front half of tail, in (b) chiefly as a large roundish smoky area surrounding vent and a smaller oval area at base of tail. In the larger specimen about five score of conspicuous black spots or splashes, mostly 3.5 mm in diameter a few much smaller, are scattered over the whole prenarial area, with half a dozen extending back to just behind level of mouth: in the smaller there are no more than ten, decidedly lighter, just behind left half of mouth.

**FAMILY BERYCIDAE**

Of the five Australian fishes referred to this family in the majority of texts from the Check-List (McCulloch 1929) onward one only appears in any Tasmanian list, *Centroberyx affinis* (Gunther, 1859) — by Johnston (1883, 1891) listed as of the genus *Beryx* Cuvier, 1829, by Lord (1923, 1927) and Lord & Scott (1924) as of the genus *Trachichthys* Gilchrist, 1903 and referred to the family Trachichthyidae (the members of which as it is currently recognized have II-I11 (modally III) anal spines whereas the berycids characteristically have IV, occasionally III-IV). This deepwater species, recorded from all Australian States (and New Zealand) was noted by Johnston as rare in Tasmania. The distribution of the second local species, *Beryx decadactylus* Cuvier, 1829, is given in the Check-List as Victoria and Bass Strait but Tasmania is expressly cited along with Victoria in the Handbook (Munro 1958); it has a wide distribution, being also met with in both the Pacific and Atlantic oceans.
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KEY TO BERYCIDAE RECORDED FROM TASMANIA

Dorsal with 7 spines, 11-12 rays. Anal with 12 rays, base (sloping) subequal to base of second dorsal. Red above cream below, with longitudinal red streaks ....................... Centroberyx affinis

Dorsal with 4 spines, 16-19 rays. Anal with 28-29 rays, base (sloping) about 1/4 base of second dorsal. Uniform carmine ......................... Beryx decadactylus

Genus Beryx Cuvier, 1829

Beryx decadactylus Cuvier, 1829, REGN. ANIM., ed.2, p.151. Type-species, Beryx decadactylus Cuvier.

Beryx decadactylus Cuvier, 1829 (Fig. 1)

Remarks

The vernacular name in the Handbook (Munro 1958) in which the first "a" of the second binomen is inadvertently omitted is the widely adopted "imperador", the other Australian species of the genus, B. splendens Lowe, 1834 being designated the "alfonsin". This reaches English dictionaries as a general name for several berycid fishes found at Madeira and in the West Indies, and Gunther (1887, p.32) quotes Lowe (1843) as reporting that Madeiran fisherman, engaged in an important fishery involving this family, call the present species the "Alfonsin a casta larga" and B. splendens as the "alfonsin a casta cumprida", its body being noticeably the shallower of the two. Australian records note the occurrence of B. decadactylus at 330-435 m, while the Challenger collected examples off Inoshima in 535 m. Remains attributed to Beryx and allied genera have been found abundantly in the Cretaceous.

Tasmanian Record

A specimen, La 385 Et 511, taken by Mr Shane Down 23 km east of Bimalong Bay, east coast, in 330 m in March 1980 (Q.V.M. Reg. No. 1980/5/54).

Meristic Characters

Counts in parentheses given first are those of the Handbook (Munro 1958, p.78) followed where appropriate by those in Matsuda, Araga & Yoshino (1975). O. IV, 20 (IV, 18-19; IV, 16-20). A. IV, 50 (III-IV, 28-29; III-IV, 27-30). V. I, 10 (1, 10; I, 9-10). P. left 16, right 20 (15-16; 16-18). C. main 24. L. lat. 73 L. (9-10/17-18). Gill rakers on lower anterior arch 19, slender, somewhat flattened, bluntly pointed, decreasing in length ventrally, longest half snout. The higher count in the right pectoral of the present specimen is accounted for by the occurrence of additional small and very small rays at the beginning of the lower border of the fin; clearly an individual peculiarity. The caudal fin is preceded above from the dorsal termination back by a series of spines developed as prolongations of the scales of the superior profile; approaching the fin base these increase notably in length (last four 4, 13, 25, 46 The), the hindmost virtually becoming an integral element in the overall structure of the fin. On the ventral surface a series of some eight scales without spines is followed by two spines 17, 23 long. Some observations on these pseudospines are made below in the account of Centroberyx affinis.

Dimensions as The

Length to end of upper caudal lone 1296 to end of lower caudal lobe 1372 to end of middle caudal rays 1169. Length to origin termination of dorsal 475 714 of anal 631 909.
Handbook (Munro standard length Aspects of Form Length of head, primary dimensions
L : 0.523 996 (1.000).

Location of dorsal origin anal origin dorsal termination anal termination caudal origin fall collinear with statistical significance (± 45.3242) on (3 5 6 9 10), the equation of the best straight line being:

\[ \log L = 0.6116 \log N + 2.5418 \]  

for calculated (measured) lengths, TLs = 348(551) 523(517) 064(1 000).

A comparison of the location pattern of vertical fin origins and terminations in this species with those for Centroberyx affinis (Günther, 1859) (in which the integral abscissal coordinates are 3 5 7 8 10) and Paraberyxichthys trauli (Hutton, 1876) (in which they are 2 5 6 7 10) is exhibited in fig. 1.

Anal spines. In a number of diverse species possessing three anal spines a common pattern that has often been noted in these studies has their logarithmic lengths a function of the logarithms of their serial numbers. While in the four other berycids found in Australian waters the spines are regularly IV (regularly so also in the allied polyzoids and the still more closely allied holocentrids), the count in the "imperator" may be either I I I or as in our example IV. In the present fish these constitute two pairs with their lengths falling in a loglog graph on the first two and the last two of the natural-number series 1-10:

\[ \log L = 0.9539 \log N + 1.1752 \]  

for calculated (measured) lengths, TLs = 111(10) 22(24) 91(80) 101(99).

Dorsal spines and rays. In this specimen the four dorsal spines exhibit the same length-number pattern as the four anal spines, being two pairs of markedly different size with their logarithmic lengths collinear when plotted on logs 1 and 2 and logs 9 and 10.

\[ \log L = 0.8810 \log N + 1.1752 \]  

for calculated (measured) lengths, TLs = 15(16) 28(26) 104(106) 114(113).

The dorsal rays show some irregularity in length, increasing to 2nd then decreasing to 11th; 12th ray marginally longer than 11th but lengths then decreasing to 17th, with 17th < 18th < 19th < 20th. The logarithmic lengths of the set of seven rays 5th-11th is significantly linear, (± 23.0892), on (as usual in a descending series) the logarithms of their reverse serial numbers, i.e., on logs 10-16.

\[ \log L = 1.1923 \log N + 0.8071 \]  

for calculated (measured) lengths, TLs = 124(125) 137(140) 149(153) 162(161) 175(169).

Ventral. The presence in this family (and in some other Beryciformes) of a number of ventral rays in excess of the very widely found complement of 5 has long been interpreted
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3.0
2.8
2.6
2.4
2.2

LOGARITHMIC LENGTH TO POINT

FIG. 1 - Location of dorsal origin, anal origin, dapsal termination, anal termination and caudal origin according to the relation \( L = b N^k \), where \( L \) = length to origin or termination (measured as thousandths of standard length) \( N \) = a natural number (2-10); illustrating the permutations exhibited by the related species, Centroberyx affinis (Günther, 1859), top graph, Beryx beaudardiplus Valenciennes, 1829 and Paraberyx caudata Hutton, 1875, bottom graph.

As found in our sub­successively the logarithms of 12 (Boulenger 1910) as the retention of an archaic character. Among Australian Berycidae three species have 7 rays while in Beryx splendens Lowe, 1834 the count ranges from 10 to 13 (such variability in this normally constant fin presumably being indicative of evolutionary instability). In the 10 in the present species the lengths (as found in our example) increase from first ray (defined as that farthest from spine) to ninth, with (as is usual also in 5-rayed fins) the last ray a little shorter than the penultimate, sub­equal to the antepenultimate. As is modally the case with the set of four successively longer rays, the logarithmic lengths of the nine here are a function of the logarithms of their serial numbers:

\[
\log L = 0.54 \log N + 1.8875; \quad t = 27.591***; \quad \text{calculated (measured) lengths, } TLa, 77(82), 112(106), 140(134), 163(158), 184(184), 204(210), 221(226), 237(242), 253(250).
\]

Precaudal pseudospines. The lengths (4 13 25 46 TLa) of the four spine-like processes developed on the dorsal profile immediately in advance of the caudal are related to their serial numbers thus \( L = b N^k \), the slope of the rectified equation \( (k) \) being 1.7369, the intercept \( (\log b) \) 0.5949: \( t = 75.737***; \) calculated values of \( L 4 13 27 44. \)
General Features

Maxilla to below 0.5 eye, its greatest width 0.42 its length (165 TII). Isthmus to below 0.1 eye. Pectoral to level of 13th dorsal ray, ventral to base of 3rd anal spine. Lower jaw slightly projecting, a median knob fitting into edentulous segment of upper jaw. Oval posterior nostril about one-sixth eye, its distance from orbit twice its length, one and a half times its distance from posterior nostril, which is about half as large, more rounded. Teeth in upper jaw in right and left narrow bands tapering anteriorly to a point, in oblique rows of up to a dozen, minute pointed, not or barely erect directed inward and backward, a symphysis diastema with arc about one-fifth eye diameter; in lower jaw much as in upper, anterior ends of bands less than half as far apart; on vomer somewhat larger, in a transverse strip with anterior border convex posteriorly slightly sinuous, 5-6 rows at its middle; on palate a single row of upwards of two score, larger than in jaws strongly recurved, acute.

Scales extending forward on to occiput in a conspicuous sharply delimited broad pennon reaching nearly to level of front of orbit, its width at back of eyes subequal to sum of widths of flanking scaleless strips there. Naked area of dorsum and whole of pre-orbital with numerous scattered minute pits with low subcircular rims. Operculum with some irregular scales much less clearly defined than those of flank. A scale sheath along whose base of anal of virtually even height throughout, 2-3 rows of scales proximally, smaller than adjacent scales, external to these a single row of decidedly larger, less pigmented scales forming a distinct frill-like somewhat crenulated free border; a rather less developed sheath along dorsal base; on caudal a conspicuous median lingulate squamous extension backward from general caudal peduncle to end of median caudal rays.

Coloration

The "imperator" is a handsome species, being bright uniform carmine on the whole of the head and body and all the fins. The inside of the mouth is mostly whitish with some traces of pale pink (contrast the "alfonsin", Beryx splendens Lowe, 1854, with inside of mouth bright red).

Genus CENTROBERYX Gill, 1862

Beryx Cuvier, 1829, REGN. ANIM., ed.2, p.151. Type-species, Beryx demadaoaty, Cuvier.

Hoplopteryx Agassiz, 1839, POISS. Ross., 4, p.4. Type-species, Hoplopteryx dentiolum Westward. (Spilth Hoplopteryx, p.131.)


Australberyx McCulloch, 1911, p.39. Type-species, Beryx affinis Günther.

Centroberyx affinis (Günther, 1859)

Fig. 1

Beryx affinis Günther, 1859, p.13. Type locality: Australia (Warwick) [=Sydney], fide McCulloch (1929, p.131).


Australberyx affinis: McCulloch, 1911, p.43, Fig.11.

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Note on Vernacular Name

There has been some continued confusion regarding the vernacular name of this species, early on concerned only with differences in orthography, more recently involving quite different appellations. Oliver (1871) described it as moora namiga'; Macleay (1881) headed his description "the Nannygai of Sydney fishermen`; Tonisson-Woods (1882) gave reasons why the aboriginal name mara ngi a gi pt had been corrupted to mar a dii, this last rendered "Mother Mar a dii" by Whitley (1962). From the first Australian catalogue of Macleay (1881) onward to the revised South Australian catalogue of Scott, Glover & Southcott (1974) systematic authors in Australia have almost invariably used nannigai nanuqal nuddei nanaqal (Castelnau, 1978) or nannigai the first being the preferred form. The Handbook (Munro 1958) provides an exception, giving redfish as an alternative name.

However, a different position has obtained more or less consistently for some two decades in the literature of commercial fisheries. While the first list of uniform names agreed upon at the annual conference of Australian Fisheries officers in February 1947, published as a large single-sheet supplement to the Commonwealth Government's Fisheries Newsletter (June 1947) compiled by G.P. Whitley and covering some 40 does not include the present species, a second list (containing 57 names, some of which were changes in the names agreed upon in 1947) formulated by a similar conference in September 1960 and published shortly afterwards (Fisheries Newsletter November 1966, p.71) gave the official vernacular name as redfish. Regarding this change of name Thomson (1974, p.117) observed this fish "is one of the best sellers under the name of redfish which the public accepted as they never did the exotic [sic] name of nannigai". Centroberyx affinis has since appeared in the Fisheries Division's periodical as redfish in monthly and yearly tables of weights of catches and market prices; special illustrations include a colored cover picture (Australian Fisheries Newsletter, February 1971), with text "Redfish or nannigai", and No.37 in a series of 60 paintings by Robert Ingpen (Australian Fisheries, February 1975, unnumbered centrefold between p.40 and p.41).

Several tangential elements of confusion remain to be noted. The closely allied, morphologically similar Trachichthodes gurnardus (Günther, 1887) — figured in color in Australian Fisheries (June 1978) — formerly known as red snapper or right snapper [Snapper = Chrysophrys guttulatus Valenciennes, 1830] is now officially designated Bight redfish, the change being made "in the hope of better selling" (Thomson 1974, p.121). In a comparison of 5 species of Berycidae Thomson (1977, p.86) heads his key, comprehensively, "Redfish". Pollard (1978, p.102) applies the name nannigai to Trachichthodes lineatua (Cuvier, 1829), previously widely known as the swallowtail, remarking "not to be confused with Centroberyx affinis or redfish". As further, it may be hoped final, complications Marshall (1964, p.128) reports that nannigai is used at the Brisbane Fish Market for Glauocoma squamulare Macleay, 1881 (Glauocomidae), elsewhere commonly known as pearl fish, pearl perch or epaulette (or epaulette fish), and Roughley (1951, p.27) states nannigai has appeared with this connotation in the official annual reports of the Queensland Fish Board. Again, Grant (1978) dealing also with Queensland usage, lists nannigai, large-mouthed nannigai, small-mouthed nannigai as alternative names for Lethrinus chrysostomus Richardson, 1844, Lutjanus malabaricus (Bloch & Schneider, 1801), Lutjanus sangalinus (Cuvier, 1828), for which the preferred vernaculars are sweetlip or sweetlip-emperor, scarlet sea-perch, saddle-tailed sea perch, respectively.

Commercial Importance

In New South Wales Centroberyx affinis is one of the State's most abundant food fishes. Examination of the tables of fish market returns published monthly in the Australian Government Australian Fisheries, in which it is listed under redfish, shows
that in 1971, it occupied first place by weight in 6 months second in 5 third in 1, the recorded catches ranging from 68 699 kg to 330 980 kg, mean 154 687 ± 23 465. It is, however, decidedly the cheapest of the fish listed, the price being 29-64 (mean 42.4) cents per kg. It does not appear in either of the lists for Victoria or Queensland, the only other states for which returns are published. Roughley (1951) stated the catch of approximately 45 000 kg of this fish in 1944-5 increased in 1948-9 to 2 500 000 kg or 38% of the total catch of the trawlers and Danish seiners.

It is of interest to note in passing that five other fish found in Tasmanian waters are represented among the three at the top of the tables, namely, gombfish, Reaxa solandri (Cuvier, 1822) (in Tasmania traditionally kingfish or Tasmanian kingfish, also king barracouta, hake; appearing in local lists also in the genera Thryraeas Cuvier, 1832, Jordaniida Snyder, 1911): the name hake, inviting confusion with the unrelated European Merluccius vulgaris remained in general use till the decision in 1974 of the Standing Committee on Fisheries (Australian Fisheries May 1975, p.18) that the fish should henceforth be marketed in New South Wales as gombfish (a name suggested (Australian Fisheries September 1974, p.12) by that of the family to which it belongs, Gempylidae) occupying first, second and third position in 3, 3, and 2 months; "flathead, trawled" (unspecified Platycephalidae) in 2, 1 and 3; morwong, Nemadactylus macropterus Bloch & Schneider, 1801 0, 2 and 5; sea (bully) mullet, Mugil cephalus Linne, 1758 2, 0 and 0; snapper, Chrysophrys guttulatus Valenciennes, 1830 (appears in the Check-List (McCulloch 1929) as a synonym of Labrus auratus Bloch & Schneider, 1801 referred by McCulloch to Pagromone Gili, 1893) 0, 0 and 1. Mean prices, cents per kg, quoted in New South Wales in 1975 for these five items were in sequence as above, 43-116 (mean 80.7), 88-143 (109.7), 91-181 (120.9), 42-118 (76.0), 210-400 (307.5). Of these species the deep-water Centroberyx affinis is, as noted earlier, seldom taken currently in Tasmania; Chrysophrys guttulatus also is uncommon; Mugil cephalus is abundant particularly on the eastern and northern coasts and is a familiar sight in fish shops; of Reaxa solandri Johnston (1881, p.25) wrote "Season, December to June. Come go in vast numbers, but disappear in some years altogether", while Lord & Scott (1924, p.81) observed "At one time these fish were abundant in Tasmanian waters, and constituted one of the chief food fishes, but they are now seldom caught", currently they make an occasional appearance in the market; several species of platycephalids are among the best known commercial fishes and are also taken in very great numbers by amateur anglers, often by spearing at night.

An important paper on the distribution and general biology of the nannygai is that of Selickaya (1971), based on material from the TNIR expeditions that carried out research in the Great Australian Bight in 1965-1967. Conclusions arrived at include: Centroberyx affinis is found in the Bight regularly between 124°40'E and 134°35'E in waters at 13°-19°, the largest catches in the central part being in 150-175 m, in the western part in 170-200 m; though a large number of trawlings were carried out, no fish were obtained outside the range 64-225 m; a substantial upward migration occurs in March-April, the latter month being the climax of the breeding season (February-March); the sex ratio is close to 1:1; the chief food is euphausians, with supplementation from prawns, crabs, fish.

Regarding the occurrence of this species in Tasmania, Johnston (1883) noted "Rare" and Lord & Scott (1924) observed "Not often taken in Tasmania. Trawling operations would doubtless secure many of this species, for they are occasionally taken off the coast. Mr. W. Beddome secured a number a few years ago when fishing from his yacht near the entrance to D'Entracasteaux Channel". Two entries in Johnston's memorandum, redacted by Whitley (1929) show the interest with which local occurrences were regarded by the doyen of Tasmanian ichthyology. "A fine specimen" caught in the Derwent in 1895 — "Examined by me and found to be in all characters identical with those caught more abundantly near Sydney", the second may be quoted verbatim from Whitley. [Note added much later, in shaky handwriting:] 4 specimens in Fish Shop, Elizabeth [Street, Hobart]. Caught in Derwent Estuary, 14th March, 1918. One of the specimens about 15 inches [38 cm] long. Evidently this is the season when the "Nannegai" Centroberyx affinis enters the estuary of the Derwent. R.M.J."
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Material

The primary data here reported has been provided by an example, (a), Le 231 at 31°5', taken by Miss P. Bennell at St Helens (Q.V.M. Reg. No. 1958/5/26). Observations on this Tasmanian fish have been supplemented by an examination of six smaller Victorian specimens (b)-(g) made available through the courtesy of Dr Martin F. Coman, Curator of Fishes, National Museum of Victoria, Melbourne - (b) (c), Le 117,111 Le 161,155, Victoria, 16 km south of Lakes Entrance, taken with Danish seine by the Tambo Bay, November 1973, Acc. No. 79.1; (d) (e) (f) (g), Le 101.5,101.90,19.5 Le 134,130,123.5, Victoria, off Phillip Island, 38°32'S 145°15'E, collected by N. Mitchell and T. Montague, 7 August 1979, Reg. No. As30.

Meristic Characters

Figures in parentheses denote number of instances. B. VII, 11(1) 12(5) 13(1). A. IV, 12(5) 15(2). V. 7. P. 1, 12(13) 15(1, left fin). C. 19(6) 15(1) (modally, upper and lower moieties each with 9 rays and an asygun median ray), preceded above and below by 5 pseudospines (see below). L. lat. 41(1), 45(5), 44(2), 45(1). L. tr. 6/11-13. Gill rakers on anterior arch 9-11 + 19-21, slender elongate more or less rodlike but slightly compressed, delicately spinulose along two edges, increasing from above and from below to angle of arch where they are subequal in length to longest gill filaments.

Dimensions

Dimensions of the seven specimens are set out in table 2, all entries being millimetre or thousandths of standard length, except those of the first line which record standard length in millimetres.

Proportions

The principal diagnostic proportions of the adult example are followed by the range and the mean with standard error of the six juveniles; values in parentheses are those of the Handbook (Munro 1958a, p. 78). Depth in standard length 2.22; 2.02-2.29; 2.11 ± 0.47, in total length 2.84; 2.81-3.19; 2.93 ± 0.7 (2.6-3.3). Depth of caudal peduncle in head 3.11; 2.09-3.07; 2.90 ± 0.7. Head in standard length 2.75; 2.59-2.75; 2.65 ± 0.02, in total length 3.51; 3.63-3.76; 3.69 ± 0.02 (3.4-3.5). Snout in head 5.50; 3.70-4.67; 4.01 ± 0.15, in eye 1.13; 1.19-1.70; 1.35 ± 0.09 (1.20). Eye in head 3.11; 2.73-3.12; 2.99 ± 0.09 (3). Interorbital in eye 1.21; 0.98-1.18; 1.06 ± 0.002. Pectoral in head 1.35; 1.05-1.21; 1.15 ± 0.03, in standard length 3.59; 2.78-3.19; 3.01 ± 0.08. Ventral in head 1.67; 1.40-1.51; 1.47 ± 0.03, in standard length 1.72; 1.71-1.78; 1.73 ± 0.01. Dorsal base in standard length 2.64; 2.69-2.96; 2.79 ± 0.05. Anal base in standard length 3.91; 3.64-4.14; 3.96 ± 0.09. Within the (narrow) length range of the juvenile set (though not with the inclusion of the adult) relative depth exhibits significant positive correlation with standard length ($r = 0.977 \pm 0.057$) and with total length ($r = 0.916 \pm 0.045$). No other clear correlations are apparent in the small sample.

General Features

The following account is based in the first instance on the adult Tasmanian specimen, variations exhibited by the Victorian juveniles receiving separate notice. Maxilla to just beyond hind margin of eye (in (b) (c) to hind margin, (d) (f) to 0.9 eye, (e) (g) to 0.8 eye); Handbook "to below hind half of eye": its greatest width 0.43 (0.40-0.45 ± 0.027 ≤ 0.007) its length, which is 203 TLs (188-207 ± 197.4 ± 2.59). It is largely overlapped by a rugose orce bone covering half or more of the width of most of the shaft and occupying the upper one-third or so of the expanded distal end, its linear (in young delicately denticulate) border here surmounting a broad subtriangular smooth maxillary component of the jaw. Isthmus to below anterior margin of orbit, its squamous part about to level of middle of eye. Dorsal originating over pectoral base, ending above 7th (7th-9th) anal ray, anal originating below 3rd (1st-3rd modally 1st) dorsal ray, pectoral extending to level of 5th (2nd-5th) dorsal ray, ventral extending to base of 1st (1st-3rd) anal spine. Upper lobe of caudal noticeably the longer (in (f) lobes subequal); emargination marked, the difference between length to tip of upper caudal lobe and length to end of middle caudal rays 229 (159-263 ± 197.3 ± 17.3) TLs, the excess in the juvenile sample showing negative correlation with standard length ($r = -0.854 \pm -1.274 \pm 3.205$).
<table>
<thead>
<tr>
<th>Dimensions of (a) an adult Tassie example, (b)-(g) six Victorian juveniles. Entries in the first line, standard length, in millimeters, all other entries as millimeters of standard length.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard length</strong></td>
</tr>
<tr>
<td><strong>Length to end of upper, lower caudal lobe</strong></td>
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<tr>
<td><strong>Length to end of middle caudal rays</strong></td>
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<tr>
<td><strong>Length to origin, termination of first dorsal</strong></td>
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<tr>
<td><strong>Length to origin, termination of second dorsal</strong></td>
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<tr>
<td><strong>Length to origin, termination of anal</strong></td>
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<tr>
<td><strong>Length to pectoral, total length of fin</strong></td>
</tr>
<tr>
<td><strong>Length to longest pectoral ray</strong></td>
</tr>
<tr>
<td><strong>Length to ventral, total length of fin</strong></td>
</tr>
<tr>
<td><strong>Head</strong></td>
</tr>
<tr>
<td><strong>Snout</strong></td>
</tr>
<tr>
<td><strong>Eye, interorbital</strong></td>
</tr>
<tr>
<td><strong>Length to max</strong></td>
</tr>
<tr>
<td><strong>Length of dorsal spines</strong></td>
</tr>
<tr>
<td><strong>Length of anal spines</strong></td>
</tr>
<tr>
<td><strong>Lengths of superior pseudes- spines</strong></td>
</tr>
<tr>
<td><strong>Lengths of inferior pseudes- spines</strong></td>
</tr>
<tr>
<td><strong>Lengths of first, last, longest dorsal rays</strong></td>
</tr>
<tr>
<td><strong>Lengths of first, last, longest anal rays</strong></td>
</tr>
<tr>
<td><strong>Lengths of ventral rays; spine</strong></td>
</tr>
<tr>
<td><strong>Depth before eye, behind eye</strong></td>
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<tr>
<td><strong>Depth at opercular border, at vent</strong></td>
</tr>
<tr>
<td><strong>Maximun depth</strong></td>
</tr>
<tr>
<td><strong>Depth at caudal peduncle</strong></td>
</tr>
</tbody>
</table>
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Lower jaw projecting, with a broad medial process, its frontal aspect in the form of a truncaated triangle (less conspicuous, more rounded in juveniles), each side with a row of 6-7 teeth, the innermost largest (in some juveniles subequal); a cluster of obscure odontoid processes on external surface at the base on either side (barely or not developed in juveniles); the whole fitting into an edentulous notch in upper jaw. Posterior nostril elliptical, its major (vertical) axis about one-sixth eye, its distance from orbit subequal to its length and to distance between its anterior border and anterior border of the posterior nostril, the latter somewhat smaller, more nearly round; both with a raised rim, that of the posterior wider, somewhat more elevated: internarial about two-thirds eye. Teeth in the upper jaw in a narrow transversely rounded band, minute, tuberculate, except for a small space anteriorly, rather less than an eye diameter, where there are a few (left side 5, right 10) larger blunt peglike teeth (rather less clearly differentiated in juveniles); behind the medial process in the lower jaw teeth larger than in upper jaw, though still small, mostly biserial in parts triserial; on vomer small, blunt in a small patch, subtriangular, apex anterior (or with the sides of the triangle produced briefly back behind the base); on each palatine in a band similar to that in one side of the upper jaw.

Scales strongly ctenoid, modally with about three dozen long slender spines projecting beyond exposed margin, usually near middle, extending forwards as conspicuous parallel ridges. Covering trunk and tail, extending as a weak sheath of one or two rows on to dorsal and anal bases, forming two contiguous patches on caudal base, small and obsolescent on pectoral base: on head ceasing abruptly on dorum above anterior one-third (middle or posterior one-third) of eye and on side above four smoothish minutely papillate areas (in juveniles three, the soft uppermost not clearly recognizable) surmounting the opercular system; covering most of opercular; on preoperculum narrowly and imperfectly fringing vertical limb, broadening to a subtriangular patch at the angle; remainder of head scaleless. Several specialized areas on head and body, including the opercular notch, sharply delimited, usually by ridges, which may be denticulate. The principal such areas are: a median lanceolate region on the interorbital dorsum extending from level of anterior nostril to that of pupil; flanking this on either side a strip of slightly greater maximum width curving back beyond the eye to bound the preoperculum, the paired strips terminating anteriorly, virtually in contact, along the hind margin of a subrectangular patch of skin, the latter bordered laterally and except for a small median hiatus also in front by an anterior extension of the preorbital, the short curved anterior margin of which carries an arc of 8-10 spines; a largely smooth minutely papillate broad arc below eye, reaching back almost to vertical limb of preoperculum, the first one-third of its inferior border with a score of small spines, the middle one-third entire, the hind one-third with some two dozen somewhat larger spines directed down and back; above the large supraorbital arc a lanceolate strip starting at level of front of pupil and reaching to level of posterior orbital border; some distance behind this at about the same horizontal level a smaller curved pennon; the space between these two filled with a smooth patch that expands above them to be in contact with the hind half of the first. Chin back to level of middle of eye with irregular striae, some feebly spinigerous; in (a) numerous small circular or oval openings between them. Hind half of orbit with three largish two-winged ridged and spined processes; a fourth above these usually developed in juveniles. Preoperculum with two subvertical borders, both denticulate, both with larger spines forming a conspicuous group at the angle; operculum with throughout most of its length parallel ridges ending in spines, two prominent spines about at level of middle of eye, the upper the larger, subequal to pupil; interoperculum minutely ridged and crenulate. All fin rays stout, more or less flattened distally, divided to or virtually to base, secondary fission occurring near middle of length, ray terminating in up to 8, exceptionally more, rami.

The Handbook (Munro 1958a, p.78) states "No keeled abdominal scutes": apart from recording the 1. lat. count (45) and 1. tr. (6/12), the account of this species by Castelnau (1878) makes no reference to scales. Here 11 median scales between the ventral base (where the foremost is partly overlapped by two or three normal scales) and shortly in advance of the vent differ trenchantly from other scales along the lower edge of the
fish (and elsewhere), taking the form of two large plates (triangular at either and of the series elsewhere more or less clearly pentagonal) sloping towards each other to meet in the midventral line where they develop a low but distinct carina. In the adult this ridge does not bear prominent spines; however, a small prone pointed process, readily detectable by touch, occurs on it at the hind border of each scute, being quasi-continuous on each side with the uppermost of a series of low subparallel longitudinal stripes that (except in the first two scutes where they are absent and in the next two or three where they are little developed) cover most of the modified scale. In specimens (b)-(g), juveniles, in which the specialized scales range in number from 9 to 12, distinct strong spines are developed, most notably in the anterior part of the series, where they may be little inferior in size to the first anal spine. There would appear to be no essential difference between these structures and those in *Paratrichichthys trilli* recognized in the Handbook as abdominal scutes.

Rays obviously identifiable as normal caudal rays are preceded on both the dorsal and ventral profiles by 5 interesting structures recorded in the meristic specifications above as pseudospines. In so far as their location is concerned, these of course correspond to the procurrent rays found in a wide range of species of many families: their nature and mode of development would appear to be such as to place them in a special class. They exhibit characters of both body scales and fin rays, being suggestive of the development of the former. The most anterior one, inserted somewhat in advance of the hypural joint, is foliate, compressed fore and aft, subtriangular in frontal view, its base wide about one-third its length, the anterior surface strongly transversely convex, the posterior surface attached by integument to the next pseudospine for about the proximal five-sixths of its height, the acute free end slightly concave: this structure is clearly a modified scale, being immediately preceded by normal scales differing notably from it in having the free posterior margin in the form of a broad spinous arc instead of a wide pennon with a single acute point. Succeeding pseudospines progressively lengthen not only absolutely but also relatively, the length of the last exceeding its basal width by a factor of about 10, the general form closely approximating that of a normal ray. The structure is decidedly spine-like in respect of its shape (in other than the first one or two members of the series), its largely (particularly distally) translucent vitreous appearance (in marked contrast to the opaque true rays, pale gold in the preserved specimen) and its very considerable rigidity. Its ray-like nature is evidenced by the progressive development, readily visible under a lens, of septa: in the first element the beginning of this process is indicated only by the presence of a basal core of undifferentiated opaque yellow; increasing differentiation leads to the formation in the last element throughout the greater part of its length of septa comparable with those of the true caudal rays. The segmentation is more extensive longitudinally in the last ventral than in the last dorsal ray, reaching virtually to the tip; however, the process is more advanced in the dorsal element in respect of the transverse extent of the septa which here extend across the full width, whereas in the anal element a narrow longitudinal strip remains uncolonized. Similar pseudospines occur in *Paratrichichthys trilli* and *Beryx decadactylus*.

Aspects of Form

Head, length to vent, standard length. In a loglog plot of the adult specimen (a) these three dimensions are significantly linear ($r = 0.654^*$) on 1 2 5 [cf. 1 2 6 for *Beryx decadactylus* and the quite exceptional 10 9 1 for *Paratrichichthys trilli*].

\[
\log L = 0.6268 \log N + 2.5659; \text{ calculated (measured) lengths, TLs, 368(364) 578(580) 1 009(1 000).}
\]

Parameters for juveniles (b)-(g): slope 0.5757, 0.7010, 0.5944, 0.6229, 0.6007, 0.6029, intercept 2.5860, 2.5708, 2.5841, 2.5670, 2.5881, 2.5752, 6 2.5877*, 17.100*, 262.688**, 48.771*, 104.621*, 98.135*.

Location of vertical fin origins and terminations. In a loglog plot (length of dorsal origin, to anal origin, to (second) dorsal termination, to anal termination, to caudal origin) fall collinear with statistical significance ($r = 0.885**$) on (3 5 7 8 10), the best straight line being:
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Log L = 0.7459 log N + 2.2554; calculated (measured) lengths, TLa, 408(411) 598(584) 796(790) 848(840) 1000(1000).

Parameters for juveniles: slope 0.6845, 1.7121, 0.7169, 0.6791, 0.6700 0.7136, intercept 2.3155, 2.2805, 2.2871, 2.3240, 2.3246, 2.2801, 29.571***, 54.823***, 45.948**, 37.115**, 21.556**, 18.2358**.

Some discussion of vertical fin location will be found in the observations on Paratransdiodon trivill below. The graph for (a) is shown in fig.1.

Dorsal anal and pectoral rays. The length-sequence pattern of the rays in these three fins exhibits one pronounced difference and several remarkable similarities. The pectoral differs from the two vertical fins in having two distal borders conveniently recognizable as distinct, a short leading (upper) edge of 3 rays (smallest inconspicuous) increasing in length from the uppermost - by the convention here adopted, 1st; see Part XIV (1974a, p.248) - followed by a long trailing edge of 11 rays, whereas in the dorsal and anal the border takes for form of a single edge, the rays decreasing in length from 1st, most anterior. The combination of an descendant and a (usually longer) descendant segment is all but universal in the pectoral, and is more usual in the soft dorsal and in the rayed (main) section of the anal than the single descendant border found here. Secondly, while the slopes of corresponding subsets differ in the three fins, inspection of what may be interpreted as in some way a measure of the energy involved in ray formation, the area under the graph, shows the area per panel (i.e., the interval between successive rays) is significantly the same in each of the fins for each of the subsets. So far as the writer is aware, such a relationship between the three fins has not previously been reported; and while effective equality in the dorsal and anal might not be wholly unexpected, the inclusion of the pectoral, in respect of its trailing (main) edge is certainly interesting and curious.

Data for the rays of the dorsal anal and pectoral are set out in the first 10 lines of table 3, the information provided comprising for each subset the serial numbers of the rays with an indication of whether they are counted directly (N) or inversely (N'), the relevant abscissal integers, parameters and significance of the best straight line for the rectified equation log L = k log N' + log b together with calculated and measured ray lengths, as TLa (member common to intersecting subsets included in both for calculation of the subset equations), total area under graph (using measured, not calculated lengths), area per panel. For lines 11-14 of table 3 see below.

Ventral rays. In earlier observations in this series it has in general been found that in fish with the modal ventral formula, I, 5, the lengths of rays 1-4 - first specified as postaxial, see Part XIX (1974b) - are linear in a loglog context on their serial numbers, with spine and ray adjacent to it, 5th, outside the series, this ray shorter than 4th (commonly subequal to 3rd). Here with V. I, 7 the overall pattern is maintained in as much as the spine and its adjoining ray are again outside the exponential length-number set, which in this case comprises 6 instead of the usual 4 rays. The relevant data for specimen (a) are set out in full in table 2. Parameters for juveniles (b)-(g): slope 0.2505, 0.3077, 0.3212, 0.2506, 0.3641, 0.1835, intercept 2.1175, 2.1377, 2.1362, 2.1295, 2.0854, 2.1695, 36.065***, 21.922***, 30.493***, 37.695***, 49.887***, 31.443***.

Precaudal Pseudospines

While in some individuals the 5th (hindmost) process is more or less obviously classifiable as a spine, in others it is distinctly sejate and on the whole more ray-like than spine-like. However, in respect of magnitude it clearly remains a member of the set, being specified by the L = b N' relation exhibited by the others; equally clearly the next element, extending to the distal border of the fin is foreign (in a typical specimen the ratios of the length of each item to the length of the following item are for the set of 5 successively 2.5,1.6,1.4,1.3, whereas for the 5th element and the obvious ray the ratio becomes 3.1). All 5 items are here regularly included in the calculation of the rectified equation, data relevant to which in the case of (a) are exhibited in table 2. Parameters for superior series in juveniles (b)-(g): slope 1.2404,1.1976,0.8593,0.8133,0.9120,1.2144
Centroberyx affinis (Günther, 1859)

Lengths of spines, rays and pseudospines as a function of their serial numbers, the relation being \( L = b N^k \) rectified as 

\[ \log L = k \log N + \log b \]

For reverse serial numbers (counted cephalad) \( N' \) is substituted for \( N \). All dimensions as millimetre.

Data for specimen (a), 231 mm in standard length, from St Helens, east coast, Tasmania.

<table>
<thead>
<tr>
<th>Radial element</th>
<th>Counting sense</th>
<th>Serial numbers</th>
<th>Abcissal integers</th>
<th>( k ) (slope)</th>
<th>( \log N ) (intercept)</th>
<th>( t )</th>
<th>Calculated (measured) lengths, millimetres of standard length</th>
<th>Area under graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorsal rays</td>
<td>( N' )</td>
<td>[12-10]</td>
<td>[1-3]</td>
<td>0.1174</td>
<td>1.9795</td>
<td>14.925*</td>
<td>95 (95), 101 (104), 109 (108)</td>
<td>0.9973, 0.4786</td>
</tr>
<tr>
<td></td>
<td>( N'' )</td>
<td>[10-7]</td>
<td>[5-6]</td>
<td>0.2523</td>
<td>1.9123</td>
<td>9.519**</td>
<td>108 (108), 116 (116), 123 (121)</td>
<td>0.6243, 0.2081</td>
</tr>
<tr>
<td></td>
<td>( N''' )</td>
<td>[7-1]</td>
<td>[6-12]</td>
<td>0.7450</td>
<td>1.5540</td>
<td>49.987***</td>
<td>128 (128), 130 (130), 146 (147), 161 (168)</td>
<td>0.6692, 0.1115</td>
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<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>176 (174), 190 (190), 204 (207)</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td>216 (215)</td>
<td></td>
</tr>
<tr>
<td>Anal rays</td>
<td>( N' )</td>
<td>[12-10]</td>
<td>[1-3]</td>
<td>0.2124</td>
<td>1.8924</td>
<td>26.636*</td>
<td>78 (78), 90 (91), 99 (98)</td>
<td>0.9266, 0.4655</td>
</tr>
<tr>
<td></td>
<td>( N'' )</td>
<td>[10-7]</td>
<td>[5-6]</td>
<td>0.2060</td>
<td>1.8919</td>
<td>13.907**</td>
<td>98 (98), 104 (103), 109 (108)</td>
<td>0.6126, 0.5041</td>
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<tr>
<td></td>
<td>( N''' )</td>
<td>[7-1]</td>
<td>[6-12]</td>
<td>0.6047</td>
<td>1.5912</td>
<td>22.929***</td>
<td>115 (113), 127 (128), 137 (139)</td>
<td>0.6463, 0.1077</td>
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<td></td>
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<td>147 (145), 157 (159), 166 (167)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>175 (173)</td>
<td></td>
</tr>
<tr>
<td>Pectoral rays</td>
<td>( N' )</td>
<td>[14-12]</td>
<td>[1-5]</td>
<td>0.2793</td>
<td>1.0816</td>
<td>36.553*</td>
<td>58 (56), 116 (117), 130 (136)</td>
<td>0.9767, 0.4888</td>
</tr>
<tr>
<td></td>
<td>( N'' )</td>
<td>[12-9]</td>
<td>[3-6]</td>
<td>0.4794</td>
<td>1.8845</td>
<td>36.644***</td>
<td>130 (130), 149 (149), 165 (165)</td>
<td>0.6582, 0.2194</td>
</tr>
<tr>
<td></td>
<td>( N''' )</td>
<td>[9-4]</td>
<td>[6-11]</td>
<td>0.6421</td>
<td>1.7616</td>
<td>21.781***</td>
<td>183 (182), 201 (199), 220 (222)</td>
<td>0.6104, 0.1213</td>
</tr>
<tr>
<td></td>
<td>( N'''' )</td>
<td>[4-1]</td>
<td>[3-6]</td>
<td>1.9253</td>
<td>1.4743</td>
<td>35.569*</td>
<td>237 (238), 253 (255), 269 (265)</td>
<td>0.9232, 0.4516</td>
</tr>
<tr>
<td></td>
<td>( N''''' )</td>
<td>[1-1]</td>
<td>[1-3]</td>
<td>1.2253</td>
<td>1.3874</td>
<td>44.884***</td>
<td>247 (248), 113 (113), 56 (56)</td>
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<tr>
<td>Dorsal spines</td>
<td>( N )</td>
<td>[1-7]</td>
<td>[1-7]</td>
<td>0.7019</td>
<td>1.6679</td>
<td>44.684***</td>
<td>45 (45), 76 (78), 101 (100), 123 (128)</td>
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<td>144 (144), 164 (168), 182 (178)</td>
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<tr>
<td>Anal spines</td>
<td>( N )</td>
<td>[1-4]</td>
<td>[1-4]</td>
<td>1.4131</td>
<td>1.2859</td>
<td>98.277***</td>
<td>19 (19), 51 (51), 91 (91), 139 (139)</td>
<td>1.0329, 0.5444</td>
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<tr>
<td>Ventral rays 1-6</td>
<td>( N )</td>
<td>[1-6]</td>
<td>[1-6]</td>
<td>0.3536</td>
<td>2.0322</td>
<td>40.820**</td>
<td>108 (108), 136 (139), 159 (156)</td>
<td>1.6886, 0.3577</td>
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<td>176 (177), 190 (199), 205 (205)</td>
<td></td>
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<tr>
<td>Ventral spine, ray 7</td>
<td>( N )</td>
<td>[7-8]</td>
<td>[1-2]</td>
<td>0.2381</td>
<td>2.2274</td>
<td>—</td>
<td>17 (17), 37 (32), 58 (53), 82 (81)</td>
<td>0.6814, 0.6814</td>
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<tr>
<td>Superior pseudospines</td>
<td>( N )</td>
<td>[1-5]</td>
<td>[1-5]</td>
<td>1.1356</td>
<td>0.2839</td>
<td>20.062***</td>
<td>105 (113)</td>
<td>1.1556, 0.2859</td>
</tr>
<tr>
<td>Inferior pseudospines</td>
<td>( N )</td>
<td>[1-5]</td>
<td>[1-5]</td>
<td>1.1285</td>
<td>0.2821</td>
<td>29.549***</td>
<td>16 (16), 35 (35), 56 (52), 77 (78)</td>
<td>1.1285, 0.2821</td>
</tr>
</tbody>
</table>

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E.G. Scott
Observations on some Tasmanian Fishes: Part XXVII

intercept 1.2205, 1.2699, 1.4446, 1.4630, 1.4474, 1.2255, t = 47.521***, 33.162***, 79.301***, 27.361***, 52.348***, 257.059***; inferior series: slope 1.1902, 1.1182, 0.8725, 1.1277, 1.0967, 1.0274, intercept 1.2294, 1.2628, 1.4624, 1.2605, 2.3443, 1.5304, t = 45.642***, 52.068***, 26.754***, 30.134***, 84.549***, 87.575***. The mean interspinous area under the graph (per panel) for the superior series is 0.27-0.31 ± 0.29 ± 0.018 for the inferior series 0.29-0.31 ± 0.29 ± 0.01 - significantly the same as for the much larger Tasmanian example (table 2).

Coloration

The appearance in life is concisely described by Castelnau (1878, p. 225): "The general colour is of a most beautiful pink, with silver stripes on the body, the edges of the opercles of the last colour". Our adult example, after preservation in formalin, is almost wholly of a uniform dark straw, with some yellow on the head and on some fin rays, otherwise more or less whitish. The Victorian juveniles, in alcohol, in general have the body fawn above the silver lateral line, silvery below it; a narrow stripe of somewhat reddish brown along dorsal profile from just in advance of to just beyond dorsal base, widest near its middle, sharply defined below; whole of hind half or so of caudal peduncle fawn; narrow yellowish strip along anal base; head mostly fawn, more or less silvery below and behind eye and on preoperculum, operculum silvery or golden or partly both; fins pale yellowish to whitish.

Family TRACHICHTHYDAE

Of the seven species listed in the Handbook (Munro 1958a) only two are found in Tasmania, the "sandpaper fish" (occasionally referred to as "roughy"), Paratracichthys trailli (Hutton, 1875), known from all Australian States other than Queensland (and with New Zealand as type locality) and the "roughy" Trachichthys ausitialis (Shaw & Nodder, 1799), reported from all Australian States. Only the former occurs in the catalogues of Johnston (1883, 1891) where it appears as the synonymic Trachichthys macleayi Johnston 1881 (type locality: Derwent River, Tasmania), being referred to the Berycidae. The latter species was first included in a local list by Lord (1923), where, as in his later list (1927) and in Lord & Scott (1924), it is associated in the Trachichthydae with the former species and with Centroberyx affinis, cited in the genus Trachichthodes Gilchrist, 1903, this species now being customarily relegated to the Berycidae.

The two species occurring in our waters seldom come under notice locally. In the course of a account of the only (Victorian) specimen of Trachichthys ausitialis that had come under his notice McCoy (1886) gave a table of measurements. No such morphometric data on an Australian specimen of Paratracichthys trailli appear to be available: metrical and other observations on two Tasmanian examples in the collections of the Queen Victoria Museum Launceston are made below.

KEY TO TRACHICHTHYDAE RECORDED FROM TASMANIA

Vent located normally, shortly in advance of anal base.

Head and trunk together subcircular, maximum depth 2 in standard length. D. III-IV, 11-12. L. lat. < 80 (32 65).

Reddish brown; a dark bar on operculum ............Trachichthys ausitialis

Vent located exceptionally, far forward between ventrals.

Head and trunk together ovate, maximum depth 2 in standard length. D. V, 13. L. lat. > 80 (32 118).

Reddish purple; no dark bar on operculum ............Paratracichthys trailli
Paratrichichthyidae Waite, 1899, p.64. Type-species, *Trachichthys trailli* Hutton.

Paratrichichthys trailli* (Hutton, 1875)

(Fig. 1)


*Trachichthys trailli*: Arthur, 1885, p.162, pl.14, fig.2; Gunther, 1887, p.23, pl.15, fig.A.


Date and Name of Species

The species is commonly taken to have been established in Hutton's paper in the Transactions of the New Zealand Institute for the session of 1875, published in May 1876, (McCulloch 1929, Munro 1958a, Lord & Scott 1924, McCulloch 1921a, Scott et al. 1974). However, Whitley (1964) gave 1875, and in his New Zealand catalogue (1968) cited the earlier account by Hutton in the* Annals and Magazine of Natural History* issued in September of that year (Gunther 1887). Whitley (1964) gave the second binomen as *trailli*, but in 1968 accepted *trailli*.

Status of Johnston's Species

In establishing his *Trachichthys maoleaqi*, based on a specimen 240 mm in total length and having "length of body" (presumably standard length) 190 mm obtained in the Derwent estuary in 1880, Johnston was clearly unaware of the description by Hutton some five years earlier of the New Zealand *T. trailli*. In the first direct comparison of the two accounts Waite (1899), while reporting 13 abdominal scutes as in Johnston as against 11 noted by Hutton (1875) and Arthur (1885) and repeated by Gunther (1887), nevertheless accepted *T. trailli*, formally placing *T. maoleaqi* in synonymy: the question of scute number was later clearly resolved by the finding by McCulloch (1911) in the 17 *Eleодеour* examples from Bass Strait and Oyster Bay, Tasmania, of a range of 12-16. In the same paper Waite proposed his genus *Paratrichichthys* on a feature Gunther (1887) had been inclined to regard as a mere individual abnormality, namely, the location of the vent in front of, instead of behind, the abdominal scutes. The synonymization of Johnston's species has been generally accepted and is probably valid — it may be observed, however, that our material shows no evidence of the lateral line scales being enlarged and "armed with one or two visibly prominent transparent spines", and, as noted below in the section on Proportions, ratios derived from the recorded dimensions of the early fish include several curious values.

Material

Two Tasmanian examples, (a) *La* 135 *Lt* 168.5, 6.4 km north of Eddystone Point, taken in 26 m by Mr S. Down (Q.V.M. Reg. No. 1980/5/44), (b) *La* 168 *Lt* 241, Tinderbox, collected by Mr P.R. Last (Q.V.M. Reg. No. 1975/5/147).

Meristic Features

D. V, 13. A. III, 10. P. 13/13 13(left)/12 (Handbook (Munro 1958a) 12). V. I, 6. L. lat. ca 110 120 (Handbook 118, Waite (1899) 118): pierced scales ca 50 (Waite 55, Johnston (1881) "about fifty"). Abdominal scutes, 13,15 (Handbook 11-16). Caudal with 19 main rays; 7,8 precaudal pseudospines on dorsal border and 7,8 on anal border (see below, Aspects of Form). Gill rakers on anterior arch 14 - 12, increasing in length from either end to near the middle of the lower limb where they are elongate, flattened,
very slowly tapering, minutely denticulate along either border, subequal to gill filaments.

Br. 8, the first 2 small and poorly developed, the rest stout, flattened, strongly recurved, the anterior half or so of the inferior border minutely spined, most conspicuously in the 3rd-5th rays.

Dimensions as TLa

The dimensions below are given as millims of standard length, smaller individual (a) cited first: where measurements of Johnston's type of his Triakytosoma maslineyi (some reported in inches, to the nearest one-eighth, some in millimetres) are available values calculated from them are here shown in parentheses. Length to end of upper caudal lobe 126,1244 (1267), to end of lower caudal lobe 1238,1233, to end of middle caudal rays 1125,1111. Length to origin of first dorsal 584,480 to termination 497,522, to origin of second dorsal 506,533 to termination 719,741, to origin of anal 649,649 to termination 804,800. Length to origin of pectoral 521,534 total length of fin 202,204 length of longest (7th 6th) ray 179,178. Length to origin of ventral 351,363 total length of fin, 175,196; for spine and rays see below. Aspects of Form. Length of first dorsal spine - 49 (79) of last - 95 (89); for other spines see below. Length of first dorsal ray 107,167 (157) of longest (4th 3th) 190,178 of last 95,107 (79). Length of first anal spine 16,17 (10) of second 45,47 (53) of third 105,108 (100). Length of first anal ray 168,141 (79) of longest (1st 2nd) 168,150 of last 107,81 (115): Length of longest precaudal pseudospine 81,85 (54). Head 345,333 (467). Interorbital 110,115. Length of mouth (oblique) 193,202. Length of series of abdominal scutes 237,235 (157). Breadth of largest scute 64,54 (37) depth 44,42 (37). Depth at front of eye 186,259, back of eye 315,356, opercular border 381,395, vent 390 (396), dorsal termination 230,259, anal termination 167,174; maximum depth 390,415 (550), depth of caudal peduncle 117,126 (117).

Proportions

Depth in standard length 2.56,2.41 (Munro 2.25-2.5; Johnston 1.82, but depth in total length 2.25; Günther "twice and one-third"). Head in standard length 2.90,3.0 (M. 3-3.2; J. 2.1). Depth of caudal peduncle in head 2.6,2.9 (J. 4.0). Eye in head 3.5, 2.9 (M 3; J 4.2; G. 3.6). Eye in interorbital 1.19,1.09. Pectoral in head 1.6,1.7. Ventral in head 1.8,1.7. Longest dorsal spine in head 3.7,3.6 (J. 3.5). Length to vent in standard length 2.60,2.61.

General Features

Where two entries occur the first relates to the smaller specimen (a). Maxilla to below hind border of pupil, to behind orbit by about one-eighth eye, its greatest diameter subequal to direct distance from its posterosuperior angle to orbit. A supplemental bone, widening in its hind half to constitute the greater part of the free end of the jaw surmounting the premaxilla, here very slender. Isthmus to below front half of eye. Dorsal originating over first one-fourth of ventral just behind posterosuperior angle of pectoral base, terminating above 4th anal ray; anal originating below 9th dorsal ray; pectoral to below 2nd dorsal ray, slightly beyond ventral tip, which is just more than halfway to anal. Jaws equal, lower projecting slightly, its tip enlarged, turned up, fitting into a shallow notch in upper jaw, its mesial anterior aspect occupied by a subvertical cutaneous strip bordered below by several small tubercosities. The whole external lower border of the upper jaw constituted by the premaxilla in the form of a narrow band continuing to narrow markedly and (save for a brief notch on the upper border about as wide as its distance from the anterior end) evenly backward; the entire surface closely beset with minute pointed elevations that appear along the inferior as downwardly pointed teeth; a short edentulous interval at symphysis. Lower jaw much the same but band in general decidedly narrower though expanding near symphysis to a width slightly exceeding maximum in upper jaw. A very small triangular patch of about a score of minute teeth on the middle of the vomer. A slender minutely dentigerous band on each palatine, similar to, but narrower than, and about half the length of, that of the upper jaw. Tongue absent in (a), in (b) stout, its tip in anterior view presenting an ovoid flattened platform above, with a mesial knob between this and the chin-like lower margin projecting above the soft tissue connecting organ to floor of mouth. Posterior nostril elliptical, with low rim, in part
dentilicate, its length twice or more its distance from orbit. Anterior nostril half as large or less, more or less circular, with elevated rim minutely crenulate.

Head without normal scales, much of it smooth usually with cutaneous pores, rugose or irregularly faveolate; with complex systems of plates, ridges, elevations and spines, only the most prominent noted here. Plates: two elongate lozenge-shaped, above front half or more of eyes, extending forward in advance of nostrils; inserted between the hind half of these, the spines of a trident with short spines, mostly about a dozen, short and directed back and continuing forward in a short double row then a single head-like row of small contiguous subhorizontal nodules terminating anteriorly in a fanlike group extending to upper lip; a somewhat concave plate bordering eye from posterior nostril to about the same horizontal level behind, subcontinuous along its hinder half with a curved plate beginning above, a prominent ridge noted immediately at the base of orbit ending in a spine immediately behind of line; one constituting the subvertical limb of a spine (largest on head) directed back and a little down; one delimiting much of free opercular border, the operculum itself with a low ridge running back and down across its upper one-third and projecting beyond margin as a strong spine (distant from spine near lateral line origin by rather more than half an eye diameter, from preopercular spine by about two diameters), the area above this ridge and the area below it each wholly covered with a fan of strong minutely spine striae; interoperculum wholly ridged, margin denticulate; preorbital fluted, margin minutely spined. Spines, additional to those noted above: several irregular spines or groups of spines on orbit, particularly on its posterior half; several small bony shelves, their free margin more or less spinuliferous, a constant one immediately above and in front of upper end of opercular border — some differences between two sides of fish.

Scales with free border irregularly scalloped, with up to a score of variably sized spines, rest of exposed surface with stout spines, modally about a dozen, all large or mostly large with some smaller subequal to largest marginal spines. Scales extending on to bases of caudal rays in two small contiguous patches, very briefly on to pectoral and ventral. A narrow band of heavily spined specialized scute-like scales along dorsal base (best developed below rays) and anal base (about a score, mainly uniserial). Abdominal scutes 13-15, extending from shortly behind the small urinogenital papilla (behind and virtually contiguous with the external anal sphincter) to short of first anal spine by an interval equal to 2-3 scute bases; each scute with a strong pungent mesial spine flanked on either side by a moiety of the strongly ridged and denticulate hind border of the scute; greatest height above base of scute about equal to pupil diameter.

Waite in reporting on the *Thetis* individual, taken off Newcastle in 77-88 m "which adds a new species to the Australian fauna" observed, "It may be noted that the first scute is with two spines, which lie one on either side of the first median series, a character not shown in the figure quoted [Gunther (1887 pl.25 fig.A)], nor mentioned in Johnston's description". With 17 *Endeavour* specimens from Bass Strait and Oyster Bay, Tasmania, at hand McCulloch (1911) remarked "I find from twelve sixteen scutes and the first either divided or single, and with one median or two lateral spines". Examination of our material suggests the lateral spines are nothing other than the uppermost spine of the extensive marginal series sufficiently enlarged above its neighbours to invite separate recognition. Such specially developed spines are barely recognizable in [a] but are apparent in the anterior half dozen scutes of [b]: their prominent presence is evidently adventitious.

Aspects of Form

Head, length to vent, standard length. The quite exceptional location of the vent, between the ventrals just behind the head, far in advance of anal origin (in these specimens by 0.29 of standard length), negates the possible existence of any of the patterns
commonly encountered in which in a logarithmic metric the lengths of these three regions fall collinear when graphed on early natural numbers (modally 1 2 3) - a configuration that, its mathematical simplicity would suggest, is presumably to be interpreted as an expression of some profound morphological detail. With the present material it is found the logarithmic lengths are satisfactorily specified (i. 3.703* 36.947*) with as abscissa values the logarithms of 10 9 1, respectively, the slopes of the best straight lines being -0.4741, -0.4649, the intercepts 3.0002, 2.9998, predicted (in parentheses measured) lengths, TLa, being 536(333), 355(356), 1 003(1 000) and 343(545), 360(358), 996 (1 000). Whether this relation, differing so markedly from the customary "obvious" early-number relation with positive slope, represents the outcome of some comparatively simple and basic clan of growth, or is an arbitrary specification, formally efficiency, remains unresolved.

Location of vertical fin origins and terminations. In a loglog plot (length to dorsal origin, to anal origin, to (second) dorsal termination, to anal termination, to caudal original fall collinear with statistical significance (t 99.890*** 72.055**) on (2 5 6 7 10), the relevant equations being:

\[ \log L = 0.5645 \log N + 2.4253; \text{calculated (measured) lengths, TL, 595(400)} \]

\[ \log L = 0.5934 \log N + 2.4029; \text{818(384) 675(649) 752(719) 802(804) 991(1 000).} \]

It may be noted that the case of the trachichthys reported from Tasmanian waters, Trachichthys australis Shaw & Nodder, 1799 occurring in local catalogues from that of Lord (1923) onward would appear probably to present a comparable length-number fin pattern to that specified above. In an account, with figure, of the Victorian example of Shaw & Nodder's that had come under his notice M 1886, (57, pl. 114) gave among other dimensions lengths to origins of dorsal, anal and caudal (last as Ls), and in a loglog plot those three dimensions are significantly collinear (13.505*) on (2 5 10), as found above. At the same time the markedly less elongate form of Trachichthys australis results in much higher relative lengths to vertical fin origins (0.629 TLs cf. 400 384, A. 837 cf. 664 649), while with the subcircular outline of the fish in advance of the caudal peduncle diminishing the difference between D. and A. origins (198 TLa cf. 264 265), the slope of the loglog length-number graph becomes less (0.28 cf. 0.57 0.59) with concomitant increase in magnitude of the intercept (2.72 cf. 2.43 2.40).

A comparison of the patterns of location of vertical fin origins and terminations noted above for Beryx deauctylus and Centroberyx affinis with that for Paratrichichthys traulii leads to the recognition of a striking relation between them, it becoming evident their diversity can be neatly accounted for as resultant upon simple permutations of the integral numbers in the length-number pattern. In the subjoined formulation the addition, in lower case, or o or e to the upper case letter conventionally employed to designate the fin (e.g., D for dorsal, here with refinement D1 first dorsal D2 second dorsal) denotes length to origin or length to termination of that fin. With lengths and serial numbers both in logarithms the situation, as represented by the present material, is as follows:

<table>
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<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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<tr>
<td>Beryx deauctylus</td>
<td>D10</td>
<td>Ao</td>
<td>D20</td>
<td>At</td>
<td>Co</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centroberyx affinis</td>
<td>D10</td>
<td>Ao</td>
<td>D20</td>
<td>At</td>
<td>Co</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paratrichichthys traulii</td>
<td>D10</td>
<td>Ao</td>
<td>D20</td>
<td>At</td>
<td>Co</td>
<td></td>
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</tbody>
</table>

Thus in all three species the relative positions of anal and caudal origins are constant. With the first species taken as standard, first dorsal origin is displaced one unit forward in the third species, second dorsal termination (i.e., termination of the continuous fin) is displaced one unit backward in the second, while anal termination is displaced in the second species one unit in the third species two units forward. These simple whole-number translations adequately specify the variation in fin disposition encountered in the three species as samples. See fig.1.

It may be remarked that in the above equations specifying the location of the vertical fins the parameters of those for the two examples of Paratrichichthys traulii,
Dorsal spines. These are damaged in the smaller individual, while in the larger all save the second are intact, their lengths increasing backward, the length-number relation being an exponential one \( L = bN^a \), common for ascendent sets of radial elements; \( k = 0.3930 \log b = 4.805; t = 9.322**; \) calculated (measured) lengths, \( Tla \), 17(10) 43(45), 108(105).

With dimensions given by Johnston (1881, p.56) for the type of his synonymic \( Trachipterus macleayi \) we find \( L = 0.62 \log N + 1.02; t = 73.560***; 10(10), 32(31), 99(100). \)

Ventral rays. In ventral fins with the most frequently encountered formula 1, 5 it is usually found the lengths of the rays increase from the 1st – here defined as in Part XIX (1974a) as the postaxial to the 4th, with the 5th somewhat shorter than the 4th (often subequal to the 3rd) and the spine shorter still; the lengths of the rays being related to their serial numbers as defined as \( L = bN + t \). It is of interest to note that in this fish with V.I, 6 a comparable pattern is maintained, the 5th ray becoming associated with the 1st-4th in the exponential relation with in the larger specimen the preaxial ray (imperfect in the smaller) and in both the spine shorter as usual (spines, \( Tla \), 124 135).

\[ \log L = 0.2552 \log N + 2.074; t = 7.200**; \] calculated (measured) lengths, \( Tla \); 119(115), 142(148) 157(163) 169(170) 179(172).

\[ \log L = 0.1565 \log N + 2.0940; t = 21.253***; 124(124) 136(136) 144(143) 150(151) 155(155). \]

A difference in slope of the magnitude found here is unusual in two conspecific specimens not differing greatly in overall size.

Precaudal pseudospines. In his account of his synonymic \( Trachipterus macleayi \) Johnston (1881) observed "Upper and lower margins of the caudal peduncle armed respectively with 8 and 7 strong adpressed translucent spines." These are the structures discussed above in an account of \( Centroberyx affinis \). In our smaller individual there are 7 on each border, while the larger has 8 on each border, 4 of the dorsal series, however, being damaged and not measurable. They are similar to those already described, with the last of either series fully septate, bound throughout its length to the adjacent regular ray, similarly pigmented (dull yellowish with numerous minute red-brown chromatophores), and distinguishable from it only by its lesser length (about one-third) and its spine-like rigidity. The earlier members are more obviously vitreous, though possessing a basal whitish or yellowish partly segmented core, and bearing some (in the dorsal series numerous) chromatophores. As in other species, the logarithmic lengths are a function of the logarithms of the serial numbers counted caudad. The following are the parameters of the rectified equations for the dorsal and ventral series of the smaller specimen followed by that for the candal series for the larger example, all lengths being milimisals of standard length. Slope: 0.8757,1.3578,1.2836; intercept 1.0478, 0.7773,0.7971; \( t = 72.394*** \); 75.006**; 146.837***; predicted (measured) lengths 11(11), 20(21),29(30),38(57),46(44),53(55),61(63); 15(16),27(27),59(38),55(56),68(88),84(81); 6(6),15(16),26(27),57(57),49(47),63(65),76(78),91(85).
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Inspection of the parameters of the smaller fish (in which alone both dorsal and ventral sets are measurable) shows that while the dorsal slope is much less than (0.65) the neutral, the dorsal intercept is much greater (1.35). The net effect of these two contrasting ratios is to bring the areas under the graphs into approximate equality, the mean areas per panel (i.e., between adjoining spines), with lengths measured as millessimals of standard length and serial extensions in common logarithms, being 0.20 and 0.19; for the dorsal set for the second specimen 0.17. Otherwise expressed, though the site of the set may differ (N = 7 7 8) and though the length of both the first members (1.5, 0.8, 1.0 mm or 11.1, 5.9, 6.0 %) and of the last (8.5, 11.0, 14.2 mm or 63.0, 81.5, 84.5 %) exhibit considerable variation, the mean logarithmic length of the spine relative to length of fish remains significantly constant, namely 1.51, 1.49, 1.54.

Coloration

The color of the fish in life is noted in the Handbook as being "reddish purple with yellow fins". The smaller of our specimens, preserved in alcohol, is faintly purplish brown with on the left side some four-fifths of trunk and tail and on the right side some small patches silvery; head except for operculum off-white. Except for dark brown on the operculum and some yellowish in the mouth region, the larger is an indefinite greyish fawn, somewhat more brownish above the lateral line. In both the fins are more or less evenly yellowish; some duskness on caudal.

Family APOGONIDAE

The Cardinal Fishes are represented in Tasmania by 5 species: (1) Dinolestes lemani (Griffith, 1834) (2) Stiphonotus ephalotes (Castelnau, 1875) (3) Loxomia falcata (Shaw, 1790) (4) Vincentia novaehollandiae (Valenciennes, 1832) (5) Gronoviichthys lepinierei (Johnston, 1883) (type locality Dunkleys Point, Tasmania). A further species, Apogon gouldi Castelnau 1872, that appears in the second list by Johnston (1891) is treated in the Check-list (McCulloch 1929) as a queried synonym of (4) (referred to the genus Apogon Lacépède, 1802) and in the Handbook (Monro 1960) is formally accepted as identical with that species (along with Apogon conspicusus Klunzinger, 1872, Vincentia waterhousei Castelnau, 1872, Micromus ramayl Fowler, 1908 — referred in the Check-list to Apogoniichthys Bleeker, 1854 — and (5), see below.)

In some recent texts — e.g., Scott (1962) Whitley (1962) Marshall (1964) Scott, Glover & Southcott (1974) — (1) is referred to the monotypic family Dinolestidae, which, however, is not recognized as distinct by Greenwood et al. (1966) in their provisional classification of living teleosts. In the Handbook (5), described in Apogon, is accommodated in Vincentia Castelnau, 1872, and identified with (4). However, there are good grounds for regarding Johnston’s Tasmanian species as valid — see Part XII (1964), which carries a full description with figure, Part XVII (1969), Part XX (1974b), which reports a local example of (4), and Part XXIV (1978), which advances reasons for transferring it from Apogon through Vincentia to Gronoviichthys Whitley, 1929. The Tasmanian species were keyed in Part XII, but as pointed out in Part XX the specification of the spines of the second dorsal involves an error, while the receipt of additional material has shown the distinction there drawn between (4) and (5) in respect of size of interorbital relative to eye cannot in all cases be relied on, the primary point of distinction between these two forms being that the dorsals are united in the former separate in the latter.

Genus DINOLESTES Klunzinger, 1872

Dinolestes Klunzinger, 1872, p.29. Type-species, Dinolestes mulleri Klunzinger.

Neosphyraena Castelnau, 1872, p.96. Type-species, Neosphyraena multibrachia Castelnau.

Esox lewini Griffith, 1834 in ANIM. KINGD. (Cuvier), 10, p.465, pl.60. Type locality: New Holland (Lewin).


Remarks
This species has the distinction of having had three genera established for it in the one year (in Germany, Australia, England): in Tasmania, which provided the type locality for Günther's genus, the type material being forwarded to England by Morton Allport, it is not uncommon. Listed under Günther's name and placed in Sphyraenidae by Johnston in both his catalogues (1883, 1891) it was entered under Dinolestes lewini (genus Künzinger, species Griffith) in the later lists of Lord (1923, 1927) and Lord & Scott (1924) being then transferred to Apogonidae. It has been reported from all Australian States other than Queensland. It differs clearly from all other Australian apogonids in having more numerous dorsal rays (18-19, cf. maximum 11, mode 8 or 9), anal rays (25-26 cf. maximum 15 mode 8 or 9), lateral line scales (64-67 cf. maximum 50 mode 20-30) and in reaching length (500 mm cf. maximum 250 mode about 200), by some recent Australian authors — e.g., Whitley (1962) Scott (1962) Scott et al. (1974) — it is referred to a monotypic family, but is retained in Apogonidae (as Apogon) in the Check-List (McCulloch 1929) and the Handbook (Munro 1960). The close superficial resemblance of this fish to the widely distributed sea pikes or barracudas led early writers — e.g., Castelnau (1872) Macleay (1881) Johnston (1891) — to associate it with them in the family Sphyraenidae, a taxon of different subordinal (or, according to authors who place it in the Mugiliformes, ordinal) rank from the Apogonidae. Vernacular names: long-finned pike, long-finned sea pike, skipjack — more commonly applied to Pomatomus saltator (Linnaeus, 1766) — Tasmanian jack.

Material
Eight specimens, Le 192-317 Lt 227-380, collected by scuba divers at an interstate competition at Croppies Point near Bridport, 28 December 1973 (Q.V.M. Reg. No. 1974/5/). The coefficient of variation of standard length (16.5) appears somewhat high for a wholly homogeneous size group for which values of ±10 are usual: however, no obvious mode of dissection of the sample presents itself.

Meristic Characters
D. V; I, 17(2)-18(6): in 1 example with 17 rays and 2 with 18 the last ray is divided to base. A. I, 21(4) 22(4) 23(5) 24(4) 25(2): in 2 examples with 27 rays and 2 with 28 the last ray is divided to base (one specimen with anal imperfect). P. 16(3) 17(4) 18(1: both right and left fins). V. I, 5. L. lat. 65(1) 64(1) 65(3) 66(1) 67(1) 70(1).

In several cases these counts involve more or less marked emendation of local published accounts, of which the more significant are that of Castelnau (1872) of his Neosphyraena multitridactyla (measured specimen cited 0.39 m) that of McCoy (1886) with figure (pl.115) and dimensions of a Victorian example of total length 0.495 m and the synopsis notice of the handbook (Nurro 1960). Spines of the first dorsal are constant at 5, though, as pointed out by McCoy, the figure by Künzinger (1872) has only 4, while the photograph in Tenison-Woods (1882) does not show the first dorsal at all, "the error in both cases probably arising from the ease with which the spines are completely concealed when depressed into a deep slit or groove at the base of the fin" (p.62). Spines of the second dorsal are noted at 2 by M'Coy, the handbook admits 1-2, while Castelnau gives a total of 17-21 elements, observing in a footnote "It would be more exact to say that the two first rays of the second dorsal are not branched, and could be called spines if they were not soft; the following (third) ray is much longer". The lower second dorsal ray counts of 17 falls outside the Handbook's range, 18-19. Anal ray counts in 5 individuals here exceed by 1-2 the maximum of 26 found in the Handbook and in McCoy (Castelnau notes...
Observations on some Tasmanian Fishes: Part XXVII

"twenty-eight rays" but his convention in this context appears to take account both of spines and soft rays). Pectoral counts in 5 specimens exceed by 1-2 the 16 given by all three authors cited above; while the lateral line range 65-70 transgresses at both limits the Handbook's synoptic 64-67 (Castelnau's "about seventy-five scales" appears clearly to be no more than a rough approximation).

Dimensions

Morphometric data on this species are few and local accounts do not provide measurements of more than a single fish. A series of dimensions of each of the present 8 individuals is set out in table 4, measurements other than that of standard length being recorded as millimsals of standard length.

<table>
<thead>
<tr>
<th>Feature</th>
<th>(a)</th>
<th>(b)</th>
<th>(c)</th>
<th>(d)</th>
<th>(e)</th>
<th>(f)</th>
<th>(g)</th>
<th>(h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard length (1st), mm</td>
<td>192</td>
<td>219</td>
<td>260</td>
<td>266</td>
<td>280</td>
<td>280</td>
<td>517</td>
<td>517</td>
</tr>
<tr>
<td>Lth to end of upper caudal lobe</td>
<td>1 172</td>
<td>1 142</td>
<td>1 158</td>
<td>1 135</td>
<td>1 182</td>
<td>1 166</td>
<td>1 186</td>
<td>1 192</td>
</tr>
<tr>
<td>Lth to end of lower caudal lobe</td>
<td>1 182</td>
<td>1 171</td>
<td>1 165</td>
<td>1 139</td>
<td>1 200</td>
<td>1 180</td>
<td>1 196</td>
<td>1 199</td>
</tr>
<tr>
<td>Lth to end of middle caudal rays</td>
<td>1 104</td>
<td>1 089</td>
<td>1 123</td>
<td>1 086</td>
<td>1 125</td>
<td>1 131</td>
<td>1 132</td>
<td>1 114</td>
</tr>
<tr>
<td>Lth to first dorsal origin</td>
<td>406</td>
<td>-</td>
<td>415</td>
<td>398</td>
<td>421</td>
<td>394</td>
<td>420</td>
<td>391</td>
</tr>
<tr>
<td>Lth to forst dorsal termination</td>
<td>432</td>
<td>-</td>
<td>438</td>
<td>444</td>
<td>464</td>
<td>429</td>
<td>426</td>
<td>426</td>
</tr>
<tr>
<td>Lth to second dorsal origin</td>
<td>589</td>
<td>584</td>
<td>608</td>
<td>575</td>
<td>625</td>
<td>557</td>
<td>584</td>
<td>587</td>
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<tr>
<td>Lth to second dorsal termination</td>
<td>750</td>
<td>753</td>
<td>773</td>
<td>763</td>
<td>790</td>
<td>772</td>
<td>803</td>
<td>779</td>
</tr>
<tr>
<td>Lth to anal origin</td>
<td>531</td>
<td>575</td>
<td>585</td>
<td>539</td>
<td>607</td>
<td>588</td>
<td>599</td>
<td>577</td>
</tr>
<tr>
<td>Lth to anal termination</td>
<td>849</td>
<td>815</td>
<td>850</td>
<td>818</td>
<td>854</td>
<td>834</td>
<td>864</td>
<td>852</td>
</tr>
<tr>
<td>Lth to vent (middle)</td>
<td>565</td>
<td>553</td>
<td>550</td>
<td>498</td>
<td>561</td>
<td>545</td>
<td>563</td>
<td>533</td>
</tr>
<tr>
<td>Lth to ventral origin</td>
<td>325</td>
<td>338</td>
<td>362</td>
<td>331</td>
<td>350</td>
<td>315</td>
<td>341</td>
<td>328</td>
</tr>
<tr>
<td>Lth (total) of ventral</td>
<td>128</td>
<td>128</td>
<td>127</td>
<td>124</td>
<td>132</td>
<td>114</td>
<td>125</td>
<td>120</td>
</tr>
<tr>
<td>Lth to pectoral origin</td>
<td>281</td>
<td>292</td>
<td>304</td>
<td>289</td>
<td>307</td>
<td>308</td>
<td>325</td>
<td>290</td>
</tr>
<tr>
<td>Lth (total) of pectoral</td>
<td>156</td>
<td>151</td>
<td>158</td>
<td>164</td>
<td>171</td>
<td>152</td>
<td>162</td>
<td>158</td>
</tr>
<tr>
<td>Head</td>
<td>292</td>
<td>292</td>
<td>308</td>
<td>299</td>
<td>314</td>
<td>322</td>
<td>338</td>
<td>306</td>
</tr>
<tr>
<td>Snout</td>
<td>130</td>
<td>128</td>
<td>135</td>
<td>124</td>
<td>136</td>
<td>125</td>
<td>142</td>
<td>136</td>
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<tr>
<td>Eye</td>
<td>52</td>
<td>53</td>
<td>50</td>
<td>53</td>
<td>46</td>
<td>45</td>
<td>50</td>
<td>47</td>
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<tr>
<td>Orbit</td>
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<td>47</td>
<td>46</td>
<td>50</td>
<td>-</td>
<td>47</td>
<td>49</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>Depth at front of eye</td>
<td>109</td>
<td>100</td>
<td>112</td>
<td>-</td>
<td>107</td>
<td>118</td>
<td>111</td>
<td>139</td>
</tr>
<tr>
<td>Depth at back of eye</td>
<td>125</td>
<td>132</td>
<td>131</td>
<td>-</td>
<td>132</td>
<td>149</td>
<td>139</td>
<td>167</td>
</tr>
<tr>
<td>Depth at opercular border</td>
<td>161</td>
<td>160</td>
<td>182</td>
<td>177</td>
<td>179</td>
<td>166</td>
<td>189</td>
<td>174</td>
</tr>
<tr>
<td>Depth at vent</td>
<td>188</td>
<td>183</td>
<td>188</td>
<td>188</td>
<td>196</td>
<td>173</td>
<td>186</td>
<td>200</td>
</tr>
<tr>
<td>Maximum depth</td>
<td>198</td>
<td>187</td>
<td>196</td>
<td>192</td>
<td>204</td>
<td>176</td>
<td>196</td>
<td>202</td>
</tr>
<tr>
<td>Depth of caudal peduncle</td>
<td>96</td>
<td>100</td>
<td>89</td>
<td>91</td>
<td>93</td>
<td>92</td>
<td>95</td>
<td>98</td>
</tr>
<tr>
<td>Lth of longest dorsal spine</td>
<td>42</td>
<td>-</td>
<td>46</td>
<td>43</td>
<td>44</td>
<td>33</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Lth of longest doral ray</td>
<td>146</td>
<td>162</td>
<td>140</td>
<td>120</td>
<td>139</td>
<td>114</td>
<td>122</td>
<td>132</td>
</tr>
<tr>
<td>Lth of longest anal ray</td>
<td>161</td>
<td>148</td>
<td>151</td>
<td>110</td>
<td>121</td>
<td>104</td>
<td>110</td>
<td>103</td>
</tr>
<tr>
<td>Lth of longest ventral ray</td>
<td>120</td>
<td>118</td>
<td>100</td>
<td>102</td>
<td>106</td>
<td>95</td>
<td>95</td>
<td>99</td>
</tr>
<tr>
<td>Lth of longest pectoral ray</td>
<td>135</td>
<td>179</td>
<td>137</td>
<td>133</td>
<td>108</td>
<td>142</td>
<td>156</td>
<td>145</td>
</tr>
</tbody>
</table>

Proportions

Each of the proportions noted below gives in succession range, mean with standard error, coefficient of variation with standard error, with the addition in parentheses of values derivable from McNicoy's single specimen, Castelnau's account, and Munro's synoptic data where these items are available.
E. O. G. Scott

Head = standard length 5.0-3.4 3.26 ± 0.05 4.5 ± 1.1 (3.3, three and two-thirds in total length, 3.4-3.5). Maximum depth in standard length 4.9-5.7 5.16 ± 0.09 4.7 ± 1.2 (5.1, about six and a half in total length, 4-6.5). Eye (horizontal) in head 5.6-7.2 6.27 ± 2.08 9.4 ± 2.4 (orbit 5.2 6.2 5.5). Eye (vertical) in head 4.6-5.7 5.43 ± 0.19 7.5 ± 1.9. Eye in snout 2.4-2.9 2.67 ± 0.08 7.9 ± 2.0 (— — 2.5). Eye in interorbital 0.9-1.1 1.06 ± 0.05 7.9 ± 2.0 (— = "equal"). Pectoral in head 1.8-2.4 1.99 ± 0.07 10.0 ± 2.5 (1.2-2.5 =). Ventral in head 2.3-3.2 2.55 ± 0.12 12.7 ± 3.3 (3.3 3.4 =). Depth of caudal peduncle in head 3.0-3.5 3.5 ± 0.08 6.8 ± 1.7. Longest dorsal spine (6 entries only) 6.7-8.5 7.30 ± 0.29 9.6 ± 2.4, longest dorsal ray 1.8-2.4 ± 2.34 ± 0.12. 15.0 ± 3.9, longest anal ray 1.8-3.1 2.57 ± 0.17 13.8 ± 5.1, all in head.

The second and third of the last three ratios each exhibit significant positive correlation with standard length, r = 0.793 (z = 1.073) ± 0.187*, r = 0.942 (z = 1.760) ± 0.907***; this systematic variation of ray length in dorsal and anal with head length (and hence with standard length, with which head length is correlated at r = 0.984) has not previously been noted. The six entries of the longest spine ratios also show positive correlation with head length but not at a formally significant level (p = 0.645 ± 0.767).

Aspects of form

(1) Length of head, length to vent, standard length. In this species, as in many others of considerable taxonomic diversity, the anteroposterior extensions of the basic regions head, head + trunk, head + trunk + tail exhibit the relation \( L = b N^k \) where \( L \) = regional length; \( N \) = an early natural number, the present set being \( \{1, 2, 4\} \); the relation is conveniently rectified as \( \log L = k \log N + \log b \). For the mean lengths for the sample the best straight line is:

\[
\log L = 2.4852 \log N + 0.8475; \; t = 32.154*; \text{ calculated (measured) lengths}, T_L, 309(309), 556(553) 990(1 000).
\]

Parameters of equations for the eight individual fish together with indications of statistical significance and with calculated and measured values are set out in table 5.

### TABLE 5

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Standard length, ( \text{mm} )</th>
<th>( k )</th>
<th>( \log b )</th>
<th>( t )</th>
<th>Calculated (measured) lengths, ( T_L )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 192</td>
<td>0.8880 2.4566</td>
<td>15.661*</td>
<td>285(292) 528(505 978(1 000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) 210</td>
<td>0.8880 2.4687</td>
<td>14.930***</td>
<td>294(292) 545(553) 1 008(1 000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) 260</td>
<td>0.8495 2.4872</td>
<td>35.524***</td>
<td>308(308) 553(550) 997(1 000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) 266</td>
<td>0.8709 2.4621</td>
<td>11.183</td>
<td>309(299) 530(498) 965(1 000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) 280</td>
<td>0.8556 2.4971</td>
<td>112.598***</td>
<td>314(314) 560(561) 1 006(1 000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) 289</td>
<td>0.8174 2.5020</td>
<td>24.311*</td>
<td>317(322) 560(545) 987(1 000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g) 317</td>
<td>0.7824 2.5243</td>
<td>29.239*</td>
<td>334(338) 575(565) 980(1 000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(h) 317</td>
<td>0.8542 2.4800</td>
<td>25.805*</td>
<td>302(306) 546(533) 988(1 000)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(2) Origins and terminations of vertical fin systems. Lengths to dorsal origin, anal origin, (second) dorsal termination, anal termination, and standard length fall significantly collinear on a loglog grid with an abscissa five integers \( \{3 5 7 8 10\} \). For mean lengths for the sample (seven entries only for lengths to dorsal origin and anal termination) the best straight line (sum of logarithmic, not arithmetical, deviations from mean minimized) is:

\[
\log L = 0.7554 \log N + 2.2455; \; t = 37.543***; \text{ calculated (measured) lengths}, T_L, 401.7 (406.4), 605.0(575.1), 761.9(772.6), 842.8(842.0), 997.5(1 000).
\]
Observations on some Tasmanian fishes: Part XXVII

Data for individual specimens are recorded in table 6.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Standard length, mm</th>
<th>k</th>
<th>log b</th>
<th>t</th>
<th>Calculated (measured) lengths, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>192</td>
<td>0.7721</td>
<td>2.2215</td>
<td>12.891**</td>
<td>389(406), 570(531), 748(750)</td>
</tr>
<tr>
<td>(c)</td>
<td>260</td>
<td>0.7377</td>
<td>2.2616</td>
<td>133.217***</td>
<td>411(413), 599(586), 767(773)</td>
</tr>
<tr>
<td>(d)</td>
<td>266</td>
<td>0.7758</td>
<td>2.2164</td>
<td>16.571***</td>
<td>386(398), 574(530), 745(762)</td>
</tr>
<tr>
<td>(e)</td>
<td>280</td>
<td>0.7192</td>
<td>2.2808</td>
<td>1030.985***</td>
<td>421(421), 607(607), 774(790)</td>
</tr>
<tr>
<td>(f)</td>
<td>289</td>
<td>0.7724</td>
<td>2.2285</td>
<td>210.242***</td>
<td>395(394), 587(588), 761(772)</td>
</tr>
<tr>
<td>(g)</td>
<td>317</td>
<td>0.7359</td>
<td>2.2724</td>
<td>103.268***</td>
<td>399(420), 610(590), 781(803)</td>
</tr>
<tr>
<td>(h)</td>
<td>3.7</td>
<td>0.7908</td>
<td>2.2144</td>
<td>128.122***</td>
<td>391(391), 585(577), 763(779)</td>
</tr>
</tbody>
</table>

(3) Ventral rays 1-4. The ray lengths are regularly 1<2<3<4<5, ray 1 being defined as in Part XIX (1974a, p.248) as that farthest from the spine (nearest to medioventral line of fish; postaxial). As is usually the case with this very common pattern the lengths of rays {1-4} are collinear in a loglog plot with their serial numbers. The relevant best straight line has been calculated for the largest specimen (h):

\[ \log L = 0.0832 \log N + 1.4487; \ t = 10.549**; \ \text{calculated (measured) lengths, mm, 28.1(28.0) 28.8(29.9) 30.8(31.0) 31.5(31.3)} \]

Family SCOMBRIDAE

Greenwood et al. (1966) in their provisional classification of living teleosts assemble in the wide taxon Scombridae six or eight groups treated by most Australian authors as separate families. The species here dealt with, the butterfly mackerel, *Gasterochisma melampum* Richardson, 1845, was placed first by McCulloch (1922) in Scombridae later (1929) in Scomberomorididae, in which it was accommodated also by Whiteley (1962); however, in the Handbook (Munro 1958) it is referred to Gasterochismatidae (rendered Gasterochismidae by Greenwood et al. in their synonymy). In all Tasmanian lists it appears in Scombridae.

**Genus GASTEROCHISMA** Richardson, 1845


Gasterochisma melampus Richardson, 1845

(pl. 1)

Gasterochisma melampus Richardson, 1845, p. 346. Type locality: Port Nicholson, New Zealand.

Gasterochisma melampus Richardson, 1846, p. 60, pl. 37.

Lepidotrigon huttonii Günther, 1889, p. 15, pl. 6, figs A, A'. Type locality: Lyttleton, New Zealand.

Lepidotrigon huttonii [sito]: McCulloch, 1929, p. 265.

Gasterochisma melampus: Johnston, 1883, p. 118 and 1891, p. 11 and Whitley, 1929, p. 60:

Waite, 1912, p. 220, pl. 8: McCulloch, 1922, p. 104, pl. 48, fig. 287a, 1929, p. 265:


Tasmanian Occurrence

In including Gasterochisma melampus in his first catalogue Johnston (1883, p. 118) noted the recent capture [by the schooner Malcolm] of an example at the mouth of the estuary of the Derwent and reported its meristic characters together with a dozen dimensions. Johnston's fin counts were included in his memoranda made available by Whitley (1929), being there accompanied by a newspaper cutting that repeated the catalogue measurements, adding "width of widely forked tail at tips 12 inches" (305 mm) and rendering total length and 'length of body' (i.e., length without caudal) as 1022 mm and 889 mm as against 991 mm and 838 mm in the memorandum and in the catalogue. This record appears to have provided the sole basis for the presence in the local lists of Lord (1923, 1927) and Lord & Scott (1924) of this "very rare oceanic species" (McCulloch 1922, p. 104) that occasionally comes ashore. Though having a wide range it has not hitherto been listed from Western Australia (Whitley 1948) or South Australia (Scott et al. 1974). An example, Le 372 Li 458, stranded at Paimouth on 14 November 1978 was reported in Fort XIV (1979). Two other Tasmanian specimens are here noted – Le 460 Li 578, collected by Mr Shane Down 3.2 km east of Sinnalong Bay in March 1980 (Q.V.M. Reg. No. 1980/5/35), Le 342 Li 417, trolled in 70-90 m about 8 km off the south of the Mersey River by Mr K.W. Sipplestad in mid June 1980 (Q.V.M. Reg. No. 1980/5/59). These individuals are denoted (a) (b) (c) in order of ascending standard length.

In quantitative statements below entries for the Queen Victoria Museum's three examples are cited, where appropriate, in order of ascending magnitude of Le, with variates for the specimen reported by Johnston, the largest individual, shown where available in parentheses.

Meristic Characters

D. XVII XVI XVI; 1, 9 9 10; 6 8 7 finlets. A. I II 1, 9 10 10; 6 8 6 finlets. P 23 22 22. L. lat. 65, not traceable beyond level of second dorsal finlet 74. — L. tr. 8/20 7/21 7/20. Caudal about 18 + 18 rays + 4/5 strong spine-like procurent rays — .

Gill Markers

The Handbook (Munro 1958B, p. 110) states "G.R. absent", Whitley (1962, p. 185) has "no gill-markers"; however, in a more qualified statement, Waite (1912, p. 222) wrote "no distinct rakers are developed, their place being taken by curved spines, irregularly disposed". Of the Paimouth specimen it was noted "While there are no elongate rodlike structures, the anterior arch bears 11 small spinulose mounds, placed about their own diameter, 2 mm, apart at the middle of the series, closer together at the ends". In the present material the arrangement is essentially similar. In the Sinnalong Bay individual several mounds at the inferior end of the series are in contact, their distal borders effectively continuous and a precise determination of their number becomes somewhat arbitrary; if 3 are counted in this region the total number on the lower limb of the anterior arch is 13: in the northwest coast individual, 14. Each mound bears from half a dozen to a dozen curved spines, in some only on the free upper surface in others extending on to the proximal part, being here usually smaller. There is some difference in size of the major spines in the present two specimens, those of the larger fish being
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relatively larger. Thus the spines are borne on discrete structures, not "irregularly disposed" as assessed by Waite, and these mammilliform structures would clearly appear, by their location number and character, to represent rudimentary or vestigial rakers.

Dimensions

The principal dimensions are recorded below as milimels of standard length; of the two versions of standard length reported for the early Derwent estuary specimen (see above) the smaller, 991 mm, given by Johnston himself (1883, p.118) has been accepted. Length to tip of upper caudal lobe 1219 1951 1952 ("total length" 1182), to tip of lower caudal lobe 1211 1304 1320; to end of middle caudal rays 1053 1054 1087. Length to origin termination of first dorsal 275 253 287 655 556 576, of second dorsal 635 594 628 (579) 757 757 715, of anal 646 632 663 (657) 731 757 740. Length to vent (middle) 620 613 653.

Length to origin of pectoral 254 250 272, of ventral 251 250 257. Total length of pectoral 122 125 133 (150), of ventral 264 284 270 (304), of anal 100 112 118 in membrane (Whitly 1929, p.60) but rendered "anal" in catalogue). Length to origin of upper caudal lobe 961 949 980, of lower caudal lobe 959 962 985.

Head 250 242 254 (250). Snout 99.4 92.7 104 (114). Eye, horizontal diameter 31.9 29.8 30.4 ("eye" 25.9), vertical diameter 33.6 32.5 32.6. Interorbital 76.0 67.2 73.9. Depth at front of eye 155 153 154, at back of eye 187 188 187. At opcular border 243 265 335, at vent 243 245 228; Maximum 275 277 261 (257 — in newspaper cutting "at shoulder"), depth of caudal peduncle 37.3 38.5 (29 — in catalogue "least depth"). Width at same points 73 85 76, 79 91 96, 89 108 107, 79 99 80; 110 118 113, 26 47 21. In first dorsal length of first spine 58 43 39, of longest intact spine 108(9th) 123(8th) 96(11th), of last spine 20 32 37; in second dorsal length of spine 37 57 57, of first ray 67 — 79, of longest ray 76(2nd) 64(3rd longest intact) 79(1st), of last (shortest) ray 19 21 17, longest (last) finlet 47 54 43. Anal spine 52 30(first) 39, first ray — (second 44) 47(longest) 85(longest), longest (last) finlet 53 54 -. Proportions

Greatest depth 5.6 3.6 3.8 3.9 (Handbook, Munro 1958b, 3.9-4.1), head 4.0 4.1 3.9 (4.0) (Handbook 4.4-1) in standard length. Depth of caudal peduncle in head 6.8 6.4 6.4. Eye, horizontal, in head 7.8 8.1 8.4 ("eye" 10) (Handbook "eye in head" 5.5-7.4). Eye, horizontal, in snout 5.1 5.1 5.0 ("eye" 4.8), in interorbital 2.4 3.3 2.4. Pectoral in standard length 6.5 6.0 6.0 (6.7), in head 1.6 1.6 1.5 (1.7). Ventral in standard length 3.1 2.9 3.1 (6.1), in head 1.5 1.4 1.3 (1.5). First dorsal base (to last spine) in standard length 3.0 3.3 3.4. Second dorsal base (to last ray) in standard length 11.0 8.6 10.3. Anal base (to last ray) in standard length 10.7 10.9 13.0.

General Features

Maxilla to below 0.5 0.4 0.3 eye ("front margin of eye", Waite), its greatest oblique width 17 15 21. Its exposed length short 0.28 0.33 0.33 mouth cleft, shortest distance from eye 14 17 21. Upper jaw projecting very slightly, mouth cleft at an angle of about 25°-30° (contrast Waite, "horizontal"). Teeth in jaws minute subconical relatively stout, somewhat variable in size, uniserial, or palisate similar rather more slender directed somewhat backward, on vomer in a kite-shaped patch. Posterior nostril a short downwardly and backwardly oblique slit, its length subequal to its distance from orbit. Anterior nostril small round aperture about on horizontal level with superior orbital border and inferior border of upper lip, direct distance from lip 1.3 1.1 1.0 that from orbit ("midway", Waite). Border of ventral fin somewhat irregular, grossly slightly concave (shown strongly by Richardson, strongly concave by Waite almost straight by Günstler), ray lengths 1-25 5-45 1-25 34-45 (1-25 34-45) (ray 1 farthest from spine), preaxial ray 1.3 1.1 1.2 postaxial ray or 2.0 3.3 2.4 spine, rays in general with three strong rami widely diverging distally remaining separate almost to base. Greatest depth of groove for reception of fin 30 32 37, inner surface fleshy smooth white.

Dorsal originating behind head being by 0.5 eye behind pectoral origin is specimens (a) (c), above hinder part of operculum being 0.5 eye in advance of pectoral margin in (b).
Anal originating shortly behind of second dorsal. Pectoral reaching to below 7th 9th 11th dorsal spine. The anal increasingly assume the tufted character of the formally distin-

from these only by being more but feebly membrane. Outer rays of in advance of JOI

to the front of the mate vertebra. Behind the level of the tail continues back as a scaled tumid fleshy lobe covering the (formed by fusion of several hypurals) and reaching nearly to the tips of Scales rounded, a little deeper than long, cycloid; diameter of scale to about two-thirds that of eye; ceasing on dorsum of head at level of , posterior nostril, anterior nostril; preoperculum squamous save for narrow gelatinous are constituting hind border; operculum without scales but a small subcircular half a dozen scales in front of it immediately in advance lateral isthmus scales to almost to, at least to level of front of orbit rest of head smooth. In his
tion of the large Kaikoura example (Ls 1473 mm) Waite the head as being
"with the exception of about 4 rows of scales on the cheeks"; a progressive decrease in cephalic scalation would appear probable. Lateral line rising about to level of middle of spinous dorsal, initially abruptly in a short arc subequal to eye diameter then gradually and evenly about to its termination below or just behind rayed dorsal base where its distance from profile is rather less than two eye diameters. A noticeable feature of the compressed head, to which attention has been drawn by Günther and Waite, is the presence of a median dorsal ridge clearly defined from in advance of posterior nostril to above hinder part of preoperculum, lapsing (variably in individuals) forward towards tip of snout backwards towards dorsal origin: this marks the site of the supraoccipital crest of the neurocranium, originating in general in scombrids at the pineal foramen and extending to or beyond the exoccipitals.

Radiograph

By courtesy of the Radiography Department Launceston General Hospital several radiographs were taken of specimen (c) (Plate 1).

Examination of the radiographs and comparison of these by Günther's reproduction of a photograph (1889, p.6 fig.1) with an articulated skeleton in the Canterbury Museum, Christchurch, New Zealand suggest the following comments. Our fish appears to have about 7th 9th 11th vertebrae (473 mm) and those in the posterior one-fifth of the series are here somewhat larger relative to the rest. As pointed out by Waite (1912) the articulation has been incorrectly carried out, the origin of the dorsal fin being made to appear too far forward: in our specimen the insertion of the fin at the dorsal profile is vertically over the 6th (c.f. about 2nd) vertebra and well behind the cranium; the first anal ray is below the 21st (about 39th). The mouth cleft in the Tasmanian example slopes distinctly down and back (extends virtually horizontally).

While the complete pattern of the caudal complex cannot be determined with certainty, the following features appear to be recognizable: a large subtriangular plate formed probably by the fusion of the hypurals 1-4 (together with 5?); a preural followed by parhypural (? fused with hypural plate; region obscured by intrusion of proximal parts of caudal rays) with moderate parhypurophysis; 4-5 of the upper and 5-6 of the lower caudal
rays extend forward over the hypural plate, the origins of the outermost virtually in contact near the front of the plate, the interval between those of the others rapidly decreasing backward, while the bases of the central rays, 7 of which are the thickest of the total series, stop short of the hind margin of the plate, leaving here in the radiograph a distinct featureless bar (Collette & Chao 1975, p.578, state "One of the diagnostic characters of the Scrombridae [Sarda Cuvier, 1828 Gymnosarda, G11, 1862 Ocyurus chrysurus Whiteley, 1935 Aliothumnae Se rently, 1948] is that the bases of the caudal rays cover over the plate as is true of Gempylidae and Trichiuridae"); 2 preural supra-support, or are level with the bases of, small early caudal rays both above and below.

Variation with Growth

Several notable changes in both quantitative and qualitative characters take place during growth. The chief age-determined morphometric features are (a) a striking decrease in relative length of ventral (b) a less pronounced increase in relative length of pectoral (c) a decrease in height of first dorsal relative to that of second dorsal.

(a) Ventral. This fin is of extraordinary size in the young (its wide membrane expanse suggesting the epithet in the vernacular name, butterfly mackerel); as figured by Richardson (1846) in a small example being almost twice length of head and extending back for a distance equal to the length of the median ventral cleft to reach virtually to the vent, whereas in an adult figured by Waite (1912) it is barely half length of head and reaches less than one-third of distance to vent. Examination of the data for Richardson's type of Gasterochisma melanura followed in sequence of increasing size by those for the four Tasmanian examples, Kaikoura fish (Waite 1912) and the synonymic Lepidothynnus huttonii (as measured by Richardson) shows that in six of the seven cases (specimen from near the Mersey estuary the exception) an increase in total length is accompanied by a decrease in relative length of the ventral fin, the total lengths, mm, being 203 417 459 578 991 1637 1664, the relative fin lengths, millesimals of standard length, 331 264 284 270 147 97 71, giving $r = -0.978 (z = -2.256)$, with $t = 10.234^{**}$. While the fin thus undergoes reduction in length midventral cleft into which it can be withdrawn continues to extend from its origin at the fin base to its termination just anterior to anal origin.

With the three fish here reported in ascending order of overall size the length of the ventral is 0.87 0.97 0.85 that of the groove.

(b) Pectoral. - While the relative length of the ventral decreases with age that of the pectoral increases, the degree of change, however, being very much less. With fish in ascending order of $L_e$ as above, $T_m$ lengths of pectoral are 110 127 123 135 149 168 (the northwest coast example again out of sequence): $r = 0.932 (z = 1.669)$, $t = 5.768^{**}$. The relevant linear equation for regression of relative fin length on total length ($L = 0.029 L_e + 110.0$) yields predicted lengths differing from measured lengths by 0.4-6.0 mean 4.15 per cent.

(c) Relative heights of dorsals. In the young the height of the spinous dorsal is decidedly greater than, in the adult noticeably less than, the height of the soft-rayed dorsal, approximate ratios with increasing length of fish being for the sample here considered 2.6 2.0 1.5 1.2 <1 (Johnston) 0.7 0.5, the height of the anterior fin being contained about 1.9 2.0 2.1 2.7 - 4.7 times in length of head. In contrasting the relative heights of the fins in his specimen with the condition as figured by Günther (1880a, p.455) - i.e., after Richardson (1846) - Johnston spoke of his specimen as "mature"; as pointed out by Waite it is of intermediate size and exhibits intermediate values of the size-related features here discussed.

The positions of the dorsals relative to one another appears to be the subject of some confusion. Munro (1958, p.110) states they are "united basally in young, widely separated in adults", and this specification was accepted in Part XXV (1979, p.120). This would appear to be substantiated by the following facts. In Richardson's 200 mm specimen the fins are virtually contiguous, while in the Queen Victoria Museum's three examples and Günther's type of Lepidothynnus huttonii as figured (relative total lengths of these fish,
Four qualitative features have been reported as exhibiting variation with growth. In older fish there would appear to be some reduction in the scales on the head. In the material at hand they extend forward on the dorsum to level of middle of anterior border of orbit (in Waite's large individual commencing behind the operculum); operculum partly or fully scaled, operculum naked. On this specimen, the scales terminate in (c), while in Waite's individual, about three times as long, it is reported as ceasing below middle of first dorsal. There is some disagreement regarding the presence or absence of lateral keels on the caudal peduncle in this species, and on evidence provided by the present material it would appear the feature is an inconstant one, perhaps without regard to overall size. In his paper on the generic characters of the new species Richardson (1845, p.346) notes "cauda gracilis sine carinis" — a reference to caudal keels doubtless being suggested by the presence of these structures in most of the Scombridae (sensu lato, as recognized in the provisional teleost classification of Greenwood et al. (1966), including Thunnidae, Katsuwonidae, Scomberomoridae and other groups treated in many Australian texts as separate families; similarly the Handbook (Nunro 1958b, p.110) states "Tail peduncle without keels"; Whitley (1962, p.185) has "no caudal keels"; while earlier McCulloch (1922, p.104), recognizing eight Australian genera in the Scombridae, keyed off two of them, Scophe and Gastrochisma with the entry in the primary couplet "Caudal peduncle without a median keel on each side". On the other hand Gunther's diagnosis of Lepidotothen includes "tail with two keels at the base of the dorsal" and Waite states "There are two low ridges on each side of the tail". No keel was found in the Falmouth specimen, La 372, reported in Part XXV (1979, p.120). In the smaller of the two other specimens, La 342, there occurs on the left side of the fish a rather deep straight groove, extending for 33 mm from the level of the middle of the 4th dorsal finlet to beyond the base of the 7th finlet by a distance subequal to the base of that finlet (falling to reach level of insertion of upper caudal) by some 10 mm, the groove is flanked throughout by an elongate elevation, the combined transverse extent of the two bolsters and intervening groove being 10 mm near the middle 7 mm shortly before the rounded ends. No similar structure is apparent on the right side. In the example of La 460 a short distance below the upper profile a low rounded linear elevation, a ridge rather than a keel, originates below base of last dorsal finlet and runs along the convex extension of the caudal peduncle back beyond the forwardly inserted uppermost and lowermost caudal rays (the forked bases of the rays, as in other scombrids, completely embracing the hypurals the early part of the caudal thus becoming part of the dorsal and anal profiles to about midway between the origin of the uppermost ray and the hind border of the peduncle); a similar ridge occurs below, in this case forming the actual profile of the fish: these ridges, between which is a shallow trough, are traceable for a distance subequal to half postorbital length of head, diverging somewhat posteriorly. Collette & Chao (1975, p.576) state "The Gasterochi- matinae and the members of the Scombrinae - mackerels and Scomberomorini - Spanish mackerels) lack supporting bony keels and have only external keels on the caudal peduncle"; and recognize a general evolutionary trend in the relative development of keels leading through low segmented keels to a wide flattened plate extending over several vertebrae. The small pits above and below at base of caudal reported by Waite are present here, but assume the form of short transverse notches rather than of pits.
In discussing variation with growth Waite remarked "The presence of a small corselet is not at all foreshadowed in Richardson's figure"; no distinct corselet is apparent in his own figure nor does a corselet receive express mention in his description, though he notes scales "clothe the whole of the body excepting a naked callous area in which lies the pectoral fin". We distinct naked area is found near the pectoral in any specimens. However, if we are found in the region a specialized condition of the scales that may possibly represent an ablation of a corselet. Above and behind the operculum 6-7 rows of scales extend from the dorsal profile to about the first one-fifth of the upper pectoral rays, their general sense being tangential to opercular border at about 30° to anterior-posterior axis of fish, their direction marking then off rather sharply from the more steeply inclined rows adjoining them. This condition is most marked in specimen (b), least in (a). In (a) and (b) several scales below the pectoral are larger than immediately adjacent scales.

Aspects of Form

Head, length to vent, standard length. In a loglog plot these three dimensions are significantly collinear on log log. With lengths expressed as milssimals of standard length the best straight lines for the Museum's specimens of the rectified relation

\[ L = b N^{p} \]

are as follows:

- \( L = 1.2970 \log N + 2.3873; t \pm 36.793 \) calculated (measured) lengths 244(242) 509(612) 1014(1 000).
- \( L = 0.2583 \log N + 2.4136; t \pm 15.726 \) 259(254) 620(652) 1 036(1 000).
- \( L = 1.2671 \log N + 2.4014; t \pm 36.895 \) 252(250) 621(620) 1 014(1 000).

Dorsal Spines

The spines are slender, highly attenuate and flexible distally, and are readily damaged. In the 1979 fish they increase in length to at least 6th = 7th, in the east coast specimen to at least 4th. In the northwest coast fish, in which all spines other than 10th and 12th are measurable, a clear pattern is evident, involving an anterior set \( A \) of 9 spines ascendant caudad, with subsets \( A_1 = \{1st - 3rd\} \) and \( A_2 = \{5th - 9th\} \) and a posterior set of 8 descendent caudad, with subset \( B_1 = \{13th - 17th\} \) and a possible subset \( B_2 = \{10th - 13th\} \). A loglog plot of \( A_1 \) is linear on \( 1-3 \) and \( A_2 \) is linear, with a lesser slope, on \( 1-5 \); while with the elements of \( B \) taken in reverse order (i.e., numbered cephalad) and thus yielding as for \( A \) a positive slope \( B_1 \) is linear on \( 1-5 \), with a suggestion from the graphing that \( B_2 \) may well be linear on \( 5-9 \) with a slope markedly less than that of \( B_1 \) (and of \( A_1 \)) but subequal to that of \( A_2 \). It will be noted \( A_1 \) and \( A_2 \) exhibit intersection (common element 3rd spine) as also do \( B_1 \) and \( B_2 \) (13th common); further if the full series of measurements for \( B_2 \) were available it might be found 9th is a member of both \( A \) and \( B \).

- \( A_1 \): \( L = 0.7021 \log N + 1.5824; t \pm 27.995 \) calculated (measured) lengths, 72(77) 38(38) 62(65) 83(82).
- \( A_2 \): \( L = 0.2477 \log N + 1.7931; t \pm 7.179 \) 82(82) 85(86) 93(92) 97(96) 101(99) 104(105) 107(108).
- \( B_1 \): \( L = 0.9349 \log N^{1.3180}; t \pm 32.761 \) 21(20) 40(41) 58(57) 76(79) 94(91).

With spine lengths in \( \pm \) units and serial numbers in common logarithms the total area under the graph of \( A \) with spines ascendant caudad is 1.7750; if it is assumed the graph for \( B_2 \) from 13th spine to 9th is linear, the total area under the graph of \( B \) with spines ascendent cephalad is 1.7917, representing with 8 interspine panels in each set 0.222 0.219 per panel, respectively. The panel figure presumably represents in some way an energy output with two measurable factors (length of spine, vector length along antero-posterior axis of fish); in the present case (accepting linearity for \( B_2 \)) it is seen to be significantly the same in the enantiomorphic expressions of spine development.

General Form

The broadly fusiform beautifully streamlined form of the Scombridae (sensu latissimo, as recognized by Greenwood et al. (1966), comprising fishes commonly distributed in Australian texts among half a dozen families) has long been recognized as a remarkable adaptation to fast swimming. That the overall configuration evolved is an efficient one is clear from its constancy -- an inspection of the figures in the Handbook.
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(Munro B58b) makes it evident that for a score of species there referred to Thunnidae, Scombridae, Scomberomoridae, Sardaïdae the general outline of any one species, with allowance made in some instances for some difference in depth, could serve tolerably well for all. In passing mention may be made of the interesting physiological adaptation for rapid and sustained locomotion by the development of homoeothermal mechanisms.

The ontogeny of \textit{Gasterochisma melampus} proceeds from the juvenile with high spinous dorsal, low soft dorsal, short pectoral and exceptionally large ventral fin (this last clearly a specialized adaptation to a specific life mode) to the more typically scombrid adult through the fin changes considered, and in large part quantified, above. Features in this species (and in general in other scombrids) conducive to speedy movement through water include: dorsal and ventral verticals (Gregory 1938) in or nearly in line and sub-equal, tending to promote equivalence of stream flow above and below the fish; curvature in the vicinity of highest and lowest points on profiles (apex and gasterion) slight, rendering transition from entrance to run gradual, minimizing turbulence; smooth mainly scaleless head compressed, with dorsal surface forming a lancet arch surmounted by a fine median ridge for ready entrance, the ventral surface is similarly rather acutely rounded each mandible bounded by a ridge comparable with that of the dorsum, these ridges diverging posteriorly, being for the greater part of the length subparallel to the general plane of the lateral surface of the head; short caudal peduncle specially modified to facilitate even flow by the presence of a stout scaled fishy pad into which the bases of the rays fit, covering the hypural plate—a condition well illustrated by the radiograph of the caudal complex in a bonito, \textit{Opisthoproctus unicolor} (St Hilaire, 1817) by Collette & Chao (1975, fig.57); large falciform caudal fin; reduced falciform or subtringular ventrals, leading evenly convex (large size in young nullified by total reception as occasion arises into the abdominal groove); similarly formed anal and second dorsal; first dorsal here (in adult) low, depressible into a groove (where more highly developed with leading edge highest, sloping markedly backward); caudal keels (inconstant) that may mediate slipstream; dorsal and anal finlets (found also in the allied \textit{Gempylidae}, and either present as discrete structures or adumbrated by a tuft-like extension of one or two posterior rays of the vertical fins in some \textit{carangids}; both speedy types); finlets are further considered below.

Dorsal and ventral profiles. - In view of the interest attached to the outline in lateral aspect, 10 equidistant measurements of the height of the dorsal profile above and 10 of the depth of the ventral profile below a horizontal axis between mouth cleft and middle of caudal peduncle have been made for specimen (a) and a polynomial calculated for each of these and for total height of fish represented by their sum. As pointed out by Snedecor (1950, p.92) at the stage of the third degree the polynomial begins to exhibit "certain snakelike curves", appropriate in a context such as the present, and while a formulation at this or even an earlier stage may yield a value of \( R = 0.9 \) or better, continued calculation not only results in a general refinement in accuracy but in particular leads to improvement in the least squares of the first and last members of the series of measurements. The relevant data for specimen (a) with 4° equations, \( R \) being the serial number of the measurement (counted caudal) and dimensions being millessimals of standard length, are subjoined.

**Dorsal profile.** \( H = 35.72 + 25.14N + 1.8481N^2 - 0.05286N^3 + 0.049358N^4; R \ 0.9946; \) calculated (measured) heights 86.6(87.7) 106.1(108.2) 117.6(115.5) 119.4(114.0) 111.3(111.1) 94.1(102.3) 69.5(70.2) 41.0(35.1) 12.8(14.6).

**Ventral profile.** \( D = 31.99 + 13.49N + 15.73N^2 - 3.21399N^3 + 0.170268N^4; R \ 0.9896; \) calculated (measured) heights 71.99(70.4) 129.9(140.4) 158.6(156.4) 175.3(171.7) 175.1(169.6) 155.9(155.0) 121.5(121.6) 87.0(85.0) 39.8(35.1) 19.3(14.6).

**Total vertical extension.** \( H + D = 92.18 + 61.252N + 5.6935N^2 - 2.7343N^3 + 0.148542N^4; R \ 0.9947; \) 156.5(152.0) 218.0(228.1) 265.9(264.6) 291.3(286.6) 291.7(283.6) 266.3(266.1) 218.2(233.9) 152.2(155.2) 84.6(70.2) 23.2(29.4).

To illustrate the improvement of prediction in the caudal region gained by taking the calculation one degree further, the data for the 5° equation for the dorsal profile are here noted for comparison with the data for the 4° recorded above.
Measurements of the width of the same individual at 10 equal intervals between snout tip and hypural have been made and a 4th polynomial calculated.

\[ W = 49.43 + 22.725 H - 0.9445 N^2 - 0.50725 N^3 + 0.003460 N^4; \]
\[ H = 0.9982; \] calculated heights (measured, as above) 59.9 91.2 106.8 113.9 117.5 113.5 97.6 98.3 86.3 14.7.

Width. When these 10 measurements of width are plotted against the 10 measurements of total depth at the same points along the anteroposterior axis an interesting relation becomes apparent. For measurements 1-5 at the front and 9-10 at the posterior part of the fish the relationship is highly significantly linear \( R = 0.996 \) (z 5.057), the slope being 0.281 the intercept 22.53 (all dimensions \( T \) ands). The three measurements 6 7 8 in which the coordinates of depth lie below the line (in a downwardly concave arc) are those at the level of the second dorsal and anal which, with the retractile first dorsal and anal withdrawn and the pectorals folded, present the only local interruptions to the general curve, a circumstance that may well account for the lapse in this region from the linear width-depth relation subsisting throughout the rest of the length.

Finlets

As suggested above the development of finlets in such fast and powerful swimmers as the scombrids is probably to be seen as a locomotory adaptation. These structures are found to present interesting relations in respect of (1) location relative to whole fish (2) location within the series (3) shape (4) size that may be presumed to have hydrodynamic significance, though in just what fashion at present remains undetermined. These aspects have been made the subject of general investigation, with quantitative data reported for specimen (c).

(1) Location relation to whole fish. The development of finlets along the profiles behind the soft dorsal and anal fins (placed about opposite) and in advance of the caudal would seem to relate to the mediation of the stream flow above the stream bed in the latter part of its emergent phase behind the point of maximum resistance (in the example here examined the greatest height of the dorsal profile the greatest depth of the ventral profile and the greatest width is in each case found at the 4th of the 10 measurements taken at equal intervals along the primary fish axis), presumably operating towards the maintenance, after the localized friction occasioned by the vertical fins, of an effective fair form (i.e., one bounded by surfaces of continuous curvature), with the contour not too abruptly decreased by the pronounced peduncular decrement in body volume.

(2) Location within the series. At the next level downward in spatial arrangement, the location of the members of the series relative to one another, a systematic pattern is recognizable. With the anterior point of insertion of the hindmost finlet taken as origin and successive distances back to the insertions of the earlier finlets measured it is found the seven lengths are a function of their reverse (i.e., cephalad) serial number, \( N' \), with \( L = b N'(c) \). For the dorsal finlets the rectified equation has slope 0.9943 intercept 1.0391 with calculated (measured) lengths, \( T \) ands, 32(32) 64(62) 95(98) 127(132) 159(161) 190(192) 221(211); the anal series has slope 0.9660 intercept 1.4883 lengths 31(30) 61(61) 89(92) 117(120) 146(148) 174(175) 202(193). For the first equation \( t \) is 50.578*** for the second 33.538***.

(3) Shape. The shape undergoes systematic change along the series, the anterior finlets being subquadrangular, with successive members backward developing a progressively lengthening pennon, the total length of the hindmost finlet being about thrice that of the first and about thrice that of its own base. These pennons (which find obvious analogues in the dorsal, particularly the second dorsal, and anal fins of some sharks) are mobile (the best developed highly so) and may be presumed to mediate filaments of flow.
Observations on some Tasmanian Fishes: Part XXVII

As here developed the tip of the last finlet extends back to make contact with the base of the rigid anterior caudal ray, about which it plays freely. Hence during differential displacement of the caudal fin and the pre-caudal region the finlets' mobility can be assumed to promote continuity of flow between the two components of the current bed.

(4) Size. The systematic change in form is associated with a regular increase in length from first finlet to last; in a log-log plot the lengths being linear on reverse serial numbers:

Dorsal. \( \log L = -0.4722 \log N^{*} + 1.8413; t = 48.535^{**}; \text{calculated (measured) lengths, } T_{E}, 26.0(25.7) \quad 27.8(28.7) \quad 29.8(29.8) \quad 32.5(32.5) \quad 36.1(35.1) \quad 41.3(40.9) \quad 50.2(50.0) \quad 69.4 \quad (70.2). \)

Ventral. \( \log L = -0.4523 \log N^{*} + 1.8148; t = 31.151^{**}; \quad 26.6(26.3) \quad 28.2(28.7) \quad 30.1(30.7) \quad 32.6(32.5) \quad 35.9(34.8) \quad 40.6(39.5) \quad 48.4(50.3) \quad 65.5(64.9) \)

The finlets increase in height to the 4th then decrease to the 8th. In both the dorsal and anal sets there is apparent some tendency for the heights in the ascendant set to be an exponential function of the serial numbers and the heights in the descendant set of the reverse serial numbers, but the relations in these small sets do not all reach statistical significance (dorsal \( t = 7.178*5.015 \) anal \( 7.376*4.904 \)). The height, however, calls for further consideration. The fact that as in both the height and the depth of the body above and below the primary horizontal axis the maximum here is attained also at about the middle of the length suggests the possible existence of a recognizable relation between the contours of the body and of the finlets; this possibility has been investigated as follows. The scale of distances between the bases of the finlets specified above has been proportionally transferred to the longitudinal extension considered for the body profile (i.e., \( L_{E} \)) and the heights and depths at the relevant levels calculated from the polynomials for the dorsal and ventral profiles of the fish given above, and against these have been graphed finlet heights. A striking result emerges, the two types of contour being strongly correlated, dorsal body with dorsal finlets ventral body with anal finlets, each pair with markedly different anterior and posterior segments. With dorsal finlets 1-4 we find \( r = 0.997 \) (\( x = 3.299 \)) with 4-8 (the segments intersecting) \( r = 0.995 \) (\( x = 3.230 \)); with anal finlets \( r = 0.991 \) (\( x = 3.225 \)) \( r = 0.972 \) (\( x = 7.124 \)). With the relation expressed as a linear equation \( y = mx + c \), for dorsal finlets 1-4 \( m = 0.064 \) \( \sigma = 6.065 \); \( t = 23.673^{**} \), for 4-8 \( m = 0.029 \) \( \sigma = 11.223 \); \( t = 17.658^{**} \); for anal finlets 1-4 \( 0.043 \) \( 6.916 \) 10.245**, for 4-8 0.023 11.469 7.141*.

As with the superior and inferior profiles of the body, the total curves constituted by the external margins of the dorsal and anal finlets are adequately specified by polynomials of the third degree. Equations for specimen (a) below.

Dorsal finlets. \( H = -0.118 + 8.23 \quad N - 1.444 \quad N^{2} + 0.07475 \quad N^{3} \), \( R = 0.9953 \), calculated heights, \( T_{E} \), 6.7 11.2 15.6 14.5 14.3 13.4 12.4 11.6.

Anal finlets. \( H = 0.501 + 8.161 \quad N - 1.5823 \quad N^{2} + 0.06743 \quad N^{3} \); \( R = 0.9898 \); 8.0 11.8 14.4 15.5 15.2 14.3 13.0 11.8.

The investigations here reported are clearly of an exploratory nature only; examination of more extensive sets of data is necessary before definitive conclusions can be reached. However, the high degree of precision of the relations encountered suggests these interesting and novel formulations may well specify morphometric patterns with significant biological and hydrodynamic implications not at present apparent.

Coloration

No mention of color occurs in the diagnosis by Richardson (1845) of the generic characters of "Gasterochisma melanops" ("homen genericeum fissuram ventris denotat"), while in his account of Lepidostoma huttonii Gunther (1889) observed merely. "Colour uniform steel-grey, lighter below; caudal fin and inside of pectoral darker". Waite reported body nearly black above and silvery beneath, head steel-blue. "Midnight blue above lilac to gunmetal on sides and greyish silvery below" (Whitley 1962); Whitley gives "blueskin" as an alternative vernacular name to the customary butterfly mackerel.
E.O.G. Scott

Among our material specimens (a) and (c) are much alike, with trunk and tail very deep blue in parts approaching black down to near midlateral line, thereafter gumminal lightening below to silvery and becoming close to white immediately above ventral profile; (b) differs noticeably, being overall much lighter and in general more bluish. Dorsum of head blackish, darkest anteriorly. Operculum in (a) (c) dark greyish narrowly bordered with off-white, in (b) much lighter and with wider more yellowish border, in all with indications of 2-3 oblique lighter stripes, obscurely yellowish or in (b) distinctly reddish. Preoperculum more or less like trunk but with some yellowish. Small yellowish area regularly present bordering eye in front and behind. Lower jaw in (a) partly yellowish partly whitish with some dusky marbling inferiorly, in (b) pale yellow virtually immaculate, in (c) blackish brown in front obscurely yellow behind with some black mottling. First dorsal hyaline, "like plastic" (Whitley 1962), spines sometimes whitish or straw (brown, Waite). Second dorsal and anal similar, dark brownish in parts close to black, tips of some rays ashen or pale yellowish. Posterol with rays brownish or deep grey, almost black on inner surface (fin silvery, Waite). Ventral black (bluish black, Whitley) except for first ray which shows some brownish red and white mottling (front ray silvery, Whitley), in (b) short orange streaks on bases of 5 rays. Caudal with outer rays blackish others greyish or whitish, on lower lobe of (b) on both lobes of (c) heavily mottled dark and light (tail black, Waite).

Family PLEURONECTIDAE

Ten species of right-hand flounder have so far been reported at one time or another from Tasmanian waters, of which individual authors have recognized half a dozen or fewer: a further species is now added. These are listed below and the status accorded them in some selected texts noted. In the subjoined schedule the presence of a cross indicates Tasmanian occurrence, that of a number signifies the species concerned has been expressly treated by the author as synonymic with the species listed with that number in the left-hand column; doubtful entries are shown with a question mark, placed after the specification (locality or taxonomic status) that is queried. Questions of synonymy are the subject of comment only by Norman (1926) McCulloch (1929) Last (1978).

<table>
<thead>
<tr>
<th>No.</th>
<th>Species Name</th>
<th>Common Name</th>
<th>Johnstone 1883-1891</th>
<th>Lord 1923-1927</th>
<th>Lord &amp; Scott 1924</th>
<th>Norman 1925</th>
<th>McCulloch 1929</th>
<th>Amaro 1927</th>
<th>Last 1978</th>
<th>Scott herein</th>
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<tbody>
<tr>
<td>1</td>
<td>Ammod Entretis littoratus (Richardson, 1845)</td>
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<td>Ammod Entretis pictor Grunther, 1862</td>
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<td>Ammod Entretis tildorii McCulloch, 1914</td>
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<td>Ammod Entretis elongata McCulloch, 1914</td>
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<td>6</td>
<td>Rhambosolea phlebota Richardson, 1845</td>
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<td>7</td>
<td>Rhambosolea monspum Geunther, 1863</td>
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<td>8</td>
<td>Rhambosolea tappriae Geunther 1863</td>
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<td>9</td>
<td>Rhambosolea flavicoda Geunther 1863</td>
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<td>10</td>
<td>Rhambosolea pinnataiuse Norman 1926</td>
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<td>11</td>
<td>Parummetis dermontica Last, 1978</td>
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With Tasmania interpreted as including Bass Strait, it is or is included among the type localities of seven species: 1 [no locality (collected by Thomas James Lemhiere 1796-1852, public official, author, artist, Hobart) = Tasmania, fide McCulloch (1929, p.281)]; 2 ["Norfolk Is." = Tasmania (McCulloch)] 3, 4, 5, 10. The generic name Ammod Entretis is regularly rendered Ammod Entretis in the early Tasmanian catalogues by Johnston.
The seven species of left-hand flourounder validly included in the Tasmanian faunal list have been keyed in Part XXI (1975).

Genus Ammotretilis Günther, 1862

Ammotretilis Günther, 1862, CAT. FISH. BRIT. MUS., 4, p.458. Type-species, Ammotretilis rostrata Günther.

Ammotretilis elongatus McCulloch, 1914

Ammotretilis elongatus McCulloch, 1914, p.123, pl.27. Type locality: "Investigator Strait, South Australia, or the area south of Kangaroo Island".

Ammotretilis elongatus: Waite, 1921, p.159, fig.260 and 1923, p.185, unnumbered fig.: Norman, 1926, p.271; McCulloch, 1929, p.289; Scott, 1962, p.90, unnumbered fig.: Scott, Glover & Southcott, 1974, p.103, unnumbered fig.: Whitley, 1904, p.49.

Identification

Ammotretilis elongatus is readily distinguishable from the six remaining species accepted as Tasmanian by Last by the following combination of characters: snout produced into a fleshy hook, two pelvic fins the right with 13 rays, joined to anal, no fleshy tubercle at tip of first ray of left pectoral, depth of body >2 (2.1-2.5) in length without caudal fin. In the key by Last (1978, p.22) it enters the last couplet, being distinguishable from the two species there included, A. lituratus and A. macrolepis by its greater number of right pelvic rays, 13 (cf. 10-12), higher pelvic ratio. >3 (cf. 1.5-2.4); further from the first species by lacking a fleshy tubercle on the left pectoral and from the second by having decidedly fewer rays along the lateral line, 66 (cf. 88-92).

Material

A specimen 65 mm in standard length 76 mm in total length, collected by Mr J. Shea at Goose Island, Bass Strait in May 1980 (Q.V.M. Reg. No. 1980/5/64).

Meristic Characters


Dimensions

The species was founded (McCulloch 1914) on a single individual 98 mm long and the account in the report on the Heterosomata collected by the Endeavour (Norman 1926) is based on three specimens 90-125 mm in total length. Neither author provided any absolute morphometric data, such dimensions as are noted being given in the form of proportions. All dimensions here recorded are thousandths of standard length 65 mm. Measurements are in general taken between parallels, those taken point-to-point being shown in parentheses.

Total length 1200. Head 285, length to preopercular border 200. Snout to lower eye 83, to upper eye 89. Lower eye diameter horizontal 65, vertical 34, diameter of eyeball horizontal 31, vertical 26, shortest direct distance to ventral profile 60; greatest external diameter of orbit 71. Interorbital 14. Length of maxillary (80), length of lower jaw of ocular side (85), of blind side (85). Snout to vent 285 (325). Left pectoral length to origin 286, total length of fin 91, length of longest (5th) ray 85, oblique length of base (28). Right pectoral length to origin 292, total length of fin 135, length of longest (6th) ray 123, oblique length of base (37). Left pelvic length to origin 197, length of base 63 (64), length of longest (5th) ray 63. Right pelvic length to origin ca 70 (some displacement of body here), length of base 300 (323), length of longest (11th = 12th) ray 77. Dorsal length to origin 0 to termination 977, length of longest ray (near middle of fin) 112 of last ray 29. Anal length to origin 315 to termination 980, length of longest ray (near middle of fin) 108 of last ray 29. Length of longest (smor) unbranched caudal ray 137, of
longest (middle) branched 185. Depth at front of eye 262 back of eye 323 operculum 477, maximum depth (at about 0.4 of standard length) 492, depth of caudal peduncle 108.

General Features

Elongate, evenly ovate, its depth 2.03 in standard length, Le, (McCulloch, 24 in Le Norman, 25-24 "in the length"), depth of caudal peduncle 2.7 in head. Head 3.51 in Le (McC., 4 in Le, N., 4-4.5 "in the length"). Snout moderate, to anterior eye 3.4 in head; rostral hook stout, its inferior border strongly concave, its length subequal to width of hook, acute, barely extending down to level of maxillary on ocular side. Lower eye slightly in advance of upper, horizontal diameter of latter 1.7 its vertical diameter, 4.4 interorbital (N., about 4), 4.6 (McC., 4.5-5, N., 4.4-5) in head, 0.7 of relevant preocular length. Mouth small, the two sides not symmetrical; on blind side the dentigerous jaws much alike but upper upwardly convex, a trifle longer than lower, which is upwardly concave; maxillary failing to reach level of eye by about one-fifth eye length; length of lower jaw of ocular side 3.4 (N., 3-3.5) in length of head. Several minute tubercles on lower lip on ocular side (N., "forming a fringe"). Teeth along whole length of both jaws on blind side, small closely set moderately acute, in a band of subequal width throughout, in 5-6 rows. Nostrils shortly in front of eyes small tubular with very slightly raised rims, anterior larger (McC., on "both sides with posterior lobes"). Upper angle of gill slit about level with inferior orbital border of upper eye, opercular lobe just above pectoral base. Gill rakers minute tubercular (N., about 10) on upper limb of anterior arch. Scales variable; on ocular side mostly cyloid, those behind and below the head either with 2-4 blunt or jagged processes or with 4-6 short tolerably acute processes inserted inside the scale border; those on blind side in general ctenoid with 8-10 slender acute processes with a bifid base and behind these a segment of blunt elevations; extending up dorsal rays, other than some anterior ones, anal and caudal rays for two-thirds of their length or more; not present on pectorals or pelvic. Lateral line almost straight from caudal peduncle to just behind level of pectoral tip where it turns a little upward in a very slightly upwardly convex segment to just above angle of gill slit, then continuing briefly (McC., continuation not shown in figure) in a nearly straight line halfway towards upper eye.

Dorsal 75 (McC., 74-75, N., 74-75) commencing at tip of rostral hook, about 30 (McC., figure, 20) anterior rays more or less free simple slender minutely serrated, forming a crest, the hindmost ray somewhat higher than the more massive ray immediately following it, those later rays briefly bifid, longest 2.5 in head; last ray inserted far back on caudal peduncle almost contiguous with uppermost caudal ray. Anal 55 (McC., 50-51 N., 50-51), in general similar to dorsal but a trifle lower than its postcephalic portion, commencing shortly behind (McC., figure, below) pectoral base, ending barely behind dorsal. Right pectoral 11 (N., 8-10), upper end of its base about level with middle of lower eye, 1.8 in head. Left pectoral 8 (N., no count; McC., overall pectoral range "P. 8-10"), length 0.7 that of (N., equal to) right. Right pelvic 15 (McC., N., 13), its anterior ray at the tip of the ilium, inserted below jaws of blind side, its base a little longer than head, in line with and joined to anal, posterior rays scaly on ocular side. Left pelvic 5 (McC., N., 3-4). 3 rays close together, the first of these located about as noted by Norman, opposite space between eleventh and twelfth of right pelvic, the 2 others in advance of those separated from them and from each other by almost as great an interval as that between third and fifth rays, total base 4.6 in head. Caudal 3/12/3, rounded, 1.4 in head. Caudal peduncle very short, last dorsal and anal rays almost contiguous with first caudal rays, depth 2.7 in head length.

Where the scales have been lost the prerigilohores form a conspicuous closely set palisade the intervals between them much less than their width, the combined height of the dorsal and ventral series accounting for one-fourth of the depth at opercular border, for rather more near middle of length; the external termination shows a bulbous enlargement, with a suggestion the radial may be briefly bisegmented (or trisegmented), but this point cannot be satisfactorily determined.
Aspects of Form

It has been shown in these contributions that for a wide range of species in a log log plot of head length to vent and standard length are effectively collinear on three low natural numbers (modally 1 2 3). While this formulation is appropriate for the majority of forms in which the vent is normally located shortly in advance of a reasonable rearward anal fin, it is clearly not applicable to species with an exception- ally forwardly placed vent. In one such species, Paratetraolichthys trollii (Hutton, 1876), in which the vent lies between the bases of the ventral fins, it is found (see above) that, with logarithmic values as before, a significant straight line is obtained with a reverse pattern of graphing involving a negative slope with standard length on 1 and the other lengths on higher natural numbers in the vicinity of 10 (in this instance 9 10).

However, it was questioned whether such a formulation was a biologically significant one or a mathematically neat but adventitious solution. It is thus of interest to note that in the present species as represented by our specimen such a solution with abscissal values of 1 9 10 is statistically significant.

\[ \log L = -0.54 \log N + 3.0002; \; r = 0.547**; \text{calculated (measured) lengths, } TLs, 288(285) 305(308) \; 1000(1000). \]

The above results have prompted the examination of another form with the vent close behind the head noted in these contributions, Carpulx rendahli Whitley, 1941, measurements of a Tasmanian example of which recorded in Part XXIV (1978) yield the subjoined equation, the abscissa here being 1 8 10.

\[ \log L = 0.5905 \log N + 3.0013; \; r = 0.4409*; \text{calculated (measured) lengths, } TLs, 103(100) 128(132) 1003(1000). \]

An equation for the low, even curve of the dorsal profile with greatest rate of change of curvature one-tenth, that should not be without comparative taxonomic signifi-
cance has been computed (displacement in the region forward of the operculum precluded a satisfactory evaluation of the ventral profile). Ten measurements of height of profile, \( H \), above a line joining most advanced point on rostral hook and middle of end of caudal peduncle were made.

\[ H = 138.93 + 22.877 \log N + 7.11004 N^2 - 2.25042 N^3 + 0.125175 N^4; \; r = 0.9991; \text{calculated (measured) heights, } TLs, 167(162) 207(203) 221(226) 233(231) 228(222) 208(202) 176(180) 137(142) 101(105) 80(77). \]

Coloration

After preservation in alcohol both sides are in general more or less uniformly yellowish, blind side the lighter. McCulloch and Normal mention the former figures minute black dots over the head, body and fins on ocular side: in our specimen a sprinkling of obscure black dots occurs on the head but only a few are evident on body and fins, the latter overall white. The location of internal organs is indicated by a dark oval patch behind the head above the vent and a pennon-like area beginning immediately behind this and extending just above the ventral pterygiophores back to within about half a head length of caudal origin; also the course of the vertebral column can be traced.

ACKNOWLEDGEMENTS

Material in the Queen Victoria Museum and Art Gallery, Launceston has been made available through the courtesy of the Director, Mr C.R. Tassell. Through the good offices of Dr Martin F. Gomon a sample of Centroberyx affinis was received on loan from the National Museum of Victoria. Lively thanks are tendered to the staff of the Radiography Department, Launceston General Hospital for radiographs of Querochothys melampus and to Dr David R. Barrett for processing prints of these; to Miss Judy Godley for assistance with the text figure, and to Miss Kaye Dimmock for painstaking preparation of the type-

script.
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