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A new species of cardinalfish from Australia (Percomorpha: Apogonidae: *Gymnapogon*)

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Abstract

A new species of cardinalfish, *Gymnapogon velum*, is described from two specimens from Australia, one from the northwest shelf of Western Australia and the other from Queensland. The new species is placed within *Gymnapogon* based on caudal osteology, one spine present on the preopercle edge, a single rod-like postcleithrum, as well as a scaleless head, body, and fins. It is distinguished by having an elongate body with relatively deep soft dorsal and anal fins, a rounded caudal fin with 15 branched principal caudal-fin rays, 13 soft dorsal-fin rays, 12 or 13 anal-fin rays, 10 or 11 upper and lower procurrent caudal-fin rays, and a single smooth spine on the edge of the preopercle. The high dorsal and anal fin-ray counts separate the new species from all congeners. *Gymnapogon annona* (Whitley, 1936) is redescribed due to discrepancies between the original description and illustration of the holotype.

Key words: taxonomy, ichthyology, coral-reef fishes, Rowley Shelf, Swain Reefs, *Gymnapogon annona*, *G. janus*, *G. philippinus*, *G. urospilotus*.

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Introduction

The genus *Gymnapogon* Regan, 1905 contains 9 species described from various widespread locations in the Indo-Pacific Ocean, from the northern Red Sea to the Line Islands (Fricke, Eschmeyer & Van der Laan 2019). The Atlas of Living Australia (<http://www.ala.org.au>, CSIRO 2019) lists three valid species of *Gymnapogon* occurring in Australian waters: *Gymnapogon annona* (Whitley, 1936), *G. philippinus* (Herre, 1939), and *G. urospilotus* Lachner, 1953. *Gymnapogon urospilotus* is comprised of a complex of species, and, since the type location is the Marshall Islands, the Australian form may not represent the same species. There are discrepancies between the description and illustration in the original description of *G. annona*, as discussed by Smith (1954), thus I redescribe the species here based on radiographs and examination of the holotype. A fourth, and undescribed species in Australia was brought to my attention by John Pogonoski of CSIRO (including a preliminary mtDNA COI tree suggesting a different species), and is described below.

Materials and Methods

Type specimens are deposited at the Australian National Fish Collection, Commonwealth Scientific and Industrial Research Organisation, Division of Marine and Atmospheric Research, Hobart, Tasmania, Australia (CSIRO). Comparative material was examined from the Australian Museum, Sydney, New South Wales, Australia (AMS). Methods for meristic data and measurements are given in Fraser (2005), except for body depth, which is measured on the vertical from the origin of the pelvic fins because the origin of the first dorsal fin is much farther back. Proportions are given as a percent of standard length. Meristic data and proportions as percent of standard length for the holotypes are presented in Table 1. The descriptive formulae of Springer & Smith-Vaniz (2008) were followed for describing the axil skeleton, supraneurals, and pterygiophore insertions. Internal characters were taken from specimen radiographs; no cartilaginous elements were examined. Counts of branched and unbranched rays of the pectoral fins were taken from specimens, while the caudal-fin procurent rays and the branched and unbranched rays of all median fins were counted from radiographs. All figures have been processed through Photoshop CS6 Extended ver. 13.06x64. Film and digital radiographs, initially negatives, were converted to positives in Photoshop and modified for clarity.

Gymnapogon velum, n. sp.

Highfin Cardinalfish

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Figures 1–6; Table 1.

Holotype. CSIRO H8279-01, 59.0 mm SL, Australia, Western Australia, North West Shelf, Rowley Shelf, -19.95°, 116.55°, 63–64 m, trawl, digital x-ray & photograph.



Figure 1. *Gymnapogon velum*, new species, fresh holotype, H8279-01, 59.0 mm SL, post mortem, North West Shelf, Western Australia, CSIRO Australian National Fish Collection, edited by T. Fraser.



Figure 2. *Gymnapogon velum*, new species, preserved holotype, H8279-01, 59.0 mm SL, North West Shelf, Western Australia, CSIRO Australian National Fish Collection (T. Fraser).

Paratype. CSIRO H6743-02, 49.0 mm SL, Australia, Queensland, Coral Sea, Swain Reefs, -21.10°, 151.42°, 53 m, trawl, digital x-ray & photograph.

Diagnosis. An elongate species of *Gymnapogon* with long and deep soft dorsal and anal fins, maximum depth about 50% of body depth and about equal to caudal peduncle depth; 12 or 13 soft dorsal-fin rays; 13 soft anal-fin rays; 14 pectoral-fin rays; caudal fin rounded, 17 principal caudal-fin rays with 15 branched, 10 or 11 upper and lower procurent caudal-fin rays; smooth spine on edge of preopercle; two teeth on each side of vomer; single supernumerary spines in dorsal and anal fins.

Description. (holotype) (Figs. 1–4) Dorsal-fin elements VI-I,12, first dorsal-fin ray unbranched, last 11 branched, last ray closely split at base (counted as one); anal-fin elements II,13, all rays branched, last ray closely split at base (counted as one); pectoral fin-rays 14, very long; pelvic fin-rays I,5, very long rays; caudal fin rounded, 9+8 segmented principal caudal-fin rays, 8+7 branched, uppermost and lowermost unbranched, 11 upper and lower procurent rays, longest two segmented; gill rakers and rudiments not counted.

Head, body, and fins scaleless. Spine on edge of preopercle long, completely covered, otherwise no serrations, infraorbitals, opercle and posttemporal smooth; preopercle ridge smooth. Some free neuromasts visible on the head; nares open. Premaxilla teeth without a gap at symphysis, some small teeth exposed with mouth closed then three large recurved canines exposed on each side, followed by a row of slightly enlarged teeth grading to exposed tiny teeth near end of premaxilla, and extending back well past eye; dentary with patch of recurved teeth at symphysis followed by a notch receiving external row of recurved enlarged teeth; palatine teeth unknown; vomer with 4 or 5 recurved canines; no teeth on basihyal, unknown state on ectopterygoid.

Vertebrae 10+14; 7 epineurals, on first and second centrum, then on first rib (third centrum) to third rib (fifth centrum), fourth through tenth rib articulating with parapophysis of sixth through tenth centra, tenth rib short; second preural centrum's crest as a spine about half length of third preural centrum's neural spine; two epurals, first long,

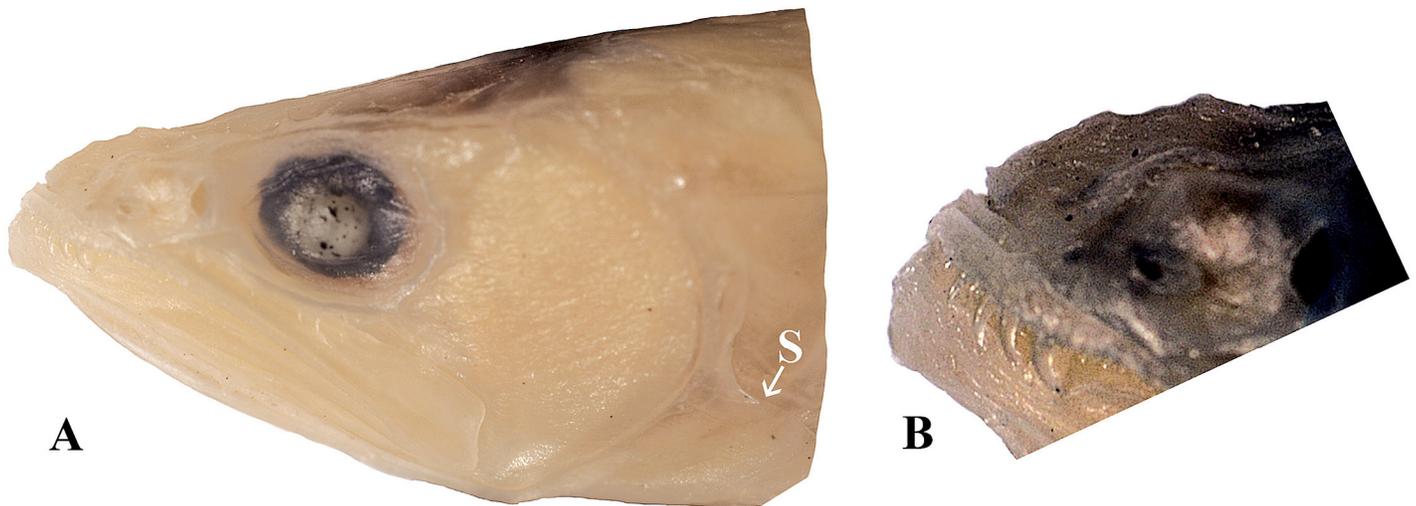


Figure 3. *Gymnapogon velum*, new species, holotype, H8279-01, 59.0 mm SL: A) Left side of head showing the preopercular spine visible under drying conditions. B) Enhanced and enlarged snout and anterior portion of the mouth showing three large canine teeth on the outside of the dentary (approximately the same angle as in A). S = preopercle spine (T. Fraser).

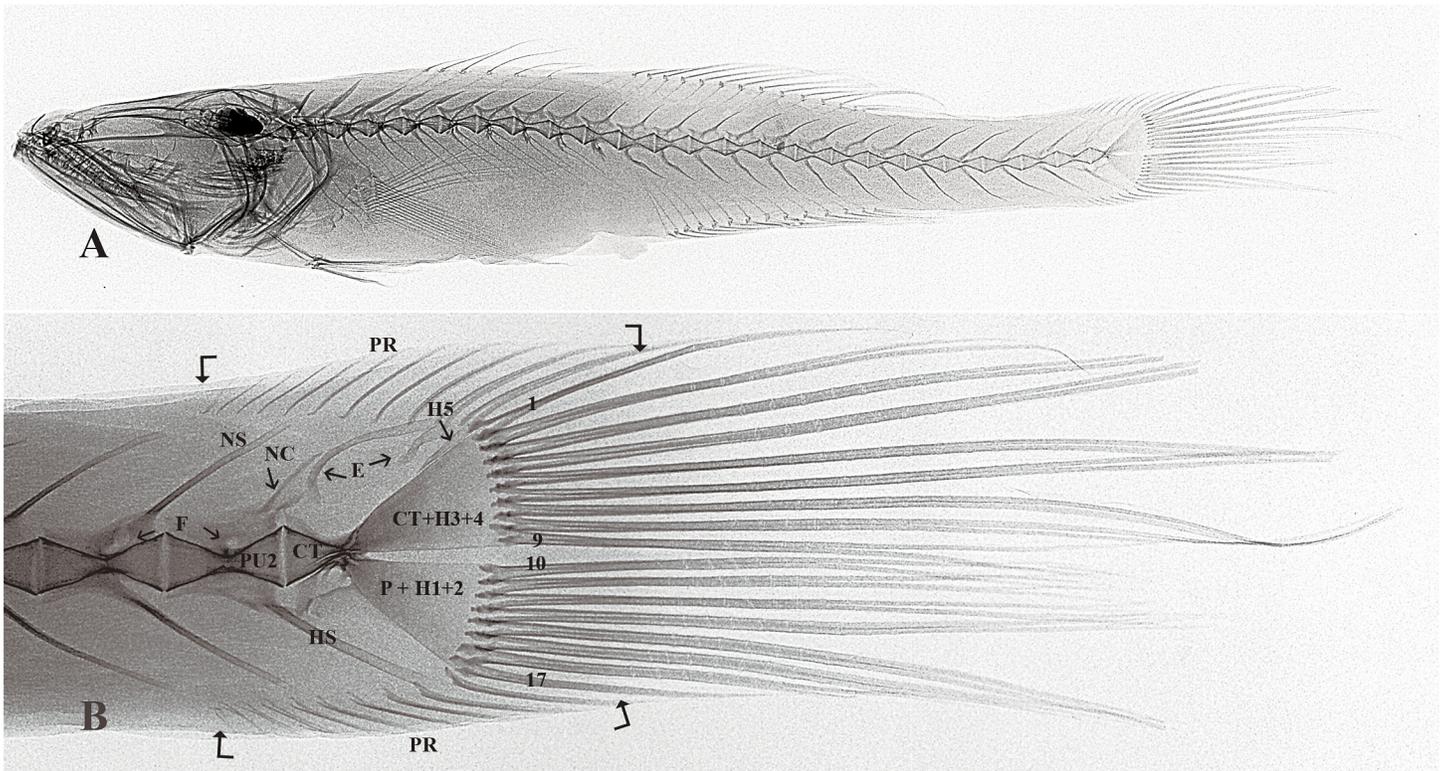


Figure 4. *Gymnapogon velum*, new species, holotype, H8279-01, 59.0 mm SL. Inverted digital radiographs edited by T. Fraser. Posterior 3 vertebrae enlarged 3.6 X in lower image: CT=terminal centrum, CT+H3+4=fused terminal centrum with hypurals 3 & 4, P+H1+2= fused parhypural with hypurals 1 & 2, E=epurals, H5=free hypural 5, HS= haemal spine, PR=procurrent rays, 1-17= principal caudal rays, PU2= second preural centrum, N=neural foramina, NC=crest with spine.

close to second preural's bifid spinous crest, second epural short; no urostylear sheath; no uroneurals; parhypural fused with fused hypurals 1+2; terminal centrum fused with fused hypurals 3+4; fifth hypural splint-like and free; large neural foramen in each centrum, no haemal foramina; supraneurals absent; dorsal-fin pterygiophore pattern 0/0/0-1/2/1/1/1/0/1/2/2/2/2/2/2; anal-fin pterygiophore pattern 4/2/2/1/2/2/2/2/2/1; first anal pterygiophore straight; single rod-like postcleithrum.

Color in alcohol. (holotype) (Fig. 2) Occiput with melanophores, none on body except abdominal internal wall blackish and blackish marks on vertebrae. Color in life unknown.

Description. (paratype) (Figs. 5 & 6) Dorsal-fin elements VI-I,13, first two dorsal-fin rays unbranched, last 11 branched, last ray closely split at base (counted as one); anal-fin elements II,13, first ray unbranched, last ray closely split at base (counted as one); pectoral fin-rays 14; pelvic fin-rays I,5; caudal fin rounded, 9+8 segmented principal caudal-fin rays, 8+7 branched, uppermost and lowermost unbranched, 10 upper and lower procurrent rays, last 4 segmented; gill rakers and rudiments not counted.

Head, body, and fins scaleless. Spine on edge of preopercle completely covered, otherwise no serrations,



Figure 5. *Gymnapogon velum*, new species, fresh paratype, H6743-02, 49.0 mm SL, post mortem, North West Shelf, Western Australia, CSIRO Australian National Fish Collection, edited by T. Fraser.

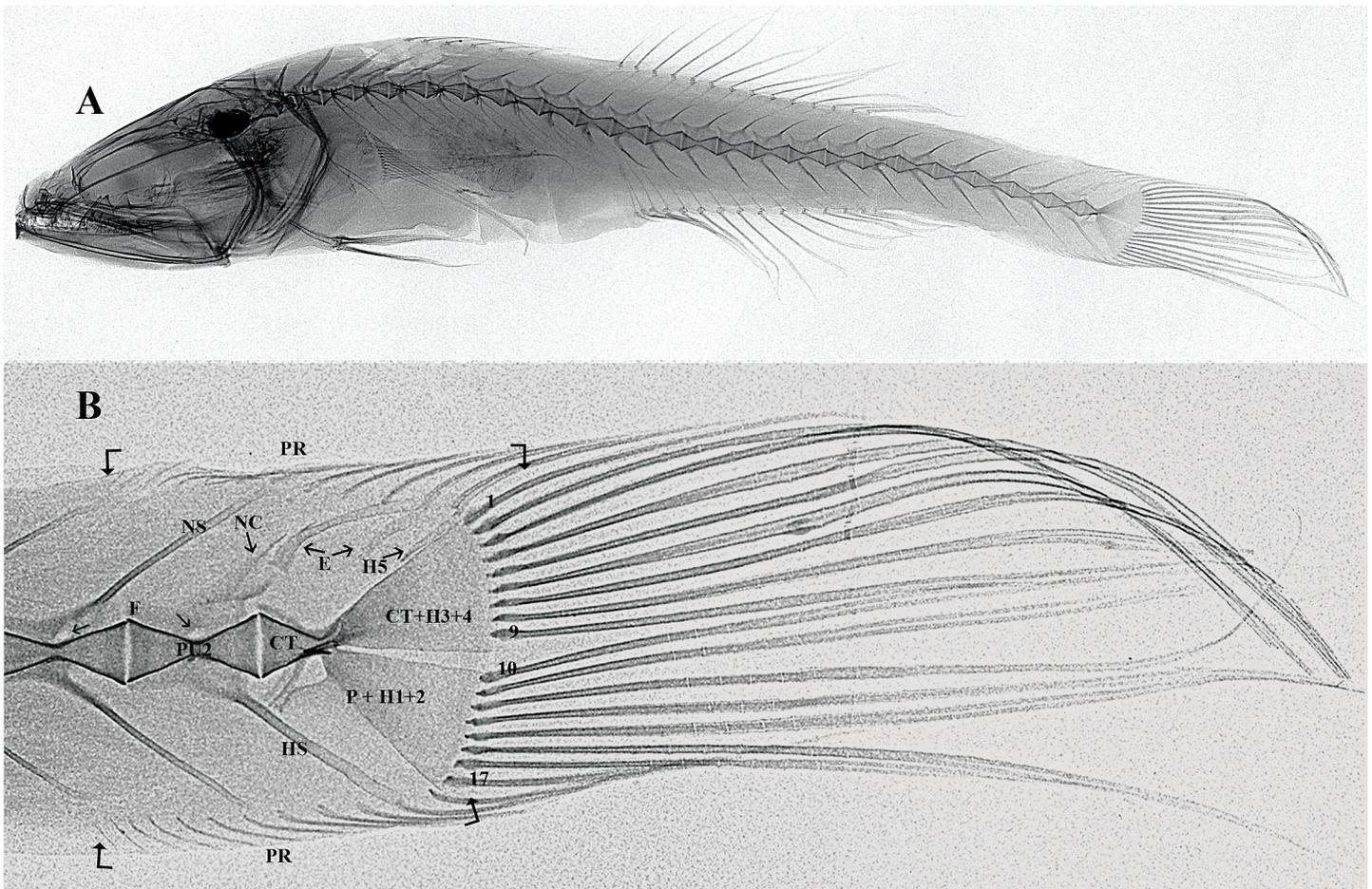


Figure 6. *Gymnapogon velum*, new species, paratype, H6743-02, 49.0 mm SL. Inverted digital radiographs edited by T. Fraser. Posterior 3 vertebrae enlarged 3.6 X in lower image: CT=terminal centrum, CT+H3+4=fused terminal centrum with hypurals 3 & 4, P+H1+2= fused parhypural with hypurals 1 & 2, E=epurals, H5=free hypural 5, HS= haemal spine, PR=procurrent rays, 1-17= principal caudal rays, PU2= second preural centrum, N=neural foramina, NC=crest with spine.

infraorbitals, opercle and posttemporal smooth; preopercle ridge smooth. No free neuromasts visible, nares closed, no ridges, most cephalic pores closed. Premaxilla teeth without a gap at symphysis, small teeth with one large recurved canine right front and two on left front, followed by one row of small to tiny teeth near end of premaxilla; dentary teeth without a gap at symphysis with smaller teeth and two anterior recurved canines on left side and one on right side, then a small to medium row of teeth followed by three recurved canines, middle one largest, with smaller teeth in between each canine, few teeth after last canine; palatine teeth unknown; vomer with 4 recurved canines; no teeth on basihyal, unknown state on ectopterygoid.

Vertebrae 10+14; 7 epineurals, on first and second centrum, then on first rib (third centrum) to third rib (fifth centrum), fourth through tenth rib articulating with parapophysis of the sixth through tenth centra, tenth rib short; second preural centrum's crest as a spine about half the length of the third preural centrum's neural spine; 2 epurals, first long, close to the second preural's bifid spinous crest, second epural short; no urostylar sheath; no uroneurals; parhypural fused with fused hypurals 1+2; terminal centrum fused with fused hypurals 3+4; fifth hypural splint-like and free; large neural foramen in each centrum, no haemal foramina; supraneurals absent; dorsal-fin pterygiophore pattern 0/0/0-1/2/1/1/1/0/1/2/2/2/2/2/1; anal-fin pterygiophore pattern 4/2/2/1/2/2/2/2/2/1; first anal pterygiophore straight; single rod-like postcleithrum.

Color in alcohol. (paratype) Melanophores on occiput, none on body except abdominal internal wall blackish. Color in life unknown.

Etymology. The species is named *velum* (Latin: sail) in reference to the long and deep dorsal and anal fins. It is treated as a noun in apposition.

Distribution. Known only from two trawl stations on the opposite sides of tropical Australia, in 53–66 m deep shelf waters.

Remarks. The new species is distinct from all gymnapogonines in having the highest known soft dorsal and anal fin-ray counts. It belongs in *Gymnapogon* based on having a scaleless head, body and fins, as well as one spine on the preopercle edge, a single rod-like postcleithrum, fused hypurals (parhypural+1+2 and 3+4+terminal central), a free fifth hypural, no urostylar sheath, two epurals, and no supraneurals.

Gymnapogon janus may be the closest relative based on the shared rounded caudal-fin, high number of procurrent caudal-fin rays, a single preopercle spine, 14 or 15 pectoral-fin rays, elongate bodies (13–18% SL), small eyes (3–5% SL), and exposed canines. Nevertheless, *G. janus* has many fewer dorsal (10) and anal-fin soft rays (9 or 10).

Compared to *G. annona*, body depth, eye diameter, and spine lengths are all much less in *G. velum* (Table 1). Furthermore, *G. annona* differs from *G. velum* in having lower fin-ray counts: 9 dorsal and anal-fin soft rays, (vs. 12 or 13); 13 branched principle caudal-fin rays (vs. 15); 7 or 8 procurrent caudal-fin rays (vs. 10–12); a forked caudal fin (vs. rounded); and a bifid preopercle spine (vs. smooth). The parhypural in the new species, as illustrated in the radiographs, appears more reduced than shown in Plate 7D for *G. annona* (Fraser 1972).

There are some differences between the holotype and paratype: in the presence and number of unbranched rays at the front of the soft dorsal and anal fins; procurrent ray counts; dorsal-fin pterygiophore pattern 0/0/0-1/2/1/1/1/0/1/2/2/2/2/2/2 vs. 0/0/0-1/2/1/1/1/0/1/2/2/2/2/2/1; and anal-fin pterygiophore pattern 4/2/2/1/2/2/2/2/2/1 vs. 4/2/1/2/2/2/2/2/2.

TABLE 1

Morphometrics of Australian type specimens of *Gymnapogon* as percent standard length.

	<i>G. velum</i>		<i>G. annona</i>
	holotype CSIRO H8279-01	paratype CSIRO H6743-02	holotype AMS IA.6469
Standard Length (mm)	57.8	49.0	35.8
Head Length	33.7	39.0	36.3
Body Depth	16.4	18.2	22.6
Eye Diameter	5.4	5.5	7.8
Snout Length	6.6	8.2	8.7
Interorbital Width	5.9	6.5	7.8
Pectoral-Fin Length	–	29.4	–
Pelvic-Fin Length	8.6	14.9	17.3
Upper-Jaw Length	16.8	16.7	19.6
Caudal-Peduncle Depth	8.3	7.8	8.9
Caudal-Peduncle Length	23.0	21.5	26.0
First Dorsal-Fin Spine	1.9	–	7.0
Second Dorsal-Fin Spine	4.2	–	10.6
Third Dorsal-Fin Spine	5.4	–	12.8
Fourth Dorsal-Fin Spine	5.0	–	12.0
Spine in Second Dorsal Fin	2.2	3.4	8.7
First Anal-Fin Spine	0.9	0.6	2.8
Second Anal-Fin Spine	2.0	1.8	9.2

Gymnapogon annona (Whitley, 1936)

Australaphia annona Whitley 1936: 49, fig. 6 (Queensland, Australia).

Figures 7–9; Table 1.

Holotype. AMS IA.6469, 35.8 mm SL, Australia, Queensland, Lindeman Island, Whitsunday Passage, April 1935, digital x-rays.

Diagnosis. A species of *Gymnapogon* with 9 soft dorsal and anal-fin rays; 14 pectoral-fin rays; caudal fin forked, 17 principal caudal-fin rays with 13 branched, 7 or 8 upper and lower procurent rays; bifid spine on edge of preopercle.

Description. (Figs. 7 & 8) Dorsal-fin elements VI-I,9; anal-fin elements II,9; pectoral-fin rays 14; caudal fin forked, 9+8 segmented principal caudal-fin rays, 7+6 branched, uppermost and lowermost two unbranched, 7 upper and 8 lower procurent caudal-fin rays, longest two segmented; gill rakers 9, upper arch 1, 8 lower arch 8, 1 upper and lower rudiments.

Spine on edge of preopercle long, exposed, bifid otherwise no serrations, infraorbitals, opercle and posttemporal smooth; preopercle ridge smooth. Premaxilla with wide band of teeth becoming one row with small recurved canines; dentary with one row of small teeth and large canines on the side; vomer with three slightly enlarged teeth; palatine with one row of small teeth; no teeth on basihyal.

Vertebrae 10+14; first rib (third centrum) to third rib (fifth centrum), and fourth through tenth rib articulating with parapophysis of sixth through tenth centra, tenth rib short; second preural centrum's crest as a spine about half length of third preural centrum's neural spine; two (?) epurals, first long, close to second preural's spinous crest, second epural not visible; no urostylear sheath; no uroneurals; parhypural fused with fused hypurals 1+2; terminal centrum fused with fused hypurals 3+4; fifth hypural splint-like and free; large neural foramen in each centrum, no



Figure 7. *Gymnapogon annona*, preserved holotype of *Australaphia annona* Whitley, 1936, IA 6469, 35.8 mm SL: September 1973 by T. Fraser (above) and in November 2012 by Amanda Hay, AMS (below).

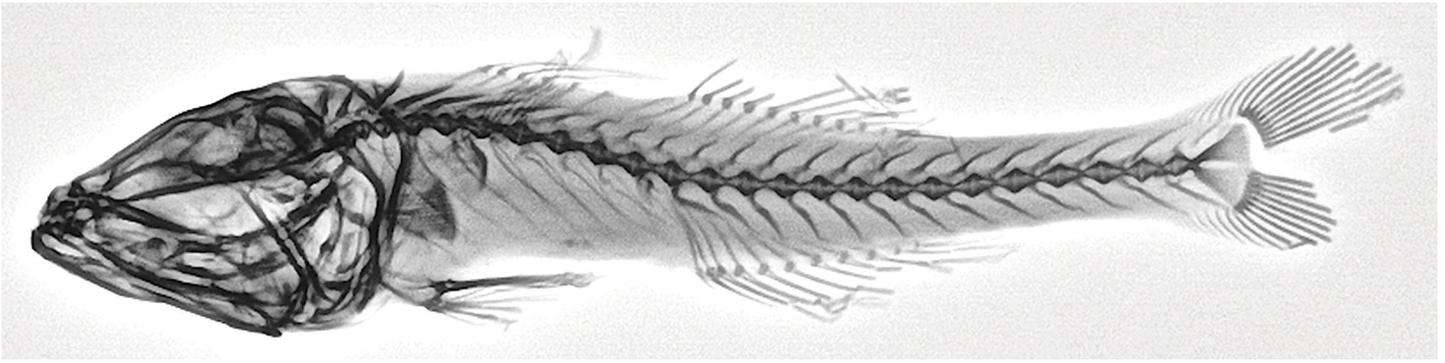


Figure 8. *Gymnapogon annona*, preserved holotype of *Australaphia annona* Whitley 1936, IA 6469, 35.8 mm SL: digital radiograph, June 2014 by Sally Reader (AMS), inverted and edited by T. Fraser.

haemal foramina; dorsal-fin pterygiophore pattern 0/0/0-1/2/1/1/1/1/1/1/1/2/2/2; anal-fin pterygiophore pattern 5/1/1/1/1/2; first anal pterygiophore straight.

Color in alcohol. (Fig. 7) Color is uniformly pale on the head, body and fins, now partially dried out and reddish yellow.

Remarks. Whitley (1936) does not describe the large spine on the preopercle. His illustration, here as Fig. 9, shows a bilobed spine- a feature shared with a few other congeners (Fraser 2016). Whitley reported the soft dorsal fin had 11 rays and the anal fin had 10 rays, but the illustration shows 9 rays for each fin. The radiograph confirms the latter counts. His notation about morphology suggest that lengths are in parentheses and amount into standard length and others into head length.

The holotype was in relatively poor shape in 2012, compared with 1973 (Fig. 7). According to Amanda Hay (AMS), it appears that the specimen is partially dried. The specimen is now missing the sixth dorsal-fin spine and the caudal fin is partially detached from the hypural plate. More information might be available with a better radiograph.

Gymnapogon philippinus, also reported from Australia, differs from *G. annona* by having 8 anal-fin rays (vs. 9), dorsal-fin pterygiophore pattern 0/0/0-1/2/1/1/1/1/1/1/2/2/2/1/1 (vs. 0/0/0-1/2/1/1/1/1/1/1/2/2/2/1/1); anal-fin pterygiophore pattern 4/1/1/1/2/1 (vs. 5/1/1/1/2/1); 15 branched principle caudal-fin rays (vs. 13), and a smooth preopercle spine (vs. bifid). The differences from *G. velum* are listed under that species' description above.

Comparative material examined: *Henicichthys philippinus*, holotype, CAS-SU 34379, 32.0 mm SL, Philippines, Luzon, Nasugbu, 11 December 1936; digital from film x-ray, digital x-rays. Paratypes: CAS-SU34380 (3, 26.5–27.5 mm SL), Philippines, Luzon, Nasugbu; CAS-SU 34381 (4, 19.0–27.9 mm SL), Philippines, Oriental Negros, Dumaguete, 26 December 1936. Indian Ocean specimens: UF 171681 (2, 16.2–20.1 mm SL), Indonesia, Lesser Sunda Islands, Flores Sea, Maumere Bay, 1.5 km NE of Nanganale, FGT1720, 5 August 1971.

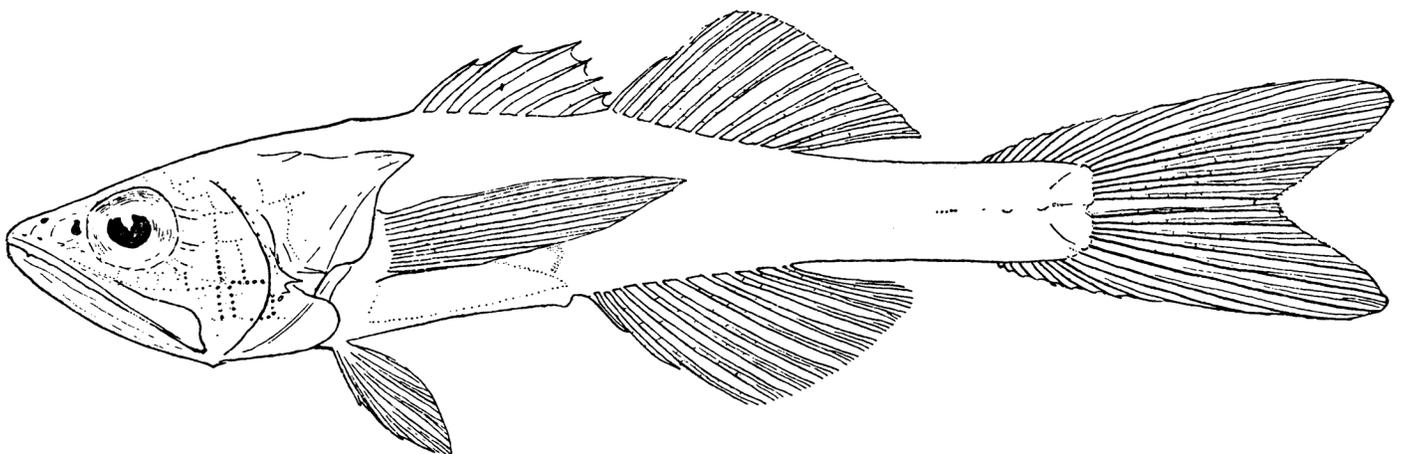


Figure 9. *Gymnapogon annona*, holotype, IA 6469, 37 mm SL, from Whitley (1936: text figure 6).

Acknowledgments

John Pogonoski, (CSIRO) sent the specimens of *Gymnapogon* after examination of radiographs suggested that undescribed species were collected in trawling programs by CSIRO. He also made available a mtDNA COI Nearest Neighbor tree including the new species. Douglas Hoese and Mark McGrouther (AMS) provided assistance during a fellowship supported by the Australian Museum in Sydney. Amanda Hay and Sally Reader (AMS) provided a photograph and radiograph of *G. annona*, respectively. William Eschmeyer and David Catania (CAS) provided assistance while visiting the museum and David Catania provided photographs and radiographs of *G. philippinus*. Robert Robins (UF) helped with the loan of specimens from CSIRO. The manuscript was reviewed by two anonymous referees.

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