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A REVIEW OF THE AUSTRALIAN ENDEMIC GOBIID FISH GENUS *CHLAMYDOGOBIUS*, WITH DESCRIPTION OF FIVE NEW SPECIES.

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ABSTRACT

The Australian endemic gobiid genus *Chlamydogobius* is reviewed and five new species described as new. One of the new species is estuarine, found in coastal northern Australia; all the other species are restricted to freshwater springs and bores in inland Queensland, South Australia and the Northern Territory. *Chlamydogobius* belongs to the subfamily Gobionellinae and may be most closely related to *Pseudogobius, Hemigobius* and *Mugilogobius*. An artificial key to species is given; species are distinguished by morphology and vertebral counts. One of the new species is considered to be endangered and two other new species are vulnerable.

KEYWORDS: *Chlamydogobius*, Gobiidae, Gobionellinae, freshwater fish, estuarine fish, new species.

INTRODUCTION

The desert goby, *Chlamydogobius eremius* (Zietz, 1896), is probably one of the most well-known gobiid fish species in Australia (Fig. 1). It is widely kept by aquarium fanciers, and has been referred to in a number of publications dealing with inland fish fauna and ecology (for example: Glover 1971; Glover 1973, Glover 1982; Glover 1989; Glover 1990; Glover and Sim 1978; Horsthemke 1989). In recent years, it has become apparent that some of the populations of *Chlamydogobius* are very isolated and may be endangered by increased pastoral activities and reduction in the water table (Harris 1987; Wager and Jackson 1993).

The taxonomic status of the genus and its possible relationships were discussed by Miller (1987), who considered it to be a monotypic valid genus most closely related to *Mugilogobius* Smitt. *Chlamydogobius* is a gobionelline *sensu* Pezold (1993) and Larson (in prep.) and is here considered to be most closely related to *Pseudogobius* Popta, *Hemigobius* Bleeker and *Mugilogobius*.

As Miller (1987) noted, Whitley (1930) erected the genus *Chlamydogobius* without any comment or diagnosis. Miller considered that, based on the six species of *Mugilogobius* he had examined, and information in Akihito *et al.* (1984), *Chlamydogobius* should remain separate from *Mugilogobius* due to it having a reduced number of sensory papillae (especially row *c*), a longitudinal (versus transverse) row *s* on the snout, a single mental papilla on each side (versus a transverse row or rows of papillae), reduced number of scale ctenii, a much convoluted gut, dark-pigmented peritoneum, one epural, metapterygoid with spur not reaching across to quadrate, and 28 vertebrae.

As will be shown in a revision of the gobionellines related to and including *Mugilogobius*, some of the above characters given by Miller (1987) can be found among some *Mugilogobius* species (Larson in prep.). These characters include: reduced numbers of mental papillae, black to brown peritoneum and broad metapterygoid. *Chlamydogobius* has one of the basic gobionelline characters, vertebral formula 3-12210 (*sensu* Birdsong *et al.* 1988), and it shares with *Mugilogobius* the 9/7 segmented caudal ray pattern and basic sensory papillae pattern (Fig. 1). Both genera have lost all lateral line pores. The relationship of these

two genera and other similar gobionellines are outlined by Larson (in prep.)

Harris (1987), Miller (1987), Glover (1989) and Jackson (1993) have indicated that there may be more than one "desert goby" species. The author considers that there are six species in this genus: five from freshwater desert habitats, and one marine/estuarine. The marine species had been recognised as undescribed by the author for some time, but was only during the course of this study that the relationship to *C. eremius* became clear. Four of the freshwater species and the marine species are described as new below. A key to species is provided.

Chlamydogobius is easily distinguished from any other fish in the freshwater environment, but in the estuaries of northern Australia, one species of *Chlamydogobius* can co-occur with species of *Hemigobius*, *Mugilogobius* and *Pseudogobius*, which are similar in appearance and may be its closest relatives (Larson: in prep.). *Pseudogobius* has headpores in the interorbital region, a rounded, somewhat inflated snout that usually overhangs the upper lip and a long gut which spirals in a corkscrew manner about itself along its longitudinal axis. *Hemigobius* also has a few interorbital headpores, the gut is long and coiled, watch-spring-like, separate from the stomach, but it has 17 segmented caudal rays, unlike the other genera (which have 16 segmented caudal rays). *Mugilogobius* is most similar to *Chlamydogobius*, as it lacks headpores and has similar basic external morphology; the status of the two genera is currently under review. To date, the two can be distinguished by the following characters: *Mugilogobius*: *s* papillae on snout in at least three rows of two or more papillae, the first of which is usually the longest and runs just above upper lip fold (few species with middle row represented by only 1-2 papillae); pectoral rays 13-20; intestine simple, with one "S-bend" and no full loops; gill opening to pectoral base or further, usually with fleshy knobs or ridge along shoulder; two epurals, metapterygoid forming distinct bridge to quadrate, 26-27 vertebrae, usually 26 (10, rarely 11, precaudal and 16-17 caudal), males often with distinctly enlarged mouths.

Chlamydogobius: *s* papillae on snout usually in two rows, rarely three (each row consists of only 1-2 papillae), first row just above upper lip absent; pectoral rays 11-14; intestine long and coiled into three loops separate from stomach; gill opening restricted to pectoral base, shoulder girdle smooth; one epural, metapterygoid not forming bridge to quadrate, 27-29 vertebrae, usually 28 (10-11 precaudal and 16-18 caudal), males with mouths not much larger than those of females.

Chlamydogobius is masculine; the exact derivation of the name is uncertain (Whitley gave no etymology, as was his way). Whether Whitley intended to refer to *Chlamydes*, nowadays a junior synonym of *Bathygobius* (some species of which, such as *B. cotticeps*, do resemble *Chlamydogobius* in general appearance), or to the more exact meaning of *chlamydos* (mantle or cloak), is only speculation.

Methods. Measurements were taken using electronic calipers and dissecting microscope. Counts and methods generally follow Hubbs and Lagler (1970), except as indicated below. Pterygiophore formula follows Birdsong et al. (1988). Transverse scale counts are taken by counting the number of scale rows from the anal fin origin diagonally upward and back toward the second dorsal fin base. Head length is taken to the upper attachment of the opercular membrane. Interorbital width is least fleshy width (not least bony width). In the descriptions, an asterisk indicates counts of the holotype (or lectotype). Numbers in parentheses after counts indicate the number of specimens with that count, or the range of counts. Vertebral counts and other osteological information was obtained by radiography and clearing and double-staining.

Abbreviations: institutions - AMS, Australian Museum, Sydney; NTM, Museum and Art Gallery of the Northern Territory, Darwin; QM, Queensland Museum, Brisbane; ZMH, Zoologische Museum, Hamburg; others - HD, head depth at rear preopercular margin; HL, head length; HW, head width at preopercle; my, million years ago; SL, standard length; TRB, transverse scale count backward.

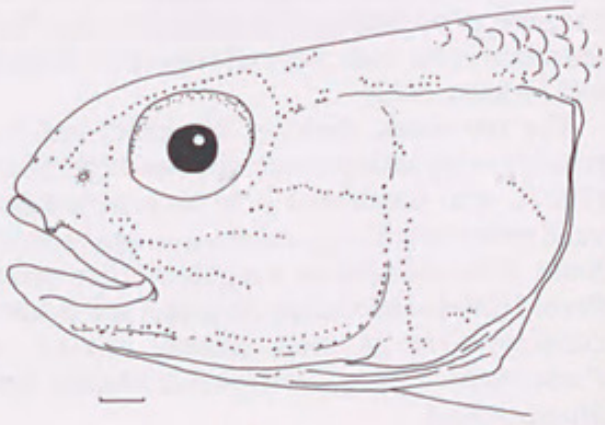

Fig. 1. *Chlamydogobius eremius*, papillae pattern. Scale bar = 1 mm.

SYSTEMATICS

Chlamydogobius Whitley, 1930

Chlamydogobius Whitley 1930: 122, central Australia (type genus *Gobius eremius* Zietz, 1896, by original designation and monotypy).

Chalamydogobius - Lake 1971: 44 (lapsus).

Diagnosis. Genus distinguished by combination of characters: single epural; 27-29 vertebrae (10-11 precaudal and 16-18 caudal); usually one more soft dorsal than anal ray present; long gut with at least two full loops in the intestine, very dark-pigmented peritoneum; gill-opening restricted to pectoral base; gill rakers without spines; shoulder girdle smooth, without bony flange, or fleshy bumps or flaps; jaws not much longer in males compared with females; headpores absent; row *c* on cheek below eye much reduced to absent, *s* rows on snout usually consist of one (rarely two) papilla each, only two *s* rows present in most species, usually only one *f* row mental papilla on each side behind symphysis; male breeding colour includes dark, white-margined second dorsal, anal and caudal fins and yellow band with blue spot below it on upper half of first dorsal fin; genus restricted to the Australian continent.

Osteology. Pterygiophore formula 3-12210; 27-29 vertebrae, 10-11 precaudal and 16-18 caudal vertebrae; neural spines of first thee vertebrae often stout, broadened or bifid at tip, usually second and third spines bifid or broad-tipped; usually two (occasionally one) anal fin pterygiophores before haemal spine of first caudal vertebra; maxilla narrow, with one adductor mandibulae attachment at half-way point; palatine broad anteriorly, becoming quite slender ventrally, not quite reaching to quadrate and sometimes falling well short of it; pterygoid short, broad-based; metapterygoid broad, not extended forward toward quadrate, with pointed, broad-based flange or spur extending anterodorsally; quadrate rather forked, with lower limb slender; symplectic without spur or process extending toward preopercle; preopercle narrow, without groove posteriorly; scapula unossified; single epural, sometimes epural partly split.

KEY TO SPECIES OF THE GENUS *CHLAMYDOGOBIUS*

1 a. Second dorsal and anal fins usually with equal number of rays, modally I,6; pectoral rays 11-12; usually 27 vertebrae; estuarine, from northern coast of Australia .... *C. ranunculus* n. sp.

b. Second dorsal fin with one more ray than anal; second dorsal usually I,7-8; anal usually I, 6-7; pectoral rays usually 13-14 (if 11-12, then second dorsal and anal not I,6); 28-29 vertebrae; freshwater, restricted to central Australia 2

2 a. Opercles, pectoral base and breast usually naked, predorsal region often naked; second dorsal modally I,8; anal modally I,7; pectoral usually 13; usually 28 vertebrae (11+17); restricted to creeks and bores south and west of Lake Eyre .....*C. eremius*

b. Opercles, pectoral base and breast at least partly scaled; predorsal region usually scaled; second dorsal rays I,6-8, anal rays I,5-8; vertebrae 28-29 3

3 a. First dorsal fin reduced in size, spines III-V (rarely VI); second dorsal I,6-7; anal I,5-6; pectoral rays 11-12; 28 vertebrae; restricted to Elizabeth Springs, western Queensland ..... *C. micropterus* n. sp.

b. First dorsal fin not reduced, spines usually VI (sometimes V in *gloveri* n. sp.); second dorsal I,7-8; anal I,6-7; pectoral usually 12-13; vertebrae 28-29 4

4 a. Cheek with small cycloid scales; usually 10 precaudal vertebrae; pectoral rays 13-14, usually 13; restricted to springs around Edgbaston Station, central Queensland (Barcoo/Thomson drainage) .... *C. squamigenus* n. sp.

b. Cheek naked; usually 11 precaudal vertebrae; pectoral rays 11-14, usually 12 or 13; from central Australia (NW of Lake Eyre) 5

5 a. Second dorsal modally I,7; anal modally I,6; pectoral rays modally 12; usually 28 vertebrae (11+17); restricted to Dalhousie Springs, northern South Australia ....*C. gloveri* n. sp.

b. Second dorsal I, 7-8; anal modally I,7; pectoral rays modally 13; usually 29 vertebrae (11+19); restricted to the upper Finke River drainage, Northern Territory ....*C. japalpa* n. sp.

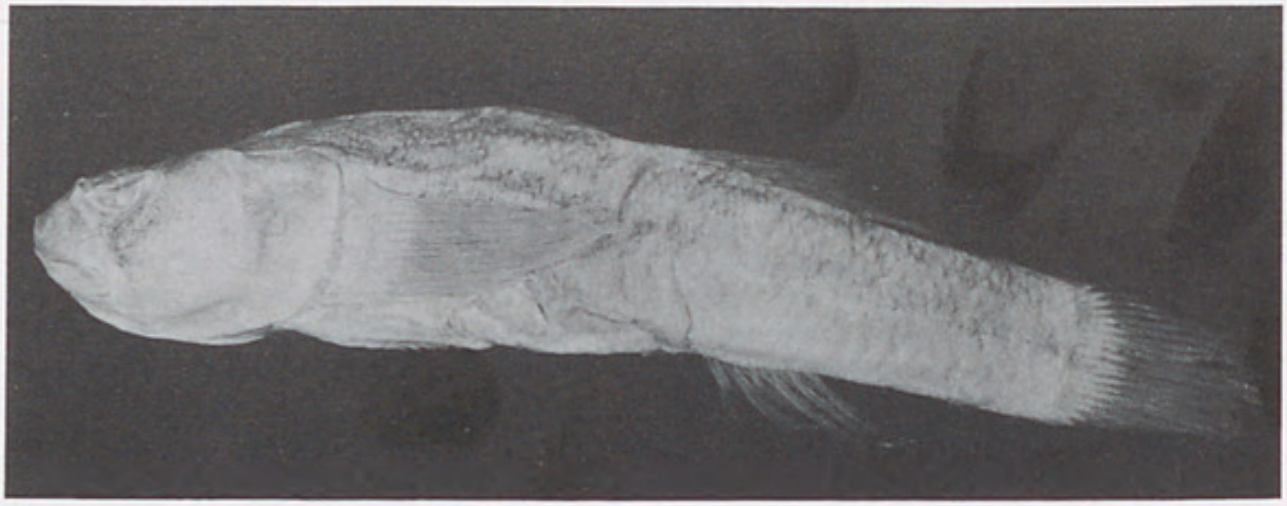

Fig. 2. Lectotype of *Gobius eremius*, SAM F.525, 51 mm SL male.

Chlamydogobius eremius (Zietz, 1896)
(Figs 1-4, Plate 1, Tables 1-4)

Gobius eremius Zietz, 1896: 180, pl. 16, fig. 5 (Central Australia). - McCulloch and Ogilby 1919: 257; - McCulloch 1929: 372.

Chlamydogobius eremius - Whitley 1930: 122; - Koumans 1931: 159-160; - Whitley 1964: 123; - Glover 1971: 1-147; - Glover 1973: 8-10; Glover 1973: 4; Scott *et al.* 1974: 271-272; - Glover and Sim 1978: 38; - Lake 1978: 73, 153; - Glover 1982: 242-244; - Thompson 1983: 17-20; - Merrick and Schmida 1984: 309-310; - Miller 1987: 687-705; - Glover 1989: 90-91; Allen 1989: 203-204; - Horsthemke 1989: 288; - Larson and Martin 1990: 62-63 (in part); - Glover 1990: 189, 191, fig.1d.

Chalamydogobius eremius - Lake 1971: 44 (*lapsus*).

Material examined. 77 specimens (10-51). SOUTH AUSTRALIA: lectotype of *Gobius eremius*, SAM F.525, 51 mm SL male, Coward Springs, bore by railway, 4 May 1894, coll. Horn Expedition. Paralectotypes of *Gobius eremius*, SAM F.7674, 5(13-43), same data as lectotype. AMS I.24673-001, 24(10-34.5), including two cleared and stained, 6 km ESE of Coward Springs, coll. D.F. Hoese and S. Reader, 23 August 1984; SAM F.3509, 10(30-44), Coward Springs Bore, coll. J. Glover, 2 July 1968; SAM F.4204, 6(27-45.5), dam near Coward Springs, coll. J. Barry, April 1976; SAM F.3999, 13(32.5-41), Margaret River, coll. T. Sim, 3 March 1975; AMS I.26285-001, 4(14.5-18.5), spring near Well Spring, Freeling Springs, coll. W. Ponder, 2 June 1988; AMS I.24493-001, 4(28-41), including one cleared and stained, Finniss Springs, coll. W. Ponder, R. Hershler, 28 January 1984; AMS I.27116-001, 10(13-29), Ockenden Spring and Bore, coll. W. Ponder, 1 June 1983.

Other material examined (but not used in description). Twenty-three specimens from the following localities. AMS I.30085-001, 2, Davenport Springs, SA; AMS I.30087-001, 15, Elizabeth Springs, SA; ZMH 31790, 2, aquarium specimens, locality unknown; NTM S.11426-001, 4, "The Bubbler", mound springs, SA.

Diagnosis. A moderate to large *Chlamydogobius* with second dorsal rays I,6-8; anal rays I,5-7; pectoral rays 12-14; longitudinal scales 33-57 (usually 45-50); TRB 13-19; vertebrae 10+17 to 11+18 (mode 11+17); predorsal scales 0-10, scales, if present, scattered on nape midline, arranged in rows on sides of nape only; most scales cycloid, ctenoid scales on sides of body extend in narrow wedge up to behind pectoral fin or in two distinct patches; opercles naked, pectoral base and breast usually naked, belly midline sometimes naked; head and body light brown, heavily mottled and marbled with darker brown irregular markings (restricted to the western and southern Lake Eyre drainage of South Australia).

Description. Based on 49 specimens, 14.5-51 mm SL. An asterisk indicates counts of the lectotype (Fig. 2).

First dorsal IV (in 1), V (1), VI* (43); second dorsal I,6-I,8 (mean I,8*); anal I,5-8 (mean I,7*, I,6 in lectotype), pectoral rays 10-15 (mean 13*), segmented caudal rays 16-17 (mean 16*); caudal ray pattern usually 9/7*; branched caudal rays 14-16* (mean 15); unsegmented (procurrent) caudal rays 7/6 (2), 7/7 (3), 7/8 (1), 7/9* (1), 8/8 (1), 8/9 (1), 9/7 (1); longitudinal scale count 33-57 (mean 46, 44 in lectotype); TRB 13*-19 (mean 16); predorsal scale count 0*-10 (mean 6;

0 in 41 specimens); circumpeduncular scales 16-24 (mean 20, 19 in lectotype). Gill rakers on outer face of first arch ranging from 2+5 to 3+10 (mode 2+6). Pterygiophore formula 3-12210* (23). Vertebrae 10+17 (2), 11+16 (3), 11+17* (26), 11+18 (3). Neural spines of first three vertebrae variably split or expanded* at tip (16). One* (28) or two epurals (3). One (3) or two* (28) anal pterygiophores before haemal spine of first caudal vertebra.

Body rounded anteriorly, compressed posteriorly. Head short, somewhat rounded, wider than deep, HL 2.8-3.5 (mean 3.2) times in SL; cheeks may be inflated and fleshy in large males. Depth at posterior preopercular margin 1.5-1.9 (mean 1.7) in HL. Width at posterior preopercular margin 1.3-4.4 (mean 1.5) in HL. Mouth terminal to subterminal, slightly oblique, forming angle of about 20° with body axis; upper jaw slightly overhangs lower jaw; jaw length not greatly different between males and females; jaws generally reach to mid-eye in males and to below front half of eye in females (to below mid-eye in lectotype). Lips usually fleshy, smooth, usually without fleshy fimbriae visible on inner edges (visible in lectotype, which is rather dehydrated); lower lip free at sides, fused across front. Upper jaw 2.1-3.7 (mean 3.2 in females, 2.8 in males) in HL. Eyes lateral, high on head, top usually forming part of dorsal profile, 2.6-5.6 (mean 4.4) in HL. Snout rounded to rather flattened, occasionally slightly inflated and partly overhanging upper lip, 3.0-4.3 (mean 3.6) in HL. Interorbital broad, flat to very slightly convex, 1.7-4.0 (mean 3.4) in HL. Top of head, from rear of interorbital space up to snout tip, with scattering of very fine villi (villi only visible in specimens with well-preserved mucous coat in this area). Body depth at anal origin 4.6-5.8 (mean 5.3) in SL. Caudal peduncle compressed, relatively long, length 3.5-7.6 (mean 3.9) in SL. Caudal peduncle depth 6.6-11.9 (mean 7.9) in SL.

First dorsal fin low, rounded, second or third spines longest or subequal; third spine usually longest; spines do not reach second dorsal origin when depressed. First dorsal spine always shorter than next three. Second dorsal spine length 7.5-10.0 (mean 9.1) in SL. Third dorsal spine length 6.6-10.6 (mean 8.8) in SL. Fourth dorsal spine length 6.6-9.8 (mean 8.6) in SL. Second dorsal and anal fins low, posteriormost rays longest, when depressed, rays barely reach caudal fin in large mature males; rays fall well short of caudal fin in all other specimens. Pectoral fin broad, rounded, central rays longest, 4.0-7.3 (mean 4.6) in SL; rays usually all branched (lowermost ray may be unbranched). Pelvic fins quite small, rounded to oval, may reach up to half distance to anus, 4.0-8.6 (mean 6.7) in SL. Caudal fin oval to rounded or rectangular in form, 3.4-4.2 (mean 3.8) in SL.

No mental frenum, chin smooth. Anterior nostril in short tube, placed on edge of preorbital, tube oriented down and forward, preorbital sometimes curved forward slightly to accommodate nostril. Posterior nostril small, oval, placed halfway between front centre margin of eye and edge of preorbital. Gill opening restricted to pectoral base. Inner edge of shoulder girdle either smooth and fleshy, or hard-edged, with no bony flange or fleshy knobs and flaps present. Gill rakers on outer face of first arch very short rounded knobs, without spines, longest one or two rakers near angle of arch; outer rakers on second and third

Table 1. Measurements (mm) of *Chlamydogobius eremius* (Zietz, 1896).

Character	Lectotype	Males			Females		
		Minimum	Maximum	Mean	Maximum	Minimum	Mean
Head Length	17.0	6.0	17.0	10.8	6.7	12.4	9.6
Head Depth	9.0	3.8	9.0	6.5	3.7	7.8	5.6
Head Width	10.5	4.6	11.5	7.9	2.5	8.5	6.5
Body Depth	9.5	3.7	9.5	6.7	3.8	8.0	6.0
Body Width	-	1.8	5.9	3.9	2.5	5.2	3.7
Caud. Ped. Leng.	12.9	5.3	12.9	8.9	5.8	10.8	8.3
Caud. Ped. Depth	7.1	2.6	7.1	4.6	2.7	5.5	4.1
Snout	4.7	1.6	4.7	3.3	1.8	3.7	2.7
Eye	3.7	1.4	3.7	2.4	1.6	2.8	2.2
Jaw	7.1	1.9	7.4	4.2	2.0	4.1	3.0
Interorbit	5.3	1.8	5.3	3.6	1.7	4.1	2.8
Pectoral	12.4	4.6	12.4	7.9	4.7	8.9	6.9
Pelvic	7.3	3.2	7.8	5.4	3.2	5.9	4.6
Caudal	-	5.8	13.2	9.1	5.7	9.9	8.2
Longest D1 spine	5.2	2.3	5.7	4.4	3.0	4.5	4.0

arches usually smaller than those on first arch, outer rakers absent from fourth arch. Gill rakers on inner face of first and all other arches nearly twice the length of first arch inner rakers. Tongue thick and fleshy, usually blunt to rounded. Teeth in outermost row of upper jaw usually larger than others, stout and curved or almost upright; behind outer row, three to five rows of slightly smaller stout curved teeth; number of rows reducing to one or two at side of jaw (teeth in lectotype, a large specimen, only slightly curved). Teeth in lower jaw in five or six rows; teeth arranged as in upper jaw apart from outermost row being not much larger than those in rows behind it. Teeth not much differing in size between males and females.

Predorsal scales usually absent; when present, midline of nape naked with scales extending forward at sides to above opercle, or small scales present immediately before first dorsal fin or scattered unevenly over nape. Operculum generally naked (seven specimens with few small cycloid scales scattered on upper third to half; usually only one to three scales present). Cheek always naked. Pectoral base naked (one specimen with few small cycloid scales present). Prepelvic area usually naked, sometimes with few small cycloid scales directly before pelvic fin. Belly sometimes with naked mid-line, otherwise covered with cycloid scales and isolated patch under pelvics of weakly ctenoid scales. Ctenoid scales on side of body present at least as scattered scales on caudal peduncle and patch behind pectoral fin; peduncle scales may extend forward in narrow wedge, often broken into patch of ctenoid scales behind pectoral fin and ctenoid scale wedge posteriorly.

Head pores absent as in all *Chlamydogobius*.

Sensory papillae pattern longitudinal, as in Figure 1. Row *p* composed of many small papillae (characteristic of genus). Two *s* rows on snout, rows consist of only one or two papillae. *F* row composed only of two (occasionally three) papillae.

Coloration of fresh material. Taken from colour slides (Plate 1).

Females and non-breeding males. Head and body greyish brown (mouse grey) with seven to eight dull to dark brown saddles or patches across back; saddles may be clearly defined square blotches or highly marbled patches. Saddles do not extend past mid-side of body, here replaced by series of brown marbled blotches, square blotches or irregular spots, markings fade ventrally very quickly to match background colour on lower half of body. Top and sides of head marbled and spotted with brown, one or two dark brown bars from eye to upper lip may be present. Lips almost bluish grey, with brownish grey edges. Iris deep golden, with dark brown margin. Silvery white peritoneum usually visible through body wall (internal lining of body cavity black), especially noticeable in gravid females. Base of caudal with one or three dark brown to greyish brown spots; spots may form Y-shape or vertical bar at fin base, with lighter background colour (yellowish brown) surrounding spots.

First dorsal fin greyish brown, with deep yellowish submarginal band, below this band, narrow blue line widening posteriorly to form bright blue spot. Second dorsal fin with light greyish brown membrane, dark brown fin rays and darker brown blotches along base. Caudal fin light greyish brown with irregular, vertically oriented rows of fine brown spots. Pectoral fin very pale greyish brown to hyaline, fin base with brown blotch on upper half. (Pelvics not visible on available slides).

Breeding males. Dark brown saddles and mottling on head and body diffuse to absent, usually only about seven ill-defined square saddles across back. Body and top of head generally plain greyish brown to yellowish brown, lower half of head distinctly yellowish brown to golden yellow (yellow increases ventrally). No distinct bars or mottling discernible on head. Iris usually pale gold, contrasting sharply with dull colouring of head.

Table 2. Frequency distribution of fin ray counts in *Chlamydogobius* species.

Species	Second dorsal rays			Anal rays				Pectoral rays				
	6	7	8	5	6	7	8	11	12	13	14	15
eremius n.sp.	1	11	43	2	10	31	1	-	4	37	3	1
gloveri n.sp.	1	15	3	-	17	2	-	1	15	3	-	-
japalpa n.sp.	-	16	15	1	12	17	1	-	2	28	1	-
micropterus n.sp.	2	20	2	5	17	2	-	9	14	1	-	-
ranunculus n.sp.	37	13	3	5	40	7	-	15	32	6	-	-
squamigenus n.sp.	2	16	14	3	21	8	-	-	-	22	10	-

First dorsal fin very dark grey, with yellow to yellow ochre submarginal band; below this band, bright iridescent light to vivid blue spot on posterior half of fin. Second dorsal and anal fins similar in colour to each other: both fins very dark grey to blackish with relatively broad bright white margin; basal half of fins speckled with vivid to dark blue, blue often more distinct on membrane between fin rays. Caudal fin similar to second dorsal and anal fins, but with only narrow dull whitish fin margin (margin not bright white), and very little blue present. Pectoral fin with membranes translucent to light dusky, fin rays greyish. Pelvic fin translucent to light dusky.

Coloration of preserved material. Colour not greatly differing from live fish, but blue and yellow pigment absent. Specimens vary in amount and kind of marbling and spotting. Marbling more distinct in preserved material; lower mid-side blotches often visible as series of elongate brown blotches ending in Y-shaped caudal blotch (this blotch often much more distinct in preserved than live specimens). On head, usually one brown bar from front of eye to mid upper lip and one brown bar from lower edge eye to just behind rictus, with conspicuous pale interspace between bars. Pectoral base pale with brown blotch on upper half. Entire lining of body cavity dense black.

Comparisons. *Chlamydogobius eremius* is most similar to *C. japalpa* n. sp. Although fin ray counts are similar, the extent of the scalation differs between the two (predorsal naked or with sides of nape scaled and scattered scales on midline in *C. eremius*; predorsal, including midline, usually scaled over opercle or to above preopercle in *C. japalpa* n. sp.; pectoral base, part of breast and opercle usually with some scales in *C. japalpa* n. sp., with these areas usually naked in *C. eremius*) and *C. eremius* modally has 17 caudal vertebrae (rarely 18, which is the mode for *C. japalpa* n. sp.) and never 19 as has been recorded in *C. japalpa* n. sp. There are modal differences in second dorsal fin ray and transverse scale counts and mean and modal differences in lateral line scales (Tables 2-4).

Table 3. Frequency distribution of transverse backward scale counts in *Chlamydogobius* species.

Species	11	12	13	14	15	16	17	18	19
eremius n.sp.	-	-	6	7	12	9	7	3	1
gloveri n.sp.	1	1	3	8	3	4	-	-	-
japalpa n.sp.	-	-	-	1	6	11	7	4	2
micropterus n.sp.	-	1	1	4	11	3	3	-	-
ranunculus n.sp.	-	7	10	17	11	4	5	-	-
squamigenus n.sp.	-	-	-	1	18	8	5	-	-

Mark Adams (pers. comm.) found that these two species are very close electrophoretically (differing by one locus) and considers that they may not warrant separation as species. The Finke River apparently has not discharged into Lake Eyre during recorded history (Kotwicki 1989) and may not have done so for 10,000 years or more (possibly not since the last glacial maximum of about 18,000 years).

Distribution. Specimens are known from the southern and western Lake Eyre drainage of South Australia. Localities (Fig. 13) from which the species has been recorded are: Forrest's Waterhole, Ockenden Spring, Algebuckina Waterhole, Wood Duck Bore, Peake Creek Siding, Old Peake Homestead Bore, Freeling Springs, Blythe Bore, Birribirriana Spring, Nilpinna Spring, Finniss Springs, North Fountain Spring, Johnson's Number 3 Bore, Honeymoon Bore, Nunn's Bore, Wobna Spring, Strangways Springs Railway Bore, Warriner's Creek, Beresford Reservoir, Railway Bore at Coward Springs, Coward Springs proper, Chamber's Creek, Margaret Creek, Wobna Spring, Elizabeth Springs, Anna Spring East Bore, un-named spring SE of Wobna Spring, Davenport Springs, Dead Woman Springs, Gregory Creek, Alberrie Creek, Clayton's Bore, Montecolina Bore and Woolatchi Bore. Glover (1971) gives latitudes and longitudes for these localities as well as for many other springs not inhabited by fish.

The last two mentioned localities, near Lake Blanche and Lake Callabonna respectively, ap-

Table 4. Frequency distribution of lateral line counts in *Chlamydogobius* species.

Species	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
eremius n.sp.	-	1	-	-	-	1	1	1	3	2	4	1	4	4	6	2	3	2	4	4	1	1	-	1	-	1
gloveri n.sp.	-	-	-	5	-	1	6	5	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
japalpa n.sp.	-	-	-	-	1	-	1	2	4	5	3	-	6	4	1	4	-	-	-	-	-	-	-	-	-	-
micropterus n.sp.	-	-	-	1	3	1	3	2	4	4	2	3	-	-	-	1	-	-	-	-	-	-	-	-	-	-
ranunculus n.sp.	2	1	2	-	1	2	3	7	4	4	7	5	5	3	1	2	2	2	-	-	1	-	-	-	-	-
squamigenus n.sp.	-	1	3	3	2	2	6	3	3	2	1	1	3	2	-	-	-	-	-	-	-	-	-	-	-	-

parently had fish in them in 1969 (Glover 1971) but Glover failed to find any during his 1968-69 survey. Additionally, Glover (1971) introduced 50 male and 50 female adult *C. eremius* into Blanche Cup Mound Spring, in September 1970, in an experiment to determine the size and age structure of a wild-living population; the introduced population flourished.

Zietz's (1896) original description states that his specimens were found in a small pool of water around an artesian well at Coward Springs. There has been some confusion over this, as there is now more than one bore sunk in the vicinity of these springs. In the narrative of the Horn Expedition, Spencer (1896) states that "By the railway side at Coward Springs one of these [artesian bores] has been sunk...", confirming Glover's (1973; unpublished notes) indications that the Coward Springs Railway Bore (29° 24'S 136° 49'E) is the type locality (and not Coward Springs proper).

Ecology. Glover's publications (Glover 1971, 1973, 1982, 1990; Glover and Sim 1978) give considerable detail on this adaptable species' physiology, environmental tolerances, dispersal and feeding behaviour, which will not be repeated here.

Chlamydogobius eremius has been shown, by experimentation in the field and the laboratory, to be tolerant of a considerable range of temperature, pH and salinity (Glover 1971; Glover and Sim 1978). It occurs in water of pH 6.8-11.0, can withstand a temperature range of 5-41°C and salinity range of 0-60‰ for short periods, and has been collected in water with very low levels of dissolved oxygen (0.8 ppm), frequently inhabiting water with concentrations below 5 mg O_2/l (Glover 1971; 1982).

Captive maintenance, behaviour and spawning have been reported by Thompson (1983), Horsthemke (1989), Wilson (1992) and in many other "aquarium hobby" magazines. It is not

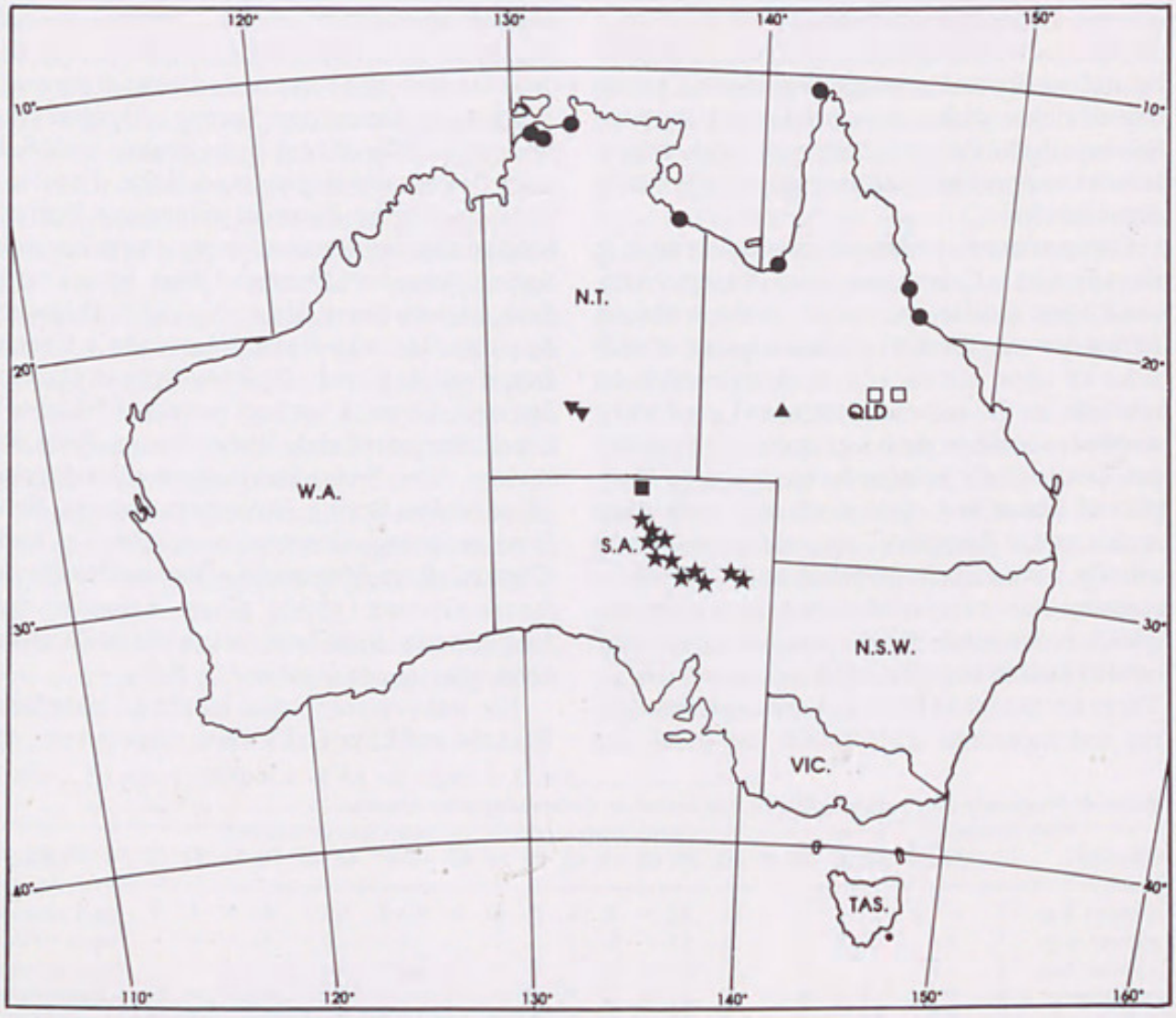

Fig. 3. Distribution of the genus *Chlamydogobius*. ★ = *C. eremius*, ■ = *C. gloveri* n. sp., ▼ = *C. japalpa* n. sp., ▲ = *C. micropterus* n. sp., ● = *C. ranunculus* n.sp., □ = *C. squamigenus* n. sp.

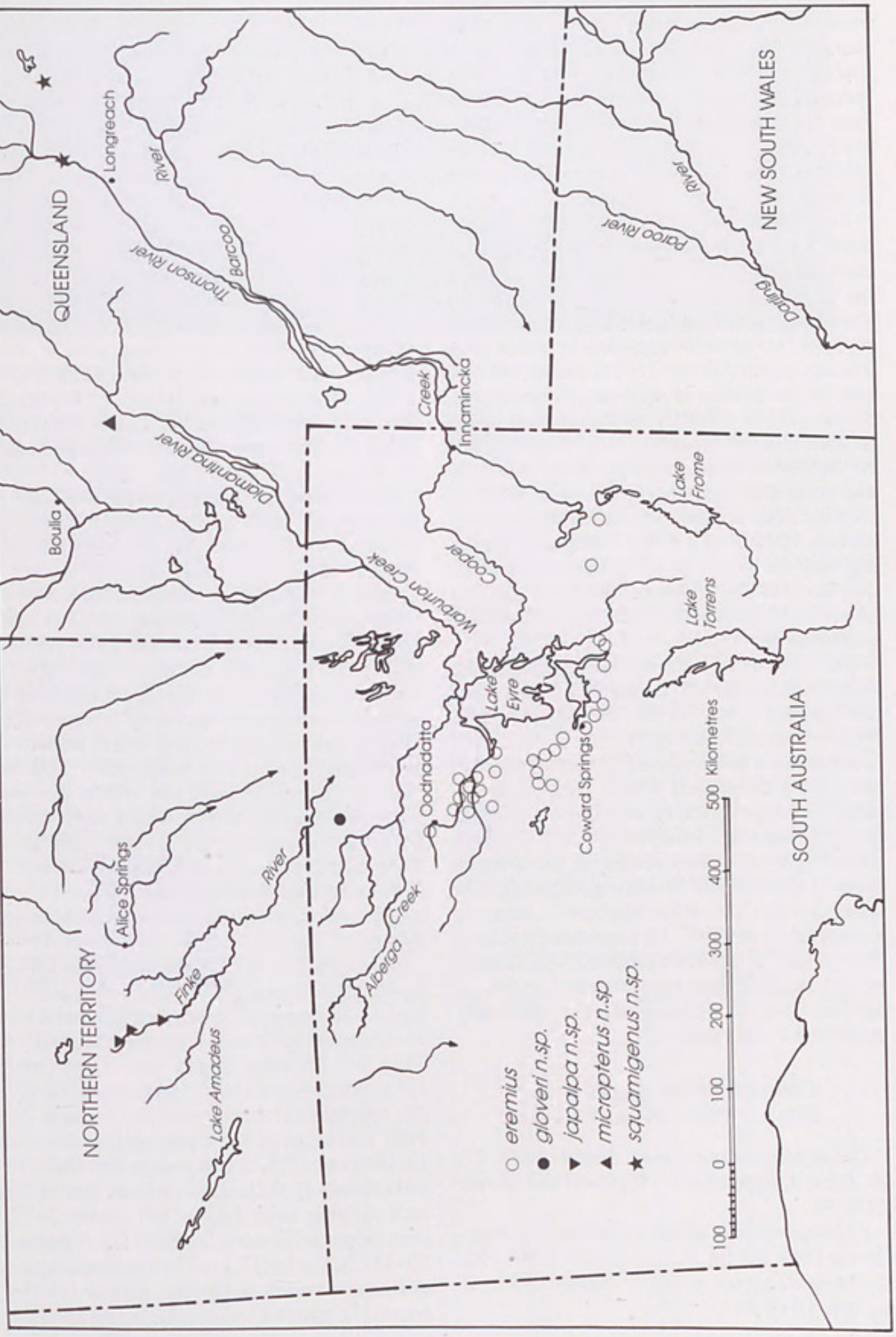

Fig. 4. Known localities of the freshwater species of *Chlamydogobius* (n.b. the two easternmost populations of *C. eremius* have not been observed since 1969).

certain that the fish reported on were all *C. eremius*, as description and provenance of the captive populations were not always given or were unclear (Thompson clearly states his specimens were collected from Coward Springs, the type locality of *C. eremius*, while Wilson's specimen's may have been *C. japalpa* n. sp.). Glover (1971) was not able to provide conditions suitable for his specimens to spawn.

Horsthemke (1989) gives detailed descriptions of embryonic and larval development, and noted that there was no planktonic larval stage; the hatchlings (5.3 mm long) quickly (precise time not given) taking up a benthic existence. He reported that up to 300 eggs may be laid by large females, while Glover (1971) found 150-250 eggs in the ovaries of wild-caught specimens. Miller (1987) correctly estimated that newly hatched *Chlamydogobius* larvae were likely to be "relatively large, probably about 4-5 mm" and compared egg sizes and numbers for *C. eremius*, *Mugilogobius abei* and *Pseudogobius olorum*. Horsthemke (1989) compared spawning and the direct larval development of *C. eremius* with that of *M. abei* and *M. chulae* (the latter two *Mugilogobius* have a four to five week planktonic larval life).

Michaelis (1985) listed this species as not threatened, along with a number of other fresh and brackish water fishes with poorly known distributions and abundances.

Remarks. The largest male, possibly the specimen illustrated by Zietz (1896), is hereby designated lectotype of the species *Gobius eremius* (Fig. 2). Spencer (1896) refers to *C. eremius* occurring around the opening of the artesian bores at Coward and Strangways Springs, and states that the Coward Springs bore "... issues at a temperature of 95° F". He considered it to be of "little doubt" that the two localities were stocked by fish hatched from eggs attached to feet or feathers of birds, although Zietz (1896) only stated that it was "possible".

Chlamydogobius gloveri n. sp.
(Figs 3-6, Plates 1-2, Tables 2-5)

Chlamydogobius eremius - Glover 1971: 77, 99, Table 1, Appendix A; - Ivantsoff and Glover 1974: 95.

Chlamydogobius sp. nov. (Dalhousie goby) - Glover 1989: 90, fig.31.1g; - Glover 1990: 191.

Chlamydogobius n. sp. - Harris 1987: 9; Jackson 1993: 24.

Chlamydogobius sp. - Kodric-Brown and Brown 1993: 1850; - Morton *et al.* 1995:30, 95.

Material Examined. 23 specimens (13-36). DALHOUSIE SPRINGS, SOUTH AUSTRALIA: HOLOTYPE - SAM F.3463, 30 mm female, coll. J. Glover, August 1968. PARATYPES - SAM F.5425, 12(13-27.5), Spring "G"ab, coll. J. Glover and T. Sim, 4 June 1985; SAM F.7675, 3(33-36), same data as holotype; SAM F.5417, 4(18-24), Spring B4, coll. J. Glover, T. Sim, 3 June 1985; AMS I.27118-001, 1(32), pool on top of mound, low mound springs, coll. W. Ponder, 29 May 1983; AMS I.25881-001, 4(7-16), Cold Spring Cc1B, outflow of medium active spring, coll. W. Ponder, D. Winn, 6 June 1985; AMS I.25879-001, 1(20), warm pool in swamp, coll. W. Ponder, D. Winn, 13 June 1985; AMS I.25880-001, 1(18), warm pool 20 m upstream from main pool, coll. W. Ponder, D. Winn, 14 June 1985.

Other material examined (but not used in description). Nine specimens from Dalhousie Springs: AMS I.25883-001, 1; AMS I.25882-001, 1; AMS I.25876-001, 1; AMS I.25867-001, 1; AMS I.25884-001, 1; AMS I.25877-001, 1.

Diagnosis. A small *Chlamydogobius* with second dorsal rays I,6-8; anal rays I,6-7; pectoral rays 11-13; longitudinal scales 35-43; TRB 11-16; predorsal scales 13-18, small, reaching to above preopercular margin or up to behind eyes; most scales ctenoid, ctenoid scales present in patch behind pectoral fin, under pelvic fins, and variably on caudal peduncle; dorsal fin low; brown with darker mottling which may form one or more lateral stripes; known only from Dalhousie Springs, northern South Australia.

Description. Based on 20 specimens, 15.5-36 mm SL. An asterisk indicates counts of holotype (Fig. 5).

First dorsal V (4), VI* (15); second dorsal I,6-8 (mean I,7*); anal I,6-7 (mean I,6*), pectoral rays 11-13 (mean 12*), segmented caudal rays 15-17 (mean 16*); caudal ray pattern usually 8/7* or 9/7; branched caudal rays 13-16 (mean 15*); unsegmented (procurrent) caudal rays 7/6 (2); longitudinal scale count 35-42 (mean 38); TRB 11-16 (mean 14*); predorsal scale count 13-18 (mean 17*), circumpeduncular scales 16-19* (mean 18). Gill rakers on outer face of first arch ranging from 2+6 to 3+7 (mode 2+7*); pterygiophore formula 3-12210 (7). Vertebrae 10+18 (2), 11+16 (1), 11+17 (10). Neural spines of first few vertebrae slender, narrow (3). One epural (7), possible two epurals in one specimen

Fig. 5. Holotype of *Chlamydogobius gloveri* n. sp., SAM F.3463, female.

(difficult to discern in X-ray). One (2) or two (6) anal pterygiophores before haemal spine of first caudal vertebra.

Body rounded to compressed anteriorly, compressed posteriorly. Head wider than deep, but not greatly so, HL 3.1-3.6 (mean 3.42) in SL; head rounded to somewhat rectangular in cross-section.. Depth at posterior preopercular margin 1.5-1.8 (mean 1.7) in HL. Width at posterior preopercular margin 1.2-1.6 (mean 1.5) in HL. Mouth terminal, rarely slightly subterminal, slightly oblique, forming angle of about 25° with body axis; jaws small, generally reach to below front half of eye. Lips usually smooth, fleshy fimbriae sometimes present on inner edges of upper lip; lower lip free at sides, fused across front. Upper jaw length not much differing between males and females, 3.0-3.5 (mean 3.1 in females, 3.2 in males) in HL. Eyes lateral, high on head, top usually forming part of dorsal profile, 3.5-4.7 (mean 3.9) in HL. Snout rounded, sometimes lightly inflated but not overhanging upper lip, 2.8-4.4 (mean 3.7) in HL. Interorbital moderately broad, flat, 3.0-3.9 (mean 3.5) in HL. Unscaled portion of top of head rarely with fine villi under mucous coat. Body depth at anal origin 4.5-5.8 (mean 5.2) in SL. Caudal peduncle compressed, length 3.3-3.9 (mean 3.6) in SL. Caudal peduncle depth 6.8-8.0 (mean 7.4) in SL.

First dorsal fin quite low, rounded, third or fourth spines longest or subequal; spine length not much different between males and females; spines fall short of second dorsal fin origin when depressed. First and second dorsal spines always shorter than next two. Third dorsal spine length 8.3-11.3 (mean 9.7) in SL. Fourth dorsal spine length 8.3-10.7 (mean 9.5) in SL. Second dorsal and anal fins short-based, very low, posteriormost rays usually longer than others, rays fall well short of caudal fin base when depressed. Pectoral

Table 5. Measurements (mm) of *Chlamydogobius gloveri* n. sp.

Character	Holotype	Males			Females		
		Minimum	Maximum	Mean	Maximum	Minimum	Mean
Head Length	8.3	5.0	8.1	6.3	6.1	10.5	8.2
Head Depth	5.6	2.9	5.1	3.8	3.7	6.6	5.2
Head Width	6.5	3.4	5.7	4.4	4.1	8.3	6.1
Body Depth	6.6	2.8	5.3	3.9	4.1	7.7	6.0
Body Width	4.0	1.5	3.5	2.5	2.3	4.5	3.8
Caud. Ped. Leng.	8.7	4.5	7.6	5.8	5.8	10.2	8.0
Caud. Ped. Depth	4.3	2.0	3.8	2.8	2.7	5.1	3.9
Snout	2.7	1.2	1.8	1.6	1.7	3.7	2.5
Eye	2.0	1.3	2.0	1.7	1.5	2.7	2.0
Jaw	2.8	1.5	2.6	2.0	1.9	3.4	2.7
Interorbit	2.5	1.3	2.6	1.9	1.7	3.3	2.5
Pectoral	6.1	3.7	6.1	4.6	4.0	7.4	5.7
Pelvic	4.4	2.1	4.2	3.2	3.3	5.5	4.3
Caudal	7.1	4.7	6.8	5.7	5.6	8.4	7.1
Longest D1 spine	2.8	2.7	3.1	2.9	2.8	3.3	3.1

fin rounded, central rays longest, 4.3-5.5 (mean 4.7) in SL; rays usually all branched. Pelvic fins short, rounded to oval, may reach half distance to anus, 6.0-7.6 (mean 6.6) in SL. Caudal fin rounded, 3.4-4.3 (mean 3.8) in SL.

No mental frenum, chin smooth. Anterior nostril in very short tube on preorbital just behind upper lip, tube oriented down and forward, preorbital curved forward slightly to accommodate nostril. Posterior nostril small, round, placed about halfway between front margin of eye and edge of preorbital. Gill opening restricted to pectoral base. Inner edge of shoulder girdle smooth with no bony ridge or fleshy knobs or flaps. Gill rakers on outer face of first arch very short, unspined rudimentary knobs, longest raker near angle of arch; rakers on inner face of first arch also short but longer than outer rakers; inner rakers on other arches nearly twice length of first arch inner rakers. Tongue broad, usually blunt or rounded. Teeth slightly larger in male compared to female. Outermost teeth in upper jaw arranged in even row, teeth curved, longer than inner teeth; behind this row are only one or two rows of quite small sharp teeth; rows narrow to one at side of jaw; tips of teeth sometimes lightly tinted translucent brown. Lower jaw with about three rows of small, curved, pointed teeth across front, outermost row may be larger, stouter or less curved; usually only one row at side of jaw; teeth sometimes tinted translucent brown.

Predorsal scales small, evenly sized, usually reaching forward to above preopercular margin or further up to behind eyes. Operculum with patch of small cycloid scales on upper three-quarters to half. Cheek always naked. Pectoral base covered with cycloid scales. Prepelvic area covered with small cycloid scales. Belly with isolated patch of ctenoid scales under pelvics, rest cycloid. Most body scales cycloid, ctenoid scales on side of body present as patch behind pectoral fin, variably present along mid-line of body from posterior caudal peduncle forward; posterior ctenoid scales usually not reaching ctenoid patch behind pectoral fin.

Head pores absent as in all *Chlamydogobius*.

Sensory papillae pattern longitudinal, as in Fig. 6. Cheek row *c* reduced, broken; rear portion close to front part of row *b*. Two or three *s* rows of snout; posteriormost row often of two papillae, central row (if present) consists of one papilla; *s* rows placed well back from upper lip. Mental *f* row consists of two papillae.

Coloration of fresh material. Taken from colour slides. Male and female similar, except fin colour more pronounced and body pattern darker and somewhat obscured in male (Plate 1-2).

Head and upper sides of body bluish grey to greenish grey; lower sides paler, peritoneum whitish, showing through body wall. Top of head and at least upper half of body covered with fine greyish brown vermiculations and spotting; most scales with greyish brown margin or spot present, brown markings may form line along mid-side of body, especially noticeable posteriorly. Snout, suborbital, upper half of preopercle and opercle with indistinct greenish brown mottling, lower half of opercle plain whitish. Lips greenish grey, lower lip paler than upper lip in male.

First dorsal fin (in female) mostly translucent with white blotches proximally, and scattered blue spots forming central band, posteriormost blue spot largest. In male, first dorsal fin light golden brown proximally, with broad light blue band across middle of fin, band narrow anteriorly, widening posteriorly to occupy most of rear of fin; uppermost third of fin dull yellow. Second dorsal fin (in male) dull olive brown, with submarginal broad brownish grey band; lower half of fin with scattered light blue and golden spots; golden spot more abundant on lower half of fin. Second dorsal fin (in female) translucent brownish with pale gold to whitish spots and streaks alternating with light brown spots; anteriormost quarter of fin plain translucent.

Caudal fin translucent brownish with many vertical rows of fine light brown to dull whitish spots and small blotches; markings more diffuse on ventral part of fin. Anal fin translucent brownish with dull yellowish white or blue marginal band and scattered yellowish white or blue patches or streaks on proximal third of fin. Pectoral fin translucent, rays dusky, especially proximally. pelvic fins whitish to translucent brown.

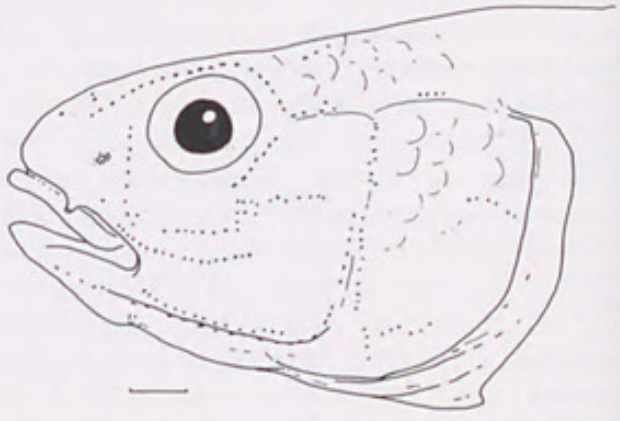

Fig. 6. *Chlamydogobius gloveri* n. sp., papillae pattern. Scale bar = 1 mm.

Coloration of preserved material. Head and body light brown or yellowish white, with blackish, brown to brownish grey irregular blotches and spots (depending upon state of preservation). Most conspicuous markings are: one series of about six irregular brown blotches across dorsal mid-line and second series of about seven elongate brown blotches along mid-line of body, anteriormost of which is just above or behind pectoral base, posteriormost is at centre of caudal base (posteriormost spot often darker than others). Blotches across dorsal mid-line often broken into two-part linear blotches: one part on dorsal mid-line and one part on upper middle of body; latter series of markings tends to form discontinuous streak. Pectoral base whitish on lower half; brownish with dark brown spot on upper half. Top of head above rear edge of preopercle with brownish band or saddle; top of snout with indistinct brownish vermiculations and spots. Side of head dark on dorsal half, pale ventrally; brown bar from front of eye to preorbital edge, indistinct brown bar from ventral edge of eye to just below rictus; oblique brown bar or blotch across rear of preopercle.

First dorsal fin with greyish brown margin, whitish to dusky grey band below this; proximal half of fin dusky or mottled with brown, with blackish to dense black spot at rear of fin (spot variable in size). Second dorsal fin with narrow whitish margin; remainder of fin mottled with dusky brown. Anal fin with narrow whitish margin; most of fin whitish with indistinct dusky mottling proximally. Caudal fin translucent to whitish, with up to nine vertically oriented rows of brown spots, spots often joined together to form irregular wavy lines; very narrow whitish margin sometimes present; indistinct pair of elongate brown blotches on either side of centre of caudal base, close to posteriormost mid-lateral spot. Pectoral fin with dusky to brown rays, membranes translucent whitish to dusky. Pelvic fins whitish, frenum and ray bases often dusky.

No large males in breeding colour pattern among material examined. Figure 13.1g in Glover (1989), although small, clearly shows the two dark spots at the base of the caudal fin, and the rows of dark spots on the fin.

Comparisons. Morphologically, *C. gloveri* is similar to *C. japalpa* n. sp. (both species have scaled napes) but usually *C. gloveri* has 17 caudal vertebrae (16-18, modally 17; versus 17-19, modally 18), second dorsal rays I,7 (versus I,8), anal rays I,6 (versus I,7) and only 12 pectoral rays (versus 13).

Distribution. Specimens are only known from spring-fed pools at Dalhousie Springs (26° 28'S 135° 29'E), in northern South Australia, where they have been reported as being "very common though variable in abundance" (Glover 1990). Glover (1989) records *C. gloveri* as being present in 30 of the 35 springs inhabited by fish (there are 89 springs in total).

Ecology. Glover (1989) gives a detailed account of the physical conditions at Dalhousie Springs and the composition of the fish species assemblages present. The springs are warm (21.6-43°C), and the gobies apparently have a thermal tolerance of up to 43.9°C. Glover (1989) observed that *Chlamydogobius gloveri*'s diet included filamentous green algae and their own species. Ivantsoff and Glover (1974) and Crowley and Ivantsoff (1990a), in their respective descriptions of *Craterocephalus dalhousiensis* and *Craterocephalus gloveri*, give additional environmental data (including colour photographs of the habitat in Crowley and Ivantsoff).

Kodric-Brown and Brown (1993) analysed fish community structure in 43 springs at Dalbhousie, and found that the communities exhibited "... an amazingly regular, deterministic structure: the number of species is highly correlated with spring size ...". They found that *C. gloveri* has apparently become extinct in one very small spring (E3) since 1989 (Kodric-Brown and Brown 1993: 1853).

Remarks. Glover (1989: 110-111) reported that isozyme electrophoretic analyses of the heads of the Dalhousie goby (*C. gloveri*), Elizabeth Springs goby (*C. micropterus* n. sp.) and *C. eremius* indicated that the three species show, relative to *C. gloveri* and themselves, percentages of fixed differences of 21% and 16% respectively. It is not surprising that the lower percentage separates *C. gloveri* and *C. eremius*, as they are closer together (geographically). Glover suggested that the Dalhousie goby and the Elizabeth Springs goby are distinct species, but did not discuss the Nilpinna Spring population, for which he gave a fixed difference percentage of 18%. Nilpinna Spring is part of the Nilpinna Creek system just north-west of Lake Eyre, and is inhabited by *C. eremius* (Glover 1971; this study). Crowley and Ivantsoff (1990a: 119) state that the Dalhousie Springs have been isolated for 10,000 years and that floodwaters from the Eyre/Finke system have not reached the springs since then. This is based on Kotwicki (1989), mentioned earlier, who discussed the isolation of the Dalhousie Springs region from

the rest of the Lake Eyre drainage basin, and suggested that the Finke does not flow near Dalhousie during flood events (that it may have done so during the period of about 45,000 and 25,000 years before present is more likely).

Jackson (1993) lists this species as having "restricted" conservation status. The true status of this species should be investigated, along with that of the other freshwater species of this genus, as indicated by Glover (1990). The conservation status of this species was first noted in Harris (1987), where it was listed as "Restricted" (ie. having a restricted distribution but not yet at risk).

Etymology. Named for the late John Glover, in recognition of the considerable work he carried out on desert gobies and other Australian arid zone fishes. John was convinced that the Dalhousie goby was separate from *C. eremius*; he just never quite got around to describing it. It is somehow appropriate that there should be more than one fish species called *gloveri* living at Dalhousie Springs (*Craterocephalus gloveri* was described by Lucy Crowley and Walter Ivantsoff in 1990, and the undescribed Dalhousie *Neosilurus* is rumoured to become named after John also).

Chlamydogobius japalpa n. sp.
(Figs 3-4, 7-8, Tables 2-4, 6)

Chlamydogobius eremius - Larson and Martin 1990: 62-63 (in part).

Material examined. 84 specimens (12-44). FINKE RIVER, NORTHERN TERRITORY: HOLOTYPE - NTM S.11436-007, 44 mm SL male, Ormiston Creek, at junction of Pioneer Creek, 23° 40'S 132° 42'E, coll. H. Larson and P. Horner, 15 September 1984. PARATYPES - NTM S.11436-009, 41(15-44), same data as holotype; NTM S.11439-006, 10(15-38.5), including one cleared and stained, off Palm Valley Road just N of Park border, coll. H. Larson, 17 September 1984; AMS I.35467-001, 8(15-28), same data as preceding; NTM S.11437-005, 25(12-45), just above Glen Helen N of main road crossing, coll. H. Larson and P. Horner, 16 September 1984; NTM S.11639-001, 1(40), Hermannsburg Rockhole, coll. R. Moses, 21 June 1983; SAM F.7677, 3(25-34), same data as preceding; NTM S.11628-001, 1(29.5), Boggy Hole, coll. R. Moses, 23 June 1983; NTM S.11650-002, 2(25.5-27), Running Waters, coll. R. Moses, 14 July 1983; NTM S.11632-001, 1(37), Palm Valley, 25 June 1983.

Other material examined (but not used in description). Eight specimens from the following localities. NTM S.11651-001, Running Waters, Finke River; NTM S.11653-003, same locality; NTM S.12503-001, Finke River pools near highway; NTM S.1667, Hermannsburg.

Diagnosis. A moderate to large *Chlamydogobius* with second dorsal rays I,7-8; anal rays I,5-8; pectoral rays 12-14; longitudinal scales 36-47; TRB 14-19; 28-29 vertebrae; predorsal scales 7-18, scales nearly always present on midline of nape, reaching forward over opercle, or to above preopercular margin; pectoral base and opercle often with few scattered scales; ctenoid scales present on caudal peduncle, sometimes forming narrow wedge forward to behind pectoral fin; dorsal fin low; head and body brown with darker spots and mottling which may form lateral stripe; known only from Finke River system in central Northern Territory.

Description. Based on 32 specimens, 18.5-44 mm SL. An asterisk indicates counts of the holotype (Fig. 7).

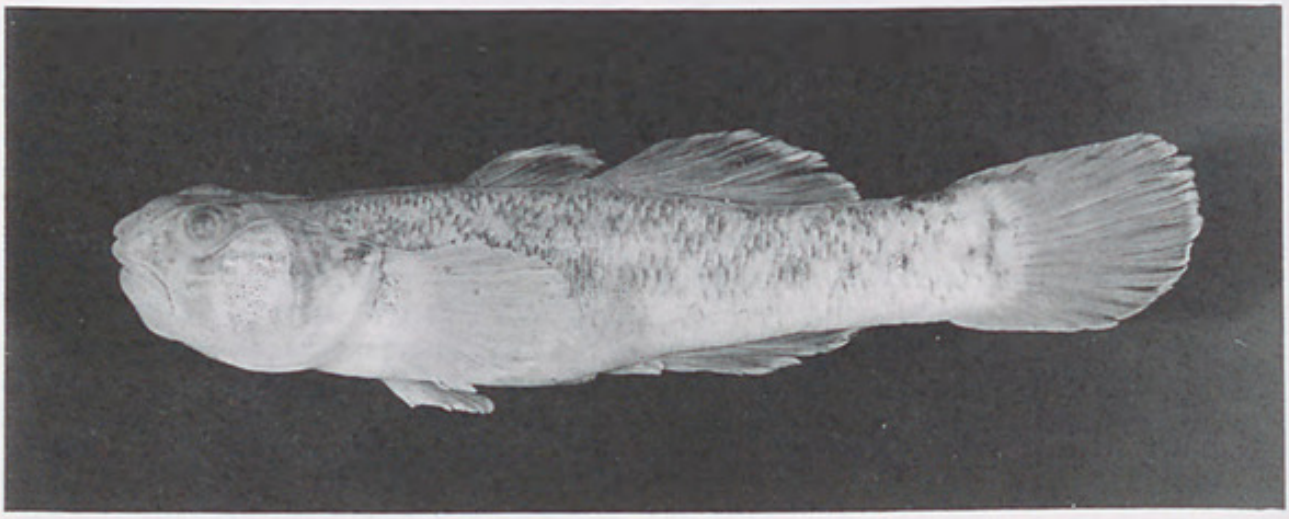

Fig. 7. Holotype of *Chlamydogobius japalpa* n. sp., NTM S.11436-007, male.

First dorsal V (in 3), VI* (28); second dorsal I,7*-I,8 (mean I,8); anal I,5-8 (mean I,7; I,6 in holotype), pectoral rays 12-14 (mean 13*), segmented caudal rays 16; caudal ray pattern usually 8/7* or 9/7; branched caudal rays 15-16 (mean 15*); unsegmented (procurrent) caudal rays 7/7 (2); longitudinal scale count 36-47 (mean 43, 45 in holotype); TRB 14-19 (mean 17, 15 in holotype); predorsal scale count 7-18 (mean 14, 11 in holotype); circumpeduncular scales 15-22 (mean 19, 18 in holotype). Gill rakers on outer face of first arch ranging from 2+5* to 3+6 (mode 2+5); pterygiophore formula 3-12210 (15). Vertebrae 10+18 (3), 10+19 (4), 11+17 (2), 11+18 (12). Neural spines of first three vertebrae expanded at tip (10) or stout and pointed (1). One epural (17). One (1), two (16) or three (1) anal pterygiophores before haemal spine of first caudal vertebra.

Body rounded to slightly compressed anteriorly; compressed posteriorly. Head wider than deep, HL 3.2-3.7 (mean 3.4) in SL; cheeks may be quite fat in mature males. Depth at posterior preopercular margin 1.6-1.9 (mean 1.8) in HL. Width at posterior preopercular margin 1.2-1.5 (mean 1.4) in HL. Mouth terminal to subterminal, slightly oblique, forming angle of about 20° with body axis; upper jaw slightly overhanging lower jaw; jaws generally reach to below mid-eye in males and to below front half of eye in females (to below mid-eye in holotype). Lips usually smooth, fleshy fimbriae sometimes visible on innermost edges of upper lip; lower lip free at sides, fused across front. Upper jaw 2.2-4.8 (mean 3.2 in females, 3.0 in males) in HL. Eyes lateral, high on head, top usually forming part of dorsal profile, 3.0-5.1 (mean 4.0) in HL. Snout rounded to somewhat inflated and partly overhanging upper lip, 2.1-4.0 (mean 3.5) in HL. Interorbital broad, flat, 1.3-4.3 (mean 3.3) in HL. Top of head, from above preopercular margin up to snout tip, often with very fine pigmented villi (in many recently collected specimens, villi and surrounding mucous coat well-preserved). Body depth at anal origin 4.5-5.9 (mean 5.1) in SL. Caudal peduncle long, compressed, length 3.1-7.5 (mean 3.7) in SL. Caudal peduncle depth 3.7-8.5 (mean 7.4) in SL.

First dorsal fin low, rounded, third or fourth spines longest or subequal; in large males, spines barely reach second dorsal origin when depressed; spines fall well short of second dorsal fin in all other specimens. First dorsal spine always shorter than next three. Second dorsal spine length 8.5-9.6 (mean 9.1) in SL. Third dorsal spine length 7.5-10.7 (mean 9.2) in SL. Fourth dorsal spine length 7.3-10.3 (mean 9.1) in SL. Second dorsal and anal fins low, short-based, posteriormost rays longest, but rays fall well short of caudal fin base when depressed. Pectoral fin rounded, central rays longest, 4.3-9.6 (mean 4.9) in SL; rays usually all branched. Pelvic fins quite short, oval to somewhat pointed (innermost rays longest), may reach only half distance (or less) to anus, 5.0-7.1 (mean 6.6) in SL. Caudal fin oval to rectangular in form, rounded posteriorly, 3.1-6.9 (mean 3.8) in SL.

No mental frenum, chin smooth. Anterior nostril in very short tube, placed on edge of preorbital, tube oriented down and forward, preorbital curved forward slightly to accommodate nostril. Posterior nostril oval, placed halfway between front edge of eye and edge of preorbital. Gill opening restricted to pectoral

Table 6. Measurements (mm) of *Chlamydogobius japalpa* n. sp.

Character	Holotype	Males			Females		
		Minimum	Maximum	Mean	Maximum	Minimum	Mean
Head Length	13.5	5.6	13.5	9.4	5.8	12.0	8.9
Head Depth	8.3	2.9	8.3	5.4	3.1	7.5	5.1
Head Width	11.2	3.7	11.2	6.9	3.8	9.1	6.4
Body Depth	9.4	3.6	9.3	6.2	3.4	9.3	6.3
Body Width	5.9	2.2	5.9	4.0	2.1	5.5	4.1
Caud. Ped. Leng.	11.9	5.9	12.0	8.8	5.5	12.1	8.7
Caud. Ped. Depth	6.3	2.3	6.3	4.3	2.5	6.1	4.2
Snout	4.5	1.5	4.5	2.8	1.7	3.5	2.6
Eye	2.8	1.5	2.8	2.3	1.6	3.2	2.2
Jaw	5.6	1.7	5.9	3.4	1.7	4.3	2.8
Interorbit	4.6	1.4	4.7	3.0	1.6	4.0	2.7
Pectoral	8.8	4.2	9.0	6.7	4.4	8.9	6.5
Pelvic	6.4	3.0	6.6	4.7	2.9	6.4	4.6
Caudal	10.9	5.6	11.0	8.5	5.8	10.8	8.2
Longest D1 spine	5.9	2.8	5.9	3.7	2.6	4.6	3.6

base. Inner edge of shoulder girdle smooth with no bony ridge or fleshy knobs or flaps. Gill rakers on outer face of first arch very short unspined knobs, longest raker by angle of arch; outer rakers on other arches smaller than those on first arch, outer rakers on fourth arch rudimentary; inner rakers on other arches nearly twice the length of first arch inner rakers. Tongue large, round to bluntly rounded. Teeth in female slightly smaller than those of male. Teeth in outermost row in upper jaw usually larger than others, stout and curved or almost upright; behind this row, two to three rows of slightly smaller stout curved teeth; rows narrow to one or two at side of jaw. Teeth in lower jaw in four to five rows; teeth arranged as in upper jaw apart from outermost row being not much larger than those in rows behind it.

Predorsal scales small, cycloid, usually reaching forward to above preopercular margin, often anteriormost rows of scales placed irregularly, somewhat scattered; predorsal scales in holotype do not quite reach to above preopercular edge (two specimens have predorsal midline completely naked). Operculum naked or with patch of small cycloid scales on upper third to half (sometimes only one or two scales present). Cheek always naked. Pectoral base with few cycloid scales, occasionally naked. Prepelvic area with small cycloid scales posteriorly (anterior half of breast usually naked). Belly with isolated patch of weakly ctenoid scales under pelvics; remainder cycloid. Ctenoid scales on side of body in narrow wedge extending forward to behind pectoral fin, usually broken into patch of ctenoid scales behind pectoral fin and weakly ctenoid area on caudal peduncle only (as in holotype).

Head pores absent as in all *Chlamydogobius*.

Sensory papillae pattern longitudinal, as in Fig. 8. Rear portion of cheek row *c* indistinguishable from anterior part of row *b* (possibly absent). Two or three *s* rows on snout; rows close together and composed only of one papilla each. Mental row *f* consists of two or three papillae only.

Coloration of fresh material. From colour slides of two fish (dorsal views only) taken in field conditions. Photographed specimens immature; do not show any bright blue or yellow colouring in dorsal fin.

Background colour of head and body light yellowish brown, with six brown to greyish brown square saddles across back and one across nape and opercles; saddles mostly composed of

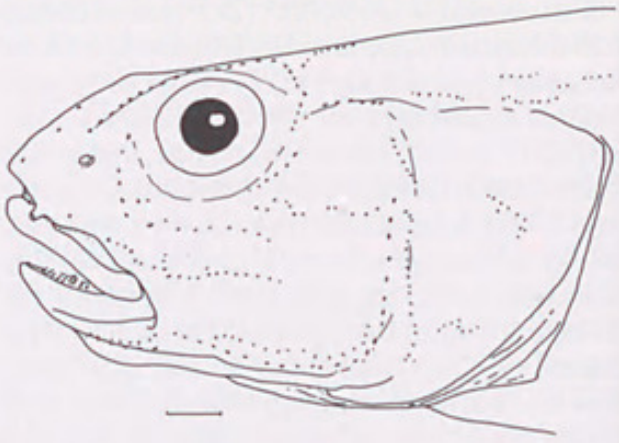

Fig. 8. *Chlamydogobius japalpa* n. sp., papillae pattern. Scale bar - 1 mm.

blotches and dark vermiculations; anterior part of head with vermiculate greyish brown marbling and small spots. Dorsal saddles partly connected to each other by irregular lines and small blotches. Anterior half of body generally darker than posterior half. Dorsal saddle across nape mostly broken up into darker brown vermiculations. Anterior half of head relatively unmarked, with most distinct pattern being dark brown vermiculations on snout and anterior part of interorbital; dark brown bar extends from front of eye to upper lip; part of dorsal snout vermiculation forms intense dark irregular line to snout tip. Fins pale brownish to fawn; axil of pectoral base pale with dark brown vermiculations.

Coloration of preserved material. Preserved colour not greatly different from living specimens. Background colour yellowish to yellowish brown, with darker brown complex mottling and irregular spots and broad streaks. Seven brown dorsal saddles present, sometimes difficult to distinguish, often broken up into series of vermiculate blotches and irregular blotchy lines (saddles more easily distinguished in dorsal view). Along mid-side of body, series of six or seven rectangular brown blotches, blotches often interconnected above and below by irregular lines. Pectoral base pale yellowish brown with upper half of base marbled or blotched. At caudal base, but not extending onto fin, distinct blackish brown vertical bar or Y-shaped blotch present. Anteriormost dorsal saddle, which crosses nape and onto opercle, usually composed of dark brown vermiculations and small marbled blotches; pale, relatively unpatterned area usually present on top of head from anterior to preopercular margin to rear of interorbital

space. Interorbital and top of snout covered with dark brown complex vermiculate lines and blotches; usually dark line from mid-snout to snout tip, dorsal to posterior nostril. Broad brown bar from front lower edge of eye to upper lip; diffuse brown bar from ventral edge of eye across cheek to fade out behind rictus; sometimes another bar extends from ventral rear edge of eye back to ventral edge of preopercle. Rear half of preopercle variably blotched with brown patches, sometimes pale. Underside of head and body pale whitish yellow. Entire lining of body cavity dense black.

Fins darker and more intensely marked in males than in females. First dorsal fin greyish to brownish grey, with sub-marginal whitish band (probably white or yellow in live mature males); below whitish band, broad dark grey to black band, most intense posteriorly (probably blue in live mature males). In mature males, second dorsal and anal fins dusky greyish with conspicuous white margin; in females and immature males, second dorsal and anal fins translucent whitish to translucent, fin rays brownish, with dusky brownish blotches usually variably present along fin bases. In mature males, caudal fin plain dusky grey with narrow whitish margin. In females and immature males, caudal fin translucent with many rows of small, vertically aligned, diffuse brown spots; spots sometimes fused together to form irregular lines. Pectoral fins translucent to dusky. Pelvic fins whitish, or dusky with whitish margin and frenum.

Comparisons. See under *C. eremius* (the most similar species) for comparisons. In *C. japalpa* the head markings are more fine and vermiculate than in *C. eremius*, which often consist of marbled blotches.

Distribution. Found only in the Finke River system of the Northern Territory, from Ormiston Gorge to Finke River National Park.

Ecology. This species has been collected in shallow pools with rock, sand or fine gravel substrate; the fish were hiding among detritus/mulm accumulated over sand. Fish in Ormiston Creek were observed to be active only at night, possibly to escape predators or high daytime temperatures (or both). A photograph of typical habitat is on the front cover of Larson and Martin (1990); the holotype and other specimens from NTM S.11436 are from the site illustrated.

Remarks. This species is considered to be probably the same species as *C. eremius* by Adams (pers. comm.) due to similar percentages of fixed difference obtained by isozyme electrophoresis. Morphologically, the two are distinguishable and are here considered separate species (see remarks under *C. eremius*).

Etymology. From the Western Aranda name *Japalpa*, given to the part of the Finke River which extends through what is now called Glen Helen Gorge, as given by Strehlow (1947, 1971). The main waterhole in this gorge is just downstream of the Ormiston Creek type locality, and is a significant site in Aranda traditions. The Finke is also "... said to be the oldest river on Earth." (Kotwicki 1989).

Chlamydogobius micropterus n. sp.
(Figs 3-4, 9-10, Tables 2-4, 7)

Chlamydogobius sp. nov. - Glover 1989: 98, 110.

Chlamydogobius sp. A - Wager and Jackson 1993: 85.

Chlamydogobius n. sp. - Harris 1987: 8; Jackson 1993: 23.

Chlamydogobius sp. - Morton *et al.* 1995: 53, 119

Material examined. 37 specimens (9.5-23). ELIZABETH SPRINGS, QUEENSLAND: HOLOTYPE - QM I.25096, 22.5 mm male, Springvale Station, coll. J. Covacevich, P. Couper, 27 April 1988. PARATYPES - AMS I.25261-001, 3(8.5-20.5), Springvale, coll. W. Ponder, P. Colman, 10 September 1984; AMS I.25256-001, 6(10.5-21.5), same data as preceding; QM I.29552, 27(9.5-23), same locality data as holotype.

Diagnosis. A small *Chlamydogobius* with first dorsal spines III-VI (mode V; pterygiophore formula 4-2210 or 4-22000); second dorsal rays I,6-8; anal rays I,5-7; pectoral rays 11-13; longitudinal scales 35-47; TRB 12-17; predorsal scales 14-22, small, reaching to above preopercular margin or further; scales on body mostly cycloid, ctenoid scales restricted to patch under pectoral fin; fins small, especially first dorsal; preserved colour pale with indistinct broken-up rows of light brown spots and mottling; known only from Elizabeth Springs and associated pools on Springvale Station, western Queensland.

Description. Based on 24 specimens, 12-23 mm SL. Counts of holotype indicated by asterisk (Fig. 9).

First dorsal III* (1), IV (10), V (12), VI (1); second dorsal I,6-8 (mean I,7*); anal I,5-7 (mean I,6*), pectoral rays 11-13 (mean 12*), segmented caudal rays 15-17, mean 16*; caudal ray pattern 7/6 (4), 8/6 (4), 8/7* (11) or 9/7 (5); branched

Fig. 9. Holotype of *Chlamydogobius micropterus* n. sp., QM I.25096, male.

caudal rays 13-16 (mean 15*); longitudinal scale count 35-47 (mean 41, 43 in holotype); TRB 12-17 (mean 15, 16 in holotype); predorsal scale count 14-22* (mean 18); circumpeduncular scales 16-23 (mean 20, 22 in holotype). Gill rakers on outer face of first arch ranging from 1+6 to 2+6 (mode). Pterygiophore formula 4-2210 (3), 4-22000 (2). Vertebrae 10+17 (2), 10+18 (7), 11+18 (3). No information available on the shape of neural spines of first few vertebrae; X-rays not sufficiently clear. One epural (9). One (1) or two (6) anal pterygiophores before haemal spine of first caudal vertebra.

Body somewhat rounded anteriorly, compressed posteriorly. Head rounded, wider than deep, but not greatly so, HL 3.3-3.6 (mean 3.5) in SL. Depth at posterior preopercular margin 1.1-1.7 (mean 1.6) in HL. Width at posterior preopercular margin 1.3-1.5 (mean 1.4) in HL. Mouth terminal, slightly oblique, forming angle of about 25° with body axis; jaws reach to below front half of eye in both sexes. Lips usually smooth, fleshy fimbriae may be discernible; lower lip free at sides, fused across front. Upper jaw 2.7-3.5 (mean 3.3) in HL. Eyes lateral, high on head, top usually forming part of dorsal profile, 3.2-4.2 (mean 3.7) in HL. Snout rounded to somewhat flattened, not overhanging upper lip, 3.1-4.4 (mean 3.8) in HL. Interorbital broad, flat, 2.9-3.8 (mean 3.3) in HL. Top of head above preopercular margin up to snout with very fine villi sometimes present. Body depth at anal origin 4.6-6.3 (mean 5.1) in SL. Caudal peduncle compressed, length 3.1-3.7 (mean 3.3) in SL. Caudal peduncle depth 6.3-8.1 (mean 7.1) in SL.

First dorsal fin reduced, somewhat pointed, longest spine not much longer than eye width; second or third spines longest or subequal; spines no different between males and females; spines fall far short of second dorsal fin origin when

Table 7. Measurements (mm) of *Chlamydogobius micropterus* n. sp.

Character	Holotype	Males			Females		
		Minimum	Maximum	Mean	Maximum	Minimum	Mean
Head Length	6.8	3.8	6.8	5.3	3.7	6.7	4.7
Head Depth	4.2	2.6	4.3	3.4	2.6	4.0	3.1
Head Width	4.8	2.8	5.0	3.9	2.8	4.7	3.4
Body Depth	4.8	2.3	4.8	3.6	2.4	4.9	3.2
Body Width	3.2	1.5	3.5	2.5	1.6	3.5	2.2
Caud. Ped. Leng.	6.1	3.9	6.9	5.4	3.8	7.2	4.9
Caud. Ped. Depth	3.3	1.8	3.3	2.6	1.8	3.4	2.3
Snout	2.0	0.9	2.0	1.5	0.9	1.9	1.2
Eye	1.8	1.1	1.8	1.5	1.1	1.6	1.3
Jaw	2.3	1.1	2.5	1.7	1.1	1.2	1.5
Interorbit	2.2	1.0	2.2	1.6	1.1	2.2	1.5
Pectoral	4.7	2.6	4.7	3.6	2.7	5.0	3.4
Pelvic	3.2	1.7	3.2	2.4	1.7	3.3	2.2
Caudal	5.9	3.7	5.9	4.8	3.5	6.7	4.5
Longest D1 spine	1.9	1.0	1.9	1.5	1.4	1.9	1.5

depressed. First dorsal spine always shorter than next two. Second dorsal spine length 10.4-14.5 (mean 12.3) in SL. Third dorsal spine length 11.8-14.5 (mean 12.8) in SL. Second dorsal and anal fins very low, short-based, posteriormost rays longest, rays fall far short of caudal fin base when depressed; length of second dorsal fin fits into space between tip of last fin ray and caudal base. Pectoral fin rounded, central rays longest, 4.1-5.6 (mean 5.0) in SL; rays usually all branched (uppermost ray may be unbranched). Pelvic fins short, rounded to oval, may reach half to two-thirds of distance to anus, 6.5-8.8 (mean 7.6) in SL. Caudal fin rounded, 3.4-4.6 (mean 3.7) in SL.

No mental frenum, chin smooth. Anterior nostril in very short tube placed on preorbital edge, tube oriented down and forward, preorbital may be produced forward slightly to accommodate nostril. Posterior nostril small, round, placed between front margin of eye and preorbital, nostril closer to eye than preorbital edge. Gill opening restricted to pectoral base. Inner edge of shoulder girdle smooth with no bony ridge or fleshy knobs. Gill rakers on outer face of first arch small fleshy unspined knobs, longest raker near angle of arch; rakers on inner face of first arch small but broader than those on outer face; inner rakers on other arches nearly twice length of first arch inner rakers; outer face rakers of fourth gill arch rudimentary to absent. Tongue usually blunt. Outer teeth in upper jaw largest, pointed, curved or almost straight, behind this row are about two rows of small sharp teeth; rows narrow to one or two at side of jaw (no sexual dimorphism); tips of teeth (especially outer row) often tinted translucent pale brown. Lower jaw with about four rows of small pointed teeth across front, outermost row oriented nearly upright with tips turned inward; usually only one row of teeth at side of jaw; tips of teeth often tinted translucent pale brown.

Predorsal scales small, cycloid, evenly sized, usually reaching forward to at least above preopercular margin or to behind eyes. Operculum with patch of small cycloid scales on upper third to half. Cheek always naked. Pectoral base covered with small cycloid scales. Prepelvic area at least with small cycloid scales posteriorly, anterior portion often naked. Belly with isolated patch under pelvics usually ctenoid (in 10), rest cycloid; or belly scales all cycloid (10). Ctenoid scales on side of body restricted to small patch beneath pectoral fin; ctenii weak.

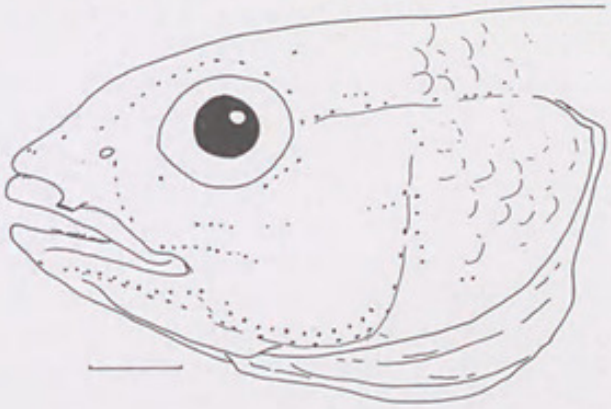

Fig. 10. *Chlamydogobius micropterus* n. sp., papillae pattern. Scale bar = 1 mm.

Head pores absent as in all *Chlamydogobius*.

Sensory papillae pattern longitudinal, as in Fig. 10. Cheek rows *b* and *c* reduced, broken. Two *s* rows on snout, consisting of one or two papillae each. Mental *f* row of one papilla on each side.

Coloration of fresh material. From colour slide of captive male specimen.

Head and body pale greyish yellow, with white abdomen. Rear portion of some scales yellowish white, forming irregular marbled pattern over upper half of body. Dense, very dark brown spots widely scattered over body, few on dorsal surface of head (apparently restricted to scaled portion of nape). Brown spots larger and more evenly spaced along posterior mid-side of body; largest spot at centre of caudal fin base. Head mostly plain, with broad dark-margined pale brownish bar extending from below eye to end behind jaws. Opercle with brownish markings and yellowish white-margined scales present. Snout, jaws and lower half of head pale yellowish white. Iris pale golden with brownish margin.

First dorsal fin (very small) appears to be yellowish grey anteriorly with large bright sky blue spot occupying most of fin (fin partly folded). Second dorsal fin with membranes mostly translucent, some dusky barring visible; fin rays yellowish grey. Anal fin grey with white margin (fin mostly obscured by body). Caudal fin translucent yellowish grey, uppermost fin rays nearly whitish. Pectoral fin folded, but appears whitish. Pelvics not visible.

Coloration of preserved material. All available preserved specimens pale; no males in breeding colouring present.

Head and body pale yellowish white to pale brownish yellow, with indistinct light brown

markings; peritoneum shows through body wall as silvery white or shiny purplish brown, depending on state of preservation. Upper half of body light dusky, with irregular and very variable light brown mottling and speckling, scale margins often outlined with light brown, forming irregular zig-zag streaks. Five to seven variable brown blotches or short bars may cross dorsal mid-line from first dorsal fin origin backward; nape generally plain. Mid-line of body sometimes shows diffuse series of light brown spots or short vertical dashes; most distinct mark is roughly rounded light brown spot at centre of caudal base, spot may be partly joined to two diffuse brownish spots on base of fin itself. Pectoral base dusky. Top and sides of head dusky pale brownish with slightly darker brown indistinct mottling; usually three markings distinguishable: brown area from front of eye forward to preorbital edge below anterior nostril, brown blotch from ventral edge of eye reaching down to behind rictus and diffuse brown blotch from rear edge of eye across preopercle. Lips pale to dusky, chin pale. Peritoneum black internally.

First dorsal fin pale to dusky with dark brown to dark grey blotch posteriorly. Second dorsal fin translucent to whitish with brownish fin rays. Anal, pectoral and pelvic fins whitish. Caudal fin translucent to dusky with indistinct brownish barring or rows of spots proximally, fin unspotted distally; two brown spots on either side of fin base, spots sometimes coalesced into broad dusky brownish vertical bar.

Comparisons. This species is distinctive in possessing a greatly reduced (reduced in size as well as number of spines) first dorsal fin; only one specimen had six spines. It also differs in colour pattern, apparently being pale with dark fine spots which do not form marbling or vermiculation as in most of the other species.

Distribution. Specimens are only known from spring-fed pools on the Springvale Station (Spring Valley on older maps), western Queensland (23° 30' S 140° 35' E).

Ecology. There appears to be very little information about the environment this species inhabits, other than it being extremely vulnerable to destruction. Wager and Jackson (1993) indicate that the water level and flow of Elizabeth Springs "...is decreasing due to a reduction in the water table caused by water extraction through artificial bores".

Remarks. The holotype, although possessing the least number of dorsal spines, was chosen due to its good condition and fairly dark pigmentation (dark when compared with other specimens of this apparently pale species).

Wager and Jackson (1993) discuss the conservation status of this species and indicate that it deserves high priority for action, before the wild population becomes extinct due to a combination of water draw-down by artificial bores and habitat destruction by stock trampling; they propose several management actions which should be taken. Apparently *Gambusia* has not yet invaded this area.

To date, *C. micropterus* remains on the Australian Society for Fish Biology's 1993 Threatened Fishes (sixth) Supplement list as "endangered"; one of the 11 Australian freshwater fishes (and the only goby) to be so honoured. It has been on the ASFB's Threatened Fish list supplements, under a variety of categories, since 1987 when it was listed as "potentially threatened" (Harris 1987).

Etymology. From the Greek, *micropterus* (small fin), in reference to the reduced first dorsal fin.

Chlamydogobius ranunculus n. sp.
(Figs 3-4, 11-12, Plate 2, Tables 2-4, 8)

Mugilogobius sp. 9 - Gee and Gee 1991: 19, 21-26.

Material examined. 167 specimens (4-31). HOLOTYPE - NTM S.11427-001, 27.5 mm male, partly dried-up buffalo wallow, Beatrice Lagoon, Adelaide River drainage, 12° 37'S 131° 21'E, coll. H. Larson, 20 May 1984. PARATYPES - QUEENSLAND: AMS I.22959-001, 5(22-25.5), lagoon behind wharf, Townsville, coll. J. Gee, 16 June 1981; QM I.19003, 1(31), Norman River near Karumba, coll. D.J. Russell, 11 June 1981; QM I.19005, 1(27), same data as preceding; AMS I.20928-001, 27(9.5-17.5), Smith Point, Prince of Wales Island, Torres Strait, coll. D.F. Hoese, 1979. NORTHERN TERRITORY: NTM S.11427-002, 7(19-27.5), same locality data as holotype; NTM S.11509-007, 118(4-31), bombholes at Leanyer Swamp, coll. NT. Fisheries, 9 October 1984; AMS I.32051-022, 5(20.5-31), Alligator River mouth, coll. T. Davis, April 1979; ex AMS I.32051-020, 2(23-27), cleared and stained, Alligator River, coll. T. Davis, April 1979.

Other material examined (but not used in description). 150 specimens from the following localities. AMS I.26677-007, 14, Hinchinbrook Channel, Queensland; NTM S.11935-001, 1,

Fig. 11. Holotype of *Chlamydogobius ranunculus* n. sp., NTM S.11427-001, male.

McArthur River, NT; NTM S.11510-003, 3, Leanyer Swamp, NT; NTM S.11509-006, 61, Leanyer Swamp, NT; AMS I.19229-001, 1, Marjarie Creek, NT; AMS I.32051-012, 29, Alligator River drainage; AMS I.32051-027, 5, Alligator River drainage; AMS I.32051-020, 12, Alligator River drainage; AMS I.32051-019, 10, Alligator River drainage; AMS I.32051-011, 4, Alligator River drainage.

Diagnosis. A moderately sized *Chlamydogobius* with second dorsal rays I,6-8mean; anal rays I; pectoral rays 11-13; longitudinal scales 32-52; TRB 12-17; predorsal scales small, reaching to above preopercular margin and or further forward; ctenoid scales on body usually consist of narrow wedge along mid-side or as two discrete patches; head rounded, almost as deep as wide; usually 27 vertebrae; estuarine, known from low salinity muddy habitats in northern Australia (Queensland and the Northern Territory).

Description. Based on 54 specimens, 14-31 mm SL. Counts of holotype indicated by asterisk (Fig. 11).

First dorsal V (1), VI* (48); second dorsal I,6-8 (,5-7 I,6*); anal I,5-7 (mean I,6*), pectoral rays 11*-13 (mean 12), segmented caudal rays 15-17 (mean 16, 15 in holotype); caudal ray pattern 7/6* (11), 7/7 (4), 8/6 (11), 8/7 (22) or 9/7 (1); branched caudal rays 11-16 (mean 14, 13 in holotype); unsegmented (procurrent) caudal rays 6/6 (2), 6/7 (1), 7/6 (1); longitudinal scale count 32-52 (mean 42, 39 in holotype); TRB 12-17 (mean 14, 13 in holotype); predorsal scale count 3-20 (mean 14, 16 in holotype, 0 in two specimens); circumpeduncular scales 15-23 (mean 20, 18 in holotype). Gill rakers on outer face of first arch ranging from 1+6 to 4+7 (mode 2+8). Pterygiophore formula 3-12210 (15), 3-12200 (1), 3-122110 (1). Vertebrae 10+16 (5), 10+17 (6), 11+16 (12), 11+17 (4), 11+18 (1). Neural spines of first three vertebrae split or expanded at tip (11) or narrow and pointed (2). One (18) or two (3) epurals. One (11) or two (13) anal pterygiophores before haemal spine of first caudal vertebra.

Body compressed (less so anteriorly). Head rounded, usually wider than deep, HL 3.0-3.6 (mean 3.4) in SL; sometimes almost square in cross-section. Depth at posterior preopercular margin 1.4-1.8 (mean 1.6) in HL. Width at posterior preopercular margin 1.2-1.6 (mean 1.4) in HL. Mouth terminal to subterminal, somewhat oblique, forming angle of about 25° with body axis; jaws generally reach to below mid-eye in both sexes; in smaller females, jaws may reach to below front half of eye. Lips less fleshy than in other *Chlamydogobius*, usually smooth, fleshy fimbriae may be present mostly on inner edges of upper lip, less often on lower lip (present on both lips in holotype); lower lip free at sides only, broadly fused across front. Upper jaw slightly longer in males than in females, 2.0-3.5 (mean 2.9 in females, 2.4 in males) in HL. Eyes lateral, high on head, top may form part of dorsal profile, 2.8-4.6 (mean 3.7) in HL. Snout somewhat steep, rounded, 2.9-4.1 (mean 3.6) in HL, occasionally somewhat inflated and may partially overhang upper lip. Interorbital broad, flat, 2.9-5.4 (mean 3.9) in HL; in large specimens, eyes may be placed high on head with flesh surrounding eye giving interorbital concave appearance. Top of head, from above preopercular margin up to snout, may have very fine dark-pigmented villi

present. Body depth at anal origin 4.3-8.8 (mean 5.1) in SL. Caudal peduncle compressed, length 3.2-7.5 (mean 3.9) in SL. Caudal peduncle depth 6.3-12.1 (mean 7.4) in SL.

First dorsal fin low, rounded, third and fourth spines longest or subequal; spines often slightly longer in males than females; in mature males, spines barely reach second dorsal origin when depressed; fin usually falls short of second dorsal in females. First dorsal spine always shorter than next three. Second dorsal spine length 9.8-10.4 (mean 10.1) in SL. Third dorsal spine length 7.6-10.2 (mean 8.9) in SL. Fourth dorsal spine length 7.2-10.8 (mean 9.0) in SL. Second dorsal and anal fins low, posteriormost rays longest, rays fall well short of caudal fin base when depressed, in both sexes. Pectoral fin rounded, central rays longest, 3.8-5.1 (mean 4.4) in SL; rays usually all branched. Pelvic fins short, usually oval, may reach half distance to anus, 5.4-7.9 (mean 6.5) in SL. Caudal fin broad, rounded, 2.9-3.9 (mean 3.5) in SL.

No mental frenum, chin smooth. Anterior nostril in very short tube, placed on preorbital edge just behind upper lip, tube oriented down and forward, preorbital curved forward to accommodate nostril. Posterior nostril small, rounded to oval, placed halfway between front margin of eye and preorbital. Gill opening restricted to pectoral base. Inner edge of shoulder girdle smooth with no bony ridge or fleshy knobs. Gill rakers on outer face of first arch very short unspined knobs, longest raker near angle of arch, sometimes rudimentary rakers alternate with "full-sized" rakers on lower limb, outer rakers on fourth arch very rudimentary but visible; rakers on inner face of first arch also stubby; inner rakers on other arches unspined, short, but nearly twice length of first arch inner rakers. Tongue broad, usually concave (nearly bilobed in several specimens) to bluntly rounded. Outer teeth in upper jaw largest, curved, with bluntly pointed tips; behind this row are two or three rows of smaller teeth; rows narrow to one or two at side of jaw. Lower jaw with two or three rows of smaller pointed teeth across front, outermost row oriented upright, teeth of inner rows tend to curve inward; usually only one or two rows of teeth at side of jaw (no sexual dimorphism). Tips of teeth (especially outermost) in both jaws often tinted translucent orange or honey brown.

Predorsal scales cycloid, small, evenly sized, usually reaching forward to above preopercular margin or slightly further, predorsal scales in holotype just reach over preopercular edge. Operculum with small cycloid scales on upper third to half; sometimes only few scales present. Cheek always naked. Pectoral base covered with cycloid scales. Prepelvic area naked, or with few cycloid scales before pelvics, or occasionally completely covered with scales. Belly usually with isolated patch under pelvics of weakly ctenoid scales, rest cycloid; some specimens with entire belly cycloid. Ctenoid scales on side of body in narrow wedge along midline, or more usually, broken into patch of scales behind pectoral fin, with remaining ctenoid scales beginning below second dorsal fin origin or further back on caudal peduncle (ctenii weak, often obscured by skin and mucous coat).

Head pores absent as in all *Chlamydogobius*.

Sensory papillae pattern longitudinal, as in Fig. 12. Cheek rows *b* and *cp* short and/or broken into short sections; row *c* usually only consists of

Table 8. Measurements (mm) of *Chlamydogobius ranunculus* n. sp.

Character	Holotype	Males			Females		
		Minimum	Maximum	Mean	Maximum	Minimum	Mean
Head Length	8.3	4.1	9.6	7.4	5.1	9.1	6.9
Head Depth	5.6	2.5	6.0	4.7	3.2	6.4	4.5
Head Width	6.4	2.8	7.0	5.4	3.5	7.7	5.2
Body Depth	5.7	2.9	6.8	5.0	3.6	7.2	5.0
Body Width	3.6	1.6	3.6	2.8	2.0	3.5	2.8
Caud. Ped. Leng.	7.6	4.1	8.1	6.6	4.7	8.0	6.5
Caud. Ped. Depth	4.4	2.0	4.5	3.5	2.5	5.0	3.4
Snout	2.5	1.0	2.9	2.1	1.3	2.9	1.9
Eye	2.2	1.2	2.4	2.0	1.4	2.5	1.9
Jaw	3.5	1.6	4.7	3.1	1.5	4.1	2.5
Interorbit	1.9	0.9	2.9	2.0	1.2	3.0	1.8
Pectoral	6.4	3.5	7.7	5.9	4.1	7.1	5.4
Pelvic	4.8	2.6	5.1	4.1	2.8	5.3	3.7
Caudal	8.1	4.3	9.3	7.3	5.4	8.7	6.9
Longest D1 spine	3.6	2.6	4.0	3.1	2.4	3.5	2.7

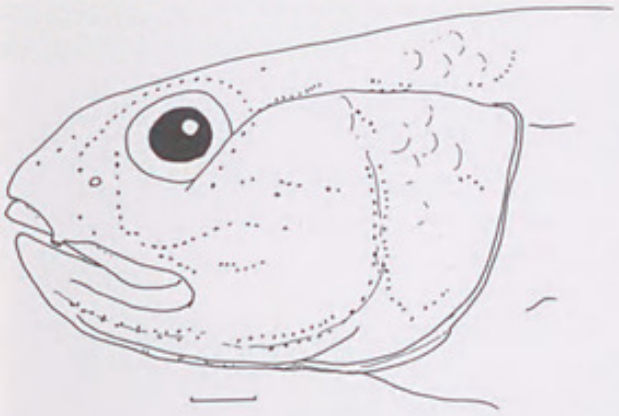

Fig. 12. *Chlamydogobius ranunculus* n. sp., papillae pattern. Scale bar = 1 mm.

one papilla. Two or three *s* rows on snout, rows close together, usually consisting of one papilla each; anteriormost row often consists of two papillae. Mental *f* row with two or four papillae.

Coloration of fresh material. From slides of freshly dead specimens (Plate 2), and one living specimen (Plate 2).

Mature male. Head and body brownish grey, pale yellowish white to whitish grey on underside of head and abdomen. Six or seven brownish grey (darker than background colour, but not greatly so) bars or saddles across back to mid-side of body; posteriormost bars somewhat oblique. Indistinct brownish grey spot at centre of caudal base. Head relatively plain brownish grey with no dark spots or bars other than two diffuse dark bars from eye extending to upper lip and to behind rictus respectively; lower half of opercle very pale bluish grey. Iris marbled with dark brown and gold. Pectoral base mostly brownish grey, whitish yellow anteriorly.

First dorsal fin dark grey along outer margin and on lower half of fin. Broad maize yellow submarginal band, below this and to rear of fin, light blue to greyish blue oval spot, spot edged with black ventrally; fin rays dark grey to black. Second dorsal fin dark grey to blackish with broad white margin, fin rays grey; lower half of fin with broad band of greyish blue, blue brighter toward rear half of fin; on fin membranes at about middle of fin, series of vertically oriented black blotches present. Anal fin similarly coloured to second dorsal fin but with no series of black blotches across middle of fin; greyish blue on proximal half of fin brighter than in second dorsal fin. Caudal fin grey with indistinct, vertically oriented oval dark grey blotch on each side of fin base; vertically oriented rows of small dark spots and blotches extend half length of fin, growing more indistinct distally; narrow dull white margin present. Pectoral fin membranes translucent, fin rays greyish to yellowish white. Pelvic fins yellowish white.

Female or immature male. Head and body translucent yellowish grey, underside of head and abdomen whitish. Body with indistinct grey to darker yellowish grey saddles and mottling; diffuse greenish grey streak extends from behind eye along upper half of body to below origin of second dorsal fin; scattered scales along mid-side of body with bluish white spots. Dorsal surface and upper sides of head with greenish grey spots, small blotches and vermiculate lines; lower half of opercle greenish silvery white. Iris pale gold with narrow brown ring around pupil. Peritoneum (through body wall) with upper half pinkish white overlain by diffuse blackish narrow bars, ventral half whitish. Pectoral base pinkish white, greyish close to ray bases.

First dorsal fin with narrow grey margin, broad greyish yellow band across distal half of fin; below this, bright pale blue rounded spot between fourth and sixth spines; lower half of fin translucent dusky grey. Second dorsal fin translucent pale grey with pinkish white margin, lower half of fin irregularly marked with slightly darker greyish or pinkish white vermiculate lines or diffuse blotches. Anal fin dark grey with bright white margin, proximal half of fin with greyish white markings (form indiscernible from photograph). Caudal fin translucent light grey with white margin; most of fin with vertically aligned rows of small grey or white spots; diffuse greenish grey dark spot on either side of fin base. Pectoral fin membranes translucent; rays pale translucent grey. Pelvic fins dark grey.

Coloration of preserved material. Males in breeding colour very similar to pattern as described for live material. Head and body pale yellowish brown to yellowish white (depending on preservation), with brown to light brown markings; spots and bars more conspicuous in preserved than live material. Pattern on body variable and often difficult to distinguish, but roughly formed by seven variably shaped (often square to rectangular) brown blotches on upper half of body and seven slightly darker brown spots or elongate blotches along mid-side of body (these two series of markings slightly offset). Body markings sometimes partly joined by diffuse lines and series of vague spots, forming diffuse streaks; markings may be formed by brown spots in scale centres or by brown margins

to scales. Predorsal and top of snout generally plain brown, as is top of opercle; lower half of opercle light brown; preopercle diffusely mottled or spotted with brown. Brown bar extends from front of eye to upper lip (bar runs just below nostrils so they appear to be in pale stripe between dark top of snout and dark eye-bar); second brown bar extends from ventral edge eye to just behind rictus; third indistinct bar or blotch may extend from lower rear edge of eye across cheek. Lower lip and chin speckled with brown; underside of head and abdomen yellowish white to yellowish brown. Pectoral base brown, or brown on upper half and pale on lower. Caudal base with brown spot at centre; spot not always darker than other body markings. Internally, peritoneum dark brown to black dorsally, fading ventrally and on lower sides to light brown or dusky grey.

First dorsal fin with greyish brown margin, broad submarginal transparent to translucent whitish band below this; lower half of fin greyish brown; usually dark grey to black spot on rear half of fin. Second dorsal and anal fins light greyish brown with broad translucent margins; second dorsal (less often, anal) fin may have one or two rows of darker brownish vertically elongate blotches on membrane; blotches in series in middle of fin. Caudal fin dusky grey with rows of vertically aligned diffuse small dark spots, and narrow whitish or translucent margin; sometimes spots nearest caudal base dark brown. Pectoral fins translucent to yellowish white, rays dusky. Pelvic fins translucent to yellowish white, bases of rays dusky.

Comparisons. This species differs from other *Chlamydogobius* by possessing an equal number of soft dorsal and anal fin rays, in having the lowest pectoral ray count (11-12), and being the only coastal species of the genus.

Distribution. Specimens are so far known only from northern Queensland and the Northern Territory, Australia.

Ecology. Northern Territory specimens have been collected from shallow, muddy, low salinity (0-9‰), coastal habitats. A number have come from rather precarious habitats such as tiny muddy creeklets draining mangrove samphire plain or freshwater floodplain, artificial habitats such as flooded bomb craters, water buffalo wallows, and concrete town drains (in general, the worse-looking the creek or puddle, the more likely that *C. ranunculus* will be present). No information has yet been obtained on this species' thermal and salinity tolerances, but they are likely to be wide, as may be the case with all the freshwater species.

Gee and Gee (1991) describe methods of aquatic surface respiration used by this species (reported as *Mugilogobius* sp. 9) when it was exposed to low oxygen levels; the fish used bubble-holding, with the body held in an arched or vertical position.

Neil Armstrong of the Australia New Guinea Fishes Association successfully induced (by abundance of food and TLC) captive specimens to spawn (1994: pers. comm.). About 30 large eggs were laid, which took about nine days to hatch at 25°C; the male guarded the eggs. Shortly after hatching, the young fish were observed clinging to the walls of the aquarium and appeared to be feeding on the surface film.

Remarks. This species, although displaying some specialisations (such as the even ratio of dorsal to anal rays) is likely to be closer to the marine ancestor of the group than any of the freshwater *Chlamydogobius*. The question of the desert gobies' ancestors have intrigued me and Miller (1987) for some time (did *Chlamydogobius* come from a temperate southern Australian group similar to *Mugilogobius paludis* or its ancestor, or from a northern tropical group?); the question is discussed later in this paper.

This species has been identified in some museum collections as *Mugilogobius* sp. 9 (or DFH sp. 9, in reference to Doug Hoese of AMS).

Etymology. From the Latin *ranunculus*, meaning tadpole, a resemblance to which this rather frog-headed goby displayed to the author upon first their encounter, at the edge of a drying-up water buffalo wallow.

Chlamydogobius squamigenus n. sp.
(Figs 3-4, 13-14, Tables 2-4, 9)

Chlamydogobius n. sp. - Jackson 1993: 23.

Material examined. 46 specimens (14-39). QUEENSLAND: HOLOTYPE - SAM F.6595, 34 mm male, "Western" spring, approximately 2.4 km NE of Edgbaston Station Homestead, coll. J. Glover, T. Sim and T. Scott, 7 May 1989. PARATYPES - SAM F.7676, 8(21-34.5), same locality data as holotype; SAM F.6738, 1(34), small mound artesian spring approximately 3.3 km SSE of Edgbaston Homestead, coll. W. Zeidler, 4 May 1988; SAM F.7184, 35 (14-39), "Crossmoor Flowing Bore", Crossmoor Station,

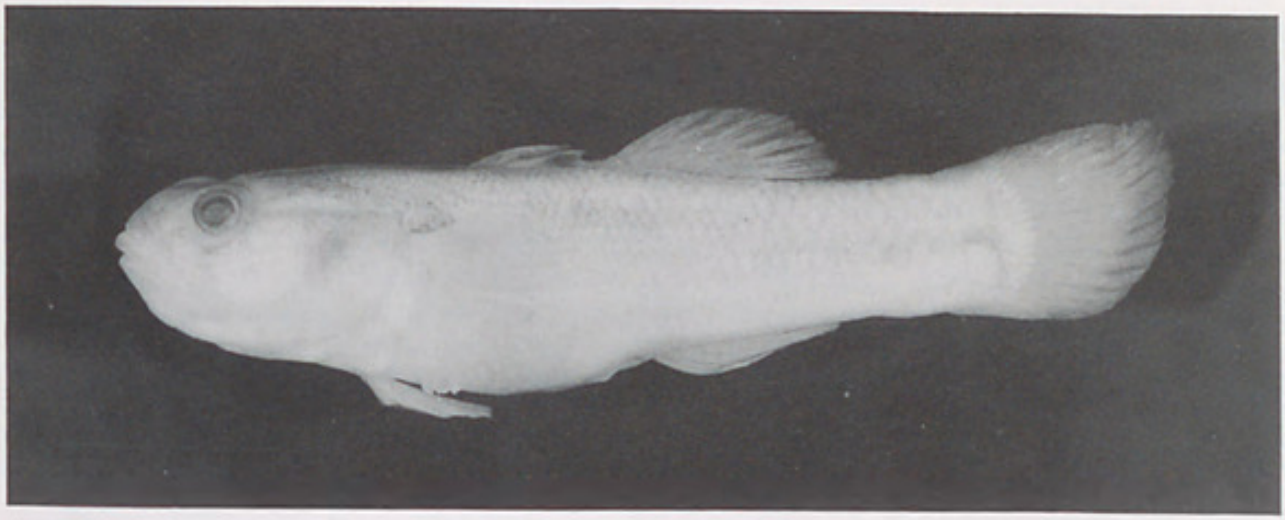

Fig. 13. Holotype of *Chlamydogobius squamigenus* n. sp., SAM F.6995, male.

on Longreach-Muttaburra Road, coll. T. Sim and P. Num, 3 June 1993; SAM F.7206, 1(35), Crossmoor Station, Bore Number 1652, south arm of drain, coll. T. Sim and P. Num, 5 June 1993.

Diagnosis. A small *Chlamydogobius* with second dorsal rays I,6-8; anal rays I,5-7; pectoral rays 13-14; longitudinal scales 33-45; TRB 14-17; 28 vertebrae; predorsal scales small, reaching past preopercular margin nearly to behind eyes; preopercle with small cycloid scales at least in patch by lower rear corner or below eye, ctenoid scales on side of body weak, in two separate patches; species known only from springs and pools on Edgbaston and Crossmoor Stations, Thomson River drainage, central Queensland.

Description. Based on 32 specimens, 21-39 mm SL. An asterisk indicates counts of the holotype (Fig. 13).

First dorsal V (5), VI* (25), VII (2); second dorsal I,6-8 (mean I,7*); anal I,5-7* (mean I,6), pectoral rays 12-14 (mean 13, 14 in holotype), segmented caudal rays 15-18 (mean 16*); caudal ray pattern usually 8/7 or 9/7*; branched caudal rays 14-17 (mean 16*); unsegmented (procurrent) caudal rays usually indiscernible in X-rays, 7/5 (1), 7/6 (1), 7/7 (1); longitudinal scale count 33-45 (mean 39, 40 in holotype); TRB 14-17* (mean 16); predorsal scale count 15-22 (mean 19, 21 in holotype); circumpeduncular scales 17-21 (mean 19, 18 in holotype). Gill rakers on outer face of first arch ranging from 0+6* to 2+7 (mode 2+6). Pterygiophore formula 3-12210 (10), 3-11210 (2). Vertebrae 10+18 (15), 11+17 (2). Neural spines of first few vertebrae narrow, pointed (7). One broad epural, sometimes partly split (14). Two (13) or one (2) anal pterygiophores before haemal spine of first caudal vertebra.

Body somewhat rounded anteriorly, compressed posteriorly. Head wider than deep, HL 2.2-3.3 (mean 3.0) in SL; in small specimens, head almost square in cross-section. Depth at posterior preopercular margin 1.5-1.8 (mean 1.7) in HL. Width at posterior preopercular margin 1.3-1.6 (mean 1.4) in HL. Mouth subterminal, slightly oblique, forming angle of about 20-23° with body axis; jaws generally reach to below front half of eye or to front margin of eye; in large males jaw may reach to below mid or rear half of eye. Lips usually smooth, fleshy fimbriae sometimes present on inner edges of upper lip; lower lip free at sides, broadly fused across front. Upper jaw 2.2-3.2 (mean 3.0 in females, 2.7 in males) in HL. Eyes lateral, high on head, top usually forming part of dorsal profile, 3.5-5.3 (mean 4.6) in HL. Snout rounded, slightly flattened to steep, 3.1-4.1 (mean 3.6) in HL. Interorbital moderate to broad, flat, 2.8-4.1 (mean 3.5) in HL. Top of head above preopercular margin up to front of interorbital with very fine, usually widely scattered villi. Body depth at anal origin 3.3-5.3 (mean 4.8) in SL. Caudal peduncle compressed, length 2.7-4.3 (mean 3.7) in SL. Caudal peduncle depth 4.7-7.4 (mean 6.8) in SL.

First dorsal fin low, rounded, third or fourth spines longest or subequal; spines about the same length in males and females; in both sexes, spines fall short of second dorsal origin when depressed (even in mature males). First dorsal spine always shorter than next three. Second dorsal spine length 10.3-17.0 (mean 10.5) in SL. Third dorsal spine length 6.7-10.8 (mean 9.7) in

Table 9. Measurements (mm) of *Chlamydogobius squamigenus* n. sp.

Character	Holotype	Males			Females		
		Minimum	Maximum	Mean	Maximum	Minimum	Mean
Head Length	10.4	7.0	12.7	9.4	6.8	11.7	9.5
Head Depth	7.0	4.0	8.0	5.7	4.0	7.2	5.7
Head Width	8.3	4.7	9.7	6.7	4.7	8.5	6.6
Body Depth	7.7	4.3	7.9	5.9	4.3	8.0	6.1
Body Width	4.6	2.5	4.8	3.6	2.7	5.2	3.7
Caud. Ped. Leng.	9.1	6.1	10.2	7.7	6.0	9.8	7.8
Caud. Ped. Depth	5.4	3.0	5.7	4.2	3.1	5.5	4.3
Snout	3.3	1.9	3.9	2.6	1.7	3.5	2.7
Eye	2.2	1.6	2.5	2.0	1.6	2.4	2.1
Jaw	3.9	2.5	5.9	3.5	2.1	4.1	3.2
Interorbit	3.5	1.9	4.4	2.8	1.8	4.0	2.7
Pectoral	6.8	4.7	8.3	6.2	4.4	7.7	6.2
Pelvic	5.0	3.5	6.8	4.8	3.3	6.0	4.8
Caudal	8.3	5.4	9.8	7.4	5.8	9.0	7.4
Longest D1 spine	3.2	2.5	4.6	3.2	3.0	4.4	3.2

SL. Fourth dorsal spine length 8.4-13.6 (mean 10.2) in SL. Second dorsal and anal fins short-based, low, posteriormost rays longer in mature males; rays generally equal in others; rays never reach caudal fin when depressed. Pectoral fin broad, rounded, central rays longest, 3.3-5.0 (mean 4.6) in SL; rays usually all branched. Pelvic fins short, oval, may reach half distance to anus, 4.1-6.8 (mean 6.0) in SL. Caudal fin rectangular to rounded, 2.9-4.6 (mean 3.9) in SL.

No mental frenum, chin smooth. Anterior nostril in short tube on preorbital edge just behind upper lip, tube oriented down and forward, preorbital curved forward to accommodate nostril. Posterior nostril small, round, placed halfway between front edge of eye and preorbital. Gill opening restricted to pectoral base. Inner edge of shoulder girdle smooth with no bony ridge or fleshy knobs or flaps. Gill rakers on outer face of first arch low fleshy knobs, without spines; longest raker near angle of arch; rakers on inner face of first arch also short and stubby; inner rakers on other arches nearly twice length of first arch outer rakers. Tongue usually blunt or rounded. Outer teeth in upper jaw largest, relatively slender and very slightly curved, behind this row are three rows of small sharp curved teeth; rows narrow to one or two at side of jaw (no sexual dimorphism); tips of teeth sometimes slightly tinted translucent honey brown. Lower jaw with three or four rows of moderate sized, curved pointed teeth across front, outermost row largest and least curved; teeth of inner rows more curved, tending to point posteriorly; usually only one or two rows of teeth at side of jaw; tips of teeth sometimes slightly tinted translucent honey brown.

Predorsal scales cycloid, small, evenly sized, usually reaching forward to past preopercular margin, sometimes extending up to behind eyes. Operculum with small cycloid scales on upper third to half. Cheek at least with one or two cycloid scales below eye or on rear part of preopercle, usually distinct patch of scales present; cheek apparently without scales in one 21 mm male specimen. Pectoral base covered with cycloid scales. Prepelvic area covered with small cycloid scales. Isolated area of ctenoid scales covered by pelvic fins, rest cycloid. Body scales mostly cycloid, with small separate patch of ctenoid scales behind pectoral fin; weakly ctenoid scales scattered along mid-line of caudal peduncle or sometimes further; ctenoid scales extend forward up to mid-body, at most.

Head pores absent as in all *Chlamydogobius*.

Sensory papillae pattern longitudinal, as in Fig. 14. Cheek row *c* broken into two widely separated portions; anterior part (below front

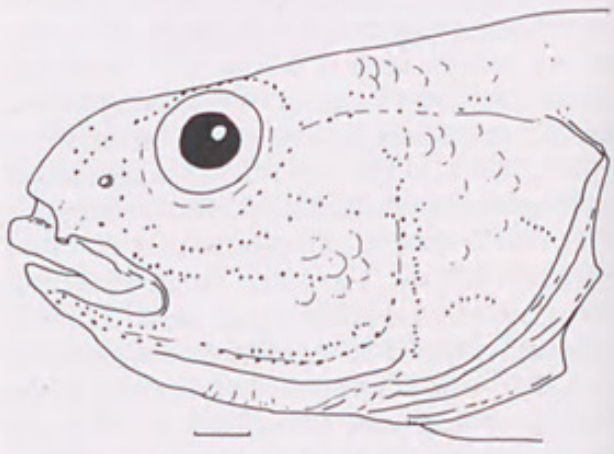

Fig. 14. *Chlamydogobius squamigenus*, papillae pattern. Scale bar = 1 mm.

edge of eye) of two or three papillae and posterior part of one or two papillae very close to, and just below, anterior portion of row *b*. Two *s* rows on snout; each row of one papilla each. Mental *f* row consists of two papillae.

Coloration of fresh material.

Mature male. From colour slide. Head and body dusky greyish yellow; head whitish yellow underneath; peritoneum, through body wall, silvery white. Indistinct narrow grey bars and mottling across upper half of body. Head plain greyish yellow; lips grey to whitish grey; iris pale gold.

Dorsal fin blackish with narrow chrome yellow submarginal band, band widest anteriorly, becoming narrower and darker posteriorly; broad vivid blue band across centre of fin; lower third of fin blackish. Second dorsal and anal fins blackish with broad bright greyish blue margin; second dorsal fin with diffuse greyish blue band across proximal half of fin. Caudal fin very dark grey with narrow dull whitish grey margin; indistinct vertically aligned rows of yellowish to light grey spots present.

Coloration of preserved material. Head and body dull yellowish white to greyish white with brownish grey or grey scale margins, diffuse narrow blotches and spots on upper half; lower half of body, and underside of head, plain. Scales on body diffusely outlined with grey or brownish grey, forming indistinct bars, blotches and cross-hatching which vary among specimens; from dorsal view about six indistinct blotches or short bars cross dorsal mid-line. Mid-side of body with indistinct row of dark spots, only defined spot in series is at mid-base of caudal fin. Pectoral base mostly pale, dusky patch across upper part. Nape behind eyes, interorbital and top of snout often with short, diffuse grey vermiculate lines and spots. Broad diffuse brownish bar from front of eye to upper lip, ending just below anterior nostril tube. Second diffuse brownish mark runs along lower edge of eye then curves down to behind rictus.

First dorsal fin colour variable, usually translucent to light grey with narrow dusky to blackish margin, and blackish streak across middle to upper half of fin, streak intensified as dense black blotch posteriorly. Second dorsal and anal fin whitish. Second dorsal may have series of vertical dusky blotches forming band below margin; other diffuse dusky grey blotches scattered irregularly over proximal half of fin. Caudal fin translucent to whitish, with many rows of small vertically aligned dark grey or diffuse grey spots; margin clear or white. Pectoral fin translucent whitish, rays dusky proximally. Pelvic fins whitish; few heavily pigmented specimens have dusky markings along rays but not frenum.

Mature male (SAM F.7206) similar to live colour pattern described above, but dusky irregular grey barring on upper sides more prominent.

Comparisons. *Chlamydogobius squamigenus* is distinctive in having at least one or two cycloid scales on the cheek (usually a patch of scales present), unlike other species of the genus.

Distribution. Specimens are known only from springs and pools at Edgbaston Station, NE of Aramac, Queensland, and from bores and drains on Crossmoor Station just NNE of Longreach; both on the Thomson River drainage.

Edgbaston Station is at 22° 44' S 145° 25' E, according to Ivantsoff *et al.* (1991). Although there are many spring-fed pools on the station, the number which contain *C. squamigenus* has not been ascertained. "Crossmoor Flowing Bore" from which most of the Crossmoor Station specimens came from, is at 22° 54' S 144° 35' E.

Ecology. This species was first collected from a small artesian mound spring (at 22° 45' 40" S 145° 25' 30" E), badly stock-damaged, on Edgbaston Station in 1988. A second lot of nine specimens came from the "Western" spring, about 2.4 km NE of the station homestead. The pools and springs are fed by Artesian Basin water (Ivantsoff *et al.* 1991). Ivantsoff *et al.* (1991), in describing the habitat of a new pseudomugilid, indicated that *Chlamydogobius* shared its habitat, which consists of small, clear, very shallow, clay-bottomed pools, with grass tussocks growing in the water and an unidentified red-leafed plant.

There has been concern expressed (Unmack 1992) that the pools on Edgbaston Station may become degraded by trampling (sheep, cattle and human beings), and that the fish populations may become more directly threatened by the introduced pest fish, *Gambusia holbrooki*, which is already present in a number of the pools, including those with *Chlamydogobius* present. The status of the population of *C. squamigenus* is not known, although Unmack (1992) indicates that there were populations in several pools. The ASFB Threatened Fish Committee lists this species as "vulnerable" (Jackson 1993).

Bruce Grose (in litt.) has been able to spawn and raise this species in captivity, and reports that the eggs take about a week to hatch into free-

swimming larvae which actively disperse through the aquarium. He estimates at least a hundred eggs per batch are laid.

Remarks. Ivantsoff *et al.* (1991) refer to this species as "... possibly a new species of the desert goby" in their description of the unusual pseudomugilid *Scaturiginichthys*, but do not discuss the goby further.

Crossmoor Bore specimens included two with vertebral counts of 11+17 and two with dorsal pterygiophore patterns of 3-11210.

Etymology. From the Latin *squama* (scale) and *gena* (cheek), referring to the cycloid scales present on the preopercular region of this species. All other species of the genus lack scales on the preopercle.

PALAEOBIOGEOGRAPHY

The present Australian freshwater fish fauna is well known for its several ancient Gondwanan relicts such as *Neoceratodus* and *Scleropages*, which are now restricted to tropical/sub-tropical areas. However, the origins of the remaining marine-derived fauna is not known (Allen 1989). The present temperate (southern) freshwater fish fauna does include a number of families of probable Gondwanan coastal marine ancestry (Aplochitonidae, Galaxiidae, Prototroctidae, Retropinnidae, Percichthyidae, Gadopsidae); most of these families include species occurring in southern Australia, New Zealand and South America. The present northern and central freshwater fish fauna includes groups with SE Asian affinities (Plotosidae, Melanotaeniidae, Ambassidae, Terapontidae, Gobiidae). Allen (1982) speculated that many Australian freshwater fish species may possibly have evolved only in the last 2 my. Allen and Cross (1982) state that rainbowfish (family Melanotaeniidae, endemic to Australia and New Guinea) are capable of speciating rapidly (7,000 years estimated for the *M. trifasciata*/*M. goldei* species pair; the former is from northern Australian, the latter from southern New Guinea).

Fossil gobiids have been known since the Eocene, based on otoliths (Miller 1973), and are known from the famous Monte Bolca site (middle Eocene) which includes the first records of many modern coral reef groups such as labrids, pomacentrids, zanclids, acanthurids siganids and ephippids (Bellwood 1993). Miller considered that the other gobioids may have split from the rhyacichthyids in the late Cretaceous, when many teleost fish families appeared. There are no fossil gobioids known so far from Australia (Long and Turner 1984).

Larson (in prep.) and Miller (1987) both consider that the closest relative of *Chlamydogobius* may be *Mugilogobius*, an estuarine genus related to other Indo-West Pacific genera such as *Pseudogobius* and *Hemigobius*. These fish are likely to have radiated from the SE Asian Archipelago via New Guinea along with other shallow-water fish groups to the Australian coast. Miller (1987) has postulated that *Chlamydogobius* became isolated in central Australia approximately 1.6 my, after entering the continent about 20 my. To determine how *Chlamydogobius* entered central Australia and radiated, one must depend upon hypotheses of phylogenetic relationships, palaeogeographic recontructions, physiological tolerances of the fish, and climate indicators, rather than a fossil record. In Australia, there is only one poorly known Palaeogene (65-22.5 my) vertebrate fossil deposit, while the Neogene (Miocene and Pliocene, 22.5-1.8 my) and Pleistocene (1.8 my to 10,000 years) faunas are better known (Rich 1991). Long (1991) indicated that many modern genera of shallow-water marine fishes such as *Lactarius*, *Diodon*, *Sillago* and *Platycephalus* were established in Australia during the early Miocene, but this should be taken as a minimum age because there is no older fish record with which to time their arrival (Megirian pers. comm.).

Based on available information (e.g. Frakes and Rich 1991; Megirian 1992; McGowran and Li 1994), the early to mid Miocene were possibly optimum times for the introduction and dispersal of gobiids into the interior (in general agreement with Miller 1987). During the "Miocene oscillation" (McGowran and Li 1994), sea surface temperatures and sea levels rose and some tropical marine groups were able to spread around the southern coast of Australia. Inland, conditions also ameliorated, but were still relatively dry (Megirian 1992). However, there was probably significantly more permanent water inland than there is today, fresh grading to brackish in enclosed or endorheic basins. The general low relief of most of the continent was established at least since the Early Cretaceous (e.g. Fig. 18 in Frakes and Rich 1991 shows much of the continent flooded, indicating its flatness); many major drainages were probably already separated by divides of very low relief which probably would not have formed barriers to dispersal during times of flood. The low drainage divide

between the (present-day) Gulf and Lake Eyre drainages may have been present since the early Cretaceous (Swarko 1966), or Palaeocene (Veevers 1991).

There are two possible paths that the ancestor(s) of present-day *Chlamydogobius* could have taken to enter central Australia: along coastal New Guinea into the Gulf drainage and thus into the Lake Eyre basin (where radiation into centralian drainages could occur), or along coastal New Guinea, around the eastern coast of Australia to the southern margin, then north into the Lake Eyre basin and centralian drainages. The former scenario requires a connection between the Gulf and Lake Eyre drainages. The old but probably low drainage division between the two may have been breached during one of the wetter climatic periods. Given the present-day ability of many gobioids (such as the world-wide subfamily Sicydiinae, the Indo-West Pacific genus *Glossogobius*, the Australia-New Guinea genus *Mogurnda*, and *Gobiomorphus* of New Zealand and south-eastern Australia) to colonise high-gradient fast streams and/or climb nearly vertical surfaces, and the present distribution of *C. ranunculus*, this scenario is not unlikely.

Whichever route was used, *Chlamydogobius* must have been established in central Australia before the arid conditions of today were established, as could have other genera such as *Neosilurus* and *Craterocephalus*, which have also speciated in the interior (it is interesting to note that central Australian fishes are a mixture of widely distributed, opportunistic species, such as *Leiopotherapon unicolor* and *Nematalosa erebi*, or those with relatively restricted distributions such as the species of *Chlamydogobius*, *Craterocephalus centralis* and two undescribed *Neosilurus*). The aridification of the interior to the extent observed today began in the late Miocene/early Pliocene, with the formation and mobilisation of desert dune systems first occurring in the late Pliocene and becoming widespread in the Pleistocene, especially during glacial epochs, as a result of global temperature gradients, formation or intensification of subtropical high-pressure belts and consequent increases in climatic seasonality in the continental interior. The Finke drainage system may have been isolated quite recently from the Lake Eyre basin by dune development and migration in the Pleistocene (Megirian pers. comm.), which would seem consistent with the small genetic difference exhibited by *Chlamydogobius eremius* and *C. japalpa* (as observed by Adams). Thus, the intensifying aridification of Australia led to isolation of *Chlamydogobius* populations and subsequent speciation.

DISCUSSION

Preliminary work by Mark Adams at the South Australian Museum indicated that there were possibly four distinct freshwater species of this genus, based on isozyme electrophoresis (Terry Sim and Mark Adams, pers. comm.). Mark Adams conducted enzyme electrophoresis on five inland populations of *Chlamydogobius* and considered that four of them were probably valid (Adams, in prep.). He did not consider that there was sufficient difference between the Finke and Coward Springs populations to warrant placing them in separate species (consensus analysis of his data indicated no genetic difference, although one locus, Ck, showed as a separating factor depending on how the data was input into the clustering procedure). He found considerable difference between *C. gloveri* and *C. eremius*, reflecting the isolation between the Lake Eyre system and Dalhousie Springs as proposed by Kotwicki (1989). The link between the Lake Eyre and Finke systems is supported by Crowley and Ivantsoff (1990b), who found an allele shared by *Craterocephalus centralis* (restricted to the Finke system) and *C. eyresii* (Lake Eyre drainage) which was absent from others in their species-group. Given the long-term hydrologic isolation of the Finke system from Lake Eyre, and the morphological and axial skeleton differences between the two populations of *Chlamydogobius*, they are treated here as separate species. As Ivantsoff, Larson and Ponder each note (in Department of the Environment, Sport and Territories 1994: 49), more species of freshwater fish are being found to be narrowly restricted in their distributions, i.e. found only in a particular group of springs.

As Miller (1987) noted, *Chlamydogobius* exhibits several adaptive features which contribute to its survival in hostile environments: a wide tolerance range for temperature, pH, salinity and oxygen levels, and large egg size with almost no larval stage, the young fish clinging almost immediately to the substrate; the latter two traits differing from *Mugilogobius* (Horsthemke 1989; Armstrong 1994 pers. comm.), which has a short pelagic larval stage. Glover (1982) discussed the physical barriers operating which influence desert fish dispersal and present-day distribution, and showed that the ability to tolerate extremes of

Plate 1, above, *Chlamydogobius eremius*, male in breeding condition. Photo by Neil Armstrong; **center,** *Chlamydogobius eremius*, male in non-breeding coloration. Photo by Ross Felix; **below,** *Chlamydogobius gloveri* n. sp., female. Photo by Ross Felix.

Plate 2, above, *Chlamydogobius gloveri* n. sp., male. Photo by Peter Unmack; **center,** *Chlamydogobius ranunculus* n. sp., adult male. Photo by Rex Williams; **below,** *Chlamydogobius ranunculus* n. sp., adult female. Photo by Neil Armstrong.

temperature and salinity, as well as flexibility in handling other ecological factors, favour survival for fishes such as the desert goby, *Chlamydogobius*.

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