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5.—The Western Australian psolid holothurian *Ceto cuvieria* (Cuvier)

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Abstract

A unique species of psolid holothurian formerly known as *Stolinus cataphractus* Selenka, with 15 tentacles, five large radially placed oral valves, extremely numerous ventral tube feet and more than 25 Polian vesicles, is redescribed here. Its apparent identity with a species illustrated by Cuvier in 1817 necessitates a change of name to *Ceto cuvieria* (Cuvier). Definite locality data are given for the first time; the species is known from three localities in south-west Australia. On the basis of gross morphological characters, *Ceto cuvieria* is sharply distinguished from all other members in the family Psolidae.

Introduction

Holothurians of the family Psolidae are not a conspicuous element in the Australian fauna. Clark (1946) recorded five species from Australia, while more than 75 species are known from world seas. Included in the Australian fauna is a species known only from Western Australia, which is unique in having 15 tentacles, and in having the strongly arched dorsal surface of the body covered by a thick leathery skin, which overlies the dorsal scales. Clark (1946) referred to the species as *Stolinus cataphractus* Selenka, and noted that its locality data are inexact at best.

Through the courtesy of Drs. W. D. L. Ride and R. George of the Western Australian Museum I received for study a large collection of dendrochirotid holothurians from Western Australia, and included in the collection were six specimens of "*Stolinus cataphractus*". Study of earlier literature shows that at present the species is incorrectly named, and that a psolid holothurian figured by Cuvier (1817) is undoubtedly conspecific with it. The opportunity is taken here to redescribe the species, and to make the necessary name changes.

For access to material, I am particularly grateful to Drs. W. D. L. Ride and R. George of the Western Australian Museum and Miss Ailsa M. Clark of the British Museum. I thank Miss Clark, Dr. D. J. G. Griffin (Australian Museum) and colleagues at the Smithsonian Institution for helpful discussions on the status of some holothurian names.

The correct name for "*Stolinus cataphractus*":

Cuvier (1817, 1830) illustrated a holothurian on Pl. XV, fig. 9 (reproduced in fig. 1, here) in his "*Règne Animal*", and called the species *Holothuria cuvieria*. On page 239, Cuvier makes the following statement (original in French):

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"*H. squamata*, Müll., Zool. Dan., X, 1,2,3. A small species inhabiting European seas; those of hot climates produce larger ones (1)"

The (1) refers to the footnote which reads as follows:

"Those which Péron calls the Cuvieries"

It is evident from Cuvier's illustration of *Holothuria cuvieria* that this species is the psolid from Western Australia (compare figs. 1 and 2 here). Both Bell (1882) and Lampert (1885) were aware that this was so, but Bell rejected the early species name, while Lampert referred to the species as *Psolus cuvieria* Jäger.

In the terms of the International Code of Zoological Nomenclature the species *Holothuria cuvieria* Cuvier is valid, but as Bell (1882) has pointed out, Blainville (1821) and Brandt (1835) were incorrect in citing Cuvier (or Peron in Cuvier) as the author of the genus-name *Cuvieria*, using Cuvier's footnote as a basis for their decision.



Figure 1.—Original illustration of *Holothuria cuvieria*. From Cuvier (1830); pl. XV fig. 9.

Jäger (1833) was the first to diagnose the genus *Cuvieria* for the echinoderms, and he included two species, which he referred to (p. 20) as "*Sp. 1 Squamata* Müller . . ." and "*Sp. 2 Cuvieria* . . . Cuvier . . ." The species *cuvieria* is the type-species of the genus *Cuvieria* by absolute tautonymy, according to Article 68 (d) of the Code.

Cuvieria Jäger is preoccupied (by *Cuvieria* Lesueur and Petit, 1807). Nevertheless the name persisted in use as a senior synonym in the holothurians for many years (e.g. Studer, 1877; Bell, 1881). Gistel (1848) was apparently aware of the precarious position of the

echinoderm genus-name *Cuvieria*, and (p. viii) proposed a replacement name, *Callisto*, as follows:

"*Cuvieria* (Agass. prodr. echin.): *Callisto*, N."

Unfortunately *Callisto* is also preoccupied (by *Callisto* Stephens, 1834), and thus is not available for echinoderms. Later in the same work (p. 174), Gistel (1848) proposed another new name for *Cuvieria*, as follows:

"*Cuvieria* (*H. squamata*, Müll.): *Ceto* (mihi)."

As the above was included in his section "Echinodermata" (p. 175), and as the name *H. squamata* Müller is obviously used in reference to the holothurian of that name, it is obvious that Gistel was referring to the echinoderm genus-name *Cuvieria*, and not to any other synonyms. There is also little doubt in my mind that *Ceto* is in fact being proposed here as a replacement for *Cuvieria*. Gistel may or may not have been aware that *Callisto* was preoccupied, but this now has no bearing on the case.

It may be argued that it was Gistel's intention to provide the name *Ceto* for *Holothuria squamata* only, and that the species name *cuvieria* should not be construed as belonging in the genus *Ceto*, but it would seem more logical to assume that *Ceto* was proposed simply to replace the genus name *Cuvieria*, and as the species *cuvieria* is ipso facto the type-species of *Cuvieria* then the combination *Ceto cuvieria* is valid.

Later authors have referred to the Western Australian species by various names (see synonyms below), and it is indeed remarkable that a species which is known from so few specimens (approximately six specimens, not including the collection described here) has been referred to under 6 generic names, and no less than 11 binomial combinations.

It has been suggested by some colleagues that the name *Stolinus cataphractus* Selenka, 1868 should be applied to this species; it is referred to as such by Clark (1946). If this step were taken, it would require application to the International Commission on Zoological Nomenclature for suppression in the interest of stability of the names *Holothuria cuvieria* Cuvier and *Ceto* Gistel. Clark (1946) did not have occasion to study specimens of this species, and did not present a case for maintaining the name *Stolinus cataphractus*. I feel that the interests of stability would best be served by retention of the name *Ceto cuvieria*, because it definitely fixes the identity of the species named *Holothuria cuvieria* by Cuvier, because *Ceto* is, as far as I can determine, a perfectly valid generic name, and because the troublesome names *Cuvieria*, *Callisto*, *Stolinus*, *Hypopsolus* and *Theelia* are thereby reduced to the status of junior synonyms. The use of the incorrect name *Stolinus cataphractus* by Clark (1946) does not appear to be sufficient justification for retention of that name.

Order Dendrochirotida Grube, 1840 (restricted Pawson and Fell, 1965)

Family Psolidae Perrier, 1902

Ceto Gistel, 1848

Cuvieria Jäger, 1833, p. 20 (preoccupied by *Cuvieria* Lesueur and Petit, 1807); type-species *Holothuria cuvieria* Cuvier, by absolute tautonymy.

Callisto Gistel, 1848, p. viii; replacement name for *Cuvieria* Jäger (preoccupied by *Callisto* Stephens, 1834).

Stolinus Selenka, 1868, p. 110; type-species *cataphractus* Selenka, by monotypy.

Psolus (*Hypopsolus*) Bell, 1882, p. 648; type-species *ambulator* Bell, by monotypy.

Theelia Ludwig, 1892, p. 350 (preoccupied by *Theelia* Schlumberger, 1891).

Type-species: *Holothuria cuvieria* Cuvier. (By original tautonymy).

Diagnosis: Psolids with five conspicuous radially placed oral valves. Anus with five or more inconspicuous valves. Sole with extremely numerous tube feet in all three radii, and scattered in two interradii. Large dorsal scales covered with leathery skin. Dorsal surface with scattered pores which contain tube feet, and which pass through or between scales. Tentacles 15. More than 25 Polian vesicles.

Content of the genus Ceto and status of Cuvieria porifera Studer:

Ceto is here regarded as monotypic. Studer (1877) described *Cuvieria porifera* from Royal Sound, Kerguelen Island, 65 fathoms. He diagnosed the species as follows:

"Dorsum medium alepidotum, sulcis decussatis corrugatum, interstitus 1-2 porosis, granulis raris munitis, margine squamis 1-2 porosis tectum. Facies ventralis mollis, ambulacris marginalibus, mediano nullo. Color fuscus. Hab. Kerguelen."

Theel (1886, p. 130) noted that the description is "...very summary and unsatisfactory. The species is possibly identical with Bell's *Psolus ambulator*" (*Psolus ambulator*=*Ceto cuvieria*; see synonymy below). Ludwig (1892) essentially repeated Theel's suggestion, and in a later paper (1898) synonymized the two "species" under the name *Theelia porifera*. Subsequently, some authors have come to regard *porifera* as a synonym of the species here referred to as *cuvieria*. Others, of whom the most recent is Clark (1946), have maintained that they are distinct.

The presence of very numerous tube feet in the midventral radius of *Ceto cuvieria* immediately separates that species from *porifera*, in which Studer (1877, p. 452) notes that the midventral radius is naked. I have not been able to examine material of *Cuvieria porifera*, and until more material becomes available, the status of the species is problematical. It is possible, however, that *Psolidium incertum* (Theel) from the vicinity of Kerguelen Island is synonymous with *Cuvieria porifera*. In his original description, Theel (1886, p. 86) notes that *P. incertum* has a naked midventral radius and that the dorsal

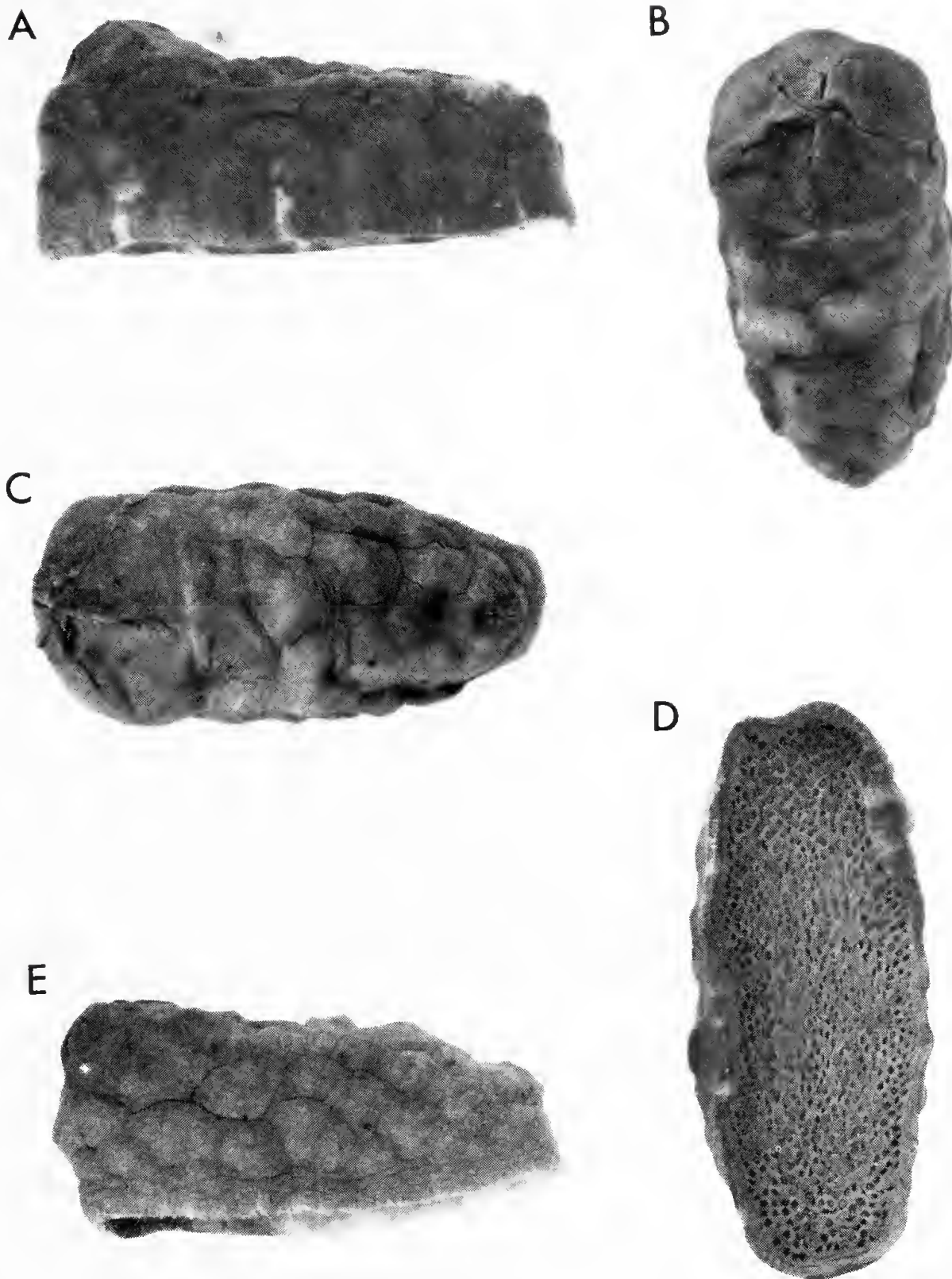


Figure 2.—*Ceto cuvieria* (Cuvier). A. Lateral view, 71mm specimen from locality 2. B. Oral view, 63 mm specimen from locality 1. C. Dorsal view, 63 mm specimen from locality 1; note dorsal pores. D. Ventral view, 71 mm specimen from locality 2. E. Lateral view, 63 mm specimen from locality 1, showing conspicuous dorsal pores.

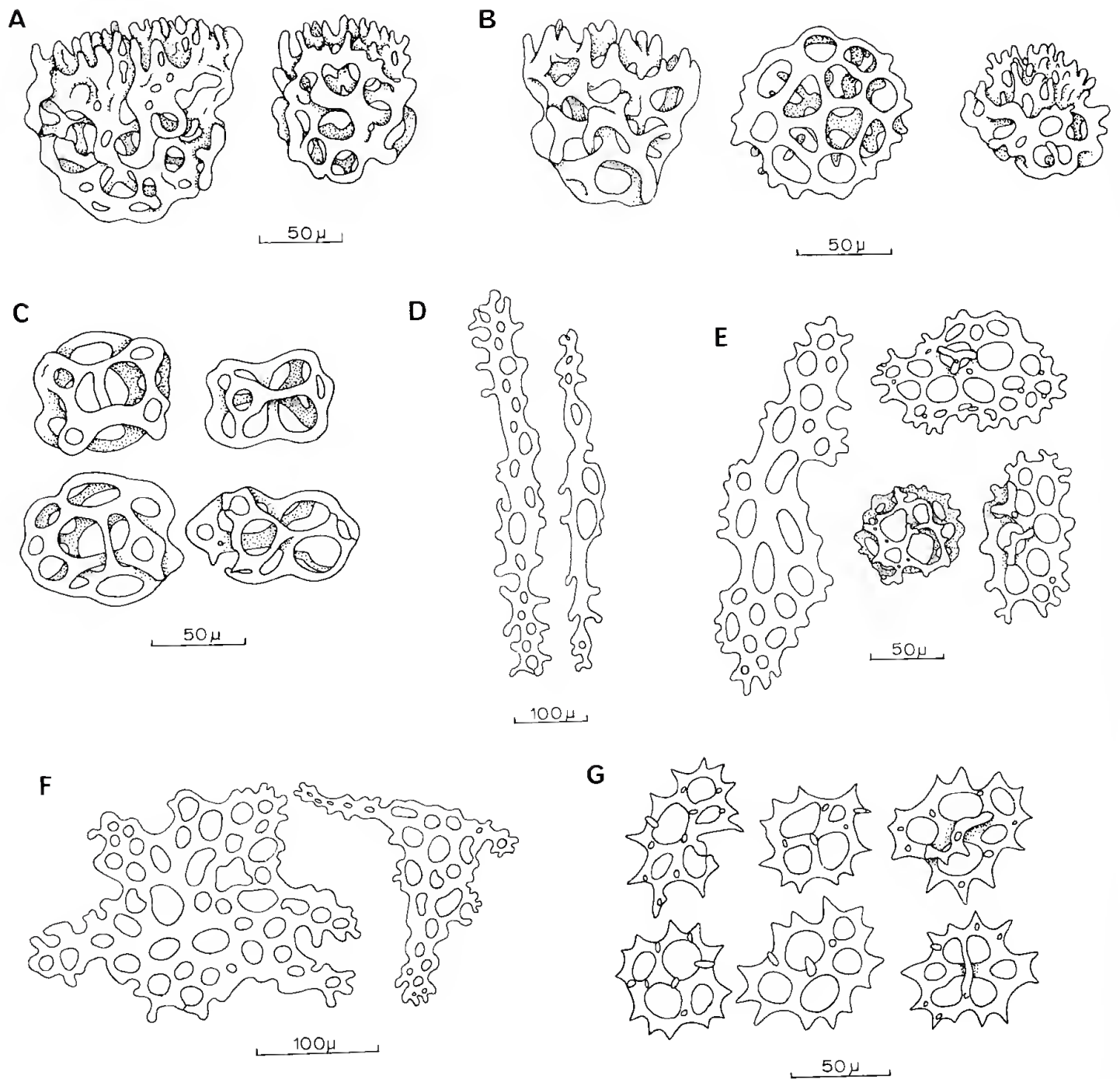


Figure 3.—*Ceto cuvieria* (Cuvier). A. Cup-shaped deposits from dorsal surface of body. B. Simpler types of cup-shaped deposits from sole. C. Open meshwork deposits from dorsal surface of body. D. Perforated rods from stems of tentacles. E. Deposits from tube feet. F. Smaller plates from branches of tentacles. G. One-to two-layered deposits from stems of tentacles.

scales carry one, two or three small pores. As both species are from the same general locality, and as both share the morphological features discussed above, the evidence for uniting them is quite strong. At least, the species *poriferus* should be referred to the genus *Psolidium*. The synonymy of the species is given here.

***Psolidium poriferum* (Studer)**

Cuvicria porifera Studer, 1877, p. 452; 1879, p. p. 123.

Psolus poriferus: Lampert, 1886, p. 122; Theel, 1886, p. 130; Lampert, 1889, p. 854.

Theelia porifera (part): Ludwig, 1898, p. 52.

Theelia ambulatrix: Erwe, 1913, p. 358.

The synonymy of *Ceto cuvieria* is now as follows:

***Ceto cuvieria* (Cuvier)**

Figures 1-3

Holothuria cuvieria: Cuvier, 1817, pl. 15 fig. 9; Blainville, 1821, p. 315; 1834, p. 192.

Cuvieria cuvieria: Jäger, 1833, p. 20.

Stolinus cataphractus: Selenka, 1868, p. 110, pl. 8 figs. 1,2; Clark, 1946, p. 413.

Psolus cuvierius: Semper, 1868, p. 63, 240.

Psolus (Hypopsolus) ambulätor: Bell, 1882, p. 648, pl. 48 fig. 2.

Psolus ambulätor: Lampert, 1885, p. 118; Theel, 1886, p. 131.

Psolus cuvieria: Lampert, 1885, p. 121.

Psolus cataphractus: Theel, 1886, p. 131.

Theelia ambulatrix: Ludwig, 1892, p. 350; 1894, p. 136, Erwe, 1913, p. 358.

Theelia cataphracta: Ludwig, 1892, p. 350.

Theelia porifera (part): Ludwig, 1898, p. 52.

Diagnosis: As for the genus (see above).

Remarks: Only approximately six specimens of this species have been recorded. Selenka (1868) had access to two specimens, and the remaining authors (Cuvier, 1817; Bell, 1882; Theel, 1886; Erwe, 1913) apparently each had one specimen at his disposal.

Material Examined: Six specimens from three localities, as follows:

1. Smith Rock, Recherche Archipelago, Southwest Australia, 15-37 fathoms (27-66 metres), 2 Feb., 1960, coll. R. W. George on "Bluefin", 2 specimens.

2. Four miles off Dunsborough, Geographe Bay, Western Australia, 55 feet (16.5 metres), 18 April, 1960, coll. B. R. Wilson, 3 specimens.

3. Three miles off Dunsborough, Western Australia, 50 feet (15 metres), 20 Dec., 1961, coll. B. R. Wilson and R. Slack-Smith, 1 specimen.

Description

External features: Total length of sole 58-71 mm. All specimens but one (locality 3) with tentacles retracted. Body elongate, oval, with well-defined flat sole; dorsal surface arched, mouth anterior dorsal, surrounded by five conspicuous radially placed triangular oral valves;

less conspicuous anus posterior dorsal surrounded by five or more very small valves (Fig. 2c). Expanded specimen with 15 richly branched tentacles, all of approximately equal size. Colour in alcohol variable; specimens from localities 2 and 3 dark brown to black dorsally, with scattered grey-brown patches dorsally and laterally. Sole uniformly dark grey to grey-brown or black. Specimens from locality 1 mottled and variegated dark grey or greyish white dorsally; sole dark grey to greyish-white. In expanded specimen from locality 3, tentacles and introvert uniformly black.

Dorsal surface of body extremely thick (2-3 mm), consisting of several large scales up to 1 cm in diameter, overlain by thick leathery rugose skin filled with calcareous deposits. Scattered on dorsal surface but tending to be concentrated in areas of dorsal radii are pores, through which pass small tube feet, which are often retracted. Pores either single, or in pairs, sometimes superficially resembling echinoid diplopores. In greyish coloured specimen from locality 1, pores conspicuous, black, approximately 0.5 mm in diameter. In other specimens pores less conspicuous against darker coloured background. On dorsal surface of greyish specimen are 27 pores; of these 8 are located close to anal aperture. This total of 27 includes a single pore on each of the large oral valves; in some specimens, the pores are more frequently double than single; this is especially noticeable on the oral valves. Dissection shows that well developed tube feet pass either between large dorsal plates, or through them. The holes which pass through the plates, often take a meandering course.

Dorsal surface fringed toward ventral surface by numerous smaller plates; these form well-defined edge to dorsal surface, delimiting it from sole.

Sole thick, leathery, with extremely numerous tube feet, which are closely aggregated at anterior and posterior ends of sole and along lateral ventral radii. They are less numerous near centre of sole, but are nevertheless present in large numbers on midventral radius and scattered all over interradial areas. Tubefeet highly retractile, and can be retracted deep into sole, leaving conspicuous holes. Scattered around sharp ventral edge of dorsal surface are small tubefeet, which are presumably sensory.

Internal features: Dissection rendered extremely difficult by thickness of dorsal body wall and sole. Internal anatomy presents many unusual features, which will form subject of later paper. One specimen (female) dissected; briefly, major features are as follows:—

Gut typical, with single coil. Respiratory trees well developed, short, less than $\frac{1}{3}$ body length with numerous branches. Stone canal short, terminating in nodular madreporite located on right side of dorsal mesentery. Polian vesicles numerous, 28 being regularly scattered around posterior edge of calcareous ring. Vesicles bulbous, large, up to 10 mm in length.

Retractor muscles short, well developed, attaching to radial longitudinal muscles by means of a muscular membrane at a level slightly posterior to oral valve complex. Radial longitudinal muscles thin straps. Circular muscles well developed, thrown into ridges about 2-4 mm apart.

Gonad a bunch of unbranched caeca up to approximately 20 mm long, originating anteriorly at level of posterior edge of oral valves. Caeca contain eggs approximately 0.8 mm in diameter. Genital duct short, opening to exterior mid-dorsally within crown of tentacles.

Calcereous deposits: Scales on dorsal surface rounded, smooth, extremely thick (1.8 mm), joined to each other by flexible leathery integument. Overlying massive dorsal plates are two kinds of deposits. First type are longer than broad, consisting of an open meshwork of calcite (Fig. 3C) somewhat reminiscent of the hourglass-shaped deposits in some species of *Lissothuria* (see Pawson, 1967). These are extremely numerous, averaging 93 μ in length. Also present and also extremely numerous are second type, dense deposits, approximately cup-shaped, with one end rounded and the other truncate (Fig. 3A). Cup consists of a dense and intricate network of calcite. Truncate surface carries numerous rounded projections. Average length of cups 105 μ ; average greatest width, across truncate portion, 90 μ .

Sole contains "cups" which show some similarities to those of dorsal surface, except that cup portion is generally shorter, and sole spicules tend to be somewhat flatter than those from dorsal surface. However, as in cups of dorsal surface, one side of cup is rounded, while other carries numerous short projections, and entire spicule is composed of complex network of calcite (Fig. 3B). Average diameter across greatest width of cups is 96 μ . No "hourglass-shaped" deposits found in sole.

Tube feet of sole with well-developed 1-2 layered end plates approximately 800 μ in diameter. These are surrounded by smaller perforated plates which may be simple and one-layered or two-layered (Fig. 3E), and vary greatly in size. Dorsal tube feet apparently lack end plates but do contain numerous one-layered perforated plates, polygonal to circular, 136 μ in average length.

Branches of tentacles armored with massive curved plates with numerous perforations, the plates variable in shape, up to 1.1 mm long. Numerous smaller, simpler plates (Fig. 3F), greatly variable in shape and size, also present. Stems of tentacles contain elongate perforated rods (Fig. 3D) and also perforated one-to two-layered "buttons" with marginal and surface projections (Fig. 3G). All obviously derived from a four-holed form, in which two holes are larger than others.

Additional material: British Museum (Natural History) specimen No. 63.9.23.32, (holotype of *Psolus (Hypopsolus) ambulator* Bell, 1882). Specimen virtually identical to those described above. Cups in sole slightly smaller (average diameter 88 μ) than those in Western Australian Museum specimens.

Distribution: Until now, no definite locality data have been available for this species. Jäger (1833), Selenka (1868), Bell (1882), Theel (1886) and Ludwig (1898) merely cite "Australia" as the locality for their material. Erwe (1913) described a single specimen from the collection of the museum at Perth, Western Australia. The present records definitely establish the fact that the species occurs off South West Australia, in depths of 15-66 metres.

Remarks

The major morphological features of the present specimens agree in large part with those described by Selenka (1868), Bell (1882) and Theel (1886). None of these authors, however, called attention to a most conspicuous feature of this species, and that is that the oral valves are radial in position, while in all other psolids with large oral valves they are interradial. Further, although both Bell (1882) and Theel (1886) described the pores in the dorsal surface of the body, neither noted that the pores contain well-developed tube feet. The feet can be completely retracted within the pores, and usually they are retracted so that they are not visible without dissection. The most remarkable feature of the internal anatomy is the presence of a large number of Polian vesicles. Selenka (1868) noted that a "large number" (p. 111) of Polian vesicles are present, while in the specimen dissected here, there are 28 vesicles.

The relationships of *Ceto cuvieria* are not clear. Within the Psolidae, the cosmopolitan genus *Psolidium* Ludwig and the New World tropics genus *Lissothuria* Verrill also carry tube feet on the dorsal surface of the body, and the latter genus has hourglass-shaped deposits (see Pawson, 1967) which show some similarities to those of the present species. But the presence in *Ceto cuvieria* of radially placed oral valves, a large number of Polian vesicles, 15 tentacles, and a thick leathery skin overlying the scales sharply distinguish the species from all others in the family Psolidae.

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6.—Two new genera and five new species of Percophidid fishes (Pisces: Percophididae) from Western Australia

by R. J. McKAY*

Manuscript received 16 June 1970; accepted 14 December 1970

Abstract

Two new genera, *Branchiopsaron*, *Liopsaron*, and three new species belonging to the genera *Bembrops* and *Chrionema* are described from Western Australia.

Introduction

A collection of fishes trawled in 15 to 202 fathoms off the north Western Australian coast has been donated to the Western Australian Museum by Captain K. Ozawa of the Japanese Research Vessel *Umitaka Maru*. The collection contains many fishes unrecorded from Western Australia.

The family Percophididae is predominantly Indo-Pacific in distribution; *Percophis* is only found in the tropical Atlantic, and the genera *Bembrops* and *Chrionemastax* have representatives in the Atlantic Ocean as well as the Indo-Pacific.

Only the genus *Acanthaphritis*, from the Arafura Sea, has been recorded from the eastern Indian Ocean. This family has been previously recorded in eastern Australian waters by one species, *Enigmapercis reducta* Whitley, from New South Wales.

A brief key to the percophidid genera is given in Schultz (1960: 273-277) and a key to some of the genera is provided by Okamura and Kishida (1963: 47-48).

Key to the genera of Percophididae

- | | | | |
|---|----|-----------------------------------|---|
| 1.A Opercle with two conspicuous spines; subopercle with single spine; scales on body ctenoid, the anterior-most scales of the lateral line armed with a keel; branched caudal rays 11 | 2 | | |
| B Opercle with a single spine, a ridge, or unarmed; subopercle without a spine; scales on body cycloid or weakly ctenoid, the anterior-most lateral line scales without a keel; branched caudal rays 11 or less | 4 | | |
| C Opercle with a single spine; subopercle with a strong spine; no scales on body, lateral line absent; branched caudal rays 8 | | <i>Liopsaron</i> new genus | |
| 2.A A dermal tentacle or flap on the posterior end of the maxillary | | <i>Bembrops</i> Steindachner 1876 | |
| B No dermal tentacle or flap on maxillary | 3 | | |
| 3.A Space between mandibular rami naked | | <i>Chrionema</i> Gilbert 1905 | |
| B Space between mandibular rami scaled | | | <i>Chrionemastax</i> Ginsburg 1955 |
| 4.A Lower jaw projecting, noticeably longer than upper jaw; dorsal spines 8 or 9; branched caudal rays 11 | | | <i>Percophis</i> Quoy and Gaimard 1824 |
| B Lower jaws not projecting; dorsal spines 6 or less; branched caudal rays 7 or 8 | 5 | | |
| 5.A Outer edge of nasal openings ringed with inwardly projecting cirri | | | <i>Cirrinasus</i> Schultz 1960 |
| B Outer edge of nasal openings without cirri | 6 | | |
| 6.A Dorsal spines 2 or 3; dorsal rays 15-18 | 7 | | |
| B Dorsal spines 4 to 6; dorsal rays 20-26 | 8 | | |
| 7.A Branchiostegal rays 7 | | <i>Enigmapercis</i> Whitley 1936 | |
| B Branchiostegal rays 5 | | <i>Matsubaraea</i> Takai 1953 | |
| 8.A Subopercle with a posterior flap that extends on to the lower part of the pectoral base; scales on body weakly ctenoid; teeth on vomer | 9 | | |
| B Subopercle without a posterior flap; scales on body cycloid; no teeth on vomer | 11 | | |
| 9.A Ceratohyal with an inwardly directed process; dorsal fin rays 24-26; anal rays 29-31; branchiostegal rays 7 | | | <i>Branchiopsaron</i> new genus |
| B Ceratohyal without an inwardly directed process; dorsal fin rays 20-23; anal rays 24-26; branchiostegal rays 6 | 10 | | |
| 10.A Cleft of mouth oblique; opercle unarmed; no barbel on upper jaw | | | <i>Acanthaphritis</i> Günther 1880 |
| B Cleft of mouth almost horizontal; opercle with a ridge along the dorsal margin; a barbel at the symphysis of the upper jaw | | | <i>Spinapsaron</i> Okamura and Kishida 1963 |

* Western Australian Museum, Perth, Western Australia

11.A Inner edge of preopercle with a row of cirri that interdigitate with gill rakers on the first gill arch; anal rays 27; fin rays of first dorsal and anal elongate ... *Pteropsaron* Jordan and Snyder 1902

B Inner edge of preopercle without cirri; anal rays 22; fin rays not elongate ... *Osopsaron* Jordan and Starks 1904

Okamura and Kishida (1963: 46-47) have made an attempt at grouping some genera. Following a survey of the literature I have included all the genera of Percophidae in the grouping below. Many genera are monotypic and a revision of the family, although perhaps still premature, may reduce the number of genera considered below.

Group 1 contains *Bembrops*, *Chrionema* and *Chromystax*. The opercle has two spines and the subopercle one spine in this closely related group.

Group 2 contains *Acanthaphritis*, *Branchiopsaron* and *Spinapsaron*, these genera possessing preorbital spines, a subopercular flap (also found in *Matsubaraea*) and 4-5 dorsal spines.

Group 3 contains *Pteropsaron* and *Osopsaron*; these genera lack the preorbital spines and subopercular flap.

Group 4 contains *Matsubaraea* and *Enigmapercis*. These two genera seem to be morphologically similar in having teeth on the palatines, 2-3 dorsal spines, 18-19 dorsal rays, reduced gill rakers, almost cycloid body scales and no preorbital spines. The branchiostegal ray count differs, and Whitley (1944 p. 254, text fig.) shows the opercles as approaching or overlapping the pectoral fin base, whereas in *Matsubaraea* there is a distinct subopercular flap. This group is similar to groups 2 and 3.

The three remaining genera of the family, *Cirrinus*, *Percophis* and *Liopsaron* are quite distinct from the genera listed above. *Cirrinus* approaches group 4 in fin formula; *Percophis* is very different in having a large number of dorsal and anal fin elements (D.VIII-IX, 31; A.i 38-40); *Liopsaron* is most aberrant in lacking scales, and has a single opercular and subopercular spine. In general morphology this latter genus is rather similar to groups 2, 3 and 4 but shows relationships with group 1 in having a subopercular spine.

Branchiopsaron McKay, new genus

Type species: *Branchiopsaron ozawai* McKay, new species.

Body slender and subcylindrical, covered with large thin scales with weakly ctenoid ragged edge. Opercles and cheeks with cycloid scales; snout naked. Lateral line along mediolateral axis of body, scales differentiated. Eyes large, mostly dorsal in position and separated by very narrow interorbital ridge. Snout depressed, with well developed preorbital spines not projecting

beyond outer margin of upper jaw. Upper jaw slightly longer than lower; mouth slightly oblique; maxillary expanded posteriorly, without flap. Upper and lower jaws with about three rows of small depressable teeth; vomer with two well-separated, raised mounds bearing strong teeth; palatines without teeth. Tongue without teeth, narrow posteriorly between vomerine patches, but dilated anteriorly into spoon-shaped process, lying well anterior to vomer. Ceratohyal with terminal well-developed inwardly-projecting process. Opercle with single spine; subopercle with membranous posterior flap covering lower half of pectoral fin base: posterior-dorsal edge smooth. Gill membranes free from isthmus. Two dorsal fins, first fin low with five slender spines; second fin with twenty four to twenty six rays. Anal fin rays twenty nine to thirty one. Branchiostegal rays seven.

This new genus is similar to the genera *Spinapsaron* Okamura and Kishida, *Pteropsaron* Jordan and Snyder, *Osopsaron* Jordan and Starks, and *Acanthaphritis* Günther, but can be separated by the high dorsal and anal fin counts, and the presence of a well developed, flattened hook-like process on the terminal end of the ceratohyal; this process projects into the branchial chamber, and has not been reported in the above genera. The high branchiostegal ray count of 7 is also diagnostic.

Branchiopsaron is most similar to *Spinapsaron* in possessing a flap on the subopercle, preorbital spines, and edentulous palatines, but differs in having a high ray count, no barbel on the premaxillary, a process on the ceratohyal, seven branchiostegal rays instead of six, and in lacking the high posterior rays of the soft dorsal fin. The posterior-dorsal margin of the subopercular flap is smooth in *Branchiopsaron* instead of serrated as in *Spinapsaron*. *Acanthaphritis*, the only other genus with what appears to be a developed subopercular flap (Günther, 1880, pl. XVIII, fig. A), has the cleft of the mouth oblique, unarmed opercles, a lower number of dorsal and anal rays, and six branchiostegal rays.

Derivation: *Branchiopsaron* comes from the Greek *branchia* meaning gills and *psaron* meaning little fish. Gender masculine.

Branchiopsaron ozawai, McKay, new species

(Figures 1, 1a, 1b)

Description: Based on the holotype; counts and proportions of 6 paratypes given within parentheses.

Dorsal V, 26 (V, 24-26), anal 31½ (29-31½), pectoral 21 (21), pelvic I, 5 (I, 5).

Lateral line scales unlike those of remainder of body in possessing a sculptured margin (see figure 1b) 40 in longitudinal series (39-43); 3 above, 3 below lateral line.

Head 31.3 (29.4-31.1), depth 12.3 (10.9-11.8), snout 4.2 (4.0-4.7), eye 9.9 (10.1-10.9), interorbital ridge 0.7 (0.6), head width 14.9, length of maxilla 14.8, snout tip (between preorbital spines) to first dorsal origin 31.2 (32.1-33.2), snout tip to second dorsal origin 15.7, snout tip to vent 36.3. Second dorsal fin base 51.8,

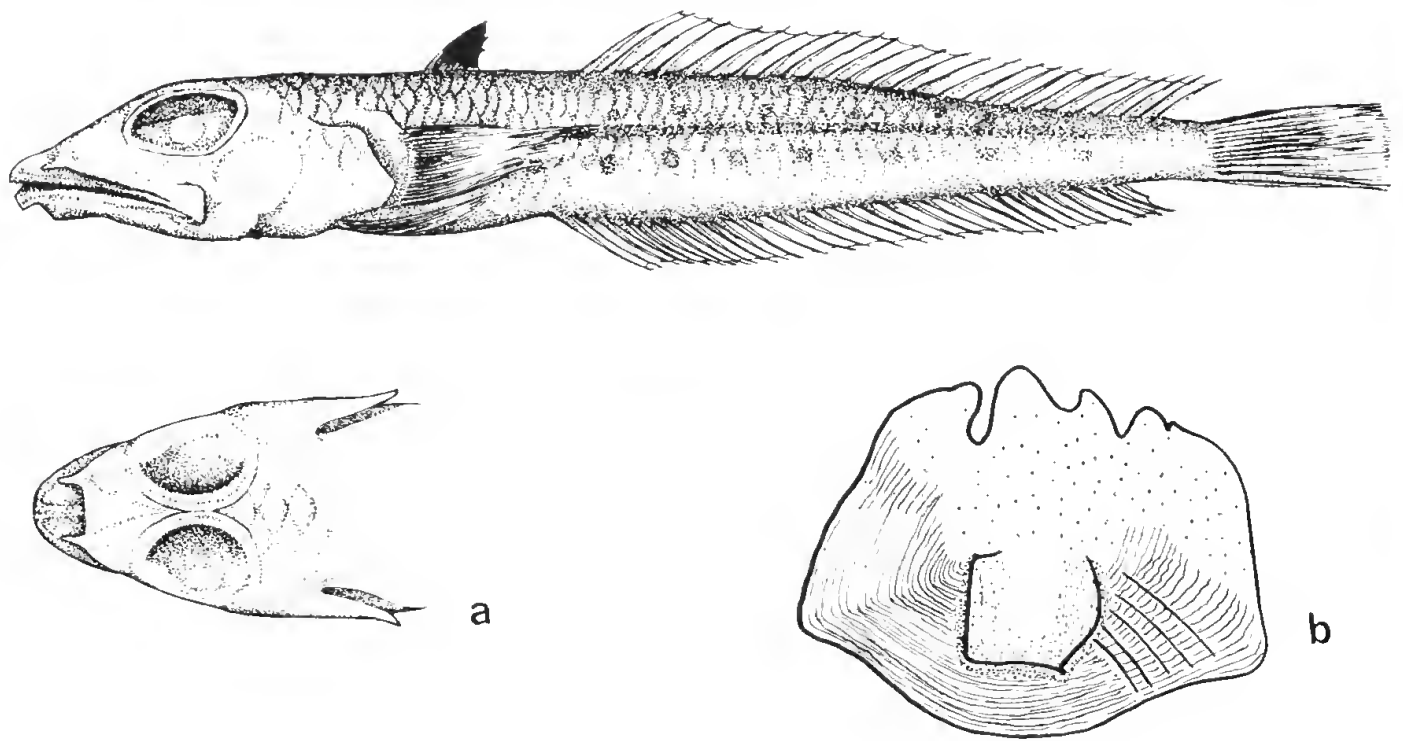


Figure 1.—*Branchiopsaron ozawai* sp. nov. lateral view; 1a. dorsal view of head; 1b. lateral line scale.

anal fin base 60.0, length of pectoral fin 20.3, length of pelvic fin 13.9, length of caudal fin 18.9, length of first dorsal spine 9.7, length of 3rd dorsal ray 9.5, length of 4th anal ray 7.2, length of preorbital spine 2.2. Depth of caudal peduncle 5.0; all expressed as percent of standard length taken from between the preorbital spines to the commencement of the caudal fin.

Head somewhat flattened above, widest at preopercle margin. Mouth wide with upper jaw slightly projecting beyond lower jaw. Nostrils situated close to anterior margin of eye. Space between preorbital spines concave; spines reaching anterior margin of premaxillae. Maxilla extending little beyond middle of orbits, its posterior end expanded and truncate, without flap. Teeth small and conical in 2-3 rows in both jaws. Gill rakers consisting of low patches of teeth situated along gill arch, one patch above angle, nine below. No row of cirri on inner preopercle edge. Hind margin of preopercle free and quite thin. Subopercle with flap of skin extending over basal half of pectoral fin. Pectoral fin extending to 4th dorsal ray. Pelvics commencing well before pectorals; their bases widely separated. Second dorsal fin originating above 4th anal ray. Caudal fin with eleven rays; seven rays branched.

Colour in formalin: Body with dorsal scale pockets possessing dark margins, sides with a diffuse longitudinal band (broken into dusky spots in one paratype), lower sides white. Head greyish, with grey opercles. First dorsal fin base pale, remainder of fin intensely black. Second dorsal, anal, pectoral, pelvic and caudal fins hyaline.

Colour in life: With about seven bright lemon-yellow spots, about one scale in diameter situated dorsally to the faint longitudinal grey band on sides.

Holotype: WAM P 19153, 105.8 mm in standard length, trawled by *Umitaka Maru* in 350 metres, Station UMPT 6905, 17°17'0"S, 119°57'0"E, December 20, 1969.

Paratypes: WAM P 19152, s.l. 108.5 mm; WAM P 19154, s.l. 86.5 mm; WAM P 19155, s.l. 93 mm; WAM P 19156, s.l. 70 mm; WAM P 19157, s.l. 65.5 mm; WAM P 19158, s.l. 57 mm; Station UMPT 6905, data as above.

Derivation: Named in honour of Captain K. Ozawa of the *Umitaka Maru*.

***Bembrops aethalea* McKay, new species**

(Figure 2)

Description: Described from the holotype; proportions and counts of 9 paratypes given within parentheses.

Dorsal fin VI 14 (VI, 14-15); anal 16½ (16½); pectoral 27 (27); pelvic I, 5 (I, 5). Gill rakers 2/13.

Lateral line scales 54 (51-56). Transverse scales below rayed dorsal fin origin 6 above, 4½ below lateral line; 3 scales between lateral line and first dorsal fin.

Head 38.3 (36.0-39.4), depth 13.7 (12.7-15.3), snout 10.3 (9.6-11.1), eye 10.7 (9.0-9.8), inter-orbital 2.3 (1.1-2.2) snout to first dorsal origin 38.1 (36.9-38.2), depth of caudal peduncle 6.5, pectoral length 21.5, pelvic length 17.5, caudal fin length 19.8, second dorsal base 33.9, anal base 35.1, greatest width of head 19.5, length of maxilla 14.7, all expressed as percent of standard length.

Head flattened dorso-ventrally, widest at opercles. Mouth wide with lower jaw projecting beyond upper jaw. No preorbital spines. Maxilla extends little beyond anterior margin of eye; posterior end truncate with well developed flap of skin extending to middle of eye. Opercular and subopercular spines present and equidistant; opercular flap reaching sixth lateral-line scales. Small spine directed posteriorly above origin of opercle. Anterior four lateral-line scales with median raised keel. Tongue without teeth; tip slightly expanded. Teeth on vomer and palatines. Fine conical teeth on both jaws, those on upper jaw extending outside mouth. Gill rakers 2/13 (2/13-4/12) well developed with a row of small spines on inner surface. Gill membranes free from isthmus. First dorsal spine not filiform.

Colour in formalin: Body with about 13 smoky cross-bars on lower sides, cross-bars varying between one and 3 scales in width. Edge of dorsal scales dark forming a network pattern on the back. Upper and lower caudal rays dusky (a caudal spot present on the base of the upper caudal rays in some paratypes, the spots fading with an increase in body length). First dorsal membranes greyish; second dorsal fin membranes with dark basal streaks. Anal and pelvic fins hyaline. Pectoral fin faintly dusky with a vague basal streak. In life, bright lemon cross-bars present on the body.

Holotype: WAM P 19144, 177 mm standard length, 250 metres, 13°45'S, 123° 30' 5"E, Station UMPT 6909, December 23, 1969.

Paratypes: WAM P 19142, s.l. 179 mm; WAM P 19143, s.l. 180 mm; WAM P 19145, s.l. 183 mm; WAM P 19146, s.l. 138 mm; WAM P 19147, s.l. 145.7 mm; Station UMPT 6909. WAM P 19148, s.l. 179 mm; WAM P 19149, s.l. 175 mm; WAM P 19150, s.l. 170 mm; WAM P 19151, s.l. 121 mm; Station UMPT 6911, depth 242 metres, 13°47'0"S, 123°18'0"E, December 23, 1969.

Two other Indo-Pacific species of *Bembrops* lack a filamentous first dorsal spine, *B. caudimaculata* Steindachner and *B. adenensis* Norman. From *B. caudimaculata* this new species differs in coloration (membranes of the first dorsal not black; no vague spots along body), and the pectoral fin ray count is 27 instead of 23-24. The lateral line count is 51 to 56 instead of 42-48. The snout of *B. aethalea* is scaled not naked as in *B. caudimaculata*.

From *B. adenensis* the higher lateral line count (46-48 in *B. adenensis*), and the presence of smoky bars on the lower sides rather than 3 or 4 dark blotches (Norman 1939: 69-70) are diagnostic.

Derivation: *aethalea* from the Greek *aethalos* meaning smoke.

***Bembrops indica* McKay, new species**

Description: Described from the holotype: proportions and counts of 5 paratypes given within parentheses.

Dorsal fin VI, 15 (VI, 15); anal 17 (17), pectoral 28 (28), pelvic I, 5 (I, 5). Gill rakers 3/15.

Lateral line scales 66 (64-65). Transverse scales below rayed dorsal fin origin 7 to lateral line, 6 below.

Head 37.8 (36.4-39.3), depth 11.3, snout 11.4 (10.3-12.1), eye 8.2 (7.8-8.5), interorbital 1.1 (0.95-1.0), depth of caudal peduncle 5.0, pectoral length 20.2, pelvic length 15.2, caudal length 18.6, second dorsal base 34.0, anal base 34.7, greatest width of head 14.2, length of maxilla 10.5, all expressed as percent of standard length.

Head flattened dorso-ventrally, widest at opercles. Mouth wide, with lower jaw projecting beyond upper jaw. No preorbital spines. Maxilla extending little beyond anterior margin of eye; posterior margin truncate with flap of skin extending almost to middle of eye. Opercular and subopercular spines present; middle spine closer to upper opercular spine than to subopercular spine. Opercular flap reaching eighth lateral line scale. Small spine directed posteriorly above origin of opercle. Anterior five lateral line scales with median raised keel. Tongue without teeth; tip slightly expanded. Teeth on vomer and palatines. Fine conical teeth on both jaws, those on upper jaw extending outside mouth. Gill rakers 4/14, well developed with a row of small spines on inner surface. Gill membranes free from isthmus. First dorsal spine filiform, reaching second dorsal ray when spine depressed.

Colour in formalin: Body with about 12 diffuse dark spots along lateral line extending 2-3 scales above and below the line. A series of about 9 faint dark spots longitudinally above lateral line, the first 2 of this series on the anterior part of the lateral line. Dorsal midline with about 12 faint dusky spots, those along the second dorsal fin situated at the base of the 2nd, 4th, 6th, 8th, 11-12th and 14th rays. A

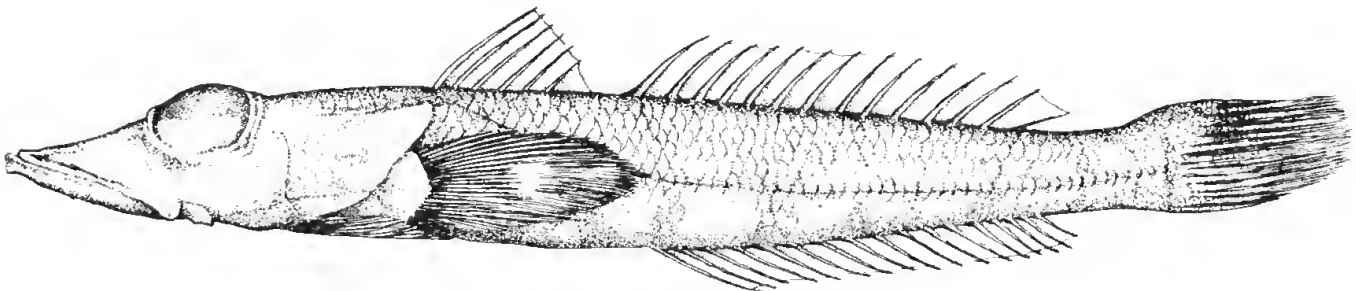


Figure 2.—*Bembrops aethalea* sp. nov. lateral view.

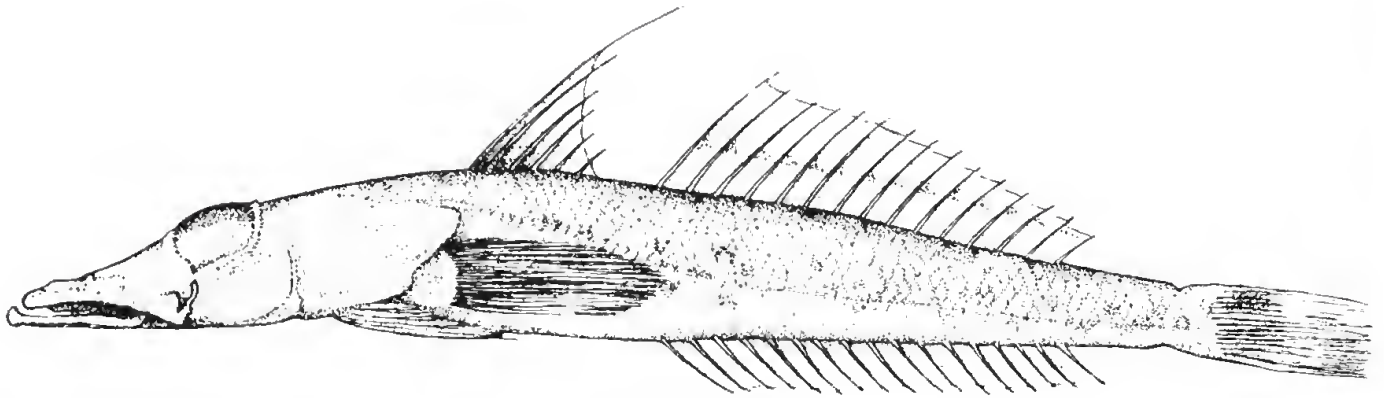


Figure 3.—*Bembrops indica* sp. nov. lateral view.

dark spot present at upper base of caudal fin. Fins pale to dusky, the membrane between the first three dorsal spines dark. A small dark spot at the base of the humeral spines. (One paratype P 19137 has well defined round spots in 2 to 3 series on sides.) Second dorsal with a submarginal black band; tip of caudal with a dark bar.

Holotype: WAM P 19138, 161.5 mm standard length, collected in 350 metres, 17°17'0"S, 119°57'0"E. Station UMPT 6905, December 20, 1969.

Paratypes: WAM P 19137, s.l. 158 mm; WAM P 19139, s.l. 79.6, Station UMPT 6905; WAM P 19140, s.l. 192 mm; WAM P 19141, s.l. 119 mm, Station UMPT 6913, 62 metres, 13°43'5"S, 128°38'6"E, December 26, 1969; WAM P 19162, s.l. 99 mm; WAM P 19163, s.l. 172 mm; Station UMPT 6910, 370 metres, 13°28'3"S, 123°09'7"E, December 23, 1969.

From *B. filifera* Gilbert this new species differs in having 17 instead of 18 anal rays, a short snout, shorter maxillary and different coloration (Gilbert, 1905 : 643-644, pl. 84). From all other species with an elongate first dorsal spine *B. indica* differs in having 64-66 lateral scales. The Atlantic *B. anatirostris* Ginsburg is morphologically similar but has the second dorsal spine produced and has only one series of lateral spots on the body (Ginsburg, 1955 : 635-637).

It is noteworthy that two specimens, from Station UMPT 6913, were taken in shallow depth (62 metres) whereas the other five all came from much greater depths, between 350 and 370 metres.

Derivation: *indica* in relation to the Indian Ocean.

***Chrionema chlorotaenia* McKay, new species**
(Figure 4)

Description: Described from the holotype; proportions and counts of 7 paratypes given within parentheses.

Dorsal fin VI, 16½ (VI, 16-17), anal 25 (25-26½), pectoral 24, pelvic I, 5. Gill rakers 5/15. Lateral line scales 79 (80-85). Transverse scales below origin of second dorsal fin 13 above lateral line, 6½ below.

Head 33.5 (33.2-35.9), depth 13.4, snout 8.8 (8.3-8.9), eye 8.1 (8.3-9.9), interorbital space 1.3 (0.84-1.4), length of maxilla 13.4 (12.8-14.4), snout tip to first dorsal origin 33.5 (33.6-34.9), greatest width of head 17.7, depth of caudal peduncle 5.2, length of pectoral 17.5, length of pelvic 15.6, length of caudal 16.9, length of second dorsal base 36.2, length of anal base 43.4, longest dorsal ray 11.9, longest anal ray 7.7, length of second dorsal spine 12.0, all expressed as percent of standard length.

Head slightly flattened dorso-ventrally, widest at opercles. Mouth wide with the lower jaw projecting beyond upper jaw anteriorly, but wide upper jaw extending beyond lower jaw laterally. No preorbital spines. Most of snout naked. Maxilla extending to front third of eye; posterior margin truncate, without a flap of skin. Opercular and subopercular spines present; middle spine closer to upper opercular spine than to subopercular spine. Opercular flap reaching eighth lateral line scale. Low spine present at commencement of lateral line. Anterior five lateral line scales with median raised keel. Tongue without teeth, tapered anteriorly with rounded tip. Teeth on vomer and palatines. Fine conical teeth on jaws, those of upper jaw extending outside mouth. Gill membranes free from isthmus. Angle of preopercle with three very small points.

Colour in alcohol: Body with about 11 vague cross-bars variable in width; sides of body with three large and 4 small alternating dusky areas. Head dusky with vague, slightly oblique bars on the opercles. Scales with darker edges forming a network pattern on cheeks and back.

Premaxillae dark, lower caudal rays dark, membrane between first and second dorsal spines slightly darker than remainder of fin, second dorsal fin hyaline, anal fin with dark margin, pectoral fins slightly dusky, pelvic fins with inner rays dark.

Colour in life: Lemon-yellow cross-bars present on the body; two large lemon spots on opercle flap, smaller lemon spots before eyes.

Holotype: WAM P 19136, 194 mm in standard length, 350 metres, 17° 17' 0" S, 119° 57' 0" E, Station UMPT 6905, December 20, 1969.

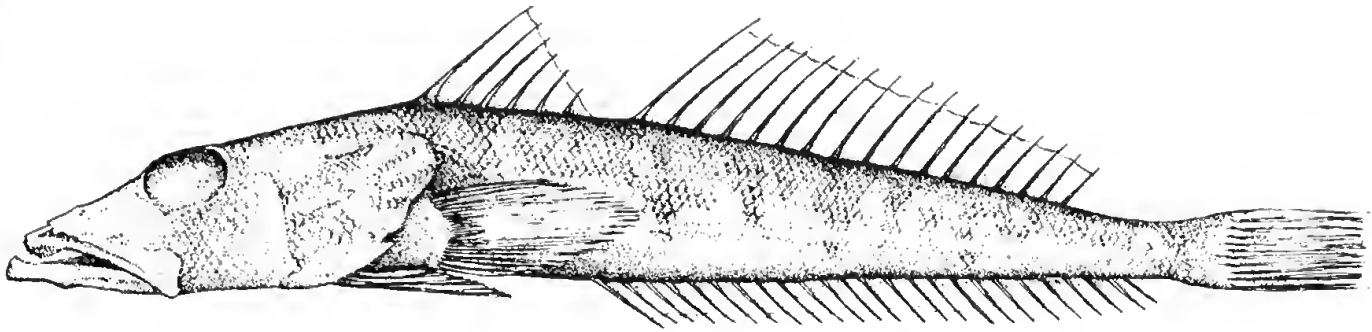


Figure 4.—*Chironema chlorotaenia* sp. nov. lateral view.

Paratypes: WAM P 19129, s.l. 187; WAM P 19130, s.l. 187 mm; WAM P 19131, s.l. 175 mm; WAM P 19132, s.l. 193 mm; WAM P 19133, s.l. 169 mm; WAM P 19134, s.l. 156 mm; WAM P 19135, s.l. 131 mm; Station UMPT 6905, December 20, 1969.

Very similar to *Chironema chryseres* Gilbert, the only other species in the genus, but differs in the higher lateral line count (79-85 instead of 72 or 76), the absence of a well developed preopercular spine, shorter snout, 25-26 anal rays (*C. chryseres* 24) and the shorter predorsal length (33.5-34.9 percent instead of 38 percent).

Derivation: *chlorotaenia* from the Greek *chloros* meaning greenish-yellow and *taenia* meaning banded.

Liopsaron McKay, new genus

Type species *Liopsaron insolitum* McKay, new species.

Body slender, without scales, head naked. Lateral line absent, no pores on body, a conspicuous nerve present below the skin immediately behind the pectoral fin; this nerve continuing along the middle of the sides, with branches originating near the upper pectoral fin origin and about midway along the pectoral fin length.

Eyes large, dorso-lateral, and separated by a very narrow interorbital space. Snout short, without preorbital spines. Upper jaw longer than lower; mouth almost horizontal, maxillary without a flap. Upper and lower jaws with two to three rows of small depressable teeth; vomer with numerous very small teeth; palatines without teeth. Tongue without teeth.

Opercle with a single strong spine projecting a little beyond the opercular flap; upper origin of opercle with a conspicuous, small, tube-like pore. Subopercle with a strong spine extending beyond the level of the opercular spine but not extending beyond the subopercular flap which is somewhat pointed and forms a horizontal floor to the posterior branchial chamber. Ceratohyal without a process. Gill membranes united to isthmus and attached posteriorly between the pectoral and pelvic fin origins. Pectoral fin with a fleshy base separate from the body anteriorly for a short distance and bound to the body posteriorly by almost transparent skin. Pelvic fins originating before pectorals, their bases widely separate. Anal fin commencing below the third to fourth dorsal ray. Branchiostegal rays six.

This new genus differs from all other genera within the family in lacking scales. Scale pockets are absent and no lateral line pores were found. The gill membranes are horizontally disposed between the subopercular spine and the isthmus to which they are joined. The closest relative is unknown at present.

Derivation: *Liopsaron* from the Greek *lios* meaning smooth and *psaron* meaning little fish. Gender masculine.

Liopsaron insolitum McKay, new species

(Figures 5, 5a)

Description: Based on the holotype; counts and proportions of 2 paratypes given within parentheses.

Dorsal III, 14 (III, 14), anal 13½ (13-13½), pectoral rays 26 (26), pelvic I, 5 (I, 5), branched caudal rays 4 + 4.

Head to tip of opercular spine 28 (28.7, 27.3), head to tip of subopercular spine 30.1 (31.0, 29.9), horizontal diameter of eye 11.8 (12.6, 11.3), length of snout 4.3 (4.6, 4.6), interorbital space 1.1 (1.1, 0.7), length of upper jaw 7.5 (7.5, 8.4), snout tip to first dorsal fin origin 30.1 (29.9, 31.8), snout tip to origin of second dorsal fin 43.0 (43.1, 43.6), snout tip to anal fin origin 50.5 (52.2, 50.7), snout tip to pectoral fin origin 30.1 (29.4, 30.1), snout tip to pelvic fin origin 25.8 (24.7, 23.2), length of second dorsal fin base 47.3 (48.2, 48.7), length of anal fin base 39.9 (40.2, 39.4), length of pectoral fin 22.6 (23.0, 21.6), length of pelvic fin 22.6 (24.1, 25.8), length of longest dorsal ray 17.2 (17.2, 29.5), length of longest anal ray 11.3 (10.7, 11.6), length of second dorsal spine 9.0 (8.5, 9.8), greatest width of head 17.2 (16.7, 16.9), greatest depth of body 14.5 (15.0, 14.8), depth of caudal peduncle 5.9 (5.8, 6.1), width of caudal peduncle 2.2 (2.3, 2.1), height of fleshy pectoral base 8.0 (8.3, 7.6), distance between tip of opercular spine and tip of subopercular spine 7.5 (8.0, 8.4); all expressed as percent of standard length taken from the tip of the snout to the commencement of the caudal fin.

Head slightly depressed; eyes large and separated by narrow interorbital space; mouth protrusible; snout slightly concave anteriorly but lacking spines; opercular and subopercular spines diverging posteriorly, both with sharp tips, opercular spine ending at about level of

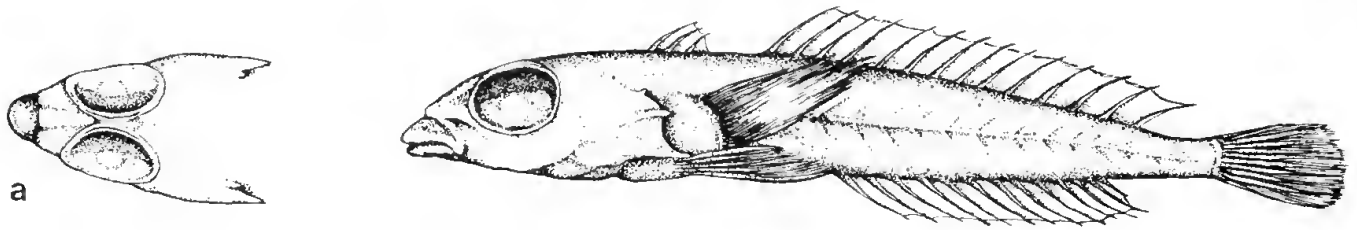


Figure 5.—*Liopsaron insolitum* sp. nov. lateral view; a. dorsal view of head.

upper pectoral origin, subopercular spine terminating almost at lower pectoral origin; pectoral fin rounded posteriorly, a free fleshy base quite conspicuous; pelvic fin with inner rays longest, spine much reduced and extending posteriorly to tip of subopercular spine; caudal fin almost truncate.

Colour in formalin: Body and head pale, almost completely faded; some faint dark blotches above opercle, before spinous dorsal fin, and one small spot on middle of pectoral base. Behind tip of pectoral fin a group of 3 somewhat variable almost vertical stripes becoming wider at base. A faint blotch present before caudal fin. All fins hyaline with occasional dorsal rays with a very fine, darker anterior margin. Eyes black above and silvery below pupil.

Colour in life: Rather pink with some lemon yellow spots on body, pectoral base yellowish and hind border of orbit orange. Much of the colour faded rapidly in formalin fixative; the colour in life is believed to be rather attractive.

Holotype: WAM P 19164 standard length 93 mm, total length 115 mm, trawled by *Umitaka Maru* in 350 metres, Station UMPT 6905, 17°17'0"S, 119°57'0"E, December 20, 1969.

Paratypes: WAM P 19165, s.l. 87 mm, t.l. 107 mm; WAM P 19166, s.l. 71 mm, t.l. 88 mm; Station UMPT 6905, data as above.

This new genus and species was taken in association with *Branchiopsaron ozawai*, *Bembrops indica* and *Chrionema chlorotaenia*; thus all the genera known from the north west of Western Australia were taken in a 30 minute, 1 mile trawl. The general construction of the gear employed is as follows: Lower-net, side-net

and upper-net have meshes of 60 mm, becoming meshes of 45 mm in the cod-end. The otter board is 2.54 x 0.9 m in size; the bridle wires from the board to the towing warp are 20 m long with a diameter of 16 mm; the wire connecting the boards to the net is 5 m long; the tickler chain is 25 m long and 8 mm in diameter.

The bottom temperature at Station UMPT 6905 was 11.4°C.

Derivation: *insolitum* from the Latin *insolitus* meaning uncommon.

Acknowledgements

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I also wish to thank Miss Jeanne-Marie Thomasz for the carefully executed figures in the text.

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7.—*Habeobdella stagni*, a new genus and species from South-Western Australia (Hirudinoidea: Richardsonianidae)¹

By Laurence R. Richardson*

Manuscript received 20 October 1970; accepted 16 March 1971.

Abstract

Leeches from Herdsmans Lake, Lake Monger, Serpentine (and possibly Greenbushes) are a new species assigned to a new genus distinct in having xxv 5/5- or 4/5-annulate, and xxvi incomplete 3-annulate. A possible second genus is indicated in leeches from near Bullsbrook and from the Donnelly River.

Introduction

This paper gives the first account of the general morphology of an aquatic, jawed, sanguivorous leech from Western Australia, a leech with somite xxv essentially 5-annulate, as shown by Johansson (1911) who had five specimens from Western Australia, and briefly described the colour, pattern, and the annulation of the posterior somites of the body. Johansson assigned these leeches to *Hirudo australis* Bosisto 1859, a species recognized at that time and until recently as the only 5-banded aquatic jawed sanguivore in the Australian Region. *H. australis* (Richardson, 1968) had been transferred to the genus *Limnobdella* Blanchard 1893. Johansson did not consider *Limnobdella* separable from the genus *Hirudo*. He followed Moquin-Tandon and Blanchard in accepting a very wide range of variation in pattern and colour in the hirudiniform species, and the '*Hirudo australis*' in his 1911 paper can now be seen as including leeches belonging to three distinct genera (Richardson, 1971¹).

It has been accepted since Whitman (1886) that the complete 5-annulate somite occurs in hirudiniform leeches only on the nephric somites, viii to xxiv; rarely on all; commonly on ix to xxiv with xxv 4-annulate or on ix to xxiii with xxiv 4-annulate and xxv 3-annulate, and with xxvi 2-annulate in both these groups.

In terms of this 'rule', the novelty shown by Johansson has been open to doubt as a possible artefact, the more so since he showed xxvi as incomplete 3-annulate, and did not consider the novelty as a sufficient basis for separation of the leeches from Western Australia from *australis* known until then only in eastern Australia.

There are other divergences from the 'rule' (Richardson, 1969; 1971¹). These can be recognized now as indications for distinct systematic status.

The annulation described by Johansson is confirmed in specimens among 23 aquatic jawed sanguivores in collections from 11 localities in Western Australia, housed in the Western Australian Museum. The collections are limited. The specimens vary in condition. From among them, it is possible to provide a necessary new genus based on a type from a convenient locality. It is hoped that studies will be undertaken on ample material to demonstrate the nature of the variation in annulation.

Habeobdella Richardson, gen. nov.

Derivation of generic name: *habere*, to be in possession of; *bdella*, a leech. Gender: feminine.

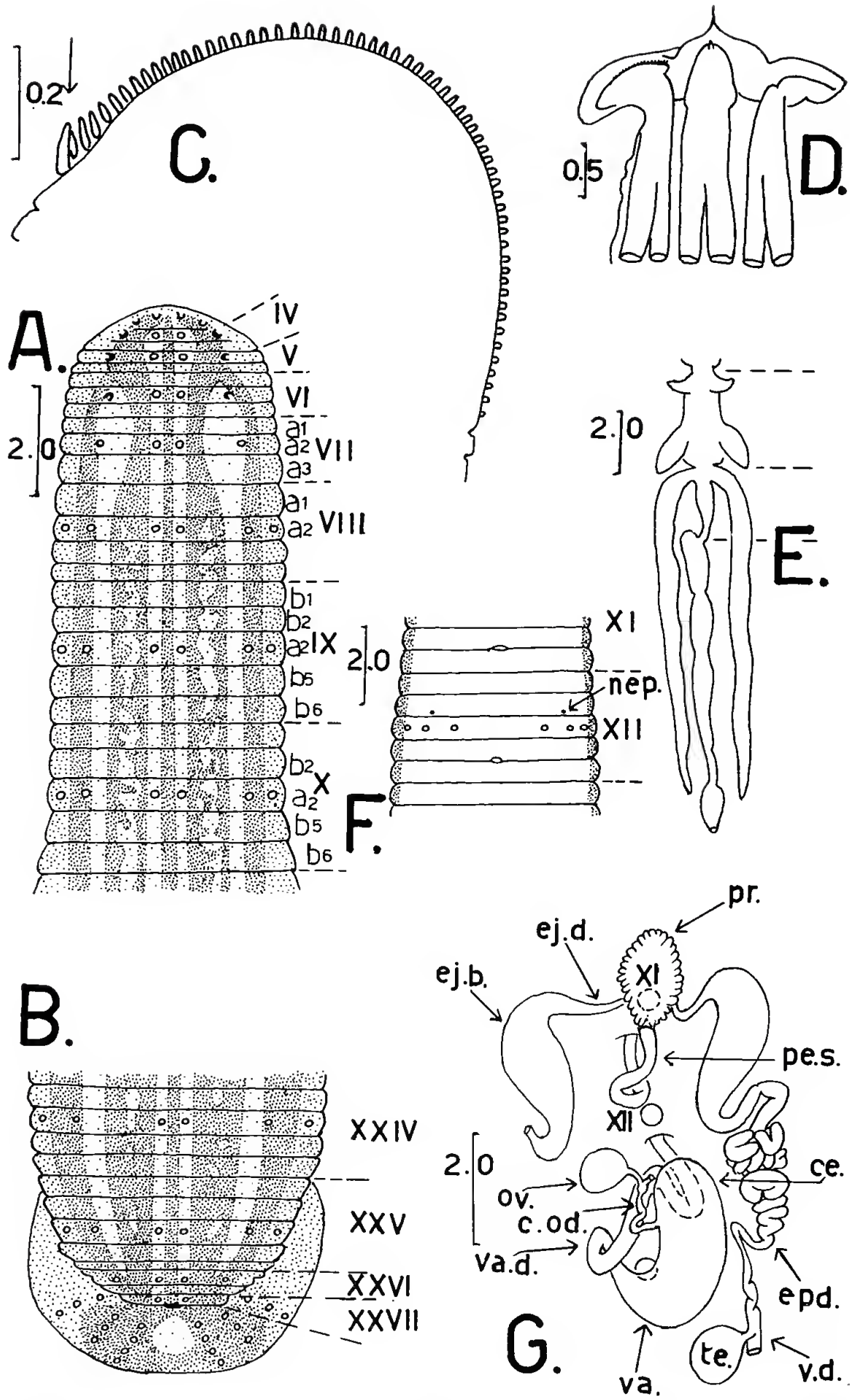
Monostichodont; ix to xxiv complete 5-annulate (total 16); xxv more or less 5-annulate above and below; xxvi incomplete 3-annulate; somital sense organs small, circular, obscure; jaws small; teeth small, about 58 to 60; no salivary gland papillae; dorsal salivary glands, compact masses with right and left columns of aggregated ducts; radial muscles an obvious extrinsic system; mouth and lumen of pharynx narrow, the lumen tubular, tapering; pharynx with 6 internal muscular ridges joining as dorsomedian and ventrolateral pairs to enter the corresponding jaws, none ending independently between the bases of the jaws; pharynx terminating in ix; crop with a short compartment in ix, x to xviii, the compartments each with anterior small and posterior larger pairs of caeca, the anterior in xix forming the postcaeca extending to xxvi; genital pores xi and xii b₅/b₆; testes normally 10 pairs; epididymis in the posterior half of xii and in xiii, posterior to the simple fusiform ejaculatory bulb in the contiguous halves of xi and xii; median regions bimyomeric, mesomorphic; penis sheath cylindrical, reflected in xii; oviducts, short; common oviduct, longer; vagina fusiform, on recurrent limb of primary loop; vaginal caecum enlarged, of the width of the vagina and as long as wide; vaginal duct longer than the vagina.

Size, medium. Pattern, a medium dorsal and two pairs of uninterrupted median longitudinal dark bands. Aquatic. Sanguivorous South Western Australia.

Type species: *Habeobdella stagni* sp. nov.

¹ Prepared during the course of studies on the Australian leeches assisted by a grant from the Nuffield Foundation.

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Habeobdella stagni Richardson, sp. nov.
(Figure 1.)

Type specimen: Western Australian Museum, Coll. No. 49-69, taken in mud, south end of Herdsmans Lake, Perth, W.A., 5 Nov. 1965. Length 43.0 mm, dissected, xx/xxi to xxvi opened along left side, dorsomedian and right ventrolateral jaws mounted separately. The type has xxv complete 5-annulate.

With this, one paratype, 42.0 mm long, xxv with (b_5+b_6) on dorsum, the furrow b_5/b_6 marginal and complete across the venter; dissected.

The description is taken from the type.

General form

Slightly contracted, preserved, a leech of medium size; elongate, depressed, the dorsum low convex, the venter nearly flat, the margins broadly rounded, the posterior sucker large. The velum thick with rounded margins; behind this, the margins subparallel, diverging very gradually from iv/v to x b_5/b_6 , slightly wider as the clitellum to xiii a_2 , then almost subparallel diverging only slightly to the maximum width at about xx to xxii; converging behind this in the postnephric region to form the base, which is about half the width of the sucker, and the sucker slightly wider than the maximum width of the body.

The total length 43.0 mm; 2.0 mm wide at iii/iv; 3.0 mm wide at v/vi; the width 4.5 mm and the depth 2.0 mm at the male pore, 9.0 mm from the tip of the velum; maximum width 5.0 mm and depth 3.5 mm at 30 mm from the tip of the velum; the basis of the posterior sucker 3.0 mm and the sucker 6.0 mm in diameter.

Colour

Preserved: generally darkish grey; the dorsum with five black longitudinal bands, a narrow medial and wider inner and outer paired bands, the inner pair subdued along most of their length by much pale greyish clouding to such a degree and in such a manner as to appear as two narrow separate longitudinal bands; the dark bands separated by narrow pale yellow stripes; lateral to the outer paired bands, pale, faintly yellowish to brownish grey wide marginal bands sharply marked off in the submarginal field from the light grey immaculate venter. The sucker with a large wide black patch containing a central pale yellow patch, otherwise, laterally and anteriorly, the sucker pale, of the colour of the venter.

The colour in life possibly brownish black, divided by bright yellow, even golden, stripes; venter, ashen grey.

Pattern Figure 1 A,G,F.

The first four pairs of eyes marginal on a wide ocular patch in ii to vi a_1 , divided by the narrow inner pair of light stripes which define the median band from ii/iii, just behind the 1st pair of eyes, to the posterior border of xxvii. The median band generally about two thirds of the width of the median field and narrower than the inner pair of light stripes on either side of it which extend along the paramedian lines and include sense organs of this series. The inner pair of dark bands is defined between the inner and outer paired stripes between vi a_1/a_2 and xxv/xxvi, posteriorly joining a dark patch extending across the paramedian and intermediate fields of xxvi and xxvii, divided by the inner paired stripes and median band. The inner paired bands are wide, occupy about the medial two thirds of the paramedian field, widening as this field widens along the body, narrowing in and posterior to xxiv; clouded liberally from the middle of viii to xxiii with paler grey to brownish grey, appearing then more as black margins to a pale stripe as wide or wider than the combined widths of the margins; but the whole constitutes one dark band.

The outer paired light stripes are lateral in the paramedian field from vi a_1/a_2 to xxvi $a_1/a_2/a_3$ wider than the inner paired stripes, and generally uniform in width along the greater part of the body.

The outer paired dark bands separate from the ocular band at vi a_1/a_2 and extend to xxvi $a_1/a_2/a_3$, pass immediately lateral to the 5th pair of eyes and the intermediate organs of vii, but behind this, the sense organs of the intermediate series lie on or just within the inner margin of these bands which also occupy the greater part of the intermediate field, being narrowly separated from the supramarginal line of sense organs which lie in the marginal band extending across the supramarginal and submarginal fields as pale bands continuous from the velum to xxvii and onto the sucker, and are sharply distinct from the paler venter. The outer pair of dark bands show minor clouding behind viii a_2 .

The right and left dark patches on xxvii are continuous with the dark patch on the sucker which occupies the inner half or just less of the intermediate fields, the paramedian and median fields except for the central light ovoid

Figure 1.—*Habeobdella stagni* Richardson, gen. et sp. nov. A, B.—Somital annulation and pattern, dorsal aspect—A, somites i to x; B, somites xxiv to xxvii and sucker. C.—Dorsomedian jaw and dental ridge (arrow indicates medial end of ridge). D.—Anterior half of pharynx opened along the midventral line to show internal muscular ridges; jaws. E.—Crop and caecation, somites xviii and xix; intestine; rectum. F.—Ventral aspect, somites xi and xii, showing genital pores, nephropores, etc. G.—Anterior region of male paired ducts, male median region, and female reproductive system (median aspect of the organs on the male paired ducts shown; the dorsal aspects lateral in the figure.)

All figures prepared from the type. Somites and somital ganglia indicated by Roman numerals. Scales in millimetres.

Abbreviations: ee., caecum; c.od., common oviduct; ej.b., ejaculatory bulb; ej.d., ejaculatory duct; epd., epididymis; nep., nephropore; ov., ovary; pe.s., penis sheath; pr., prostate; te., testis; va., vagina; va.d., vaginal duct; v.d., vas deferens.

patch which is separated more narrowly from the posterior edge of xxvii than from the posterior edge of the sucker.

Annulation Figure 1A, B.

Somital sense organs are small, rounded, detectable often with difficulty on the dorsum excepting the intermediates, not always as continuous series, and much smaller and quite obscure on the venter. Secondary sensillae are most difficult to detect. The nephropores are obvious in the postclitellar region where most are raised on low papillae; elsewhere concealed. Interannular and intersomital furrows essentially equivalent, the annuli not arranged in obvious couplets or triplets, and somital limits without definition along most of the body. Generally the annuli are richly divided into longitudinal rectangles by fine lines which are lacking on well-extended somites, and seem to have no morphological value.

The velum consists of i, ii and iii, carries the 1st and 2nd pairs of eyes, shows no defined furrows and the margin is entire, without incisions. Somite iv is marked off anteriorly by iii/iv which extends across the median and intermediate fields; a longer furrow dividing iv into $a_1 a_2 / a_3$, with $a_1 a_2$, including the 3rd pair of eyes and first detectable paramedian sense organs $> a_3$; the furrow iv/v not quite reaching the margin of the sucker so that the dorsolateral lobe of the margin of the sucker is poorly defined; v 2-annulate above, the 4th pair of eyes in $a_1 a_2 - a_3$, the furrow $a_1 a_2 / a_3$ extending into the submarginal field so that $a_1 a_2$ forms the lateral portion of the margin of the sucker and uniannulate v, the ventral portion; vi 3-annulate above, $a_1 < a_2 < a_3$, the 5th pair of eyes in a_2 , the furrow a_1 / a_2 extending to the ventral intermediate line, and then vi 2-annulate below with $a_1 a_2 > a_3$ in the paramedian and median fields; vii 3-annulate above and below, $a_1 < a_2 < a_3$ (- viii a_1) - - - (a_3 with a very fine furrow extending between the supramarginal sense organs dividing a_3 apparently into $b_5 < b_6$ which would suggest it may not be morphological); viii 4-annulate, $a_1 > a_2 > b_5 > b_6$, the first nephropores close to the posterior border and just medial to the ventral intermediate lines on a_1 ; ix to xxiv complete 5-annulate (total 16); from ix to xxiii the somites variously contracted and the relative lengths of the annuli cannot be determined with full confidence; in general it would seem that the somital annulation for ix to xviii is $b_1 = b_2 < a_2 = b_5 > b_6$; for xix to xxi, $b_1 = b_2 < a_2 < b_5 > b_6$; for xxii to xxiv, $b_1 = b_2 > a_2 > b_5 = b_6$; the last nephropore on xxiv b_2 ; xxv complete 5-annulate, $b_1 < b_2 = a_2 > b_5 > b_6$, the furrow b_5 / b_6 strongly defined and deep on both the dorsum and venter, with a_2 , b_5 and b_6 reduced in length on the venter where $b_1 = b_2 > a_2$ $b_5 > b_6$; xxvi 2-annulate above, $a_1 a_2 > a_3$, the somital sense organs posterior in $a_1 a_2$, and at the margin a shallow wide groove in $a_1 a_2$ which deepens into a definite furrow across the venter where although $a_1 a_2$ is reduced in length it is weakly but definitely

divided into a_1 and a_2 , and a_2 is the last annulus complete across the venter, a_3 extending onto the dorsum of the sucker as also xxvii which is uniannulate above. The anus at the posterior border of xxvii. The dorsum of the sucker shows 4 paramedian sense organs in each line, and three in each of the intermediate and supramarginal series; some 7 or 8 concentric rows of tessellations show on the posterior half of the dorsum.

Alimentary tract Figure 1C, D, E.

The jaws are small, tall, compressed, the dorsomedian in profile at the median end, about 0.5 mm high and slightly narrower at the base; the dorsomedian housed in an open groove, the ventrolaterals in pits with such poorly defined margins as to be nonmorphological; the dental margin long, so highly convex as to be almost semicircular; the teeth about 60 on the dorsomedian, the largest about 0.05 mm high, the row reducing gradually and the teeth in the middle of the row about half as tall as those at the median end, the row progressively reducing to the last few teeth which are low, rounded, almost granular; about 56 teeth on the ventrolateral.

The pharynx is relatively thin-walled with 3 pairs of internal muscular ridges, each pair joining to enter the base of a jaw, none ending independently between the bases of the jaws; mouth narrow, little wider than the base of the dorsomedian jaw; lumen of the pharynx narrow, tubular, tapering; radial muscles sparse, but an obvious extrinsic system extending back into x; dorsal salivary glands compact right and left masses extending back into x, each drained by a poorly defined column of aggregated ducts, the columns continuing independently into the dorsomedian jaw.

The pharynx terminates in ix a_2 , followed by a short caecate compartment in ix; the crop in x to xviii fully compartmented, each compartment with a pair of simple anterior and a pair of simple posterior caeca, the two pairs nearly equivalent in x and xi; then the posterior pair progressively longer, and from xv back extending in the paramedian chamber posteriorly into the following somite where they are lateral to the anterior caeca, but all as seen were simple and not folded; the post-caeca originate from the lateral aspect of the anterior end of the compartment in xix, behind this the compartment tubular, with the lining epithelium in longitudinal rugae as elsewhere in the crop, tapering briefly to enter the intestine subterminally in the anterior annuli of xx; the postcaeca extend to xxv/xxvi.

The intestinal epithelium is raised in transverse rugae. The intestine commences with a caecate tubular segment in xx, another simple segment in xxi, followed by a tapering tubular length entering terminally into the rectum which tapers to the anus.

Reproductive system Figure 1G.

The relationship of structures on the anterior portion of the male paired ducts is richardsonianoid; the median regions bimyo-meric, mesomorphic; the vagina caecate formed

essentially on the recurrent limb with a vaginal duct on the procurrent limb. The specimen is adult, but does not appear to be in a condition of sexual maturity.

The genital pores at xi b_5/b_6 and xii b_5/b_6 ; the penis-sheath elongate, cylindroid.

The first testes are at xiii/xiv; the last in the posterior portion of xxii; behind xix, the testes are in the paramedian longitudinal chamber of the body-cavity; anterior to this, in the median chamber, all connecting by short vasa efferentia to the vas deferens in the paramedian chamber which reduces in diameter in the posterior annuli of xiii before expanding into the initial narrowly tubular portion of the epididymis which is thin-walled, tortuous and much folded on itself and becomes more widely tubular before joining the ejaculatory bulb; the whole epididymis in the contiguous annuli of xii and xiii and not readily separable into two masses. The bulb is muscular, tapering elongate fusiform, connected by a short ejaculatory duct to the male atrium situated above g.xi. The atrium continues in the strongly muscular penis sheath, slightly folded on itself, and reflected at the level of g. xii as two nearly equal limbs.

The simple saccular ovaries are posterior in xii, connect by short oviducts, neither longer than the ovary, to a distinct atrium from which the thin-walled common oviduct of large lumen extends tortuously without close relationship to the vaginal duct, to join the ventral face of the vagina more remote than usual from the caecate end, about two fifths along the body of the vagina so that the caecum is quite long, the length of the width of the vagina, and the caecum unusually large; the common oviduct opens into the vagina on the tip of a low papilla at the level of the point of attachment; an epithelium with longitudinal rugae continues from the vagina into the caecum.

The caecum and vagina are in the posterior annuli of xii and in somite xiii. The muscularized body of the vagina is stoutly tubular, completes the recurrent limb of the primary loop and tapers abruptly on the initial portion of the procurrent limb into the strongly muscular vaginal duct which has a reduced lumen, is distinctly longer than the body of the vagina, and is folded closely on itself on both sides of the ventral nerve cord.

The prostate glands form an elongate tapering subovoid cap on the atrium and extending briefly along the penis sheath. The albumin glands invest the atrium and the length of the common oviduct.

Paratype

Similar in colour and anteriorly in pattern to the type; posteriorly as in the type excepting that the narrow paramedian light stripes extend onto the dorsum of the sucker, but only so much as to closely encircle the anus, and there is a small light patch central on the posterior margin of the sucker. The paramedian bands along the body fill half or slightly more of the paramedian fields, each with a wide dark inner margin about half the width of the whole band, and the rest clouded so that there is no dark outer margin.

Annulation differs from the type: iv a_1a_2/a_3 , the first furrow extends only to the intermediate line, as also iv/v; the clitellar annuli, xb_5 to $xiiia_2$, each with a distinct deep furrow between the submarginals so that these annuli are all strongly subdivided on the ventral surface; xxv 4-annulate above, with $b_1 = b_2 < a_2 < a_3$, but the furrow b_5/b_6 commences in the marginal fields and continues across the venter where b_5 and b_6 are distinctly represented and $b_1 = b_2 > a_2$ $b_5 > b_6$; xxvi as in the type, a_1a_2 on the dorsum but divided on the venter into a_1 and a_2 , with a_2 the last annulus complete on the venter; xxvi a_3 and xxvii continue onto the dorsum of the sucker.

Alimentary tract as in the type.

Clitellar glands well developed. Ejaculatory bulbs shorter, more stoutly fusiform; penis sheath with the recurrent and procurrent limbs of the same length; oviducts, both very short; vaginal caecum at least as long as wide, of the width of the vagina and about a quarter of its length.

Other material

Leeches identifiable as *H. stagni* were present in the following collections:

1. W.A.M. 9034. *Hirudo australis* Bosisto. Serpentine, W.A.B., K.A.B., & I.J.D. No other data.
Four specimens, 23.0 to 33.5 mm long; faded; pattern as in type; xxv $b_1 < b_2 < a_2 - b_5 > b_6$ above and below, with b_6 the last annulus across the venter; xxvi a_1a_2/a_3 above, a_1/a_2 in the submarginal field; vaginal caecum as in type.
2. W.A.M. 52-69. Lake Monger, Oct. 1952.
Five specimens, 14.0 to 33.0 mm. Stripes, yellow; pattern and annulation as in type; pattern fully established in the 14.0 mm specimen; vaginal caecum as in type. One specimen retained, deposited the Australian Museum, Coll. No. W 4269.
3. W.A.M. 50-69. Greenbushes swimming pool (in abundance), coll. H. Williams, 26 Dec., 1962.

Two specimens, 32.0 and 49.0 mm. Stripes yellow; pattern and annulation as in type excepting xxv incomplete 5-annulate below with a_2 the last annulus across the venter; enlarged vaginal caecum, of the width of the vagina, but not as long as wide. Note: with a full knowledge of variation in *stagni*, this might prove distinct.

Discussion

The genus *Habeobdella* conforms in morphology to the Richardsonianidae of the Australian Region.

Lacking salivary gland papillae on the jaws, with 16 complete 5-annulate somites (ix to xxiv), bimyomeric mesomorphic median regions on the reproductive systems, simple fusiform ejaculatory bulbs and vagina, a vaginal duct, and a pattern of 5 uninterrupted dark longitudinal dorsal bands, *Habeobdella* is similar

(Richardson, 1970) to the genus *Richardsonianus* Soos 1968 based on *Hirudo australis* Bosisto 1859.

Habeobdella differs from *Richardsonianus*, as also from the other 16 5-annulate genera so far known in Australia, in the essentially 5-annulate condition of xxv, the 3-annulate condition of xxvi and the very large vaginal caecum which has not been seen in other Australian leeches.

In the collections there is another leech possibly representative of a second genus; but the material is not adequate for a complete description.

A specimen from near Bullsbrook (W.A.M. 56-69), 65.0 mm long, and two specimens from the Donnelly River (W.A.M. 54-69) 16.0 and 28.0 mm long, differ from *H. stagni* in having elongate almost subcylindrical ejaculatory bulbs resembling the bulbs in bassianobdellid leeches; the vaginal caecum small, short, the vagina simple fusiform with a vaginal duct.

Both have xxv 5-annulate above, with a_2 the last annulus across the venter in the Bullsbrook specimen, and b_5 the last such annulus in the Donnelly River specimens. Somite xxvi is 2-annulate above in all three.

There are about 50 teeth on the dorsomedian jaw of the Bullsbrook specimen. These are distinctly small, the tallest at the median end being 0.03 mm high, and the row diminishes so gradually as to appear almost uniform in height along the greater part of its length.

They differ from *H. stagni* in pattern. The larger of the Donnelly River leeches lacks the outer paired light stripes lateral in the paramedian fields; the smaller has these stripes, but they are interrupted and extend only between $x a_2$ (right) and $xi a_2$ (left) to xxii/xxiii. In both, a dark marginal band commences in the lateral half of the intermediate field and extends to just include the marginal line of sense organs, where it is then sharply separated from the pale venter which has a few spaced large maculae.

In the Bullsbrook leech there are poorly defined narrow outer paired light stripes which extend along the line of the intermediate somital sense organs. There are dark marginal bands which are continuous with the immaculate venter.

The differences in the topography of pattern in the Bullsbrook and Donnelly River leeches are indicative of possible distinct species (Richardson, 1971^b); but as I cannot determine the relative lengths of the annuli in the midnephric group of somites, the matter cannot be taken further on these specimens.

Acknowledgements

I am indebted to the Director of the Western Australian Museum and to Dr. R. W. George for the privilege of examining leeches in the collections of the Museum; to Miss E. Pope, the Australian Museum, Sydney, for assistance in many ways; to Professor Marvin C. Meyer, the University of Maine, for assistance in the matter of difficult literature; the Librarian, the University of New England, for help with other literature; and to the Science and Industry Endowment Fund for the loan of microscopic equipment.

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8.—Remains of *Potorous platyops* (Marsupialia, Macropodidae) and other mammals from Bremer Bay, Western Australia

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Abstract

Mammal remains, probably derived from disintegrated pellets regurgitated by an owl, are described from sand dunes at Bremer Bay. Murid bones from this sample have been dated at 1190 ± 80 radiocarbon years B.P. (GaK-2887). The sample includes remains of the small rat kangaroo *Potorous platyops*, and other remains of this little known species are discussed. A radiocarbon date of 620 ± 90 years B.P. (GaK-2888) on dead wood from the site, taken in conjunction with the bone date and with the present condition of the site suggests that vegetation of the area, presumably by wind blown sand, has extended over more than a thousand years.

Introduction

In March 1970, W. H. Butler collected a small sample of bones from what appeared to be the dispersed remains of owl pellets at Bremer Bay, and presented them to the Western Australian Museum. Remains of two little known marsupials, *Potorous platyops* and *Antechinus apicalis*, were recognized in this sample, and both authors visited the site later in the same month in order to make further collections and field observations.

We follow the nomenclature of Ride (1970), including his use of *Potorous tridactylus* for the populations formerly known as *P. gilberti*. The catalogue numbers quoted represent specimens in the Western Australian Museum collection.

The Bremer Bay site

About $4\frac{1}{2}$ km north east of the old telegraph station at Bremer Bay, the channel of the Hunter River is blocked by sand drift about 1 km inland from the coast. Extensive dunes of mobile sand lie south west of this blocked river channel, and these mobile dunes at present appear to be encroaching on low vegetated dunes west of the channel of the Hunter River. About central in the mobile dunes, bones lay unevenly scattered in an area about 200 m long in a north to south direction and about 250 m long east to west. The site is at 239753 on the Bremer Bay sheet (SI 50-12) of the Australia 1: 250,000 series of maps, lat. $34^{\circ}22'S$, long. $119^{\circ}24'E$.

Bones representing more than 650 animals were recovered from the 200 x 250 m zone, lying on bare sandy surfaces. Only about 10 animals were represented by bones collected on similar surfaces of the remainder of the mobile dune area, about 1 km x 1 km in extent.

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Within the 200 x 250 m zone relatively rich in bone, local concentrations were evident, five such local concentrations accounting for more than 600 of the animals represented. Our collection from the principal one of these local concentrations, about 5 x 20 m in extent, represented nearly 500 animals. We did not recover every piece of bone exposed at the surface of the 200 x 250 m area, and our recovery rate varied from place to place, being higher in the local concentrations. We estimate that more than 700 but less than 1,000 animals of various sizes were represented by bony remains within the 200 x 250 m bone rich zone.

Remains of dead trees and shrubs were represented at all the sites of bone concentration mentioned above, some of them upright in the position of growth, but more lying scattered on the sandy surface. The largest of these plant remains is shown in Fig. 1. This represents a fallen tree in which roots and branches were clearly distinguishable, showing that the tree extended at least 7 m above the ground. A comparison was made of wood from this fallen tree with wood specimens from peppermint and eucalypt trees growing nearby. This comparison, kindly made for us by Mr H. D. Ingle of the C.S.I.R.O. Division of Forest Products, Melbourne, showed that the fallen tree was peppermint (*Agonis* cf. *A. flexuosa*) rather than eucalypt.

Fig. 1 also shows (top left) a tree stump in the growth position: not more than 1 m thickness of sand or soil has been removed by deflation from round the roots of this tree. The principal bone concentration, representing nearly 500 animals, lay to the left of the large fallen tree shown in Fig. 1.

Many bones and most tree trunks showed signs of sand blasting or corrosion, but most bones, especially of the smaller mammals (of about the size of a rabbit or less), were unbroken, save that skulls usually had come apart at the sutures.

Thickets of swamp yate (*Eucalyptus occidentalis*), peppermint (*Agonis flexuosa*) and other small trees occupied the banks of the Hunter River, but the vegetation otherwise consisted primarily of shrubby plants.

Weather data are available for the nearby township of Bremer Bay, which has an average annual rainfall of about 620 mm, with a marked maximum in winter (June average 91 mm, January average 14 mm). The mean minimum temperature for July, the coldest month of the year



Figure 1.—Fallen peppermint tree near principal local accumulation of bone, Bremer Bay. The bow saw is propped against a branch of this tree, partly buried by sand; the roots of the tree are in the foreground. The tree has fallen uphill away from the sea, presumably in the direction of the strongest winds; it lived over 600 years ago. Note stump in growth position on sky line, top left.

is about 8°C, and the mean maximum temperature for February, the hottest month, is about 24°C (Director of Meteorology 1962). Winds are frequent and strong, predominantly from the south west, but often with an easterly component in summer.

Animals represented

Most of the animals represented in our bone collection—about 540 in a total of about 650—were murids. A few other eutherian species, dasyurid, peramelid and phalangeroid marsupials, reptiles, amphibians and fish were represented by bones, while shells of the land snail *Bothriembryon* were prominent among invertebrate remains.

The following mammal species were present:

Murids

<i>Rattus fuscipes</i>	—e.g. 70.3.40
<i>Pseudomys shortridgei</i>	—e.g. 70.4.61
<i>Pseudomys albocinereus</i>	—e.g. 70.4.114
<i>Notomys</i> cf. <i>N. mitchellii</i>	—e.g. 70.4.10

Other eutherians

Bat, not specifically identified—	70.4.48
<i>Oryctolagus cuniculus</i>	—e.g. 70.4.43
<i>Ovis aries</i>	— 70.4.155
<i>Canis familiaris</i>	— 70.3.59
<i>Vulpes vulpes</i>	— 70.4.167

Marsupials

<i>Dasyurus geoffroii</i>	—e.g. 70.3.58
<i>Antechinus apicalis</i>	—e.g. 70.4.98
<i>Antechinus flavipes</i>	—e.g. 70.4.103
<i>Sminthopsis murina</i>	—e.g. 70.4.106
<i>Isodon obesulus</i>	—e.g. 70.4.91
<i>Perameles</i> cf. <i>P. bougainville</i>	—e.g. 70.3.15
<i>Pseudocheirus peregrinus</i>	—e.g. 70.3.29
<i>Potorous platyops</i>	—e.g. 70.4.66
<i>Bettongia penicillata</i>	—e.g. 70.4.1
<i>Macropus eugenii</i>	—e.g. 70.3.61
<i>Macropus irma</i>	—e.g. 70.3.28
<i>Macropus</i> (probably <i>fuliginosus</i>)	—e.g. 70.3.60

The whole collection from this locality is included under the catalogue numbers 70.3.12 to 70.3.21, 70.3.28 to 70.3.70 and 70.4.1 to 70.4.197.

Potorous platyops

According to Glauert (1950), one or more specimens of this species were obtained from a locality not recorded in the south west of Western Australia by L. Preiss about 1839, but the name *Hypsiprymnus platyops* was conferred by Gould (1844) on a specimen obtained by John Gilbert probably in the Goomalling district (Calaby 1954).

According to Thomas (1888), Gilbert also obtained a specimen in the Albany district, and according to Glauert (1950), G. Masters obtained four specimens in the King George's Sound in Pallinup (Salt) River district between 1866 and 1869. Five specimens from unknown localities in Western Australia reached the National Museum of Victoria in 1874 and 1875 (Ride 1970). Glauert (1933) recorded a specimen from the Margaret River district in the extreme south west of Western Australia, but this record is believed to be erroneous (Ride 1970), and Glauert did not repeat it in his later paper (Glauert 1950).

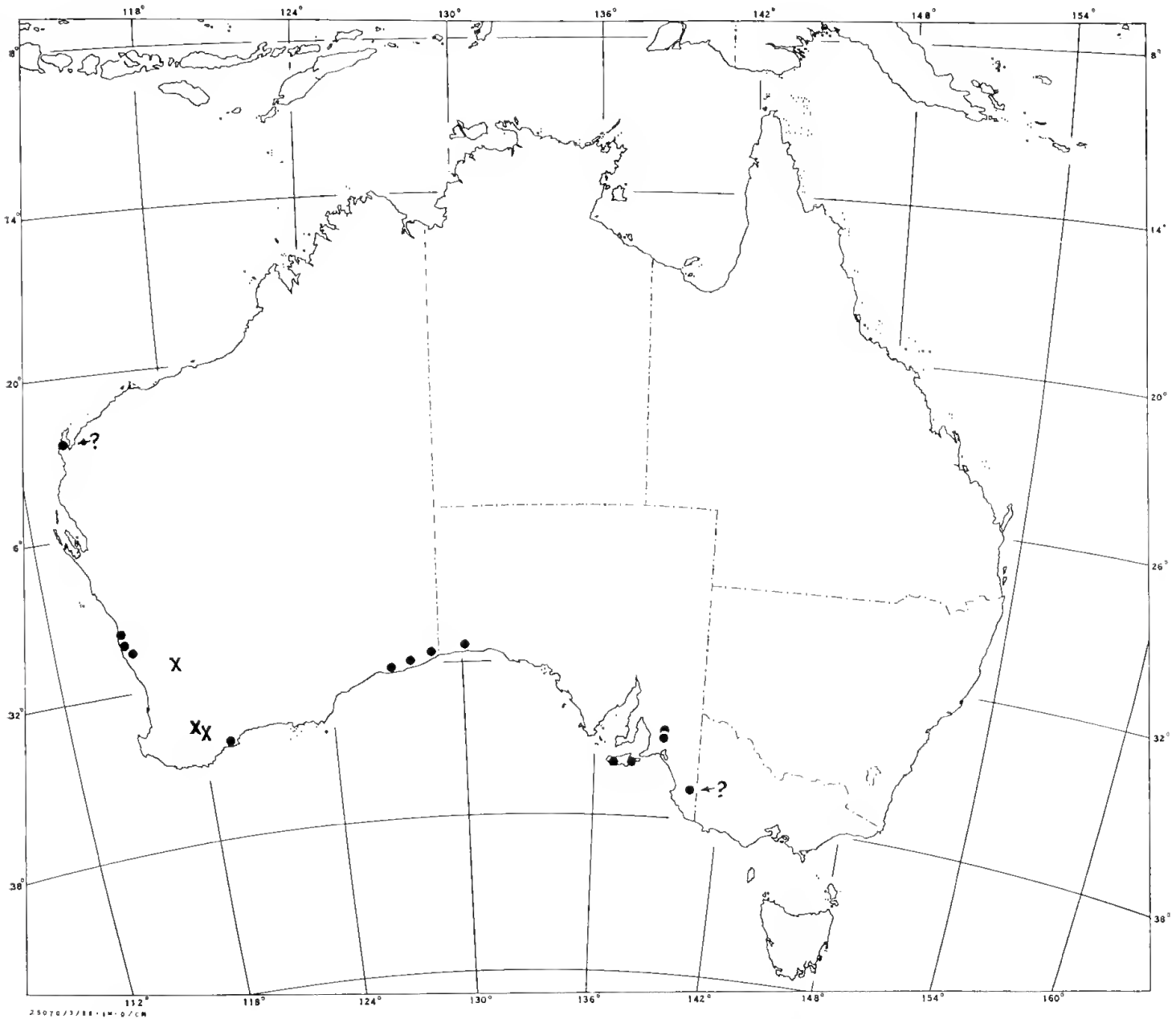


Figure 2.—Occurrences of *Potorous platyops* in geologically Recent (including historic) time.

- X Historic records
- Prehistoric

(Few animals have been taken in historic time, and for many of these, locality records are vague. Thus historic localities other than those shown may be involved. The prehistoric locality on North West Cape is queried because it is based only on one molar tooth, and that near Naracoorte, South Australia, because it may represent a time earlier than Recent.)

There are no specimens of *Potorous platyops* in the Western Australian Museum collection of modern mammals, but the collection of fossil mammals contains fragmentary remains from Bremer Bay (discussed herein), and from several caves in the Moore River-Dongara coastal region (61.7.32, 62.1.15, 64.10.35, 68.2.25-26 from Hastings Cave, 65.12.422-423, 70.6.66, 70.6.77 from Wedge's Cave, 69.5.12 from Smithy's Cave, and 70.4.203 from Weelawadji Cave). A single lower molar tooth (68.7.102) from a cave in North West Cape also appears to represent *P. platyops*; this record represents a great extension of the known range of the species, and because it is based only on an isolated tooth, is queried on the distribution map (Fig. 2). The geological age of these specimens is not known, but all come from surface litter or shallow excavations, and are likely to be of late Quaternary if not late Recent age.

Lundelius (1957, 1960, 1963) records fossil specimens, probably of Recent age, in Hastings and Wedge's Caves in the Moore River-Dongara region, and also from Webbs Cave in the south central Nullarbor region. Neither the South Australian Museum (N.S. Pledge, personal communication) nor the Western Australian Museum collections of fossil mammals contains any specimen of *P. platyops* from the Nullarbor region. However, small numbers of *P. platyops* specimens have been found in cave deposits near Madura, Eucla and Koonalda, southern Nullarbor region, excavated by the Australian Institute of Aboriginal Studies Nullarbor Plains Archaeological Survey; all appear to be of late Recent age (P. Thompson, personal communication).

Finlayson (1938) based a separate species *Potorous morgani* on bony remains of two animals from a cave in the south west of Kangaroo Island, South Australia. This species is now generally included in *Potorous platyops* (c.g. Ride 1970). Finlayson's specimens have been examined by one of us (D.M.) and found closely to resemble the Western Australian Museum fossil specimens listed above, ascribed to *P. platyops*. Other specimens, representing up to seven individuals, have been found in surface litter in a cave near the type locality of *P. morgani* (P. F. Aitken and C. R. Tidemann, personal communications), and Finlayson (1959) records the finding of another specimen in the south east of Kangaroo Island.

Hale and Tindale (1930) record *Potorous* remains from three levels in an archaeological excavation at Devon Downs, on the bank of the lower Murray River, and Finlayson (1959) records these specimens as *P. morgani*. In archaeological excavations in Shelter 2 at the nearby Fromm's Landing site, two levels yielded remains of *P. morgani* (Wakefield, in Mulvaney, Lawton and Twidale 1964). Remains of several individuals attributed to *P. morgani* have been found recently in an excavation in Victoria Cave in the Naracoorte district, South Australia (M. J. Smith and R. T. Wells, personal communication).

Thus, the species appears to have been wide ranging but not abundant. There appears to have been no record of it alive for nearly a century (Ride 1970), and it may be extinct. The Bremer Bay specimens (70.3.21, 70.3.43-46, 70.4.4-5, 70.4.11, 70.4.19, 70.4.55, 70.4.66-88, 70.4.134 and 70.4.177) are fragmentary and represent only a few animals (probably about five), but even so are a welcome addition to the few known remains of *Potorous platyops*.

The Western Australian specimens cited above, which include tooth-bearing fragments of skulls and mandibles and some post-cranial elements, show that in these respects *Potorous platyops* closely resembled Gilbert's potoroo (*Potorous tridactylus* from the extreme south west of Western Australia) except in being considerably smaller. Thus *Potorous platyops* femur 70.4.68 has a length of about 55 mm, whereas *P. tridactylus* femur 65.6.73, of comparable stage of growth, is 68 mm long. For comparison, rabbit femur M 6935 is 78 mm long. The length of the lower cheek tooth row in adult *P. platyops* is about 15 mm (14.3 mm in 70.4.134, 15.3 mm in 70.4.66) whereas the lower cheek tooth row is about 21 mm long (20.5 mm in 65.9.49) in adult *P. tridactylus*. The length of the lower permanent premolar in *P. platyops* ranges from 3.5 to 4.1 mm in 9 measurable specimens (including one of *P. morgani* from Kangaroo Island) and the width from 1.4 to 2.1 mm in the same specimens; the lower permanent premolar in *P. tridactylus* specimen 65.9.49 is 5.2 x 2.6 mm.

Interpretation of the site

The preponderance of murids, the scarcity of animals larger than rabbit size, the preponderance of mammals over other vertebrates, the predominantly unbroken character of individual bones, and the occurrence of local concentrations of bone all point to a large night-hunting predatory bird as being responsible for the bone concentrations. The Barking Owl (*Ninox connivens*) or the Masked Owl (*Tyto novaehollandiae*) appear to be the species most likely involved. We suggest that each of the local bone concentrations described above represents the feeding place of a Barking or Masked Owl.

These owls normally kill their prey at first attack, transport the body to a feeding site, and either swallow very small animals whole or tear off lumps of meat and open the body cavity and then swallow larger mammals (of about the size of a rat). The carcasses remain in the modified upper portion of the alimentary canal during digestion of soft tissues. The remaining hair, bone and other indigestible tissue from each meal is worked by muscular contractions into a compact, coherent pellet which is then regurgitated. Breakdown of such pellets and removal of hair by insect and other scavengers, and physical weathering, would then leave just such bone concentrations as we found.

An owl pellet origin satisfactorily accounts for almost all the smaller animals, not only mammals, but also the very small numbers (about 25) of small birds, lizards and frogs represented. However, such an origin for animals as large as a dog or sheep, or as well armed as an adult *Dasyurus*, is most improbable, unless they represent carrion. Nor can fish, large or small, reasonably be ascribed to the activities of owls. We suggest that the basic owl pellet deposit has been overlaid at various times by other bone from various sources. Fox droppings with chewed bone (e.g. 70.4.167) would decay to leave fragmented remains of large as well as small vertebrates, and other carnivores such as *Sarcophilus* might also be involved in this way. Fish remains could result from scavenging by foxes on the beach nearby, or perhaps more likely, scavenging by birds such as ravens, ospreys, or whistling eagles (all of which were observed during our visit, carrying fish in the first two cases). Remains of sheep might well be due

to animals dying naturally on the site; *Macropus irma* specimen 70.3.28, consisting of most of the bones of a single animal found in close association, almost certainly represents such a natural death.

It is most unlikely that the 200 x 250 m zone of bone concentration would attract owls to roost in its present state, completely devoid of living plants, and almost devoid of perching places above the ground. But there are areas a few hundred metres further inland which might attract owls. Such an area is shown in Fig. 3, in which "islands" of living trees and shrubs occur among the mobile dunes, distant only a few hundred metres from continuously vegetated areas. It is conceivable that owls would hunt in the vegetated areas, but take their prey to an "island" of vegetation from which the approach of enemies would be readily visible.

We suggest, then, that at the time of accumulation of the bones, each site of local bone concentration within the 200 x 250 m bone-rich



Figure 3.—Stands of living peppermint trees and shrubs isolated among mobile sand dunes, Bremer Bay. Such stands, if not too far from continuously vegetated areas of profitable hunting, conceivably could serve as owl roosts.

zone was an isolated clump or "island" of vegetation somewhat resembling those shown in Fig. 3, in an area in which the general plant cover had already begun to deteriorate, and the sandy soil to shift. In such a deteriorating area, owl pellets might be buried before they disintegrated, thus protecting the enclosed bones from direct exposure to the weather, which would have resulted in a more cracked and split appearance than they have in fact.

Age of the deposit

Radiocarbon dates on wood from the fallen peppermint tree shown in Fig. 1 and on murid bones and teeth from the main bone accumulation near this tree have been obtained. They are 620 ± 90 years B.P. on the wood (GaK-2888) and 1190 ± 80 years B.P. on the bones and teeth (GaK-2887).

Discussion

The 250 x 200 m bone rich zone mentioned above is now completely devoid of living vegetation, but presumably at the time of accumulation (about A.D. 760) supported clumps of trees like those shown in Fig. 3, if not more continuous vegetation. Nearly six centuries later (about A.D. 1330) it still supported at least one large peppermint tree, very much larger than those shown in Fig. 3. At the present time, isolated clumps of peppermint trees still grow a few hundred metres away, within the same complex of mobile dunes. Thus it would appear that devegetation of the dune area by (or accompanying) drifting sand has been a very slow process, still not complete after more than a thousand years.

Early in this history of slow devegetation, it would appear that one or more owls inhabited the area. Assuming that a single owl catches mammals of about rat size at an average rate of one mammal per night, the total bone collection made by us represents only about two years' residence by one owl.

The native mammal species listed above fit the concept of their having been drawn by an owl from a territory consisting partly of heath, partly of gallery forest on the banks of a stream, as the area is now, and under a similar climate. Similar associations of species are known from other deposits of Recent geological age currently under study.

For example, in Hastings Cave in the Jurien Bay district, all four murid species listed above (and others) occur with the marsupial species *A. apicalis*, *S. murina*, *I. obesulus*, *Perameles* cf. *P. bougainville*, *P. platyops* and others (A. Baynes, personal communication). In an archaeological deposit in the Wanneroo district known informally as Orchestra Shell Cave, *A. apicalis*, *A. flavipes* and *S. murina* occur together with other marsupial and eutherian species (M. Archer, personal communication).

Similar associations of species are also known from historic time. For example, in the Cheyne Beach district, in which *A. apicalis* was recently found still to persist (Ride 1970), *A. flavipes* and *S. murina* also have been found living. According to Glauert (1950), the collector

George Masters obtained specimens of *Perameles myosurus* (now generally regarded as conspecific with *P. bougainville*, e.g. by Ride 1970) as well as *Perameles obesulus* (now generally known as *Isoodon obesulus*), along with *Hypsiprymnus platyops* (= *Potorous platyops*), *Antechinus apicalis* and other marsupial species in the King George's Sound-Pallinup (Salt) River region in 1868-69.

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