A REVISION OF THE FAMILY MORIDAE (PISCES: ANACANTHINI) WITHIN THE NEW ZEALAND REGION

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ABSTRACT

Moridaceae are characterised by four features: large fontanelles in the exocirrals through which elongate projections of the swim bladder extend and contact the auditory capsule, the ossous nature of the entire canal of the olfactory nerve and part of the inter-orbital septum, the structure of the caudal skeleton, and the ostiolar structure.

Eleven genera and fifteen species of Moridaceae occur in the New Zealand region. A dichotomous key to the species is provided, and descriptions, synonyms, illustrations, and distributional notes are given for all species. A new species, Physiodes hawkesii, is described. Leptilia physis, Leiomogoma globiceps, L. ? multiradiatum, Austrophycus margarita, and Pseudophycus barbatus are newly recorded for the New Zealand region. Mura pacifica and Tripriolepis intermedius are junior synonyms of Mura moro and Tripriolepis gladiator respectively. Other morids previously recorded from New Zealand include Pseudophycus burchi, Pseudophycus breviscula, Leptilia rhizophora, Austromona ruminata, Halicyanus johnsoni, Leptilimia microphthalmus, and Anacanthus pacificus. The occurrence of Saitheida within New Zealand waters remains unconfirmed, while Melampops and Eucinostomus, both recorded from the area, belong to other families.

Moridaceae are considered to have diverged from a generalized ancestral stock along a number of independent evolutionary lines. Osteid structure has proved reliable in determining the phylogenetic relationship of the different genera.

INTRODUCTION

Increased exploitation of the deep sea fish resources within the New Zealand Exclusive Economic Zone (EEZ, Fig. 23) in recent years has greatly increased the number of fish species known from the region. Whiteley (1968) recorded in excess of 500 fish species from New Zealand, but the number of identified benthiic species within the total EEZ is now approximately 600, and if pelagic species (e.g. myctophids) are included, the total would approach 700 (National Museum of New Zealand, unpublished catalogue). The codfish family Moridaceae is a small (17 genera, about 70 species) group of fishes occurring world-wide. In the New Zealand region, the family is represented by 11 genera and 15 species of which the best known commercially are the red cod (Pseudophycus burchi) and ribaldo (Mura moro). The New Zealand morids are, however, poorly known biologically and taxonomically; indeed, 2 genera and 4 species have been added to the fauna in only the last 5 years (this paper). Only one species, P. burchi, has received any detailed attention in recent years (Habib 1975).
In that study, Habib recorded 9 genera and 12 species of morids from New Zealand; one, *Solitona australis* (Gunther), is an uncertain record, for data provided by Habib suggest that his (now lost) specimens may have been juvenile *Austrophycus marginata* (Gunther). With the exception of the ahurú, *Auchenoceros punctatus* (Hutton), all the New Zealand morids are also found in Australian waters, and some Australian material has been used for comparison in the present study. Two species of *Physicus* present in Australia have not been recorded from New Zealand.

Examples of the New Zealand morids are held by the National Museum of New Zealand. This paper, which is largely based on that collection, redescribes and illustrates the species, provides new distributional data, and reviews the characteristics and taxonomy of the family and genera.

**METHODS**

Many genera of morids are superficially similar and can only be separated on ootolith structure. Generic criteria used by other authors were in some instances found to be unreliable for Australasian specimens (see below). Generic diagnoses presented here are based on characters found to be consistent for all the Australasian specimens examined.

Counts and measurements follow Templeman (1968, 1970). Apart from standard lengths and caudal lengths, which are shortest distances between perpendicular parallel planes, other measurements are direct distances between points, based on the methods of Hubbs & Lagler (1958).

In all genera of Morididae examined, there is a minute rudimentary ray anterior to the first long ray in the first dorsal fin. This small ray is usually concealed in the slight swelling anterior to the base of the first long ray, and has not been counted by some authors. In the genera *Mora, Halargyreus, Austrophycus, Pseudophycus*, and to a lesser extent *Lepidon*, this ray can be observed without the use of radiographs and has been reported (Vinciguerra, 1893; Ogilby, 1897; Collett, 1905; Koefoed, 1927; Templeman, 1968, 1970). In *Anatoma, Physicus, Lotella, Auchenoceros, Tripodiphycus* and *Laemones* the ray cannot be observed without dissection or the use of radiographs.

The first ray of the anal fin is usually relatively short and closely bound to the second ray, and can be missed if the skin covering this portion of the fin is not removed, or if radiographs are not used. It is also possible to miss the posterior-most second dorsal and anal rays which may be very slender and lie against the body.

Within the genera *Auchenoceros* and *Tripodiphycus*, the second dorsal fin is depressed along the middle of its length and the very short fin rays may be concealed by scales. Fin ray counts for these species are expressed as number of visible rays in first portion + ? + number of visible rays in second portion, rather than as total counts which can be determined from radiographs. This has been done to complement future identifications and studies where x-ray facilities may not be available.

The backward extension of the maxilla in relation to the orbit is quite variable in all genera of morids examined, and the character is not reliable for species distinction.

Dentition of morid genera examined in the present study varies (Fig. 1) and cannot be used as a generic criterion.

Cohen (1979) noted that the dentition of *Physicus* varied and that species have a single band of brush-like teeth, or a graded band with larger teeth on the outer margin. Cohen used dentition, together with the presence or absence of a light organ, as a principal character to distinguish *Physicus* from *Lotella*, which he described as having an outer series of large, widely spaced teeth and an inner band of small brush-like teeth.

Specimens of *Lotella rhyacina* and *L. physicus* examined from New Zealand and Australia show these two types of dentition. Most specimens have an outer series of larger teeth as described by Cohen. Specimens collected in Victoria, Australia, however, lack the outer series of larger teeth, and only have a band of brush-like, equal sized teeth as described for some *Physicus*. The generic placement of these *Lotella* specimens was confirmed by examination of ootoliths.

The presence or absence of vomerine teeth is also of questionable value for determining genera. In the present study the presence or absence of vomerine teeth is regarded as only of developmental significance, being, for example, present in very large specimens of *Lotella*, and absent in small specimens.

Measurements used by previous authors (Cowper, 1955; Habib, 1975; McCulloch, 1927; Phillips, 1926; Waite, 1914) for distinguishing morid species are variable, and unreliable. Counts of vertebrae and fin rays are also variable, and overlap considerably, and can only be used in combination to identify species. A key has been constructed using the simplest
combination of characters found to be reliable (p. 15). Table 1 details the range of counts used in identification of New Zealand morids. Counts were made of fin rays in the first and second dorsal, anal, pectoral, and ventral fins; gill rakers on the upper and lower arms of the first gill arch; pyloric caeca; branchiostegal rays; vertebrae (not including the terminal ural centrum); vertical scale rows crossing the lateral line between the opercular cleft and the base of the caudal; and transverse scale rows between the origin of the first dorsal fin and the lateral line. The following measurements were taken with vernier calipers and the ranges are given for each species in Table 2: standard length (tip of snout to hypural); head length (tip of snout to furthest posterior point of opercular flap); predorsal length (tip of snout to origin of first dorsal); preanal length (tip of snout to centre of anus); snout length (tip of snout to anterior margin of orbit); orbit diameter (horizontal diameter of orbit); interorbital width (distance between inside edges of bony orbits); length of upper jaw (total length of upper jaw); length of barbel; length of first and second dorsal, and anal fins (length of bases); height of first and second dorsal, and anal fins (length of longest ray); length of pectoral, ventral, and caudal fins (length of longest ray); least depth of caudal peduncle.

Many of the characters measured exhibit proportional and allometric growth. All measurements were made on preserved material (formalin and isopropyl alcohol). Otoliths from
Fig. 2. The morid otophysic connection. A, roof view of skull; B, lateral view of skull, vertebral column and air bladder; C, ventral view of same. au, auditory ossicles; bso, basioccipital; cl, clavrum; exo, exoccipital; oc, occipital condyle; operc, opercular complex; ope, opisthotic; ps, parasphenoid; pto, post temporal; pso, parotic; scl, supracleithrum; v, vertebral processes.
fresh specimens were stored dry and examined under reflected light.

Colour descriptions were made from specimens preserved in formalin and iso-propyl alcohol unless otherwise stated.

**ABBREVIATIONS**


**CHARACTERISTICS OF THE FAMILY MORIDAE**

The unique accessory auditory apparatus of the Morididae — a connection between the air bladder and the auditory capsules — was first described by Parker (1883) in a brief paper on the anatomy of the red cod (*Pseudophycis bachei*) and subsequently by Holt & Calderwood (1895) from examination of specimens of ribaldo (*Mora moro*). This apparatus had not been noticed in other gadoid fishes, however, and its importance was not fully appreciated until Svetovidov’s (1937, 1940, 1946) studies established Morididae as a separate and distinct family within the order Anacanthini. Later, Svetovidov (1945, 1947) distinguished additional morid genera, reaffirmed the importance of the otophycic connection, and recognised the osseous interorbital septum as a familial character. Since then, other workers have revealed familial characters in the caudal complex (Rosen & Patterson, 1969; Fitch & Barker, 1972) and the otoliths (Schmidt, 1968; Karrer, 1971).

The present investigation of New Zealand codfishes has confirmed the following Morididae family characteristics:

i. The otophycic connection: large fontanelles in the exoccipitals through which elongate horn-like projections of the swim bladder extend and contact the auditory capsules (Fig. 2).

ii. The osseous nature of the entire canal of the olfactory nerve and, to a considerable extent, the interorbital septum (Fig. 3).

iii. The structure of the caudal skeleton in which the two lowermost hypurals (1 and 2) are fused at the base lying adjacent to the penultimate uveal vertebra, but which are otherwise autogenous; and above these, hypurals 3, 4 and 5 diverge posteriorly as separate entities from the ultimate uveal vertebra (Fig. 4).

iv. Otoliths with deeply channelled bifurcate cauda (posterior portion of the sulcus, or groove on the inner face of an otolith) (Fig. 5).

The morid otophycic connection: On the rear surface of a skull of a morid there are two large foramina, one on either side of the occipital condyle. These foramina are bounded medially by the basi- and ex-occipitals and laterally by
the opisthotic, and are covered by an extremely thin lamina formed partially of bone and partially of membrane. This lamina forms the lower part of the posterior wall of the auditory capsule and together with the foramen is called the auditory fontanelle.

The walls of the air bladder are for the most part thick and tough, but on the anterior half of its dorsal surface the wall becomes extremely thin. The air bladder passes from the posterior part of the abdominal cavity forwards as a regular oval body. Near its anterior end it becomes constricted, then diverges dorsally, forming a right and a left cornua. These cornua pass laterally, slightly anteriorly and dorsad, and fit closely against the posterior surface of the skull, attached, immediately adjacent to the auditory fontanelle, to a ventrally directed process of the basi-occipital, the opisthotic, and a third attachment point on the pterotic.

Against the auditory fontanelle, the wall of the bladder becomes thickened forming a pad that fits tightly into the foramen and is in contact with the lamina. The free end of each cornua is in close contact with the skin immediately anterior to the cleithrum and medial to the opercleum.

The swimbladder can be located by external examination of the fish without causing excessive damage to the specimen. The opercleum is bent forwards and upwards, and a small longitudinal incision made above the branchial arches. By moving the branchial arches downwards, the silvery-white swimbladder can be located among the darker surrounding tissues in the angle between the rear margin of the gill cover and the gill arches. The fontanelle below the process of the swimbladder may then be located with a probe if the bladder is bent aside.

The morid olfactory nerve canal: In all gadiform fishes the olfactory nerves lie in a narrow canal, formed by the extension forward of the cranial cavity above the interorbital septum. Thus, unlike the majority of the Teleostei, the olfactory nerves do not pass through the orbit, and are therefore not separated by the interorbital septum. This anatomical peculiarity was first noted by Stannius (1854), but its importance in classification was not fully appreciated until Svetovidov (1948) reviewed the classification of the gadoids.

In a few teleost families the structure of the interorbital region is similar to the Gadiformes. The olfactory lobes are far removed from the forebrain — as in many of the Gadidae (Svetovidov, 1948), Galaxiidae (Swinnerton, 1903), Plecotognathus (Owen, 1846), and some Cypriniformes (Sageneh, 1885). Svetovidov (1948) noted that the interorbital region was variable in structure and in some groups cannot be accepted as an important systematic character.

The interorbital septum and lower part of the canal of the olfactory nerve in the Anacanthini are membranous (Stannius, 1944; Goodrich, 1909). Svetovidov (1948) was the first to point out that in a number of representatives of the family Gadidae, the canal of the olfactory nerve, and to a considerable extent the interorbital septum, was osseous (Fig. 3). Svetovidov further noted that those fishes with an osseous olfactory nerve canal and partially osseous interorbital septum, also possessed a connection between the swimbladder and auditory capsules.

The morid caudal skeleton: The morid caudal skeleton differs from that of most other gadiform fishes, and is highly characteristic in structure. The two lowermost hypurals (1 and 2) are fused at their base, which lies adjacent to the penultimate and ultimate vertebrae, but are otherwise autogenous. Above these, three further hypurals (3, 4 and 5) diverge posteriorly as separate entities from the compound centrum or ultimate ural vertebrae (Fig. 4). In other gadiform codfishes the hypurals are fused into two single plates, one on the compound centrum, and one on the second ural (Rosen & Patterson, 1969). The remainder of the caudal skeleton, although typical of morids, is not unique to that family (Fitch & Barker, 1972). Anterior to the dorsal-most hypural there are successively two autogenous epurals with bases
adjacent to the penultimate ural vertebrae, a neural spine arising from the first pre-ural centrum, a free floating splinter bone (or dorsal accessory bone) (Rosen & Patterson, 1969), and then neural spines on successive centra. Preceding the lower-most hypural is an autogenous parhypural with its base adjacent to the penultimate ural centrum, a haemal spine affixed to the first preural vertebra, a free floating ventral accessory bone, and then haemal spines on each successive centra. In most other gadoids the two epurals and the parhypurals are present, but the dorsal and ventral accessory bones may or may not be present.

Fisch & Barker (1972) considered that "... in any fossil skeletal imprint, if one could locate either the autogenous lower-most hypurals (1 and 2) with their fused base, or the diverging uppermost hypurals (3, 4 and 5) which project posteriorly from the ultimate ural centrum, the imprint unquestionably would be that of a morid". Examination of the caudal skeleton, otoliths, and swimbladder of Eucichthys polygnemus McCulloch (1926) indicates that this statement is not entirely correct. Although the monotypic genus Eucichthys was provisionally assigned to the Morididae by Svetovidov (1967), and accepted as a member of the family by subsequent authors (McCann, 1972; Habib, 1975), the structure of the otoliths (Karrer, 1971) and the absence of a connection between the swimbladder and oesic capsule (Svetovidov, 1969) preclude the inclusion of the genus within that family. In the caudal skeleton of Eucichthys polygnemus, hypurals 1 and 2 are fused at their base, but otherwise autogenous; and hypurals 3, 4 and 5 are partially fused into a single plate (Fig. 5). Thus, to identify any fossil skeletal imprint as "unquestionably a morid", it is necessary to locate and identify both the lowermost hypurals (1 and 2) and the uppermost hypurals (3, 4 and 5).

The morid otolith: The structure of the morid otolith has been described by Vaillant (1881), Frost (1924), Svetovidov (1969), and Kotthaus (1970), but its morphological importance at the family level was not recognised by these authors. Schmidt (1968) illustrated otoliths from five genera of Atlantic morids and noted
"... although the form of the otolith within this family is by no means uniform, it is so characteristic that one can speak of a morid type ..."

The feature of morid otoliths which distinguishes them from all other teleostean otoliths is the deeply channelled bilobate cauda (Fig. 6). Frost (1924) observed that the otolith of the red cod (Pseudoplesiocirrus (bachi) was the only otolith he had examined with a double cauda, but he failed to recognize the taxonomic importance of the character. Karrier (1971) pointed out that the thin blade-like ridge or crista which divides the deeply channelled cauda longitudinally is actually the posterior collum.

Karrier (1971) described morid otoliths in detail, following the nomenclature proposed by Chalmes & Duvergier (1934) and the structure by Weiler (1942), adding a few new concepts of her own. Morid otoliths are longitudinal in shape and frequently very thick, with a corresponding reduction of the marginal areas, and can be distinguished by considering the ratio of height to length of the otolith and the degree of expansion of the ostium or cauda. Detailed descriptions of otolith shape for thirteen genera are provided by Karrier (1971), and Fitch & Barker (1972). Otolith shape is reliable enough for identification of morid genera (Fig. 7).

**Taxonomic Limits of Moridae**

If the family Moridae is characterised by the four features described above, then the following extant genera should be recognised as belonging to the family: *Morus Risso*, 1826; *Leptodactylus* Swainson, 1838; *Gonostomus Lowe*, 1843; *Lotella Kaup*, 1858; *Pseudoplicaria* Kaup, 1858; *Halicore* Gunther, 1862; *Laemonomia* Gunther, 1862; *Pseudoplicaria* Gunther, 1862; *Antimora Gunther*, 1887; *Santaluma* Gunther, 1887; *Bromusculus Vaillant*, 1888; *Auchenoceros* Gunther, 1889; *Astrophyton* Ogilby, 1897; *Microlepidium* Garman, 1899; *Tripterygius Boulenger*, 1902.

Special genera have been established for a number of juvenile forms, provisionally assigned to the Moridae, but their exact status remains unclear (Karrier, 1971).

McCann (1972) and Habib (1975) recorded *Melanopus gracilis* and *Euclichthys polyrhynus* from the New Zealand region and regarded both species as belonging to the family Moridae. However, Marshall (1965) and Marshall & Cohen (1973) placed *Melanopus* in a separate and distinct family, Melanomidae, on the basis of the position of the olfactory bulbs, the absence of a swimbladder-inner ear connection, and the presence of five hyurpals in the caudal skeleton.

The correct familial placement of *Euchichthys* is still unclear. Svetovidov (1960) stated that the structure of the brain, with the olfactory lobes close to the forebrain, is similar in *Melanopus* and *Euchichthys*. Marshall (1965) had considered that *Melanopus* was unique within the order Anacanthini in having this character. *Euchichthys* further resembles *Melanopus* in the absence of a swimbladder-inner ear connection and in possessing five hyurpals in the caudal skeleton. Although the more detailed examination of the skull, vertebral column, and other morphological characters required to determine the correct familial placement of *Euchichthys* is beyond the scope of the present study, the characters examined suggest that *Euchichthys* should be placed close to or within the family Melanomidae, occupying an evolutionary position between the Moridae and the Gadidae.
Fig. 7. Osseous shape of morid genera. A. Actuaria; B. Aschomacer; C. Aaastrophyc; D. Pseudophyc; E. Lotelie; F. Physiculus; G. Tripteryphyc; H. Laemnema; I. Mosi; J. Halargyreus; K. Antimora; L. Lepidus.
Key to the Species of the Family Moridae Recorded from the New Zealand Exclusive Economic Zone

1. Second dorsal fin more or less uniform in height throughout its length. Second dorsal fin depressed along middle portion and apparently divided into two fins — a high, short anterior portion and a long, low posterior near caudal.  

2. Anal fin more or less uniform in height. Anal fin greatly depressed along middle portion, often dividing the fin into two portions.  

3. Abdominal walls thin, peritoneum visible beneath the skin. Abdominal walls thick and muscular, peritoneum not visible.  

4. An elliptic, scaleless phosphorescent organ present on midline of the belly; anus in advance of anal fin.  

   Physiculus luminosus  

5. No phosphorescent organ present; anus immediately anterior to anal fin.  

6. Head broad, cavernous; barbel small or microscopic. Head not broad or cavernous; barbel greater than one third diameter of eye.  

7. Longest ray of first dorsal greatly elongated. Longest ray of first dorsal not greatly elongated.  

   Laemonema globiceps  

   Laemonema ?multiiradiatum  

8. Pyloric caeca 16–20; 13–16 scales above lateral line. Pyloric caeca 6–8; 7–9 scales above lateral line.  

   Pseudophycis barbata  

   Pseudophycis bachus  


   Lotella rhacinus  

   Lotella phycis  

10. Snout long, pointed, produced beyond mouth. Snout short, rounded, not produced beyond mouth.  

   Antimora rostrata  

11. Pyloric caeca present on chin. A small barbel present on chin.  

   Halagyrus johnstonii  

12. Longest ray of first dorsal greatly elongated, exceeding length of head; 11–15 scales in transverse row above lateral line. Longest ray of first dorsal not greatly elongated, not exceeding length of head; 6–11 scales in transverse row above lateral line.  

   Lepidion microcephalus  

   Mora moro  

13. First dorsal fin visible as a single elongate ray, barbel absent. First dorsal fin with more than a single ray visible (usually 5–6), small barbel present.  

   Auchenoceros punctatus  

   Tripterus gilchristi

Generic Diagnoses and Species Descriptions

Genus Pseudophycis Gunther, 1862

Pseudophycis Gunther, 1862: 350

Type species (original designation) Lota brevispinosus Richardson, 1846: 61 (Bay of Islands, New Zealand).

Physiculus Gunther, 1887: 87 (part only)

Physiculus (Pseudophycis) Whitley, 1956: 403

Diagnosis: Morid fishes with an elongate body. Two dorsal and one anal fin of uniform height, a separate caudal fin. Snout broad, rounded, not projecting beyond the mouth, length equal to interorbital width. Scales small, covering body and head; extending onto loose membranes enveloping the bases of dorsal and anal fins. Ventral fins composed of five to six rays, the two outermost longest. Chin with a barbel. Branchiostegal rays seven. Gill rakers of outer branchial arch short. No luminous organs.

Otolith with ostium approximately equal to the caudal (1:1 — 1:1.4), the crista superior as long or longer than the crista inferior (Fig. 7, D). Otolith thickness 20–22% of its length.

Remarks: Gunther (1862) recognised the genus Pseudophycis for the species Lota brevispinosus Richardson, using as his principal generic character the structure of the ventral fin. In 1887, however, Gunther considered Pseudophycis a synonym of Physiculus stating:
"... In consequence of the discovery of several intermediate forms, a generic distinction ... cannot be maintained ...". Karrier (1971) and Fisch & Barker (1972) found no close family relationships between Physicus and Pseudophysicus on the basis of osteichthys structure. In addition, Pseudophysicus lacks the luminous organ considered by Cohen (in Svetovidov, 1967) to be typical of Physicus, so that Pseudophysicus cannot be a subgenus of Physicus as Whitley (1956, 1968) maintained, and must stand as a distinct genus. It is represented by three species and is confined to temperate Australasian waters.

**Pseudophysicus bachus** (Bloch & Schneider, 1801)

Fig. 8

*Enchelyopus bachus* Bloch & Schneider, 1801: xxvi, 53 (ex Forster MS) (Queen Charlotte Sound, New Zealand, type specimen lost).

*Lota bacca* Cuvier, 1829: 334

*Gadus bacca* Forster, in Lichtenstein, 1844: 120, 420

*Lotaetea bacca* Gunther, 1862: 347

*Pseudophysicus bacchus* Gunther, 1880: 26, 28, 80

*Physicus bacca* Gunther, 1887: 87

*Physicus (Pseudophysicus) bacchus* Whitley, 1956: 403

Common name: red cod.

Material examined: NMNZ, P1718, off Castlepoint, 73-109m; P1753, off Otago 219m; P1899, off Kaikoura, 192m; P2271, Wellington Harbour, 13m; P4788, Paterson Bay 140°28.5'S, 175°03'E, 80-100m; P6548, NE of Stephens Island 140°03'S, 154°07'E, 150m; P8562, N of Kapiti Island 140°13'S, 174°12'E, 100m; P6643, Southerly Passage 148°14'S, 179°07'E, 211-230m; P8794, Chatham Rise 145°16'S, 174°55'E, 298m; P6042, N of Mayor Island, 165m, P7136, Auckland Island shelf 150°09'S, 167°44'E, 120m; P1880, Western Chai, Society Islands, 120m; P7461, Chatham Rise 143°18'S, 174°35'E, 220m; P7330, Cloudy Bay 141°26'S, 174°15'E, 55-60m; P8555, Crowded Arm, Fiordland, 16m; P8356, Cloudy Bay 141°17'S, 174°58'E, 27-28m; P8557, Chatham Rise 143°36'S, 173°31'E, 355m; P8558, Chatham Rise 142°49'S, 175°16'E, 112m; P8563, Tolaga Bay 140°15'S, 178°18'E, 119m; P8365, Cloudy Bay 141°25'S, 174°08'E, 35m.

Non-New Zealand material examined: (not included in description below), AM 99988-90 (2 specimens), off one coast of Finders Island, Barat Strait, Australia (40°01'S, 140°02'E); AM 120079-889 (1 specimen), rocky reef, Rocky Cape, Tasmania, Australia (40°21'S, 145°31'E), 2-4m; AM 110287 (1 specimen), Oyster Bay, Tasmania, Australia, 71-106m.

**Diagnosis:** Dorsal fin rays 9–14, 40–50; anal fin 39–52; pectoral fin 21–26; pyrosir caeca 6–8, large, 7–9 scales in transverse row between origin of first dorsal and lateral line; vertebrae 43–46. A dark triangular spot present at base of the pectoral; caudal margin truncated.

**Description:** Body elongate, compressed; greatest depth at origin of first dorsal; from where it tapers to a narrow, caudal peduncle, snout broad, rounded (more pointed in juveniles), as long as horizontal diameter of eye. Mouth sub-horizontal, maxillary falling short of vertical from rear margin of orbit. Upper jaw overlapping lower, both with a broad band of small, equal size, villiform teeth. Chin with small barbel half as long as diameter of eye. Interorbital space flat, width equal to, or slightly greater than, diameter of eye (up to 1.5 x diameter of eye in some specimens).
Operculum terminating in a small horizontal spine which does not pierce skin; gill opening wide, gill rakers slightly less than length of opposite gill filaments. Teeth small, equal sized, arranged in brushlike band five to six teeth wide (Fig. 1, E). First dorsal fin origin vertically above insertion of pectoral; height equal to length of base. First ray minute, longest ray (6th) less than half length of head. Second dorsal commences immediately behind first, height slightly less than first and uniform throughout length. Anal fin origin immediately behind anus, equal in length and height to second dorsal. Both dorsal and anal fin bases enveloped in loose scaly membrane. Caudal fin truncated (slightly rounded in juveniles), free of dorsal and anal. Pectoral inserted slightly lower than midway down body, pointed, more than one half length of head. Ventral, outer rays filamentous, longest ray (2nd) falling short of anus by a distance equal to diameter of eye. Scales small, cycloid, covering body, head and extending onto vertical fin membranes. Maximum size 80 cm (Habib, 1975).

Colour: Pale tan over body and head, a darker triangular spot at base of pectoral. Scale pockets with darker margins. Buccal and branchial cavities pale. Vertical fins with dark margins. Fresh specimens predominantly reddish pink; red-tan above, pink-tan laterally and pink-white below, black pectoral blotch prominent. Red and pink colours intensify on removal from water giving rise to the vernacular name ‘red cod’ (Habib, 1975).

Remarks: The first published description of the red cod (Pseudophycis bachus) was that of Enchelyopus bachus (Bloch & Schneider, 1801), based on J. R. Forster’s manuscript description, but with alteration of the specific name bachus to bacchus. The original publication of Bloch & Schneider’s Systema Ichthyologiae (1801) was plagued by typesetter’s errors, as outlined by Schneider in his introduction (p. xii: ‘... Cum hypotha mutatae dehinc fuent etiam ipsae literae, et admisis erroribus multi et pudendi, quos corrigere in tabula corrigendum conatus sum ...’). Although Schneider corrected many errors, bacchus was not altered. Forster’s manuscript name was based on the Greek god of wine, Bacchus, in reference to the red wine colouration of the body: ‘... ego vero ob insignem vinaceous ruborem corporis et pinнатum huic speciei Bacchi nomen dedit ...’ (Lichtenstein, 1844). Schneider had consulted Forster’s manuscript and ‘... abbreviated the more wordy accounts, while quoting the author verbatim as far as possible ...’ (Systema Ichthyologiae, p. xiv). Although the etymology would suggest the correct spelling is bacchus there is no clear evidence of an inadvertent error in the original publication and the original spelling, bacchus, must be retained.

Cuvier (1829) followed Forster’s spelling of bacchus in referring the species to Lota bacchus. Forster’s description, published by Lichtenstein (1844) as Gadus bacchus, was based on a specimen collected in Queen Charlotte Sound on the first of James Cook’s voyages to New Zealand, 1768–1771.

Published references to the red cod followed Cuvier’s and Forster’s spelling of bacchus until Ogilby (1886) in Catalogue of Fishes of New South Wales, misquoted Gunther (1880) and used the spelling bacchus. New Zealand and Australian workers then appear to have followed Ogilby, while European workers continued to follow Cuvier, resulting in a somewhat confused synonymy. Present day workers alternate between the correct bacchus and the incorrect bacchus.

The type specimen of Pseudophycis bacchus has been lost. However, morphometric and meristic data of specimens examined in the present study are the same as in Forster’s (in Bloch & Schneider, 1801) diagnosis. A single species is represented in both New Zealand and Australia, although the few Australian specimens examined had fin ray and scale counts in, and exceeding, the upper range of counts for New Zealand specimens (Table 1). Examination of a larger sample of Australian specimens might show some differences but, in view of the variability within species of Moridae, there would probably be little justification for separating the two populations at the species level.

Inadequate species description has resulted in some difficulty in distinguishing P. bacchus from its congeners, P. barbula and P. breviuscula (described below). All published descriptions of these species rely on fin ray counts to separate them. Results of the present study show that fin ray counts alone are unreliable in separating the species and that a combination of characters must be used.

P. bacchus can be distinguished from P. barbula on second dorsal fin ray, vertebral, and scale counts, number and size of pyloric caeca and other characters. P. bacchus has fewer fin rays in the second dorsal (40–50), fewer vertebrae (43–46), and larger scales (7–9 between origin of first dorsal and lateral line) than P. barbula with 53–63 second dorsal fin ray, vertebral, and scale counts.
rays, 48–51 vertebrae, and 13–16 scales between origin of first dorsal and lateral line. Australian specimens of *P. bicuspidatus* show transverse scale counts approaching those for *P. barbata*, and hence this character may not reliably for the Australian population.

*P. bicuspidatus* can be readily separated from *P. barbata* on the number and size of pyloric caeca. In *P. bicuspidatus* the 6–8 pyloric caeca are large, whereas pyloric caeca of *P. barbata* are small and numerous (16–20). Other characters used in separating the two species are the shape of the caudal margin (square in *P. bicuspidatus*; rounded in *P. barbata*) and the presence in *P. bicuspidatus* of a dark pectoral blotch.

Differences between *P. bicuspidatus* and *P. breviusculus* are less marked. The two species can be reliably separated only on the shape of the caudal margin (rounded in *P. breviusculus*) and the presence of a dark pectoral blotch in *P. bicuspidatus*.

**Pseudophycis breviusculus** (Richardson, 1846)

*Fig. 9*

*Lox breviusculus* Richardson, 1846: 61 (Bay of Islands, New Zealand, type specimen in BMNH).

*Pseudophycis breviusculus*, Günther, 1862: 250

*Pseudophycis breviusculus*. Gunther, 1872: 47

*Physicus bicuspidatus*. Günther, 1887: 87 (part only)

*Physicus bicuspidatus*. Graham, 1939: 399

*Physicus* (*Pseudophycis*) *breviusculus*. Whitley, 1956: 403

Common name: northern bastard red cod.

**Material examined:** NMNZ P256, Hasaki Gulf; P258, off Mauao Island, 206'220m; P258, off Mauao Island, 102'240m; P259, Mauao Harbour; P315, Urupukapuka, Bay of Islands, 8m; P3617, E of White Island, 192'220m; P3756, Napier, 9m; P3757, Poor Knights Islands (36°22'S, 173°32'E), 115m; P5006, N of Alderney Island (37°29'S, 178°33'E), 64m; P5998, Whangarei Harbour, 5–9m; P6085, N Taranaki Bight (38°15'S, 173°34'E), 135–137m; P3978, Bay of Plenty (37°45'S, 177°01'E), 68–70m; P3985, Bay of Plenty (37°11'S, 176°11'E), 190–265m; P3999, Bay of Plenty (37°51'E, 176°36'E), 35–38m; P3949, N of Maud Island (37°15'S, 176°14'E), 119–198m; P3962, Taka Bay (38°15'S, 178°38'E), 138m; P3963, Bay of Islands; P4963, Goat Island, Leigh; P4967, Doubtless Bay.

Non-New Zealand material examined: (not included in description below). WAM 26506–003 (1 specimen), Midway Island, National Antarctic Programme, Western Australia, 13m. season; AMS 12047–002, (2 specimens) E of Green Cape, N.S.W., Australia (36°24'S, 130°18'E), 0–440m, KC77–19–01.

**Diagnosis:** Dorsal fin rays 8–11, 42–60; anal fin 46–68; pectoral fin 19–27; pyloric caeca 6–8, moderate sized; 6–8 scales in transverse row between origin of first dorsal and lateral line; vertebrae 42–46. No dark blotch at base of pectoral fin; caudal margin rounded.

**Description:** Body elongate, slightly compressed, greatest depth at origin of first dorsal, from where it tapers to a narrow caudal peduncle. Snout broad, obtuse, equal in length to width of interorbital, and slightly less than horizontal diameter of eye. Mouth subhorizontal, maxillary falling short of vertical from rear margin of orbit. Upper jaw overlapping lower, both with broad band of small, equal sized, villiform teeth. Chin with barbel two thirds as long as horizontal diameter
of orbit. Interorbital space flat, width slightly greater than horizontal diameter of eye. Operculum terminating in small horizontal spine which does not pierce skin. Gill opening wide; gill rakers half length of opposite gill filaments. Teeth small, equal sized, arranged in brushlike band five to six teeth wide (Fig. 1, E). First dorsal fin origin vertically above intersection of pectoral; length less than height; first ray minute, longest ray (5th or 6th) less than half length of head. Second dorsal commences immediately behind first, height slightly less than dorsal, and uniform throughout length. Anal fin origin immediately behind anus, equal in height and length to second dorsal. Both dorsal and anal fin bases enveloped in loose scaly membrane. Caudal fin rounded, free of dorsal and anal. Pectoral inserted midway down body, rounded, length equal to post-ocular portion of head. Ventrals narrow, outer rays filamentous, the longest (2nd) reaching the anus. Scales medium in size, cycloid, covering entire body and head, except for tip of snout, and extending onto ventral fin membranes. Maximum size of specimens 17 cm (Richardson, 1846).

Colour: Body and head pale brown, darker above. Buccal and branchial cavities pale. Vertical fins with a dark margin. Fresh frozen specimens pinkish tan on upper parts of body and head, silver below. Suboperculum and base of pectoral silver.

Remarks: Richardson (1846) described Lota breviseta from the Bay of Islands, noting that it resembled Pseudophycis baccus but differed in the number of fin rays. Gunther (1862) established the genus Pseudophycis for Lota breviseta and mistakenly assigned P. baccus to the genus Lota, apparently without examining specimens. In 1880, Gunther corrected this error, but further confused the situation by regarding P. breviseta as a junior synonym of P. baccus. Graham (1939) reinstated P. breviseta for the "bastard red cod" but did not give "...clear distinguishing characters ..." as stated by Karrer (1971). Graham's description, apparently reinterpreted from the literature, lacks vertebral, pyloric caeca and scale counts and hence is inadequate to determine if the species referred to is P. breviseta, or P. barbata described below. Other authors have regarded P. baccus and P. breviseta as one species (McCulloch, 1929; Norman, 1937), or as distinct species (Graham, 1953; Whitley in Graham, 1956; Svetovidov, 1967).

Morphometric and meristic data of specimens examined are the same as those in Richardson's (1846) diagnosis. All specimens of P. breviseta examined in the present study, were collected north of Napier (37°29'S, 174°53'E) while all specimens of 'bastard red cod' collected south of Napier were referable to P. barbata. Characters for distinguishing the two species include transverse scale, vertebral and pyloric caeca counts, and are detailed below.

Pseudophycis barbata Gunther, 1863

Fig. 10

Pseudophycis barbata Gunther, 1863: 116
(Victoria, South Australia, type specimen in BMNH).

Lotella grandis Ramsay, 1881: 462
(Wollongong, New South Wales, type specimen in AMS).

Physiculus barbatus. Norman, 1937: 53
(Pseudophycis breviseta). Graham, 1939: 399

Pseudophycis breviseta. Habib, 1975: 32-57
(not breviseta Richardson)

Common name: southern bastard red cod.

Material examined: SMNZ P1216, Makara, 40m; P1407, Cape Start, 36m; P1990, Ohake Point, Makara, 18m; P2950, NW of Mayor Island, 81m-210m; P2309, N of Cape Egmont, 60m; P2795, Tahi Bay south, 3m; P5385, Challenger Plateau (45°38'S, 172°37'E), 247-273m; P6583, Breaker Bay, Wellington; P7707, Matrose Bank (44°23'S, 175°06'E), 120-126m; P7799, off Griffiths (39°27'S, 175°12'E), 254-306m; P8201, Kakoora; P8380, off Mayor Island, 260-220m; P8361, Tolaga Bay (38°10'S, 178°18'E), 1986; P8638, West Coast, South Island.

Non-New Zealand material examined: (not included in description below). AM 07813-005 (1 specimen) New South Wales (17°10'S, 139°45'E), 06m, person; AM 11608-005 (5 specimens) Estuary at Peterborough, Victoria (38°05'S, 142°52'E), 1m, person; AM 133970-014 (1 specimen) Nuttona Bay, New South Wales (37°38'S, 141°50'E), 1m, person; WAM P25781-002, (1 specimen), Rottnest Island, Perth, Western Australia.

Diagnosis: Dorsal fin rays 9-11, 53-63; anal fin 47-63; pectoral fin 21-26; pyloric caeca 10-20; small; 13-16 scales in transverse row between first dorsal origin and lateral line; vertebrae 48-51. No dark blotch at base of pectoral; caudal margin rounded.

Description: Body elongate, slightly compressed, greatest depth at origin of first dorsal from where it tapers to narrow caudal peduncle. Snout broad, obtusely rounded, as long as interorbital width and slightly longer than horizontal diameter of orbit. Mouth subhorizontal, maxillary reaching the vertical from hind margin of orbit. Upper jaw overlapping lower, both with broad band of
small, equal sized, villiform teeth. Chin with barbel two thirds as long as diameter of eye. Operculum terminating in small horizontal spine which does not pierce skin. Gill opening wide, gill rakers two thirds length of opposite gill filaments. Teeth small, equal size, arranged in a brushlike band five to six teeth wide (Fig. 1, E). First dorsal fin origin vertically above insertion of pectoral, height equal to length, first ray minute, longest ray (6th) one third length of head. Second dorsal commences immediately behind first, height slightly less than first and uniform throughout length. Anal fin origin immediately behind anus, equal in height and slightly shorter in length than second dorsal. Both dorsal and anal fin base enveloped in loose scale membrane. Caudal fin rounded, free of dorsal and anal. Pectoral inserted midway down body, rounded, one half length of head. Ventral narrow, outer rays filamentous, the longest (2nd) reaching the anus. Scales very small, cycloid, covering body and head except for the tip of snout, extending onto vertical fin membrane. Maximum size 64 cm (present study).

Colour: Body and head pale brown, darker above. Buccal and branchial cavities pale. Vertical fins with dark margins. McCoy (1878) recorded the colour of fresh specimens as "whole body pale brownish-olive, the centre or basal part of the scales on the lower part of the sides lighter and their edges minutely flecked, fading into pinkish-white on the throat and belly; slightly darker, and with slight purplish tinge on back, top of head, snout and lips, but the operculum silvery. Ventral fins pinkish white like the throat. Pectoral fins pale-purplish, with a large purplish black spot at the upper part of its base. Dorsals, caudal and anal fins purplish at base, with a dull orange tinge higher up, and a narrow blackish-purple border; the lower portion of each fin is covered nearly up to the margin by very small olive scales on a loose skin."

Remarks: Pseudophycis barbata was described from Australian specimens in a three line paragraph by Gunther (1863). This description was expanded by McCoy (1878). However, the unavailability of McCoy's paper in New Zealand probably contributed to the confusion surrounding the two species of "bastard red cod" and the true "red cod".

Graham (1939) noted that P. breviscula was a distinct species and had been incorrectly synonymised with P. bachus by Gunther (1887). Graham referred specimens of bastard red cod collected in Otago waters to P. breviscula but this description, lacking vertebral, pyloric ceca and scale counts, is inadequate to determine the actual species to which his specimens should be referred. In view of the distributions recorded in the present study, it is unlikely that the specimens were in fact P. breviscula. Subsequent authors appear to have followed Graham in referring specimens of bastard red cod to P. breviscula, overlooking P. barbata.

P. barbata has been recorded from New Zealand by Steindachner (1901), as Lotetica grandis, McCulloch (1923) and Norman (1937) who considered the species probably identical to P. bachus. Whitley (1955) recorded P. barbata from New Zealand in his translation of Steindachner (1901), but later omitted the
species from his checklist of New Zealand fishes (1968). Morphometric and meristic data of specimens examined are the same as those in Gunther’s (1863) diagnosis. *P. barbarus* can be distinguished from *P. brevissima* on counts of transverse scales between first dorsal origin and lateral line (13–16 cf. 6–8 respectively), number of vertebrae (48–51 cf. 42–46 respectively) and number and size of pyloric caeca (16–20, small cf. 6–8, large). Both species have a rounded caudal margin and lack the dark pectoral blotch present in *P. bahia*.

**Genus Physicus** Kaup, 1858

**Physicus Kaup**, 1858: 88

Type species (by monotypy) *Physicus darwini* Kaup, 1958: 88 (Madozela).

**Diagnosis:** Morid fishes with an elongate body, two dorsal and one anal fin of uniform height, a separate rounded caudal fin. Snout broad, obtusely rounded, not projecting beyond the mouth, length slightly greater than interorbital width. Scales very small, covering body and entire head, not extending onto tip of snout or vertical fin membranes. Ventral fins narrow, with five rays, the outer two filamentous. An elliptical luminescent organ on midline of belly, extending beneath the skin to a second luminescent area surrounding anus. Anus in advance of anal fin. Chin with a barbel. Branchiostegal rays seven; gill rakers of outer branchial arch short.

Otolith with a relatively short ostium, comprising about one third or less of the total otolith length, the crista inferior almost twice as long as the crista superior. The anterior end of the otolith usually bluntly pointed or rounded but never expanded (Fig. 7, F).

**Remarks:** Poor definition of characters used to diagnose *Physicus* by early workers has caused much of the confusion surrounding the genus in present day literature. Cohen (in Svetovidov, 1967) considered the presence of a luminescent organ on the belly to be typical of the genus. The presence or absence of a luminescent organ has been omitted in all but a few descriptions of species assigned to *Physicus*, and a worldwide revision of the genus is required.

*Physicus* is closely related to the genus *Sangiota* Gunther 1887. Both genera have a similar light organ on the belly, and differ only in otolith shape (Karrer 1971), and in the presence of vomerine teeth in *Sangiota*. The presence or absence of vomerine teeth is of questionable value taxonomically within the Morididae and a revision of the two genera is required.

**Physicus luminosa** n.sp.

Fig. 11

**Common name:** luminous cod.

**Type material:** Holotype: NMNZ P9556, 140.5 mm SL, between Alderman and Red Mercury Islands (36°45’ S, 176°03’ E), 487 m, prawn trawl, 29 Sept. 1982. Paratypes (15): NMNZ P7827, E of Alderman Islands (36°57’ S, 176°19’ E), 443–527 m; P7871, SE of Alderman Islands (37°59’ S, 176°16.5’ E), 304–308 m; P8005, Bay of Pecnty; P8007, same collection as holotype; P9555, NE of White Island (37°29’ S, 176°54’ E), 248–283 m; P9557, off Schooner Rocks (37°25’ S, 176°31’ E), 384 m; AIM 690, E of Alderman Islands, 365–475 m; AIM 3241, same collection as P9557; AIM 3333, (37°26’ S, 176°34’ E), 365–475 m.

**Material examined:** NMNZ P7800, E of Mayor Island (37°22’ S, 176°28’ E), 482–509 m; P8006, E of Alderman Islands (36°57’ S, 176°17’ E), 329–356 m; P8008, SE of Alderman Islands (37°32’ S, 176°13’ E), 256–292 m; P8009, N of Mayor Island, 510 m; AIM 1246, (37°36’ S, 176°50’ E), 457–512 m; AIM 1321, SE of Mayor Island (37°26’ S, 176°26’ E), 374–394 m; AIM 11950, 380 m; 3 specimens; off Queensland (26°31’ S, 133°50’ E), 263–336 m; Agincourt, Nimrod station 54; AIM 11957, 360 m; 3 specimens + otolith) E of Ulladulla, New South Wales (35°30’ S, 150°44’ E), 237 m.

**Diagnosis:** Dorsal fin rays 7–8, 63–69; anal fin 66–71; pectoral fin 21–25; pyloric caeca 7–10; large; 11–14 scales between origin of first dorsal and lateral line; vertebrae 51–59.

**Description:** Body elongate, compressed, greatest depth at origin of anal fin from where it tapers to a very narrow caudal peduncle. Snout broad, obtusely rounded, as long as horizontal diameter of eye. Mouth subhorizontal, maxillary extending just behind vertical from centre of eye. Upper jaw overlapping lower, both with broad band of small, equal sized villiform teeth. Chin with barbel half as long as horizontal diameter of eye. Interorbital space flat, width slightly less than diameter of eye. Operculum terminating in small horizontal spine which does not pierce skin; gill opening wide, gill rakers one half as long as opposite gill filaments. Teeth small, arranged in brushlike band four to five teeth wide. Teeth either equal sized or in graded series with larger teeth on outer margin (Fig. 1, G-H). Luminescent organ situated on midline of belly, slightly behind insertion of ventral; elliptical, free of scales. A narrow line of apparently luminescent tissue beneath skin connects luminescent organ to a similar luminescent area surrounding anus. First dorsal fin origin vertically above anus, slightly behind insertion of pectorals. First dorsal fin twice as
high as long, longest ray (3rd or 4th) one third
length of head. Second dorsal commences
immediately behind first, equal in height to first
and uniform throughout length. Anal fin origin
some distance behind anus, equal in length to,
and slightly lower in height than, second dorsal.
Both dorsal and anal enveloped in loose
scaleless membrane. Caudal fin rounded, free
do not extend origin of anal. Pectoral inserted
slender, with outer rays filamentous, the longest (2nd)
origin of anal. Scales very small, covering head
and body but not extending onto vertical fin
membranes or snout. Maximum size 30 cm.
Colour: Pale pinkish brown on head and body,
abdominal region much darker and bluish.
Scale pockets edged with darker brown;
branchial membranes black. Pectoral and
ventral fins dark at insertions, vertical fins
tipped with black. Buccal and branchial cavities
white.

Etymology: Luminosa, Latin, full of light, in
reference to the light organ on the belly.

Remarks: The genus Physicus is
cosmopolitan in distribution in subtropical and
warm temperate seas, and has not previously
been recorded from the southern Pacific
(Karrer, 1971). Norman (1937) attributed 17
species to Physicus, other authors attribute
"about 20" species to the genus (Lindberg &
Legera, 1965). Karrer (1971) reduced this
number, but examined only some of the species
and noted that a revision of all of them was
required. Cohen (1979) noted that over 20
species have been assigned to the genus and that
several more are represented in Japanese fish
collections.

The following species have been examined
and confirmed as belonging to the genus
Physicus on the basis of ototh shape
(Karrer, 1971): P. capensis, P. dalwigkii, P.
japonica, P. edelmanni and P. natalensis.
Physicus luminosa can be distinguished from
P. capensis and P. natalensis on the number of
vertical scale rows crossing the lateral line
(117–125 cf. 95–104 respectively) whilst the
presence of a barbel on Physicus luminosa
distinguishes it from P. edelmanni (Norman,
1936). Physicus luminosa is closely related to
P. japonica and differs from descriptions of
that species provided by Tanaka (1927),
Lindberg & Legera (1965) and Cohen (1979), in
having fewer first dorsal fin rays (7–8 cf. 9),
fewer anal rays (66–71 cf. 76–77), a slightly
larger head (3.3–4.2 in SL cf. 4.4 in SL) and a
larger eye (6.2–8.0 % SL cf. 5.1–5.6 % SL).
Meristic and morphometric measurements of
P. luminosa (Tables 1, 2) overlap with those of
Physicus dalwigkii (Kaup, 1858; Gunther,
1862, 1887; Vaillant, 1888; Norman, 1937),
but the two differ in the position of the anus and
origin of the first dorsal fin. The anus and
origin of the first dorsal fin of P. luminosa are
situated behind the vertical from the insertion
of the pectorals, whereas the anus and dorsal
fin of P. dalwigkii are on the vertical from the
pectoral insertion.

The two species have antipodal distributions.
P. luminosa is found in northern New Zealand
(Fig. 23) and off New South Wales, Australia.
P. dalwigkii has been recorded from Madeira
and off Sudan (Norman, 1937).
Genus Lotella Kaup, 1858

Lotella Kaup, 1858: 88

Type species (by monotypy), Lota physis Temminck & Schlegel, 1846: 248 (Japan).

Diagnosis: Morid fishes having a compressed elongate body, two dorsal and one anal fin of uniform height, a separate caudal fin. Snout obtusely rounded, not projecting beyond mouth. Scales very small, cycloid, covering entire body and head, extending onto vertical fin membranes. Ventral fins with a flat base, composed of several rays, two outermost filamentous. Chin with a barbel; gill rakers of outer branchial arch very short. No luminescent organs. Abdominal walls thick and muscular.

Otolith with the ostium approximately equal in length to the cauda (1:1–1:1.4), the crista superior two thirds as long as the crista inferior, valvus deeply recessed at the colloid (Fig. 7, E).

Remarks: Svetovidov (1967) noted that there was no clear-cut delimitation between the genera Lotella and Physiculus, and that the correct placement of a number of species was in doubt. Cohen (in Svetovidov, 1967) regarded the presence or absence of a light organ as an important difference between the genera, and Karrer (1971) and Fitch & Barker (1972) found differences in otolith shape. Few published descriptions provide information regarding these characters. The number of species assigned to the genus is in doubt and a complete revision is required. Two species of Lotella are found throughout the Australasian region in shallow coastal waters.

Lotella rhacinus (Bloch & Schneider, 1801) (Fig. 12)

Gadus rhacinus Bloch & Schneider, 1801: 56. (ex Forster MS) (Queen Charlotte Sound, type specimen lost, neotype designated NMNZ P9640).

Lota rhacina Richardson, 1843: 222.

Lotella rhacinus Gunther, 1862: 347.

Lotella fulgens Gunther, 1862: 347. (No type locality, type specimen in BMNH).

Lotella caffariana Gunther, 1863: 116. (Victoria, South Australia, type specimen in BMNH).

Lotella marginata Macleay, 1881: 114 (Port Jackson, type specimen in AM) (preoccupied, L. marginata Gunther).

Lotella swami Johnston, 1883: 126 (Tasmania).

Lotella limbata Ogilby, 1886: 47. (nomen novum pro L. marginata Macleay)

Lotella maculaei Rendahl, 1920: 54 (nomen novum pro L. marginata Macleay)

Common name: rock cod.
immediately behind first, height slightly less than first, uniform throughout length. Anal fin origin immediately behind anus; equal in length and height to second dorsal. Both dorsal and anal fins enveloped in loose scaly membranes. Caudal fin rounded, free of dorsal and anal. Pectoral inserted midway down body, rounded, more than one half length of head. Ventral with flat base, outer rays filamentous, the longest (3rd) just reaching anus. Scales very small, cycloid, covering body, on head except for snout and extending onto vertical fin membranes. Maximum size 40 cm.

Colour: Body and head light to dark brown or black. Scale pockets with darker margins, fins dark brown. Buccal and branchial cavities pale.

Remarks: Specimens of Lotella collected in the Australian region are variable in many morphometric and meristic characters and a number of nominal species have been described. The results of the present study show that two species of Lotella occur in Australasian waters and that the species can be reliably separated on scale counts. L. rhacinus has 22-30 transverse scale rows above the lateral line, L. phycis 12-16 scale rows. Scale counts not given in original descriptions were either provided by D. M. Cohen and P. J. Whitehead or determined from type specimens. The type specimen of L. rhacinus has been lost (Whitehead, 1968) and scale counts were not recorded by Bloch & Schneider (1801).

The specific name rhacinus has been used for New Zealand Lotella in all publications to date, and predates L. fusiginosa and L. callarias. Specimens of Lotella from the type locality of L. rhacinus were examined in the present study and are of the small scaled species. I have selected NMNZ P9640 as a neotype for L. rhacinus. Lotella rhacinus is common throughout New Zealand (Fig. 24) and Australian waters. To date Australian specimens have been referred to L. callarias Günther. The presence of a second closely related species, L. phycis, occurring sympatrically has not been recognised, and there is some confusion in the literature. Although two species of Lotella were recorded from Australia by Castelnau (1879) and McCulloch (1929), no descriptions were provided to enable subsequent authors to distinguish them. McCulloch (1927) noted that L. fusiginosa (= L. rhacinus) was recorded "... on the very unreliable authority of Castelnau (and) ... there is no reason to suppose the species occurs here". Ogilby (1899) considered specimens of Lotella from Lord Howe Island to be "... identical with the Australian species and not the New Zealand rhacinus ...". Allen et al., (1976) considered that specimens of Lotella from Lord Howe Island "... may be conspecific with L. rhacinus from New Zealand ...".

Phillips (1926) provided a key to separate L. rhacinus and L. callarias on the basis of depth of body and stated that the two species were restricted to New Zealand and Australia respectively. The results of the present study show that Phillips’ specimen, recorded as L. rhacinus, is in fact referable to L. phycis, and that the two species cannot be separated on depth of body or other morphometric measurements. The two species can be distinguished on scale counts as detailed below. References (except for original descriptions) to specimens of Lotella collected in New Zealand and Australia, other than Phillips (1926), do
not include descriptions with fin ray or scale counts, and it is not possible to determine whether the species referred to is *L.* *rhipinus* or *L.* *physicus*.

**Lotella physicus** (Temminck & Schlegel, 1846)

Fig. 13

*Lotella physicus* Temminck & Schlegel, 1846: 248
(Japan, type specimen in Rijksmuseum van Natuurlijke Historie, Leiden).

*Lotella physicus*. Günther, 1862: 346

*Lotella schwerti* Steindachner, 1866: 416 (Peru).

*Lotella rhipinus*. Phillipps, 1926: 532 (not *rhipinus* Bloch & Schneider).

**Common name**: beardie.

**Material examined**: AM 120270-008, near White Rock, Phillip Island, Norfolk Island, 8-16m; AM 120280-015, W side Napano Island, Norfolk Island, 0-20m; NMNZ P8470, off Phillip Point, Lord Howe Island, 20m; AM 120223-006, Mundaun Island; Recherche Archipelago, Western Australia, 0-9m; WAM P26072-022, Beacon Island; Heard Island, Recherche Archipelago, Western Australia; WAM P28060-016, Fish Hook Bay, Rossie Peninsula, Western Australia, 11m; WAM P26004-011, Lucky Bay, Rossie Peninsula, Western Australia; WAM P25765-005, Long Island, Australian Recherche Archipelago, Western Australia.

**Diagnosis**: Dorsal fin rays 5-8, 47-64; anal fin 42-56; pectoral fin 22-25; pyloric caeca moderate sized, 8-11; 12-16 scales in transverse row between origin of first dorsal and lateral line; vertebrae 45-47.

**Description**: Body elongate, thickset, slightly compressed, greatest depth at origin of second dorsal from where it tapers to narrow caudal peduncle. Snout broad, obtusely rounded, as long as horizontal diameter of eye. Mouth subhorizontal, maxillary reaching vertical from rear margin of orbit. Upper jaw over-lapping lower; upper jaw with an outer series of distinctly larger teeth separated from an inner series of small teeth, or with brushlike band of small equal sized teeth (Fig. 1, I-J). Lower jaw with single series of teeth, equal in size to those of outer series of upper jaw or with brushlike band and small teeth. Chin with barbel equal to diameter of orbit. Operculum obtusely rounded, terminating in small horizontal spine which does not pierce skin. Gill openings wide; gill rakers short, less than half length of opposite gill filaments. First dorsal fin origin vertically above insertion of pectoral, slightly higher than long; first ray minute, longest ray (2nd) one third length of head. Second dorsal commences immediately behind first, height less than first, uniform throughout length. Anal fin origin immediately behind anus, equal in length and height to second dorsal. Both dorsal and anal fins enveloped in loose scaly membranes. Caudal fin rounded, free of dorsal and anal. Pectoral inserted midway down body, rounded, more than half length of head. Ventral with flat base, outer rays filamentous, longest (3rd) just reaching the anus. Scales small, cycloid, covering body and head except for snout, extending onto vertical fin membranes. Maximum size 18 cm.

**Colour**: Body and head dark to light brown. Scale pockets with darker margins, fins dark brown. Buccal and branchial cavities pale.

**Remarks**: *Lotella physicus* has been recorded from New Zealand as *L.* *rhipinus* (Phillipps, 1926), and from Australia as *L.* *schwerti* (Steindachner, 1866). Specimens examined overlap in morphometric and meristic measurements with those of *L.* *physicus* collected in Japan (Temminck & Schlegel, 1846; Svetovidov, 1936; Cohen, 1979). I have not
examined the type specimen of L. phyiscs. L. phyiscs closely resembles its congener L. rhacinus and may be distinguished from it by scale counts and the number of pyloic caeca. L. rhacinus has 219-242 vertical scale rows between the opercular cleft and base of the caudal fin, 22-30 transverse scale rows between the origin of the first dorsal fin and the lateral line, and 14-16 small pyloic caeca. L. phyiscs has 125-170 vertical scale rows, 12-16 transverse scale rows above the lateral line, and 8-11 moderate sized pyloic caeca. L. phyiscs has, on average, fewer first and second dorsal and anal fin rays, fewer vertebrae, and more pectoral fin rays than L. rhacinus. The ranges for both overlap considerably (Table 1) and the two species cannot be clearly separated on these characters or on morphometric measurements.

Genus Austrophycis Ogilby, 1897
Austrophycis Ogilby, 1897: 90
Type species (by monotypy) Austrophycis megalepis Ogilby 1897: 91 (Maroubra Bay, New South Wales).
(Physiculus), Karrer, 1971: 181
Actuariolus. Fitch & Barker, 1972: 575 (in part)

Diagnosis: Morid fishes with a compressed elongate body, two dorsal and one anal fin. Second dorsal and, more especially, anal fin depressed in height along middle of length, a separate, truncated caudal. Snout broad, rounded, short, not project beyond mouth, length greater than width at interorbital space. Eye very large. Scales small, cycloid, covering entire body and head, not extending onto vertical fin membranes. Ventral fins narrow, with five rays, the outer two filamentous. Chin with a barbel; branchiostegal rays seven; gill rakers of the outer branchial arch long. No luminous organs.

Otoliths with a short ostium (40% otolith length), a crista superior almost as long as the crista inferior, and an expanded anterior end. The otolith is thick, 27-33% in the length (Fig. 7, C).

Remarks: The genus Austrophycis was described by Ogilby (1887). To date, no specimens, other than the beach-cast holotype, have been assigned to this genus or reported in the literature. Svetovidov (1967) provisionally attributed the genus to Moridaceae but noted that the description was insufficient and that, as only a single poorly preserved specimen was known, the genus was altogether doubtful.

Karrer (1971) recognised that Lotella marginata Günther belonged in a genus other than Lotella or Physiculus, where the species had been placed by Norman (1937), but was unable to suggest an alternative. She did not consider Austrophycis, and followed Svetovidov in giving the genus only provisional status within the Moridaceae. Austrophycis was also overlooked by Fitch & Barker (1972) who considered that specimens collected south of New Zealand represented an undescribed species which they assigned to Actuariolus Karrer.

Examination during the present study indicates that the swimbladder, caudal complex and otolith shape of specimens of Austrophycis have the typical morid structure. Thus, Svetovidov’s (1967) provisional placing of the genus within the Moridaceae is correct. Austrophycis is closely related to, and possibly descended from the Lower Miocene genus Actuariolus. Fitch (1924; 1933) described morid otoliths from Tertiary deposits in New Zealand strata, attributing them to the genus Physiculus. In a comprehensive re-examination of Fitch’s material, Karrer (1971) noted that Fitch had compared the fossil otoliths with Physiculus bachei and that no close relationship existed between these genera. Karrer erected a new genus Actuariolus for the fossils. Fitch & Barker (1972) assigned an extant “Antarctic” species to this genus and considered it to represent a distinct group from other living morids.

The results of the present study show Fitch & Barker’s “Antarctic” species to be Austrophycis marginatus, a species not considered by Karrer (1971), and that Austrophycis is distinct from Actuariolus in the structure of the otoliths. Actuariolus resembles Austrophycis in the thickness of the otolith, uniform inside structure, the ratio between the cauda and ostium (1:2.2-2.4 cf. 1:2.0-2.2), and the closed ostium. Austrophycis differs from Actuariolus in having a narrower cauda (notably less expanded in the dorsal field and area) and in the expansion of the anterior portion. In Austrophycis the greatest expansion occurs at the junction between the ostium and cauda; in Actuariolus the greatest expansion occurs at the midpoint of the ostium. The two genera differ in the ratio of height to length. In Actuariolus the ratio is 1:1-1.6, in Austrophycis 1:2 (Fig. 7, A).

Material examined: Actuariolus bicaudatum (Fitch, 1924), holotype and 2 paratypes (NZGS); A. revakoensis (Fitch, 1933), holotype (NZGS), Lower Miocene deposits; Austrophycis marginatus, 14 otoliths (NMNZ).
4.8–7.3 mm long, from specimens 120–190 mm SL, Chatham Rise.

**Austrophycis marginata** (Gunther, 1878)

**Fig. 14**

**Lotreia marginata** Gunther, 1878:19 (Pacific coast of south-western South America, type specimen in BMNH).


**Actinostomus** sp. Fitch & Barker, 1972:575

**Common name:** dwarf cod.

**Material examined:** Holotype, BMNH 1879.5.14.44, Messier Channel sta. 307, 140 fathoms, Challenger expedition; NMNZ P1747, off Otago, 450–540 m, P1756, off Otago, 548 m; P5051, S of Auckland Islands (51°05’S, 166°22’E), 438–440 m; P5054, Bounty Rise, 49°15’S, 172°34’E, 320–380 m; P1900, off Fiordland (44°52’S, 166°41’E), 383–420 m; P5765, Turakirae trench, 440–658 m; P5831, S of Auckland Islands (51°09’S, 166°18’E), 507–500 m; P6319, Hikurangi trench (41°21’S, 174°15’E), 640 m; P6738, Campbell Rise (52°27’S, 170°49’E), 487–528 m; P6741, Campbell Rise (52°27’S, 171°12’E), 510–522 m; P6756, Bounty Plateau (48°25’S, 179°48’E), 512–530 m; P6873, Bounty Plateau (48°25’S, 179°53’W), 586–596 m; P6900, Bounty Plateau (48°28’S, 178°56’S), 582–565 m; P7277, Bounty Plateau (48°25’S, 179°36’E), 556–557 m; P7410, Pegasus Canyon (43°13’S, 172°51’E), 403 m; P7591, Chatham Rise, 821 m; P8085, Chatham Rise; P8086, SE of Pit Island (44°25’S, 176°04’W), 660 m; P8087, SE of Pit Island (44°25’S, 176°04’W), 660 m; P8088, Chatham Rise (43°42’S, 178°35’W), 512 m; P8111, Chatham Rise (43°51’S, 178°03’E), 500 m; P8122, Pegasus Canyon, 43°43’S, 43°43’S; P9334, Chatham Rise (44°04’S, 178°04’W), 476 m; P9366, Chatham Rise (43°18’S, 177°19’W), 532 m.

**Diagnosis:** Dorsal fin rays 8–10, 51–69; anal fin 48–69; pectoral fin 21–27; pyloric caeca 7–9 of moderate size; 10–12 scales in transverse row between origin of dorsal fin and lateral line; vertebrae 49–52. Fins pale in colour except for a black spot at the top of first dorsal.

**Description:** Body elongate, compressed, greatest depth at origin of second dorsal, from where it tapers to very narrow caudal peduncle. Snout broad, rounded, short, two thirds horizontal diameter of eye but much greater than concave interorbital space. Mouth oblique, maxillary extending to the vertical from the centre of the eye. Upper jaw overlaps lower; upper jaw with an outer series of distinctly larger teeth. Chin with small barbel equal in length to interorbital space which is one third diameter of eye. Eye very large and prominent. Operculum terminating in small horizontal spine which does not pierce skin; gill opening wide, gill rakers equal in length to opposite gill filaments. Upper jaw with an outer series of distinctly longer teeth (Fig. 1D, F). First dorsal origin slightly behind the vertical from insertion of pectoral, first ray very short, longest (5th) half length of head. Second dorsal origin immediately behind first dorsal. Second dorsal and more especially anal slightly depressed in height along middle of length. Caudal fin variable, slightly rounded to truncated, free from dorsal and anal fins. Pectorals inserted mid-way down body, pointed, reaching to origin of anal. Ventral fin narrow, two outer rays filamentous, longest (2nd) reaching anus. Scales small, cycloid, covering entire body and head but not extending onto snout or vertical fin membranes. Maximum size 20 cm.

**Colour:** Pale pinkish tan over head and body. Dark peritoneum showing through body walls. Buccal and branchial cavities pale. Fins pale with a black spot on tip of first dorsal; caudal tipped with black. Gunther (1887) reported the colour of specimens as light, with black margins to the vertical fins.

**Remarks:** Karrer (1971) recognised that (Physicusculus) marginatus (Gunther) belonged to a genus other than Physicusculus but, lacking undamaged otoliths, she was unable to ascertain which one. The species was originally
attributed to the genus *Loligo* by Gunther (1878) but later referred to *Physiculus* by Norman (1937). Karrer considered that the species was unrelated to any genus within the *Physiculus* group but was either related to *Pseudophysicus* or represented a new genus (possibly *Actinaria*um—Karrer 1971). Fitch & Barker (1972) omitted consideration of (*Physiculus*) marginatus from their study and attributed specimens of what they regarded as an undescribed species to *Actinaria*um, apparently influenced by correspondence with Karrer in which she thought that “one day a recent species will be found which will belong to this genus or show very close relationship” (Fitch & Barker 1972). *Austrophycus marginatus* is distinguished from the congeneric *A. megalopis* by the higher number of dorsal and anal fin rays (51–69, 48–69 cf. 45, 49 respectively).

*A. marginatus* is widespread in the southern oceans, and is possibly one of the most common morid species in the New Zealand subantarctic region in depths of 300–700 m. The species is easily distinguished from other morids with similar fin structure (second dorsal and anal of more or less uniform height) by the large prominent eye, and narrow interorbital space.

**Genus Auchenoceros** Gunther, 1889

*Callopilium* Hutton, 1873: 266 (preoccupied by *Callopilium* Richardson, Pisces).

Type species (by monotypy) *Callopilium punctatum* (mouth of Thames River and Cape Campbell, New Zealand).

Auchenoceros Gunther, 1889: 24 (nomen novum for *Callopilium* Hutton)

**Diagnosis:** Morid fishes with a compressed elongate body. Two dorsal fins, the first reduced to one minute ray and one long elongate ray, the second depressed along middle of its length so as to appear to be divided into two fins, a single anal fin, a separate caudal. Snout short, not produced beyond mouth. Scales small, thin, extending onto vertical fin membranes. Ventral fins rudimentary, each composed of two elongate rays. Chin without a barbel. Branchiostegal rays seven; gill rakers of the outer branchial arch long. No luminescent organs.

Otoliths with ostium subequall to caudal, crista superior less than three quarters length of crista inferior. Anterior portion greatly expanded (Fig. 7, B).

**Remarks:** Gunther (1889) proposed Auchenoceros as a nomen novum for *Callopilium* Hutton, stating that *Callopilium* was preoccupied. Hutton (1873) incorrectly adopted the name *Callopilium* for his new genus, noting that *Callopilium* Richardson was a junior synonym of *Bresniuoceros* Thompson. Auchenoceros is apparently confined to the New Zealand region.

**Auchenoceros punctatus** (Hutton, 1873)

Fig. 15

*Callopilium punctatum* Hutton, 1873: 267 (mouth of Thames River and Cape Campbell, type specimen not located).

*Auchenoceros punctatus* Gunther, 1886: 471

Common name: aluru.

**Material examined:** NMNZ P.1239, outlet from Lake Perry, Wairarapa; P.1812, Otago Harbour; P.1794, off Otago, New Zealand; P.1814, Cobourn area, towered; P.2475, Parakatiki Beach, beach seine; P.4695, Waiwera, beach seine; P.5508, Tiaki Range, beach seine; P.5509, Solander Trench (40°32′ S, 175°06′ E), 186–429m; P.5605, 5 miles E. of Porere Bay, Banks Peninsula (43°35′ S, 175°06′ E), 49–80m.

**Diagnosis:** Dorsal fin rays 2, 12–18 + 7, 28–36; anal fin 62–82; pectoral fin 19–21; pyloric caeca 8–11; 6–7 scales in a transverse row between origin of first dorsal and lateral line; vertebrae 46–49.

**Description:** Body elongate, compressed, greatest depth at origin of second dorsal. Snout rounded, as long as horizontal diameter of eye. Mouth oblique, maxillary extending beyond vertical from centre of eye. Lower jaw slightly projecting beyond upper and both with band of very small villiform teeth. Operculum terminating in small horizontal spine which does not pierce skin; gill opening wide, gill rakers equal in length to or longer than opposite gill filaments. No barbel on chin. Jaws with band of very small villiform teeth (Fig. 1, F). First dorsal origin vertically above origin of pectoral, fin reduced to two rays; first ray very short, not protruding above profile of back, second as long as head. Second dorsal origin some distance behind first, fin consisting of a high, short anterior portion, and a longer, low posterior portion near caudal. Space between two portions of fin occupied by variable number of rudimentary rays which are more apparent in juvenile specimens; in very small specimens fin continuous. Anal fin commences immediately behind anus, slightly in advance of second dorsal, more or less of even height throughout its length. Caudal fin rounded, half length of head and free of dorsal and anal fins. Pectoral inserted midway down body, equal to length of head. Ventral composed of two slender rays, the longer reaching anus. Scales thin, cycloid, covering body and head except...
for snout and extending onto vertical fin membranes.

Colour: Head and body pinkish-tau with numerous dark spots. Operculum, abdominal region and side of body silver. Fins pale. Gunther (1889) reported the colour of specimens as uniform silvery. Graham (1956) recorded the colour of fresh specimens as pinkish with a black spot on each side of the head, and a broad yellow band along the lateral line.

*Remarks:* Hutton (1873) described *Auchenoceros punctatus*, stating that the species represented a new genus, but incorrectly adopting the name *Calliptilum*. Gunther (1876) expanded Hutton’s description but did not recognise *Calliptilum* Hutton as being distinct from *Calliptilum* Richardson, which had previously been synonymised with *Bregmaceros* Thompson (Gunther, 1862). The acquisition of further specimens by the ‘Challenger’ Expedition enabled Gunther (1889) to re-examine the generic position of the species. He followed Hutton in recognising *Calliptilum* punctatus as the type of a distinct genus but pointed out that Hutton’s use of *Calliptilum* was incorrect.

Morphometric and meristic data of specimens examined in the present study are the same as in Hutton’s (1873) diagnosis. Graham (1956) recorded larval crustaceans and pelagic copepods from the stomachs of specimens. This and the anterior projection of the lower jaw indicates that the species is a pelagic feeder. *Halargyreus*, the only other genus of Moridae within New Zealand with a projecting lower jaw, is also a pelagic feeder (Templeman, 1968). Both *Auchenoceros* and *Halargyreus* lack a barbel, characteristic of all other morid genera examined in the present study, and indicates a similar specialised feeding habit rather than any taxonomic relationship.

*Genus Tripterygicis* Boulenger, 1902

*Tripterygicis* Boulenger, 1902: 335

*Type species* (by monotypy) *Tripterygicis gilchristi* Boulenger, 1902: 335 (South Africa).

*Diagnosis:* Morid fishes with an elongate, compressed body; posterior portion attenuate, short preanal region. Two dorsal fins, the first very short on snake, the second divided into two widely separate portions; anterior portion short and high, situated behind vertical from anus, posterior portion elongate and low, nearly reaching the separate caudal. A single long anal fin of uniform height. Snout short, not protruding beyond mouth; scales small, cycloid, covering entire body and head; not extending onto snout or fin membranes. Ventral with a narrow base, composed of five rays, the two outermost prolonged and filamentous. A black glandular, luminous, organ surrounding anus. Chin with a minute barbel; branchiostegal rays seven.

Otolith spindle shaped, thick. Ostium less than one third length of otolith, crista inferior twice as long as crista superior (Fig. 7, G).

*Remarks:* Whiteley (1948) proposed a separate family for *Tripterygicis* which alleged to show relationship with the Macrouridae, but differed in having three dorsal fins and a transverse fin. The air bladder of *T. intermedia* Whiteley, was described as “... a simple bag without horns and with an elongated neck anterior...”: Examination of Whiteley’s dissected paratype of *T. intermedia* (ANIB17727) shows the air bladder to be bicornuate.
of typical morid structure and not a simple bag as reported by Whitley.

Otoliths of specimens of Tripterygionides were examined by Karre (1917), Fitch & Barker (1972) and in the present study, and show the characteristic bifurcate cauda of the morids. Dissections and radiographs of the caudal region of Tripterygionides examined in the present study show the typical morid structure of the hypurals and ultimate urostyle. The structure of the airbladder, caudal elements and otoliths of Tripterygionides provide no basis for separation from the Moridae.

Tripterygionides gilchristi Boulenger, 1902

Tripterygionides gilchristi Boulenger, 1902: 335
(40 miles off Table Mountain, South Africa, 250 fath.)
Tripterygionides intermedius Whiteley, 1948: 79
(Victoria and South Australia, 190-450 fath.)
Tripterygionides gilchristi: Stephenson, 1971: 235

Common name: grenadier cod.

Material examined: NMNZ, P2348, Bay of Plenty (37°17′50″S, 176°39′20″E), 499m; P3566, NE of Motuihe Island, 350m; P3512, NE of Poor Knights Islands, 548-630m; P3521, N of Cape Reinga, 660m; P3535, NE of Table Island, 731-599m; P3592, ENE of Poor Knights Islands, 512m; P3506, NE of Cape Reinga, 425-493m; P3570, N of Cape Reinga, 750m; P3571, N of Motuihe Island, 619m;

P3579, E of Table Island, 829m; P3587, between Alderman and Red Mercury Islands, 457m; P3583, Bay of Plenty (37°09′30″S, 176°14′30″E), 329-370m; P6431, northern Chatham Rise (41°15′30″S, 178°52′30″W), 527-556m; P6643, northern Chatham Rise (47°35′S, 177°35′W), 470-480m; P7266, W of Stewart Island (46°29′S, 166°29′E), 530m; P7686, Bay of Plenty (37°22′S, 176°17′E), 435-520m; P7833, Bay of Plenty (37°22′S, 176°28′E), 440-580m; P8089, between Alderman and Red Mercury Islands.

Non-New Zealand material examined (not included in description below): AM, 181127, Tripterygionides intermedius Whiteley (paratype), Great Australian Bight, south of Eucla (31°51′S, 129°53′E), 350-450 fath.

Diagnosis: Dorsal fin rays 5-7, 14-17+7-29-30; anal fin 95-112; pectoral fin 19-20; 11-12 scales between origin of first dorsal and lateral line; vertebrae 67-70.

Description: Body elongate, compressed, greatest depth at origin of second dorsal, from where it tapers to very narrow caudal peduncle. Profile of back elevated below anterior portion of second dorsal. Snout bluntly rounded, shorter than eye. Mouth sub-horizontal, maxillary reaching vertical from centre of eye. Jaws equal in length, each with single row of closely set, truncate, compressed teeth. Chin with minute barbel one quarter as long as horizontal diameter of eye. Interorbital space flat, width less than diameter of eye. Operculum terminating in small horizontal spine which does not pierce skin. Gill opening wide, gill rakers as long or longer than opposite gill filaments. Teeth on jaws in single series, small closely set (Fig. 1, A). First dorsal fin origin vertically above insertion of pectorals. First dorsal much higher than long, 1st ray minute, longest ray (2nd) slightly greater than horizontal diameter of orbit. Second dorsal commences a short distance behind first, divided into two portions: a high, short anterior portion and a longer, low posterior portion near caudal. Both portions connected by fin ray supports and minute rudimentary fin rays, visible in radiographs. Anal fin origin a short distance behind arm, decreasing in height from about 10th ray, and extending to caudal peduncle. Caudal fin pointed, half length of head. Pectoral inserted high on body, pointed,
two thirds length of head. Ventral with outer rays extended but not filamentous. Scales small, cycloid, on body and head, not extending onto vertical fin membrane or snout. Anus surrounded by a naked black area which also embraces an elliptical luminescent organ. Maximum size 20cm (Smith, 1950).

Colour: Body and head pinkish tan, abdominal region with dark blue peritoneum showing through body walls. Head and body covered with small brown spots. Fins pale, ventral fins dark at insertions. Two specimens uniform blue grey, with spots. The colour was recorded by Boulenger (1902) as yellowish brown, finely speckled with dark brown; abdominal region bluish black. Whitley (1948) reported the colour of Australian specimens as brownish pink, eyes and viscerum blue, fins pale yellowish or whitish. Brown spots on sides of head and thickly distributed below head. A conspicuous blackish area around vent. Inside of mouth pale brownish.

Remarks: The genus Tripterygophrys is represented by a single species, T. golchristi, which is known from throughout the south temperate oceans. Variations in proportional measurements and counts are associated with body size (Table 2) and do not justify taxonomic separation of populations (Weber & de Beaufort, 1929; Stephenson, 1971; McCann, 1972). Tripterygophrys occupies a position within the Moridae analogous to that of Auchenogaster. Both have the second dorsal fin greatly depressed along the middle of its length and apparently divided into two fins. Juvenile specimens of Auchenogaster have a continuous second dorsal fin, with the intermediate fin rays becoming lost as the fish grows, and adult specimens have a divided fin. The second dorsal of Tripterygophrys may be continuous in juvenile specimens (not available during the present study). The two portions of the second dorsal are connected by fin ray supports and minute rudimentary rays which are not visible externally.

T. golchristi was first recorded in the New Zealand region by Stephenson (1971) from a number of specimens collected in the Bay of Plenty region, and McCann (1972) from a single specimen collected on the Chatham Rise.

Genus Lepidion Swainson, 1838

Lepidion Swainson, 1838: 318

Type species (by original designation) Gadius lepidion Risso, 1810: 118 (Mediterranean) (= L. rissoi Swainson).

Holoporphyrus Gunther, 1862: 358

Diagnosis: Morid fishes with elongate body, two dorsal fins, the second of uniform height, and single anal fin depressed along the middle of its length, separate truncated caudal. Snout rounded, conical, not projecting beyond mouth, length slightly greater than inter-orbital width. Scales small, covering body and entire head, extending onto vertical fin membranes. Ventral fins with 5–6 rays, the outer two filamentous. Chin with barbel. Branchiostegal rays seven; gill rakers of outer branchial arch short. No luminescent organs.

Otoliths with an outward bend of crista inferior. Crista superior more than three quarters length of posterior colliculum. Ratio of height into length 1:2.5–2.6 (Fig. 7, L).

Remarks: The genus Lepidion was described by Swainson (1838) for the species Gadus lepidion Risso. Gunther (1862) erected the genus Holoporphyrus, stating that Lepidion was preoccupied. Gill (in Goode & Bean, 1896) noted that Gunther gave no record of an earlier use of Lepidion, and considered the name sufficiently distinct.

Ten species have been referred to the genus Lepidion. All are found in deep water on the continental slopes of the Pacific, Atlantic and Indian Oceans and the Mediterranean Sea. The genus was first recorded in New Zealand waters by Whitley (1968).

Lepidion microcephalus Cowper, 1956

Fig. 17


Lepidion microcephalus. Whitley, 1968: 41

Common name: long-finned cod.

Material examined NMMZ P4513, Pflaizer Bank, 2,100ms; P8951, northern Chatham Rise (42°50'S, 178°28'W), 940m; P8956, off West Coast (42°15'S, 170°36'W), 792m; P7452, northern Chatham Rise (43°42'S, 176°44'E), 880m; P7751, Hokurungia Trench (42°36'S, 174°20'W), 417–790m; P7964, Chatham Rise (42°47'S, 175°47'E), 883–890m; P7945, Chatham Rise (42°48'S, 174°35'E), 836–840m; P8125, Chatham Rise trawled; P8439, Chatham Rise (42°48'S, 170°07'W), 888–901m; P8448, Chatham Rise (42°50'S, 176°52'W), 900m.


Description: Body elongate, compressed greatest depth at about seventh ray of second dorsal, from where it tapers to narrow caudal peduncle. Snout rounded, subconical, length less than horizontal diameter of orbit an
greater than interorbital width. Mouth subhorizontal, maxilla falling short of vertical from the centre of eye. Upper jaw overlapping lower, both with band of villiform teeth. Vomer with small patch of teeth. Chin with small barbel, rarely exceeding one half the diameter of eye. Anterior nostril with forward directed tube. Operculum terminating in small horizontal spine which does not pierce skin; gill openings wide, gill rakers half length of opposite gill filaments. Teeth small villiform, in bands on both jaws, a small patch on vomer (Fig. 1, E). First dorsal origin behind vertical from pectoral insertion. First ray minute, rudimentary; second ray greatly elongated, much greater than length of head and laterally flattened in large specimens. Second dorsal commences immediately behind first, slightly depressed in height along posterior third of its length. Anal fin origin immediately behind anus, fin depressed along the middle of its length, equal in height to second dorsal. Both dorsal and anal fin bases enclosed in a loose scaly membrane. Caudal fin truncated, slightly forked in large specimens, free of dorsal and anal fins. Pectoral inserted midway down body, pointed, more than one half length of head. Ventral with a broad base, the outer rays filamentous, the longest (2nd) falling short of anus by distance equal to diameter of orbit. Scales small, covering entire body and head, extending onto vertical fin membranes between fin rays. Maximum size 41 cm (present study).

Colour: Pale grey over head and body, fins darker grey distally. Scale pockets edged with dark brown. Buccal cavity pale, branchial cavity black. Cowper (1956) recorded the colour of fresh specimens as motiled pinkish brown on grey with black edges to the second dorsal and anal fins.

Remarks: Specimens of Lepidion collected in the New Zealand Exclusive Economic Zone are referable to L. microcephalus Cowper, and closely resemble L. lepidion (Risso, 1810), from the Atlantic. Cowper (1956) described L. microcephalus and noted that the species had close affinities with other members of the genus, particularly L. eques and L. lepidion. Cowper considered that differences between his species and the published description of other species in radial formula, body proportions such as relative head length and eye diameter, and scale counts, were sufficient to distinguish L. microcephalus as a distinct species.

With the exception of Templeman (1970) and Nakaya, Amaoka & Abe (1980) who provided variation data for specimens examined, published descriptions of Lepidion species refer only to a few type specimens or reiterate descriptions of earlier authors. Few morphometric and meristic data, or standard lengths, are available. Templeman (1970) examined specimens of L. eques, L. lepidion, L. guentheri and L. schmitti from the North Atlantic. He considered that, although closely related, these species could be separated using...
eye diameter, head length, and some meristic and morphometric characters, although there was considerable overlap.

Vertical scale row counts separate L. microcephalus from L. guntheri, L. capensis, L. estiferus, L. lepidopterus and L. schmidti (141-180 cf. 200-250) and anal fin ray counts separate the species from L. eques and L. natatorius (40-46 cf. 49-55). L. microcephalus closely resembles L. lepidopterus but differs from that species in having, on average, more second dorsal and anal fin rays. Also, the caudal peduncle is only 1-1.5 times as long as deep compared to 3.75-4 times as long as deep in L. lepidopterus (Norman, 1936). However, this may be an artifact of preservation because Templeman (1970) found shinkage occurred when formallipreserved specimens were placed in alcohol, and disregarded the character for taxonomic purposes.

The high number of species referred to the genus Lepidopterus is unusual within the Moridae and is exceeded only by Physodorus and Laemonema. Karrer (1971) and Fitch & Barker (1972) considered Lepidopterus to be closely related to Morea, Antimora and Halargyreus on the basis of otolith shape. These genera are each represented by a single species, although there are differences between populations. The results of the present study, and those of Templeman (1970), show that nominal species of Lepidopterus from the Pacific Ocean closely resemble those from the North Atlantic. It is not unusual for deepwater species to be widespread (Grey, 1956), and worldwide revision of the genus may reduce the number of species.

**Genus Halargyreus Gunther, 1862**

*Halargyreus* Gunther, 1862: 342

Type species (by monotypy) *Halargyreus johnsonii* Gunther, 1862: 342 (Madeira, type specimen in BMNH).

**Diagnosis:** Morid fishes with compressed elongate body, two dorsal fins, one anal fin depressed along middle of its length, separate caudal. Snout rounded, conical, slightly greater than interorbital width. Scales small, covering body, entire head, extending onto vertical fin membranes. Ventral fin narrow, with five rays, not elongated. Anus immediately anterior to anal fin, no luminescent organs. Chin without barbed. Branchiostegal rays seven; gill rakers of the outer branchial arch long.

Otoliths with an outer bend of the crista inferior. Crista superior more than three quarters length of posterior colliculum. Otolith with an expanded anterior end; ratio of height to length: 1.2:0-2.4 (Fig. 7, J).

**Remarks:** Gunther (1862) recognised the genus Halargyreus and described *H. johnsonii* from a damaged specimen taken from a fish stomach. Later, Gunther (1887) supplied additional meristic information from specimens collected in New Zealand. Variant (1888) described *H. brevispinus* from a single specimen in poor condition collected off Morocco. Collin (1904) described *H. affinis* from five specimens of 106 collected on the Faroe slopes. Templeman (1968) examined specimens from the North Atlantic and New Zealand and reduced three nominal species to one, *H. johnsonii*, tentatively accepting Gunther's identification of the New Zealand specimens as that species. Cohen (1973) compared data from a larger sample of northern and southern hemisphere specimens and confirmed that a single species was represented, and that the variation of local forms was within the range of intra-specific variability.

*H. johnsonii* is an epibenthic species known from temperate waters of the North Atlantic (Templeman, 1968; Haedrich & Horn, 1970), South Atlantic (Svetovidov, 1967; Perimart, 1969) western South Pacific (Gunther, 1887; Cohen, 1973) and eastern South Pacific (Cohen, 1973). The genus was first recorded from New Zealand by Hutton (1872) from beach-cast specimens.

**Halargyreus johnsonii** Gunther, 1862: 342

Type locality: Madeira (BMNH).

**Diagnosis:** Dorsal fin rays 6-8, 48-60; anal fin 39-53; pectoral fin 17-20; pyloric caeca 8-11; 8-12 scales between origin of first dorsal and lateral line; vertebrae 55-58.

**Description:** Body and head elongate, compressed, greatest depth at origin of first dorsal fin.
dorsal fin, from where it tapers to narrow caudal peduncle. Snout rounded, conical, equal to horizontal diameter of eye. Mouth oblique, maxillary extending to vertical from centre of eye. Lower jaw protrudes beyond upper, a small bony tubercle at symphys of mandibles. No barbel. Both jaws with a band of minute, equal sized, villiform teeth. Interorbital space flat, width slightly less than diameter of eye. Operculum terminating in a small horizontal spine which does not pierce skin; gill opening wide, gill rakers one third longer than opposite gill filaments. Teeth very small, equal sized, in bands on jaws (Fig. 1, F). First dorsal fin origin behind the vertical from insertion of pectoral, twice as high as long, 1st ray minute, rudimentary, longest ray (2nd) two fifths length of head. Second dorsal commences immediately behind first, less than first in height, slightly depressed in height along the middle of its length. Anal fin origin immediately behind anus, fin two-thirds length of second dorsal; height of anal greatly depressed along the middle of its length — 4th to 7th and 45th to 50th rays longest, equal to second dorsal, 15th to 19th rays short, less than a fourth of the horizontal diameter of eye. Caudal fin ovate to forked in larger specimens, pectoral inserted two thirds down side of body, its length greater than half length of head. Ventrals narrow, slender, not elongated into tactile organs, longest ray (1st) falling short of anus by a distance equal to two-thirds length of head.

Colour: Günther (1862) stated “... the colour appears to have been a delicate red on silvery ground; pectoral and anal transparent. Mouth and gill cavity black ...”. Vaillant (1888) and Collett (1905) recorded the colour as “reddish, silvery on the jaws and ventrally” and “light red grey, abdomen and sides of head silvery” respectively. Mauel (1952) noted that the colour of specimens in formalin was brown on the head and body, and lighter below, with dorsal, anal and pectorals brown, the anal and pelvis whitish, and the inside of the mouth, branchiostegal membranes, and iris blackish. Templeman (1968) examined specimens stored in formalin for a number of years and noted that the initial whitish grey and silvery colour had faded and the general colour had become brownish grey, caused by the flesh colour showing through the translucent skin. Fresh specimens examined in the present study were silver over head and body, with buccal and branchial cavities black. After preservation in formalin and isopropyl alcohol the specimens appeared whitish grey, with the black branchiostegal membrane and anus prominent.

Remarks: The results of the present study agree with those of Templeman (1968) and Cohen (1973) in that the New Zealand population of *H. johnsonii* has, on average, a greater number of second dorsal fin rays, more total anal rays, more vertebrae and more ventral rays than the northern hemisphere populations. Morphometric measurements overlap considerably and are within the range of species variability. Hence there is little justification for recognising subspecies.

Two specimens of *H. johnsonii* (NMNZ P8420) examined in the present study measured 555 mm and 560 mm SL, respectively, and are considerably longer than the previously reported largest specimen of 452 mm SL collected at Madeira (Templeman, 1968). Templeman examined several large specimens between 218 mm and 432 mm SL. With the exception of two females (406 mm and 432 mm SL) which contained “a few tiny or small eggs” (0.13-0.3 mm diam.), all were immature or showed no sign of having spawned previously. He concluded that “it is likely that considerably larger individuals of this species exist, possibly in very deep water ...”. The present specimens were females and both were sexually mature.
with fully developed ovaries (preserved weight: 1.6, 1.7 kg; weight of ovaries: 305, 250 g respectively). Both fish had opaque yolk-like eggs, 0.9 mm in diameter. The specimens were taken north-west of the Chatham Islands (42°50' S, 176°18' W) in a depth of 1022 m (L. J. Paul, pers. comm.).

Genus Antimora Gunther, 1887

_Holophrypus_ (Antimora) Gunther, 1878: 18

_Antimora_ Gunther, 1887: 93

Type species (by original designation)

_Holophrypus rostrata_ Gunther 1878: 18

(midway between Cape of Good Hope and Kerguelen Island; east of mouth of Rio Plata)

_Diagnosis:_ Morid fishes with a compressed, elongate body, two dorsal fins, the second of uniform height, a single anal fin depressed along the middle of its length, a separate truncated caudal. Snout produced, forming a short triangular, pointed lamina, sharply keeled on sides and overlapping cleft of mouth. Scales small, covering body, head and extending onto vertical fin membranes. Ventral fins with 5-6 rays, outer rays filamentous. Chin with small barbel. Branchiostegal rays seven, gill rakers of outer branchial arch short. No luminous organs. Otoliths with an outward bend of the crista inferior. Crista superior more than three quarters the length of posterior colliculum. Otolith with an expanded anterior end; ratio of height into length 1:2.6-2.8 (Fig. 7, K).

Remarks: Gunther (1878) described _Holophrypus rostrata_ and regarded it as the type of distinct subgenus _Antimora_. Later Gunther (1887) recognised _Antimora_ as a distinct genus, differing from _Holophrypus_ (= _Leptiodon_) in the form of the snout, backward position of the anus and imperfect division of the anal fin.

_Antimora_ is cosmopolitan in distribution, descending to greater abyssal depths than other morid genera. Grey (1856) recorded the vertical range of _A. rostrata_ as 403-2904 m. The genus was first recorded from the New Zealand region by Saitoh (1972).

Six nominal species of _Antimora_ have been described. Koefoed (1927) and Schroeder (1940) regarded _A. viole_., _A. microlepis_, _A. rhina_, and _A. australis_ as junior synonyms of _A. rostrata_, recognising a single species, but noting that there may be local intraspecific forms. _Antimora meandi_ Pequeno (1970) was described from a single specimen. The characteristics of _A. meandi_ are within the range of variation of _A. rostrata_ and do not warrant recognition of a distinct species. However, recent investigations have shown that _A. rostrata_ and _A. microlepis_ may possibly be distinct species (D. M. Cohen, pers. comm.).

_Antimora rostrata_ (Gunther, 1878)

_Fig. 19_

_Holophrypus rostratus_ Gunther, 1878: 18

(off Montevideo)

_Holophrypus viole_ Goode & Bean, 1878: 257

(L. Hav Bank)

_Antimora viole_ Jordan, 1887: 917

_Antimora rostrata_ Gunther, 1887: 93

_Antimora rhina_ Garman, 1889: 85

(off Panama)

_Antimora australis_ Barnard, 1925: 499

(South Africa)

_Antimora meandi_ Pequeno 1970: 14

(South America)

_Antimora viola_ Saitoh, 1972: 186

Common name: violet cod.

Material examined: NMNZ P3215, Campbell Plateau (53°59'S, 169°37'E), 950m; P9815, Kermadec Ridge (3°11'S, 170°32'W), 1060-1000m; P7588, Pukaki Rise (48°30'S, 171°58'E), 890m; P7572, Campbell Plateau (52°10'S, 170°15'E), 9000m; P7722, Hikurangi Trench (42°41'S, 174°28'E), 1730-1550m; P7756, Hikurangi Trench (42°41'S, 174°28'E), 1730-1550m; P9846, Campbell Plateau (53°46'S, 168°23'E), 8700m.

Non-New Zealand material examined (not included in description below), RUSS 464, 1 specimen off Natal coast, South Africa, 29 Dec. 1938.

_Diagnosis:_ Dorsal fin rays 5-7, 48-55; anal fin 36-49; pectoral fin 17-25; pectoral caeca 10-14; 9-14 scales between origin of first dorsal and lateral line; vertebræ 56-59.

_Description:_ Body elongate, moderately compressed, greatest depth at origin of second dorsal, from where it tapers to narrow caudal peduncle. Snout pointed, produced beyond the mouth forming short keeled lamina. Preoral portion of snout equal to half horizontal diameter of eye. Maxillary falling short of vertical from hind margin of eye. Upper jaw overlapping lower, both with band of small villiform teeth. A small patch of similar teeth on the head of vomer. Chin with a small barbel, its length rarely exceeding one third of horizontal diameter of eye. Interorbital space flat, width equal to the diameter of eye. Operculum terminating in small horizontal spine which does not pierce skin. Gill opening wide, gill rakers of first branchial arch equal to half length of opposite gill filaments. Gill filament length 1.5-2.4 % SL. Number of gill filament pairs 70-87. Teeth small, villiform, equal sized, in bands on jaws, a small patch on vomer (Fig. 1, E). First dorsal fin origin behind...
vertical from insertion of pectoral; first ray minute, rudimentary, the longest ray (2nd) filamentous, equal to length of head. Second dorsal commences immediately behind first, less than first in height and uniform throughout its length. Anal fin origin immediately behind anus, fin half as long as second dorsal and depressed along the middle of its length. Both dorsal and anal fin bases enveloped in loose scaly membrane. Caudal fin truncated, free of dorsal and anal fins. Pectoral inserted midway down body, pointed, two-thirds as long as head. Ventral with a broad base, outer rays filamentous, longest (2nd) falling short of anus by a distance equal to twice diameter of eye. Scales small, covering entire body and head and extending onto ventral fin membranes.

Colour: Head and body pale grey with pinkish tan body tissue showing through. Abdominal region with darker colour of peritoneum showing through skin. Buccal and branchial cavities dark. Vertical fins pale with darker margins, paired fins dark. All specimens examined had been taken in trawls and were considerably abraded, edges of scale pockets remaining pale grey-blue or brown in some specimens.

Remarks: Koefoed (1927), Schroeder (1940), Grey (1956) and Svetovidov (1967) recognised a single species of *Antimora* occurring throughout the Atlantic and Pacific Oceans. The present study shows that meristic and morphometric data for New Zealand specimens overlap with the published descriptions of nominal species of *Antimora* (Goode & Bean, 1878, 1883, 1896; Gunther 1878, 1887; Bean 1890; Collett 1896; Garman 1899; Jordan & Evermann, 1900; Gilchrist & von Böröde, 1924; Barnard 1925; Koefoed 1927; Clemens & Wilby, 1946; Svetovidov 1948; Smith, 1950; Pequeno, 1970).

Small (1981) recognised *Antimora microlepis* in the north Pacific, and *A. rostrata* in the south-eastern Pacific, Southern Ocean and Atlantic Ocean as distinct species, noting differences in number and length of gill filaments and head length between the two species. Comparison of data from New Zealand specimens with those presented by Small (1981) corroborates Small’s conclusions that the populations can be separated. New Zealand specimens of *A. rostrata* have 70–87 relatively short gill filament pairs, north Pacific specimens of *A. microlepis* have 90–103 relatively long gill filament pairs. Other measurements can be used but with less distinct separation of species (Small, 1981).

**Genus Mora Risso, 1826**

*Maris Risso, 1826: 224*

*Type species (by monotypy) Mora mediterranea Risso, 1826: 224 (Mediterranean Sea) (= Gadus mora Risso, 1810: 116).*

Diagnosis: Morid fishes with moderately elongate body; two dorsal fins, the second of uniform height; single anal fin greatly depressed along the middle of its length; separate truncated caudal. Snout broadly rounded, not projecting beyond mouth, length equal to interorbital width. Scales moderate in size, covering body, entire head and extending onto ventral fin membranes. Ventral fins with five to six rays, the two outermost filamentous. Chin with small barbel. Branchiostegal rays seven; gill rakers of the outer branchial arch long. No luminescent organs. Otoliths with an
outward bend of crista inferior and a greatly expanded anterior end. Ratio of height into length 1:1.7-1.8 (Fig. 7, 1).

Remarks: Risso (1826) established the genus Mora for his species Gadus moro, altering its name to Morus mediterranea. Guenée (1826) Vaillant (1888), Goode & Bean (1895), and Holt & Calderwood (1895) followed Risso in referring the species to M. mediterranea. Roule (1949) and subsequent authors (Kooi, 1927; Noronha & Sarmiento, 1948; Maul, 1952; Forster, 1968; Schmidt, 1968; Tortone, 1970; Kellett, 1971; Fitch & Barker, 1972) have referred the species to M. moro. However, Risso (1810) used the common name 'mora' as the source for the scientific name moro, which should be treated as a noun in apposition and retain its original orthography.

Mora is benthic in habits, and fairly common on the lower continental shelf and upper slope. The genus has been recorded from the temperate eastern North Atlantic from Iceland and the Faroes to the western Mediterranean (Cohen, in Hureau & Monod, 1973), and the temperate South Pacific (Whitley, 1948; Moreno, 1974).

**Mora moro** (Risso, 1810)

*Fig. 20*

**Gadus moro** Risso, 1810: 116 (Mediterranean Sea)

**Mora pacifica** Waite, 1914: 128 (Kaiikoura, New Zealand)

**Mora dannevigi** Whitley, 1948: 82 (Great Australian Bight)

**Common name:** ribaldo.

**Material examined:** NNMZ: P71, Cook Strait; P140, off Otago, Kaiikoura; P201, off Otago, Kaiikoura; 1097m, P267, off Otago, Kaiikoura; 477-500m, P288, Cook Strait, 823m, P163, 9.5 km E of Whale Island, 731-598m, P162, 20 miles N of Cape Brett, 733m, P152, off Palliser Bay, 845-914m, P150, off Cape Turakirae 61°56'S, 174°53'E, 659m, P349, Chatham Rise 43°31'S, 177°50'E, 490m, P653, Moreton Bank 43°31'S, 174°53'E, 448-459m, P661, 40m, N of Chatham Rise 42°56'S, 170°40'W, 733m, P668, N of Chatham Rise 42°52'S, 175°33'E, 659m, P662, Moreton Bank 42°56'S, 179°43'E, 733m, P668, N of Chatham Rise 42°52'S, 178°33'E, 508m, P668, N of Chatham Rise 43°13'S, 179°52'W, 535-536m, P671, Chatham Rise 43°13'S, 179°53'W, 618-558m, P680, 6 miles E of Whale Island, 628m, P680, 26 miles ENE of Point Knights Islands, 585-622m, P346, Chatham Rise 42°44'S, 176°48'E, 800m, P748, Campbell Plateau 52°31'S, 169°57'E, P770, 9 miles NE of Mayor Island 37°9'S, 176°24'E, 730-822m, P772, 20 miles NE of Mayor Island 37°22'S, 176°33'E, 618-666m, P774, 19 miles NW of Oreti Point 37°29'S, 177°32'E, 815-939m, P775, 19 miles from Clarence River Mouth 42°16'S, 174°20'8'E, 860-790m, P788, Chatham Rise 42°23'S, 175°20'E, 560-577m, P800, West Coast 42°11'S, 170°19'W, 682m; AM B1729-31 (3 paratype specimens of M. dannevigi).

**Diagnosis:** Dorsal fin rays 7-11, 42-53; anal fin 35-43; pectoral fin 18-25; pyloric caeca 17-20; 6-11 scales between origin of first dorsal and lateral line; vertebrae 50-54.

**Description:** Body elongate, thickset, greatest depth at origin of second dorsal from where it tapers to narrow caudal peduncle. Snout broadly rounded, less than horizontal diameter of eye in length and equal to interorbital width. Mouth subhorizontal, maxillary extending to vertical from centre of eye. Upper jaw overlapping lower, both with broad band of small equal sized, cardiform teeth. A small patch of similar teeth on head of vomer. Chin with small barbel, rarely exceeding one third horizontal diameter of eye. Interorbital space flat, width two thirds diameter of eye. Operculum terminating in very small horizontal spine which does not pierce skin. Gill opening wide, gill rakers as long as opposite gill filaments. Teeth small, arranged in brushlike band on jaws; a patch of teeth on vomer (Fig. 1, E). First dorsal fin length two thirds its height, origin behind vertical from insertion of pectorals, first ray minute, rudimentary, longest ray (2nd) half length of head. Second dorsal commences immediately behind first, less than first in height, only slightly depressed along middle of its length. Anal fin origin immediately behind anus, fin greatly depressed along middle of its length, sometimes divided into two portions. Anterior portion usually higher and longer than posterior. Both dorsal and anal fin bases enveloped in loose scaly membrane. Caudal fin truncated or slightly forked in larger specimens, free of dorsal and anal fins. Pectoral inserted midway down body, ovate pointed in shape, two thirds length of head. Ventrals with a broad base, outer rays filamentous, longest (2nd) falling short of anus by a distance equal to its length. Scales of moderate size, covering entire body and head, extending onto vertical fin membranes.

**Colour:** Pale grey over body and head with flecks of brown on scale pocket edges. Flanks with pale brown membranes. Buccal cavity pale; branchial cavity black. Maul (1952) recorded the colour as a uniform dark grey on body and head; fins and snout much darker; scaleless parts of fins bluish grey with white narrow edge.

**Remarks:** *Mora pacifica* was described by Waite (1914) from a specimen collected in 160 m off Kaiikoura, New Zealand. Waite compared his specimen with a figure of *Mora*
moror provided by Goede & Bean (1895) and noted that the species differed from the temperate eastern Atlantic and Mediterranean fish in having a shorter snout and a less advanced first dorsal fin. The variation in these proportions shown by the present southwest Pacific material are within the ranges given for M. moror by Holt & Calderwood (1895) (Tables 1, 2). Hence, there is no justification for taxonomic separation of the New Zealand population.

Whitley (1948) described M. dannevigi from Australia. The measurements and counts do not differ from the range for M. pacificus in the present study and the Australian population is considered conspecific. Whitley's statement that M. dannevigi was different in having slightly different proportions, fewer lateral line scales, fewer vertebrae and paler colouration than specimens of M. moror reported by Holt & Calderwood (1895). Comparison of Whitley's data with those provided by Holt & Calderwood, and the present study show slight differences (Table 1). Whitley's statement that M. dannevigi was fewer vertebrae than M. moror is incorrect. Holt & Calderwood recorded 51 vertebrae for M. moror; Whitley (1948) recorded 33 vertebrae for M. dannevigi. Whitley (1948) gave a lateral line scale count of c.60 for the holotype, but did not distinguish the holotype from the 7 paratypes held at the Australian Museum. Because of the small size range of the eight specimens it is not now possible to determine whether this is the holotype. Vertical scale row counts of paratype specimens fall within the range of M. moror examined in the present study (84-94 cf. 72-101). Eye proportions of the Australian paratypes differ because of their smaller size (167-190 mm SL cf. 250-672 mm SL).

Fitch & Barker (1972) found differences in otolith shape between M. pacificus and M. moror. Examination of otoliths (19 pairs) in the present study showed considerable variation in the configuration of the expanded anterior end. No consistent differences were found between otoliths from New Zealand specimens of M. moror when compared with illustrations (Vaillant, 1883; Schmidt, 1908; Karrer, 1971) and otoliths (6 examples) from northern hemisphere specimens. The genus Moror is therefore considered to be represented by a single worldwide species, M. moror.

Mora moro and Pseudophycis burchi are the only morid species taken in commercial quantities by New Zealand fishing fleets. M. moror accounted for 15.8% of the total Japanese longline catch in New Zealand waters between 1975 and 1977 and was represented in trawl catches in small quantities (Paul & Robertson, 1978). Catches of M. moror by New Zealand vessels are insignificant and are generally restricted to by-catches whilst fishing for other species. Lack of interest in morid codfishes by New Zealand fishermen is a result of low consumer demand, and considerable quantities are dumped at sea (Waite, 1911; Graham, 1933; Watkins & Smith 1972; Vooren 1972; Habib, 1973).

Genus Laemonema Gunther, 1862
Laemonema Gunther, 1862: 356
Type species (by original designation) Phycis yarrelli Lowe.

Diagnosis: Morid fishes with elongate body, compressed. Head broad, cavernous. Two dorsal and one anal fin of uniform height, caudal fin separate. Snout broad, blunt, not
projecting beyond mouth, length less than interorbital width. Scales small, covering head and body but not extending onto vertical fin membranes. Ventral fins reduced to two long rays. Branchiostegal rays seven. Barbel present or absent. Gill rakers of outer branchial arch long. No luminescent organs.

Otoliths spindle shaped, thick. Ostium relatively short, crista inferior more than twice as long as crista superior (Fig. 7, H).

Remarks: Karner (1971) noted that a large number of species had been assigned to the genus Laemonema and that a revision of all species would possibly result in a subdivision of the genus, as suggested by Rass (1954).

Laemonema globiceps Gilchrist

Fig. 21

Laemonema globiceps Gilchrist, 1906: 157 (off Cape Point).

Material examined: ♀ syntype, SAM 12488, Cape Point, South Africa: P10258, P10263, off Raglan, 848-811 m, NZH 1909, northern New Zealand.

Diagnosis: Dorsal fin rays 5, 56-72; anal fin 61-71; pectoral fin 19-23; 11-12 + 27-28 gill rakers on first gill arch.

Description: Body elongate, compressed, greatest depth at origin of first dorsal from where it tapers to a narrow caudal peduncle. Head broad. Mouth oblique, lower jaw slightly larger than upper, both with a band of small, equal sized, villiform teeth. A minute barbel present, visible only with aid of a microscope. Operculum terminating in a small, horizontal spine. Gill openings wide, gill rakers more than twice the length of opposite gill filaments. Teeth on jaws reduced in number, those of the outer series slightly larger (Fig. 1, B-C). First dorsal fin origin vertically above insertion of pectoral, second ray greatly elongated. Second dorsal commences immediately behind first, height equal throughout its length. Anal fin origin immediately behind anal, shorter than second dorsal but equal in height. Dorsal and anal fin enveloped in loose scaly membranes. Caudal fin ovate, free of dorsal and anal. Pectoral inserted midway down side of body pointed, slightly longer than half head length. Ventraals narrow, reduced to two long rays and a few rudimentary rays. Scales lost from the present specimens.

Colour: Light yellowish-brown over head and body. Abdominal region silver, with dark pigment on belly. Buccal and branchial cavities dark brown.

Remarks: Morphometric and meristic data for the present specimen are the same as Gilchrist's (1906) diagnosis. The high number of gill rakers distinguishes L. globiceps from other species described in this genus. Globiceps can be distinguished from other morids taken in similar depths in the New Zealand region by its small size and elongate first dorsal ray. Laemonema globiceps is a deep-water species previously only found off South Africa (Smith, 1950). Specimens of this species from Australian waters were examined in the present study and a wide distribution expected when suitable depths are sampled in other regions.
Laemonema multiradiatum Thompson

Fig. 22

Laemonema multiradiatum Thompson, 1916: 469 (off Lota, Chile)

Material examined: AM E3211, Goose Cape, New South Wales, Australia, 860 m; AM E3210, taken with \( E3211 \), damaged, lacking portion of tail and partially dissected; NMNZ P9043, South Canterbury bank (44°45' S, 172°38' E), 1000 m.

Diagnosis: Dorsal fin rays 5; 62–64; anal fin 59–61; pectoral fin 23–26; 10 scales in transverse row between origin of first dorsal and lateral line.

Description: Body elongate, tapering, compressed, greatest depth at nape. Head broad, cavernous. Mouth oblique, lower jaw longer than upper. Upper jaw with band of small cuneiform teeth, lower jaw with single row of larger teeth. A few teeth on vomer. Barbel extremely small. Operculum terminating in small horizontal spine. Gill openings wide, gill rakers longer than length of opposite gill filaments. Teeth reduced in number—an outer series of large teeth and a small patch of small teeth on inner side. A small patch of teeth on vomer (Fig. 1, B–C). First dorsal fin longer than origin vertically. Insertion of pectoral, first ray minute, longest ray (2nd) less than one third length of head. Second dorsal commences immediately behind first, height equal to first and uniform throughout its length. Anal fin origin immediately behind anus, shorter than second dorsal, but equal in length. Dorsal and anal fin enveloped in loose scaleless membranes. Caudal fin rounded, free of dorsal and anal. Pectoral inserted slightly lower than mid-way down body, rounded, length slightly more than half head length. Ventrals narrow, reduced to two long rays and three rudimentary rays which may not be visible in larger specimens. Scales small, cycloid, covering head and body, not extending onto snout and vertical fin membranes.

Colour: Uniform pinkish tan to light brown over head and body with darker margins to scale pockets; abdominal region black ventrally and faintly silver on sides. Vertical fins pale basally, black at tips. Buccal and branchial cavities pale.

Remarks: Laemonema multiradiatum is distinguished from L. melanurum, L. gracilipes, L. latifrons, and L. rhodocheir by the lower number of vertical scale rows (116 cf. 120–160) and from L. globiceps by the upper number of gill rakers (7–17 cf. 11–12 + 27–28). L. nana lacks the minute barbel of L. multiradiatum; L. longipes and L. barbarula have a lower number of pectoral fin rays (23–26 cf. 15–20); and the anal origin, beneath the 5–7th dorsal fin rays distinguishes L. multiradiatum from L. robustum and L. yarrelli, in which the dorsal origin is beneath the 9th or 10th dorsal ray. Australian and New Zealand specimens most closely resemble L. multiradiatum from the south east Pacific but differ from it in having a lower number of fin rays in the second dorsal and anal fins (62–64; 59–61 cf. 74; 71). They are provisionally referred to L. multiradiatum until further material is available and their status re-examined.

Distribution

The distribution of morid fishes within New Zealand waters is poorly known; many records are doubtful because the species have been inadequately defined whilst some distributions reflect the fishing effort rather than the natural range.
Sea floor substrate data have been recorded for some specimens held at NMNZ. Although most species are taken in a variety of habitats, *Pseudophycis bachus*, *Australophycis marginata*, *Mora moro*, *Lepidion microcephalus* and *Antimora rostrata* are generally taken on soft sediments whereas *Pseudophycis breviscula*, *P. barbata*, *Physiciulus luminosa*, and *Lottia rhacina* are generally associated with rocky habitats. *Tripetraphycis gilchristi* and *Auchenoceros punctatius* are usually taken in midwater trawls. *Halargyreus johnsonii* is taken in both midwater and bottom trawls.

**Geographical distribution:** (Figs 23, 24, 25). *Pseudophycis bachus* is widely distributed throughout the New Zealand region from North Auckland to Campbell Island plateau (Habib, 1975). The species is fished commercially around Banks Peninsula and the Mercury Bay (Paul, 1979), while in other areas it is taken as part of the by-catch. *P. breviscula* is a northern species, and does not occur south of Napier. Records of this species south of Napier are misidentifications of *P. barbata*. *P. barbata* is common throughout the cooler waters of southern New Zealand but specimens have been taken as far north as the Bay of Plenty. Neither *P. barbata* nor *P. breviscula* are of commercial importance. All three species of *Pseudophycis* have been taken in the East Cape region from the Bay of Plenty to Napier. The species is restricted to coastal waters, with most specimens taken in 0-300m. *Pseudophycis* also occurs in cooler Australian waters, but the distribution of each of the three species is unknown. The genus has not been recorded outside Australasia.

*Physiciulus luminosa* is known from New Zealand waters in the vicinity of Alderman and Mayor Islands in depth of 250-622m. The species probably occurs throughout the Bay of Plenty and northern coastal waters, an area which has not been sampled extensively due to the rocky nature of the substrate. The species is also found off New South Wales, Australia. A second undescribed species of *Physiciulus* has been taken in Queensland waters (D. M. Coates, pers. comm.), and *P. edelmanni* is found in Queensland and New South Wales waters (specimens in AM).

*Australophycis marginata* is restricted to, but widely distributed in, cooler waters south of Cook Strait. It is common in this southern zone in depths of 300-650m but is not taken commercially because of its small size. The species is also found in South American and Australian waters.

*Lottia rhacina* occurs in rocky habitats throughout New Zealand from the Three Kings Islands to Stewart Island in depths of 0-30m. Although few specimens from the South Island were examined in the present study, the species is apparently common in suitable habitats in that area (J. M. Moreland, pers. comm.). The full distribution of *L. phyllos* within New Zealand waters is unknown because it has not previously been distinguished from *L. rhacina*. At present it is only recorded from north of Cape Brett (Phillips, 1926). Both species are found in Australian waters and *L. phyllos* has also been recorded from Japan.

*Auchenoceros punctatius* appears to occur sporadically throughout New Zealand from Coromandel (Graham, 1952) to Foveaux Strait in depths up to 420m. Little is known about the biology of this species which is at times pelagic and often occurs in great abundance in localized areas. The species has not been taken outside the New Zealand region.

*Tripetraphycis gilchristi* is a midwater species found throughout New Zealand in depths of 100-750m. Although the distribution recorded in the present study suggests the species prefers warmer northern waters, South Island waters have been inadequately sampled by midwater trawls. *T. gilchristi* is also found in Australian and South African waters.

The deep sea cods *Lepidion microcephalus*, *Halargyreus johnsonii*, and *Mora moro* show restricted ranges on the Chatham Rise and southern plateau areas — these distributions reflect the trawling stations in suitable depths of 500-1000m. *Mora moro* is frequently taken by long-line in northern New Zealand waters. *Antimora rostrata* occurs widely in the abyssal depths beyond the usual range of current commercial or experimental trawling operations, the known distribution being a result of fishing in suitable depths of over 1000m. *Halargyreus johnsonii*, *Mora moro*, and *Antimora rostrata* are cosmopolitan in distribution, and *Lepidion microcephalus* is restricted to Australasia.

**Vertical distribution:** Meehrs in New Zealand waters are found from the intertidal zone to 2000m + (Fig. 26). Competition between species is presumably reduced by different habitat requirements, different feeding methods, different in size of adults, and geographical separation.

Three main habitats can be recognised: benthic, in association with soft sedimented sea floors, benthic, in association with rock sea floors, and pelagic. *Pseudophycis bachus* and *Mora moro* are the two most common species associated with soft sediments, and the
Fig. 23. Collection localities of specimens examined.
Fig. 24: Collection localities of specimens examined.
Fig. 25. Collection localities of specimens examined.

- Physicus luminosa
- Moro moro
- Haliotrygon johnsoni
- Antimora rostrata
- Lepidion microcephalus

500 metres
2000 metres
6000 metres
depth ranges do not overlap. *Austrophycis marginata* occurs in depths at the lower limit of the range of *P. beckeri* and the upper limit of *M. moro*. The small size of *A. marginata* reduces competition between these species. The range of *A. marginata* overlaps the range of *P. beckeri* less than it overlaps the range of *M. moro*; *A. marginata* is closer to the size of *P. beckeri* than *M. moro*, and competition between the latter species is probably greater. *Lepidion microcephalus* and *M. moro* occur in similar depths between 500 and 1000 m; there are, however, no apparent differences in biology or geographical distribution. *Antimora rostrata* is restricted to abyssal depths, beyond the range of the other morids.

In rocky habitats, *Pseudophycis breviacule* and *P. barbata* are the most common species and occur sympatrically in only a small portion of their ranges. Two species of *Lotella*, *L. rhacina* and *L. phyllictis*, are restricted to very shallow sublittoral habitats in areas of tidal and wave surge, where *Pseudophycis* is less successful, but very little information is available on their biology. *Physicusus luminosa* is found in depths below the range of *Pseudophycis*.

Although the pelagic morids *Auchenoceros punctatus* and *Tripterosicyclicus giglittisi* occur at similar depths, *A. punctatus* is more common in shallow inshore waters whereas *T. giglittisi* is more common offshore. *Halargyreus johnsonii* has a wide depth range and is frequently taken in trawls with *M. moro*, *L. microcephalus*, and *A. rostrata*. The pelagic feeding of *H. johnsonii* presumably reduces competition between it and the benthic feeding morids. Competition between *H. johnsonii* and *T. giglittisi* is reduced by the large size differences between these species.

**Generic Affinities**

Svetovidov (1967) pointed out that the systematics of the Moridae were in need of revision, and both he and Karrer (1971) noted that many characters, although valid for identification purposes, could not be used as criteria for determining generic affinities. However, independent studies of the morid otolith by Karrer (1971) and Fitch & Barker (1972) have shown that the morphology of this structure is sufficiently reliable to permit generic identification. Both authors constructed phylogenies based on otolith shape but did not relate the phylogenies to external morphology of the fish.

Phylogenetic relationships determined from otolith structure are in fact supported by the other morphological features such as luminescent organs and fin structure, indicating that otoliths are probably not similar because of convergent evolution.

Karrer (1971) established three groups of living morids, while Fitch & Barker (1972) added a fourth group to include an "antarctic" species (= *Austrophycis*) and two New Zealand taxa based on fossil material. Karrer (1971) omitted consideration of the fossil genus and did not examine specimens of *Austrophycis*. The results of the present study differ in that only two groups of living morids are recognized (*Mora* group and *Physicusus* group), while the remaining genera are considered to represent a number of independent divergent lines.

The *Mora* group of species (*Mora moro*, *Lepidion microcephalus*, *Antimora rostrata*, and *Halargyreus johnsonii*) can be readily distinguished from the remaining morids by the bending outwards of the crista inferior of the otolith. The placement of the four species in a phylogenetic group is supported by the fin structure of the fish (Fig. 27, F-I). All four species have an anal fin which is much lower in the middle and often divided into two portions.
All other morids examined have an anal fin of more or less even height. *Halarcythus johnstonii* (Fig. 27, I) is considerably modified for life in midwater and differs from the other *Mora* group species in having a more elongate body form and in the absence of a barbel, while retaining the oolith shape and anal fin structure common to the others.

The *Physiculus* group of genera (*Physiculus, Tripterophycus, Laemonomus*) is characterised by spindle-shaped ooliths and the presence of luminescent organs. *Physiculus* and *Tripterophycus* are widely divergent in external morphology as a result of adaptations to their respective benthic and pelagic modes of life. The luminescent organs differ in position in relation to the anus. However, it is unlikely that both the luminescent organs and the oolith shape have arisen independently in fish with such widely divergent habits. *Laemonomus* lacks luminescent organs, but has characteristic spindle-shaped ooliths. A revision of all species within this genus is required.

The ancestral stock is here considered to be most closely represented by the genera *Pseudophycys* and *Austrophyicus*. Neither genus shows any specialization of fin structure, nor any development of luminescent organs. Differences in tooth structure preclude placement of these two genera within the same phylogenetic group. A lack of fossil material, other than ooliths, of *Actuarious* prevents any detailed assessment of affinities between this genus and *Austrophyicus*. Although similar, the ooliths are sufficiently different to warrant generic separation, but it is not apparent from the fossil record if *Austrophyicus* is descended from *Actuarious*, or if the two genera represent independent, parallel evolutionary lines.

*Lotella* shows affinities with the ancestral stock in the generalised fin structure and lack of luminescent organs, and was placed within the *Pseudophycys* group by Fitch & Barker (1972). Kaarre (1971) placed *Lotella* close to the *Physiculus* group, but considered that the position of the genus could not be clarified on the basis of ooliths. The deeply recessed sulcus of the oolith and similarities in dentition (which is variable in both *Lotella* and *Physiculus*) indicate that the affinities of *Lotella* lie closer to the *Physiculus* group than *Pseudophycys*.

The correct placement of *Auchenoceros* within the phylogeny is unclear. The genus has become considerably modified for a pelagic mode of life and has evolved along similar lines to the *Bregunocerosidae*, in which family it was placed before recognition of the *Moridae*. *Auchenoceros* is similar to *Halarcythus* in the elongate body form, protruding lower jaw, and the absence of a chin barbel; it is similar to *Tripterophycus* in body form and the tripartite dorsal fin. These characters have resulted from adaptations to midwater life and do not indicate any phylogenetic relationships. The ooliths of *Auchenoceros* and *Austrophyicus* are similar, suggesting a common origin for these genera.

The divergent structure of the morid oolith shows no close relationships to any other gadiform oolith. The morids therefore cannot be ancestral to the other gadids and must reflect a long period of separation from the gadiform stock.

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