

Comparative scale morphology and squamation patterns in triplefins (Pisces: Teleostei: Perciformes: Tripterygiidae)

Laith A. Jawad

15 Birkinshaw Grove, Riverstone Terraces, Upper Hutt, New Zealand
(zainab.issa@clear.net.nz)

ABSTRACT: Scale surface morphology and squamation patterns provide new and useful information for tripterygiid systematics. A comparative study comprising 48 tripterygiid species was conducted to identify the most useful scale and squamation characters within the family and to clarify their systematic significance. Several characters were established. Three types of bending of the first interradial circulus were found: straight, bulging rostrad, bulging caudad. The genera *Forsterygion*, *Grahamina*, and *Obliquichthys* have a straight interradial circulus, which separates them from the remaining triplefin genera. Also, body scales with a pentagonal shape were found uniquely in those three genera. Several features of the lateral line scales proved to be of particular value for taxonomic purposes. The squamation on the head, belly, caudal peduncle, and fins was also found to be of interest in this context. From the results, it is concluded that scale and squamation studies can be valuable tools in investigating systematic relationships among the Tripterygiidae.

KEYWORDS: scale morphology, squamation patterns, triplefins, Tripterygiidae, SEM.

Introduction

The use of scale morphology and squamation for fish classification, also known as lepidology, can be traced back to the time of Agassiz (1833–1843) who apparently was the first to use fish scales for taxonomy. In his work, he divided fishes into four groups according to the structure of their scales: Placoidei, Ganoidi, Ctenoidei, and Cycloidei (Creaser, 1926).

The importance of scale morphology in systematic studies increased dramatically during the late nineteenth century and the first half of the twentieth century with the great advances in light microscopy (e.g. Williamson 1851; Baudelot 1873; Timms 1905; Cockerell 1910, 1915; Chu 1935; Lagler 1947; Kobayashi 1951, 1953, 1955; McCully 1961). Later, scale morphology became more important in

fish systematics and phylogeny after the introduction and development of scanning electron microscopy (De Lamater & Courtenay 1973, 1974; Hughes 1981; Lippitsch 1990, 1992; Roberts 1993).

Using scales and squamation as taxonomic criteria in Tripterygiidae goes back to 1842 when Jenyns gave a concise description of the squamation pattern in *Tripterygion capito* Jenyns, 1842 (= *Grahamina capito* (Jenyns, 1842)). In 1879, Clarke included some squamation characters in his description of the two triplefin species *Tripterygion dorsalis* Clarke, 1879 (= *Blennodon dorsale* (Clarke, 1879)) and *Ruanoho decemdigitatus* (Clarke, 1879). Hutton (1879) included a short description of the lateral line scales of '*Tripterygium*' *jenningsi* Hutton, 1879 (= *Grahamina capito*). From the 1900s onwards, several papers (Table 1) record the taxonomic value of scales and the pattern of

Table 1 Twentieth century publications dealing with the pattern of squamation in different species of Tripterygiidae (genera and species arranged alphabetically).

Genus/Species	Author(s)
<i>Apopterygion</i>	Kuitter 1986
<i>Bellapiscis lesleyae</i>	Hardy 1987c
<i>Bellapiscis medius</i>	Hardy 1987c
<i>Blennodon dorsale</i>	Hardy 1987b
<i>Brachynectes fasciatus</i>	Scott 1977
<i>Ceratobregma</i>	Holleman 1987; Shen & Wu 1994
<i>Cremnochorites capensis</i>	Holleman 1982
<i>Cryptichthys jojettae</i>	Hardy 1987c
<i>Enneapterygius</i>	Clark 1979; Holleman 1982; Shen & Wu 1994
<i>Enneapterygius abeli</i>	Clark 1979
<i>Enneapterygius ventermaculus</i>	Holleman 1982
<i>Forsterygion lapillum</i>	Hardy 1989a
<i>Forsterygion malcolmi</i>	Hardy 1987d
<i>Forsterygion varium</i>	Hardy 1989a; Waite 1909, 1913
<i>Gilloblennius abditus</i>	Hardy 1986
<i>Grahamina capito</i>	Fricke & Roberts 1993
<i>Grahamina gymnota</i>	Fricke & Roberts 1993; Scott 1977
<i>Grahamina nigripenne</i>	Fricke & Roberts 1993
<i>Helcogramma</i>	Holleman 1982; Hansen 1986; Shen & Wu 1994
<i>Helcogramma obtusirostre</i>	Clark 1979; Hansen 1986; Shen & Wu 1994
<i>Helcogramma springeri</i>	Hansen 1986
<i>Karalepis stewarti</i>	Hardy 1986
<i>Lepidoblennius haplodactylus</i>	Hardy 1987c
<i>Lepidoblennius marmoratus</i>	Hardy 1987c
<i>Norfolkia</i>	Clark 1979; Kuitter 1986; Holleman 1991; Shen & Wu 1994
<i>Norfolkia clarkei</i>	Kuitter 1986
<i>Notoclinops caerulepunctus</i>	Hardy 1989b
<i>Notoclinops segmentatus</i>	Hardy 1987a
<i>Notoclinops yaldwyni</i>	Hardy 1987a
<i>Obliquichthys maryannae</i>	Hardy 1987d
<i>Ruanoho decemdigitatus</i>	Hardy 1986
<i>Ruanoho whero</i>	Hardy 1986
<i>Springerichthys</i>	Shen & Wu 1994
<i>Tripterygion medium</i>	Waite 1913; Hardy 1986
<i>Ucla xenogrammus</i>	Holleman 1993

squamation but, in most, descriptions are brief and do not include any details about scale morphology.

Tripterygiid species usually differ in details of scale morphology. Differences in scale size are of course reflected in the number of scale rows and in the number of scales above and below the lateral line. Thus, in genera where the sides are often incompletely scaled, e.g. *Helcogramma* and *Axoclinus*, the latter two counts are difficult to use. This difficulty also exists in small-scaled forms, since the rows tend to be irregular and the angle of the rows may change along the body (Rosenblatt 1959). The pored scales are the most important in the lateral line and should be counted carefully. This count has a limited range of variation within species, but it is more variable between species. Although Hardy's (1984, 1986, 1987a,b,c,d, 1989a,b) publications provide the only available information on squamation in this group of fishes, they are brief and most omit some important aspects of squamation such as the meristic characters of the pattern.

In tripterygiid classification, lepidology was often used by taxonomists to describe new taxa. Holleman (1982) described three new species, *Helcogramma fuscopinna*, *Enneapterygius clarkae*, and *Enneapterygius ventermaculus*, and a new genus *Cremnochorites*. In 1993, Holleman described *Ucla xenogrammus* Holleman, 1993 based on squamation characters. Hardy (1984, 1986, 1987a,b,c,d, 1989a,b) described and revised several genera and species according to their pattern of squamation. Kuitter (1986) erected a new genus (*Apopterygion*) and a new species (*A. alata* Kuitter, 1986) based on the shape of the lateral line. Rosenblatt (in Gon 1990) revised the genus *Helcogrammoides* and used squamation pattern as a diagnostic character for the description of *H. antarcticus*. Shen & Wu (1994), in their revision of the tripterygiid fishes from the coastal waters of Taiwan, successfully used lateral line squamation to describe two genera and five species.

For the above reasons, this paper aims to discuss the question: what scale characters are most useful for systematic purposes in the family Tripterygiidae? It should serve as a basis for further studies on scale morphology and its possible usage in phylogenetic analyses. Since a detailed account of tripterygiid squamation has not been published and the diversity of patterns observed has never been documented, a survey of triplefin squamation is presented here, especially as this character complex seems to have considerable taxonomic significance (Greenwood 1979; Lippitsch 1990).

Materials and methods

Fish specimens were obtained from: New Zealand (several localities); Australia (Tasmania, Kangaroo Island, Rob Island, Lizard Island, Avalon, Israelite Bay, Port Philip Bay, Bruny Island); South Africa (False Bay, Sodwana Bay); Chile (Quintero); Mexico (Roqueta Island); Belize; USA (California: West Ventura); Vanuatu (Reef Islands); Adriatic Sea (Cija Island); France (Banyals); and Spain (Portinax, Ibiza) (*see* Appendix 1). The material examined is biased in favour of New Zealand species, but it covers a wide range of genera. From a total of 132 valid species belonging to 30 genera of Tripterygiidae (Eschmeyer 1990), 48 species from 29 genera have been examined and documented in this paper. Alcohol-preserved material was preferred over formalin-preserved specimens, to avoid artefacts due to decalcification. Only adult specimens were examined to avoid features associated with developmental stages.

Squamation patterns, including those of fins, were recorded following Lippitsch (1990, 1992). A total of 42 characters was established for scales and squamation patterns in triplefins, including scale distribution over different parts of the fish body. Lepidological observations using light microscopy were performed following Takagi (1953), Lippitsch (1992), Roberts (1993), and Kuusipalo (1998). The fish body was divided into eight regions (Fig. 1) in order to facilitate the study of variation in the shape and size of the scales. Fish scale descriptive terminology follows Lippitsch (1992) and Kuusipalo (1998) (Figs 2, 3). Scales were removed from each region with a pair of tweezers, and bleached with 1% potassium hydroxide solution until all colouration was removed. Any remaining tissue was gently removed from the scale surface under a dissecting microscope. Scales were stained with alizarin Red-S stain for 2–3 days, mounted flat between two microscope slides, and stored for further examination.

Scanning electron microscopy (SEM) was used to investigate scale ultrastructure following Lanzing & Higginbotham (1974), Lippitsch (1992), Roberts (1993), and Kuusipalo (1998). Scales examined by SEM were air-dried and mounted on aluminium stubs using double-sided sticky tape. When dry, the scales and stubs were sputter coated with gold to a thickness of 28–30 nm in a vacuum of about 40×10^{-3} torr. Scales were viewed using the secondary electron image of Philips XL45 FEG at an accelerating voltage of 5.0 KV.

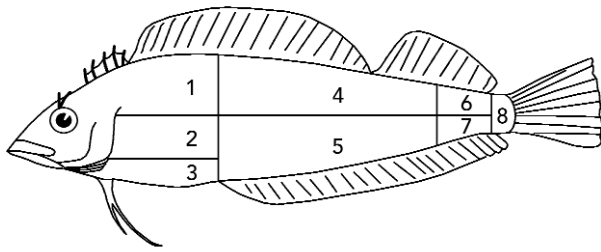


Fig. 1 Body regions selected for this study.

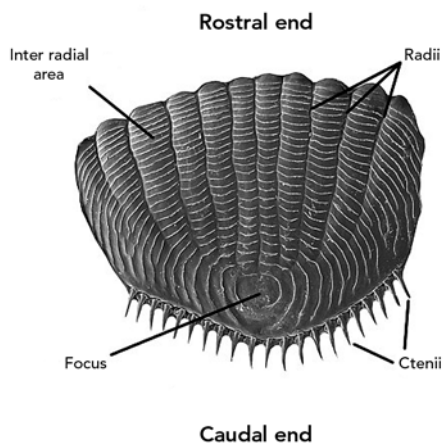


Fig. 2 Surface view of body scale showing different structures.

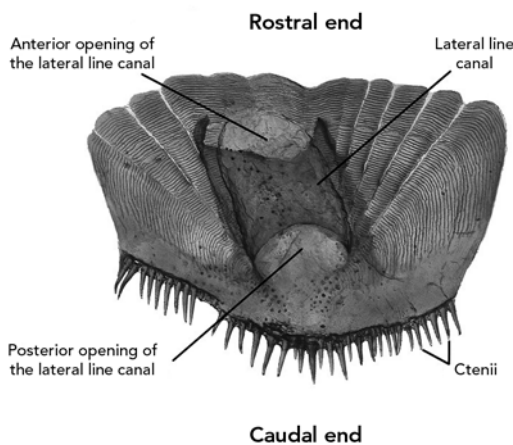


Fig. 3 Surface view of lateral line scale showing different structures.

Results

Morphology of the scale surface

Tripterygiid scales are of the bony ridge type (Lagler *et al.* 1977). Scales are usually divided into four parts: rostral, caudal, ventral, and dorsal fields, with the last two forming the lower and the upper lateral parts, respectively. In some species, the parts of the scale vary greatly depending on the relative size of the fish and the body region from where the scales were taken. Scales imbricate each other and, consequently, only the caudal field is exposed and visible on the surface, while the rostral field lies embedded in the dermis.

Body scales in triplefins can be divided into eight types according to their shape, namely: oblong, elliptical, rounded, rectangular, triangular, square, pentagonal, and cycloid (Fig. 4). In some species, scale shapes vary within different body regions. The margin of the rostral field of the scale can be classified into five types: smooth, undulate, crenate, emarginate, and dentate (Fig. 5). Scales are usually not smooth, but show a characteristic surface ornamentation that, in the simplest case, consists of ridges and grooves forming circular rings around a centre called the 'focus'. The focus is the part of the scale that developed first during ontogenesis. The position of the focus on the scale remains the same through the life history of the scale (Liu & Shen 1991). In most of the triplefins studied, the focus is in the posterior portion of the exposed area. This position probably reflects lateral scale growth rather than a combination of lateral and posterior scale growth (Roberts 1993). In triplefins, the shape of the focus can be of five types: oblong, oval, rounded, pear-shaped, or semicircular (Fig. 6), with the oblong and oval types being the most common. The area enclosed by the focus can be (1) smooth, (2) with fine granules, or (3) with coarse granules (Fig. 7). The smooth condition is the most common among the triplefins studied. The circulus that surrounds the focus appears to be either complete or incomplete (Fig. 8), with the former being the most common. The ridges, called 'circuli', are more or less continuous and typically arranged in circles. The circuli form convex arches, which in some species degenerate or disappear. The rostro-lateral surface of the scale is covered by a number of circuli. In the transitional area between the rostral and the caudal fields, the number of circuli decreases because some circuli are abruptly interrupted or merge with adjacent circuli. As a result, the number of circuli in the caudal field is reduced. The grooves between the circuli are called 'circular grooves'.

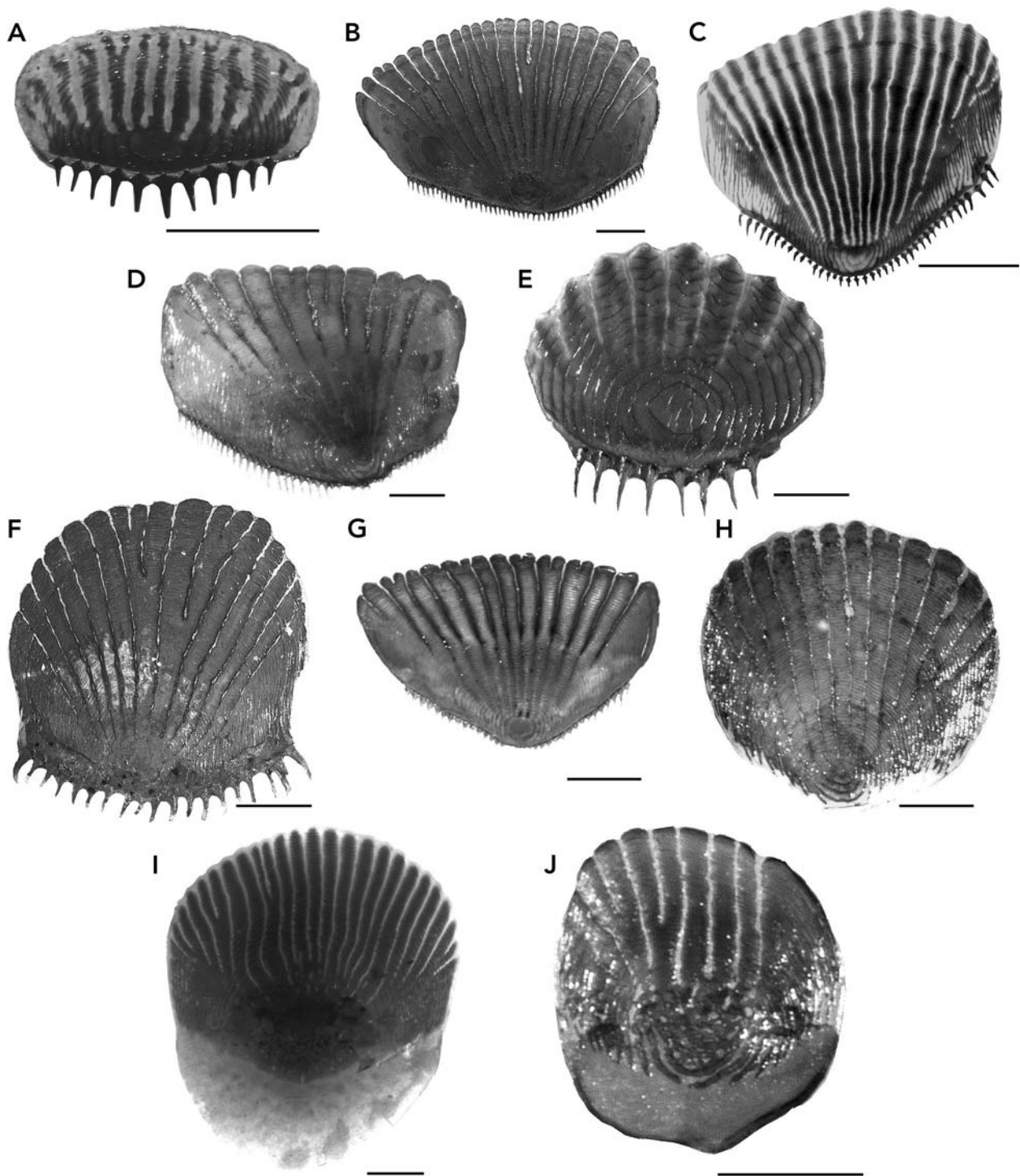


Fig. 4 Types of body scales: A, elliptic, *Bellapiscis lesleyae* (SL 57 mm); B, oblong, *Ruanoho decemdigitatus* (SL 90 mm); C, pentagonal, *Grahamina capito* (SL 77 mm); D, rectangular, *Norfolkia clarkei* (SL 60 mm); E, rounded, *Karalepis stewarti* (SL 127 mm); F, square, *Blennodon dorsale* (SL 155 mm); G, triangular, *Enneapterygius rufopileus* (SL 40 mm); H, cycloid, *Forsterygion varium* (SL 107 mm); I, cycloid, *Notoclinus compressus* (SL 70 mm); J, cycloid, *Lepidoblennius marmoratus* (SL 113 mm). Scale bars = 0.5 mm, except for A = 0.25 mm. SL = Standard body length.

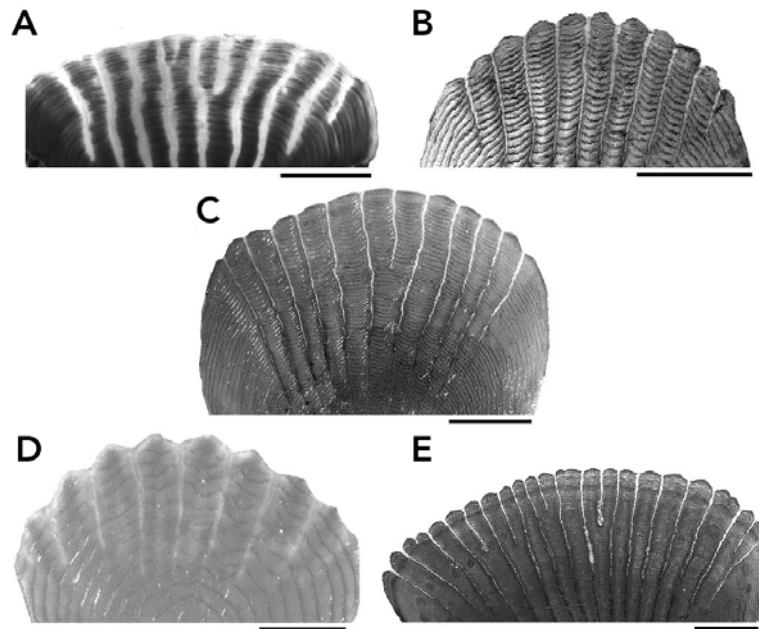


Fig. 5 Shapes of the anterior margin in body scales: A, smooth, *Cryptichthys jojettae*, (SL 45 mm); B, undulate, *Crocodilichthys gracilis* (SL 47 mm); C, crenate, *Trianectes bucephalus* (SL 62 mm); D, dentate, *Karalepis stewarti* (SL 127 mm); E, emarginate, *Ruanoho decemdigitatus* (SL 90 mm). Scale bars = 0.5 mm. SL = Standard body length.

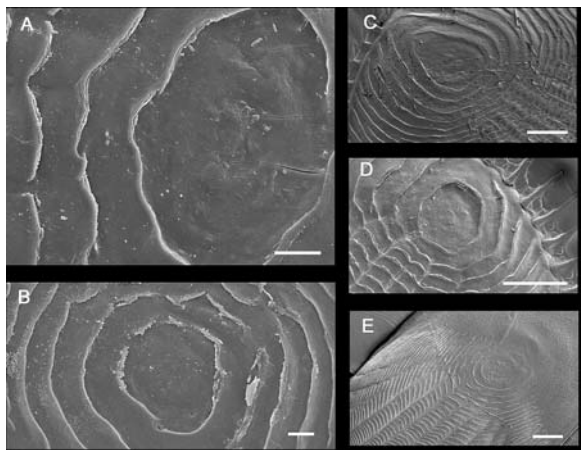


Fig. 6

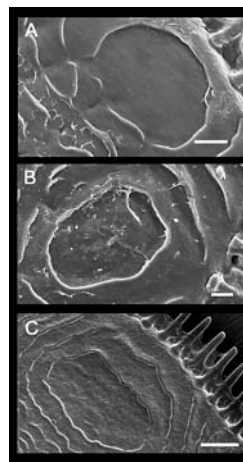


Fig. 7

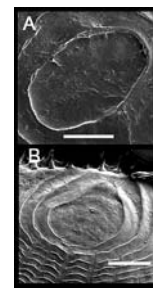


Fig. 8

Fig. 6 Shapes of the focus in body scales: A, oblong, *Bellapiscis lesleyae* (SL 55 mm); B, oval, *Brachynectes fasciatus* (SL 115 mm); C, pear-shaped, *Apopterygion oculus*, SL 58 mm); D, rounded, *Axoclinus carminalis* (SL 66 mm); E, semicircular, *Notoclinus compressus* (SL 70 mm). Scale bars = 100 μ m, except for B = 0.4 μ m, and E = 200 μ m. SL = Standard body length.

Fig. 7 Surface of area enclosed by the focus: A, smooth, *Forsterygion malcolmi* (SL 45 mm); B, with fine granules, *Gilloblennius tripennis* (SL 66 mm); C, with coarse granules, *Grabamina gymnota* (SL 108 mm). Scale bars = 100 μ m. SL = Standard body length.

Fig. 8 Shapes of circulus surrounding the focus: A, complete, *Lepidoblennius haplodactylus* (SL 94 mm), scale bar= 50 μ m; B, incomplete, *Norfolkia clarkei* (SL 60 mm), scale bar = 100 μ m. SL = Standard body length.

In the rostral field the circuli are very densely spaced and the grooves are quite narrow.

In the rostral field the continuity of the circuli may be interrupted by the development of radii fanning outwards from the focus of the scale. These radii are known as ‘primary radii’. Occasionally, some radii fail to develop completely, so the circuli remain uninterrupted in that part of the scale. These radii are known as ‘secondary radii’. Both types of radii are present in the scales of the triplefins studied. In some species, the rostral rim of the scale at the interradial space forms tongue-like projections that are free or filled with circuli near the rim. The tongue-like structure may be present with or without circuli, or may be absent altogether (Fig. 9), the last condition being the commonest in this study. The first circulus may bulge rostrally (curving outward towards the head), be straight, or bulge caudally (curving inward towards the tail) (Fig. 10). The material studied included the three different types of first circulus, with some of the types being characteristic of some tripterygiid genera.

Both in the interradial space of the rostral field and in older circuli, there are minute – spaced or crowded – tooth-

like processes known as ‘scalar denticles’ that can be seen only under high magnification (Fig. 11). Denticles can be short and slender, long and slender, rounded (Fig. 12), or simply absent. Although the denticles are well developed in the anterior part of the lateral field, they gradually disappear in the more posterior parts. Hence, no scalar denticles occur in the boundary area between the lateral and the caudal fields. In general, there is no variation in the shape and size of the scalar denticles in scales from different regions of the body of a fish, but some variation in their distribution is evident in some triplefin species, such as *Grahamina nigripenne* (Valenciennes, 1836) and *G. capito*.

Two types of scales are found in tripterygiid fishes: cycloid and ctenoid. There is a clear distinction between these two scale types: ctenoid scales have strong spinous teeth called ‘ctenii’ on and near the caudal rim, while cycloid scales lack such teeth. Tripterygiid ctenoid scales belong to the peripheral type, which are characterised by having one row of discrete spines on the caudal margin of the scale. Ctenoid scales of the peripheral type are commonly found in many species of Perciformes, some Scorpaeniformes (Zhu & Jin 1981; Poss & Collette 1990),

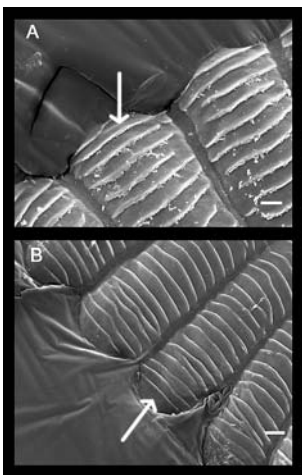


Fig. 9

Fig. 9 Shapes of the interradial tongue: A, with circuli, *Obliquichthys maryannae* (SL 52 mm); B, without circuli, *Forsterygion malcolmi* (SL 115 mm). Scale bars = 100 μ m. SL = Standard body length.

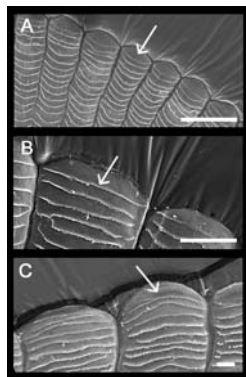


Fig. 10

Fig. 10 Shapes of the first circulus: A, bulging caudad (concave), *Enneapterygius paucifasciatus* (SL 28 mm); B, straight, *Forsterygion lapillum* (SL 115 mm); C, bulging rostrad (convex), *Karalepis stewarti* (SL 127 mm). Scale bars = 200 μ m, except for 10B = 50 μ m. SL = Standard body length.

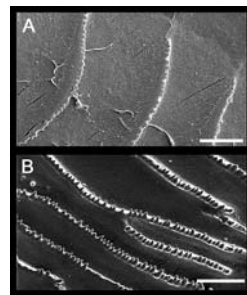


Fig. 11

Fig. 11 Spaces between interradial denticles: A, spaced, *Enneapterygius ventermaculus* (SL 18 mm), scale bar = 10 μ m; B, crowded, *Gilloblennius trippensis* (SL 108 mm), scale bar = 20 μ m. SL = Standard body length.

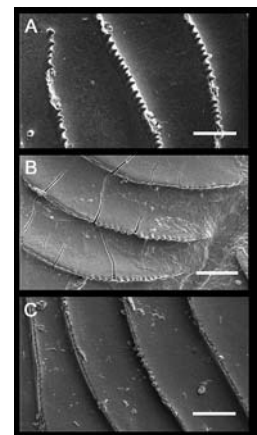


Fig. 12

Fig. 12 Shapes of interradial denticles: A, long, *Ceratobregma acanthops* (SL 42 mm); B, short, *Helcogramma springeri* (SL 39 mm); C, rounded, *Enneapterygius paucifasciatus* (SL 28 mm). Scale bars = 10 μ m. SL = Standard body length.

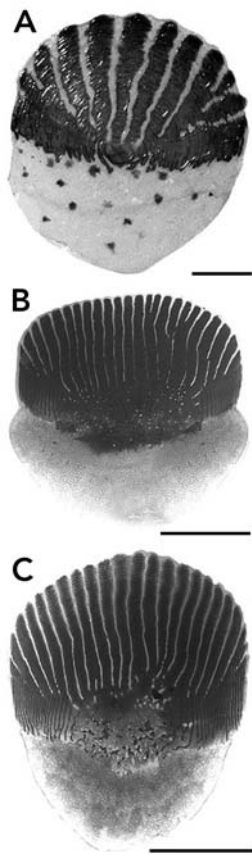


Fig. 13

Fig. 13 Scales of triplefin without ctenii: A, *Lepidoblennius haplodactylus* (SL 73 mm); B, *Notoclinus compressus* (SL 70 mm); C, *Notoclinus fenestratus* (SL 98 mm). Scale bars = 1 mm, except for 13A = 200 μ m. SL = Standard body length.

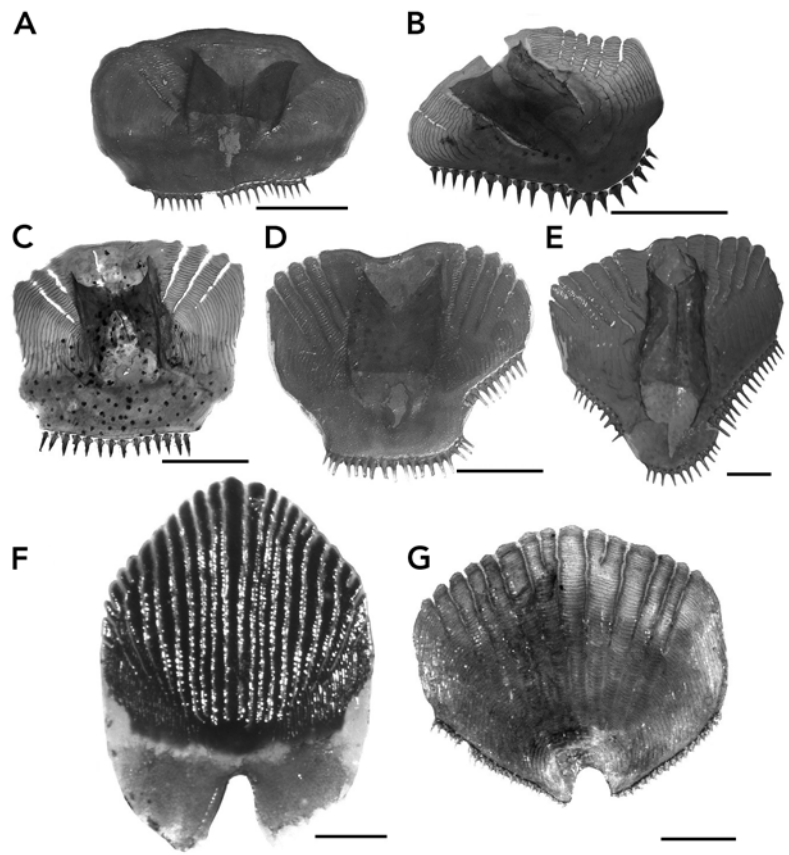


Fig. 14

Fig. 14 Shapes of lateral line scales and grouping of ctenii: A, oblong, *Notoclinops segmentatus* (SL 40 mm); B, oval, *Axoclinus carminalis* (SL 28 mm); C, group I (one group of ctenii), rectangular, *Brachynectes fasciatus* (SL 30 mm); D, group II (two groups of ctenii), tongue-like, *Ruanoho decemdigitatus* (SL 95 mm); E, group III (three groups of ctenii), triangular, *Karalepis stewarti* (SL 127 mm); F, lower lateral line scale (cycloid type), *Notoclinus compressus* (SL 56 mm); G, lower lateral line scale (ctenoid type), *Norfolkia clarkei* (SL 60 mm). Scale bars = 0.5 mm. SL = Standard body length.

and some Pleuronectiformes (Amaoka, 1963a,b, 1969). A mixture of long and short ctenii is found in the scales of tripterygiids, but long ctenii are most common. Peripheral ctenii are usually stout and acute with an expanded base.

Triplefin scales were found to have a variety of straight and curved ctenii. Five species have curved ctenii: *Ceratobregma acanthops* (Whitley, 1964) *Cremnochorites capensis* Gilchrist & Thompson, 1908, *Karalepis stewarti* Hardy, 1984, *Norfolkia clarkei* (Morton, 1888), and *Ruanoho decemdigitatus*; while three species lack ctenii: *Lepidoblennius haplodactylus* Steindacner, 1867, *Notoclinus*

compressus (Hutton, 1872), and *Notoclinus fenestratus* (Forster, 1801) (Fig. 13).

Tripterygiids have only notched scales on their lower lateral line (Fricke & Roberts 1993). In addition, this study has shown that there are other scale shapes on the upper lateral line. There are six types of lateral line scales according to their shapes: rectangular, triangular, oblong, elliptical, tongue-like, and oval (Fig. 14). The rectangular shape is the most common among lateral line scales in triplefins, with only one species, *Axoclinus carminalis* (Jordan & Gilbert, 1882), having oval scales, and two *Ruanoho* species having tongue-like scales on the

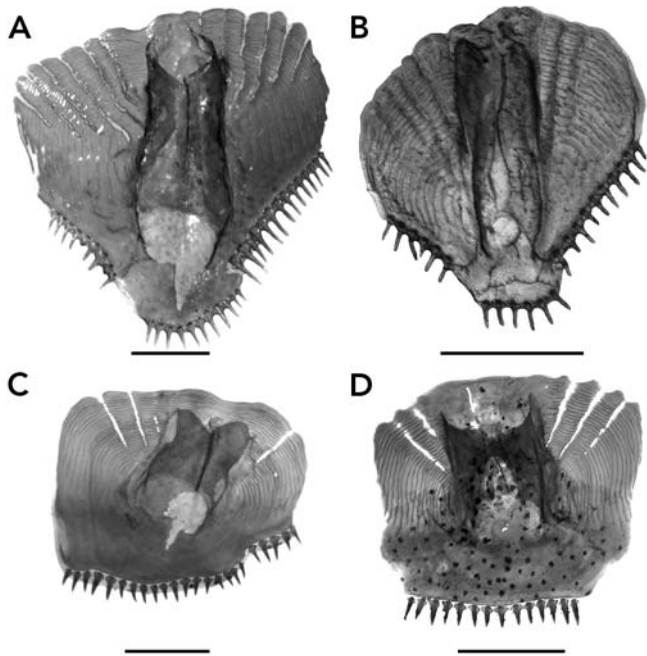


Fig. 15

Fig. 15 Shapes of the lateral line scale canal: A, long and constricted, *Forsterygion lapillum* (SL 67 mm); B, long, straight, *Cryptichthys jojettae* (SL 36 mm); C, short and constricted, *Grahamina nigripenne* (SL 77 mm); D, short and straight, *Brachynectes fasciatus* (SL 19 mm). Scale bars = 0.5 mm.

Fig. 16 Lateral line scale, with more than one row of ctenii, *Cremnochorites capensis* (SL 74 mm). Scale bar = 0.5 mm. SL = Standard body length.

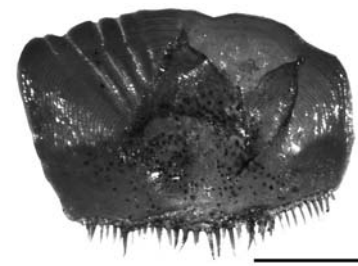


Fig. 16

lateral lines. Besides the shape of the lateral line scales, the canal on the lateral line scales ('lateral line canal', Fig. 3) has been used to identify triplefins in this study. Results show that the lateral line canal can be short or long, and constricted or straight (Fig. 15). The most common lateral line scale in the triplefins studied is a combination of long and straight. Ctenii of lateral line scales also show some variation among tripterygiids, and can be divided into three groups: I, II, and III (Fig. 14c,d,e). Some species have all three groups of scales (as in *Cryptichthys jojettae* Hardy, 1987, *Gilloblennius tripennis* (Forster, 1801), and *Ruanoho whereo* Hardy, 1986); in other species, two different groups are present (groups I and II, as in *Brachynectes fasciatus* Scott, 1957, *Grahamina gymnota* Scott, 1977, *Lepidoblennius marmoratus* (Macleay, 1878), *Notoclinops segmentatus* McCulloch & Phillipps, 1923, *Ruanoho decemdigitatus*, and *Trianectes bucephalus* McCulloch & Waite, 1918; groups II and III, as in *Karalepis stewarti*). Also, ctenii may be arranged in more than one row, as in *Cremnochorites capensis* (Fig. 16).

Patterns of squamation

Patterns of body squamation in tripterygiids are first summarised and then described in detail for each species. This study includes some new squamation characters used in the morphology of scales of triplefins as well as other known characters.

Usually, triplefins have a scaled body and caudal peduncle. The squamation pattern of the bases of the fins varies among species. The head is usually devoid of scales except for two species that have squamation with body-type scales (*Matanui bathytaton* (Hardy, 1989) and *Norfolkia clarkei*). Several species have head ctenoid scales modified into tiny spicules of different shapes (*Acanthonectes rufus* Holleman & Buxton, 1993, *Apopterygion oculus* Fricke & Roberts, 1994, *Axoclinus carminalis*, *Ceratobregma acanthops*, *Cremnochorites capensis*, *Enneanectes boehlkei* Rosenblatt, 1960, *Forsterygion malcolmi* Hardy, 1987, *Forsterygion varium* (Forster, 1801), *Karalepis stewarti*, *Matanui bathytaton*, *Norfolkia clarkei*, *Notoclinops caerulepunctus* Hardy, 1989).

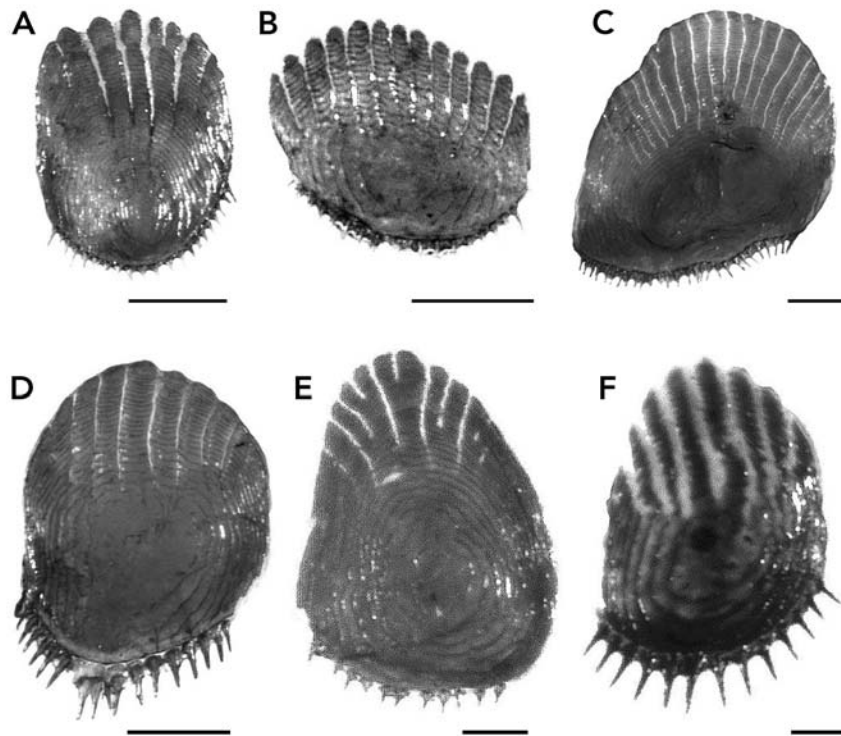


Fig. 17 Shapes of body scales at the base of caudal fin: A, oblong, *Norfolkia clarkei* (SL 60 mm); B, rectangular, *Helcogrammoides cunninghami* (SL 28 mm); C, irregular, *Trianectes bucephalus* (SL 62 mm); D, irregular, *Trianectes bucephalus* (SL 62 mm); E, irregular, *Springerichthys kulbickii*. (SL 28 mm); F, irregular, *Springerichthys kulbickii* (SL 28 mm). Scale bars = 0.5 mm. SL = Standard body length.

The arrangement of scales in triplefins is in the form of a series, being either horizontal (row) or vertical (column). Nape, operculum, belly are all usually naked except for a few species (*Acanthanectes rufus*, *Apopterygion oculus*, *Blennodon dorsale*, *Brachynectes fasciatus*, *Cremnochorites capensis*, *Enneapterygius rufopileus* (Waite, 1904), *Grahamina capito*, *Grahamina tripennis*, *Lepidoblennius haplodactylus*, *Notoclinops caerulepunctus*, and *Trianectes bucephalus*). In species where the belly is scaly, cycloid scales are present. Bases of the fins (both paired and median) are naked except for the base of the caudal fin, which is scaly in most of the triplefins studied. Near the base of the caudal fin, there are a few columns of scales, which resemble those on the caudal peduncle in having a similar structure and radii. Further, distally on the fin, scales are simple, and occur in several shapes: oblong, pentagonal, rectangular, and irregular (Fig. 17). Some species have scales at the base of their pectoral, dorsal, and anal fins (on pectoral fins: *Apopterygion oculus*, *Cremnochorites capensis*, *Karalepis stewarti*, *Matanui profundum* (Fricke & Roberts,

1994), *Ruanoho decemdigitatus*, *Notoclinops compressus*, and *Ruanoho whero*; on dorsal and anal fins: *Crocodilichthys gracilis* Allen & Robertson, 1991, *Enneanectes boehlkei*, and *Enneapterygius abeli* (Klausewitz, 1960); on anal fins *Enneapterygius ventermaculus*).

The most common type of cycloid scale among tripterygiids (Fig. 4h) is usually found on the belly, but in some species, it is also found at the base of the pectoral and dorsal fins (pectoral fins: *Acanthanectes rufus*, *Blennodon dorsale*, *Forsterygion malcolmi*, *Forsterygion varium*, *Ruanoho decemdigitatus*, and *Ruanoho whero*; dorsal fins: *Grahamina capito*, *Grahamina gymnota*, *Karalepis stewarti*, *Ruanoho decemdigitatus*, and *Ruanoho whero*). Areas around the anus and genital pores are covered with the same type of cycloid scales in most triplefins, but some species are naked in those areas.

Except for species of *Bellapiscis* and *Gilloblennius*, as well as *Helcogramma obtusirostre* (Klunzinger, 1871) and *Lepidoblennius haplodactylus*, triplefins have a scaly caudal peduncle. In *Gilloblennius abditus* Hardy, 1986, there are

some cycloid scales in body regions 1, 2, 3, and 4 (Fig. 1). This species has a mixture of cycloid and ctenoid scales, which is unusual for triplefins because, as mentioned above, they mostly have cycloid scales on the belly, the anus, and the genital pores. In *Lepidoblennius haplodactylus*, *Notoclinus compressus*, and *Notoclinus fenestratus* cycloid scales cover the body. However, in *Lepidoblennius marmoratus*, cycloid scales only cover the lower half of the body, while the upper part is covered with ctenoid scales. Cycloid scales are present on the base of the dorsal fins of both species of *Ruanoho*. In *Helcogrammoides cunninghami* (Smitt, 1898), head ctenoid scales are modified as wart-like structures. In a few species, scales with upward projecting ctenii are present on the edges of the eye orbit.

Detailed descriptions of scales

Genus *Acanthanectes*

Acanthanectes rufus Holleman & Buxton, 1993

Head and operculum covered with ctenoid scales that have upward projections. Belly, area around the anus and genital pores, and base of pectoral fins covered with cycloid scales. Three scales between anterior end of second dorsal fin and lateral line; three scale rows between second and

third dorsal fins; 10 scales around caudal peduncle. Generally, smaller scales in the upper part and larger scales in the lower part of the body. Shape and size of scales as in Table 2. Largest scales in region 2, smallest in 1. Undulate anterior scale margin; secondary radii usually absent; number of radii 5–10; wide circuli in the interradiial region; peripheral ctenii irregular in length and arrangement.

Lateral line scales rectangular with both anterior and posterior ends straight; lateral line canal short, wide, straight, traverses almost the whole surface of the scale, with C-shaped openings; lateral line lacking constriction; ctenii in one group arranged in more than one line; another line of irregularly arranged ctenii extends over the lateral line canal towards the anterior end, on scales numbered 1–8, but these ctenii are absent from scale 9 onwards.

No denticles on circuli; tongue absent; area inside the tongue free of circuli; focus rounded, with incomplete circulus around it; focus area smooth.

Genus *Apopterygion*

Apopterygion oculus Fricke & Roberts, 1994

Posterior edge of head and the upper, lower, and posterior rim of the eye orbit covered with upward projecting ctenii; row of ctenoid scales found along supra-orbital and post-

Table 2 Scale shapes in different body regions of some triplefin species: C, cycloid. E, elliptic. N, no scales. O, oblong. P, pentagonal. R, rectangular. RO, rounded. S, square. T, triangular (see Fig. 4). V, various shapes.

Species	Body Regions (see Fig. 1)							
	1	2	3	4	5	6	7	8
<i>Acanthanectes rufus</i>	S	R	C	R	R	S	S	V
<i>Axoclinus carminalis</i>	T	O	N	O	O	P	P	V
<i>Crocodilichthys gracilis</i>	O	O	N	P	P	P	P	P
<i>Cryptichthys joettae</i>	E	E	E	E	P	E	E	V
<i>Enneapterygius abeli</i>	E	O	N	O	O	O	RO	V
<i>Enneapterygius atrogulare</i>	R	R	R	R	S	S	S	V
<i>Enneapterygius gracilis</i>	R	R	R	R	S	S	RO	V
<i>Enneapterygius paucifasciatus</i>	R	R	S	R	S	S	O	V
<i>Enneapterygius rufopileus</i>	O	O	C	S	T	RO	P	S
<i>Enneapterygius ventermaculus</i>	T	O	N	S	O	S	S	V
<i>Helcogramma obtusirostre</i>	P	E	N	P	P	P	P	V
<i>Helcogramma springeri</i>	P	P	O	P	O	P	O	V
<i>Karalepis stewarti</i>	P	P	C	P	P	O	RO	V
<i>Ucla xenogrammus</i>	E	E	E	E	E	P	S	V

orbital sensory line canals; nape densely covered with scales; belly and area around the anus and genital pores covered with cycloid scales; base of caudal fin scaly. Size and shape of scales are uniform over body regions, elliptical; two scale rows between anterior end of second dorsal fin and lateral line; five scales between second and third dorsal fin; seven or eight scales around caudal peduncle; deep crenate anterior margin; secondary radii present; 4–12 radii present; narrow circuli; peripheral, long and short ctenii irregular in size.

Lateral line scale rectangular with a wide posterior extension that widens anteriorly; posterior notch present; long, straight lateral line canal that traverses two-thirds of the scale surface and with no constriction; ctenii belong to two groups at mid and upper posterior region of the scale.

Denticles are rounded in shape and regular in arrangement; no tongue; pear-shaped focus with fine granules and a complete circulus around it.

Genus *Axoclinus*

Axoclinus carminalis (Jordan & Gilbert, 1882)

Head covered with tiny spicules, not scales; nape, operculum, base of pectoral fin, belly, base of dorsal fin, base of anal fin all naked; area around the anus and genital pores naked; body covered with ctenoid scales; scale shape and size vary among different body regions (Table 2) being small on the dorsal part of the body (over lateral line) and larger on the ventral part (under lateral line); five or six scale rows between anterior end of second dorsal and lateral line; three or four scales between second and third dorsal fins; 12–14 scales around caudal peduncle; smooth anterior margin; secondary radii present; ctenii regular in size, long.

Lateral line scales oval; long, constricted, straight lateral line canal that traverses the scale surface with C-shaped anterior and posterior openings, no constriction; ctenii belong to one group.

No denticles on circuli; tongue present with free circuli area; first circulus bulging caudad; rounded focus with finely granulated area and a complete circulus around it.

Genus *Bellapiscis*

Bellapiscis lesleyae Hardy, 1987

Head, nape, operculum, pectoral fin base, belly, base of dorsal and anal fins, around the anus and genital pores are all naked; remainder of body with small ctenoid scales; body scales elliptical; five scale rows between anterior end

of second dorsal fin and lateral line; five or six scales between second and third dorsal fins; no scales on ventral side of caudal peduncle; 10 or 11 scales around it; smooth anterior scale margin; secondary radii present in some body region scales; 7–13 radii; mostly short, peripheral, short sized ctenii.

Lateral line scales rectangular; long, straight lateral line canal that traverses the length of the scale with V-shaped anterior and C-shaped posterior openings; no constriction; ctenii belong to one group, with a postero-dorsal position on the scale forming a line of a few ctenii; postero-lateral line scales have no ctenii.

No denticles on circuli; tongue absent; first circulus bulging rostrad; oblong focus with smooth area and a complete circulus around it.

Bellapiscis medius (Günther, 1861)

Head, nape, operculum, pectoral fin base, belly and narrow bands along dorsal and anal fins, area around the anus and genital pores all naked; remainder of body with small elliptical ctenoid scales; five or six scale rows between anterior end of second dorsal fin and lateral line; four scales between second and third dorsal fins; ventral side of caudal peduncle naked; 13 or 14 scales around it; smooth anterior scale margin; secondary radii present; 10–16 radii; long, slender, peripheral, regularly shaped ctenii.

Lateral line scales rectangular; long, straight lateral line canal that traverses the length of the scale with no constriction and with C-shaped anterior and posterior openings; ctenii belong to one group forming a row on the upper posterior side of the scale.

No denticles on the circuli; tongue absent; oblong focus with smooth area.

Genus *Blennodon*

Blennodon dorsale (Clarke, 1879)

Head, nape, operculum, and base of caudal fin naked; very small cycloid scales on the base of pectoral fin, belly, and along the lower half of body above anal fin; square ctenoid scales cover body; usually, area around the anus and genital pores naked; body scales square; 12 or 13 scales between anterior end of second dorsal fin and lateral line; seven scales between second and third dorsal fins; 14 or 15 scales around caudal peduncle; ventral side of caudal peduncle scaly; smooth anterior scale margin; secondary radii present in some body regions; 5–15 radii present; long and short peripheral ctenii present.

Lateral line scales rectangular; a posterior tongue-like extension present, small at posterior side enlarging anteriorly; anterior lateral line scales with an upper and lower posterior notch behind tongue extension; long, straight lateral line canal that traverses the length of the scale, with V-shaped posterior and undulate anterior openings, and with a constriction at the middle; no ctenii.

No denticles on the circuli; no tongue; first circulus bulging rostrad; oblong focus, broader at posterior side than anterior, sides bent with very coarse granulations; complete circuli around focus. Scales usually covered with a very hard skin at the posterior one-third (from the posterior side to just over the focus area).

Genus *Brachynectes*

Brachynectes fasciatus Scott, 1957

Head, operculum, and base of pectoral fin naked; cycloid scales on belly and around the anus and genital pores; elsewhere, ctenoid scales; base of caudal fin covered with scales; two scale rows between anterior end of second dorsal fin and lateral line; two scales between second and third dorsal fins; seven scales around the caudal peduncle area; body scales an oblong shape; slightly crenate anterior scale margin; secondary radii present in some regions; 6–12 radii; ctenii straight, peripheral, and irregular in size.

Lateral line scales rectangular; no posterior extension present; anterior part of scale broader at middle and with narrow projection at the posterior side; short and wide lateral line canal with no constriction, that traverses two-thirds of scale surface and with C-shaped anterior and posterior openings; ctenii belong to one group in anterior scales and two groups in the remaining lateral line scales.

Denticles spaced, short, and with broad bases on scales; no tongue; focus oval, smooth but with a fine granules, with an incomplete circulus around it.

Genus *Ceratobregma*

Ceratobregma acanthops (Whitley, 1964)

Small, hard, bony scales with vertical ctenii form a continuous cover on head, a narrow streak on the snout, nape, dorsal and dorso-lateral side of orbit; body heavily scaled with ctenoid scales continuing onto base of caudal fin; two lines of large cycloid scales at the base of pectoral fin; area around the anus and genital pores covered with small cycloid scales; body scales pentagonal-rounded; three or four scale rows between anterior end of second dorsal fin and lateral line; seven or eight scales between second and

third dorsal fins; 12–14 scales around caudal peduncle, which has a scaly ventral side; undulate anterior scale margin; secondary radii present in all scales from different body regions; 8–11 radii; short and long conical, bent, peripheral ctenii.

Lateral line scales rectangular with a slight posterior extension, which begins from posterior end of lateral line canal and continues to lower posterior corner of scale; straight, long lateral line canal that traverses over half of scale surface, without constriction, and with C-shaped anterior and posterior openings; ctenii belong to one group forming a straight line, which is bent forward from scale 6 onwards to the last lateral line scale; in scales 1 and 2 the ctenii become crowded and in double lines; some ctenii found on the dorsal surface of the lateral line canal and at upper anterior plane of the scale; long, straight lateral line canal, with no constriction, traverses over half of surface of scale; C-shaped anterior and posterior opening of lateral line canal.

Long and spaced denticles on circuli; tongue present; first circulus bulging caudad; area inside tongue free of circuli; pear-shaped focus with coarse granules and a complete circulus around it.

Genus *Cremnochorites*

Cremnochorites capensis Gilchrist & Thompson, 1908

Hard, bony scales with vertical ctenii form a continuous cover on head, snout, nape, operculum, and lower surface of head; body heavily scaled with ctenoid scales continuing on base of caudal fin; base of pectoral fin scaly; area around the anus and genital pores covered with small cycloid scales; body with rounded scales; four scale rows between anterior end of second dorsal fin and lateral line; six scales between second and third dorsal fins; 14 scales around caudal peduncle, which has a scaly ventral side; deep crenate anterior scale margin; secondary radii present in all body regions; 5–12 radii; bent, hooked, short and long ctenii; ctenii crowded and sometimes in more than one line arranged alternately; ctenii curved.

Lateral line scales rectangular; last scale usually flat from posterior side; all lateral line scales except last with a hump-like structure at their posterior side; straight, long lateral line canal, with no constriction, that traverses over almost entire scale surface; C-shaped anterior and posterior openings of lateral line canal; ctenii belong to one group as a straight line on all scales; ctenii alternately arranged in multiple lines at the mid posterior side of scale in all

lateral line scales except last three scales; first five scales have ctenii on dorsal surface of lateral line canal, the number decreasing posteriorly.

No denticles; tongue present with free circuli area; first circulus convex (bulging rostrad), oblong focus with fine granules and a complete circulus around it.

Genus *Crocodilichthys*

Crocodilichthys gracilis Allen & Robertson, 1991

Head, nape, operculum, pectoral fin base, and belly all naked; dorsal fin base, anal fin base, and caudal fin base covered with scales; area around the anus and genital pores naked; scale shape and size vary among different body regions (Table 2); four scale rows between anterior end of second dorsal fin and lateral line; three scales between second and third dorsal fins; 14 scales around caudal peduncle, which has a scaly ventral side; anterior scale margin slightly undulate; no secondary radii; 7–14 radii; long, slender, peripheral ctenii.

Lateral line scales rectangular with a wide posterior extension; long, declined upward, lateral line canal that traverses the scale surface with no constriction; straight anterior and C-shaped posterior openings of lateral line canal; ctenii in two groups in some scales and form a line in others.

Denticles are high, elongated, blunt, not regular, straight, and with a narrow base; tongue present with free circuli area; first circulus convex (bulging rostrad); oval focus with fine granules surrounded by a complete circulus.

Genus *Cryptichthys*

Cryptichthys jojettae Hardy, 1987

Head, nape, operculum, pectoral fin base, caudal fin base, and belly naked; body covered with small ctenoid scales; area around the anus and genital pores naked; scale shape and size vary among body regions (Table 2); four or five scale rows between anterior end of second dorsal fin and lateral line; four scales between second and third dorsal fins; 11 or 12 scales around caudal peduncle, which has a scaly ventral side; smooth anterior scale margin; secondary radii present in scales from all body regions; 6–12 radii; slender, long and short, peripheral ctenii.

Lateral line scales rectangular with a short posterior projection in some scales; straight, long, lateral line that traverses the scale surface with a constriction at mid-length of the canal; C-shaped anterior and straight posterior lateral canal openings; ctenii belong to two groups in scales

1–4, three groups in scales 5–25, and one group in scales 26 and beyond.

No denticles; no tongue; oblong focus with smooth area and an incomplete circulus around it.

Genus *Enneanectes*

Enneanectes boehlkei Rosenblatt, 1960

Head covered with a tiny spicules, no scales; pectoral fin base, operculum, and belly naked; base of dorsal, anal and caudal fins scaly; area around the anus and genital pores naked; body with oblong scales; three or four scale rows between anterior end of second dorsal fin and lateral line; four scales between second and third dorsal fins; 10–12 scales around caudal peduncle, which has a scaly ventral side; undulate anterior scale margin; secondary radii present in all regions; long, straight, peripheral, regularly sized ctenii.

Lateral line scales triangular; straight, long lateral line canal that traverses the scale surface, with no constriction, and with C-shaped anterior and posterior openings; ctenii belong to one group, forming a straight line.

No denticles; tongue present; first circulus bulging caudad; pear-shaped focus with finely granulated area and a complete circulus around it.

Genus *Enneapterygius*

Enneapterygius abeli (Klausewitz, 1960)

Head, operculum, base of pectoral fin, and belly naked; nape, bases of caudal, dorsal, and anal fins scaled; area around the anus and genital pores naked; elsewhere body covered with ctenoid scales; scale shape and size vary among different body regions (Table 2); four scale rows between anterior end of second dorsal fin and lateral line; three scales between second and third dorsal fins; 10 scales around caudal peduncle, which has a scaly ventral side; smooth anterior scale margin; secondary radii present in scales from all body regions; 5–9 radii; short, pointed, conical, peripheral ctenii.

Lateral line scales triangular with no posterior extension; straight, long lateral line canal that traverses the surface of the scale, with no constriction, and with C-shaped anterior and V-shaped posterior openings; ctenii belong to mainly one group, sometimes in more than one group.

Denticles are short, blunt, broad based, and spaced; tongue absent; oblong focus with smooth area and a complete first circulus around it.

Enneapterygius atrogulare (Günther, 1873)

Head, nape, operculum, base of pectoral fin, and anterior part of belly naked; body covered with small ctenoid scales; cycloid scales on posterior part of belly and around the anus and genital pores; scale shape and size vary among different body regions (Table 2); three or four scale rows between anterior end of second dorsal fin and lateral line; four or five scales between second and third dorsal fin; 12 or 13 scales around caudal peduncle, which has a scaly ventral side; undulate anterior scale margin; secondary radii present in scales from some body regions; 8–12 radii; short, conical, pointed, peripheral ctenii.

Lateral line scales rectangular; long, straight lateral line canal with constriction present in some scales (scales 1–6) and with V-shaped anterior and C-shaped posterior openings; ctenii belong to one group, form a line, not straight in scales 1–6, 16, 17, straight in scales 7–15.

Denticles are short, spaced, pointed, broad based; tongue absent; oblong focus with coarse granules and a complete circulus around it.

Enneapterygius gracilis Fricke, 1994

Head, nape, operculum, base of the pectoral fin, and belly naked; body covered with small ctenoid scales continuing onto base of caudal fin; area around the anus and genital pores naked; scale shape and size vary among different body regions (Table 2); three scale rows between anterior end of second dorsal fin and lateral line; seven scales between second and third dorsal fins; 10 or 11 scales around caudal peduncle, which has a scaly ventral side; strongly undulated anterior scale margin; no secondary radii; 5–10 radii; short, conical, pointed, peripheral ctenii.

Lateral line scales are rectangular; short, straight lateral line canal that traverses two-thirds of scale surface, with no constriction; ctenii belong to one group covering the posterior edge of scale, from scale 5 onwards; the lines of ctenii are interrupted at the posterior end of the lateral line canal and appear as two lines, one behind the other.

Denticles are rounded, with pointed ends, spaced; no tongue; pear-shaped focus with area filled with fine granules and an incomplete circulus around it.

Enneapterygius paucifasciatus Fricke, 1994

Head, nape, operculum, base of pectoral fin, and belly naked; body covered with small ctenoid scales continuing onto base of caudal fin; area around the anus, genital pores, and dorsal edge of belly covered with cycloid scales;

scale shape and size vary among different body regions (Table 2); three or four scale rows between anterior end of second dorsal fin and lateral line; four scales between second and third dorsal fins; 12 or 13 scales around caudal peduncle, which has a scaly ventral side; undulate anterior scale margin; no secondary radii; 6–9 radii; slender, short, peripheral ctenii.

Lateral line scales rectangular with a posterior hump; straight long lateral line canal that traverses over two-thirds of the scale surface, with no constriction, but with V-shaped anterior and C-shaped posterior openings; ctenii belong to one group, forming a line.

Denticles are short, broad, rounded at the base, spaced, and some are elongated; tongue present, with free circuli area; first circulus bulging caudad; rounded focus with smooth area and a complete circulus around it.

Enneapterygius rufopileus (Waite, 1904)

Head, operculum, and base of pectoral fins are naked; elsewhere covered with ctenoid scales; belly and area around the anus and genital pores covered with cycloid scales; scale shape and size vary in different body regions (Table 2), generally the dorsal side of body having small scales and the lower part having larger scales; three scale rows between anterior end of second dorsal fin and lateral line; five scales between second and third dorsal fins; 12 scales around caudal peduncle, which has a scaly ventral side; crenate anterior scale margin; secondary radii present in all scales from different body regions; 6–12 radii; short, slender, peripheral ctenii.

Lateral line scales rectangular, with posterior extension that is either rounded or straight; long, straight lateral line canal that traverses two-thirds of scale surface with constriction present at anterior one-third of the canal; lateral line canal with V-shaped anterior and posterior openings; ctenii belong to one group in all scales.

Denticles are short, spaced, broad based, with broadly pointed ends; no tongue; oval focus with coarse granules off centre towards the posterior end; complete circulus around the focus.

Enneapterygius ventermaculus Holleman, 1982

Head, operculum, belly, base of pectoral fin naked; base of caudal fin, dorsal fin, and anal fin covered with ctenoid scales; area around the anus and genital pores naked; scale shape and size vary among different body regions (Table 2), dorsal anterior part having small scales, lower part with

large scales; two scale rows between anterior end of second dorsal fin and lateral line; three scales between second and third dorsal fins; 10 scales around caudal peduncle, which has a scaly ventral side; undulate anterior scale margin; secondary radii present in scales from all body regions; 5–11 radii; long, straight, pointed, peripheral ctenii.

Lateral line scales rectangular with no posterior extension; short, wide lateral line canal that traverses half of scale surface, with no constriction; lateral line canal with V-shaped anterior and C-shaped posterior openings; ctenii belong to one group.

Denticles are short, broad based, blunt, spaced, uniformly arranged; tongue present with free circuli area; first circulus bulging rostrad; oblong focus with smooth area surrounded by a complete circulus.

Genus *Forsterygion*

Forsterygion flavonigrum Fricke & Roberts, 1994

Head, nape, operculum, pectoral fin base, belly, dorsal fin, and anal fin naked; base of caudal fin scaly; remainder of body covered with ctenoid scales; area around the anus and genital pores surrounded by small cycloid scales; body with pentagonal scales; four scale rows between anterior end of second dorsal fin and lateral line; five or six scales between second and third dorsal fins; 13 or 14 scales around the caudal peduncle, which has a scaly ventral side; undulate anterior scale margin; secondary radii present in scales from all body regions; 8–13 radii present; short, slender, peripheral ctenii.

Lateral line scales triangular; long, oblique lateral line canal with constriction and with C-shaped anterior and posterior openings; ctenii belong to one group, and are grouped together in adult fishes and in a straight line in small fishes (< 28 mm total body length).

Denticles are short, broad, rounded, spaced; tongue present with free circuli area and fine bumps; first circulus straight; oblong focus with smooth area and a complete circulus around it.

Forsterygion lapillum Hardy, 1989

Head, nape, pectoral fin base, and anterior region of belly naked; body covered with ctenoid scales, continuing onto base of caudal fin; cycloid scales around lateral margin of belly and in areas around the anus and genital openings; body with pentagonal scales; five or six scale rows between anterior end of second dorsal fin and lateral line; four scales between second and third dorsal fins; 12 or 13 scales

around caudal peduncle, which has a scaly ventral side; undulate anterior scale margin; secondary radii present in scales from all body regions; 8–13 radii; long, slender, peripheral ctenii.

Lateral line scales triangular with a distinctive posterior extension; long, constricted lateral line canal that traverses the scale surface with no constriction and with W-shaped anterior and posterior openings; ctenii belong to three separated groups, in small specimens (< 35 mm total body length) ctenii are absent.

Denticles are short, broad, spaced, blunt; tongue present with free circuli area; first circulus straight; oblong-rectangular focus with smooth area; focus surrounded by a complete circulus.

Forsterygion malcolmi Hardy, 1987

In adult fishes, vertical ctenii-like processes arising densely from the scale surface form a continuous cover over the head from the inter-orbital to the nape; in young fishes small ctenii are scattered over the inter-orbital and nape areas; operculum naked; body covered with ctenoid scales extending onto base of caudal fin; cycloid scales cover pectoral fin base, belly, and area around the anus and genital pores; body covered with pentagonal scales; eight or nine scale rows between second dorsal fin and lateral line, no scales between them; second and third dorsal fins connected by membrane; 17 or 18 scales around caudal peduncle, which has a scaly ventral side; undulated anterior scale margin; secondary radii present in scales of some body regions (only 2 and 7); 9–16 radii; long, curved, pointed, peripheral ctenii.

Lateral line scales triangular; long, straight, constricted lateral line canal that traverses the surface of the scale, with C-shaped anterior and W-shaped posterior openings; ctenii belong to two groups, each group forming a line, usually the upper line being longer than the lower one; sometimes more than one line in each group.

Denticles are long, curved, well spaced; tongue present with free circuli area; first circulus straight; oval focus with smooth area and a complete circulus around it.

Forsterygion varium (Forster, 1801)

In adult fishes, vertical ctenii-like processes arising dorsally from the scale surface form a largely continuous cover on the head from the inter-orbital to the nape; young individuals lack such cover except for scattered ctenii distributed irregularly over the inter-orbital and nape areas;

operculum, belly, base of dorsal fin, and anal fin naked; body covered with ctenoid scales extending onto the base of caudal fin; cycloid scales cover base of pectoral fin and areas around the anus and genital pores; body covered with pentagonal scales; 10 or 11 scale rows between anterior end of second dorsal fin and lateral line; four or five scales between second and third dorsal fins; 16 or 17 scales around the caudal peduncle, which has a scaly ventral side; smooth anterior scale margin; secondary radii present in scales from some body regions (1, 2, 3, and 7); 9–16 radii; long, conical, peripheral ctenii.

Lateral line scales triangular with a peculiar posterior wide extension; long, straight lateral line canal that traverses the length of the scale with a constriction at the middle of the canal; ctenii belong to three separate groups (dorsal, middle, ventral).

Denticles are long, broad based, with curved ends, spaced, pointed; tongue present with free circuli area; first circulus straight; oblong focus with smooth area and a complete circulus around it.

Genus Gilloblennius

Gilloblennius abditus Hardy, 1986

Head, nape, operculum, pectoral fin base, caudal fin base, and belly naked; no scales on either side of body for the full length from the dorsal to the anal fins; body with small oblong scales; areas around the anus and genital pores naked; cycloid scales in body regions 1, 2, 3, and 4; square ctenoid scales in areas 5 and 6 only; 2 or 3 scale rows between the anterior end of second dorsal fin and lateral line; no scales between second and third dorsal fin; 10 or 11 scales around the caudal peduncle, which has naked dorsal and ventral sides; smooth anterior scale margin; secondary radii present in scales from all body regions; 8–13 radii; long, straight, peripheral ctenii.

Lateral line scales are rectangular with a posterior extension that enlarges posteriorly; long, straight, lateral line canal with no constriction traverses the scale surface; no ctenii.

No denticles and no tongue; oblong focus with an area filled with fine irregular granulation; focus surrounded by a complete circulus.

Gilloblennius tripennis (Forster, 1801)

Head, nape, operculum and pectoral fin base naked; body heavily scaled; cycloid scales on belly and in the areas around the anus and genital pores; elsewhere with small

evenly sized scales with ctenii; body covered with a oblong-shaped scales; five scale rows between anterior end of second dorsal fin and lateral line; two scales between second and third dorsal fin; 12 or 13 scales around caudal peduncle, which has a scaly ventral side; undulate anterior scale margin; secondary radii present in scales from all body regions; 6–13 radii; long, slender, peripheral ctenii; sometimes they are mixed of short and long, straight and bent ctenii; posterior portion of body scale is hyaline with no growth lines.

Lateral line scales are rectangular, mainly without a posterior extension, scales from different regions varying in the width of this extension; long, straight lateral line canal that traverses two-thirds of the scale surface, with no constriction; ctenii belong to one group, forming a crescent (from scale 1 and 9 onwards), three groups (scales 2–5), two groups at the lower and the middle part of the posterior side of the scale (scales 7, 8).

Denticles are long, crowded, sometimes curved and pointed; tongue present with free circuli area; first circulus bulging rostrad; oblong focus with an area filled with fine granulation and surrounded by a complete circulus.

Genus Grabamina

Grabamina capito (Jenyns, 1842)

Head, nape, pectoral fin base naked; body with ctenoid scales continuing onto the base of the caudal fin; belly, areas around the anus and genital pores are surrounded by small cycloid scales, some cycloid scales embedded in the area ventral to the first dorsal fin; body scales pentagonal; four or five scale rows between anterior end of second dorsal fin and the lateral line; two or three scale rows between second and third dorsal fins; 20 or 21 scales around the caudal peduncle, which has a scaly ventral side; crenate anterior scale margin; secondary radii present in scales from all body regions; 9–13 radii present; long, slender, peripheral ctenii.

Lateral line scales are triangular with a posterior wide extension; straight, long, lateral line canal that traverses the scale surface, with no constriction, and with V-shaped anterior and C-shaped posterior openings; ctenii belong to one group, forming a straight line that is sometimes discontinuous.

Denticles present in the scales from some body regions (5, 6, and 7), being short, slightly curved, spaced, broad based; denticle shape varies among different body regions, being slender and pointed in regions 6 and 7;

tongue present with free circuli area; first circulus is straight; rounded focus with an area filled with fine and coarse bumps; focus rounded with a complete circulus.

Grahamina gymnota Scott, 1977

Head, nape, operculum, and pectoral fin base naked; body covered with ctenoid scales, continuing onto the base of the caudal fin; cycloid scales on belly and in areas around the anus and genital pores; ctenoid scales in the area under first dorsal fin; body with pentagonal scales; six or seven scale rows between anterior end of second dorsal fin and lateral line; two or three scales between second and third dorsal fin; 16 or 17 scales around the caudal peduncle, which has a scaly ventral side; crenate anterior scale margin; secondary radii present in scales from all body regions; 7–13 radii; long, straight, peripheral ctenii.

Lateral line scales are triangular; straight, long lateral line that traverses the scale surface with no constriction and with straight anterior and C-shaped posterior openings; ctenii belong to one group at the dorsal posterior edge (scale 1) and two groups at the dorsal posterior and middle posterior sides (scale 2 onwards); ctenii form more than one line, in alternate rows.

Denticles are long, broad based, blunt, spaced; tongue present with a free circuli area; first circulus straight; rounded focus with an area filled with a coarse granules; focus surrounded by a complete circulus.

Grahamina nigripenne (Valenciennes, 1836)

Head, nape, pectoral fin base naked; body with ctenoid scales continuing onto the base of the caudal fin; cycloid scales on the belly and in the areas around the anus and genital pores; body with pentagonal scales; five or six scale rows between anterior end of second dorsal fin and lateral line; two scales between second and third dorsal fins; 20 or 21 scales around caudal peduncle, which has a scaly ventral side; crenate anterior scale margin; secondary radii present in scales from all body regions; 8–13 radii; long, slender, peripheral ctenii.

Lateral line scales are triangular with a slight posterior extension; short, constricted lateral line canal that traverses the scale surface, with a constriction at the middle of the canal; lateral line canal with straight anterior and C-shaped posterior openings; ctenii belong to two groups.

Denticles present only in region 2, long, blunt, spaced, some curved and pointed; tongue present with area filled with circuli; first circulus straight; oval focus with area filled with fine granules; focus surrounded by a complete circulus.

Genus Helcogramma

Helcogramma obtusirostre (Klunzinger, 1871)

Head, operculum, nape, belly, base of pectoral, and anal and dorsal fins naked; body covered with ctenoid scales continuing onto the base of the caudal fin; area around the anus and genital pores naked; scale shape and size vary among different body regions (Table 2); five scale rows between anterior end of second dorsal fin and lateral line; three scales between second and third dorsal fins; 13 scales around caudal fin, which has a naked ventral side; undulate anterior scale margin; secondary radii present in scales of some body regions; 5–9 radii; long, slender, pointed, peripheral ctenii.

Lateral line scales are rectangular without a posterior extension; long, straight lateral line canal that traverses over two-thirds of the scale surface, with no constriction; lateral line canal with C-shaped anterior and V-shaped posterior openings; ctenii belong to one group.

Denticles are short, broad based, pointed, spaced; tongue present with free circuli area; first circulus bulging caudad; oval focus with smooth area and an incomplete circulus around it.

Helcogramma springeri Hansen, 1986

Head, nape, operculum, base of pectoral fin, and belly naked; body covered with small ctenoid scales continuing onto the base of the caudal fin; areas around the anus and genital pores naked; a narrow line of naked area extends ventral to the first dorsal fin; scale shape and size vary among different body regions (Table 2); four or five scale rows between anterior end of second dorsal fin and lateral line; six scales between second and third dorsal; 14–16 scales around the caudal peduncle, which has a scaly ventral side; smooth anterior scale margin; secondary radii present in scales of body regions 2, 3, 4; 6–11 radii; short, conical, peripheral ctenii.

Lateral line scales are rectangular with a posterior extension; long, straight lateral line canal with no constriction traverses the scale surface; lateral line canal with C-shaped anterior and posterior openings; ctenii belong to three groups at the upper, lower, and middle portion of the scale.

Denticles are short, broad based, blunt, spaced; tongue present with free circuli area; first circulus concave (bulging caudad); oval focus with area filled with fine granules and an incomplete circulus around it.

Genus *Helcogrammoides****Helcogrammoides cunninghami* (Smitt, 1898)**

Head, operculum, belly, and base of pectoral fin naked; head covered with wart-like structures; body covered with small ctenoid scales; cycloid scales around the area of the anus and genital pores; body covered with rounded scales; three scale rows between anterior end of second dorsal fin and lateral line; three scales between second and third dorsal fins; crenate anterior scale margin; secondary radii present in scales from all body regions; 5–11 radii; long, curved, peripheral ctenii.

Lateral line scales are rectangular with no posterior extension; short, wide lateral line canal that traverses two-thirds of the scale surface, with no constriction; lateral line canal has V-shaped anterior and C-shaped posterior openings; ctenii belong to one group, forming a straight line.

There are no denticles; tongue present with free circuli area; first circulus convex (bulging rostrad); rounded focus with an area filled with fine granules mainly at the centre and posteriorly; focus surrounded by a complete circulus.

Genus *Karalepis****Karalepis stewarti* Hardy, 1984**

Hard, bony scales with vertical ctenii form a continuous cover on the head and snout, which extends as dense patches on upper one-third of operculum, and upper one-half of preoperculum, with small irregular scattered scales under the orbit and forward of the anterior nostril; body heavily scaled; cycloid scales on the base of pectoral fin, belly, and in areas around the anus and genital pores; rest of body regions covered with small ctenoid scales continuing onto the base of caudal fin; scale shape and size vary among different body regions (Table 2); 14 or 15 scale rows between anterior end of second dorsal fin and lateral line; one or two scales between second and third dorsal fins; 14 scales around caudal peduncle, which has a scaly ventral side; dentate anterior scale margin; secondary radii present in scales from all body regions; 11–24 radii; long, bent, peripheral, curved ctenii.

Lateral line scales are triangular, the last scales having a posterior extension; long, constricted lateral line canal with no constriction and with W-shaped anterior and C-shaped posterior openings; ctenii belong to two groups (anterior scales) and three groups (posterior scales).

Denticles are short, broad based, blunt, spaced; tongue present with free circuli area; first circulus concave (bulging rostrad); oblong focus with a smooth area; radii

reach second circulus around focus; complete circulus around focus.

Genus *Lepidoblennius****Lepidoblennius haplodactylus* Steindacner, 1867**

Head, operculum, nape, pectoral fin base, caudal fin base, belly, and a narrow strip along the base of the dorsal and anal fins, and areas around the anus and genital pores naked; remainder of body covered with oblong cycloid scales; five scale rows between the anterior end of second dorsal fin and lateral line; two scales between second and third dorsal fin; 15 or 16 scales around caudal peduncle, which has a naked ventral side; smooth anterior scale margin; no secondary radii; 9–12 radii; no ctenii.

Lateral line scales are rectangular; scales 4 onwards have a posterior extension; long, straight lateral line canal that traverses half of the scale surface, with a constriction from scale 4 onwards; no ctenii.

No denticles; no tongue; oval, very narrow focus with an area filled with coarse granules and a complete circulus around it.

***Lepidoblennius marmoratus* (Macleay, 1878)**

Head, operculum, nape, pectoral fin base, and belly naked; rectangular ctenoid scales on the dorsal half of the body and cycloid scales on the ventral half; 6 or 7 scale rows between anterior end of second dorsal fin and lateral line; no scales between second and third dorsal fins; 16 or 17 scales around caudal peduncle, which has a scaly ventral side; smooth anterior scale margin; secondary radii present in scales from all body regions; 5–11 radii; long, slender, peripheral ctenii.

Lateral line scales are mostly rectangular, some being rounded or oblong; long, straight lateral line canal that traverses the scale surface, with no constriction; ctenii belong to one or two groups, being located either on the upper or the lower posterior corner of the scale.

There are no denticles and no tongue; rounded, narrow focus with an area filled with a few fine granules; focus surrounded by a complete circulus.

Genus *Matanui****Matanui bathytaton* (Hardy, 1989)**

Head region covered with irregular scales from inter-orbital area to nape; scales with vertical ctenii-like processes; operculum and pectoral, anal, dorsal fins all naked; area around the anus and genital pores with small cycloid scales; three

or four scale rows between the anterior end of second dorsal fin and lateral line; three or four scales between second and third dorsal fins; 12 or 13 scales around a scaly caudal peduncle; crenate anterior scale margin.

Lateral line scales are triangular; long, straight lateral line canal that traverses the scale surface with no constriction; ctenii in three groups.

Denticles are short, spaced, rounded on circuli (length < width); no tongue; first circulus bulging rostrad; focus oval with complete circulus around it and coarse granules.

Matanui profundum (Fricke & Roberts, 1994)

Head and nape naked; occipital region with small irregular scales bearing vertical spicules; belly scaled; pectoral fin base with few scales; two scales between anterior end of second dorsal fin and lateral line; three or four scales between second and third dorsal fins; 14 or 15 scales around caudal peduncle; crenate anterior scale margin.

Lateral line scales are elliptical; long, straight lateral line canal that traverses the surface of the scale with no constriction; ctenii in three groups.

Denticles are long, spaced, on circuli; first circulus bulging rostrad; tongue present with free circuli area; scale focus rounded with incomplete circulus around it and fine granules.

Genus *Norfolkia*

Norfolkia clarkei (Morton, 1888)

Head and operculum scaly; base of pectoral fin naked; cycloid scales on belly and in areas around the anus and genital pores; body covered with rectangular scales; three scale rows between anterior end of second dorsal fin and lateral line; three scale rows between second and third dorsal fins; nine scales around caudal peduncle, which has a scaly ventral side; crenate anterior scale margin; secondary radii present in scales from all body regions; 6–13 radii; long, curved, peripheral ctenii.

Lateral line scales are rectangular; some scales with a slight posterior projection with the posterior scale edge either rounded or in a declined line; short, broad, straight lateral line canal that traverses two-thirds of the scale surface with C-shaped anterior and posterior openings; ctenii belong to one group.

Denticles are long, broad based, spaced; no tongue; incomplete focus opening towards the posterior side, with a smooth area.

Genus *Notoclinops*

Notoclinops caerulepunctus Hardy, 1989

Head, snout, nape covered with reduced, slender, curved, posteriorly-angled spines; base of first dorsal fin, anterior-most base of second dorsal fin, operculum, pectoral and anal fin bases, and belly naked; large ctenoid scales cover the rest of the body and extend to the base of the caudal fin; body covered with elliptical scales; one or two scale rows between anterior end of second dorsal fin and lateral line; no scales between base of second and third dorsal fins; 10 or 11 scales around the caudal peduncle, which has a scaly ventral side; smooth anterior scale margin; secondary radii present in scales from all body regions; 5–13 radii; mixture of long and short, slender, peripheral ctenii.

Lateral line scales are oblong, some scales with a posterior extension; short, straight, broad lateral line canal that traverses half of the scale surface, with a constriction at the middle; ctenii belong to one group, forming a line, or to three groups.

Denticles are long, broad based, curved, spaced; no tongue; oval focus with smooth area; complete circulus around focus.

Notoclinops segmentatus McCulloch & Phillipps, 1923

Head, nape, operculum, and pectoral fin base naked; fine scales with raised ctenii on post-temporal rim of orbit; body covered with moderately-sized ctenoid scales that continue onto the base of the caudal fin; areas around the anus and genital pores are naked; body covered with rounded scales; three scale rows between anterior end of second dorsal fin and lateral line; two scale rows between last pored scale and second dorsal fin; 10 or 11 scales around caudal peduncle, which has a scaly ventral side; undulate anterior scale margin; secondary radii present in scales from all body regions; 8–16 radii; long, slender, peripheral ctenii.

Lateral line scales are oblong, some scales with a posterior projection; short, straight lateral line canal that traverses the scale surface, with no constriction, and with C-shaped anterior and posterior openings; ctenii belong to one group or two groups.

Denticles and tongue absent; oval-oblong focus with smooth area; focus surrounded by a complete circulus.

Notoclinops yaldwyni Hardy, 1987

Head, nape, operculum, pectoral fin base, and belly naked; scales with raised ctenii on the posterior rim of orbit; ctenoid scales covering the rest of the body, continuing

onto the base of the caudal fin; areas around the anus and genital pores naked; body covered with elliptical scales; three or four scales between the anterior end of the second dorsal fin and the lateral line; three scales between second and third dorsal fins; 10 or 11 scales around the caudal peduncle, which has a scaly ventral side; smooth anterior margin; secondary radii present in scales from all body regions; 6–14 radii; mixture of long and short, slender, peripheral ctenii.

Lateral line scales are rectangular, some scales with a posterior extension; straight, long lateral line canal with no constriction traverses the surface of the scale; lateral line canal with W-shaped anterior and C-shaped posterior openings; ctenii belong to two groups on the dorsal and middle posterior part of the scale, three groups on the upper, middle, and lower parts of the scale.

Denticles short, broad based, blunt, spaced; tongue present with free circuli area; first circulus concave (bulging rostrad); round focus with smooth area and a complete circulus around it.

Genus *Notoclinus*

Notoclinus compressus (Hutton, 1872)

Head, nape, operculum, and preoperculum naked; pectoral fin base covered with one line of large scales; body covered with cycloid scales, continuing onto the base of the caudal fin; belly with small scales; areas around the anus and genital pores surrounded by small cycloid scales; body covered with cycloid scales; four scale rows between anterior of second dorsal fin and lateral line; three scales between second and third dorsal fins; 9 or 10 scales around caudal peduncle, which has a scaly ventral side; smooth anterior scale margin; secondary radii present in scales from all body regions except region 7; 10–20 radii; no ctenii.

Lateral line scales are rectangular; long, straight lateral line canal that traverses three-quarters of the scale surface, with no constriction; no ctenii.

There are no denticles; tongue present with free circuli area; first circulus bulging caudad; semicircular shape focus with an area filled with fine granules; circuli absent in the posterior side of the scale, which has a fine granular structure; focus surrounded by incomplete circulus.

Notoclinus fenestratus (Forster, 1801)

Head, nape, preoperculum, operculum, and base of pectoral fin are naked; body covered with cycloid scales, continuing onto the base of the caudal fin; belly covered

with small scales; area around the anus and genital pores surrounded by small cycloid scales; body covered with cycloid oblong scales; four scale rows between anterior end of second dorsal fin and lateral line; three scales between second and third dorsal fins; 10 or 11 scales around caudal peduncle, which has a scaly ventral side; smooth anterior scale margin; secondary radii present in scales from all body regions; 11–19 radii; no ctenii.

Lateral line scales are oblong; long, straight lateral line canal with no constriction traverses two-thirds of the scale surface; lateral line canal with C-shaped anterior and undulate posterior openings; no ctenii, posterior third portion of the scale is semi-transparent without growth lines.

There are no denticles; tongue present with free circular area; first circulus bulging caudad; oval focus with smooth area; focus surrounded by an incomplete circulus.

Genus *Obliquichthys*

Obliquichthys maryannae Hardy, 1987

Head, nape, operculum, base of pectoral and first dorsal fins, and anterior region of belly naked; body covered with small ctenoid scales continuing onto the base of the caudal fin; small cycloid scales on the posterior side of the belly and in the areas around the anus and genital pores; body covered with pentagonal scales; two or three scale rows between anterior end of second dorsal fin and lateral line; two or three scales between second and third dorsal fins; 20 or 21 scales around caudal peduncle, which has a scaly ventral side; undulate anterior scale margin; secondary radii present in scales of body regions 2–5, 7; long, slender, blunt, peripheral ctenii.

Lateral line scales are triangular, some with a posterior projection; long, straight lateral line canal with a constriction present at the anterior end; lateral line canal traverses the scale surface; ctenii belong to two groups at the dorsal and middle parts of the posterior side of the scale; some scales with only one ctenii group situated at the middle posterior side.

Denticles are short, broad based, blunt, spaced; tongue present with area filled with circuli; first circulus straight; rounded focus with smooth area and a complete circulus around it.

Genus *Ruanoho*

Ruanoho decemdigitatus (Clarke, 1879)

Head, nape, and operculum naked; body densely covered with ctenoid scales; small cycloid scales directly ventral to

first dorsal fin, on pectoral fin base, on the sides under the pectoral fins, on belly, and around the anus and genital pores; body covered with oblong scales; four or five scale rows between anterior end of second dorsal fin and lateral line; three scales between second and third dorsal fins; 14 or 15 scales around caudal peduncle, which has a scaly ventral side; emarginate anterior scale margin; secondary radii present in scales from all body regions; 9–20 radii; long, slender, hooked, peripheral ctenii.

Most lateral line scales are tongue-like in shape, some are rectangular; short, straight, lateral line canal that traverses the scale surface with no constriction; lateral line canal with C-shaped anterior and V-shaped posterior openings; ctenii belong to one group, forming a single line, or two groups situated on the dorsal and the middle parts of the posterior side of the scale.

Denticles are long, rounded, broad based, and spaced; no tongue; oval focus with an area filled with coarse granulation; circulus around focus incomplete.

Ruanoho whero Hardy, 1986

Head, nape, and operculum naked; body covered with ctenoid scales; base of caudal fin scaly; cycloid scales found directly ventral to the first dorsal fin, on pectoral fin base, low on the sides ventral to the pectoral fin, to various extents on the belly, and in the area around the anus and the genital pores; body covered with oblong scales; two or three scale rows between anterior end of second dorsal fin and lateral line; two scales between second and third dorsal fins; 10 or 11 scales around caudal peduncle, which has a scaly ventral side; strongly emarginate anterior scale margin; secondary radii present in scales from all body regions; 9–20 radii; long, slender, peripheral ctenii.

Most lateral line scales are tongue-like in shape, but some are square or sub-triangular; long, straight lateral line canal that traverses the scale surface with C-shaped anterior and posterior openings; ctenii belong to one group (as a straight line) on scales 1 to antepenultimate, to two groups on the penultimate scale at its dorsal and middle posterior parts, and to three groups on the last scale.

Denticles are long, rounded, spaced; tongue absent; oval focus with an area filled with a coarse granulation; circulus around the focus incomplete.

Genus *Springerichthys*

Springerichthys kulbickii Fricke & Randall, 1994

Head, operculum, base of the pectoral fin naked; body cov-

ered with ctenoid scales that extend onto the base of the caudal fin; cycloid scales on belly and in the areas around the anus and genital pores; body covered with rounded scales; two scale rows between anterior end of dorsal fin and lateral line; five scales between second and third dorsal fins; seven scales around caudal peduncle, which has a scaly ventral side; undulate anterior scale margin; secondary radii present in scales from all body regions; 5–11 radii; mixture of long and short, slender, peripheral ctenii.

Lateral line scales are rectangular with a posterior extension; short, wide lateral line canal that traverses two-thirds of the scale surface, with no constriction, and with V-shaped anterior and posterior openings; ctenii belong to one group.

Denticles are short, triangular, broad based, spaced; tongue present with free circuli; first circulus bulging caudad; pear-shaped focus with fine granules and an incomplete circulus around it.

Genus *Trianectes*

Trianectes bucephalus McCulloch & Waite, 1918

Head, operculum, and base of pectoral fin naked; cycloid scales on belly and around the genital pores; rounded ctenoid scales on the body; two scale rows between anterior end of second dorsal fin and lateral line; three scales between second and third dorsal fins; 12 scales around caudal peduncle, which has a scaly ventral side; crenate anterior scale margin; secondary radii present in only a few scales of body regions 1 and 2; 5–13 radii; mixture of long and short, slender, peripheral ctenii.

Lateral line scales are rectangular with a tongue-like structure at the posterior side that widens anteriorly; long, straight lateral line canal that traverses two-thirds of the scale surface, with no constriction; lateral line canal with V-shaped anterior and C-shaped posterior openings; ctenii belong to one group (scales 1–5), two groups (scales 6–21), one group (last scale).

Denticles are long, rounded, spaced; very narrow tongue present with free circular area; first circulus bulging caudad; pear-shaped focus with smooth area surrounded by incomplete circulus.

Genus *Triptyerygion*

Triptyerygion tripterotonus (Risso, 1810)

Head, operculum, base of the pectoral fin, and the areas around the anus and genital pores are naked; body covered with ctenoid scales of oblong shape; cycloid scales found

in lesser amounts in the area behind the anus; three scale rows between anterior end of second dorsal fin and lateral line; one scale between second and third dorsal fins; 10 scales around caudal peduncle, which has a scaly ventral side; crenate anterior scale margin; secondary radii present in scales from all body regions; 6–16 radii; mixture of long and short, slender, peripheral ctenii.

Lateral line scales are oblong, usually with no posterior extension; long, narrow lateral line canal that traverses two-thirds of the scale surface, with no constriction; lateral line canal with V-shaped anterior and C-shaped posterior openings; ctenii belong to one group (scales 1–9) and three groups (scales 10–20), when the scale has a posterior extension.

Denticles are short, broad based, spaced, sometimes curved; tongue absent; oval focus with smooth area and a complete circulus around it.

Genus *Ucla*

Ucla xenogrammus Holleman, 1993

Head, nape, operculum, base of the pectoral, first and second dorsal fins, belly, and the areas around the anus and genital pores naked; body covered with small ctenoid scales continuing onto the base of the caudal fin; scale shape and size vary among different body regions (Table 2); five or six scale rows between anterior of second dorsal fin and lateral line; eight or nine scales between second and third dorsal fins; 14–16 scales around caudal peduncle, which has a scaly ventral side; smooth anterior scale margin; secondary radii present in scales from body region 2; 8–12 radii; mixture of long and short, peripheral ctenii.

Lateral line scales are rectangular with a posterior extension; long, straight lateral line canal with no constriction traverses the scale surface; lateral line canal with C-shaped anterior and posterior openings; ctenii belong to one group, forming a straight line.

There are no denticles; tongue present with free circular area; first circulus bulging rostrad; oblong focus with smooth area and a complete circulus around it.

Discussion

This study of scale morphology and squamation patterns in triplefins illustrates the wide range of scale characters present in the family Tripterygiidae. From those characters, it was possible to select some that are useful in the systematic study of this family of fishes. This study must be considered

preliminary because, of a total of about 132 tripterygiid species, only 37% have been examined so far. However, 26 of 29 genera have been studied, so a reasonable survey was possible at this level. It was possible to distinguish two groups of scale characters: (1) exclusive characters that clearly define a taxonomic group (genus or species); and (2) characters that are shared by several genera, but that may be useful to define certain species within a genus.

In some species, scales have different shapes and sizes making their identification difficult (Table 2). However, within certain genera scale shapes appear rather similar. Because the rectangular scale shape is reported only for *Norfolkia clarkei*, this character might be considered as an autapomorphy for this species. But since only one species of *Norfolkia* was studied, it is not possible to know whether that character is shared by other members of the genus. This is also true for *Helcogrammoides cunninghami*, in which the body scales are rounded. Elliptical scales were found in *Bellapiscis* and in only one species of *Notoclinops* (*N. caerulepunctus*). For *Bellapiscis* this character can be considered as a synapomorphy for the genus, but not for *Notoclinops*. Pentagonal scales are found in members of the genera *Forsterygion*, *Grahamina*, and *Obliquichthys* only. Therefore, these three genera can be clearly separated from the rest of the triplefin genera by this character.

Growth phenomena are evident in tripterygiid scales by the presence of primary and secondary radii (Lippitsch 1992; Kuusipalo 2000). However, in the species *Acanthanectes rufus*, *Crocodilichthys gracilis*, *Enneapterygius gracilis*, *Enneapterygius paucifasciatus*, and *Lepidoblennius haplodactylus* secondary radii are absent. The absence of these radii may be a good taxonomic tool to identify those species.

When the tongue-like structure is present, the shape of the first interradial circuli (bulging caudad, straight, or bulging rostrad) is characteristic within a group of related species or even among members of the same genus. For example, within the genera *Forsterygion*, *Grahamina*, and *Obliquichthys*, all the species examined had a markedly straight first circulus. On the other hand, a convex (bulging rostrad) circulus is found in *Belapiscis leseyae*, *Blennodon dorsale*, *Cremnochorites capensis*, *Crocodilichthys gracilis*, *Enneapterygius rufopileus*, *Gilloblennius tripennis*, *Helcogrammoides cunninghami*, *Karalepi stewarti*, *Matanui profundum*, *Notoclinops yaldwyni*, and *Ucla xenogrammus*. The concave (bulging caudad) circulus is found in *Ceratobregma acanthops*, *Enneanectes boehlkei*, *Helcogramma*

obtusirostre, *Notoclinus compressus*, *Notoclinus fenestratus*, *Ruanoho whero*, *Tranectes bucephalus*, and *Enneapterygius pausifasciatus*. Obviously, these characters show ambiguous relationships among the taxa mentioned above.

Scalar denticles on the circuli in the rostral field have different shapes in different species, but their taxonomic significance is unclear. On the other hand, the absence of denticles from the interradial circuli might be considered a distinctive character for those taxa, as follows: *Acanthanectes rufus*, *Bellapiscis medius* (Günther, 1861), *B. lesleyae*, *Blennodon dorsale*, *Cremonochorites capensis*, *Cryptichthys joettae*, *Enneanectes boehlkei*, *Gilloblennius abditus*, *Helcogrammoides cunninghami*, *Lepidoblennius*, *Notoclinops segmentatus*, *Notoclinus*, and *Ucla*.

A variety of shapes in scalar denticles is evident among the triplefin species studied. Short, slender denticles are characteristic of *Enneapterygius pausifasciatus*, *Matanui bathytaton*, *Brachynectes fasciatus*, species of the genus *Enneapterygius* (except for *E. gracilis*), *Forsterygion flavonigrum*, *Forsterygion lapillum*, *Grahamina capito*, *Obliquichthys maryannae*, both species of *Helcogramma*, *Karalepis stewarti*, *Notoclinops yaldwyni*, *Springerichthys kulbickii*, and *Tripterygion tripteronotus*. Long, slender denticles are present in *Ceratobregma acanthops*, *Gilloblennius tripennis*, *Matanui profundum*, *Obliquichthys maryannae*, *Tranectes bucephalus*, *Crocodilichthys gracilis*, *Norfolkia clarkei*, *Notoclinops caerulepunctus*, both species of *Ruanoho*, *Grahamina gymnota*, *Grahamina nigripenne*, *Forsterygion malcolmi*, and *Forsterygion varium*. Short, wide denticles with a rounded tip were found in *Enneapterygius gracilis* and *Enneapterygius pausifasciatus* only. Denticle shape is useful to distinguish species within the genera *Forsterygion* and *Enneapterygius*, as well as to differentiate between some genera. It may be an apomorphic character in the taxa mentioned above.

The arrangement of denticles on the circuli is a variable character across triplefin species. Most of the species have spaced denticles. Crowded denticles are found in *Gilloblaneius tripennis* only. Denticle arrangement is useful to differentiate *G. tripennis* from the rest of the triplefin fishes.

The denticle characters discussed above show that a given type of scalar denticle might be found in taxonomic groups for which a close relationship was already assumed, but in some cases the same type is shared by genera for which a close relationship has not been confirmed. Since the most recently formed circuli were never observed to

carry denticles, it is assumed that scalar denticles start to develop only after the circulus involved has been fully formed. Considering their position (pointed backwards) and their presence on the rostral field, denticles may act as minute hooks preventing movement of, or aiding attachment to, the scale.

The distinction between cycloid and ctenoid scales is very clear in Tripterygiidae, unlike in other fish families such as Cichlidae (Lippitsch 1990). Among the 48 triplefin species studied, only two species appear to have the body completely covered with cycloid scales: *Notoclinus compressus* and *Notoclinus fenestratus*. In *Lepidoblennius marmoratus* the upper part of the body is covered with ctenoid scales and the lower part with cycloid scales. This character is regarded as a useful tool to distinguish the genus *Notoclinus* and the species *Lepidoblennius marmoratus*. The presence of cycloid scales on the base of the anal fin of *Blennodon dorsale* and the nape region of *Grahamina capito* can be considered as a distinctive character for those species also.

The majority of the tripterygiid fishes studied have long ctenii on their scales. This feature is shared by taxa such as *Forsterygion* (except for *F. flavonigrum*), *Enneapterygius ventermaculus*, and *Notoclinops* (except for *N. caerulepunctus*), but it is not considered a good taxonomic criterion to use in the separation of the triplefins studied. Short ctenii are found in the following species: *Bellapiscis lesleyae*, *Forsterygion flavonigrum*, *Helcogramma springeri*, *Notoclinops caerulepunctus*, *Enneapterygius abeli*, *Enneapterygius atrogulare*, *Enneapterygius gracilis*, *Enneapterygius paucifasciatus*, and *Enneapterygius rufopileus*.

A focus with rounded shape is found in scales of *Acanthanectes rufus*, *Axoclinus carminalis*, *Enneapterygius pausifasciatus*, *Grahamina capito*, *Grahamina gymnota*, *Helcogrammoides cunninghami*, *Lepidoneustes marmoratus*, *Norfolkia clarkei*, *Notoclinops yaldwyni*, and *Obliquichthys maryannae*, while the semicircular shape is found in *Notoclinus compressus*. That character differentiates this species from the remaining triplefin fishes studied. The focus of the scales in the remaining tripterygiid species was oblong, oval, or pear-shaped (in the species *Apopterygion oculus*, *Ceratobregma acanthops*, all species of *Enneapterygius*, *Springerichthys kulbickii*, and *Tranectes bucephalus*). The focus area shows another variable character: it can be smooth, with fine granules, or with coarse granules. This latter feature of the focus may be useful for distinguishing genera.

Variation in the morphology of the lateral line scale surface is restricted to the shape of the scale and the grouping of the ctenii. The oval and tongue-like shapes are characteristic of *Axoclinus carminalis*, *Karalepis stewarti* and both species of *Ruanoho*, respectively. This character might be considered as a synapomorphy for the members of those genera.

Ctenii on lateral line scales are found distributed in groups (one, two, or three) on each scale. However, within a species, various combinations of those groups can be found. Ctenii are present across the genera, except for the absence of ctenii, which separates *Blennodon dorsale*, *Gilloblennius abditus*, *Lepidoblennius haplodactylus*, *Notoclinus compressus*, and *Notoclinus fenestratus* from the rest of the species studied, and ctenii distribution not be a valuable taxonomic tool. Thus, the absence of ctenii can be considered as a synapomorphy for the genera *Blennodon* and *Notoclinus* and an autapomorphy for the species *Gilloblennius abditus* and *Lepidoblennius haplodactylus*. Another interesting result, in the grouping of the ctenii in lateral line scales, is that the species *Forsterygion lapillum* and *Forsterygion varium* have three groups of ctenii on these scales and therefore this character might be considered a good for species diagnosis.

Most of the characters described above are remarkably stable within each species. In most species the head, nape, operculum, belly, area around the anus and genital pores, and base of pectoral fin are naked. Some tripterygiid species have a naked base of the caudal fin (*Blennodon dorsale*, *Cryptichthys jojettae*, *Gilloblennius abditus*, and *Lepidoblennius haplodactylus*), otherwise it is scaly. In those species that are scaly in the above-mentioned areas, the head has a most unique pattern of squamation. *Acanthanectes rufus* and *Norfolkia clarkei* are the only species that have a scaly head: this character seems to be useful for systematic purposes. Ctenoid scales of the head are modified into certain shapes, which enable the differentiation of some species from the remainder. Such modification is present in *Apopterygion oculus*, *Ceratobregma acanthops*, *Cremonochorites capensis*, *Forsterygion malcolmi*, *Forsterygion varium*, and *Karalepis stewarti*; the head scales show upwardly projected ctenii. In other species, such as *Axoclinus carminalis*, *Enneanectes boehlke*, and *Notoclinops caerulepunctus*, head scales are modified into tiny spicules, which also cover the snout and the nape.

A scaly operculum is found only in *Acanthanectes rufus*, *Cremonochorites capensis*, and *Norfolkia clarkei*, while

a scaly nape is found in *Apopterygion oculus*, *Cremonochorites capensis*, and *Enneapterygius abeli*. Squamation of fins also seems to be useful for taxonomic purposes. The dorsal and anal fins are scaly in *Enneanectes boehlkei*, *Crocodilichthys gracilis*, *Enneapterygius abeli*, and *Enneapterygius ventermaculus* only, while the pectoral fin is scaly in *Cremonochorites capensis*, and *Notoclinops compressus* only. A naked caudal peduncle has been found in only six species belonging to four genera: *Bellapiscis medius*, *Bellapiscis lesleyae*, *Gilloblennius abditus*, *Helcogramma obtusirostre*, and *Lepidoblennius haplodactylus*.

From this comparative study it can be concluded that scale surface morphology and squamation patterns are valuable for systematic purposes. The distribution of some characters is congruent with that of other types of characters, thus confirming existing systematic arrangements. This is true for two characters: pentagonal shape of the body scale and a straight first interradial circulus. These characters are unique to the genera *Forsterygion*, *Grahamina*, and *Obliquichthys*, suggesting a similarity among these three genera, as shown by Eyton's (1999) molecular work. Further phylogenetic research using additional morphological characters might prove that they belong to one genus. The present scale morphology study also supports the taxonomic validity of the genera *Ruanoho* and *Bellapiscis*, and reveals the close similarities between the genera *Cryptichthys* and *Bellapiscis* as suggested by Eyton's (1999) molecular studies. In other cases, however, differences in scale characters cut through accepted taxa or unite groups for which a close relationship has not been suggested.

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Appendix 1. List of the material examined

All localities are in New Zealand, except for those where the country has been given. Specimens without registration number belong to the University of Auckland, Auckland, New Zealand. (AMSA = Australian Museum, Sydney, Australia; FMNH = Field Museum of Natural History, Chicago, Illinois, USA; NMNZ = Museum of New Zealand, Te Papa Tongarewa, Wellington, New Zealand; SL = standard body length).

Acanthanectes rufus (n=3). 27–28 mm SL, South Africa, 1999.

Apoptyrygion oculus (n=8). 40 mm SL, west side, outer Chetwode Islands, 29 Mar 1984, NMNZ P. 15396; 30 mm SL, Canterbury Bight, R/V *James Cook*, Jun 1974, NMNZ P. 17205; 48 mm SL, Mernoo Bank, Chatham Rise, *Tangaroa*, 12 Jan 1979, NMNZ P. 25176; 2, 25–28 mm SL, Mernoo Bank, 12 Jan 1970, NMNZ P. 25263; 35 mm SL, Dees Island to Tucker Point, Auckland Islands, 18 Jan 1963, NMNZ P. 25285; 37 mm SL, Foveaux Strait, Oyster dredge, no date, NMNZ P. 25335; 32 mm SL, Turn Point, Crooked Arm, Doubtful Sound, 29 Mar 1995, NMNZ P. 32300.

Axoclinus carminalis (n=28). 28, 20–28 mm SL, Roqueta Island, Acapulco, Guerrero, Mexico, 8 Feb 1955, FMNH. 61801.

Bellapiscis lesleyae (n=18). 5, 30–45 mm SL, Waitangi, Chatham Islands, 12 Feb 1987, NMNZ P. 21076; 40–49 mm SL, Mathesons Bay, Hauraki Gulf, 27 Jan 1997; 2, 40–45 mm SL, Cape Rodney, Hauraki Gulf, 20 Nov 1997; 2, 44–47 mm SL, Stirling Point, 26 Jan 1998; 42 mm SL, Horseshoe Bay, Stewart Island, 31 Jan 1998; 45 mm SL, Whakatu Point, Kaikoura, 3 Feb 1998; 38 mm SL, Breaker Bay, Wellington, 9 Feb 1998; 2, 39–49 mm SL, Mokohinau Islands, 17 Aug 1998; 2, 41–43 mm SL, Great Barrier Island, 3 Sep 1998.

Bellapiscis medius (n=33). 5, 33–50 mm SL, Ocean Beach, Jackson Bay, south Westland, 2 Aug 1995, NMNZ P. 32786; 2, 47–61 mm SL, Mathesons Bay, 6 Oct 1997; 6, 28–58 mm SL, Horseshoe Bay, Stewart Island, 3 Jan 1998; 6, 26–51 mm SL, Whakatu Point, Kaikoura, 3 Feb 1998; 13, 38–65 mm SL, Island Bay, Wellington, 7 Feb 1998; 55 mm SL, Music Point, 31 Mar 1998; 10, 41–66 mm SL, Huia, Manukau Harbour, Auckland, 21 Jun 1998.

Blennodon dorsale (n=10). 98 mm SL, off Horoera Point, East Cape, 24 Jan 1993, NMNZ P. 29792; 4, 115–120 mm SL, Pyramid Rock, north of Greymouth, 3 Aug 1995, NMNZ P. 32766; 53 mm SL, Man O'War Passage, Great Barrier Island, 15 Oct 1997; 2, 25–30 mm SL, Muriwai, 9 Oct 1999; 76 mm SL, Whatipu, Manukau Entrance, 8 Apr 2001; 4, 112–135 mm SL, First Point, Makara Beach, Wellington, 15 Apr 2001.

Brachynectes fasciatus (n=32). 2, 25–32 mm SL, Rock Pier, Port Arthur, Tasmania, Australia, 2 Dec 1972, I.17551-001 (AMSA); 21, 29–40 mm SL, Kingscote, Kangaroo Island, Australia, 13 Mar 1978, I.20189-032 (AMSA); 9, 20–24 mm SL, off Cape Le Grande, Rob Island, Western Australia, 20 Mar 1978, I.20216-011 (AMSA).

Ceratobregma acanthops (n=6). 6, 23–36 mm SL, Lizard Island, Australia, 24 Dec 1997.

Cremnochorites capensis (n=4). 4, 54–74 mm SL, False Bay, South Africa, Jan 1997.

Crocodilichthys gracilis (n=20). 20, 31–47 mm SL, West Ventura, California, USA., 1997.

Cryptichthys jojettae (n=40). 13, 28–42 mm SL, Turamai Road, New Plymouth, 9 May 1989, NMNZ P. 24227; 6, 26–39 mm SL, Breaker Bay, Wellington, 9 Feb 1998; 6, 30–41 mm SL, Mokohinau Islands, 16 Apr 1998; 4, 37–40 mm SL, Great Barrier Island, 3 Sep 1998; 11, 22–28 mm SL, Three Kings Islands, 2 Mar 1999.

Enneanectes boehlkei (n=55). 55, 19–22 mm SL, Leeward, South west side, East Snake Cay, off Puta Gorda, Toledo, Belize, Central America, 19 Jun 1979, FMNH. 87895.

Enneapterygius abeli (n=6). 6, 18–23 mm SL, Sodwana Bay, South Africa, 29 May 2001.

Enneapterygius atrogulare (n=17). 17, 18–27 mm SL, Lizard Island, Australia, 19 Dec 1997.

Enneapterygius gracilis (n=9). 9, 16–21 mm SL, Lizard Island, Australia, 19 Dec 1997.

Enneapterygius paucifasciatus (n=5). 5, 18–24 mm SL, Lizard Island, Australia, 23 Dec 1997.

- Enneapterygius rufopileus* (n=15). 7, 30–36 mm SL, Australia, 18 Apr, 1997, UN.7710-014; 8, 28–33 mm SL, Avalon, Sydney, Australia, 23 Apr 1997, UN.9710-015.
- Enneapterygius ventermaculus* (n=7). 7, 14–18 mm SL, Sodwana Bay, South Africa, 28 May 2001.
- Forsterygion flavonigrum* (n=64). 18, 38–49 mm SL, North Cape, 28 Feb 1999; 5, 36–42 mm SL, Ti Point, Hauraki Gulf, 14 May 1998; 5, 33–40 mm SL, Great Barrier Island, 5 Sep 1997; 38 mm SL, Nelson Island, Great Barrier Island, 5 Sep 1998; 2, 32–38 mm SL, Hen and Chicken Islands, Hauraki Gulf, 6 Feb 1997; 13, 32–42 mm SL, Mokohinau Islands, 9 Dec 1997; 47 mm SL, Breaker Bay, Wellington, 9 Feb 1998; 7, 37–42 mm SL, Milford Sound, 3 Apr 1998; 2, 26–28 mm SL, Otago, 2 May 1998; 5, 45–50 mm SL, Ulva Islands, Stewart Island, 30 Jan 1998.
- Forsterygion lapillum* (n=101). 18, 29–47 mm SL, North Cape, 5 Mar 1999; 27, 38–56 mm SL, Ti Point, Hauraki Gulf, 27 Feb 1997, 21 Oct 1997; 27, 35–52 mm SL, Nelson Island, Great Barrier Island, 12 Jan 1997; 4, 23–24 mm SL, Hen and Chicken Islands, Hauraki Gulf, 6 Feb 1997; 4, 35–42 mm SL, Great Barrier Island, 5 Sep 1997; 54 mm SL, Manukau Harbour, 21 Jan 1998; 48 mm SL, Stirling Point, 26 Jan 1998; 2, 21–23 mm SL, Whakatu Point, Kaikoura, 3 Feb 1998; 8, 48–56 mm SL, Island Bay, Wellington, 7 Feb 1998; 9, 46–59 mm SL, Ulva Islands, Stewart Island, 1 Feb 1998.
- Forsterygion malcolmi* (n=40). 9, 42–96 mm SL, Mokohinau Islands, 18 Feb 1998; 10, 52–71 mm SL, Great Barrier Island, 15 Oct 1997; 2, 72–74 mm SL, Nelson Island, Great Barrier Island, 12 Sep 1998; 9, 71–82 mm SL, Ti Point, Hauraki Gulf, 21 Oct 1997; 6, 48–116 mm SL, Breaker Bay, Wellington, 9 Feb 1998; 4, 38.8 mm SL, Stewart Island, 30 Jan 1998.
- Forsterygion varium* (n=68). 14, 56–96 mm SL, Three Kings Islands, 1 Mar 1999; 17, 42–88 mm SL, North Cape, 28 Feb 1999; 14, 61–88 mm SL, Ti Point, Hauraki Gulf, 12 Aug 1997; 8, 66–85 mm SL, Great Barrier Island, 5 Sep 1997; 3, 74–89 mm SL, Nelson Island, 10 Oct 1997; 52 mm SL, Sphinx Island, Mokohinau Islands, 21 Jan 1998; 42 mm SL, Stirling Point, 26 Jan 1998; 5, 48–100 mm SL, Island Bay, Wellington, 7 Feb 1998; 5, 37–100 mm SL, Ulva Island, Stewart Island, 1 Feb 1998.
- Gilloblennius abditus* (n=10). 2, 41–50 mm SL, Lyall Bay, Wellington, 19 Sep 1923, NMNZ P. 13486; 5, 27–41 mm SL, Kapiti Island, 6 Mar 1996, NMNZ P. 33278.
- Gilloblennius tripennis* (n=10). 5, 80–100 mm SL, south of Aramoana, Hawke's Bay, 19 Jan 1991, NMNZ P. 26400; 2, 93–113 mm SL, north end of Ringaringa Bay, Oban, Stewart Island, 7 Mar 1992, NMNZ P. 27627; 67 mm SL, Horoera Point, 23 Jan 1993, NMNZ P. 29990.
- Grahamina capito* (n=240). 4, 79.1–82.3 mm SL, Enderby Island, Auckland Islands, 17 Mar 1954, NMNZ P. 1489; 24, 34.8–56.5 mm SL, Portobello, Otago Harbour, 45°50'S 170°39'E, 13 Aug 1962, NMNZ P. 13491; 72.4 mm SL, Oamaru, 1963, NMNZ P. 10663; 5, 34–82 mm SL, Elizabeth Island, Fiordland, 28 Feb 1985, NMNZ P. 16952; 5, 36–64 mm SL, Elizabeth Island, Fiordland, 9 Mar 1985, NMNZ P. 16955; 5, 72.7–82.4 mm SL, Antipodes Islands, 8 Mar 1985, NMNZ P. 17083; 5, 61–72 mm SL, Kawarua, New Plymouth, 39°03.4'S 174°03.7'E, 24 Jan 1986, NMNZ P. 18137; 86 mm SL, Edwardson Sound (west bank), Fiordland, 9 May 1986, NMNZ P. 19857; 55 mm SL, Charnley Island, Auckland Islands, 3 Jun 1986, NMNZ P. 20111; 4, 64–78 mm SL, Charnley Island, Auckland Islands, 3 Jun 1986, NMNZ P. 20112; 7, 31–73 mm SL, Islet Cove, Port Pegasus, Stewart Island, 25 Jan 1989, NMNZ P. 24135; 9, Stewart Island, Jan 1989, NMNZ P. 24362; 7, 31–73 mm SL, Islet Cove, Port Pegasus, Stewart Island, 25 Jan 1989, NMNZ P. 24135; 9, Feb 1998, NMNZ P. 24362; 5, 56–66 mm SL, Tinopai Wharf, Kaipara Harbour, 11 Apr 1998; 6, 36–46 mm SL, Whangateau Wharf, Whangateau Estuary, 13 Dec 1999; 18, 37–68 mm SL, Orapiu Wharf, Waiheke Island, 29 and 30 Dec 1999; 7, 34.1–82.8 mm SL, Island Bay, Wellington, 7 and 8 Jan 2000; 5, 57.3–73.3 mm SL, Seatoun Wharf, Wellington, 8 Jan 2000; 6, 46.5–62.8 mm SL, Akaroa Wharf, Akaroa, 31 Aug 2001; 3, 30.3–35.4 mm SL, Terror Cove, Auckland Islands, 24 May 2002.
- Grahamina gymnota* (n=98). 4, 36–58 mm SL, Muriwai Beach, Auckland, 36°50'S 174°26'E, intertidal pools, 17 Jan 1962, NMNZ P. 13557; 3, 43–68 mm SL, Castle Rock, Seal Rocks, Sugar Loaf Islands, New Plymouth, 39°0.35'S 174°00.2'E, 25 Mar 1985, NMNZ P. 17082; 10, 36–66 mm SL, Higgins Wharf, Napier Harbour, 22 Mar 1988,

- NMNZ P. 24347; 1, 47 mm SL, south-eastern Tasmania, Aug 1976, NMNZ P. 25282; 2, 46–47 mm SL, cleared and stained, Kettering Jetty, S. Bell, 11 Jan 1966, NMNZ P. 25422; 3, 80–93 mm SL, Wrest Point, Hobart, Derwent River estuary, 1982, NMNZ P. 30579; 2, 47 and 82 mm SL, Wrest Point, Hobart, Derwent River estuary, 1982, NMNZ P. 30580; 3, 80–93 mm SL, West Point, Hobart, Derwent River Estuary, 1982, NMNZ P. 30579; 2, 47 and 82 mm SL, Wrest Point, Hobart, Derwent River estuary, 1982, NMNZ P. 30580; 2, 45–71 mm SL, Musick Point, 31 Mar 1998; 2, 56 and 65 mm SL, Whatipu, North Head, Manukau Harbour, 14 Aug 1999; 11, 50–75 mm SL, Whatipu, North Head, Manukau Harbour, 5 Sep 1999; 15, 27–70 mm SL, Te Arai Point, 15 Dec 1999; 12, 43–56 mm SL, Orapiu Wharf, Waiheke Island, 29 and 30 Dec 1999, 1 Jan 2000; 11, 36–85 mm SL, Queens Wharf, Wellington, 23 Apr 2000.
- Grahamina nigripenne* (n=29). 5, 55–84 mm SL, Wanganui River estuary, Apr 1950, NMNZ P. 1327; 10, 40–69 mm SL, Mill Creek, Halfmoon Bay, Stewart Island, 3 Mar 1992, NMNZ P. 27830. 2, both 55 mm SL, Pataua Estuary, Ngunguru Bay, 3 Aug 1999; 12, 33–86 mm SL, Whangateau Wharf, Whangateau Estuary, 13 Dec 1999.
- Helcogramma obtusirostre* (n=10). 10, 21–38 mm SL, Sodwana Bay, South Africa, 27 May 2001.
- Helcogramma springeri* (n=20). 20 24–32 mm SL, Lizard Island, Australia, 24 Dec 1997.
- Helcogrammoides cunninghami* (n=1). 24 mm SL, Playa El Durazno, Quintero, Chile, 28 Nov 1999.
- Karalepis stewarti* (n=49). 5, 107–117 mm SL, islet off South-West Point, Mana Island, 8 Mar 1996, NMNZ P. 33349; 18, 41–102 mm SL, Mokohinau Islands, 21 Jan 1998; 3, 82–110 mm SL, Horseshoe Bay, Pukoro Bay, Stewart Island, 30 Jan 1998, 28 Jan 1998; 2, 97–113 mm SL, Breaker Bay, Wellington, 9 Feb 1998; 6, 81–115 mm SL, Little Barrier Island, 3 Sep 1998; 89 mm SL, North Cape, 28 Feb 1999; 19, 36–117 mm SL, Three Kings Islands, 1 Mar 1999.
- Lepidoblennius haplodactylus* (n=30). 30, 36–76 mm SL, Avalon, Sydney, Australia, 23 Apr 1997.
- Lepidoblennius marmoratus* (n=5). 5, 30–95 mm SL, Israelite Bay, Western Australia, 3 Mar 1984, NMNZ P. 17273.
- Matanui bathytaton* (n=35). 63.0 mm SL, Mernoo Bank, 43°06.1'S 175°20.5', 153 m, *Tangaroa* Stn R14 (NMNZ Biological Stn 656), 12 Jan 1979 (Holotype), NMNZ P.22058; 5, 80 mm SL, Pukaki Rise, Campbell Plateau, 22 Nov 1965, NMNZ P.5046; 3, 58–69 mm SL, off south-east corner of South Island, 3 Sep 1970, NMNZ P.7097; 5, 42–80 mm SL, Oamaru, 5 Feb 1962, NMNZ P. 10705; 2, 35–36 mm SL, south-east of Pitt Island, Chatham Islands, 3 Feb 1954, NMNZ P. 25495; 82 mm SL, NZOI. Stn B. 176, no date, NMNZ P. 25308; 5, 35–60 mm SL, Mernoo Bank, 12 Jan 1979, NMNZ P. 25319; 4, 48–52 mm SL, 'Canyon C' off Otago Peninsula, 16 Aug 1955, NMNZ P. 25330; 2, 74–76 mm SL, Urry Bank, no date, NMNZ P.34284; 7, 52–89 mm SL, R/V *Munida*, Otago, May 1998, 45°50.66'S 170°51.54'E, dredge, 60–110 m.
- Matanui profundum* (n=21). 3, 68–72 mm SL, off Palmerston, 13 Dec 1971, NMNZ P. 7096; 78 mm SL, Oamaru, Aug 1963, NMNZ P. 10642; 36 mm SL, Waitiu Bay, Marlborough Sounds, 5 Mar 1976, NMNZ P.28819; 71 mm SL, off south Otago coast, 46°22.27'–19.66S 170°15.71'–17.87'E, 73–83 m, 25 Feb 1994, NMNZ P.31133; 68 mm SL, NZOI Stn, YO28; R/V *Munida*, Otago, May 1998, NMNZ P.35898. Auckland University specimens: 2, 67 mm SL, 45°50.66'S 170°51.4'E, 60–110 m, dredge; Pakiri Beach, 1 Jul 1999, 53 mm SL, 174°47.13'S 36°12.03'E, trawl survey, 46.7 m, Omaha Bay, 19 Nov 1999; 2, 42 and 49 mm SL, 24 m off Mathesons Bay, Leigh, Hauraki Gulf, current metre mooring, 10 Apr 2001.
- Norfolkia clarkei* (n=24). 6, 35–57 mm SL, Port Phillip Bay, Victoria, Australia, 9 Apr 1997; 18, 42–50 mm SL, Port Phillip Bay, Victoria, Australia, 12 Feb 2000.
- Notoclinops caerulepunctus* (n=27). 5, 24–30 mm SL, south-west corner of White Island, Bay of Plenty, 24 Apr 1999, NMNZ P. 36691; 29 mm SL, Mokohinau Islands, 19 Jan 1998; 3, 30–33 mm SL, Mokohinau Islands, 20 Nov 1998; 5, 25–30 mm SL, Cathedral Rock, 20 Jan 1998; 12, 28–38 mm SL, Fanal Island, Hauraki Gulf, 20 Jan 1998; 23 mm SL, Mokohinau Islands, 21 Jan 1998.
- Notoclinops segmentatus* (n=67). 3, 15–26 mm SL, Hen and Chicken Islands, Hauraki Gulf, 6 Feb 1997; 4, 31–37 mm SL, Catherine Bay, Hauraki Gulf, 6 Feb 1997; 16, 24–39 mm SL, Great Barrier Island, 5 Jul 1997; 2, 34–31 mm SL, Mathesons Bay, Hauraki Gulf, 7 Oct 1997; 5, 26–41 mm SL, Nelson Island, Hauraki Gulf, 14 Oct 1997; 4, 31–36 mm

SL, Mokohinau Islands, 9 Dec 1997; 9, 25–38 mm SL, Mokohinau Islands, 20 Jan 1998, 21 January 1998; 8, 34–47 mm SL, Horseshoe Bay, Pukoroi Bay, Stewart Island, 28 Jan 1998; 3, 37 mm SL, Island Bay, Wellington, 7 Feb 1998; 4, 33–37 mm SL, Breaker Bay, Wellington, 9 Feb 1998; 9, 24–37 mm SL, North Cape, 28 Feb 1999.

Notoclinops yaldwyni (n=53). 4, 38–46 mm SL, Manukau Bay, Owenga, Chatham Island, 4 Feb 1991, NMNZ P. 26644; 3, 40–46 mm SL, Ti Point, Hauraki Gulf, 20 Nov 1997, 7 Oct 1997; 3, 33–37 mm SL, Mokohinau Islands, 8 Dec 1997, 10 Dec 1997; 6, 33–44 mm SL, Mokohinau Islands, 19 Jan 1998; 4, 20–47 mm SL, Mokohinau Islands, 20 Jan 1998; 12, 34–50 mm SL, Mokohinau Islands, 21 Jan 1998; 9, 40–51 mm SL, Breaker Bay, 9 Feb 1998, Wellington, 9 Feb 1998; 42 mm SL, North Cape, 28 Mar 1999; 11, 26–48 mm SL, Three Kings Islands, 1 Mar 1999.

Notoclinus compressus (n=10). 71 mm SL, north end Ringaringa Bay, Oban, Stewart Island, 7 Mar 1992, NMNZ P. 27634; 58 mm SL, V-Bay, Cape Rodney, Hauraki Gulf, 18 Aug 1997; NMNZ P. 26636 5, 64–72 mm SL, Manukau Bay, Owenga, Chatham Island, 4 Feb 1991; 3, 54–58 mm SL, Rurina Island, off Whale Island, eastern Bay of Plenty, 7–10 m, 2 Jun 1998.

Notoclinus fenestratus (n=10). 116 mm SL, Oamaru Harbour, Jun 1965, NMNZ P. 10574; 6, 44–132 mm SL, south of Slipper Island, 5 Dec 1986, NMNZ P. 21628; 3, 55–85 mm SL, Wharekura Point, 30 Apr 1992, NMNZ P. 28263.

Obliquichthys maryannae (n=65). 5, 38–41 mm SL, North Cape, 28 Feb 1999; 18, 27–47 mm SL, Three Kings Islands, 1 Mar 1999; 24, Mokohinau, 9 Dec 1997; 35 mm SL, Hen and Chicken Islands, 6 Feb 1997; 51 mm SL, Catherine Bay, Great Barrier Island, 4 Sep 1997; 6, 36–50 mm SL, Great Barrier Island, 4 Sep 1997; 8, 44–53 mm SL, Kaikoura, 15 Oct 1997; 2, 35–51 mm SL, Breaker Bay, Wellington, 9 Feb 1998.

Ruanoho decemdigitatus (n=44). 5, 92–100 mm SL, north side of Smoothwater Bay, Jackson Bay, 8 Feb 1999, NMNZ P. 36269; 4, 44–51 mm SL, Great Barrier Island, 5 Sep 1997; 55 mm SL, Nelson Island, Great Barrier Island, 12 Jun 1997; 19, 40–76 mm SL, Ti Point, 7 Oct 1997, 21 Oct 1997; 70 mm SL, Cape Rodney, 20 Nov 1997; 2, 48–61 mm SL, Mathesons Bay, Leigh, 21 Oct 1997; 38 mm SL, Island Bay, 7 Feb 1998; 10, 62–102 mm SL, Breaker Bay, 9 Feb 1998; 55 mm SL, North Cape, 5 Mar 1999.

Ruanoho whero (n=103). 5, 53–65 mm SL, Whangatete Bay, Chatham Islands, 5 Feb 1991, NMNZ P. 26722; 4, 44–55 mm SL, Hen and Chicken Islands, 6 Feb 1997; 11, 40–54 mm SL, Great Barrier Island, 4 Sep 1997; 11, 40–55 mm SL, Ti Point, 7 Oct 1997; 2, 36–45 mm SL, Catherine Bay, Great Barrier Island, 4 Sep 1997; 6, 41–56 mm SL, Nelson Island, Great Barrier Island, 16 Sep 1998; 9, 57–77 mm SL, Ulva Islands, Stewart Island, 30 Jan 1998; 10, 54–75 mm SL, Breaker Bay, 7 Feb 1998; 12, 30–56 mm SL, Mokohinau Islands, 19 Jan 1998; 15, 31–63 mm SL, North Cape, 28 Feb 1999; 18, 35–62 mm SL, Three Kings Islands, 1 Mar 1999.

Springerichthys kulbickii (n=14). 3, 23–25 mm SL, leeward side of reef, Banks Group, Rowa Island, Vanuatu, 20 May 1997, I.37928-060 (AMSA); 4, 21–24 mm SL, Reef Island, Santa Cruz, Solomon Islands, 19 Sep 1998, I.39013-055 (AMSA); 7, 20–24 mm SL, Nialo Point, east side of Forrest Passage, Reef and Lomlom Islands, Santa Cruz, Solomon Islands, 18 Sep 1998, I.39010-094 (AMSA).

Trianectes bucephalus (n=11). 50 mm SL, Bruny Island, Quiet Corner, Australia, 16 Feb 1972, I.16240-001 (AMSA); 3, 28–50 mm SL, Portsea Pier, Port Phillip Bay, Victoria, Australia, 12 Apr 1977, I.19773-011 (AMSA); 4, 65–67 mm SL, Portsea Pier, Port Phillip Bay, Victoria, Australia, 12 Apr 1977, I.19777-003 (AMSA); 3, 55–60 mm SL, Portsea Pier, Port Phillip Bay, Victoria, Australia, 14 Feb 2000.

Tripterygion tripteronotus (n=20). 46 mm SL, Ceja Island, Adriatic Sea, 14 Jul 1972, NMNZ P. 25365; 3, 38–48 mm SL, Elounda, Crete, 10 Aug 1977, NMNZ P. 25421; 3, 28–55 mm SL, Banyals, France, 1977, NMNZ P. 11609; 7, 38–48 mm SL, Portinax (Ibiza), Spain, Jul 2001; 6, 36–46 mm SL, Pizza, Italy, Aug 2001.

Ucla xenogrammus (n=25). 25, 23–44 mm SL, Lizard Island, Australia, 14 Dec 1997.