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ABSTRACTS

THE IDENTITY OF *HELICARION SEMONI* MARTENS, 1894: A LARGE SEMI-SLUG FROM THE WET TROPICS, NORTHEASTERN QUEENSLAND (PULMONATA: HELICARIONIDAE)

JOHN STANISIC

Stanisic, J. 1993 12 24: The identity of *Helicarion semoni* Martens, 1894: a large semi-slug from the Wet Tropics, northeastern Queensland (Pulmonata: Helicarionidae). *Memoirs of the Queensland Museum* **34**(1):1-9. Brisbane. ISSN 0079-8835.

The identity of the semi-slug *Helicarion semoni* Martens, 1894, is established. The name is applied to a large species from the northern region of the Wet Tropics, NEQ, and the type locality is redesignated as the Big Tableland, south of Cooktown, NEQ. On the basis of conchological and anatomical features the species is referred to *Thularion* gen.nov. and redescribed. Some aspects of its biogeography and relationships are discussed. ☐ *Pulmonata, Helicarionidae, Thularion semoni (Martens, 1894), new genus, semi-slug, systematics, biogeography, Wet Tropics.*

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Semi-slugs belonging to the family Helicarionidae are particularly diverse in eastern Queensland. Iredale (1937) listed 8 species while Smith (1992) listed 7 with a further 2 as incertae sedis. Based on material acquired by the Queensland Museum over the past 13 years these are underestimations. Among the described forms several, including *Helicarion semoni* Martens, 1894, are taxonomic enigmas. Although listed under *Parmacochlea* Smith, 1884, by Iredale (1937) the species was considered incertae sedis by Smith (1992). Long efforts by the author to locate the type were fruitless until a chance discovery of two syntypes by Dr Rudolf Kilias in the collections of the Zoological Museum, Humboldt University, Berlin. Examination of the types revealed that they were conspecific with a large helicarionid semi-slug from the northern region of the Wet Tropics, NEQ.

The type locality given by Martens (1894) was Burnett R., SEQ (Fig. 1), which may explain the confusion surrounding this species even though the original descriptions of both shell and animal were excellent. Marten's introduction of *H. semoni* was included in a listing of molluscan species (land and freshwater) collected from eastern Queensland in 1891-1893. Although the Burnett R. featured in several species descriptions other Queensland localities were visited by the expedition and these included Hammond Is., Torres Strait, and Cooktown, NEQ. Since both the original description and the types agree with the NEQ animal, I consider that there was a labelling error during either collection or study of the specimens.

Cooktown is situated in the far north of the Wet Tropics and would have provided ready road access to the area where *H. semoni* occurs. The black form of the animal (Fig. 3a), which was referred to in the original description, comes from the Big Tableland area, near Helenvale, NEQ. The species is placed in *Thularion* gen.nov.

Studies of Australian helicarionid semi-slugs are sparse. Baker (1941) figured the anatomy of a specimen of '*Helicarion*' *leucospira* (Pfeiffer, 1857) and R. Kershaw (1979, 1981, 1983) and Dartnall and R. Kershaw (1978) completed studies on some southeastern Australian species. Most references consist of brief single species descriptions and mentions in faunal checklists. Hence it is not surprising that generic relationships and even species identities are poorly understood. Although a comprehensive revision of the group is clearly required the author has dissected a number of other eastern semi-slug taxa in order to place the following observations in a wider context. I am grateful to Ron C. Kershaw for supplying many personal notes and drawings on eastern semi-slugs. They have facilitated this project.

The following abbreviations are used:-

Q-Queensland, NSW-New South Wales, ZMB-Museum für Naturkunde der Humboldt Universität, Berlin, Germany, QM-Queensland Museum, CMVF-complex mesophyll vine forest. DG-prostate, E-epiphallus, EC-epiphallic caecum, EF-epiphallic flagellum, EP-epipallic pore, G-ovotestis, GD-hermaphroditic duct, GG-albumen gland, LL-left shell lappet, LML-left mantle lobe, P-penis, PPM-main penital pilaster, PRM-penial retractor muscle, PS-penial sheath, RL-right shell lappet, RML-right mantle lobe, S-spermatheca, SH-shell, SP-spermatophore, SS-spermathecal stalk, UT- uterus, UV- free oviduct, V-vagina, VD-vas deferens, Y-atrium, Z-digestive gland.

SYSTEMATICS

Family Helicarionidae

Thularion gen.nov.

DIAGNOSIS

Shell degenerate with incomplete early whorls and membranous base, depressed, and with reduced whorl numbers. Shell sculpture of fine crowded spirals on the protoconch becoming obsolete on the adult whorls; body whorl with widely spaced, spiral furrows. Animal large with shell lappets prominently united posteriorly; left mantle lobe forming a prominent cephalic shield. Genitalia with epiphallic caecum and flagellum. Penis with sheath, internally with a large lamellate pilaster and pustular wall ornamentation; no verge or papilla present.

ETYMOLOGY

Latin *thule* north; referring to the distribution of the genus in northern Australia.

TYPE SPECIES

Helicarion semoni Martens, 1894; herein designated.

COMPARISONS

Thularion differs most markedly from *Fastosarion* (+*Vercularion*) (type species: *Vitrina superba* (Cox, 1871) by its degenerate, depressed shell which has lower whorl numbers. The external animal characters of *Thularion*, particularly the enlarged shell lappets and mantle lobes, are additional discriminating features. *Parmacochlea* (type species: *Parmacochlea fischeri* Smith, 1884) has an even more reduced shell and greatly enlarged shell lappets and mantle lobes. The penis of *Thularion* is pustulose with a lamellate pilaster apically and no vergic structures. In contrast the penial wall sculpture of *Fastosarion* consists of obliquely arranged, longitudinal pilasters complemented by a large central pilaster and either an apical verge or papilla (R. Kershaw, pers. comm.). *Parmacochlea* has a strongly papillose penis interior with a large central papillose pilaster and a verge.

Thularion semoni (Martens, 1894) comb. nov. (Figs. 1-7)

Helicarion semoni Martens, 1894, p.87, pl.4, fig.8a-e; Smith 1992, p.244.

Parmacochlea semoni (Martens); Iredale, 1937, p.10.

COMPARATIVE REMARKS

Thularion semoni can be distinguished from *Fastosarion brazieri* (Cox, 1873) (type locality: Mt Bellenden Ker, NEQ) by its depressed, degenerate shell (Fig. 2a-b), lower whorl numbers and enlarged shell lappets which are strongly fused posteriorly (Fig. 5a). *Parmacochlea* spp. are smaller and have a simple, plate-like shell. Anatomically the very long penis with apical pilaster (Fig. 5b,c) immediately differentiates *T. semoni* from other sympatric semi-slugs (Stanisic, unpubl.).

PREVIOUS STUDIES

Martens (1894) compared *T. semoni* with *Peloparion helenae* (Godwin-Austen, 1883) from the Sydney region, NSW, on the basis of overall similarity of *T. semoni* to Godwin-Austen's drawings. However, the Sydney semi-slug is much smaller and is only grossly like the northern species (R. Kershaw, pers. comm.). Iredale (1937) referred *T. semoni* to *Parmacochlea* Smith, 1884, without giving reasons. Presumably the allocation was based on the degenerate nature of the shell. However, although the shell of *T. semoni* is reduced it is not plate-like as in *Parmacochlea* spp. The superficial nature of this conchological similarity is highlighted by major differences in anatomy (external and internal) between *Parmacochlea* and *T. semoni*. Smith (1992) listed the species as incertae sedis and indicated that the type was probably lost.

TYPE LOCALITY

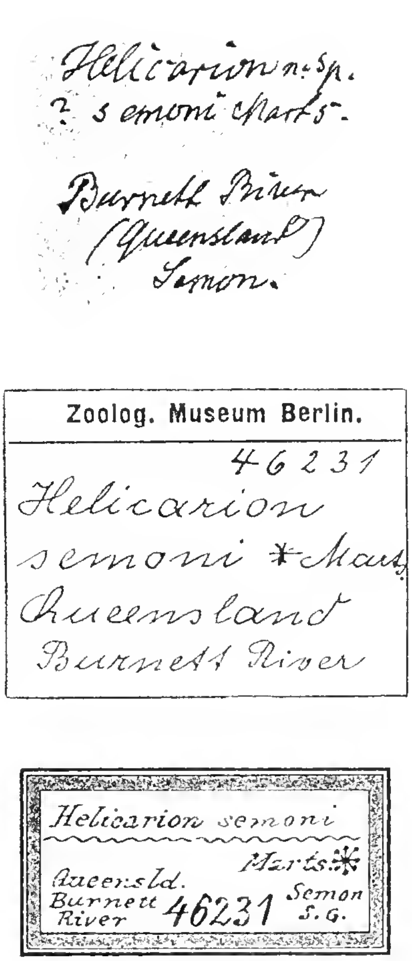
Big Tableland, c. 15k S of Helenvale, NEQ - herein designated.

MATERIAL EXAMINED

LECTOTYPE: ZMB46231, Burnett River (error), Queensland. Collected by R.W. Semon. Height of shell 7.00mm, max. diameter 24.92mm, min. diameter 16.58mm, H/D ratio 0.28, whorls 2⅝ - herein designated.

PARALECTOTYPE: ZMB46231, 1 specimen, same collection data as lectotype (damaged).

OTHER MATERIAL:NEQ; Lorna Doone, c. 15k SE



Helicarion n. sp.
? semoni Marts.
Burnett River
(Queensland)
Semon.

Zoolog. Museum Berlin.
46231
Helicarion
semoni * Mart
Queensland
Burnett River

Helicarion semoni
Marts.*
Queensld.
Burnett River
46231
Semon
S. G.

FIG. 1.Provenance of type material

Helenvale, (15°47'S, 145°17'E), CMVF/Palms, under Logs and discarded palm fronds (9, QMMO23769, 4 Oct 1988, J. Stanisic, D. Potter); Mt Finnigan, summit, 1050m (15°48'S, 145°17'E) (4, QMMO44296, 3-5 Dec 1990; 5, QMMO44295 16-17 Jan 1991, G.B. Monteith); Big Tableland, via Helenvale, rainforest, under logs (1, QMMO14166, 17 Dec 1983, J. Covacevich); Mt Misery, via Shiptons Flat (15°53'S, 145°14'E), summit, 850m (1, QMMO44297, 6 Dec 1990, G.B. Monteith); Big Tableland (15°43'S, 145°17'E), 700m (3, QMMO44299, 19-20 Dec 1990, G.B. Monteith); Mt Sorrow, via Cape Tribulation, 300-800m, rainforest (1, QMMO43308, 15 Oct 1980, G.B. Monteith); Table Top, Mt Finnigan, Shipton's Flat, rainforest, in litter (1, QMMO4697, 11 Jun 1971, D. Douglas).

DIAGNOSIS

Shell (Fig. 2a,b) large, maximum diameter 22.00-25.30mm (mean 24.14mm), minimum diameter 16.58-18.82mm (mean 17.49mm), very thin, lenticular, horny, poorly calcified. Whorls 2½+ - 2⅝+ (mean 2⅝), rapidly expanding. Body whorl greatly inflated and descending slightly in front, with lower margin membranous. Spire and apex flattened. Height of shell 6.49-11.69mm (mean 9.51mm), H/D ratio 0.27-0.53 (mean 0.40). Protoconch (Fig. 4a) of 1¼ whorls, sculptured with fine, crowded, incised spiral lines. Post-nuclear sculpture (Fig. 4c-e) of fine radial growth lines and sparse spiral furrows on the body whorl. Microsculpture (Fig. 4e-f) of very fine, almost obsolete, periostracal, spiral wrinkles. Sutures (Fig. 4b) shallowly impressed. Whorls flattened above and rounded below the periphery. Internal walls of early whorls (Fig. 2b) membranous and incomplete. Lip thin, membranous below. Colour yellow with whitish apex; interior chalky white.

Animal (Figs. 3a,b; 5a) large, body length in preservative 45.9-59.4mm (mean 53.0mm, n=7). Foot moderately broad, tripartite, rounded anteriorly, tapered posteriorly. Tail relatively long, high, sharply keeled mid-dorsally. Caudal horn vestigial; caudal foss a long vertical slit in the tail. Pedal grooves typically aulacopod. Colour (in life) black and reddish-brown with

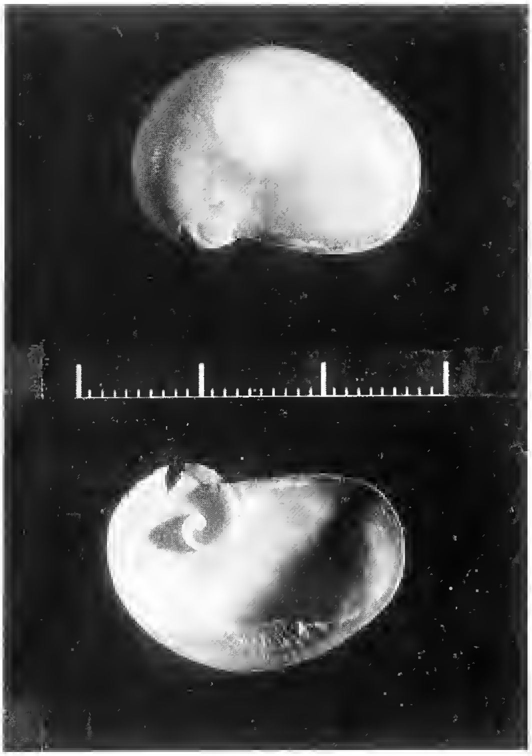


FIG. 2. Lectotype of *Thularion semoni* (Martens 1894), ZMB46231. Scale in mm.

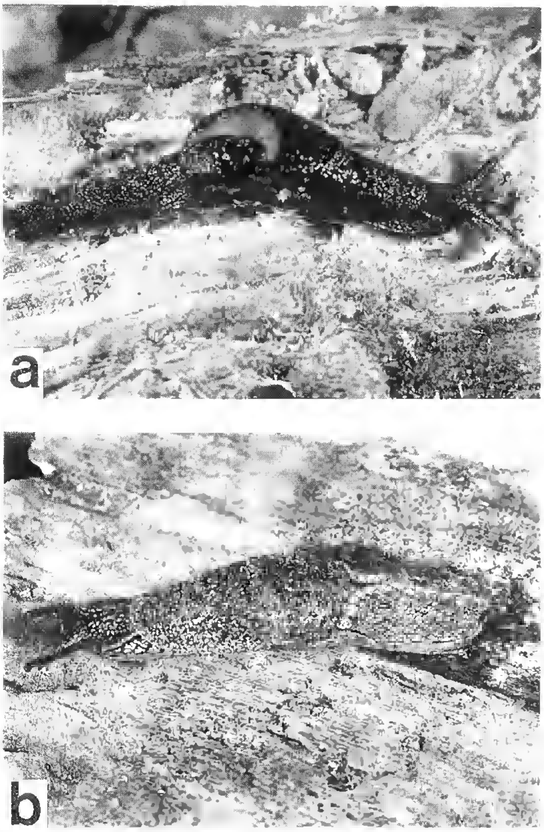


FIG. 3.Colour morphs of *Thularion semoni*. a, black, Big Tableland, NEQ, QMMO14166; b, brown, Mt Finnegan, NEQ, QMMO4697.

brown markings to black (Fig. 3a,b), always with varying degrees of paler creamy-yellow markings on the body ornamentation; pustules on mantle lobes and shell lappets also with paler markings. Foot black to reddish-brown with paler edges and paler central region. Right mantle lobe small, with short, lobate anterior extension. Left mantle lobe large, with a triangular, tapered lobe posteriorly, expanded into a cephalic shield anteriorly, and fused with left shell lap anteriorly. Right shell lap fused with right mantle lobe at lower margin and with left shell lap posteriorly. In life, right shell lap covering apex and about one-third of shell; left shell lap covering remainder of shell.

Genitalia (Fig. 5b) with multilobate ovotestis buried in the digestive gland. Talon a blind spherical pouch on a short peduncle embedded in the surface of the albumen gland. Hermaphroditic duct long and convoluted; carrefour embedded in the albumen gland. Prostate a band of creamy alveoli appressed to the upper three-quarters of uterus. Uterus with a short, narrow basal section, giving rise to a larger, highly sacculated apical portion. Vas deferens arising from the prostate-uterus as a highly convoluted, thin tube, descending to the penioviducal angle then ascending the penis as a straight narrow tube to enter a wider, muscular epiphallus. Epiphallus shorter than penis, apically with a long thin flagellum which is weakly connected to the side of the penis, internally with longitudinal pilasters basally, becoming transverse apically. Penial retractor muscle inserting sub-apically onto epiphallus at a point where a short, club-shaped caecum arises. Vagina short with irregularly arranged, thin, longitudinal thickenings. Free oviduct expanded, internally with longitudinal thickenings that become transverse apically, entering vagina sub-apically. Spermatheca with a long, thin stalk and an ovately elongate head, inserted apically on vagina. Penis (Figs. 5b,c) long, reflexed centrally; apical region with simple entrance of epiphallus and short, crowded, transversely elongate pustules that become less crowded in some areas and a long, slender, lamellate pilaster; basal region with a sheath, internally with short, narrow, crowded, transverse pustules, tending to be more crowded centrally. Atrium short, without unusual features. Spermathophore (Fig. 5d) elongately ovoid with a long, thin chitinous tail. Based on three (two dissected) specimens (QMMO23769, QMMO14166).

Radula (Fig. 6a-f) having a tricuspid central tooth with lanceolate mesocone and reduced lateral cusps; laterals strongly bicuspid with endocone reduced to a tiny point on the edge of the mesocone, ectocone short and pointed, anterior edge irregularly swollen and grooved; marginals bicuspid with a long curved shaft, long and curved mesocone, short ectocone, no endocone, rounded cusps. Basal plates of central and laterals short, squarish, asymmetrical in laterals with an elevated lateral ridge. Interrow support provided by interlock of anterior edge with basal plate of tooth in front. Radular formula 83.23.1.23.83.

DISTRIBUTION AND HABITAT

Tropical rainforests of the coastal region between Cape Tribulation and Cooktown, NEQ (Fig.7); mainly in the uplands and highlands; probably an opportunistic riparian species in the foothills where circumstances allow. Its apparent absence from the Thornton Peak area, south of Cape Tribulation needs confirmation.

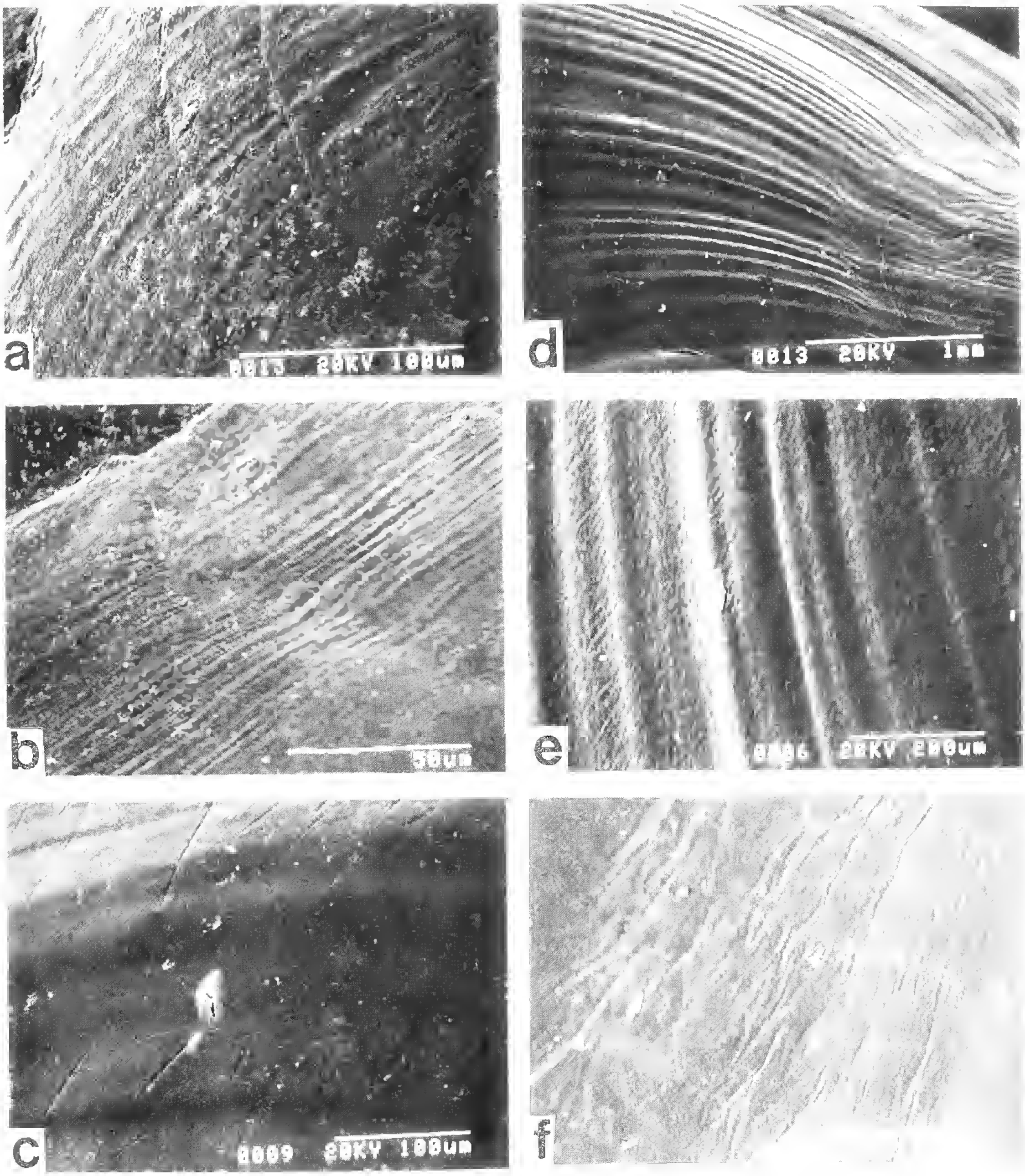


FIG. 4.Shell details of *Thularion semoni*. a-c, Mt Finnegan, NEQ, QMMO44296; d-f, Lorna Doone, NEQ, QMMO23769. a, spiral furrows on body whorl; b, protoconch sculpture; c, periostracal scratches on body whorl; d, radial growth ridges on body whorl; e, microsculpture on body whorl; f, radial periostracal wrinkles due to drying. Scale lines as marked.

REMARKS

Thularion semoni differs from species of *Fastosarion* and *Parmacochlea* in external anatomy, shell features and genitalia and appears to represent a level of semi-slug development intermediate between these two genera. For these reasons it has been given separate generic status.

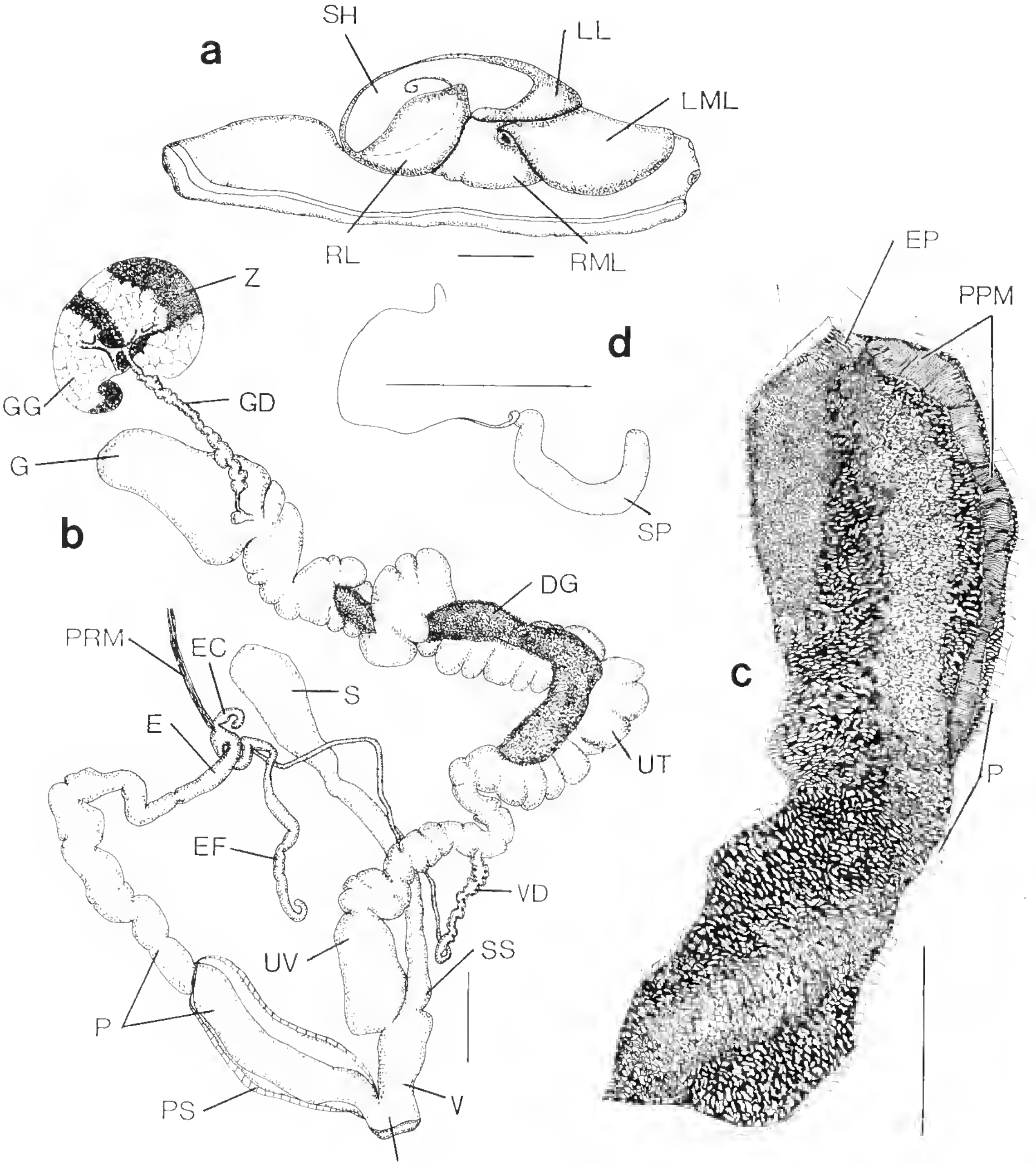


FIG. 5.Anatomy of *Thularion semoni*. a, Big Tableland, NEQ, QMMO14166; b-d, Lorna Doone, NEQ, QMMO23769. a, whole animal showing shell lappets and mantle lobes (body ornamentation not shown); b, reproductive system; c, penis interior; d, spermatophore. Scales lines = 5mm.

DISCUSSION

Establishing the identity of *T. semoni* provided an opportunity to study some features of the east coast semi-slug fauna. Although most species have a superficial similarity this gross resemblance overlays a complex evolutionary history.

Concentration of helicarionid semi-slugs in the coastal and subcoastal mountain ranges of eastern Australia is not accidental. These mountains are mostly volcanic and their eastern slopes lie in the

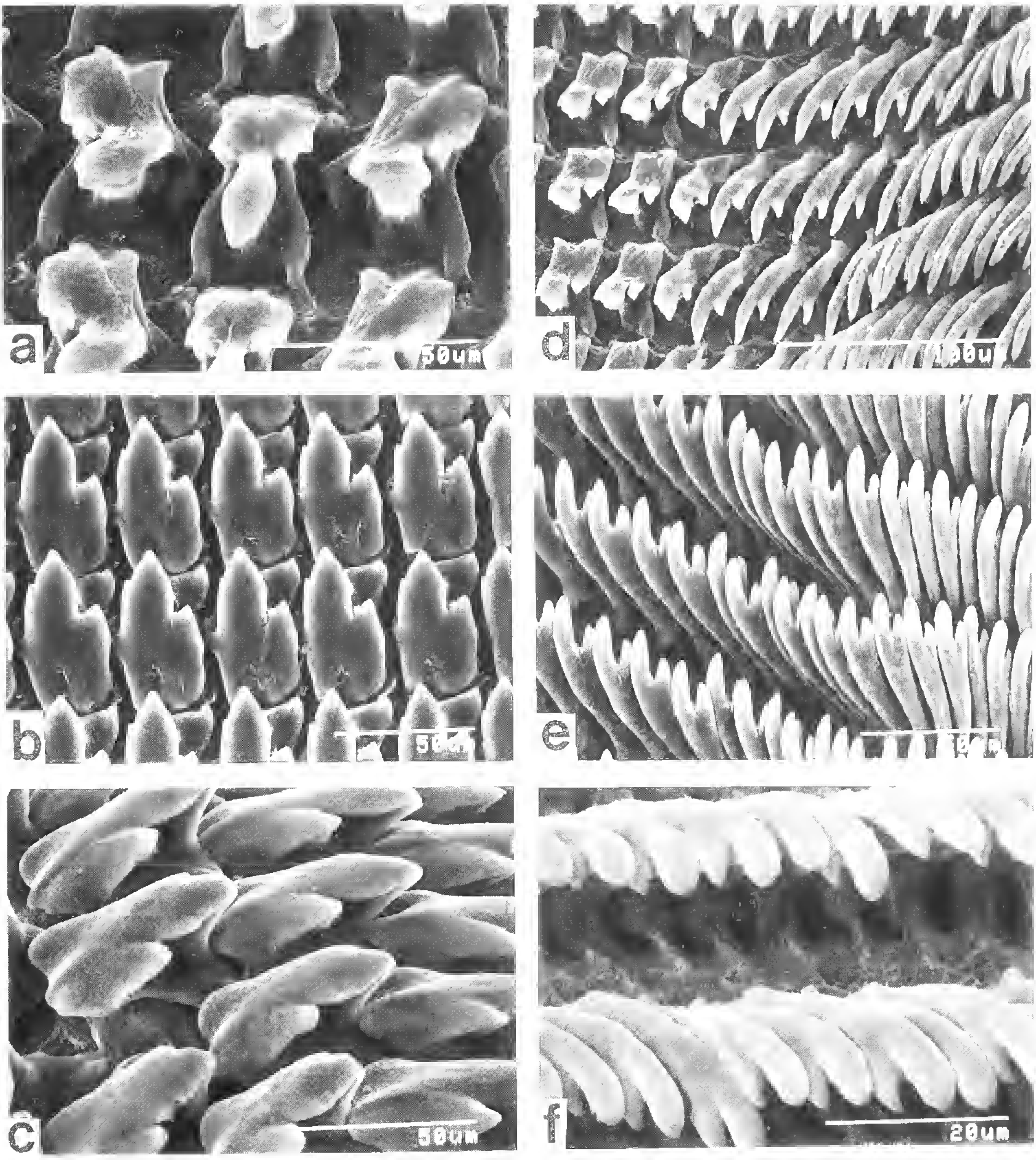


FIG. 6.Radular details of *Thularion semoni*, Lorna Doone, NEQ, QMMO23769. a, central and lateral teeth showing irregular anterior edge and elevated ridges on basal plates; b, laterals; c, laterals showing interrow support mechanism; d, laterals and marginals; e-f, marginals. Scale lines as marked.

path of prevailing winds which provide plentiful rain. The derived soils are acidic and there is relatively little calcium available for shell manufacture. Under these conditions the need for a shell to resist desiccation is reduced and the energy budget required to produce a shell is increased providing an ideal environment for slug evolution.

The Helicarionidae is considered a recent addition to the Australian land snail fauna having migrated from the Indo-Malayan area following collision of the Australian plate with the Sunda

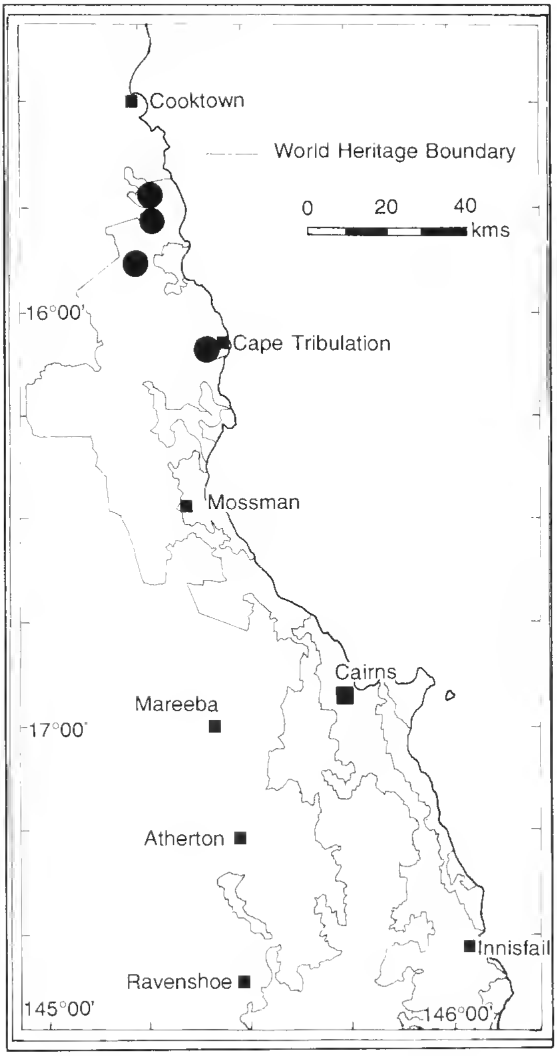


FIG. 7. Distribution of *Thularion semoni* (dots).

Island arc in the mid-Miocene (Bishop, 1981). The post-Miocene drying of the continent, which led to the retreat of mesic habitats elsewhere, would have been ameliorated along the east coast by the presence of elements of the Great Dividing Range. They maintained moist forests along their length and, most likely, provided a corridor for movement and colonisation of semi-slugs in eastern Australia. Drying events of the late Quaternary occurred in more rapid succession than those of the Miocene and Pliocene (Galloway and Kemp, 1981) and would have had severe impacts on moisture-sensitive animals such as semi-slugs. Many groups would have survived only in upland refugia and the present-day distribution patterns of *Mysticarion* (highlands of the Great Dividing Range from SEQ to central NSW) and '*Helicarion*' *australis* in the uplands of the Border Ranges, SEQ (alt>800m), are probable examples of the results of this climatic attrition.

The move to slugdom (limacization) has occurred more than once and probably in more than one way, and in the Wet Tropics region three distinct grades of semi-slug development are evident. These correlate with degrees of shell reduction - least in *Fastosarion* (relatively high whorl count, fully formed whorls, spire elevation) and greatest in *Parmacochlea* (very low whorl count, shell flat and plate-like). *Thularion* with a depressed shell that has a relatively low whorl count, incomplete internal whorls and a membranous base is intermediate between these extremes. Elsewhere along the east coast many semi-slugs e.g. *Helicarion* s.s. show the *Fastosarion* shell form but in the wetter parts of the eastern ranges (Border Ranges, SEQ; New England - Barrington Tops area, NSW; Clarke Range, MEQ) more extreme examples of shell reduction are evident.

The distribution and habitat of *Thularion semoni* indicate that the high mountains of the northern Wet Tropics were probably crucial in its survival, especially during more recent drying events (Kershaw, 1981). Compared with *Fastosarion brazieri*, which has been recorded from many upland (Atherton Tableland) and lowland localities in the Innisfail-Cairns area, *T. semoni* is known almost exclusively from upland and highland localities. The greater shell reduction in *T. semoni* and concommitantly greater area of exposed animal tissue (including expanded shell lappets and mantle lobes) makes this species potentially more sensitive to climatic fluctuation than *F. brazieri*. This provides an ecological basis for explaining not only its current distribution pattern but also past restrictions of the species. The role of montane refugia in Wet Tropics land snail biogeography has been previously highlighted for the Gondwanan family Charopidae (Stanisic, 1987). Their importance to 'modern' families highlights the significant effects of Late Tertiary climatic fluctuations on all east coast terrestrial molluscs.

The relationships of *Thularion* are problematic, due mainly to the lack of adequate revisionary studies on related taxa. The conchological and anatomical features of *Thularion* can be derived from the more generalised *Fastosarion* and it is probable that it is a localised derivative of a *Fastosarion* - like ancestor. Interestingly no *Fas-*

tosarion grade semi-slug is found north of the Daintree R., indicating that *Thularion* may have colonised this region in the absence of *Fastosarion*. The restriction of *T. semoni* to the northern part of the Wet Tropics again exposes the role of the Daintree R. as a possible barrier to land snail dispersal in the region (Stanisic, 1987). Whether or not *Parmacochlea* is a direct descendant of a *Thularion* - like ancestor or whether it is derived independently from a more generalised ancestor has yet to be determined.

ACKNOWLEDGEMENTS

I wish to thank Ron Kershaw (Queen Victoria Museum and Art Gallery, Launceston) for supplying essential notes on the Australian Helicarionidae which contributed to the success of this project.

I would also like to thank Kylie Williams (SEM illustrations); staff of the Queensland Museum Photographic Section; Darryl Potter for assistance with the preparation of illustrations; and Jennifer Mahoney and Vedette McGuire for typing the manuscript.

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DANIELLEILONA GEN.NOV., FROM THE WET TROPICS, NORTHEASTERN QUEENSLAND (PULMONATA:CHAROPIDAE)

JOHN STANISIC

Stanisic, J. 1993 12 24: *Danielleilona* gen.nov., from the Wet Tropics, northeastern Queensland (Pulmonata:Charopidae). *Memoirs of the Queensland Museum* 34(1):11-20 Brisbane. ISSN 0079-8835.

A new genus of charopid, *Danielleilona* gen.nov., is described from the summits of the high mountains in the Wet Tropics, NEQ. Two species, *D. marycolliverae* sp.nov. and *D. multicostata* sp. nov., occur in geographically proximate, yet isolated, mountain ranges south of Cairns. The distribution pattern is novel in relation to previously described charopids from the region and its biogeographic significance is discussed. The unusual conchological and anatomical features of the genus are related to other Australian charopids. ☐ *Pulmonata, Charopidae, Danielleilona, new genus, D. marycolliverae, D. multicostata, new species, systematics, biogeography, Wet Tropics.*

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Stanisic (1987) reviewed the status of the charopid genus *Oreokera* and briefly referred to the diversity of the Charopidae in the Wet Tropics. Traditionally this family has been regarded as having a temperate distribution with only a few species living in tropical Queensland (Iredale, 1937; Smith, 1984). Field work by staff of the Queensland Museum has revealed a significant number of species in both subtropical and tropical eastern Queensland (Stanisic, 1990).

Danielleilona gen.nov. includes two new, large species of Charopidae from the tops of high mountains south of Cairns, NEQ. These mountains are renowned for the restricted floral and faunal elements near their peaks (Monteith 1980). The two land snails are similarly restricted and add to knowledge of this area. This study examines the conchological and anatomical characters of *Danielleilona* and places them in a biogeographic context.

The following abbreviations are used: Q–Queensland; QM–Queensland Museum, Brisbane; AM– Australian Museum, Sydney; A–anus; DG– prostate; E– epiphallus; EC– epiphallic caecum; G–ovotestis; GD–hermaphroditic duct; GG–albumen gland; GT–talon; H–heart; HG–hindgut; HV–hindvein; I–intestine; K–kidney; KD–ureter; KX–ureteric pore; MC–mantle collar; P–penis; PC–penial caecum; PCP–penial caecum pore; PP–penial pilaster;PPM–main penial pilaster; PRM–penial retractor muscle; PS–penial sheath; S–spermatheca, SS–spermathecal stalk; UT–uterus; UV–free oviduct; V–vagina; VD–vas deferens; X–carrefour; Y–atrium; Z–digestive gland.

SYSTEMATICS

Family Charopidae

Danielleilona gen.nov.

ETYMOLOGY

For my eldest daughter Danielle Ilona

TYPE SPECIES

Danielleilona marycolliverae sp.nov.

DIAGNOSIS

Shell large, with about 4½ tightly coiled whorls, the last expanding more rapidly. Apex and spire flat to very slightly elevated. Apical whorls with low, rounded, rugosely sculptured spiral cords. Postnuclear sculpture of prominent, very strongly protractively sinuated, moderately crowded (*multicostata*) to widely spaced (*marycolliverae*), broad radial ribs; apices with radial riblets. Microsculpture of fine, crowded radials and spirals crossing in a regular lattice. Umbilicus deep, narrow U to V-shaped, margins rounded. Sutures strongly channelled. Lip simple with a prominent apertural sinus; aperture roundly lunate.

Genitalia with ovotestis consisting of two clumps of finger-like lobes oriented parallel to the plane of coiling. Talon with long, coiled shaft. Epiphallus partially enveloped in the penial sheath, with a short caecum and entering penis apically. Penis long with a lateral outpocket (*marycolliverae*) or a long muscular caecum (*multicostata*); internally with longitudinal pilasters; sheath present. Penial retractor muscle inserting on epiphallus at junction with penial sheath. Free oviduct long. Pallial cavity with complete sigmurethrous ureter. Kidney with large pericardial lobe and rectal lobe reduced to a vestige.

Radula (Fig. 8a-f) with long mesocone on tricuspid central and lateral teeth; marginal teeth almost bicuspid with endocone lengthened and minor ectoconal splitting.

COMPARISONS

Danielleilona has a number of features which clearly separate it from other genera of Charopidae occurring in the Wet Tropics. These include the large, almost discoidal, flammulated shell, the channelled sutures and apertural sinus together with penial diverticulum and sheath. *Oreokera* Stanisic, 1987, has a trochoid shell; *Biomphalopa* Stanisic, 1990, has a biconcave shell; *Setomedea* Hedley, 1924, has a depressed helicoid shell with periostracal hairs; *Hedleyoconcha* Pilsbry, 1893, has a whitish, trochoid shell; and '*Roblinella*' *intermedia* Odhner, 1917 is very small, with a monochrome brown shell. All lack channelled sutures and an apertural sinus. *Danielleilona* and *Oreokera* both have spirally sculptured protoconchs but this superficial similarity is not reflected in anatomy, in particular the difference in pallial structures. Unlike *Danielleilona*, *Oreokera* has an incomplete secondary ureter. *Oreokera* also shows a right angle orientation of the ovotestis, a feature common to few east coast charopids (Stanisic, 1990) and in contrast to the widespread, parallel condition also seen in *Danielleilona*. In addition, the optically observed similarity in apical spiral cords is shown to have structural inconsistency when viewed with the SEM. In *Oreokera* the spirals are much higher than wide and appear as periostracal additions to the protoconch whereas in *Danielleilona* they are low, wider than high, elevations of the protoconch surface.

Conchologically *Danielleilona* bears a striking resemblance to *Roblinella mathinnae* (Petterd, 1879) and to a lesser extent *Robinella curacoae* (Brazier, 1871) from Tasmania (Fig. 9a-f). Features which these species have in common with *Danielleilona* include coiling pattern, very strongly protractively sinuated radial ribs, channelled sutures, apertural sinus and spiral protoconch. No soft parts are available in collections to allow rigorous assessment of kinship.

Danielleilona marycolliverae sp.nov.
(Figs. 1-4)

ETYMOLOGY

Named for Mary Colliver in recognition of her voluntary contribution to the Queensland Museum Malacology Section.

COMPARISONS

D. marycolliverae differs from *D. multicostata* in having a shell with more widely spaced radials and larger umbilicus. Anatomically the short penial outpocket of *D. marycolliverae* contrasts with the long, muscular penial caecum of *D. multicostata*.

TYPE MATERIAL

HOLOTYPE: QMMO15803, Mt Bellenden Ker, NEQ. Summit TV Stn, 1560m, rainforest (17°16'S, 145°51'E), 29 Apr 1983, G.B. Monteith, D. Yeates. Height of shell 3.83mm, diameter 6.38mm, D/U ratio 4.69, H/D ratio 0.60, whorls 4½.

PARATYPES: NORTHEASTERN QUEENSLAND: Mt Bartle Frere, summit centre pk, ca 1540m, SMVFT (17°23'S, 145°48'E) (1 dead adult, QMMO16473, 7-8 Nov 1981); Mt Bartle Frere, summit north-west pk, 1440m (1 dead adult, AMC150086, 7 Oct 1980, G.B. & S.R. Monteith); Mt Bellenden Ker, summit, 1560m, SMVFT (1 live adult, QMMO11263, 25-31 Oct 1981, Earthwatch/QM); Mt Bartle Frere, summit north-west peak, 1440m, SMVFT (17°23'S, 145°48'E) (1 live adult, QMMO11419, 8 Nov 1981, Earthwatch/QM); Mt Bellenden Ker, summit, 1560m, SMVFT (4 live adults, QMMO16474, AMC150087, 17-24 Oct 1981, Earthwatch/QM); Mt Bellenden Ker, just below summit, approx. 1500m, under bark of rotting logs (6 live adults, QMMO14877, 4 Jul 1983, J. Stanisic, D. Potter).

OTHER MATERIAL: Mt Bellenden Ker, summit, 1560m, SMVFT (2 dead sub adults, QMMO11251, 17-24 Oct 1981, Earthwatch/QM); Mt Bartle Frere, summit centre peak, c.1540m, SMVFT (17°23'S, 145°48'E) (1 broken dead adult, QMMO11398, 7-8 Nov 1981, Earthwatch/QM); Mt Bellenden Ker, summit TV Stn, 1560m, SMVFT (17°16'S, 145°51'E) (1 dead adult, QMMO11893, 17-24 Oct 1981, Earthwatch/QM); Mt Bellenden Ker, summit centre peak, litter, (1 dead juvenile, QMMO16475, 9 Jun 1980, G.B. Monteith); Mt Bellenden Ker, summit TV Stn, 1560m, rainforest (17°16'S, 145°51'E) (1 broken dead sub adult, QMMO15806, 1-7 Nov 1981, Earthwatch/QM); Mt Bellenden Ker, summit TV Stn, 1560m, rainforest (1 specimen, QMMO16476, 29 Apr 1983, G.B. Monteith, D. Yeates).

DIAGNOSIS

Shell large (for family), 6.38-7.23mm (mean 6.64mm) in diameter, with 4½ tightly coiled whorls; body whorl expanding more rapidly.

FIG. 1.Shell of *Danielleilona marycolliverae* sp. nov. Mt Bellenden Ker, NEQ, QMMO15803, holotype. Scale line = 2mm.

Apex and spire flat, last whorl descending more rapidly. Height of shell 3.49-3.86mm (mean 3.71mm); H/D ratio 0.53-0.60 (mean 0.56). Protoconch (Fig. 1a) of 1¾ whorls, 850 µm in diameter at 1½ whorls. Apical sculpture (Fig. 2a-c) of 20-25 regularly spaced, rugosely sculptured, low, broad, spiral cords. Postnuclear sculpture (Fig. 2d-f) of very prominent, high, broadly rounded, rugosely and radially sculptured, strongly protractively sinuated radial ribs, 45-68 (mean 57) on the body whorl, without periostracal blades, with intertices 5-10 times their width. Ribs/mm 2.24-3.39 (mean 2.78). Microsculpture (Fig. 2e) of fine radial riblets, 15-30 between each pair of major ribs, crossed by fine, similarly spaced, spiral cords; microsculpture not reduced below the periphery and also continued onto the sides of the major radials. Umbilicus (Fig. 1b) narrow V-shaped, regularly decoiling, D/U ratio 4.30-4.81 (mean 4.62). Sutures channelled (Figs 1a, 2a); whorls rounded above and below the periphery (Fig. 1c). Colour yellowish-light brown with prominent, irregular, darker reddish-brown flammulations. Aperture roundly lunate. Lip simple, retracted at the parieto-palatal margin to form a deep, apertural sinus. Columella weakly reflected; parietal callus weak. Based on 4 measured adults (QMMO15803, QMMO16473, AMC150086, QMMO16474).

Foot and tail broad, bluntly rounded posteriorly. Body colour (in preservative) creamy white with no obvious markings on foot or neck region; irregular black pigmentation on pallial roof and apical whorls of visceral hump. Ommatophores black. Mantle collar well developed, without mantle gland. Pallial region (Fig. 3f) about ½ whorl apically; kidney twice as long as broad, with prominent pericardial lobe and vestigial rectal lobe. Ureter sigmurethrous with complete secondary ureter and widely diverging arms.

Ovotestis (Fig. 3e) two clumps of finger-like lobes embedded in the apical whorls of the digestive gland and oriented parallel to the plane of coiling. Talon (Fig. 3c) with long coiled stalk, embedded in the albumen gland. Prostate-uterus typical. Vas deferens a thin tube entering epiphallus apically. Epiphallus, thick, muscular, reflexed, partially enveloped in penial sheath; with a small diverticulum at flexure; entering penis apically through a simple pore; internally, ascending branch with longitudinal pilasters, descending branch with small pustules. Penis (Fig. 3b,d) large, sub-cylindrical, with a sub-apical outpocket containing a terminal, pocket-like, fleshy pilaster and central, longitudinal pilaster which continues into the penis proper. Penis interior (Fig. 3b) with main corrugated longitudinal pilaster and many secondary, low, longitudinal thickenings. Free oviduct longer than vagina. Vagina short, internally with simple longitudinal thickenings. Spermatheca typical. Based on four dissected specimens (QMMO14877, QMMO-11419, QMMO16474).

Range and Habitat

Known only from the summits of Mt Bellenden Ker and Mt Bartle Frere (Fig. 4) in the Bellenden Ker Ra., in simple microphyll vine-fern thickets and forests. Collected above the ground under the bark of rotting logs suggesting semi-arboreality.

Remarks

D. marycolliverae has been collected

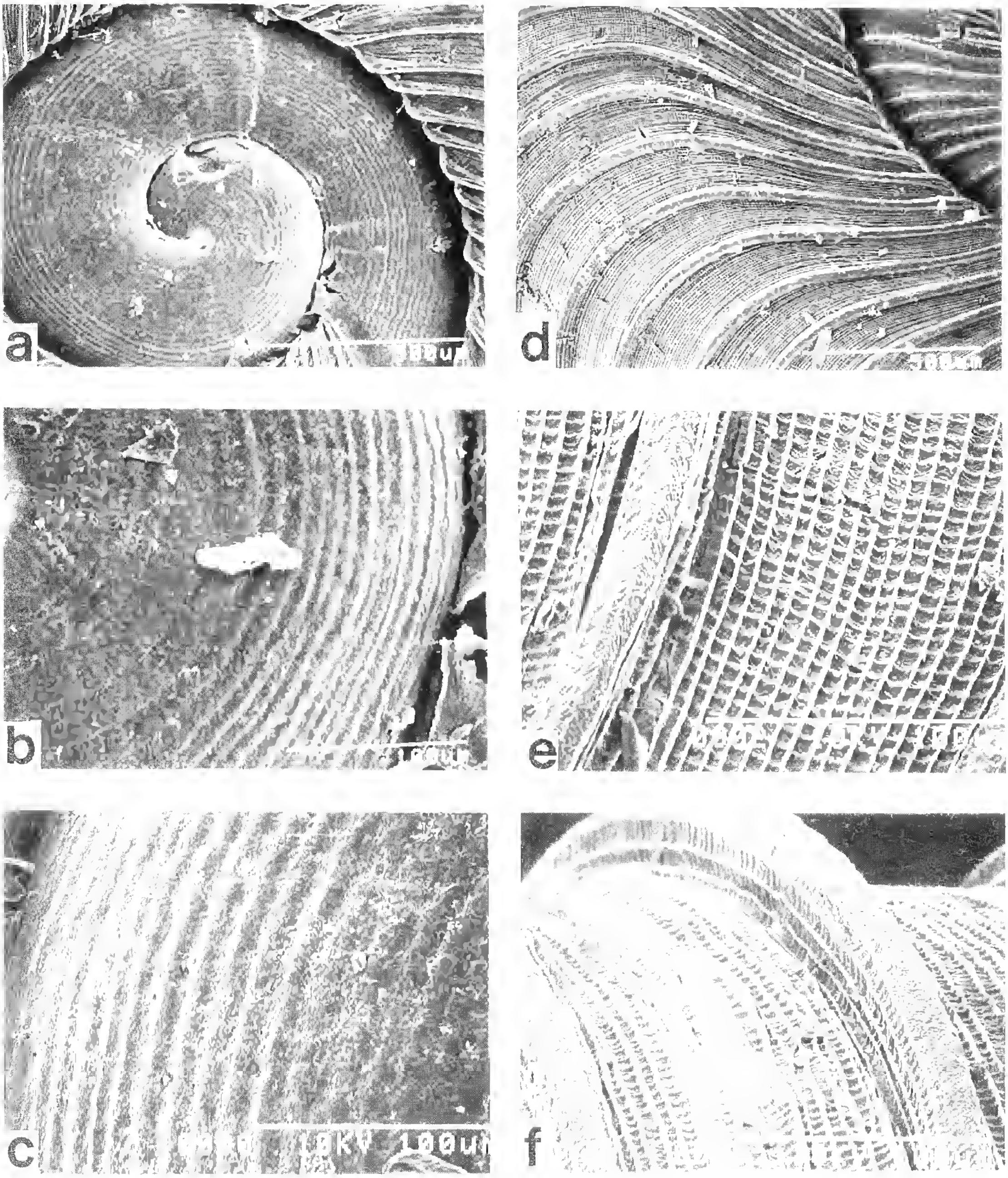

FIG. 2. Shell features of *Danielleilona marycolliverae* sp. nov. Mt Bellenden Ker, NEQ, QMMO16476, paratype. a, protoconch showing channelled suture; b-c, details of protoconch sculpture; d, postnuclear sculpture; e-f; details of postnuclear microsculpture and major rib structure. Scale lines as marked.

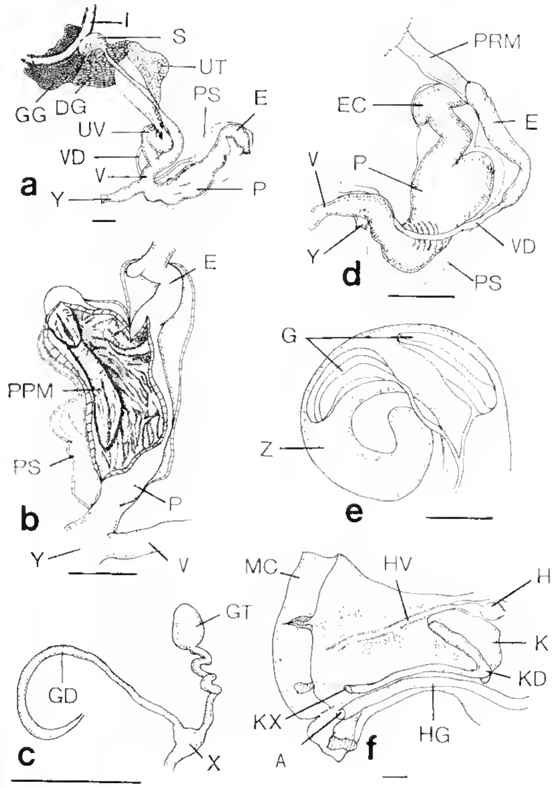

FIG. 3.Anatomy of *Danielleilona marycolliverae* sp. nov. Mt Bellenden Ker, NEQ, QMMO14877, paratype. a, reproductive system; b, penis interior; c, details of talon and carrefour region; d, penis; e, ovotestis; f, pallial cavity. Scale lines = 1mm.

microsympatrically with *Oreokera cumulus* (Odhner, 1917) on Mt Bellenden Ker (QMMO-14877).

Danielleilona multicostata sp.nov.
(Figs. 4-8)

ETYMOLOGY

From the Latin *multi* -, many; *costa* - rib; referring to the adult sculpture of crowded, radial ribs.

COMPARISONS

D. multicostata bears an overall similarity to *D. marycolliverae* but is marginally smaller with narrower umbilicus, and has more crowded ribs on the body whorl (Figs. 1, 5).

TYPE MATERIAL

HOLOTYPE: QMMO33817, North Bell Pk, Malbon Thompson Ra., NEQ, 800-900m (17°05'S, 145°53'E). 19-22 Nov 1990, G.B. Monteith, G. Thompson. Height of shell 3.78mm, diameter 5.71mm, D/U ratio 6.80, H/D ratio 0.66, whorls $4\frac{3}{8}$-.

PARATYPES: North Bell Pk, 20km S Cairns, NEQ, 900-1000m (2 dead adults, 1 dead sub-adult, QMMO15490, 15-16 Sept 1981, G.B. Monteith, D. Cook).

DIAGNOSIS

Shell large (for family), 5.71-5.96mm (mean 5.88mm) in diameter with $4\frac{1}{4}$-$4\frac{5}{8}$- (mean $4\frac{1}{4}$+) tightly coiled whorls; body whorl expanding more rapidly. Apex and spire flat, last whorl descending rapidly in front. Height of shell 3.49-3.78mm (mean 3.61mm); H/D ratio 0.59-0.66 (mean 0.62). Protoconch (Fig. 6a) of $1\frac{3}{4}$ whorls, 850µm in diameter at $1\frac{1}{2}$ whorls. Apical sculpture of 18-22 regularly spaced, rugose, spiral cords. Postnuclear sculpture of prominent,

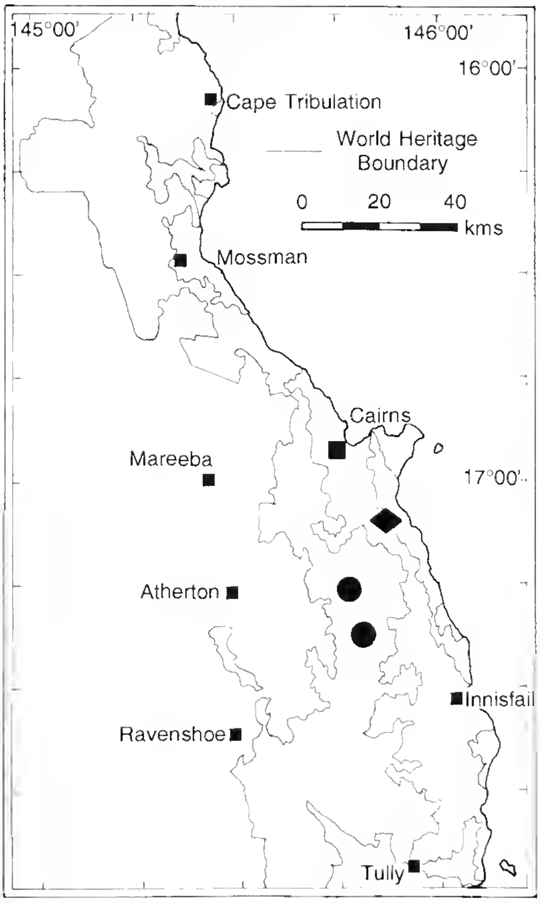

FIG. 4.Distribution of *Danielleilona marycolliverae* sp. nov. (dots) and *D. multicostata* sp. nov. (diamond) in the Wet Tropics region.

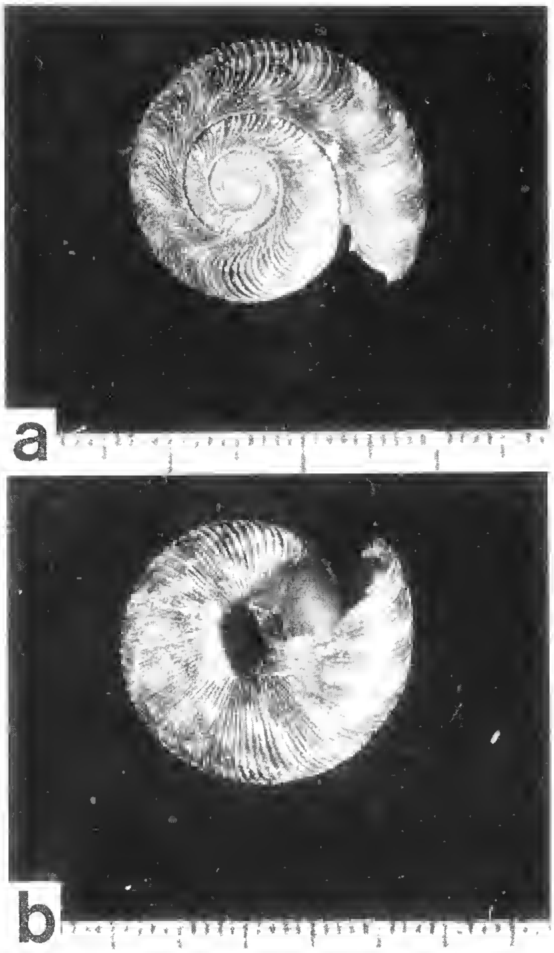

FIG. 5.Shell of *Danielleilona multicostata* sp. nov. North Bell Peak, NEQ, QMMO33817, holotype. Scale in mm.

crowded, strongly protractively sinuated, radial ribs, 93-108 (mean 101) on the body whorl, with interstices 5-7 times their width. Ribs/mm 5.18-5.77 (mean 5.47). Microsculpture of fine radial riblets, 12-20 between each pair of major ribs, crossed by fine spiral cords to form a reticulate pattern; sculpture continuous on base. Microsculpture (Fig. 6b) continuous on sides of major radials. Umbilicus (Fig. 5b) very narrow, U-shaped, barely decoiling. D/U ratio 5.38-6.80 (mean 6.00). Sutures channelled; whorls rounded above and below the periphery. Colour light yellow-brown with irregular, darker, brown suffusions. Aperture roundly lunate. Lip simple, retracted at the parieto-palatal margin to form a conspicuous apertural sinus. Columella slightly reflected over the umbilicus. Parietal callus present. Based on 3 measured adults (QMMO-33817, QMMO15490).

External animal features similar to *D. marycolliverae*. Pallial cavity with typical kidney and complete sigmurethrous ureter. Apical genitalia not studied. Terminal genitalia (Fig. 7a) similar to that of *D. marycolliverae* except for penis morphology. Penis (Fig. 7b) with long, muscular caecum; internally with simple, low longitudinal pilasters. Penial caecum entering penis subapically about ⅓ of the way down through a muscularised pore. Penis sheath present.

Radula (Fig. 8a-f) with tricuspid central and lateral teeth; marginals multicuspid with enlarged endocone, ectocone split into minor cusps.

Based on one dissected specimen (QMMO-33817).

RANGE AND HABITAT

Known only from 4 specimens collected from the top of North Bell Pk on the Malbon Thompson Ra., NEQ (Fig. 4), in simple microphyll vine- fern forest. No microhabitat data is available.

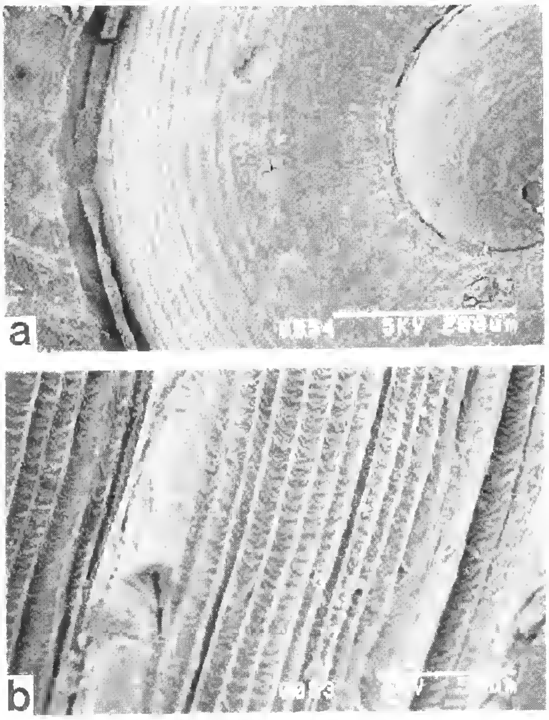

FIG. 6.Shell sculpture of *Danielleilona multicostata* sp. nov. North Bell Peak, NEQ, QMMO15490, paratype. a, apical sculpture; b, postnuclear microsculpture. Scale lines as marked.

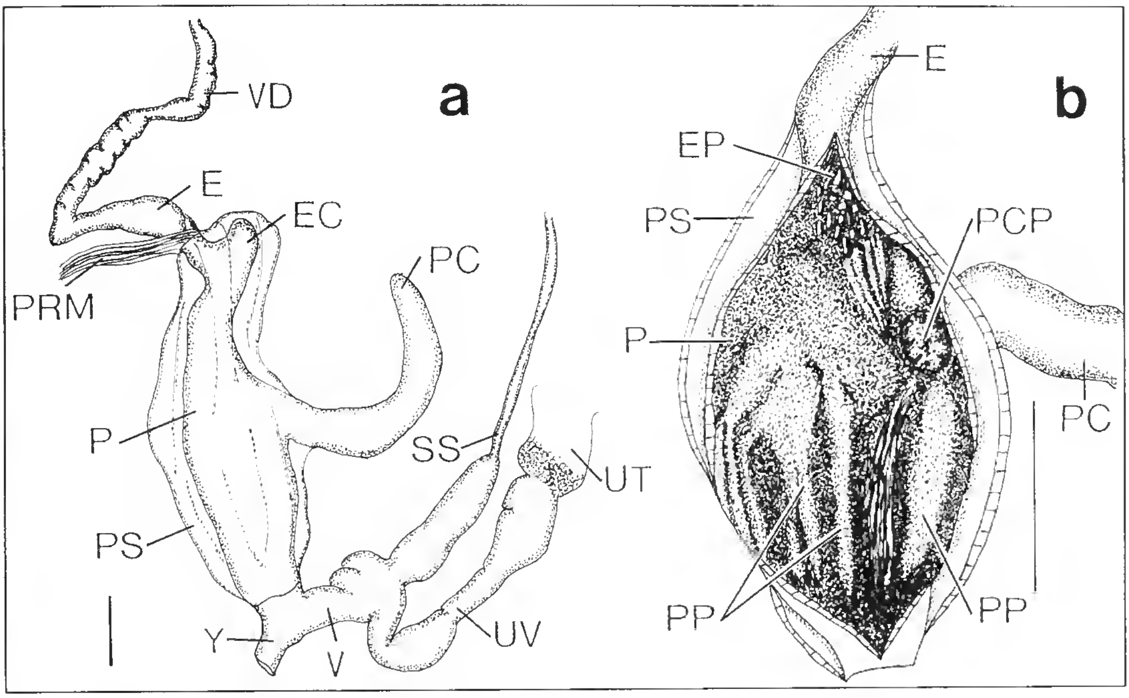

FIG. 7.Anatomy of *Danielleilona multicostata* sp. nov. North Bell Peak, NEQ, QMMO33817, holotype. a, terminal genitalia; b, penis interior. Scale lines = 1mm.

REMARKS

Although this species is known from very limited material, shell and anatomical characters readily separate it from *D. marycolliverae*.

DISCUSSION

The discovery of *Danielleilona* highlights the unusual nature of the mountain top communities in tropical northeastern Queensland. Previously, Stanisic (1987, 1990) provided examples of land snails from these environments which displayed both narrow and widely disjunct generic distributions. This is the first example involving the Bellenden Ker and Malbon Thompson Ranges. Summits of their higher peaks are characterised by the occurrence of simple microphyll vine-fern forest (SMVFF). This grades into thicket (SMVFT) on the higher mountains of the Bellenden Ker Ra. Presumably these cool moist, largely temperate mountain top communities would have had a more widespread distribution involving the lowlands in cooler, wetter times. Climatic change, particularly in the Plio-Pleistocene, had a dramatic impact on 'temperate' communities (Galloway & Kemp, 1981) leading to their present-day restriction in the north. Temperate communities remained only on those peaks with the high altitudes necessary to preserve them, and extinctions undoubtedly occurred on lower peaks.

A key ingredient in the survival of *Danielleilona* appears to be the presence of SMVFF on the Bellenden Ker and Malbon Thompson Ranges. However the absence of SMVFT from the latter could be the crucial factor in the disparate distribution of *Oreokera* Stanisic, 1987, which is sympatric with *Danielleilona* in the Bellenden Ker Ra., but missing from the Malbon Thompson Ra. The morphological gap between species of *Danielleilona* is greater than that recorded for species of *Oreokera* which may indicate a more stringent environmental and climatic selection regime on North Bell Pk montane communities.

Some species of Charopidae, (e.g. *Setomedea monteithi* Stanisic, 1990), are found in the warm humid mesophyll vine forests of the lowlands and foothills of the Wet Tropics, but most are confined to the uplands and highlands. Those now found in lower areas also would probably have depended on montane refugia for survival in the past, but have been able to disperse rapidly in recent times (Stanisic, 1990). Significantly, *Setomedea* has species in central and southern Queensland, indicating wide environmental

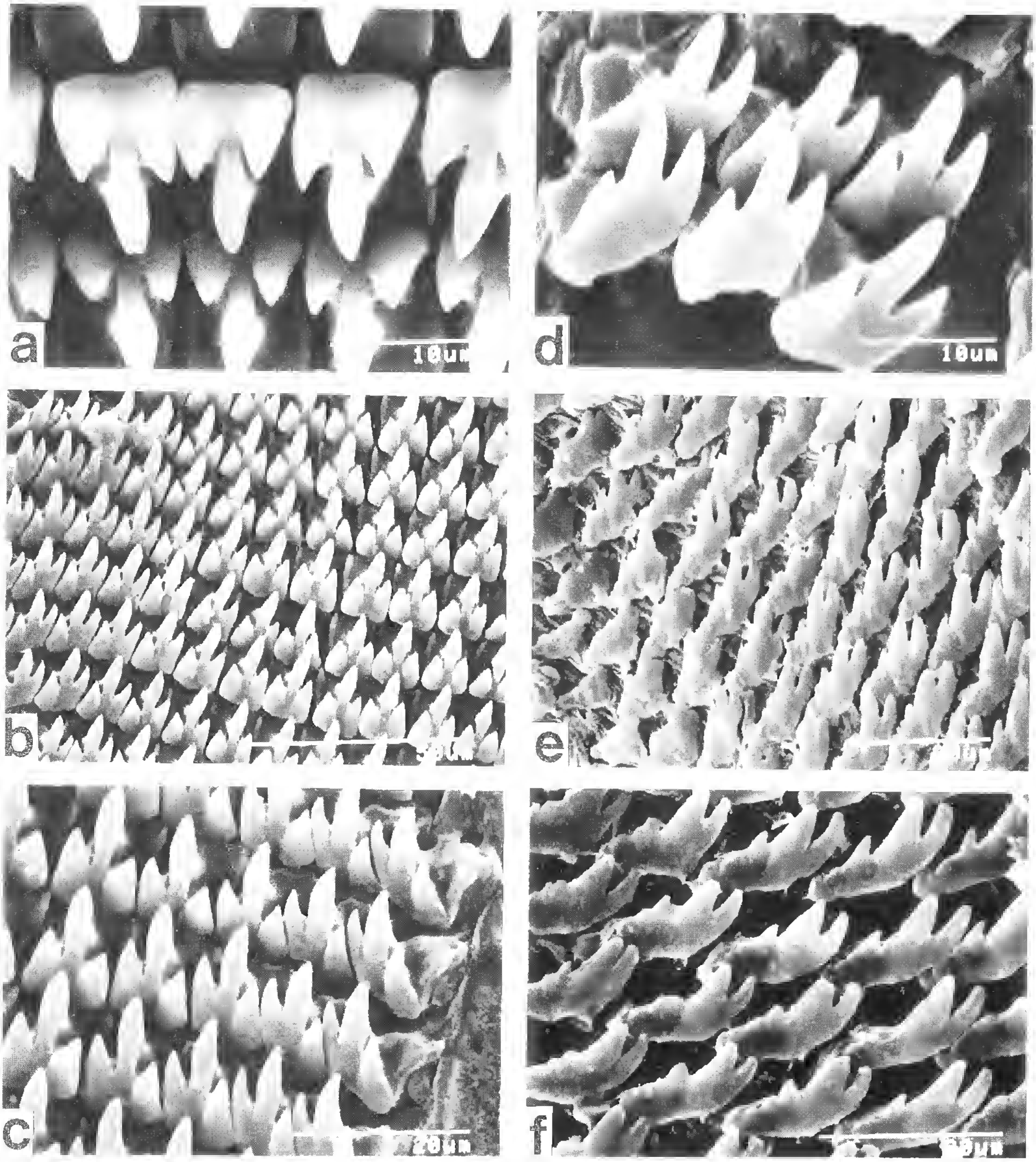

FIG. 8.Radula of *Danielleilona multicostata* sp. nov. North Bell Peak, NEQ, QMMO33817, holotype. a, central and inner lateral teeth; b, laterals and lateromarginals; c, lateromarginals showing squarish basal plate; d, laterals and first lateromarginal showing ectoconal reduction; e-f, lateromarginals and marginals showing ectoconal reduction and ectoconal splitting. Scale lines as marked.

tolerance. The specialised microhabitat of *Danielleilona* (semi-arboreal) probably reflects a higher degree of environmental sensitivity than for generalist 'under-the-log'-dwelling species such as *Setomedea*.

Danielleilona displays a suite of conchological and anatomical characters which place it outside the mainstream of charopid evolution in tropical and subtropical eastern Queensland. The large shell with channelled sutures, apertural sinus and very strongly, protractively sinuated radial ribs,

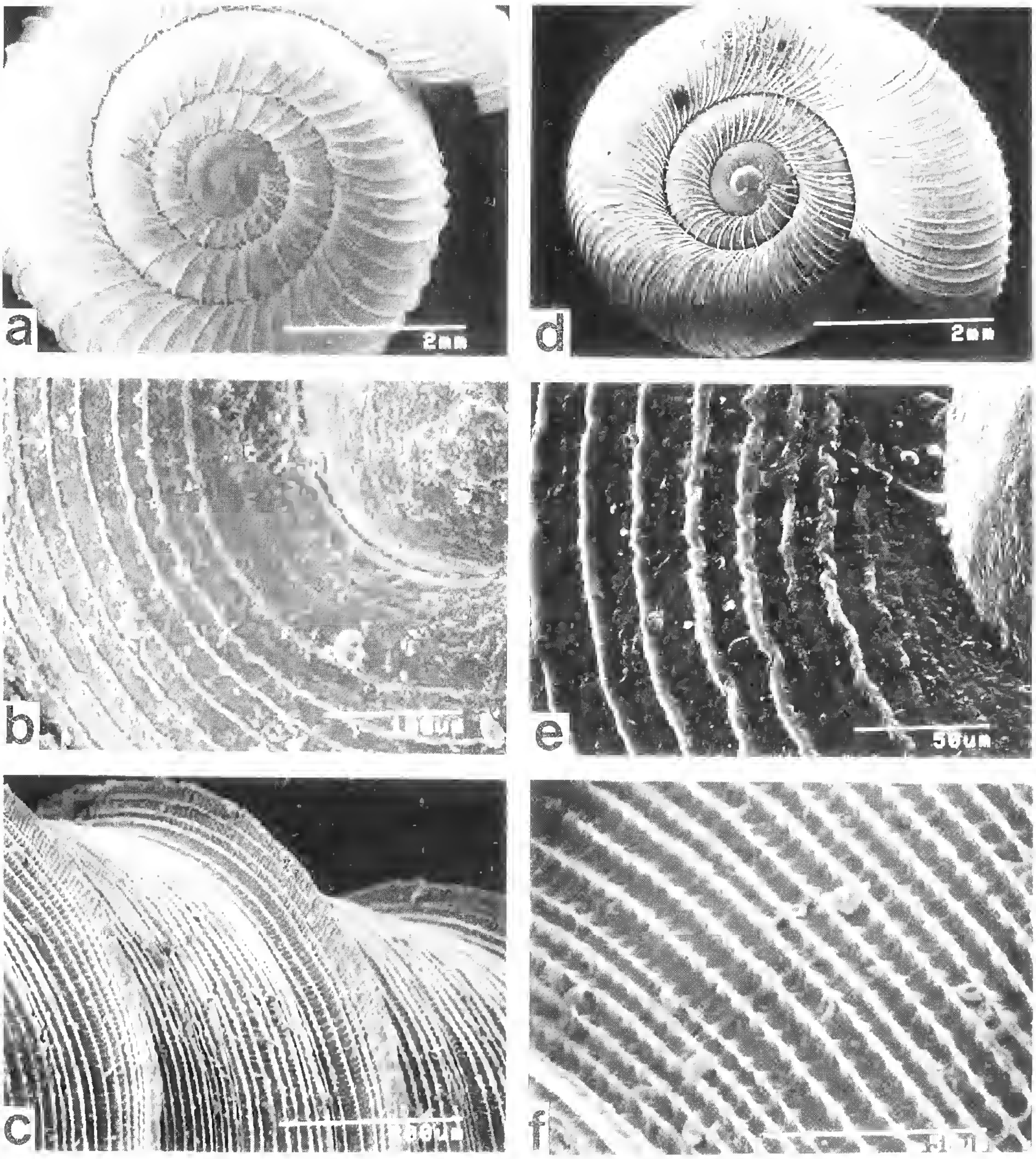

FIG. 9.a-c, *Roblinella mathinnae* (Petterd, 1879). Tasmania, AMC103794. a, shell; b, protoconch sculpture; c, postnuclear sculpture. d-f, *Roblinella curacoae* (Brazier, 1871). Tasmania, AMC103518. d, shell; e, protoconch sculpture; f, postnuclear microsculpture. Scale lines as marked.

together with the penial sheath and penial diverticulum are major differentiating features.

The occurrence of a number of very similar shell features in Tasmanian taxa (Fig. 9a-f) may have important biogeographic implications. Southern relationships have been demonstrated in a number of Wet Tropics charopid genera by Stanisic (1990), but a Tasmanian connection would span a geographic gap shared by plants (*Orites*), the Peloridiidae (moss bugs) and the stag-beetle genus *Lissapterus*. These are all 'antarctic' relicts (Monteith, 1980) occurring in montane refugia in subtropical and tropical areas.

Stanisic (1990) showed that protoconch sculpture and adult microsculpture were useful shell characters for indicating relationships among the Charopidae. A spirally lirate protoconch is rare in tropical and subtropical Australian species. Most have radially ribbed or reticulate protoconchs. The presence of spirally lirate protoconchs (Fig. 9b,c) and similar shell microsculpture (Fig. 9c,f) in *R. mathinnae* and *R. curacoae* may not be sufficient to indicate possible relationships. However, combined with the co-occurrence of an apertural sinus, strongly protractively sinuated radial ribs and channelled sutures (Fig. 9a,d) there is a tantalising prospect that these taxa are more closely related than they are to others in the family.

ACKNOWLEDGEMENTS

Part of the material was collected on fieldwork sponsored by the Earthwatch organisation. This support is gratefully acknowledged, as are the collecting efforts of Dr Geoff Monteith, Queensland Museum and his many co-workers. Thanks are due also to Kylie Williams, for the excellent SEM illustrations which were processed by the Queensland Museum's Photography Section; Darryl Potter, who assisted with preparation of illustrations; and Jennifer Mahoney and Vedette McGuire, who typed the manuscript.

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LENWEBBIA PALUMA SP. NOV., FROM THE WET TROPICS, NORTHEASTERN QUEENSLAND (PULMONATA: CHAROPIDAE)

JOHN STANISIC

Stanisic, J. 1993 12 24:*Lenwebbia paluma* sp. nov., from the Wet Tropics, northeastern Queensland (Pulmonata: Charopidae). *Memoirs of the Queensland Museum* 34(1): 21-26. Brisbane. ISSN 0079-8835.

A new species of charopid, *Lenwebbia paluma* sp. nov., is described from the Paluma Range, in the south of the Wet Tropics, NEQ. This discovery establishes a widely disjunct north-south distribution for the genus. The biogeographic significance of this pattern is discussed in relation to rainforest evolution and the specific microhabitat preference of the species. ☐ *Charopidae, Lenwebbia paluma, systematics, biogeography, Wet Tropics.*

John Stanisic, Queensland Museum, PO Box 3300, South Brisbane, Queensland 4101, Australia; 10 November, 1993.

The charopid fauna of the Wet Tropics, NEQ, is poorly known. Only six species have been described (Odhner, 1917; Hedley, 1924; Stanisic, 1987, 1990). Their small size and limited vagility, and relatively large numbers in eastern Australia make them a potentially powerful tool in biogeography. Stanisic (1987, 1990) has highlighted a number of unusual aspects of the distributions and relationships of several Wet Tropics charopids.

The discovery of a new species of *Lenwebbia* from Mt Spec in the Paluma Range, NEQ, provides an additional opportunity to examine charopid distribution patterns in relation to the evolution of mesic communities in eastern Australia.

The following abbreviations have been used in the text: NEQ, northeastern Queensland; QM, Queensland Museum.

SYSTEMATICS

Family Charopidae

Lenwebbia Stanisic, 1990

Lenwebbia Stanisic, 1990, p.52.

TYPE SPECIES

Lenwebbia protoscrobiculata Stanisic, 1990, by original designation.

REMARKS

Lenwebbia is a distinctive genus of charopid characterised by its greatly reduced shell sculpture, and is unlikely to be confused with other northeastern Queensland members of the family. It could be mistaken for some of the Wet Tropics Helicarionidae, such as *Tarocystis* Iredale, 1937, and *Expocystis* Iredale, 1937, which also have macroscopically featureless shells. However, these genera differ microscopically from *Lenwebbia* in having incised spirals on the protoconch and notched incised grooves on the postnuclear whorls. They also lack the impressed sutures of *Lenwebbia*. The features of *L. paluma* sp. nov. are consistent with the generic diagnosis given by Stanisic (1990).

Lenwebbia paluma sp. nov.
(Figs. 1-4)

ETYMOLOGY

For the type locality, Paluma, NEQ.

COMPARATIVE REMARKS

The shell of *L. paluma* is grossly similar to that of *L. protoscrobiculata* Stanisic, 1990, from southeastern Queensland. Differences in *L. paluma* include a smaller umbilicus (D/U ratio 10.5-14.9 compared with 5.34-5.62 for *protoscrobiculata*) and finer microsculpture that does not include spiral grooves. The shell of *L. paluma* is also slightly smaller and flatter, due mainly to a smaller body whorl width. Anatomically, the unequal length of the penial pilasters in *L. paluma* contrasts with the condition in *L. protoscrobiculata* (Stanisic, 1990, Fig. 30b).

TYPE MATERIAL

HOLOTYPE: QMMO43311, Mt Spec NP, c. 0.5k E Paluma, NEQ (19°01'S, 146°13'E), rainforest, 800m, under bark of trees. Collected by J. Stanisic, D. Potter, 6 May, 1990. Height of shell 2.68mm, diameter 4.30mm, H/D ratio 0.61, D/U ratio 14.6, whorls 4⅛.

PARATYPES: 2 adults, 5 subadults, QMMO29085, same collection data as holotype.

DIAGNOSIS

Shell (Fig. 1a,b) small, glossy, turbinate, diameter 4.30-4.47mm (mean 4.38mm) with 4⅛ evenly coiled whorls, the last descending slowly in front. Apex and spire moderately elevated, SP/BWW ratio 0.29-0.44 (mean 0.38), height 2.68-3.06mm (mean 2.82mm). H/D ratio 0.61-0.69 (mean 0.64). Body whorl width 1.45-1.53mm. Apical sculpture (Fig. 2a) of crowded dimples. Protoconch of 1½ whorls, mean diameter 939µm. Post-nuclear sculpture (Fig. 2b-d) of weak radial growth ridges, fine crowded threadlike radial ridgelets and irregular spiral cords; sculpture reduced on the base. Umbilicus (Fig. 1b) very narrow, partially covered by reflection of the columella, diameter 0.31-0.41mm (mean 0.38mm), D/U ratio 10.5-14.9 (mean 13.3). Sutures impressed. Whorls rounded above and below the periphery. Lip simple, columella dilated. Parietal callus prominent. Colour brown. Based on three measured adults (QMMO29085, QMMO43311).

Animal colour (in life) grey, becoming darker on the mantle collar, neck, top of foot and in the region between the pedal grooves. Foot short and broad. Pallial cavity (Fig. 3c) with well developed mantle collar (MC) and prominent mantle gland (MG). Pallial roof with black speckling. Kidney (K) subtriangular, orangy-brown with an incomplete sigmurethrous ureter (KD). Ureteric pore (KX) situated in the angle between the kidney and the rectum (HG). Hindvein (HV) prominent. Genitalia (Fig. 3a) with enlarged albumen gland (GG). Ovotestis (Fig. 3b, G) consisting of several white clumps of alveoli located in the apical whorls of the digestive gland (Z) and oriented at right angles to the plane of coiling. Epiphallus (E) short, stout, entering penis apically through two fleshy lips (EP). Penis (P) cylindrical, tapering toward atrium (Y), internally (Fig. 3d) with a large fleshy longitudinal pilaster and a shorter, apical, secondary pilaster (PP). Vagina (V) short. Free oviduct (UV) long. Spermatheca (S) typical, stalk (SS) long. Radula with tricuspid central and lateral teeth (Fig. 2e) in which the mesocone is long and lanceolate; anterior flare present. Marginal teeth (Fig. 2f) multicuspid with endocone and ectocone split into several minor cusps. Basal plates squarish, with a central ridge that articulates with the anterior flare of the tooth behind. Based on two dissected specimens (QMMO-29085).

FIG. 1.Shell of *Lenwebbia paluma* sp.nov. Mt Spec NP, 0.5km E Paluma, NEQ, QMMO43311, holotype. Scale line = 3mm.

RANGE AND HABITAT

Known from only the type locality near Paluma, NEQ (Fig. 4). Cooler peaks of this area support rainforest in contrast to the drier eucalypt forest of the foothills. The peaks are not high when compared with mountains of the Wet Tropics, and the altitudinal stratification of rainforest communities is less pronounced. Upper reaches support simple notophyll vine forest which grades into mesophyll vine forest in warmer sheltered gullies. *L. paluma* lives under the bark of standing live or dead trees.

REMARKS

L. paluma has a specialised microhabitat compared with most eastern Australian charopids (including *L. protoscrobiculata*) which live under logs. The flatter shell (when compared with *L. protoscrobiculata*) is probably an adaption for this lifestyle. This selective microhabitat may account for the comparative rarity of the species in collections. However, considerable collecting effort in the moister parts of the Wet Tropics, north of the Herbert R., makes it unlikely that the genus has representatives in those forests. Conversely its presence in areas such as the Seaview Ra., Bakers Blue Mtn and Bluewater Ra. cannot be discounted until additional collecting is undertaken.

DISCUSSION

The north-south, widely disjunct distribution of *Lenwebbia* has parallels among other charopid genera (*Setomedea* Iredale, 1941; *Hedleyoconcha* Pilsbry, 1893; *Biomphalopa* Stanisic, 1990). All have species in the Wet Tropics with nearest relatives either in mideastern or southeastern Queensland. However, in contrast to *Lenwebbia*, their northern representatives occur in the northern, moister parts of the Wet Tropics, between

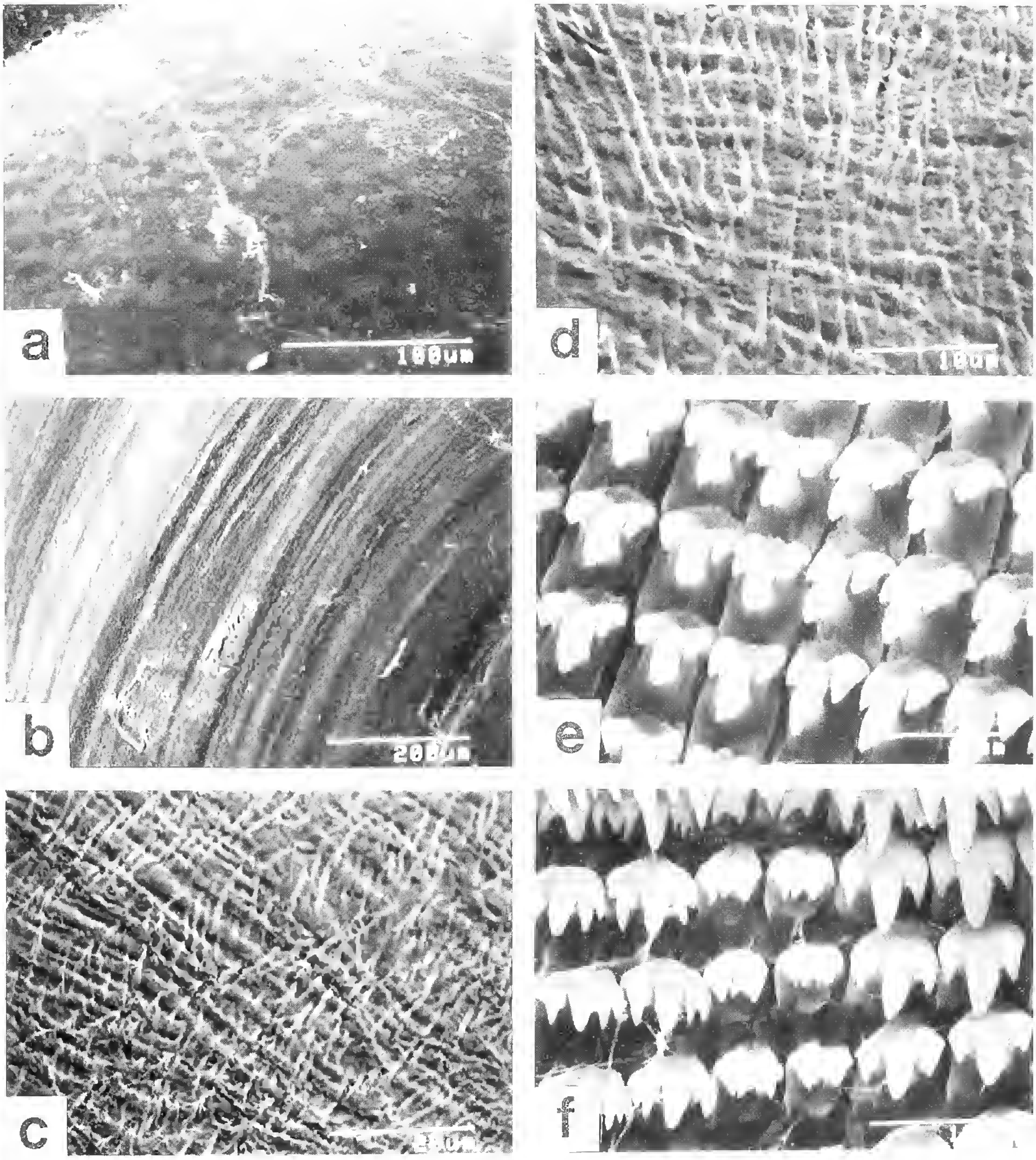

FIG. 2. Shell and radular details of *Lenwebbia paluma* sp.nov. Mt Spec NP, 0.5km E Paluma, NEQ, QMMO29085, paratype. a, protoconch sculpture; b, adult sculpture; c-d, post nuclear microsculpture; e, central and inner lateral teeth; f, marginal teeth (note malformation). Scale lines as marked.

Ingham and Cooktown, NEQ. The restriction of *L. paluma* to the southern, drier end is unusual in this context.

The Paluma Ra. is a southern outlier of the main Wet Tropics rainforest massif. It is wetter than the more northerly Seaview Ra. because of its greater altitude and closer proximity to the sea, and higher areas have a mean annual rainfall greater than 2000mm. The main vegetation type is simple notophyll vine forest on the summits and mesophyll vine forest at lower elevations (Nix, 1991). The 'temperate' summit communities

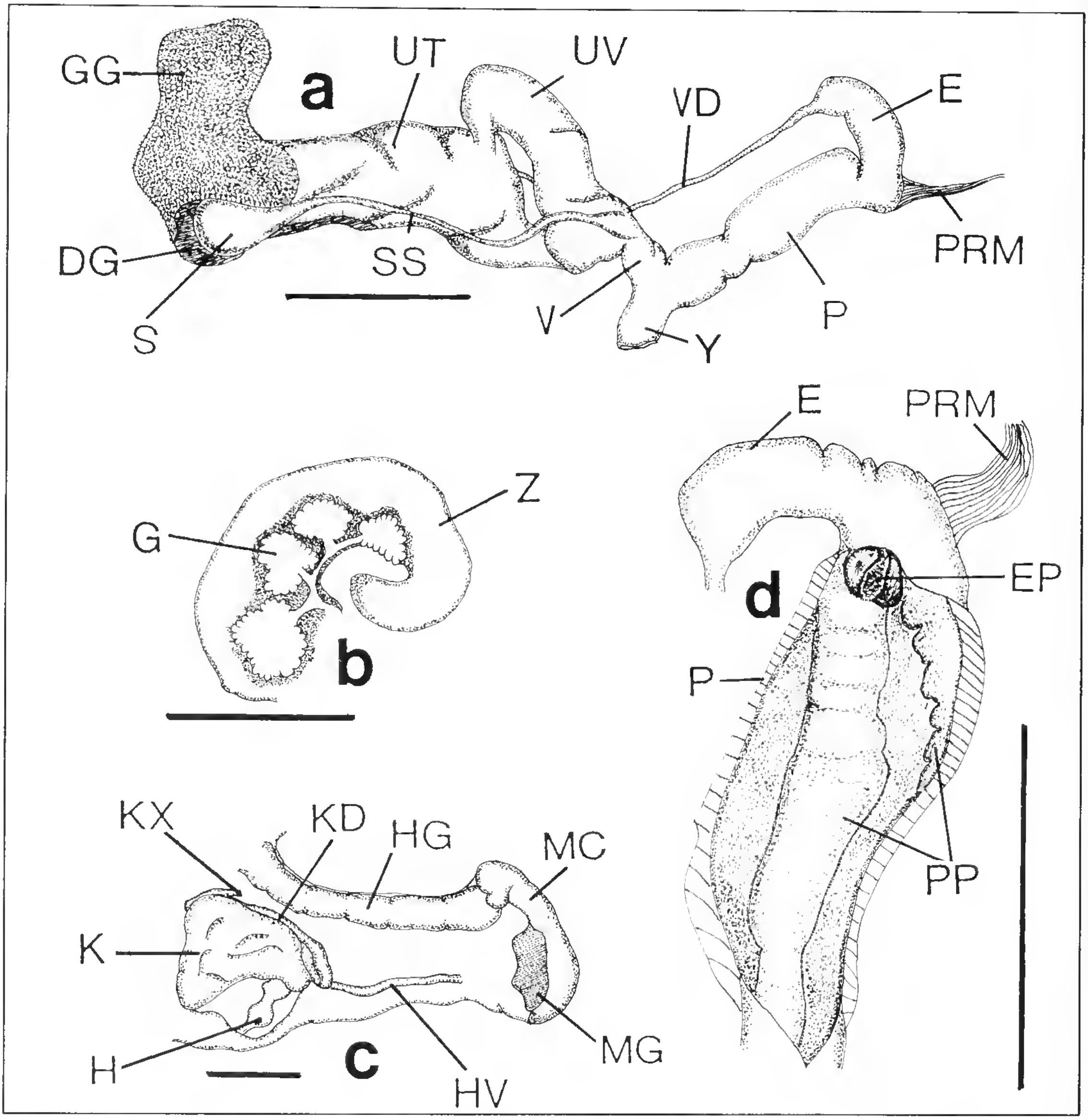

FIG. 3. Anatomy of *Lenwebbia paluma* sp.nov. Mt Spec N.P., 0.5k E Paluma, NEQ. QMMO29085, paratype. a, reproductive system; b, ovotestis; c, pallial structures; d, penis interior. Scale lines = 1mm.

found on mountains further north are absent and Nix (1991) considered that the southern outliers of the Wet Tropics would not have provided significant refuges during the last glacial.

Rainforest in eastern Australia experienced its major retreat in the Pliocene when plant genera such as *Eucalyptus* gained ascendancy and occupied the drier areas vacated by rainforest vegetation (Galloway & Kemp 1981). Major north-south disjunctions evident today in eastern Australian biota probably date from this epoch. The establishment of the Fitzroy and Burdekin dry corridors (Nix, 1991) fragmented populations of formerly widespread mesic communities. Land snails would have suffered considerable range attrition during the drying of the late Tertiary and Quaternary because of their extreme moisture sensitivity and low vagility. In the Wet Tropics region, temperate and subtropical communities were isolated in upland refugia and, in spite of Holocene 'wet-phases' (Kershaw & Nix, 1988), did not re-emerge because of potent bioclimatic barriers operating at lower elevations (Nix, 1991). *Lenwebbia* is a significant element of these environmentally-cornered assemblages and the restriction of *Lenwebbia* in the north is inextricably linked with the fragmentation and reduction of rainforest communities since the mid-Miocene.

Nix (1991) has shown a strong association between bioclimates and rainforest structural types. The bioclimatic parameters used (radiation, temperature, moisture and rainfall) translate directly to the critical factors in land snail survival. So it is not surprising that the distribution of rainforest structural types (Webb, 1968) and land snail assemblages (communities) show great coincidence (Stanisic, unpubl.). As indicators of past and present climatic and edaphic profiles rainforest types provide a framework for understanding land snail evolution in eastern Australia. The drying events of the Pliocene, and their more radical effects in the Pleistocene (Galloway & Kemp, 1981) most likely caused the initial fragmentation of *Lenwebbia*. Climatic changes in the last 100,000 years which also caused major vegetation changes in eastern Australia (Kershaw, 1981) probably attenuated the morphological disparities between the northern and southern species.

In the south, *L. protoscrobiculata* Stanisic, 1990 is associated with comparatively drier subtropical araucarian microphyll vine forests. It is absent from the wetter refugia of the Border Ranges, which suggests long-term adaptation to a subtropical seasonally moist/dry rainforest type where mean annual rainfall is 900-1100mm (Webb & Tracey, 1981). The araucarian forests which flourish in the south are now only relicts in the north. Pollen sampling on the Atherton Tableland indicates that they were replaced by drier sclerophyll vegetation during the last glacial (38000-26000 BP) (Kershaw, 1981). Dry conditions reached a climax at 17000 BP and persisted until 10000 BP. Prior to this the araucarian forests persisted under a rainfall regime of about 1200mm per annum which is not unlike their present-day requirements in the south. The elimination of this forest type in all but refugia in the north reflects a climatic shift which probably caused significant changes in land snail communities including numerous extinctions. The isolation of *L. paluma* in the Paluma Ra. from the main mass of rainforest further north probably occurred during this period. It is likely that the distribution of *Lenwebbia* in the north was more extensive.

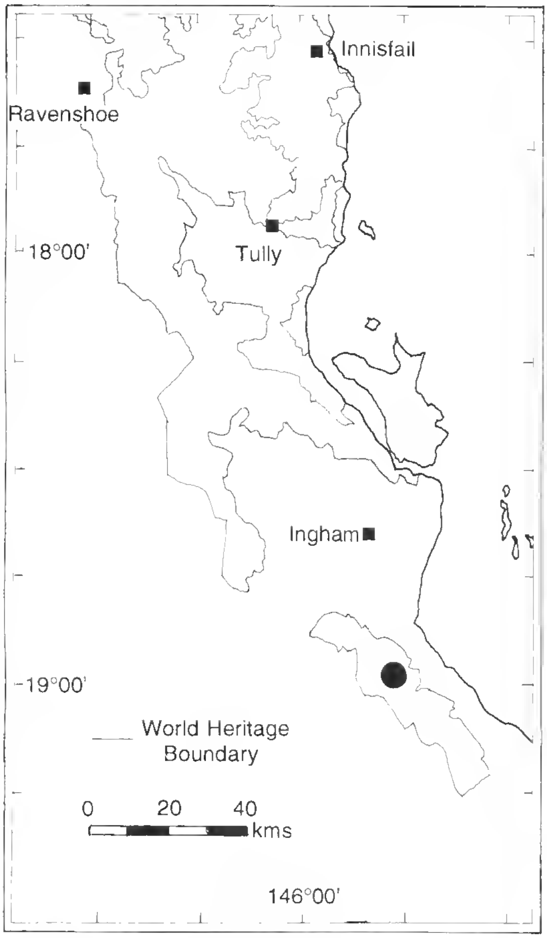

FIG. 4.Distribution of *Lenwebbia paluma* sp.nov. (dot).

Although some recolonisation of areas outside the Paluma Ra. by *Lenwebbia* was possible when major rainforest units and outliers were united during the cool, wet phase of the Holocene (7500-6000 BP) (Kershaw & Nix, 1988; Nix, 1991) this does not appear to have occurred.

L. paluma shows a greater degree of microhabitat specialisation than *L. protoscrobiculata* . Its flatter shell with smaller body whorl width is an expression of this major shift to life under bark of trees. This microhabitat specialisation is a likely contributing factor to the current restricted distribution of *Lenwebbia* in the north. Relatively exposed microhabits and specialised microhabitats presumably have greater probability of perturbation by climatic change. *Hedleyoconcha*, *Lenwebbia* and *Setomedea* all have widespread species in subtropical southeastern Queensland. *Hedleyoconcha* lives in exposed situations on the leaves, trunks and branches of shrubs and trees. Significantly, *Hedleyoconcha* survives only in the very wet, cloudy moist summits of the Wet Tropics and is absent from the mideastern Queensland rainforests. In contrast, *Setomedea*, which lives under logs where ambient conditions are considerably more stable, has managed to persist in mideastern Queensland, even in the somewhat drier habit of Mt Dryander. The Wet Tropics species, *S. monteithi* Stanisic, 1990, is comparatively widespread in the uplands, foothills and lowlands (mountain-mass effect?) between Innisfail and Cooktown. In comparison, *Lenwebbia* is absent from mideastern Queensland and has a narrow distribution in the Wet Tropics, a situation not unlike that seen in *Hedleyoconcha*.

Microhabitat specialisation in *L. paluma* may have resulted from the need to adapt to habitat change. However, in the process the species has probably increased its sensitivity to climatic changes. As an environmentally-cornered species, *L. paluma* must be regarded as a key indicator species of the Paluma biogeographic unit of Nix (1991).

ACKNOWLEDGEMENTS

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EUNGARION MCDONALDI GEN. ET SP.NOV., A MONTANE SEMI-SLUG FROM MIDEASTERN QUEENSLAND RAINFORESTS (PULMONATA: HELICARIONIDAE)

JOHN STANISIC

Stanisic, J. 1993 12 24: *Eungarion mcdonaldi* gen. et sp.nov., a montane semi-slug from mideastern Queensland rainforests (Pulmonata: Helicarionidae). *Memoirs of the Queensland Museum* **34**(1):27-34. Brisbane. ISSN 0079-8835.

Eungarion mcdonaldi gen. et sp.nov. is described from the montane rainforests of mideastern Queensland. *E. mcdonaldi* has a suite of unusual features which are discussed in relation to other eastern Australian semi-slugs and eastern Australian rainforest biogeography. ☐ *Pulmonata, Helicarionidae, Eungarion mcdonaldi, semi-slug, systematics, biogeography, rainforest.*

John Stanisic, Queensland Museum, PO Box 3300, South Brisbane, Queensland 4101, Australia; 8 November, 1993.

The rainforests between Sarina and Proserpine, mideastern Queensland (MEQ) are significant land snail habitats. Many species are endemic to the region, and some are restricted to the moist uplands. Indications are that these montane habitats were important refugia for land snails in drier times (Stanisic, 1990). Snails are particularly moisture sensitive animals and utilise their shells primarily for protection from desiccation. Semi-slugs have reduced shells which have developed in response to stable, high-moisture levels, and a comparatively low calcium environment (Solem, 1978). Eastern Australia provided favourable habitats for semi-slug evolution during the late Tertiary and Quaternary and, today, helicarionid semi-slugs are particularly diverse in this region. The species display varied degrees of shell reduction, ranging from a reduced shell which is complete and still provides shelter for the animal, e.g. *Helicarion rubicundus* of Tasmania (Dartnall & Kershaw, 1978) to a flat, plate-like, almost internalised shell (e.g. *Parmacochlea fischeri* Smith, 1884, of northeastern Queensland). Between these extremes are a number of species with highly membranous, lenticular shells in which the internal walls of the early shell whorls are incomplete. *Eungarion mcdonaldi* gen. et sp.nov. from the summit refugia of the Clarke Range, MEQ, is one of these.

This paper details the morphological features of *E. mcdonaldi* and relates them to other eastern Australian semi-slugs. It also places the species in biogeographic context. The study is based on specimens in the Queensland Museum (QM).

SYSTEMATICS

Helicarionidae

Eungarion gen. nov.

PREVIOUS STUDIES

The only semi-slug previously described from MEQ is *Fastosarion superba* (Cox, 1871). It was described from Mt Dryander but, according to Queensland Museum records, also occurs in the Clarke Ra. Iredale (1933) created the monotypic *Fastosarion* for this species on the basis of shell features. Smith (1992) considered that *Fastosarion* included *Vercularion* Iredale, 1933 (type species: *Helicarion bullaceus* Odhner, 1917) and also added to it several subtropical and tropical species. The extent of the *Fastosarion* radiation needs rigorous testing by revisionary studies, but unpublished work (R.C. Kershaw, pers. comm.) shows that at least *F. superba* and *F. bullaceus* may be closely related.

DIAGNOSIS

Shell small, glossy, poorly calcified with membranous base and incomplete internal whorls. Shell sculpture obsolete. Animal with long and slender foot; caudal horn prominent. Shell lappets and mantle lobes well developed. Genitalia with epiphallic caecum and flagellum. Penis with sheath, internally pustulose and with conical verge. Spermatophore with a thin chitinous tail, otherwise without ornamentation. Radula with increased numbers of marginal teeth.

ETYMOLOGY

From Eungella (the township near the type locality) and helicarion (the epithet most commonly applied to this group of semi-slugs).

Type Species

Eungarion mcdonaldi sp.nov.

Comparisons

Reduced shell size, absence of shell sculpture and the degenerate nature of the shell (poor calcification, incomplete early shell whorls, membranous shell base) are features which separate *Eungarion* from *Fastosarion* Iredale, 1933. The pustulose internal penial sculpture of *Eungarion* (Fig. 4c) contrasts with the pattern of obliquely arranged, thin longitudinal pilasters seen in *Fastosarion superba* (Cox, 1871) (Kershaw, pers.comm.). *Eungarion* shows a similar level of shell reduction to that seen in the north-eastern Queensland *Thularion* Stanisic, 1993, but differs in key shell features such as sculpture, size and degree of calcification. Anatomically, the much stronger development of shell lappets and mantle lobes, lack of a prominent caudal horn and absence of a penial verge in *Thularion* are key differentiating features.

Eungarion mcdonaldi sp.nov.

(Figs 1-5)

Etymology

Named for Keith McDonald, Conservation Strategy Branch, Queensland Department of Environment and Heritage, for his invaluable assistance in providing specimens and field data on Queensland land snails.

Comparative Remarks

Eungarion mcdonaldi (Fig. 2) is readily distinguished from the sympatric *Fastosarion superba* (Cox, 1871) by its smaller size and degenerate shell. *F. superba* is one of the largest semi-slugs in eastern Australia (approx. animal length = 50-70mm) and has a less reduced shell with prominent spiral sculpture. In the juvenile state the shell features are also useful discriminating features.

Material Examined

Holotype: QMMO43309, Dalrymple Heights, Eungella NP, MEQ. 21°02'S, 148°36'E. 1000m, notophyll vine forest. M.J. Bishop, Nov 1976. Height of shell 4.81mm, max. diameter 11.30mm, min. diameter 8.31mm, H/D ratio 0.43, whorls $2\frac{7}{8}$-.

Paratypes: MEQ: QMMO43310, 35 juveniles and adults, same collecting data as holotype; slopes of Mt Dalrymple, W of Mackay, 900m, on dead leaves, simple notophyll evergreen vine forest (21°04'S, 148°35'E) (5, QMMO36087, 21 May 1990, D. & N. Potter, J. Stanisic); slopes of Mt Macartney, SW Proserpine, 900m, in discarded palm fronds, notophyll vine forest/tree ferns (20°50'S, 148°33.5'E) (1, QMMO35628, J. Stanisic, D. & N. Potter, 18 May 1990); Mt Dalrymple, Eungella NP, in cave in rainforest (1, QMMO43307, V. Hansen, 19 Aug.1975).

Diagnosis

Shell small, glossy, maximum diameter 9.74-11.30mm (mean 10.46mm), minimum diameter 7.14-8.31mm (mean 7.76mm), lenticular, very thin, poorly calcified. Whorls $2\frac{7}{8}$, rapidly expanding. Body whorl expanded, not descending in front, with basal margin membranous. Spire and apex flat. Height of shell 3.25-4.81mm (mean 4.26mm), H/D ratio 0.33-0.44 (mean 0.41). Protoconch (Fig. 3a) of $1\frac{1}{4}$ whorls, smooth except for very faint growth ridges. Post-nuclear sculpture (Fig. 3b) of weak, arcuate, radial growth ridges. Sutures weakly impressed to flat. Whorls rounded above the periphery, with internal walls, membranous and incomplete. Colour yellow to golden, apex creamy-white. Based on 4 measured adults (QMMO43309, QMMO43310).

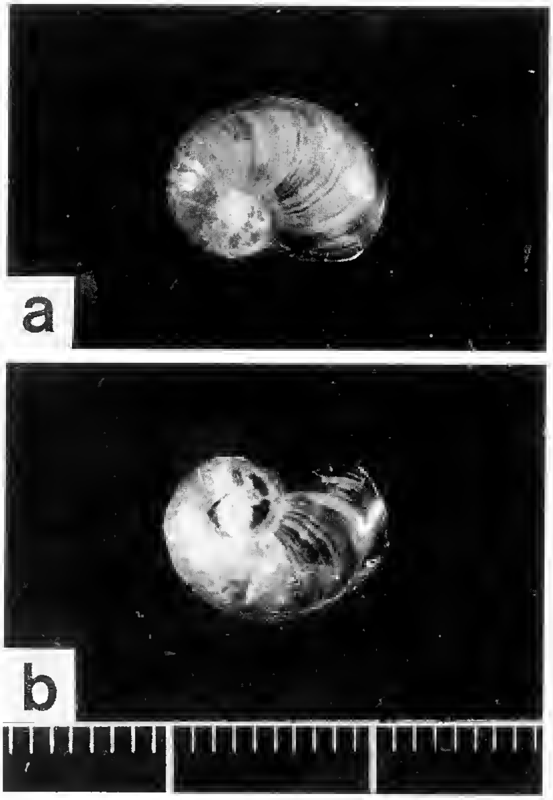

FIG. 1.Holotype of *Eungarion mcdonaldi* sp.nov., QMMO43309. a, top view; b, bottom view. Scale in mm.

Animal (Fig. 4a) small, body length (in preservative) 24.1-33.7mm (mean 29.9mm, n=5). Foot long, slender, tripartite, broadly rounded anteriorly, tapered posteriorly. Tail long, keeled mid-dorsally, with a prominent caudal horn. Caudal foss a long vertical slit in tail. Pedal grooves typically aulacopod and united above the tail. Colour (in live) reddish-brown on foot, neck, tentacles, and mantle lobes; visceral hump yellow; shell lappets pale with darker reddish-brown circular markings, also present in preserved specimens. Body ornamentation strongly developed on tail and in neck region; shell lappets with widely spaced subcircular pustulations, mantle lobes smooth. Right mantle lobe (RML) small, subtriangular, fused to right shell lappet posteriorly; left mantle lobe (LML) large, tapered posteriorly, weakly developed anteriorly and fused to left shell lappet. Right shell lappet (RL) large, subcircular, weakly fused with left shell lappet posteriorly; left shell lappet (LL) semi-circular, fused to narrow mantle collar anteriorly.

Genitalia (Fig. 4b) with multilobate, creamy-coloured ovotestis (G) embedded in the apical whorls of a dark-brown digestive gland (Z). Hermaphroditic duct (GD) swollen and convoluted. Talon (GT) with spherical head and short stalk. Carrefour (X) sub-ovoid, white. Albumen gland (GG) a multilobate mass of creamy-brown acini. Prostate (DG) a band of creamy-white alveoli appressed to the surface of a sacculate uterus (UT). Vas deferens (VD) arising from the prostate - uterus as a thin tube, descending to the penioviducal angle then ascending a short distance before entering a much thicker, muscular reflexed epiphallus (E). Epiphallus longer than penis, with a long, apical flagellum (EF) and a large epiphallic retractor caecum (ERC) arising mid-length; internally with longitudinal rib-like thickenings below level of caecum, pustulose above. Penial retractor muscle (PRM) short, attached to epiphallus adjacent to caecum. Penis (P) relatively short, cylindrical, muscular with a thick sheath (PS) surrounding the lower two-thirds; internally (Fig. 4c) with bold, nodulose pustules apically, becoming transversely elongate basally and two pustulose longitudinal pilasters (PP). Epiphallus entering penis through a smooth, conical verge (PV) that has a terminal pore (EP). Male terminal genitalia enveloped in a thin connective sheath. Vagina (V) short with sub-apical entrance of free oviduct; internally with fleshy longitudinal thickenings. Free oviduct (UV) twice as long as vagina, internally with transverse spongy folds. Spermatheca (S) with a short expanded stalk (SS) inserted at the base of the free oviduct and subovate head attached about halfway along the uterus. Atrium (Y) short.

FIG. 2.Animal of *Eungarion mcdonaldi* sp.nov. Mt Macartney, MEQ, QMMO35628.

Spermatophore (Fig. 4d, SP) elongately ovoid with a long chitinous tail.

Radula with a tricuspid central tooth (Fig. 3d) that has a broadly lanceolate mesocone and two small, pointed lateral cusps; lateral teeth (Figs 3d,f) strongly bicuspid with endocone reduced to a small point high up on the edge of the mesocone, ectocone short and pointed, anterior edge irregularly grooved and ridged; marginals (Fig. 3e) bicuspid with two, equally short, pointed cusps and a long sinuate shaft. Latero-marginal transition abrupt. Basal plates of central and lateral teeth short, squarish with lateral ridges. Interrow support (Fig. 3f) provided by interlock of basal plates with anterior edge of tooth behind. Jaw (Fig. 3c) arcuate with low, concentric growth ridges. Radular formula. 140.11.1.11.140.

Based on 4 dissected specimens (QMMO-35628, QMMO43309, QMMO36087).

RANGE AND HABITAT

Known from only simple notophyll vine forests of the summits and near summits (900-1200m) of the Clarke Ra., MEQ (Fig. 5). The absence of the species from the Conway Ra. and Mt Dryander to the north, is probably real. Considerable collecting has been undertaken in these areas. *E.mcdonaldi* has been collected from inside discarded palm fronds and on leaves on the ground.

REMARKS

Relationships of *E. mcdonaldi* are not clear. A number of other semi-slugs in both northeastern and southeastern Queensland are altitudinally restricted and have degenerate shells. These will need to be dissected in order to determine whether 'very reduced-shell' forms are derivatives of local semi-slugs with more complete shells or whether they are in fact closely related species that have been separated by climatically-induced habitat fragmentation.

DISCUSSION

The eastern Australian semi-slug fauna (family Helicarionidae) is largely undescribed. Based on the collections of the Queensland Museum, it is likely that the number of species, currently 25 (Smith, 1992), will at least double. Of the named species, only a handful have been studied to a standard acceptable in modern systematics. Generally there has been undue emphasis on gross shell characters, in a group displaying a diverse range of shell reduction, to the detriment of anatomical studies. The distribution of the eastern Australian semi-slugs is mainly focussed around the archipelago of rainforest refugia occurring along the eastern edge of the continent. This is not surprising in view of their moisture sensitivity, and suggests a complex evolutionary history since their ancestors reached the continent from the Indo-Malay region in the mid-Miocene (Bishop, 1981). Sympatry involves 2, rarely 3-4 species, and there is considerable microhabitat diversification among the sympaters. Microsympatry has yet to be observed. There are no identifiable large, local radiations (Stanisic unpubl.) so that ordering of character states and identifying direction of character change probably hinges on revision of the entire semi-slug fauna. Against this background attempts to draw relationships between *E. mcdonaldi* and other described helicarionid semi-slugs need to be tempered with caution.

The use of shell characters in a group most remarkable for degrees of shell reduction requires a focus on fundamental features (Fig. 1) such as sculpture and coiling pattern rather than gross similarity. Hence, although the shell of *Thularion semoni* (Martens, 1894) from the Wet Tropics, NEQ, also has incomplete early whorls, poor calcification and membranous shell base (Stanisic, 1993) these alone are not sufficient to warrant close association with *E. mcdonaldi*. The shell of *E. mcdonaldi* is rounded, and, apart from its flattened spire and degenerate nature, more closely resembles the shell of *Helicarion* s.s. and *Fastosarion* sensu Smith (1992). Sculpture (Fig. 3a-b) is obsolete, but this should be viewed in the context of shell reduction and the concomitant loss of key features. Although reduced, the shell of *T. semoni* retains typical helicarionid spiral sculpture on both protoconch and post-nuclear whorls and has a much more expanded final whorl which gives the shell an elliptical aspect.

The animal of *E. mcdonaldi* (Figs. 2,4a) has retained the basic features (reasonably discrete shell lappets and mantle lobe, prominent caudal horn) seen in temperate species (Dartnall & Kershaw, 1978; Kershaw, 1979, 1981) and some subtropical *Fastosarion*. In contrast *T. semoni* has the lappets and lobes more fused and greatly expanded anteriorly to form a cephalic shield. Stanisic (1993) considered this exuberant development of the accessory respiratory surfaces in *T. semoni* as an evolutionary experiment intermediate between the *Helicarion* s.s. and *Parmacochlea* Smith, 1884.

E. mcdonaldi differs from southern species assigned to *Helicarion* s.s. such as *H. nigra* (Quoy and Gaimard, 1832), *H. rubicundus* (Dartnall and Kershaw, 1978) and *H. cuvieri* Ferussac, 1821, in genital anatomy (Fig. 4b-d), by possessing an epiphallic retractor caecum and lacking an epiphallic gland. The penis of *E. mcdonaldi* has a verge and simple sculpture of discrete pustules contrasting with the pattern of penial papilla and complex penial sculpture seen in the southern species (Dartnall & Kershaw 1978; Kershaw 1979, 1981). The relatively simple spermatophore of *E. mcdonaldi* is also quite distinct from the heavily ornamented (spined) spermatophores seen in *H. nigra*, *H. rubicundus* and *H. cuvieri*. I consider these to be fundamental differences above the level of changes associated with species interactions. In contrast, *E. mcdonaldi* shares some basic anatomical features with *T. semoni* (e.g. shape of spermatophore and presence of an epiphallic retractor caecum). *T. semoni* lacks a penial verge but retains pustular sculpture in the penis chamber (Stanisic, 1993). The highly modified *Parmacochlea* from far north Queensland possesses pustular penial sculpture, penial verge, epiphallic caecum and has a spermatophore not unlike that of *E. mcdonaldi* and *T. semoni* in shape. It differs only in having fine spination on the chitinous section (Simroth, 1898).

Hence there are several basic differences which separate the tropical and temperate semi-slugs. At the same time, I do not necessarily consider *E. mcdonaldi* and *T. semoni* close relatives. Whereas *T. semoni* appears to represent a distinct lineage of semi-slug development (Stanisic 1993), *E. mcdonaldi* can be readily derived from species with less reduced shells by simple but more extensive reduction in shell.

The radulae of eastern Australian semi-slugs

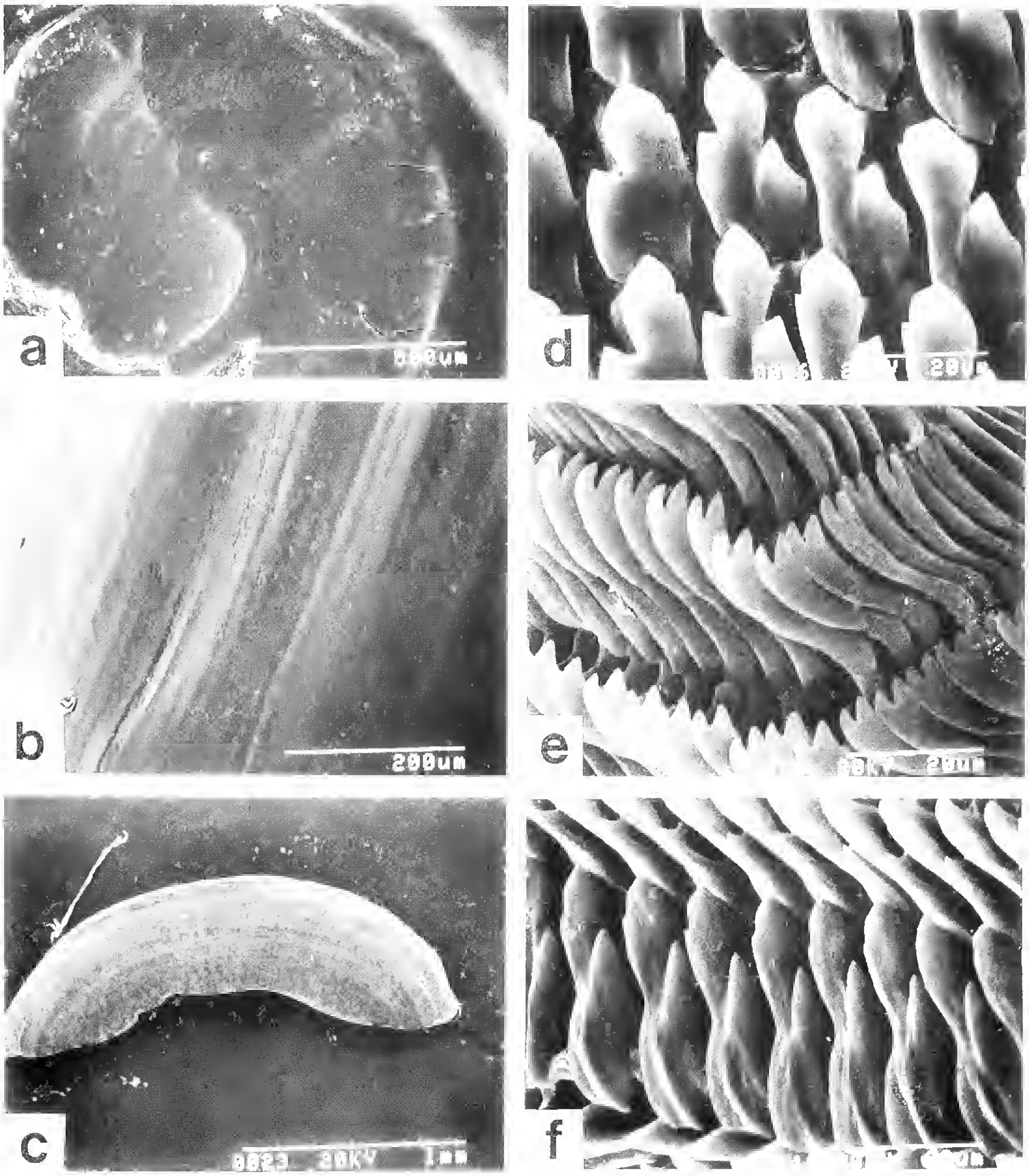

FIG. 3. *Eungarion mcdonaldi* sp.nov. Mt Dalrymple, MEQ, QMMO36087. a, protoconch; b, adult shell sculpture; c, jaw; d, central and inner lateral teeth; e, marginal teeth; f, lateral teeth showing interrow support. Scale lines as marked.

appear to be fairly generalised (Baker, 1941; Dartnall & Kershaw, 1978; Hedley 1893; Kershaw, 1979, 1981; Semper, 1885; Stanisic, 1993) in form and function (interrow support). Minor differences should probably relate to niche specialisation due to sympatry. *E. mcdonaldi* shows some radular differences from both the temperate species (*H. nigra*, *H. cuvieri*, *H. rubicundus*) and the tropical *T. semoni*. In *H. nigra*, *H. cuvieri*, *H. rubicundus* and *T. semoni* the marginal teeth have subequal, somewhat elongate cusps. In *E. mcdonaldi* the cusps (Fig. 3e) are very short and

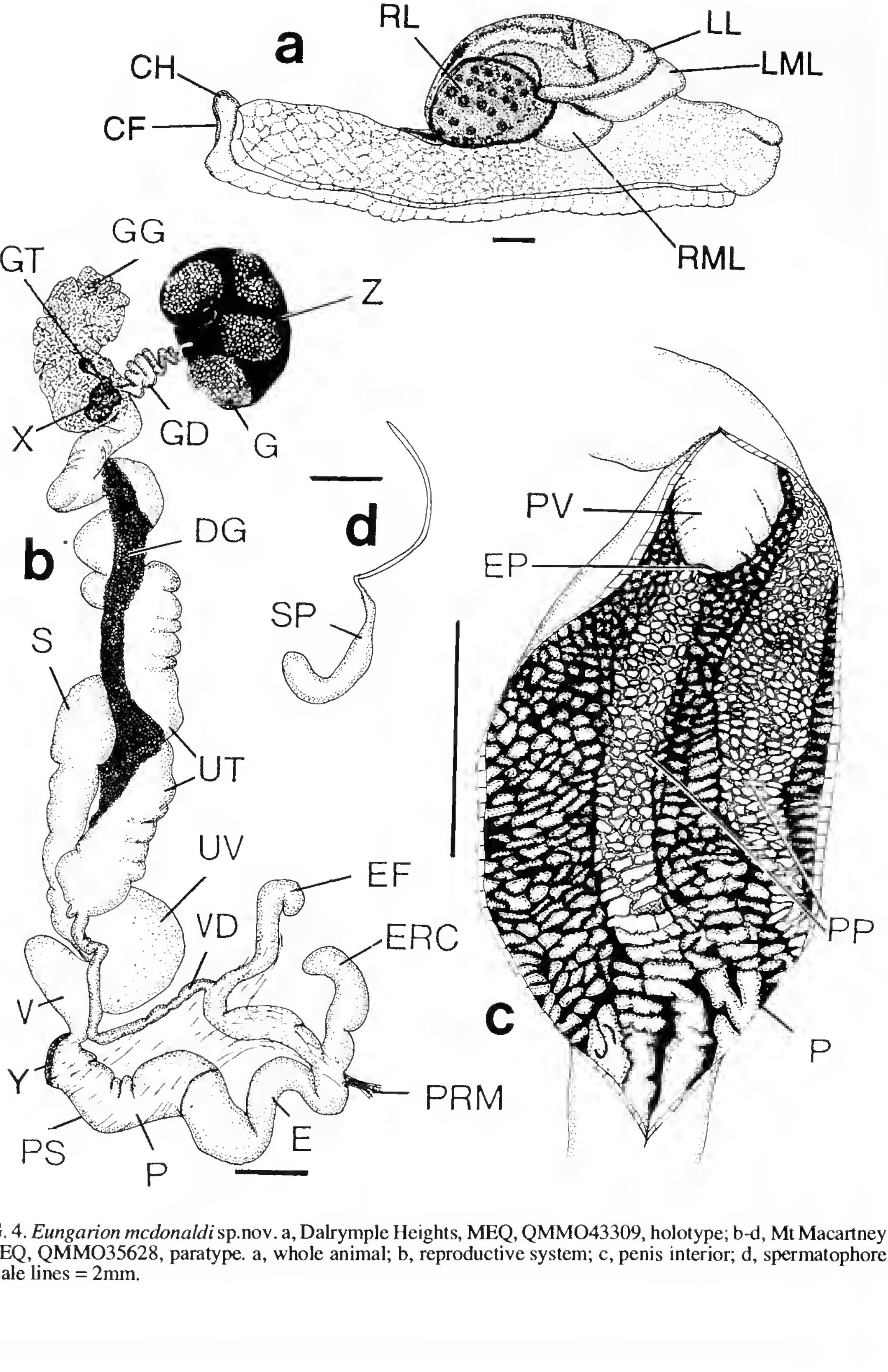

FIG. 4. *Eungarion mcdonaldi* sp.nov. a, Dalrymple Heights, MEQ, QMMO43309, holotype; b-d, Mt Macartney, MEQ, QMMO35628, paratype. a, whole animal; b, reproductive system; c, penis interior; d, spermatophore. Scale lines = 2mm.

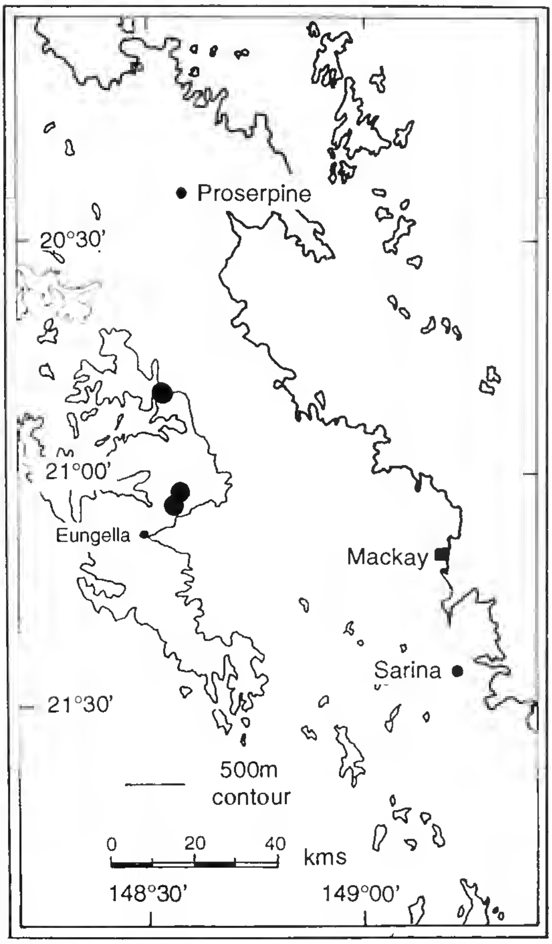

FIG. 5. Distribution of *Eungarion mcdonaldi* sp.nov. (dots).

equal. In addition, the number of marginal teeth in *E. mcdonaldi* is greatly increased (140) when compared with *H. nigra* (38), *H. cuvieri* (30), *H. rubicundus* (80) and *H. semoni* (83). While it is possible that these features may be phylogenetically significant it is also probable that they are merely related to feeding specialisation by *E. mcdonaldi* in response to its sympatry with *Fastosarion superba* (Cox, 1871).

The distribution of *E. mcdonaldi* (Fig. 5) in the summit refugia of the Clarke Ra. suggests that it has been restricted in drier times and has become environmentally-cornered. Hence, its nearest relatives may not survive in MEQ. These refugia are also home to other restricted endemic land snails, e.g. *Setomedea janae* Stanisic, 1990; *Biomphalopa recava* (Hedley, 1912) and the slug-like caryodid, *Pandofella whitei* (Hedley, 1912). With the exception of *B. recava*, which also occurs at lower altitudes at Finch Hatton Gorge, they are confined to these upland refugia. Relationships of these relict species are both with the south (*P. whitei*, *S. janae*), or north (*B. recava*, *S. janae*) and not locally, providing evidence of past connections between regions now separated by tracts of dry, snail-poor countryside. It is possible that the nearest relatives of *E. mcdonaldi* will be similarly located. At a subregional level these restricted taxa are key elements of a largely endemic MEQ snail subfauna (Stanisic, unpubl.).

The Charopidae and Caryodidae are Gondwanan groups and occurrences of family relicts in the MEQ montane communities highlight the importance of these refugia to the persistence of ancient land snail faunal elements in the region. The discovery of the restricted *E. mcdonaldi* extends their significance to modern groups.

ACKNOWLEDGEMENTS

I am grateful to R. Kershaw for supplying personal notes; to Kylie Williams for producing the SEM illustrations; and to the Queensland Museum Photography Section. Thanks are due also to Jennifer Mahoney for typing the manuscript.

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A REVISION OF THE TRIBE COLPURINI FROM AUSTRALIA (HEMIPTERA-HETEROPTERA-COREIDAE)

H. BRAILOVSKY

Brailovsky, H. 1993 12 24: A revision of the Tribe Colpurini from Australia (Hemiptera-Heteroptera-Coreidae). *Memoirs of the Queensland Museum* 34(1):35-60. Brisbane. ISSN 0079-8835.

Four new genera (*Grosshygia, Grosshygioides, Pachycolpuroides* and *Woodwardhygia*); one new subgenus, *Hygia* (*Australocolpura*); and eight new species (*Grosshygia lobatula, G. monticeps, G. nigra, Grosshygioides mandibularis, H. (A.) sandaracine, P. monteithi, W. bifida*, and *Sciophyrus australicus* are added to the Colpurini (Coreidae) of Australia. These, along with previously known Australian coreids, are described, illustrated and keyed. *Acanthotyla fasciata* and *Sciophyrus sortita*, long known from New Guinea, are recorded on northern Cape York Peninsula, the first Australian record. □ *Insecta, Hemiptera, Heteroptera, Coreidae, Colpurini Australia, taxonomy, rainforest.*

H. Brailovsky, Instituto de Biología UNAM, Departamento de Zoología, Apdo. Postal # 70153, México 04510 D.F; 1 September 1993.

This contribution summarizes knowledge of the tribe Colpurini (Hemiptera, Heteroptera, Coreidae) for the Australian region, bringing together information from the literature and from previously unstudied collections. A number of species now known to be present in Australia were either undescribed or were previously known only from New Guinea or adjacent islands to Australia's north.

The Australian Colpurini have never been revised. The first species recorded were by Breddin (1900) who described one new genus and two new species from the region under the binomial names, *Pachycolpura manca* and *Acantholybas brunneus*. The third known species was *Acantholybas kirkaldyi* (Bergroth, 1909), described from 'Tasmania'. The fourth and last previously known Australian species was *Agathyrna praecellens* Stål (1861) described from Aru Islands and later recorded from New Guinea, D'Entrecasteaux Islands, Bismarck Archipelago, Waigeo, Ternate, Misool and Australia (Dolling, 1987).

The Australian members of the tribe Colpurini are usually black or dark coloured. Among the unique aspects of this tribe are the striking structural differences in the hemelytra, as well as the great diversity in the male genital capsule and in the female genital plates, in contrast to other tribes of coreids (Brailovsky, 1990). They are typically species of the rainforest where species occur on the ground associated with piles of freshly dead leaves from recently fallen trees. This revision brings the known Australian fauna to 15 species in 13 genera. Queensland has the richest fauna with 13 species. There are 5 species in northern New South Wales. The only record from a state other than Queensland and New South Wales is of the problematic *Acantholybas kirkaldyi* from Tasmania. This locality needs confirmation.

In the following text I include all the species of Colpurini now known from Australia and describe four new genera, one new subgenus and eight new species.

The following abbreviations are used to identify institutions where types are deposited or which generously lent material for this paper: ANIC- Australian National Insect Collection, Canberra; BPBM Bernice P. Bishop Museum, Honolulu, Hawaii; BMNH- The Natural History Museum, London, England; CAS- California Academy of Sciences (Golden Gate Park); DEI- Deutsches Entomologisches Institut, DDR, Germany; IBUNAM- Colección Entomologica del Instituto de Biología, Universidad Nacional Autónoma de México; QMBA- Queensland Museum, Brisbane, Australia; SAMA- South Australian Museum, Adelaide, Australia; UQIC- University of Queensland Insect Collection, Brisbane, Australia; ZIL- Zoological Institut, Leningrad, USSR; ZMUH- Zoological Museum, University of Helsinki.Geopraphical abbreviations are: FNEQ, NEQ, MEQ, SEQ – far northeastern, northeastern, mideastern, southeastern Queensland; NENSW – northeastern New South Wales.

All measurements are given in millimetres.

The name of Dr G.B. Monteith is shortened to GBM in the lists of specimens.

KEY TO THE KNOWN AUSTRALIAN COLPURINI

1. Each side of head immediately in front of eyes with a long, pointed spine (Figs 12A,B) .... *Pachycolpura manca* Breddin

Sides of head in front of eyes unarmed 2

2. Tylus projecting as a single, large, acute spine 3

Tylus globose, truncated or bifid 5

3. Femora unarmed; callar region of pronotum conspicuously convex; pronotal disc behind middle line with a transverse wrinkle; male genital capsule with a small median projection .... *Acanthotyla fasciata* (Walker)

Femora strongly armed with long, sharp ventral spines; callar region of pronotum weakly convex to flat; pronotal disc without transverse wrinkle; posteroventral edge of male genital capsule without median projection 4

4. Mandibular plate armed with a short projection; posteroventral edge of male genital capsule convex, obtusely rounded *Agathyrna praecellens* Stål

Mandibular plate unarmed; posteroventral edge of male genital capsule elongate and bifurcate .... *Woodwardhygia bifida* sp. nov. (in part)

5. Antenniferous tubercles armed 6

Antenniferous tubercles unarmed 10

6. Bucculae armed with an obvious spine near the middle third; scutellum longer than wide ....*Acantholybas brunneus* Breddin*

Bucculae uniformly rounded 7

7. Micropterous; hemelytral membrane reduced to a small flap; ocelli inconspicuous; head with dorsal region convex to globose in lateral view; abdominal sternite VII of female with plica and fissura 8

Macropterous to submacropterous; hemelytral membrane well developed; ocelli clearly developed; head with dorsal region practically flat in lateral view; abdominal sternite VII of female without plica or fissura .... *Pachycolpuroides monteithi* sp. nov.

8. Head wider than long; apex of scutellum globose; hemelytra reaching anterior third of abdominal segment II .... *Grosshygia nigra* sp. nov.

Head longer than wide; apex of scutellum subacute; hemelytra reaching median third of abdominal segment III 9

9. Antenniferous tubercles armed with long lobes (Fig. 11A); antennal segment II longer than 1.96mm ....*Grosshygia lobatula* sp. nov.

Antenniferous tubercles armed with a short lobe (Fig. 11B); antennal segment II shorter than 1.73mm ....*Grosshygia monticeps* sp. nov.

10. Abdominal sternite VII of female without plica or fissura: frontal angles of pronotum rounded, blunt, not produced 11

Abdominal sternite VII of female with plica and fissura; frontal angles of pronotum produced forwards as conical teeth 13

11. Body length shorter than 10.10mm; posteroventral edge of male genital capsule produced into medium and wide lateral projections, enclosing a deep, U-shaped concavity (Fig. 3B) ....*Sciophyrus diminutus* Horvath

Body length longer than 10.30mm; posteroventral edge of male genital capsule not as above.......... 12

12. Posteroventral edge of male genital capsule with a small Vshaped concavity, with its lateral arms shorter (Fig. 3C) ...... *Sciophyrus sortita* (Horvath)

Posteroventral edge of male genital capsule, with a very large U-shaped concavity, laterally enclosed by two strong divergent arms (Fig. 3A) .... *Sciophyrus australicus* sp. nov.

13. Mandibular plate armed with a large prominent tubercle, pronotal disc with a deep longitudinal furrow along midline; hemelytra staphylinoid, membrane absent ....*Grosshygioides mandibularis* sp. nov.

Mandibular plate unarmed; pronotal disc flat, without midline furrow; macropterous; hemelytral membrane well developed 14

14. Femora armed with two rows of ventral spines; tylus apically bifid .... *Woodwardhygia bifida* sp. nov. (in part)

Femora unarmed; tylus apically globose .... *Hygia (Australocolpura) sandaracine* sp. nov.

* = *Acantholybas kirkaldyi* Bergroth not available.

Acantholybas brunneus Breddin
(Figs 6E,F, 15A)

Acanthoclybas brunnea Breddin, 1900: 40-41.

MATERIAL EXAMINED

SEQ: 3 ♂♂, 3♀♀ : Brisbane, 20.iii.1930, 1.iv.1965, C. Hembrow and viii.1971, M.B Malipatil. 4♀♀ : Mt Glorious, 13.ix.1966, GBM. 1 : Tamborine, A.M. Lea. 1♀: Central Station, Fraser Is., 14-15.x.1978, GBM. NSW: 1♀, Tooloom Plateau via Urbenville, 31.x.1970, GBM. ANIC, BPBM, QMBA, UQIC, IBUNAM.

DIAGNOSIS

Largely dull orange yellow; tylus globose; antenniferous tubercles armed with a large, sharp, pointed spine; bucculae with a short, blunt mesal projection; femora unarmed or with small denticles along their ventral surface; pronotal margins straight; macropterous. Spermatheca: Bulb elongate, duct heavily coiled, chamber slender.

DISTRIBUTION

Lowlands and plateaux from NNSW to SEQ, north to Fraser Is. (Fig. 15A). Breddin described

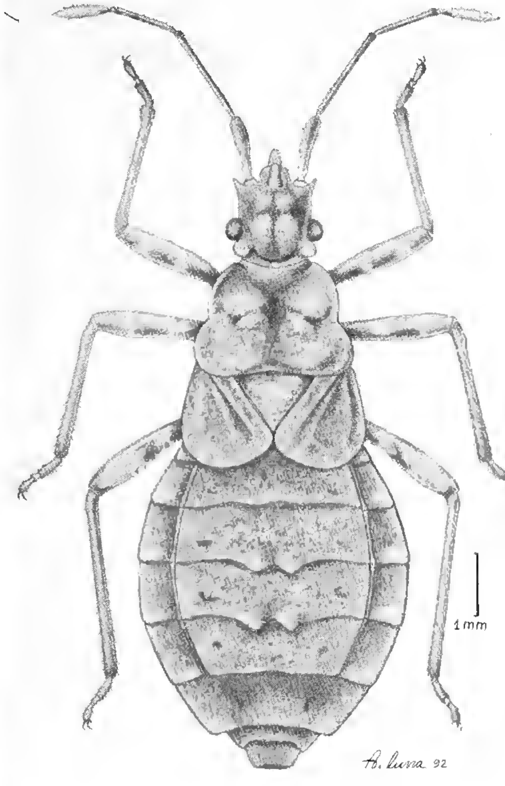


FIG. 1. Dorsal view of *Grosshygia lobatula* sp. nov., ♀.

A. brunneus from New South Wales, without definite locality.

Acantholybas kirkaldyi Bergroth
(Fig. 15A)

Acantholybas kirkaldyi Bergroth, 1909: 185-186.

This species was described from Tasmania without definite locality. I have not been able to locate the type specimen which was a male 10mm long. No additional material was available for this study.

Bergroth (1909) distinguished *A. kirkaldyi* from *A. brunneus* Breddin because the latter species has the rostrum longer, the pronotum shorter, the abdominal sterna with a median furrow and the posteroventral edge of the male genital capsule conspicuously sinuate.

Acanthotyla fasciata (Walker)
(Figs 10C, 15A)

Cletus fasciatus Walker, 1871: 196-197.

Material Examined

FNEQ: 1 ♂, 2 ♀♀: Iron Ra., Cape York Pen., 5-10.v.1968 and 30.vi-4.vii.1977, GBM. 3 ♂♂: West Claudie R., Iron Ra., 3-10.xii.1985, GBM & D. Cook. 1 ♂, 1♀: Cape York, Rocky R., 1958, Darlington. 1 ♂: Gordon Ck, Iron Ra., 16.x.1974, M.S. Moulds. QMBA, SAMA, UQIC, IBUNAM.

Diagnosis

Pale yellow, punctures orange to dark brown red and with a median black red longitudinal stripe located on prosternum, mesosternum, metasternum, abdominal sternite III to VII and between callar region of pronotum; each antenniferous tubercles armed with a short lobe; tylus projecting in front of jugae, upturned to form a median acute horn at apex; mandibular plates armed with a prominent tubercle; bucculae with small spiny anterior projection; callar region of pronotum globose; pronotal disc with posterior lobe wrinkled; macropterous; abdominal sternite VII of female without plica or fissura.

Distribution

In Australia from only the lowland rainforests of central Cape York Peninsula (Fig. 15A). This species was originally described from Misool (Walker, 1871) and was later recorded from New Guinea (Stål, 1873). It is here recorded from Australia for the first time.

Agathyrna praecellens Stål
(Figs 10A, 15A)

Agathyrna praecellens Stål, 1861: 145.

Previous Records

Northern Queensland: Cape York Peninsula and Iron Range (Dolling, 1987).

Material Examined

FNEQ: 9 ♂♂, 1♀ : West Claudie R., Iron Ra., 3-10.xii.1985, GBM & D. Cook. 3 ♂♂, 1♀ : Gordon's Mine area, Iron Ra., 12-18.ii.1976, GBM. IBUNAM, QMBA, UQIC.

Diagnosis

Largely bright orange red; femora strongly denticulate; antenniferous tubercles truncate; tylus projecting in front of jugae, upturned to form a small robust horn at apex; mandibular plates armed with a prominent tubercle; bucculae with small spiny anterior projection; pronotal margins straight; pronotal disc without posterior wrinkle; macropterous; abdominal. sternite VII of female without plica or fissura.

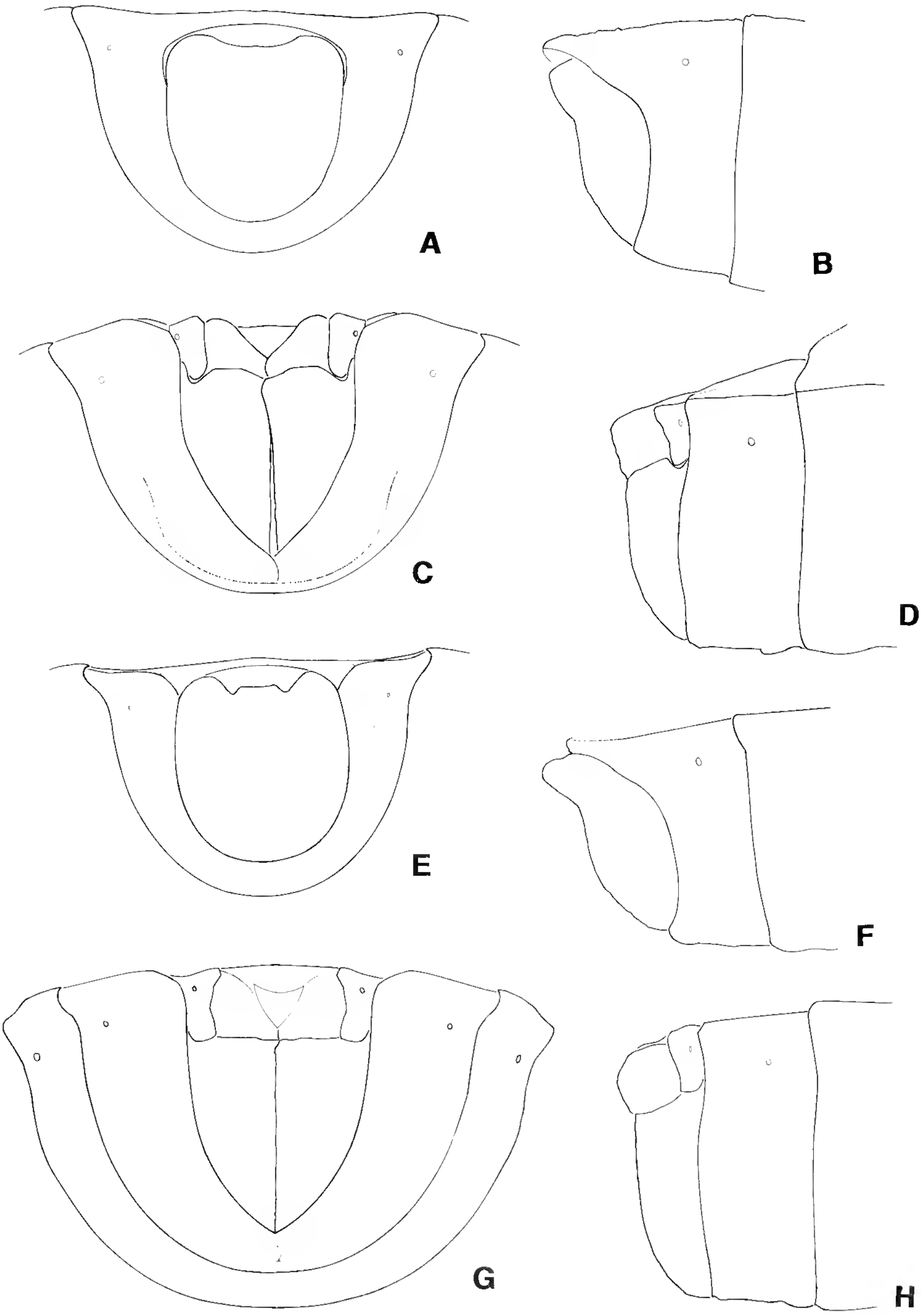


FIG. 2. *Grosshygia* spp. nov.: *Grosshygia lobatula* ♂ genital eapsule, posterior view (A), lateral view (B); ♀ genital plates, posterior view (C), lateral view (D): *G. monticeps* ♂ genital capsule, posterior view (E), lateral view (F); ♀ genital plates, posterior view (G), lateral view (H).

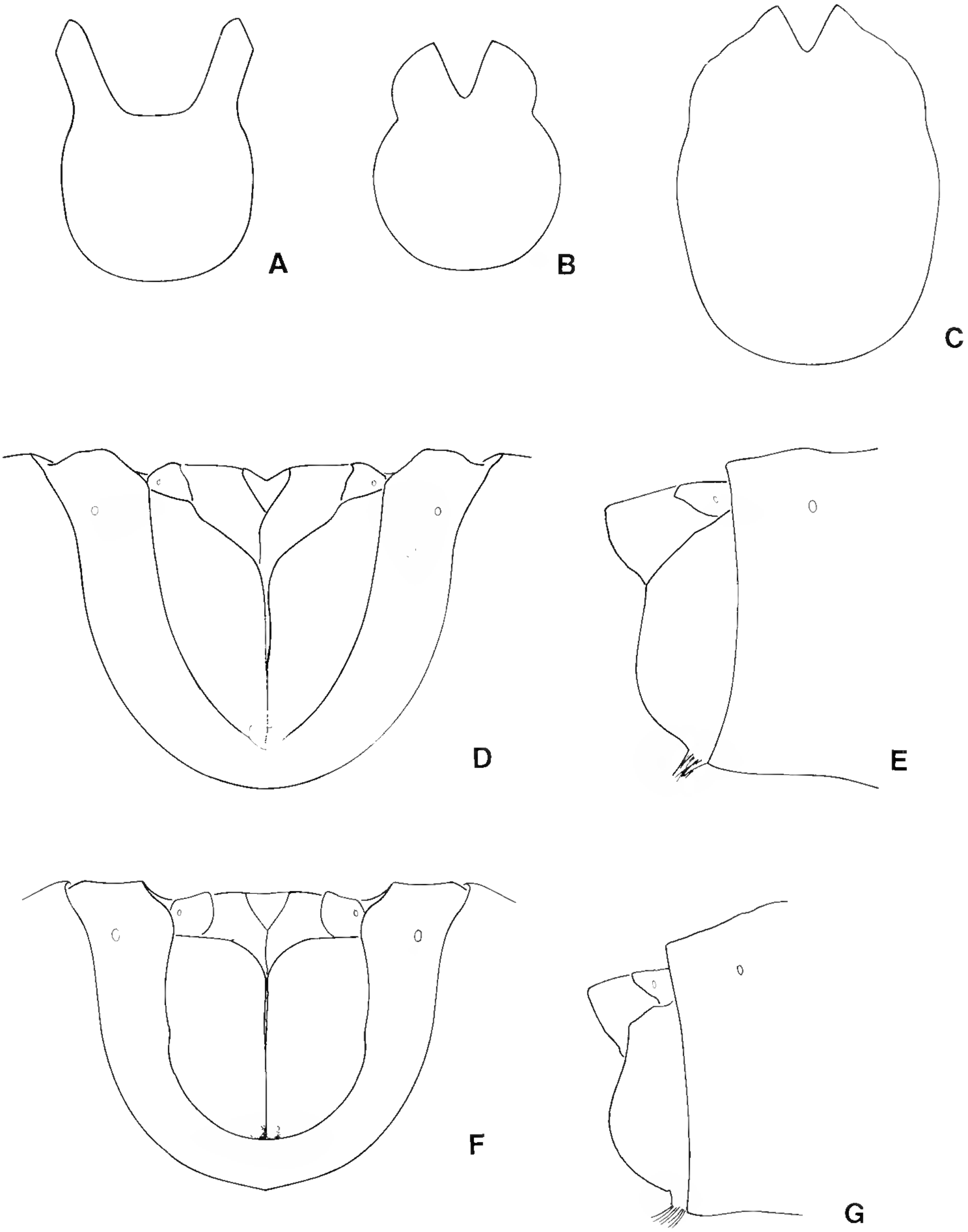


FIG. 3. *Sciophyrus* spp. ♂♂ genital capsules; *S. australicus* sp. nov.(A), *S. diminutus* Horvath (B), *S. sortita* (Horvath) nov. comb (C); ♀♀genital plates, *S. australicus* sp. nov; posterior view(D), lateral view (E); *S. diminutus* Horvath posterior view (F), lateral view (G).

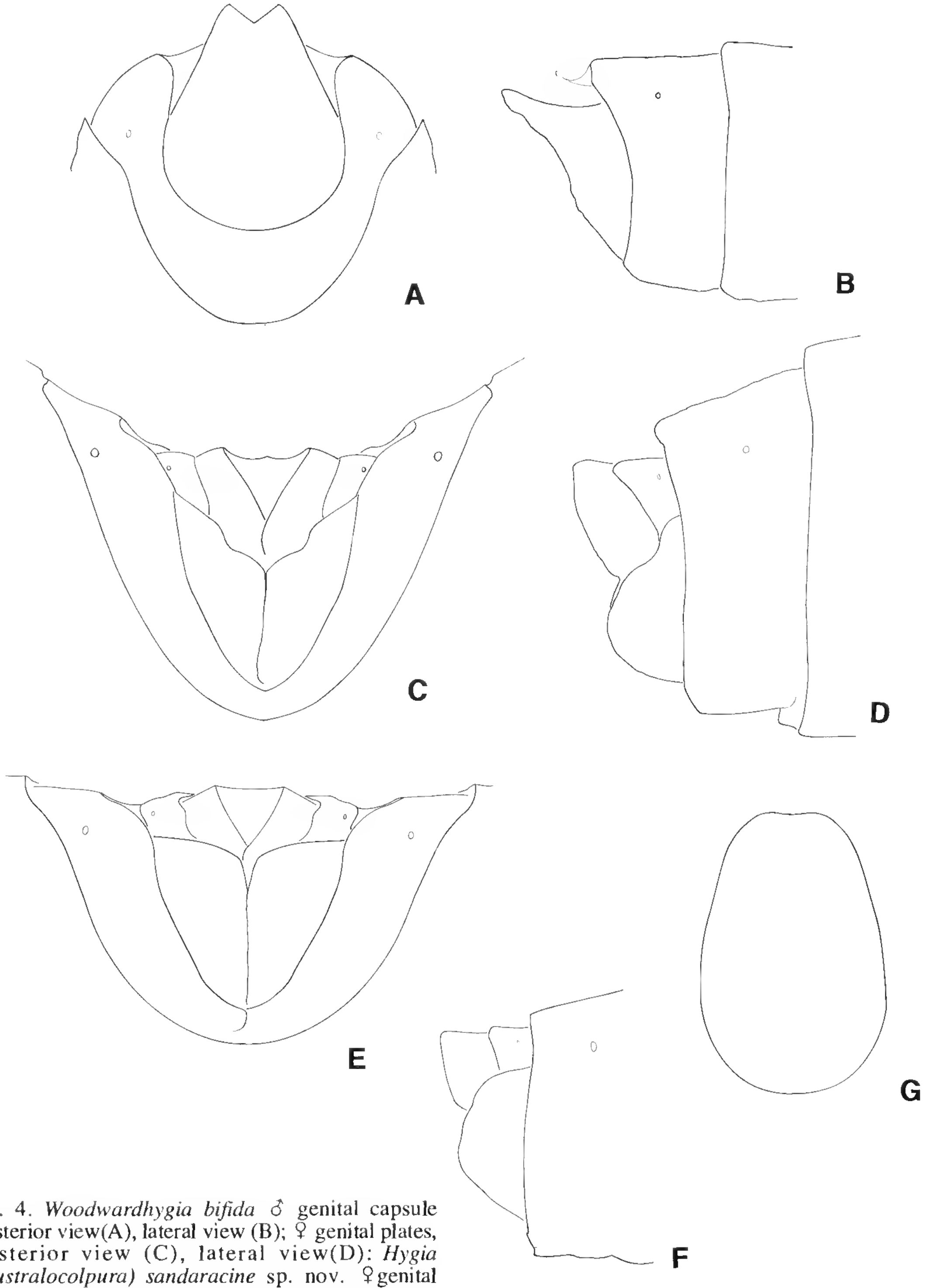


FIG. 4. *Woodwardhygia bifida* ♂ genital capsule posterior view(A), lateral view (B); ♀ genital plates, posterior view (C), lateral view(D): *Hygia (Australocolpura) sandaracine* sp. nov. ♀genital plates, posterior view (E), lateral view (F), ♂ genital capsule in posterior view (G).

DISTRIBUTION

In Australia from only lowland rainforests of Iron Ra., FNEQ (Fig. 15A).This is the most common and widespread species of the genus. Described from Aru Islands, and later recorded from Australia, New Guinea, D'Entrecasteaux Islands, Bismarck Archipelago, Waigeo, Ternate, and Misool (Dolling, 1987).

Pachycolpura manca Breddin
(Figs 6C,D, 12A,B, 15B)

Pachycolpura manca Breddin, 1900: 39-40.

MATERIAL EXAMINED

NSW: 4 ♂♂, 4♀♀ Sydney, Lea. 3 ♂♂ Parramatta, Macarthur's Bridge, 29.iii-12.iv.1980, R. Patterson. 1♀ : Carlingford, 10.X.1970, F.H. Uther Baker. SEQ: 1 ♀: Mt Glorious, 24-28.ii.1961, J.L. and M. Gressitt. 1 ♀: Bunya Mts, 19.xi.1967, J. and M Sedlacek. 2 ♂♂, 1♀ : Bald Mt. area, via Emu Vale, 16-20.ii.1970 3-4000', GBM. 3 ♂♂, 7♀♀ : Brisbane, 17.iii.1957, J.H Martin. 3 ♂♂, 2 ♀♀: South Pine River, 17.i.1963, GBM. 1♀ : Whiteside Xing, N Pine River, 12.vii.1963, GBM. 1♀ : Ravensbourne, 15.ix.1971, B. Cantrell. 1 ♀: Bald Mtn area, via Emu Vale, 27-31.i.1972 3-4000', GBM. 1♀ : Indooroopilly, 7.ix.1979, G. Gordh. ANIC, BPBM, BMNH, CAS, IBUNAM, QMBA, SAMA, UQIC, ZIL.

DIAGNOSIS

Largely dull pale ochre yellow, with brown and orange reflections; sides of head in front of eyes with a long and pointed spine; antenniferous tubercles and femora unarmed; tylus globose; macropterous to brachypterous (*sensu* Slater, 1975) bucculae with small spiny anterior projection; abdominal sternite VII of female entirely fissurated. Spermatheca: bulb somewhat elongate, duct relatively coiled, chamber more or less globose. Parameres, Figs 6C,D.

DISTRIBUTION

Widespread, Sydney, NSW to Brisbane and Bunya Mts, SEQ (Fig. 15B) This species is described from Australia (Breddin 1900, Blöte 1936, Kumar 1966).

NOTES

Kumar (1966) described the life history stages and recorded its feeding on stinging nettles (*Urtica dioica* L.), tomatoes, pumpkins and *Coreopsis lanceolatus* L.

Sciophyrus diminutus Horvath
(Figs 3B,F,G, 5C-E, 13A, 15B)

Sciophyrus diminutus Horvath, 1900: 635.

MATERIAL EXAMINED

FNEQ, NQ, SEQ: 7 ♂♂, 7 ♀♀: Cape York, Lockerbie area, 13-27.iv.1973, GBM. 1♀ : Upper Mulgrave R., 1-3.xii.1965, GBM. 2 ♂♂, 2 ♀♀: Cape York Pen., Iron Ra., 28.iv-17.v.1968, GBM, 16-23.xi.1965, GBM. 4 ♂♂, 2♀♀: Kowanyama, 7.i.1977, D.L. Hancock. 1 ♂: Mt Webb NP, 50km N Cooktown, 11-14.vii.1976, G.B. and S. Monteith. 7 ♂♂, 8♀♀: Hibberd Pt, Weipa, 3-5.ii.1976, GBM. 1 ♂: Mt Glorious, 7.V.1959, A.C. Robinson. IBUNAM, QMBA, SAMA.

DIAGNOSIS

Surface dull, dark brown, with orange or pale ochre yellow reflections; size less than 10.10mm; antennal segments I to III pale orange hazel with basal third pale yellow; antennal segment IV yellow with basal and apical third pale brown; macropterous; posteroventral edge of male genital capsule extending into medium and wide lateral projections, enclosing a deep U-shaped concavity (Fig. 3B); parameres, Figs 5C-E. The genital plates of the female are straight, with a dorsoventral enlargement and with external face of gonocoxa I clearly convex (Figs 3F,G).

DISTRIBUTION

Widespread on both eastern and western Cape York Peninsula, south to the Mulgrave R., NEQ. One specimen is labelled 'Mt Glorious' but this locality needs confirmation since it is 1500km beyond the range of the other specimens (Fig. 15B).

This species was originally described from Thursday Island and later recorded from Kei Islands and New Guinea (Horvath, 1919 and Blöte 1936).

Sciophyrus sortita (Horvath) nov. comb.
(Figs 3C, 5J,K, 13B, 15B)

Colpura sortita Horvath, 1900: 635-636.

MATERIAL EXAMINED

FNEQ 1 ♂: W Claudie R., Iron Ra., 3-10.xii.1985 (50m), GBM & D. Cook 2 ♂♂: Iron Ra., Cape York Pen., 5-10.v.1968, GBM. Same locality, 4.vii.1977, GBM. 2 ♂♂: Cape York, Lockerbie area, 13-27.iv.1973, GBM. IBUNAM, QMBA.

DIAGNOSIS

This is a large striking species, similar in colour and habitus to *S. australicus* sp. nov., but differing in having the posteroventral edge of male genital capsule with a small 'V' concavity, with lateral arms conspicuously shorter (Fig. 3C); parameres like Fig. 5J,K. Anterior and middle femora armed; posterior femora unarmed; anterior lobe of pronotum mostly smooth; macropterous. Female: Unknown.

DISTRIBUTION

In Australia, known only from the rainforests of Lockerbie and Iron Ra., FNEQ (Fig. 15B). This species was originally described from New Guinea and was known only from there until now.

Sciophyrus australicus sp. nov.
(Figs 3A,C,D, 5A, 13C, 15B)

MATERIAL EXAMINED

HOLOTYPE ♂: NEQ: Mt Fisher, 7km SW Millaa Millaa, 27-29.iv.1982 (1050-1100m), GBM, Yeates and Cook, in QMBA (T12708).

PARATYPES: NEQ: 3 ♂♂, 1♀: Malanda Falls, 9.xii.1989 (750m), GBM, Thompson & Janetzki, 2 ♂♂ and 1♀ in QMBA and 1 ♂ in IBUNAM. 1 ♀: Bakers Blue Mt., 17km W Mt Molloy, 11.ix.1981 (900m), GBM & D. Cook, in QMBA. 1♀ : Townsville, 19.i.1964, J. Sedlacek, in CAS. 4 ♂♂. Broadwater Park, 35km NW Ingham, 16.xii.1986 (60m), GBM, Thompson & Hamlet, 3 in QMBA and 1 in IBUNAM. 3♀♀ : Mt Fisher, 7km WNW Cape Tribulation (site 2), 23.ix-7.x.1982 (50m) GBM, Yeates & Thompson, in QMBA. 1 ♂, 2 ♀♀: Kirrama Ra. (Yuccabine Ck. area), 9-12.xii.1986 (600m), GBM, Thompson & Hamlet, 1 ♂ & 1 ♀ in QMBA and 1♀ in IBUNAM. 1♀ : Kirrama SF, via Cardwell, 17-18.viii.1966, GBM in UQIC 1♀: Mission Beach, 128km S Cairns, 19-20.i.1964, J. Sedlacek, in CAS. 1 ♂: Cooper Ck, 18m N Daintree R., 14.xi.1969, T. Weir in UQIC. 1 ♂: Lacey's Creek, Mission Beach, 21.iv.1970, GBM, in UQIC. 1 ♂: Upper Little Mulgrave R., SW Cairns, 4.ix.1969, J.E. Tobler, in QMBA. 3 ♂♂, 2 ♀ ♀: Upper Mulgrave rd, Kearney's Falls, 10.xii.1988, GBM & Thompson, 2 ♂♂ 2♀♀ in QMBA and 1 ♂ in IBUNAM. 2 ♂♂: Kirrama Ra. (Barracks area) 11-12.xii.1986 (600m), GBM, Thompson & Hamlet in QMBA. 7 ♂♂, 12♀♀ : Bellenden Ker Range, Cableway Base Stn, 17-31.x.1981 (100m), GBM, 5 ♂♂ & 10♀♀ in QMBA & 2 ♂♂ & 2♀♀ in IBUNAM. 1 ♂: Baldy Mt. rd, SW Atherton, 10.x.1980 (1200m), GBM in QMBA. 1 ♂: Palmerston NP, via Innisfail, 7-8.viii.1968, B. Cantrell, in UQIC. 1 ♂ Mossman Gorge, 7.xii.1966, B. Cantrell in UQIC. 1 ♂, 1♀ : Lake Eacham, 24.ix.1970, GBM, female in UQIC. male in IBUNAM. 1 ♂: The Boulders, via Babinda, 15.xii.1966, B. Cantrell in UQIC. 1 ♂, 1♀ : Upper Mulgrave R., 30.iv.1970, GBM, in UQIC. 2♀♀ : Upper Mulgrave R., 1-3.xii.1965, GBM, in UQIC. 1 ♂, 1♀ : Wallaman Falls, via Ingham, 7.viii.1968, B. Cantrell in UQIC. 1 ♂: Mossman Gorge, via Mossman, 28.xii.1967, B. Cantrell in UQIC. 1 ♂: Henrietta Ck, Palmerston NP, 29.xii.1964, GBM in IBUNAM. 1 ♂. Kauri Ck, Tinaroo Dam, 24.iv.1970, G.B. Monteith in UQIC. 1 ♀: Malanda Falls, 11.v.1970, GBM in UQIC. 1 ♂, 3♀♀ : Upper Mulgrave, via Gordonvale, 26-27.xii.1967, GBM, 1 ♂ & 2♀♀ in UQIC & 1 ♀ in IBUNAM. 1 ♂: Kirrama Ra. (Douglas Ck rd), 9-12.xii.1986 (800m), GBM, Thompson & Hamlet in QMBA. 1 ♂: Shipton's Flat, via Helenvale, 20-27.vii.1974, GBM & D. Cook, in QMBA. 2 ♂♂: Cape Tribulation, 12-19.x.1980, GBM in QMBA. 1 ♂: Flying Fish Pt, 21.i.1965, E.C. Dahms in QMBA. 1 ♂: Millaa Millaa Falls, 4.xii.1965, GBM in UQIC. 1 ♂, 2♀♀ : Henrietta Ck, Palmerston NP, 5.xii.1965, GBM in UQIC. 1♀ : Rifle Ck, Black Mtn, 18km ESE Julatten, 13-14.iv.1982 (400m), GBM, Yeates & Cook in QMBA. 3 : Hinchinbrook Is ., Gayundah Creek, 7-15.xi.1984 (10m), GBM, Cook & Thompson, in QMBA. 1♀ : Mossman Bluff Track, 5-10km W. Mossman, 1-16.i.1989 (360m), GBM, Thompson & ANZSES in QMBA. 1♀ ; Gordon's Mine Area, Iron R., 12-18.ii.1976, GBM, in QMBA .

DESCRIPTION

Male: Dorsal coloration: Orange brown, head and anterior lobe of pronotum alternating red brown or black spotting; following areas pale yellow: a longitudinal band running from the antenniferous tubercles to the neck, comprising the space between the eye and the ocelli and the superior area of the postocular tubercle, lateral margins of the pronotal collar, anterolateral borders of pronotum, external edge of humeral angles, an irregular spotting at the middle lobe of the pronotal disc and the greater part of the scutellar surface and its apex; antennal segments I and II ochre chestnut brown, with a shining orange red apex; segment III chestnut red and IV ochre yellow, with its basal third red brown and the apical third chestnut orange; hemelytral membrane amber brown with veins darker; connexival segments red brown, with posterior border yellow and most of the surface with orange reflections; abdominal segments orange red with the greatest part of VII orange brown. Ventral coloration: Chestnut orange on an ochre yellow background; following area chestnut orange to chestnut orange brown: middle head region, prosternum, mesosternum and metasternum as well as the area neighbouring the lobes of the metathoracic scent glands: rostral segments I to III chestnut orange and IV somewhat paler; neighbouring region of the inferior eye area pale yellow, anterior lobe of the metathoracic scent gland yellow, the posterior lobe chestnut orange; coxae red brown; trochanters yellow with some chestnut brown spots; femora red brown with two yellow rings, one basal, the other one near the middle line, tibiae alternating two yellow rings with three chestnut brown to dark brown rings; tarsi chestnut brown with orange reflections on II and III; propleura and metapleura with a black half moon and mesopleura with an anterior irregular black spot; abdominal sternites with three-coloured pleural margin, upper one red brown, posterior one dark yellow and dark orange the rest.

Structure: Eyes medium sized, prominent; ocelli with large diameter and situated on a line such that their upper margin is level with the lower margin of eyes; rostrum almost reaching the posterior third of sternal segment V; rostral segment I reaching anterior margin of prosternum. Pronotum: Middle and posterior lobe densely punctate, inconspicuously striate; anterior lobe with small diameter punctures and some smooth areas; frontal angles blunt, slightly produced; anterolateral borders clearly emarginated and bilobate, with anterior lobe short and convex, and posterior one higher and convex; humeral angles rounded, not exposed, in lateral view feebly convex; posterolateral borders straight and somewhat sinuate; posterior border straight. Legs: Femora armed with a double row of minute denticles. Scutellum: Abruptly punctate and irregularly striate; apex short and blunt. Hemelytra: Macropterous, reaching the apex of the abdomen clavus; and corium with medium punctures except the posterior third of the corium which is smooth. Ventral surface densely punctate.

Genital capsule: Posteroventral margin with a pronounced U-shaped concavity, enclosed by two very open and conspicuously robust arms (Fig. 3A). Parameres: Fig. 5A,B.

Female: Coloration: Similar to male. Structure: Abdominal sternite VII without plica or fissura; abdominal segment IX trapeziform, short, with a narrow posterior border and a small U-shaped concavity, never deep.

Genital plates: Gonocoxae I straight, well developed, with an antero-posterior enlargement and with the external face entire, feebly convex; paratergite VIII small; paratergite IX medium sized and not conspicuously raised (Fig. 3D,E). Spermatheca: Bulb elongate, duct heavily coiled.

Measurements: ♂ first, then ♀: Head length: 1.50, 1.57; interocellar space: 0.45, 0.50; interocular space: 0.85, 0.87; width across eyes: 1.65; 1.70; preocular distance: 0.90, 0.97; length antennal segments: I, 1.65, 1.70; II, 2.30, 2.50; III, 1.70, 1.80; IV, 1.52, 1.55. Pronotum: Total length: 2.20, 2.32; width across frontal angles: 1.35, 1.45; width across humeral angles: 3.35, 3.60. Scutellar length: 1.75, 2.00; width: 1.60, 1.70. Total body length: 10.60, 11.56.

DIAGNOSIS

S. australicus is easily distinguished by the pronounced U-shaped concavity at the posteroventral edge of the male genital capsule, which is laterally enclosed by two strong divergent arms (Fig. 3A). In *S. annulipes* Blöte, the related species, the posteroventral edge has two long and pointed arms and the U-shaped opening is less pronounced.

The female strongly resembles that of *S. annulipes*. The determination is based upon the locality labels, assuming that both sexes were collected at the same time; however the opening of the posterior border of the abdominal segment IX in *S. australicus*, is narrower than in *S. annulipes*.

DISTRIBUTION

Widespread and common in high and low elevation rainforest of the region between Cooktown and Townsville, NEQ (Fig. 15B). One specimen from Iron Ra. needs confirmation.

ETYMOLOGY

Relating to the collecting locality.

Grosshygia gen. nov.

DESCRIPTION

Head: Slightly longer than wide across eyes or wider than long, pentagonal to subquadrate, conspicuously convex dorsally; tylus unarmed, apically truncate, extending anteriorly to the jugae and more raised in lateral view; jugae unarmed, thickened and shorter than tylus; antenniferous tubercles armed, lobes raised, diverging anteriorly and apically acute or rounded or armed with short and robust lobes (Fig. 11A,B); sides of head in front of eyes unarmed and straight; antennal segment I robust, thickest, slightly curved outwards and shorter than head; segments II and III terete and slender; segment IV fusiform; antennal segments I, III, and IV subequal, II longest of all; ocelli not elevated, difficult to see and situated on a line where the upper margin does not reach the lower margin of the eyes; preocellar pit deep; eyes small, globular; postocular tubercles protuberant, globose; bucculae rounded, short, elevated, not projecting beyond antenniferous tubercles, without teeth and with the external edges thickened; rostrum long, reaching the posterior margin

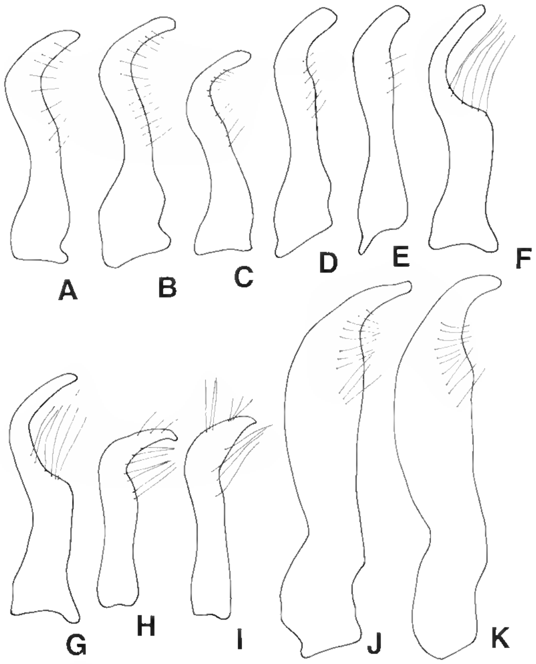


FIG. 5. Parameres, *Sciophyrus australicus* sp. nov. (A,B),*S.diminutus* Horvath (C-E),*Grosshygia lobatula* sp. nov. (F,G), *G. monticeps* sp. nov. (H,I), *Sciophyrus sortita* (Horvath) nov. comb. (J,K).

of abdominal sternite V or anterior margin of VI; rostral segment I reaching the posterior gular region; rostral segment IV longest, rostral II longer than I and III subequal to I; vertex globose, with slight transverse depression, dividing it into two elevations, the anterior one broader, irregularly nodulose and higher than posterior one which is slightly rounded.

Thorax: Pronotum quadrate, bilobed and not declivent, anterior lobe longer than posterior lobe, both with lateral margins convexly rounded, moderately elevated and slightly reflexed; anterior collar wide; posterolateral border straight and posterior border slightly concave; callar region transversely nodulose and separated along the middle line by a slightly longitudinal depression. Anterior lobe of metathoracic scent gland globose and reniform, posterior lobe sharp, small.

Legs: Unarmed; tibiae terete, with sulcus difficult to see, more slender than femora.

Scutellum: Triangular, wider than long, with subacute apex; disc convexly rounded.

Hemelytra: Micropterous, reaching anterior third of abdominal segment II or median third of abdominal segment III; wings reduced to small pads separated from each other, leaving the abdomen exposed mesally; clavus and corium fused with raised veins; membrane absent or represented by a small lobe.

Abdomen: Connexival segments higher than body, posterior angles complete, not projected into spines; dorsal segments IV-V and VI-V with two mound-like projections to the sides of the middle line; abdominal sternites with medial sternal furrow extending to posterior border of sternite VI.

Integument: Body surface rather dull. Pronotum, scutellum and hemelytra with scattered punctation. Antennae and legs minutely granulate. Head, pronotum, scutellum, legs, hemelytra, thorax and abdomen with long or short decumbent to suberect conspicuous golden or silvery bristle-like hairs. Ventral surface with circular greyish-white farinose punctures.

Male genitalia: Genital capsule: Posteroventral margin protruding as a feeble lip with edge complete (Fig. 2A,B) or with a protruding margin slightly excavated on the mid-line. Parameres: simple and straight; anterior lobe convex and continuous with body; posterior lobe ending in a sharp and slender projection (Fig. 5F,G) or in a thick projection (Fig. 5H,I); space between posterior lobe and body wide and amply indented (Fig. 5F,G) or feebly concave (Fig. 5H,I).

Female genitalia: Abdominal sternite VII with plica and fissura evident; plica narrow and transversely evolved; gonocoxae I squarish, large; paratergite VIII short, square, with visible spiracle; paratergite IX squarish, and larger than former paratergite (Fig. 2C,D,G,H). Spermatheca with bulb globose, duct heavily coiled.

Diagnosis: Like *Lygaeopharus* Stål, with rounded bucculae, short, without sharp mesal projection, femora unarmed, tylus unarmed and apically truncated or globose and hemelytra short. The females of both genera have abdominal sternite VII with plica and fissura evident.

The two genera can be separated on the basis of the following combination of characters. In *Grosshygia* the antenniferous tubercles are armed with either large or short robust lobes, the cephalic dorsum is nodule-like, scutellum is wider than long and with a convexly rounded disc; gonocoxae I larger, squarish, straight and not protruding past the apex of paratergite IX when viewed laterally; abdominal sternite VII with plica transversely narrowed. In *Lygaeopharus* the antenniferous tubercles are unarmed, cephalic dorsum slightly convex, scutellum longer than wide with disc not globose and gono-

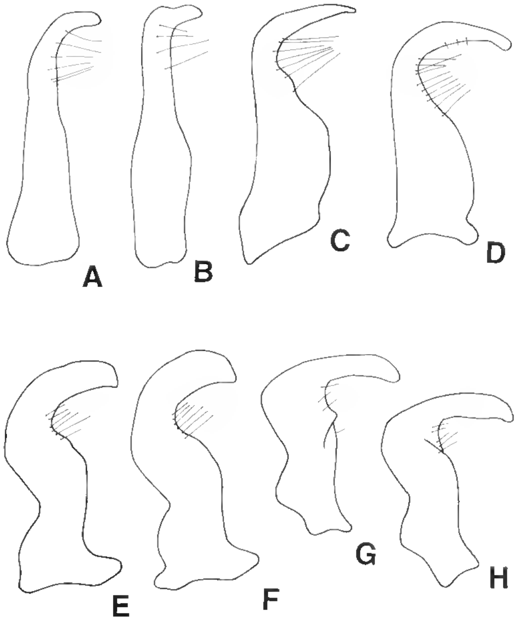


FIG. 6. Parameres, *Woodwardhygia bifida* sp. nov. (A,B), *Pachycolpura manca* Breddin (C,D), *Acantholybas brunneus* Breddin (E,F), *Pachycolpuroides monteithi* sp. nov (G,H).

coxae I short, triangular, outwardly projecting, reaching further than the apex of paratergite IX; abdominal sternite VII triangular and very broad.

ETYMOLOGY

Named for Gordon F. Gross in recognition of his many contributions to the study of Australian Heteroptera.

TYPE SPECIES

Grosshygia lobatula sp. nov.

Grosshygia lobatula sp. nov.
(Figs 1, 2A-D, 5F,G, 11A, 16A)

MATERIAL EXAMINED

HOLOTYPE ♂: NEQ: Zillie Falls, via Millaa Millaa, 12.viii.1968, B. Cantrell, in QMBA (T12709).

PARATYPES: NEQ: 1♀: Downey Ck, 25km SE Millaa Millaa, 7.xii.1988, GBM & Thompson (400m) in QMBA. 1 ♂: Mission Beach, 7.xii.1965, GBM, in UQIC. 1 ♂, 1♀ : Upper Boulder Ck, via Tully, 24-27.x.1983, GBM, Yeates & Thompson (650-900m), in QMBA. 6 ♂♂, 6♀♀ : Palmerston NP, via Innisfail, 23-25.iv.1968 & 7-8.viii.1968, GBM & B. Cantrell, 4 ♂♂ & 4♀♀ in UQIC & 2 ♂♂ & 2♀♀ in IBUNAM. 3 : Palmerston NP, Henrietta Ck, 29.xii.1964, GBM, in UQIC. 1 ♂, 1♀ : Palmerston NP, 2.i.1990, GBM in IBUNAM & QMBA. 1 ♂, 1♀ : Palmerston NP, 2.i.1990 (350-400m), GBM in QMBA. 1♀ : Upper Boulder Ck, 11km N Tully, 5-7.xii.1989 (1000m), GBM, Thompson & Janetzki in QMBA.

DESCRIPTION

Coloration: Body dark red brown, with following areas bright yellow ochre: antennal segment IV (except base), a large spot located near posterior edge of connexival segment III to VI, rostral segments I to IV and posterior angle of connexival segment III to VI; coxae bright red brown; trochanters bicoloured, with external side hazel brown and internal side bright yellow; anterior and middle femora dark hazel brown; posterior femora dark hazel brown with three yellow rings, one subbasal, other almost mesal and the third one subdistal including the greater part of the posterior half; tibiae pale hazel brown; tarsi pale hazel brown with yellow reflections.

Structure: Antenniferous tubercle armed, with lobes raised, extremely long, diverging anteriorly and with the apex acutely rounded (Fig. 1). Genital capsule: Posteroventral edge complete (Fig. 2A,B). Parameres. Fig. 5F,G.

Female: Coloration: Similar to male. Genital plate. Fig. 2C,D.

Variation: The type material has some colour variation, present on practically each specimen: 1. Upper side of postocular tubercle yellow ochre or entirely yellow ochre. 2. Rostral segments I and II pale hazel orange. 3. Posterior margin of connexival segments III to VI entirely yellow ochre. 4. Pleural margin of abdominal sternites III to VI with posterior margin yellow ochre. 5. Abdominal sternites dark red brown and conspicuously spotted with yellow ochre. 6. Anterior and posterior lobes of metathoracic scent glands dark orange. 7. Anterior and middle femora dark red brown with pale yellow ochre reflections. 8. Posterior femora yellow with two pale brown rings, one subbasal, other almost mesal. 9. Posterior tibiae pale hazel orange with two yellow internal reflections. 10. Tarsi yellow.

Measurements: ♂ first, then ♀: Head length: 1.72, 1.82; interocellar space: 0.58, 0.60; interocular space: 1.12, 1.16; width across eyes 1.64, 1.72; preocular distance: 1.32, 1.40; length antennal segments: I, 1.16, 1.14; II, 2.00, 1.96; III, 1.16, 1.16; IV, 1.24, 1.20. Pronotum: Total length of anterior lobe: 1.04, 1.08; total length of posterior lobe: 0.60, 0.60; total width of anterior lobe: 2.20, 2.36; total width of posterior lobe: 2.52, 2.56. Scutellar length: 0.88, 0.92. Width: 0.96, 0.98. Total body length: 9.66, 10.15.

DISTRIBUTION

In rainforest at high and low elevations, from southern Atherton Tableland to Mission Beach, NEQ (Fig. 16A).

ETYMOLOGY

Referring to the appearance of the antenniferous tubercles.

Grosshygia monticeps sp. nov.

(Figs 2E-H, 5H,I, 11B, 16A)

MATERIAL EXAMINED

HOLOTYPE ♂: NEQ: Upper Mulgrave R. via Gordonvale, 25.iv.1968, GBM & B. Cantrell, in QMBA (T12710).

PARATYPES: NEQ: 5 ♂♂, 1 ♀ : same data as holotype; 4 ♂♂ in QMBA and 1 ♂ and 1 ♀ in IBUNAM. 2 ♂♂: Upper Mulgrave R., 1-3.xii.1965, GBM, 1 in QMBA & 1 in IBUNAM. 1 ♂: Graham Ra., 9.iv.1979, GBM, 100-200m, in QMBA. 2 ♂♂: Bellenden Ker Ra., 1 km S Cable Tower 6, 17.x-5.xi.1981, 500m, Earthwatch/QM, pyrethrum knockdown, in QMBA; 1 ♂: Upper Mulgrave R., 30.IV.1970, GBM, in UQIC.

DESCRIPTION

Coloration: Body dark red brown, with dark orange reflections and with following areas bright or dark yellow ochre: antennal segment IV (except base), postocular tubercle, posterior edge of connexival segments III to VII, rostral segments II to IV and posterior edge or posterior angle of abdominal sterna III to VI; rostral segment I hazel orange; anterior and middle femora dark red brown with diffused dark yellow ochre spots; posterior femora mostly pale yellow with two or three incomplete dark red brown rings; tibiae and tarsi pale yellow ochre with orange brown reflections.

Structure: Antenniferous tubercles with short and robust lobes (Fig. 11B). Genital capsule: Posteroventral edge protruding, indented towards the middle line and laterally excavated (Fig. 2E,F). Parameres. Fig. 5H,I.

Female: Coloration: Similar to male. Genital plate, Fig. 2G,H.

Variation: The type material has some colour variation, present on practically each specimen: 1. All femora pale yellow ochre including the apex and with two or three rings dark red brown. 2. All tibiae dark red brown, with two yellow rings, one subbasal and the other near middle. 3. Posterior edge of abdominal sterna VII dark yellow ochre.

Measurements: ♂ first, then ♀: Head length: 1.80, 1.68; interocellar space: 0.54, 0.54; interocular space: 1.14, 1.12; width across eyes: 1.68, 1.62; preocular distance: 1.28, 1.22; length antennal segments: I, 1.14, 0.92; II, 1.72, 1.60, III, 1.04, 0.96; IV, 1.12, 1.08. Pronotum: Total length of: anterior lobe; 0.96, 1.00; total length of posterior lobe: 0.64, 0.52; total width of anterior lobe: 2.24, 2.02; total width of posterior lobe: 2.72, 2.46. Scutellar length: 0.92, 0.88; width: 1.08, 0.94. Total body length: 10.00, 8.70.

DIAGNOSIS

This species is similar in colour and general habitus to *G. lobatula*. In *G. monticeps* the antennal segment II is shorter (1.60 -1.72) and more robust, the antenniferous tubercle is armed with short and robust lobes (Fig. 11B) and the shape of the paramenes (Fig. 2A,B,E,F) is quite distinctive. In *G. lobatula* antennal segment II is larger (1.96-2.00) and more slender and the antenniferous tubercle is armed with extremely long lobes (Fig. 11A).

DISTRIBUTION

This species occurs at lowland rainforest sites in a restricted high rainfall area around the Bellenden Ker Ra., NEQ (Fig. 16A).

ETYMOLOGY

Referring to the appearance of the head viewed laterally.

Grosshygia nigra sp. nov.

(Figs 13D, 14, 16B)

MATERIAL EXAMINED

HOLOTYPE ♂: NEQ: Stewart Ck, 4km NNE Mt Spurgeon (Camp 1), 16°24'S 145°13'E, 15-20.x.1991 (1250-1300m), GBM, Janetzki, Cook & Roberts, in QMBA (T12711).

PARATYPES: NEQ: 1 ♂: same data as holotype, in IBUNAM. 1 ♂: 7km N Mt Spurgeon (Camp 2), 16°22'S 145°13'E, 17-19.x.1991 (1200-1250m), GBM, Janetzki, Cook & Roberts, in QMBA.

DESCRIPTION

Coloration: Body dark red brown, with following areas bright yellow ochre: antennal segment IV (except base), posterior edge of connexival segment III to VI and few spots scattered on the pronotal disc and on the abdominal sternites III to VI; coxae bright red brown; trochanters bright yellow with hazel brown reflections; femora pale yellow with four or five incomplete or complete hazel brown rings; tibiae and tarsi pale hazel brown. Structure: Head wider than long; antenniferous tubercle armed, with lobes, raised, extremely long, diverging anteriorly and with the apex acutely rounded; apex of scutellum globose. Hemelytra: Micropterous, reaching anterior third of abdominal segment II; membrane absent. Genital capsule: Posteroventral margin protruding as a feeble lip with edge complete.

Female: Unknown.

Variation: The type material has some colour variation. 1. Tibiae pale hazel brown with two yellow rings, one subbasal and the other almost mesial. 2. Tarsi pale yellow.

Measurements: ♂: Head length: 1.45; interocellar space 0.67; interocular space: 1.10; width across eyes: 1.55; preocular distance: 0.93; length antennal segments: I, 0.71; II, 1.14; III. 0.80; IV, 0.93. Pronotum: Total length of anterior lobe: 0.80; total length of posterior lobe: 0.43; total width of anterior lobe: 2.26; total width of posterior lobe: 2.63. Scutellar length: 0.65; width: 0.67. Total body length: 8.18.

Diagnosis

Like *G. lobatula*, has the antenniferous tubercle armed with extremely long lobes, diverging anteriorly and with the apex acutely rounded and the male genital capsule has the posteroventral margin protruding as a feeble lip with edge complete. *G. nigra* can be recognized by its head wider than long, apex of scutellum globose and hemelytra extremely micropterous just reaching anterior third of abdominal segment II. In *G. lobatula* the head is longer than wide, apex of scutellum subacute and hemelytra longer, reaching median third of abdominal segment III.

Distribution

From only higher, western parts of the Carbine Tableland, NW Mossman, NEQ (Fig. 16B).

Etymology

From the latin nigra, black.

Grosshygioides gen. nov.

Description

Head: Longer than wide (across eyes), pentagonal, non declivent and dorsally flat; tylus unarmed, apically globose, extending anterior to jugae and more raised when viewed laterally; jugae unarmed, thickened and shorter than tylus, mandibular plates, directly below apices of jugae with a large prominent tubercle; antenniferous tubercles unarmed; sides of head in front of eyes unarmed, straight and longer than total length of eye; antennal segment I shortest, robust, thickest, slightly curved outwards and shorter than length of head; segments II and III cylindrical, slender, IV fusiform; antennal segment II the longest and segment IV longer than III; ocelli absent; preocellar pit obliquely deep; eyes small, globular; postocular tubercle protuberant, globose; bucculae rounded, short, elevated, not projecting beyond antenniferous tubercle, angulate, without teeth and with the external edges thickened; rostrum long, reaching anterior margin of abdominal sternite VI; rostral segment I shortest, reaching the posterior gular region: rostral segment IV longest and rostral segments II and III subequal.

Thorax: Pronotum wider than long, trapeziform, non declivent; anterior collar wide; frontal angles projecting forward as rounded teeth; anterolateral borders weak and obliquely convex; humeral angles rounded, not exposed; posterolateral borders straight; posterior border concave; callar region convex, separated along the midline by a deep longitudinal furrow, which extends to the posterior margin. Anterior lobe of metathoracic scent gland globose and reniform, posterior lobe sharp, small.

Legs: Unarmed; tibiae cylindrical, with sulcus difficult to see and more slender than femora.

Scutellum: Triangular, flat, wider than long, with apex subacute.

Hemelytra: Staphylinoid, reaching posterior third of abdominal segment III; clavus and corium fused into a coriaceous pad and the wings meeting each other along the midline; hemelytral membrane absent.

Abdomen: Connexival segments practically at the same level as abdominal segments; posterior angle of connexiva not extending into short spines; abdominal sternites with medial furrow extending to posterior border of sternite VI.

Integument: Body surface rather dull. Pronotum, scutellum and hemelytra scattered punctate. Head, antennae, pronotum, scutellum, legs, hemelytra, thorax and abdomen with short decumbent to suberect golden or silvery bristle-like hairs, intermixed with long erect bristles in antennal segments and legs. Ventral surface with circular grey-white farinose punctures.

Female genitalia: Abdominal sternite VII with plica and fissura; plica narrow, elevated and transversely evolved, gonocoxae I squarish, large; paratergite VIII short, square, with spiracle visible; paratergite IX larger than paratergite VIII.

Diagnosis

The reduction of wings, the prominent postoeular tubercle, the pronotal disk with a deep midline furrow and abdominal sternite VII of the female with plica and fissura might suggest a relationship with *Grosshygia* Brailovsky.

In *Grosshygioides* the antenniferous tubercles are unarmed; the dorsal head is flat and the mandibular plates are armed with a large and prominent tubercle. In *Grosshygia* the antenniferous tubercles are armed, the dorsal head is conspicuously globose and the mandibular plates are unarmed.

ETYMOLOGY

Named for its external similarity to *Grosshygia*.

TYPE SPECIES

Grosshygioides mandibularis, sp. nov.

Grosshygioides mandibularis sp. nov.

(Figs 7, 10B, 16A)

MATERIAL EXAMINED

HOLOTYPE: ♀ NEQ: Mt Finnigan, 37 km S Cooktown, 19-22.iv.1982, GBM, Yeates & Cook (850-1100m) in QMBA (T12712).

PARATYPE: 1 ♀: NEQ: 2.5 km SW Mt Hartley, 35 km S Cooktown, 23-24.iv.1982, GBM, Yeates & Cook, in IBUNAM.

DESCRIPTION

Coloration: Body dark red brown, with bright or dull orange reflections and with following areas red orange yellow: posterior third of connexival segments III to VII and pleural margins of abdominal sternites III to VII; antennal segments I to III dark red brown and IV light yellow with base dark red brown; dorsal view of postocular tubercle, spot behind eyes and apex of scutellum yellow ochre; rostral segments I-IV pale hazel brown, coxae bright red brown; trochanters bicoloured, with external side brown hazel and internal side bright yellow; femora dark red brown with following areas yellow: one subbasal ring and few scattered ventral spots; tibiae pale orange brown with two or three yellow rings: one subbasal, other almost mesal and the third one subdistal; tarsi pale hazel brown with anterior or middle third yellow.

Measurements: ♀ holotype: Head length: 1.73; interocular space: 1.02; width across eyes: 1.58; preocular distance: 1.33; length antennal segments: I, 1.20; II, 1.82; III, 1.14; IV, 1.30. Pronotum: Total length: 2.04; width across frontal angles: 1.76; width across humeral angles: 3.00. Scutellar length: 1.05; width: 1.14. Total body length: 12.03.

DISTRIBUTION

Rare, known from two adjacent high altitude localities S of Cooktown, NEQ (Fig. 16A).

ETYMOLOGY

Named for the appearance of the mandibular plate.

Hygia (Australocolpura) subgen. nov.

DESCRIPTION

Head: Wider than long (across eyes), pentagonal, not elongate, dorsally flat, with frons not higher than eyes; tylus unarmed, apically globose, extending anterior to jugae and a little higher than them in lateral view; jugae unarmed, slightly thicker and shorter than tylus; genae unarmed; antenniferous tubercles unarmed with truncated apex; antennal segment I the shortest, robust, thickest, slightly curved outwards and shorter than total length of head; segment II and III cylindrical and IV fusiform; antennal segment II the longest, segment IV longer than III; ocelli conspicuous, raised and situated on an hypothetical line with superior margin just touching the inferior margin of eyes; preocellar pit deep; eyes globose; postocular tubercles prominent; bucculae angulate, short, not extending beyond antenniferous tubercles, with small spiny anterior projection; rostrum reaching the middle third or posterior edge of abdominal sternite III; rostral segment I reaching anterior margin of prosternum.

Thorax: Pronotum wider than long, trapeziform, with disc transversely cleft behind the callar region, leaving anterior and posterior thirds raised; anterior collar wide; frontal angles produced forward as conical teeth; anterolateral border weakly sinuate; humeral angles rounded, not exposed; posterolateral and posterior border straight; callar region transversely convex, separated along the middle line by a slight depression; posterior margin with a transverse ridge, distinctly raised. Anterior lobe of metathoracic scent gland globose and reniform, posterior lobe sharp, small.

Legs: Femora unarmed; tibiae terete, sulcate and more slender than femora.

Scutellum: Triangular, flat, wider than long, with apex acute.

Hemelytra: Macropterous, reaching middle third of posterior margin of the last abdominal segment; claval suture evident; apical margin obliquely straight, with a short apical angle not reaching the middle third of the hemelytral

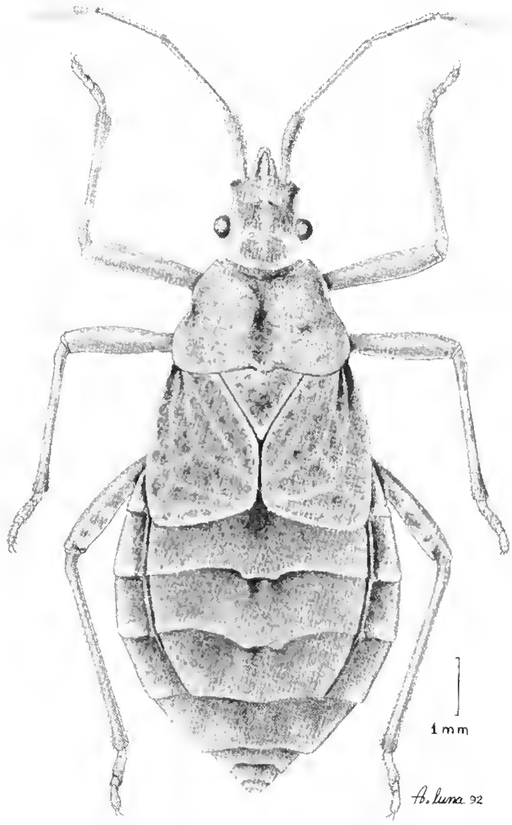


FIG. 7. Dorsal view of *Grosshygioides mandibularis* sp. nov., ♀.

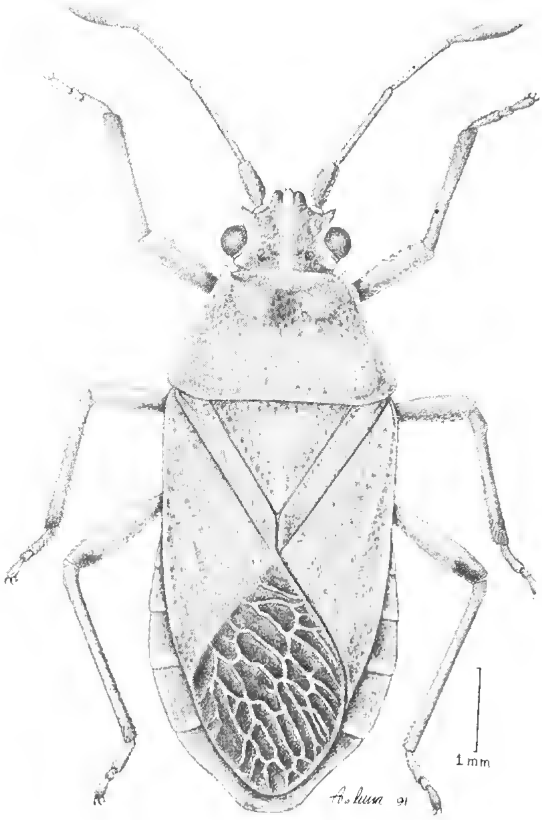


FIG. 8. Dorsal view of *Pachycolpuroides monteithi* sp. nov., ♂.

membrane; costal margin emarginate; hemelytral membrane with few bifurcate veins.

Abdomen: Connexival segments higher than body; posterior angle of connexival segments not produced into spines.

Integument: Body surface dull, covered by adpressed small hairs, not distinctly hairy. Pronotum (except callar region), scutellum, clavus, corium, thorax, abdominal sternites and exposed parts of genital segments of both sexes strongly punctate; head, antennae and legs minutely granulate.

Male genitalia: Genital capsule: Posteroventral border simple, truncate, with lateral borders weakly elongate (Fig. 4G).

Female genitalia: Abdominal sternite VII with plica and fissura; plica transversely broad, but never reaching the middle of the segment; gonocoxae I squarish, medium size, with a convex protruding external margin; paratergite VIII short, square, with visible spiracle; paratergite IX squarish and larger than former paratergite (Fig. 4E,F).

TYPE SPECIES

Hygia (Australocolpura) sandaracine sp. nov.

DIAGNOSIS

Hygia Uhler, contains nine subgenera, *Caracolpura* Breddin, *Colpura* Bergroth, *Eucolpura* Breddin, *Hygia* Uhler, *Microcolpura* Breddin, *Pterocolpura* Blöte, *Sphinctocolpura* Breddin, *Stenocolpura* Breddin and *Trichocolpura* Breddin, and approximately 72 species, widely distributed in the Oriental Region throughout Japan, China, Taiwan, India, Burma, Assam, Korea, Cambodia, Malacca, Sarawak (Borneo), West Malaysia, Sumatra, Singapore, Java, Philippines, Sulawesi (Celebes), Mentawei and New Guinea.

Hygia (Australocolpura) subgen. nov. is related to *Hygia (Caracolpura)*, the only species of which *H. (C). planiceps* (Breddin) occurs in

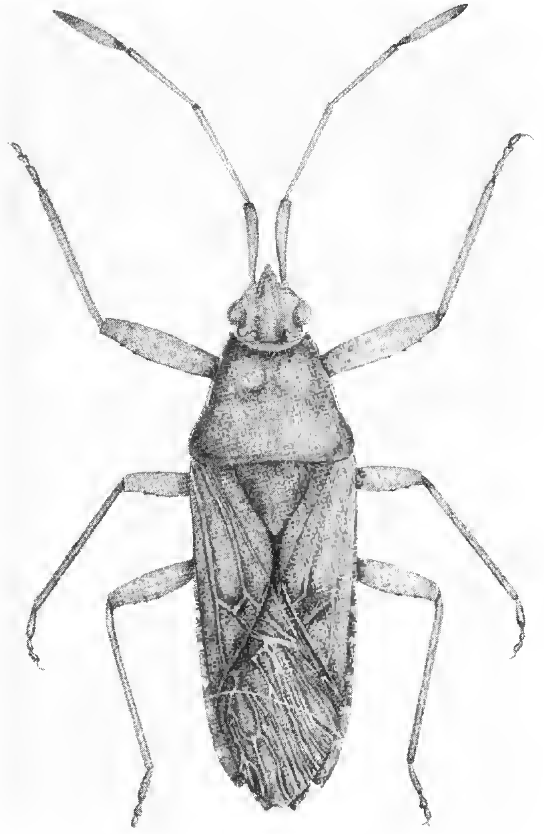


FIG. 9. Dorsal view of *Woodwardhygia bifida* sp. nov., ♀.

Sulawesi, sharing with it the following characters: 1. Body covered by adpressed small hairs, not distinctly hairy. 2. Genae completely unarmed. 3. Head not elongated, wide, above completely flat and the disc of frons not higher than eyes. 4. Femora unarmed. 5. Antenniferous tubercle unarmed. 6. Tylus globose or truncated. 7. Plica of abdominal sternite VII of the female transversely broad, but never surpassing the middle of that segment.

Members of this new subgenus are distinguished by the following combination of characters: anterior angle of the bucculae projecting as a small spine, corium without black spot, antennal segment III shorter than IV, transverse ridge of posterior border of pronotum quite raised; general body coloration is pale orange yellow. In *Hygia (Caracolpura)* the middle third of the bucculae projects as a large and acute spine, the apex of corium with a dark black spot, antennal segment III larger than IV, posterior border of pronotum not raised and general body coloration dark brown or black, with or without pale areas.

ETYMOLOGY

Named for its occurrence in Australia.

Hygia (Australocolpura) sandaracine sp. nov.
(Figs 4E,G, 11D, 16A)

MATERIAL EXAMINED

HOLOTYPE ♂: NSW: New England NP, 15.i.1978, E.I. Schlinger, in QMBA (T12713).

PARATYPE: 1♀: same as holotype, in CAS.

DESCRIPTION

Coloration: Pale orange yellow with following areas dark brown or black: apex of rostral segment IV, a large spot located below the spiracle of abdominal sternites III to VI, the genital capsule and a few scattered spots into the abdominal sternites III to VII; antennal segments I to III dark orange yellow and IV dark orange yellow with a wide subapical yellow ring; hemelytra membrane amber with veins pale yellow and following areas pale brown: basal margin and few cells into the disc; connexival segments orange brown, with posterior edge yellow; abdominal segments yellow with bright orange red reflections; anterior and posterior lobe of the metathoracic scent glands creamy yellow, punctures hazel orange.

Female: Same colour as male. Transverse carina of the posterior margin of pronotum, anterior third of claval suture and femora with bright red orange reflections; abdominal segments VIII-IX and abdominal sternites VIII-IX dark orange brown with connexival and pleural margins yellow ochre.

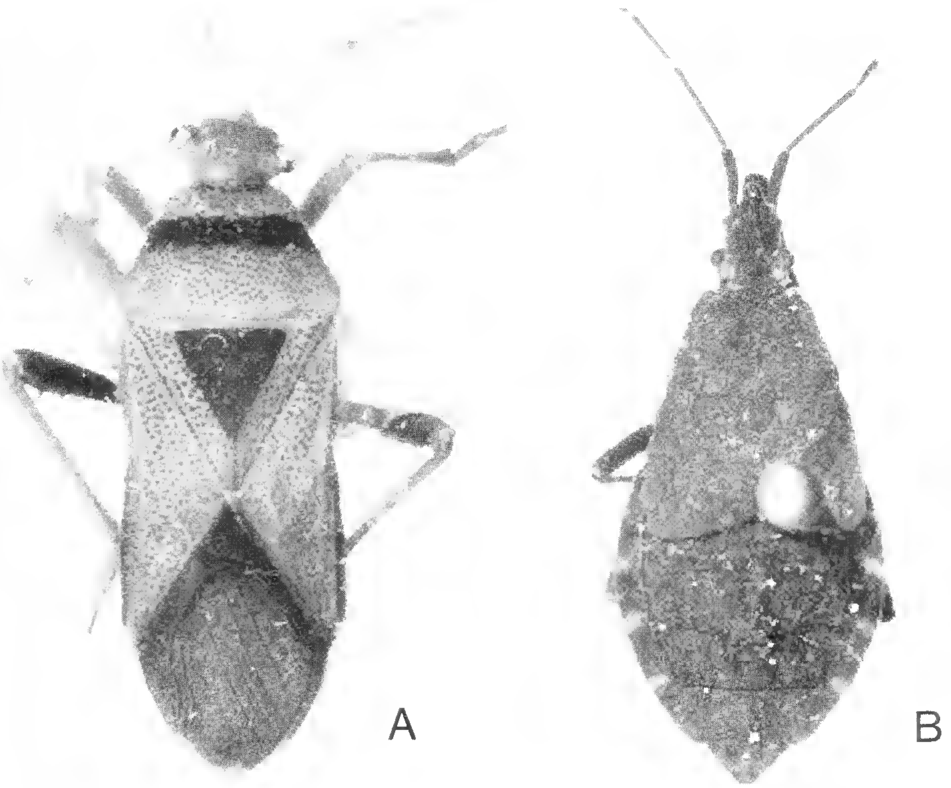
Measurements: ♂ first, then ♀: Head length: 1.33 1.48; interocellar space: 0.41, 0.48; interocular space: 0.89 1.01; width across eyes: 1.60, 1.76; preocular distance: 0.81, 0.89; length antennal segments: I, 1.22, 1.20; II, 1.72, 1.84, III, 1.20, 1.32; IV, 1.36, 1.41. Pronotum: Total length: 1.62, 1.96; width across frontal angles: 1.44, 1.60; width across humeral angles: 2.72, 3.08. Scutellar length: 1.14, 1.20; width: 1.32, 1.32. Total body length: 9.30, 10.65.

DISTRIBUTION

Known from a single pair from the high New England Tableland, NENSW (Fig. 64). The two specimens were collected in *Nothofagus* forest.

ETYMOLOGY

From the greek sandaracinos, orange coloured.



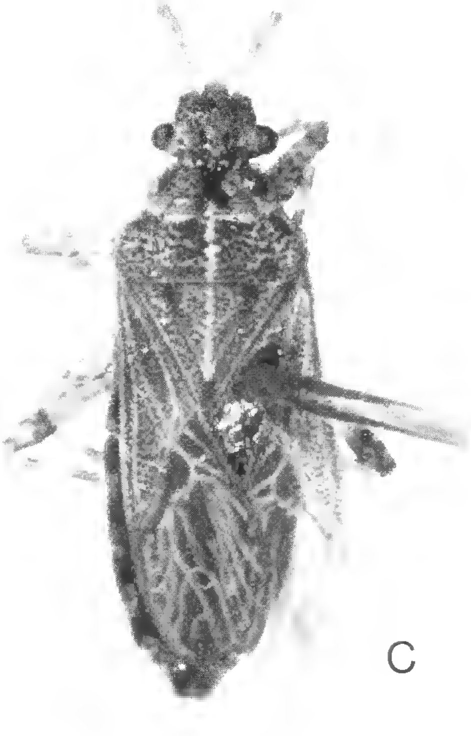


FIG. 10. Dorsal views, *Agathyrna praecellens* Stål ♂, (A), *Grosshygioides mandibularis* sp. nov., ♀ (B), *Acanthotyla fasciata* (Walker) ♀ (C).

Pachycolpuroides gen. nov.

DESCRIPTION

Head: Wider than long, pentagonal to subquadrate, scattered punctate and dorsally slightly convex; tylus unarmed, apically globose, extending anteriorly to the jugae and when viewed laterally practically level with them; jugae unarmed, thick and shorter than tylus; antenniferous tubercles armed with a long robust spine; sides of head in front of eyes unarmed; antennal segment I the shortest and shorter than head; segment II longest of all; segment IV longer than III; antennal segment I is the most robust, terete and somewhat curved outwards; segment II and III terete and slender; segment IV fusiform; ocelli not raised and based on an hypothetical line, the superior margin hardly in contact with eyes; preocellar pit deep and diagonally excavated; eyes elongate; postocular tubercle prominent; bucculae rounded, short, not projecting beyond antenniferous tubercle without teeth and with the external edges thickened; rostrum reaching the anterior margin of metasternum; rostral segment I reaching anterior margin of prosternum; rostral segment II longest; rostral segment I longer than IV and subequal to II and IV longer than III which is the shortest of all.

Thorax: Pronotum trapeziform, declivent, wider than long; collar distinct; frontal angles produced forward as conical teeth; anterolateral border obliquely straight; humeral angles rounded, not exposed, feebly convex in lateral view; posterolateral border and posterior border straight; callar region transversely convex, separated along the middle line by a slight depression. Anterior lobe of the metathoracic scent gland elevated, globose and reniform, posterior lobe sharp and small.

Legs: Unarmed; tibiae terete, sulcate and more slender than femora.

Scutellum: Triangular, flat, wider than long with apex acute.

Hemelytra: Macropterous condition (in both sexes) reaching posterior margin of abdominal segment VII; claval suture evident; apical margin obliquely straight, with a short apical angle, not reaching the middle third of the hemelytral membrane; costal margin slightly emarginate; hemelytral membrane composed of hexagonal or quadrate or elongate cells. Submacropterous condition (in both sexes): Reaching anterior or posterior margin of abdominal segment VI; clavus and corium clearly differentiated; membrane well developed, without cells and with only a few bifurcate veins (Fig. 12C,D).

Abdomen: Connexival segments higher than body, with posterior angles not produced into spines.

Male genitalia: Genital capsule: Posteroventral edge complete, thickened and with a slight median depression. Parameres. Body robust, with anterior lobe slightly convex and posterior lobe long and thick (Fig. 6G,H).

Female: Abdomen: Sternite VII complete, without plica or fissura. Genital plates: Gonocoxae I relatively short, oblique, with a concave and protruding external margin; paratergite VIII conspicuously short, square, with visible spiracle; paratergite IX elongated, with rounded margin that encompasses sternite X.

DIAGNOSIS

Externally this new genus resembles the general shape and colour pattern of *Pachycolpura* Breddin, which is the only genus within the tribe Colpurini that exhibits a long, pointed spine on the side of the head in front of the eyes.

In *Pachycolpuroides*, the frontal angle of the pronotum is produced forward as a conical tooth, the bucculae is uniformly rounded, the tylus is level with the jugum, the antenniferous tubercle is armed with a long spine and the abdominal sternite VII of the female complete without plica or fissura. In *Pachycolpura* the frontal angle is blunt and not protruding, the anterior angle of the bucculae is sharply protected, the tylus more raised than jugum, the antenniferous tubercle unarmed and truncated and sternite VII is totally cleaved (fissured) dividing the sternite into two parts with plica very short, sometimes difficult to see.

Like *Acantholybas* Stål this genus has the antenniferous tubercle armed, the femora unarmed and the abdominal sternite VII of the female complete without plica or fissura. *Pachycolpuroides* may be recognized by its short length, robust body, bucculae rounded without teeth or spiny projection, rostrum not extending beyond the anterior margin of metasternum, scutellum wider than long and the hemelytra with macropterous or submacropterous condition. In *Acantholybas* the body is large and a little more slender, the bucculae armed with a clear spine near the middle third, rostrum reaching the posterior border of abdominal sternite IV, scutellum longer than wide and the hemelytra always macropterous.

ETYMOLOGY

Named for its external similarity to *Pachycolpura*.

TYPE SPECIES

Pachycolpuroides monteithi sp. nov.

Pachycolpuroides monteithi sp. nov.
(Figs 6G,H, 8, 12C,D, 16B)

MATERIAL EXAMINED

HOLOTYPE ♂: Brisbane, 2.i.1963, GBM in QMBA (T12714).

PARATYPES: SEQ: 3 ♂♂, 5♀♀ : Brisbane, vii.1956, J.C. Donahue, 12.v.1959, B. Wilson, 9.iii.1956, H.J. Lavery, 5.iv.1964, A.E. May, iii.1955, N.J. Thompson, 30.vi.1966, B.K. Cantrell, 21.x.1956, T.A. Bull, 3 ♂♂ & 4♀♀ in UQIC & 1 ♀ in IBUNAM. 1 ♂: Bunya Mts, 14-15.x.1972, B.K. & J.A. Cantrell in UQIC. 1♀ : Millaa Millaa, 9.i.1964, GBM in UQIC. 1 ♂: Lamington NP, 17-24.v.1965, GBM in UQIC. 1 ♂, 2♀♀ : Mt Glorious, 5-15.vii.1964, T. Weir, 13.ix.1966, GBM, 1 ♂ & 1♀ in UQIC & 1 ♀ in IBUNAM. 3 ♂♂, 2♀♀ : NSW: Ebor, 11.iv.1966, GBM, B. Cantrell & T. Weir, 2 ♂♂ & 1 ♀in UQIC & 1 ♂ & 1 ♀in IBUNAM.

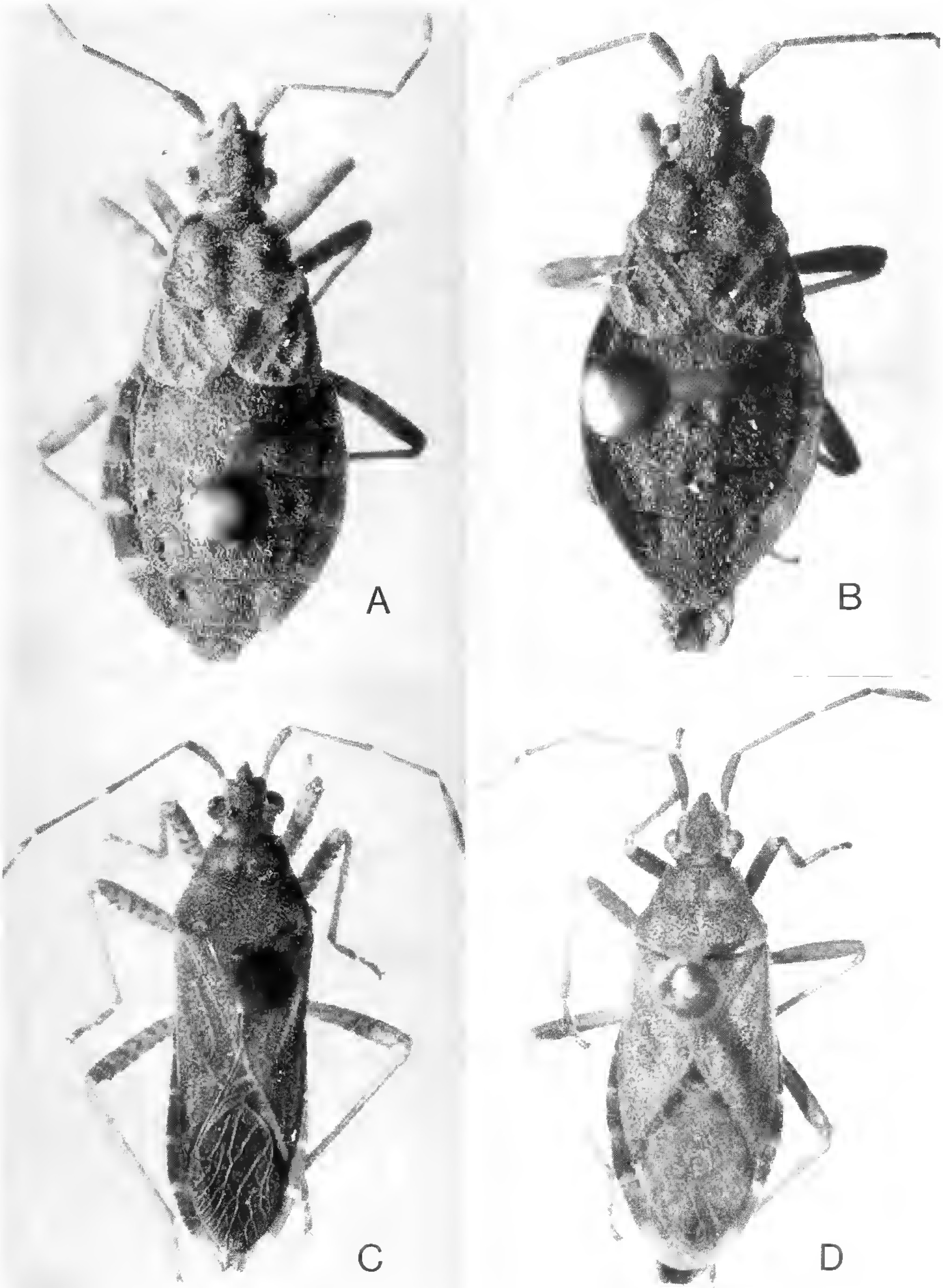


FIG. 11. Dorsal views, *Grosshygia lobatula* sp. nov., ♀(A), *G.monticeps* sp. nov., ♂(B), *Woodwardhygia bifida* sp. nov., ♂(C), *Hygia (Australocolpura) sandaracine* sp. nov., ♂(D).

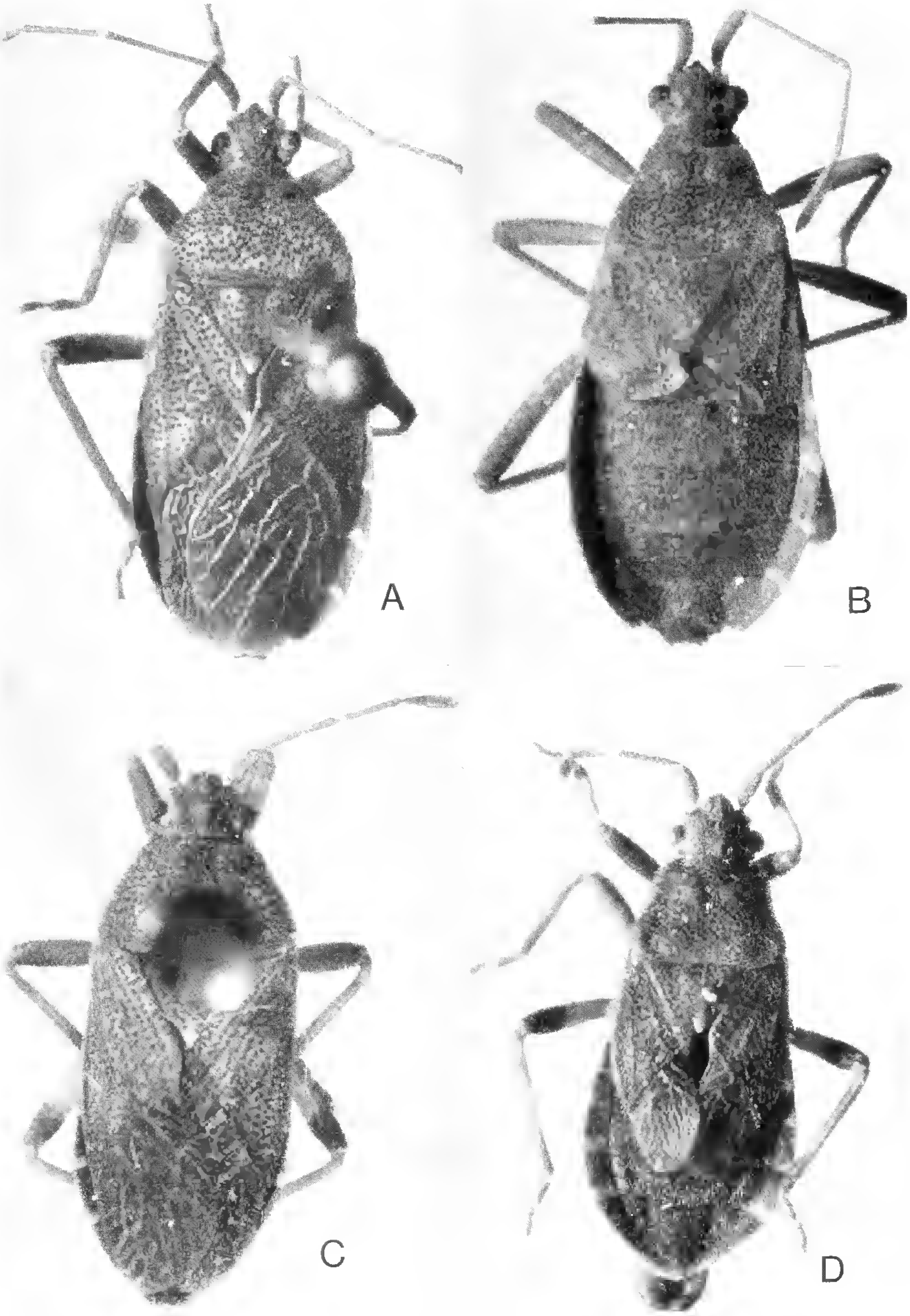


FIG. 12. Dorsal view *Pachycolpura manca* Breddin; macropterous, ♀(A), brachypterous, ♀(B): *Pachycolpuroides monteithi* sp. nov.; macropterous ♂(C), submacropterous ♂(D).

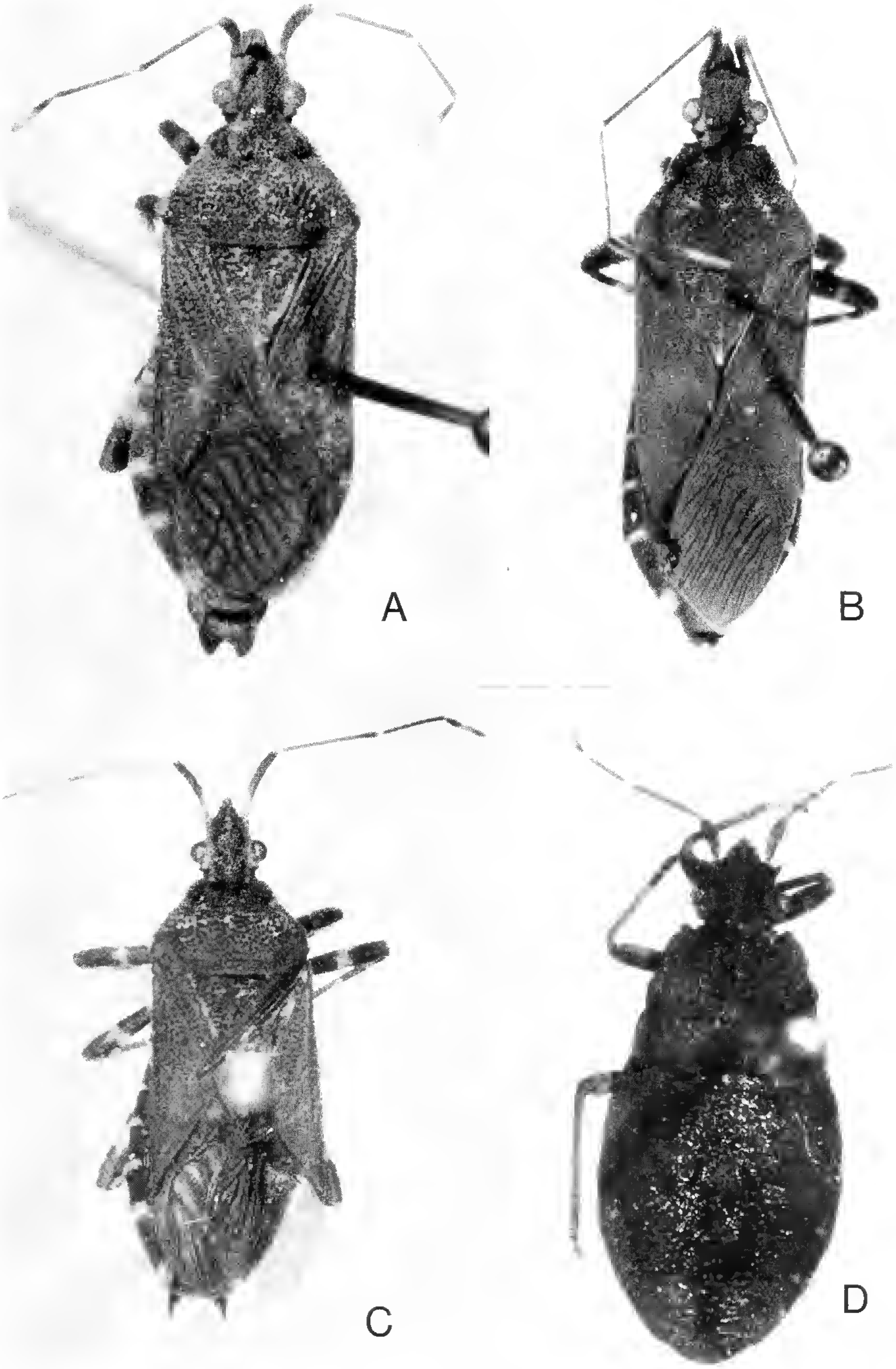


FIG. 13. Dorsal view *Sciophyrus* spp.; *S. diminutus* Horvath ♂ (A), *S. sortita* (Horvath) ♂ (B), *S. australicus* sp. nov. ♂ (C): *Grosshygia nigra* sp. nov. ♂ (D).

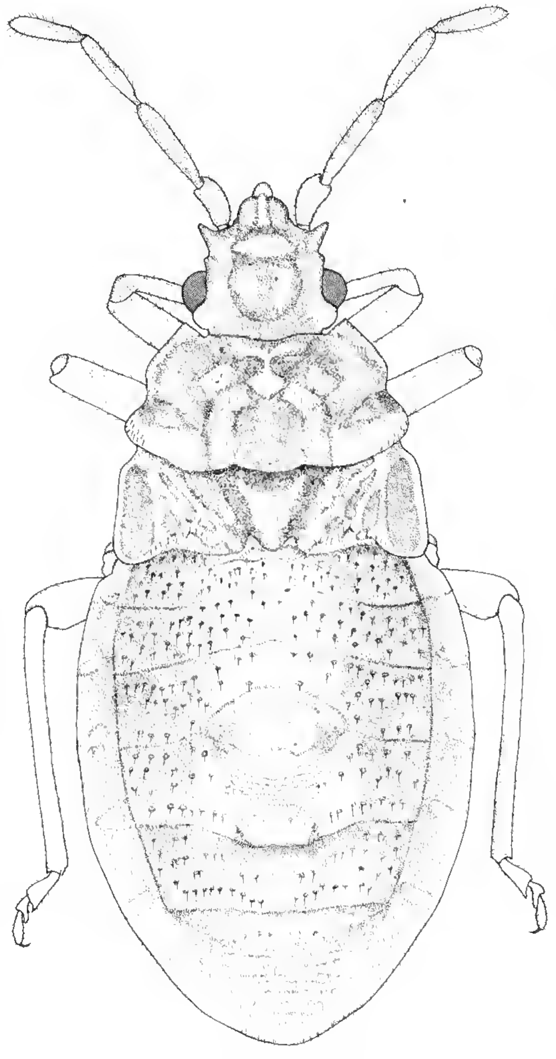


FIG. 14. Dorsal view of *Grosshygia nigra* sp. nov., ♂.

DESCRIPTION

Dorsal coloration: Pale yellow with following areas pale red orange: two wide bands running laterally along cephalic middle line, antennal segments II and III and the intercallar space; antennal segment IV bright orange yellow, with base bright red orange; postocular tubercle and apex of scutellum creamy white; hemelytral membrane amber brown with pale ochre veins; connexival segments brown red orange with posterior edge pale yellow; dorsal abdominal segments bright pale orange brown with yellow reflections; punctures of pronotum, scutellum, clavus and corium hazel orange or pale brown. Ventral coloration: Pale yellow with orange reflections; punctures hazel orange or pale brown or dark red brown; following areas black: discoidal spot in the anterior angle of mesothorax, two lateral spots on mesosternum and a line of discoidal spots running near the pleural margin of abdominal sternites III to VII; abdominal sternites III to VII with several red brown spots, irregularly scattered; coxae bright pale orange; trochanters bright yellow with red orange reflections; anterior and middle femora pale orange; posterior femora yellow with apical third and few spots pale orange; tibiae yellow with two pale orange rings, one subbasal and the other one distal; tarsi yellow with orange reflections; rostral segments I and II pale yellow and III-IV hazel yellow; anterior and posterior lobe of the metathoracic scent gland creamy white.

Female: Coloration: Similar to male. Abdominal segments VIII and IX and genital plates pale yellow with orange reflections.

Variation: The type material exhibits some colour variation on most specimens: 1. Antennal segment I bright orange red or pale yellow ochre. 2. Antennal segment IV bright orange red with apex bright orange yellow. 3. Dorsal pale orange red coloration replaced by pale brown hues. 4. Hemelytral membrane pale yellow or pale amber yellow with cells pale brown. 5. Dorsal abdominal segments dark red brown with middle portion bright orange with yellow reflections. 6. Prothorax, mesothorax and metathorax with black irregular spots. 7. Ventral granules of femora dark red brown. 8. Anterior edge of prosternum bright red brown. 9. Coxae bright red brown.

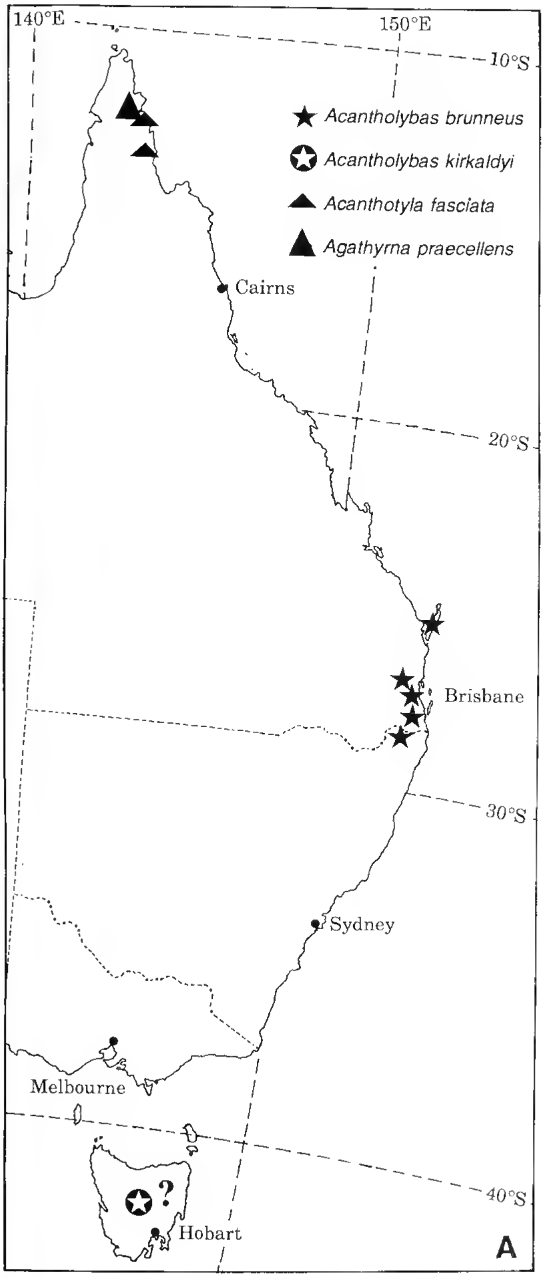
Measurements: ♂ macropter, ♂ submacropter, ♀macropter and ♀submacropter: Head length: 0.99, 0.96, 1.09, 0.99; interocellar space: 0.49, 0.43, 0.48, 0.46, interocular space: 0.91, 0.82, 1.01, 0.86; width across eyes: 1.45, 1.30, 1.53, 1.39; preocular distance: 0.66, 0.65, 0.71, 0.63; length antennal segments: I, 0.68, 0.58, 0.74, 0.65; II, 1.06, 0.83, 1.09, 0.86; III, 0.89, 0.71, 0.96, 0.71; IV, 0.89, 0.80, 0.93, 0.83. Pronotum: Total length: 1.70, 1.24, 1.86, 1.33; width across frontal angles: 1.39, 1.33, 1.42, 1.36; width across humeral angles: 2.72, 2.17, 3.03, 2.26. Scutellar length 1.30, 0.89, 1.42, 0.96; width: 1.45, 0.99, 1.64, 1.11. Total body length: 7.18, 6.18, 8.44, 6.70.

DISTRIBUTION

From the New England Tableland, NSW to Brisbane and the Bunya Mts, SEQ (Fig. 16B).

ETYMOLOGY

Named for Dr G.B. Monteith, Australian



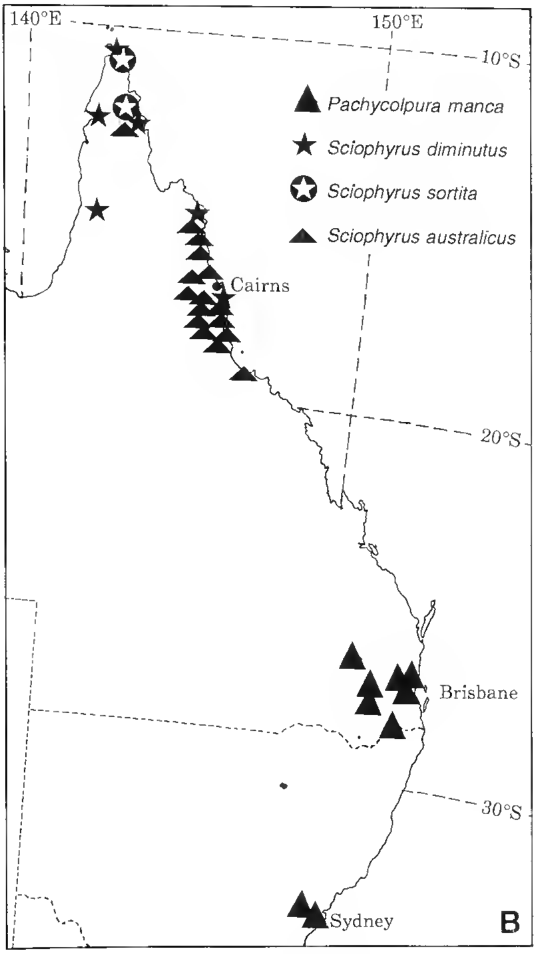


FIG. 15. Distributions, *Acantholybas brunneus* Breddin *Acantholybas kirkaldyi* Bergroth, *Acanthotyla fasciata* (Walker), *Agathyrna praecellens* Stål. (A): *Pachycolpura manca* Breddin, *Sciophyrus australicus* sp. nov. *Sciophyrus diminutus* Horvath; *Sciophyrus sortita* (Horvath) (B).

hemipterist of the Queensland Museum, and friend for many years.

Woodwardhygia gen. nov.

DESCRIPTION

Head: Wider than long, pentagonal and dorsally slightly convex; tylus unarmed, apically bifid, extending anteriorly to the jugae and more raised when viewed laterally; jugae unarmed, slightly thicker and shorter than tylus; antenniferous tubercles unarmed, with apex truncate; sides of head in front of eyes unarmed, straight and shorter than total length of eye; antennal segment I the shortest, robust, thickest, slightly curved outwards and equal or a little shorter than head; segments II and III terete and slender; segment IV fusiform; antennal segment II the longest, segment III longer or shorter than IV; ocelli conspicuously evident, raised and based on a hypothetical line with the superior margin just

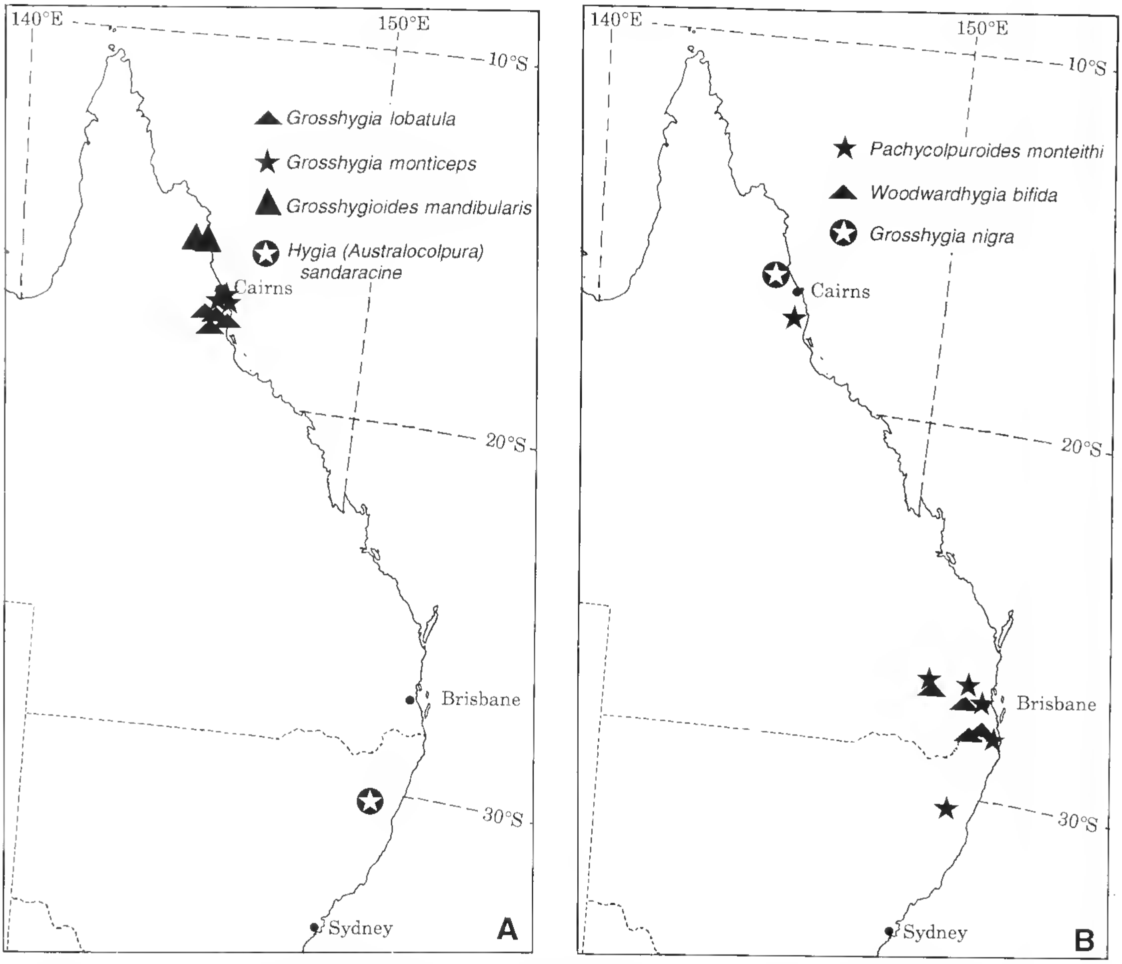


FIG. 16. Distributions, *Hygia (Australocolpura) sandaracine* sp. nov., *Grosshygia lobatula* sp. nov., *G. monticeps* sp. nov., *Grosshygioides mandibularis* sp. nov., (A): *Pachycolpuroides monteithi* sp. nov., *Woodwardhygia bifida* sp.nov., *Grosshygia nigra* sp. nov. (B).

touching the inferior border of the eyes; preocellar pit deep and circular; eyes substylate; postocular tubercles protuberant; bucculae rounded, short, not extending beyond antenniferous tubercle, with sharp spiny anterior projection; rostrum long, reaching the medial third of abdominal sternite IV; rostral segment II longest, I longer than IV and IV longer than III, which is the shortest; rostral segment I reaching anterior margin of prosternum.

Thorax: Pronotum wider than long, trapeziform, moderately declivent; anterior collar wide; frontal angles produced forward as conical teeth; anterolateral border obliquely straight; humeral angles rounded not exposed; posterolateral and posterior borders straight; callar region transversely convex, separated along the middle line by a slight longitudinal depression. Anterior lobe of metathoracic scent gland globose and reniform, posterior lobe sharp, small.

Legs: Femora with two rows of small spines and granules along ventral surface; tibiae terete, sulcate and more slender than femora.

Scutellum: Triangular, flat, wider than long, with apex subacute.

Hemelytra: Macropterous, reaching posterior margin of the last abdominal segment or extending beyond the apex; claval suture evident; apical margin obliquely straight with a short apical angle not reaching the middle third of the hemelytral membrane; costal margin emarginate; hemelytral membrane with few bifurcate veins.

Abdomen: Connexival segments higher than body, with posterior angles not produced into spines: abdominal sternites with medial furrow extending to posterior border of sternite IV or V.

Integument: Body surface rather dull. Head, pronotum, scutellum, clavus, corium, thorax, abdominal sterna and exposed parts of genital segments of both sexes strongly punctate; antennae and legs minutely granulate. Head, pronotum, scutellum clavus, corium, thorax and abdominal sterna with short decumbent silvery bristle-like hairs, intermixed with a few long erect hairs located on the abdominal sterna.

Male genitalia: Genital capsule: Posteroventral edge elongate and bifurcated, with a short depression between the two lobes (Fig. 4A,B). Parameres: body simple and straight; apical projection short with anterior lobe convex and continuous with the body and posterior lobe short and slender (Fig. 6A,B).

Female genitalia: Abdominal sternite VII with plica and fissura; plica narrow, elevated and transversely evolved; gonocoxae I relatively short, with a convex protruding external margin; paratergite VIII short square, with visible spiracle; paratergite IX squarish and larger than former paratergite (Fig. 4C,D).

DIAGNOSIS

Woodwardhygia gen. nov., most closely resembles *Homalocolpura* Breddin, including the femora armed with two rows of ventral spines, antenniferous tubercle and tylus unarmed and the abdominal sternite VII of the female with plica and fissura.

In *Woodwardhygia* the anterior angle of the bucculae is sharply projected, the tylus apically bifid, antennal segment II longer than IV, rostrum shorter, reaching the medial third of abdominal sternite VI, the femora and tibiae are longer and more slender and the plica narrow and transversely evolved. In *Homalocolpura* the bucculae are uniformly rounded, the tylus is apically rounded or truncated, antennal segment II is shorter than IV, rostrum longer, reaching or extending beyond the apex of the last abdominal sternite and the plica is wider and triangular.

An additional character to separate the two genera is the coloration. In *Homalocolpura* the total body surface is bright and highly polished with femora unspotted, vs a dull body surface, with femora spotted with dark red brown discoidal spots in *Woodwardhygia*.

ETYMOLOGY

Named for the late Dr T.E. Woodward, distinguished Australian hemipterist.

TYPE SPECIES

Woodwardhygia bifida sp. nov.

Woodwardhygia bifida sp. nov.
(Figs 4A-D, 6A,B, 9, 11C, 16B)

MATERIAL EXAMINED

HOLOTYPE ♂: NSW: Tooloom Plateau, via Urbenville, 31.x.1970, GBM in QMBA (T12715).

PARATYPES: 1 ♂, 4 ♀ ♀ : same as holotype; 1 ♂ & 2 ♀ ♀ in UQIC & 2 ♀ ♀ in IBUNAM. SEQ: 3 ♂ ♂, 2 ♀ ♀ : Bunya Mts, 14.xii.1937, F.A. Perkins, 5.vi.1959, I.C. Yeo & F. McDonald and 18-19.x.1972 B. Cantrell 2 ♂ ♂ & 2 ♀ ♀ in UQIC & 1 ♂ in IBUNAM. 1 ♂: Lamington NP, 19-22.v.1963, H.A. Rose in UQIC. 1 ♂: Tomewin Ra., Upper Currumbin, 17.v.1988, GBM in IBUNAM. 1 ♂: Brisbane, 6.v.1953, Y. Beri in UQIC. 1 ♀ : no locality or date in UQIC.

DESCRIPTION

Dorsal coloration: Pale orange brown with following areas yellow or yellow ochre: jugae, a short longitudinal band running between eye and ocelli up to posterior edge, postocular tubercle, most of the anterolateral borders of pronotum, a short longitudinal stripe on middle pronotal disc, apex of scutellum and posterior margin of connexival segments III to VII; tylus and vertex dark brown; ocellar tubercle, internal and external border of callus and irregular spots on corium black; antennal segments, I to III pale orange yellow with red brown spots on I; segment IV bright red brown with a subbasal bright orange yellow ring; hemelytral membrane brown with basal veins yellow; abdominal segments I to III and VII black and IV to VI bright orange yellow; punctures dark red brown or pale orange hazel. Ventral coloration: yellow to creamy yellow with following areas black: a small spot located on prothorax, mesothorax and abdominal sterna III to VI; rostral segment I yellow ochre and II to IV orange hazel; coxae and trochanters yellow; femora yellow and densely covered with dark red brown discoidal spots; tibiae and tarsi pale yellow orange with dark red brown granules; anterior lobe of metathoracic scent gland creamy yellow and posterior lobe brown hazel; punctures orange hazel; abdominal sterna scattered with pale red brown spots.

Female: Coloration: Similar to male. Abdominal segments VIII and IX black; genital plates yellow, with punctures orange hazel;

paratergite VIII and IX with or without pale red brown discoidal spot.

Measurements: ♂ first, then ♀ : Head length: 1.45. 1.68; interocellar space: 0.49, 0.64; interocular space: 0.84, 1.01; width across eyes: 1.64, 1.88; preocular distance: 0.89, 1.01; length antennal segments: I, 1.44, 1.68; II, 2.04, 2.64; III, 1.64, 2.00; IV, 1.83, 1.90. Pronotum: Total length: 2.08, 2.84; width across frontal angles: 1.48, 1.82; width across humeral angles: 3.04, 3.88. Scutellar length: 1.48, 1.80; width 1.56, 1.92. Total body length: 11.30, 13.40.

DISTRIBUTION

From mountains and plateaux in NENSW and SEQ (Fig. 16B). One specimen labelled 'Brisbane' needs confirmation.

ETYMOLOGY

Named for the bifid apex of its tylus.

ACKNOWLEDGEMENTS

The following individuals and institutions provided loans and other assistance: Dr Gordon Nishida (BPBM), Mrs Margerison Knight (BMNH) Dr Norman D. Penny (CAS), Dr Andreas Taeger (DEI), Drs Gordon F. Gross, E.G. Matthews and K.L. Gowlett Holmes (SAMA), Mr T. Weir (ANIC), Dr G.B. Monteith (QMBA), Miss Margaret Schneider (UQIC), Dr I.M. Kerzhner (ZIL) and Dr Antti Janson (ZMUH). Biol. Ernesto Barrera, Mrs Elvia Esparza, Mr Felipe Villegas, Biol. Cristina Mayorga, Biol. Laura Gonzalez Garcia and Biol. Albino Luna (IBUNAM) prepared the dorsal view illustrations and genital drawings. To the Consejo Nacional de Ciencia y Tecnología, México (C-ONACyT) and Dirección General del Personal Académico de la Universidad Nacional Autónoma de México (DGPA) provided financial assistance. Dr G.B. Monteith commented on the manuscript. The distribution maps were drawn by Mr G.I. Thompson, Queensland Museum.

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CARIDINA ZEBRA, A NEW SPECIES OF FRESHWATER ATYID SHRIMP (CRUSTACEA: DECAPODA) FROM NORTHEASTERN QUEENSLAND RAINFOREST

JOHN W. SHORT

Short, J.W. 1993 12 24: *Caridina zebra*, a new species of freshwater atyid shrimp (Crustacea: Decapoda) from northeastern Queensland rainforest. *Memoirs of the Queensland Museum* 34(1):61-67. Brisbane. ISSN 0079-8835.

A new species of freshwater atyid shrimp, *Caridina zebra*, from high altitude (>400 m) rainforest, northeastern Queensland, is described and illustrated. It is allied to the *typus* species-group, characterized by a short, dorsally unarmed rostrum and most closely resembles the wide-ranging species, *C. typus* H. Milne Edwards, 1837. Morphology of the rostrum and telson, and the large size of developed ova (1.1 mm length), a feature indicative of abbreviated or direct larval development readily distinguish it from *C. typus*. A distinctive black and white banded pattern distinguishes *C. zebra* from all known Indo-West Pacific species. ☐ *Crustacea, Atyidae, Caridina, new species, northeastern Australia, freshwater, rainforest, taxonomy, biology, survival status.*

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Australian species of *Caridina* were last revised by Riek (1953) who recorded 7 species: *C. gracilirostris* De Man, 1892; *C. indistincta* Calman, 1926; *C. mccullochi* J. Roux, 1926; *C. nilotica* (P. Roux, 1833); *C. serratirostris* De Man, 1892; *C. thermophila* Riek, 1953; and *C. typus* Milne Edwards, 1837. These are primarily lowland species, although *C. serratirostris* and *C. typus* occur at moderate elevations in northeastern Queensland. High altitude species have previously been described from New Caledonia (J. Roux, 1926a; Holthuis, 1970) and Fiji (Choy, 1983, 1984) in the Southwest Pacific Region.

Caridina zebra sp.nov. was first collected by Dr S. Bunn and Mr M. Bray, Griffith University during a limnological study for the proposed Tully-Millstream hydroelectric scheme in 1990. Material from the upper Tully and Herbert R. catchments brought to the Queensland Museum for identification showed affinities with *C. typus*, but the distinctive unarmed rostrum and large eggs immediately suggested that the species was new. A Queensland Museum expedition to the area (November, 1992) yielded further material and habitat information. Distinctive colour in life confirmed its new species status.

Further material was examined from the Queensland Fisheries Johnstone Rivers Survey at the invitation of Mr Warren Lee Long, Northern Fisheries Research Centre, Cairns. Two additional specimens were later discovered in the Queensland Museum collection, mis-identified as *C. typus*.

MATERIAL AND METHODS

All material examined is deposited in the Queensland Museum collection. Measurements were made with the aid of a stereo microscope and vernier callipers or an eyepiece micrometer. A camera lucida was used for the line drawings.

Physico-chemical habitat data were obtained using a TPS LC82 dissolved oxygen meter, mercury thermometer, Merck Universalindikator pH 0-14 paper, and an Aquasonic water hardness test kit. Altitudes were estimated from the Australia 1:100 000 topographic survey map series R631. The classification of rainforest types follows Webb & Tracey (1981).

Cuticle spination and setation terminology follows Felgenhauer (1992). In particular, 'hamate setae' (stout, modified setae) have been classified as spines or spinules by previous atyid workers. The term 'spine' is restricted here to large cuticular processes without a basal socket formed by folding or extrusion of the epidermis (e.g. the antennal spine). Generally setae are easily distinguished by the presence of a well-defined basal socket and often the integument is of different appearance to the surrounding cuticle (i.e. more sclerotinous or less pigmented). Developed ova are defined by the presence of eye spots. Ovigerous females are explicitly recorded whereas non-ovigerous specimens are recorded simply as 'females'.

Abbreviations used in text: QM, Queensland Museum; OCL, carapace length measured from orbital margin to dorsolateral invagination of posterior margin; TBL, total body length from orbital carapace margin to tip of telson; P, pereiopod; Pl, pleopod.

Caridina zebra sp.nov.

(Figs 1-4)

MATERIAL EXAMINED

HOLOTYPE: QM W18718, ♂ (3.4 mm OCL), O'Leary Ck, 17°50.7'S, 145°37.7'E, fringing simple notophyll vine forest, altitude c.750 m, water depth 0.1-0.5 m, scoop-netted, 06/11/1992, J. Short, P. Davie.

ALLOTYPE: QM18719, ovig. ♀ (5.0 mm OCL), same data as holotype.

PARATYPES: QM W18120, 2♂♂ (2.9, 3.4 mm OCL), 13 ovig. ♀♀ (4.0 - 4.9 mm OCL), 10♀♀ (3.5 - 4.8 mm OCL), same data as holotype; QM W18131, 3♂♂ (3.2 - 3.8 mm OCL), ovig. ♀ (4.3 mm OCL), ♀ (3.3 mm OCL), same locality data as holotype, 0.5-1.5 m, trapped, 07/11/1992, J. Short, P. Davie; QM W18719, ♀ (5.0 mm OCL), same data as holotype; QM W18124, ♂ (3.4 mm OCL), 2 ovig. ♀♀ (4.3, 4.4 mm OCL), Tully R. nr Old Culpa, 17°55.5'S, 145°37.6'E, fringing simple notophyll vine forest, altitude c.720 m, water depth 1.0 m, scoop-netted, 06/11/1992, J. Short, P. Davie; QM W18127, 5♂♂ (3.6 - 3.9 mm OCL), ovig. ♀ (4.6 mm OCL), 3 ♀♀ (3.7 - 4.3 mm OCL), same data as W18124; QM W19158, 24♂♂ (3.1 - 4.2 mm OCL), 9 ovig. ♀♀ (4.4 -5.0 mm OCL), 29♀♀ (3.1 - 4.7 mm OCL), Cardwell Ra., 18°01'S, 145°37'E, small headwater creek, fringing disturbed simple notophyll vine forest, altitude c.900 m, netted, 07/11/1992, J. Short, P. Davie.

ADDITIONAL MATERIAL: QM W17117, ♂ (3.6 mm OCL), Koolmoon Ck, 17°44'S, 145°33'E, fringing complex notophyll vine forest, altitude c.750 m, 25/07/1990, S. Bunn, M. Bray; QM W17119, 3♂♂ (3.9 - 5.1 mm OCL), ♀ (5.5 mm OCL), Koolmoon Ck, 17°44'S, 145°34'E, 25/07/1990, S. Bunn, M. Bray; QM W17116, 2♂♂ (3.2, 3.3 mm OCL), ♀ (3.7 mm OCL), Blunder Ck, 17°46'S, 145°32'E, fringing complex notophyll vine forest, altitude c.750 m, 28/11/1990, S. Bunn, M. Bray; QM W17118, ♂ (2.8 mm OCL), 2 ovig. ♀♀ (3.8, 4.5 mm OCL), 2 ♀♀ (4.0 mm OCL), same locality and habitat data as W18124, 28/11/1990, S. Bunn, M. Bray; QM W18841, ♂ (4.5 mm), Thiaki Ck, 17°24.9'S, 145°35.3'E, altitude c.750 m, water depth 0.2 m, electro-fished, 1992, Queensland Fisheries Johnstone Rivers Survey; QM W3078, 2♂♂ (3.8, 4.7 mm OCL), Atherton, from tap water, 14/05/1962, Department of Primary Industries; QM W18720, ♂ (3.9 mm OCL), 2♀♀ (4.3, 4.5 mm OCL), small creek c.6 km SW of Malanda, 17°22.7'S, 145°33.6'E, fringing *Brachiaria mutica* (Para Grass), water depth 0.2-1.5 m, altitude c.750 m, electro-fished, 1992, Queensland Fisheries Johnstone Rivers Survey; QM W18722, 12♂♂ (3.6 - 4.0 mm OCL), 5 ovig. ♀♀ (4.6 - 5.2 mm OCL), 10♀♀ (3.8 - 5.4 mm OCL), Goolagan Ck, 17°36.3'S, 145°45.5'E, fringing complex mesophyll vine forest, altitude c.400 m, electro-fished, 1992, Queensland Fisheries Johnstone Rivers survey; QM W18725, 13♂♂ (3.2 - 4.8 mm OCL), 16♀♀ (3.8 - 6.1 mm OCL), same data as W18841.

DESCRIPTION OF MALE HOLOTYPE

Cephalothorax. Rotund, breadth c.0.7 X OCL, depth c.0.9 X OCL; glabrous; smooth. Rostrum short, c.0.4 X OCL, reaching intermediate segment of antennular peduncle; unarmed; non-setose; acuminate; elongate triangular in dorsal view, dorsal carina poorly developed, slightly convex, commencing slightly behind orbit, lateral carinae strongly expanded, ventral carina obsolete. Carapace with inferior orbital margin produced, obtuse, strongly revolute; postantennal margin markedly concave, acute at junction with inferior orbit (developed as antennal spine in some paratypes); pterygostomial angle bluntly angular, well produced. Eyes with cornea large, globular, well-pigmented, hemispherical, peduncle short, broad. Stylocerite well developed, acute, slightly shorter than basal antennular segment; anterolateral spine on basal antennular peduncle segment well developed, reaching proximal half of second peduncular segment. Scaphocerite broad, mesial lamina margin strongly convex; distolateral spine well developed, about level with distal margin of antennular peduncle, distal lamina ovate (distomesially produced in some paratypes). Branchial formula typical for genus. Epipods on P1 - P4 well developed.

Mouthparts. Mandibles dimorphic; left mandible the more developed, corpus large, robust, with broad multi-cuspidate incisor process, molar process ridged, patch of long setae between incisor and molar processes; right mandible with narrow, multi-cuspidate incisor process, molar process narrow, elongate, ridged, patch of long setae between molar and incisor processes. Maxillula with broad, setose palp; basal endite elongate with row of mesial hamate setae decreasing in size distally; coxal endite large, rounded. Maxilla with well-developed, setose palp; basal endite elongate, densely setose mesially; coxal endite rounded, setose mesially; scaphognathite elongate, anterior lobe rounded, fringed with long setae, posterior lobe tapered, bearing long setae at tip. First maxilliped with elongate setose palp; basal endite elongate, setose; coxal endite setose mesially; exopod well developed, caridean lobe large, elongate. Second maxilliped with ischium and basis fused; flagellum very long, slender; dactylus with mesial margin slightly concave, densely setose; propodus sub-rectangular, mesial margin with long setae; carpus, merus and is-

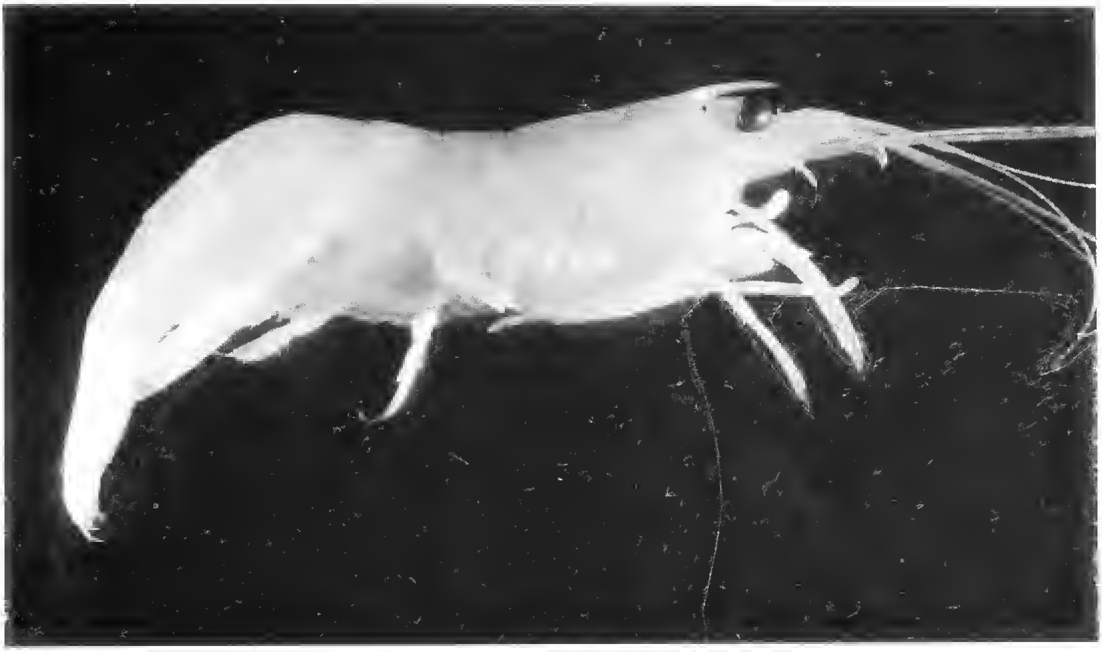

FIG.1. *Caridina zebra* sp.nov., QM W18718, ♂ holotype (3.4 mm OCL). Alcohol preserved.

chium sparsely setose; coxa setose, medially produced; podobranch well developed, with branchial lamella. Third maxilliped with terminal segment reaching distal antennal peduncle, compressed, unguiculate, slightly uncinate, about equal to penultimate segment in length, with longitudinal row of small hamate setae distally, closely-spaced transverse rows of long simple setae proximally, exopod flagellum clearly exceeding ischiomerus in length; ischiomerus and basis fused.

Pereiopods. P1 failing to reach distal antennal peduncle, propodus length slightly more than twice manus width, manus proximo-laterally produced (strongly produced in large paratypes); fingers short, robust, about equal in length to manus, setal brushes well developed; carpus distinctly shorter than chela, articulating with ventral propodus, excavated disto-dorsally, dorsal projection setose; merus broad, compressed, distinctly longer than carpus and chela. P2 more elongate than P1; reaching slightly beyond antennal peduncle; propodus length about twice manus width; fingers short, robust, slightly longer than manus, setal brushes well developed; carpus distinctly longer than chela, about equal in length to merus, subconical; merus compressed, about equal in length to carpus. P3 reaching beyond distal scaphocerite; dactylus c.0.2 X propodus length, armed with row of five robust, hamate setae; posterior margin of propodus bearing numerous small hamate setae; carpus with well developed distal projection, posterior surface with transverse rows of hamate setae, lateral margin with few hamate setae, much shorter than propodus and merus; merus the longest segment, slightly bowed, with few hamate setae along posterior margin.

P4 similar to P3, just failing to reach distal scaphocerite margin. P5 reaching past antennal peduncle but clearly failing to reach distal scaphocerite margin; dactylus unguiculate, compressed, about one quarter length of propodus, posterior margin with comb row of numerous hamate setae gradually increasing in length distally; carpus slightly less than half propodus length, bearing well developed distal projection and large distal hamate seta; merus slightly shorter than propodus, with few large hamate setae.

Abdomen. Well developed, c.2.9 X OCL; rotund; glabrous; smooth. Pl1 with well developed appendix interna arising from sub-distal endopod; endopod compressed, elongate, narrowing distally, width less than half length, margins setose.

Appendix masculina on Pl2 arising near base of endopod along with appendix interna, elongate but clearly shorter than endopod, anterior face and tip setose, apical setae hamate; endopod and

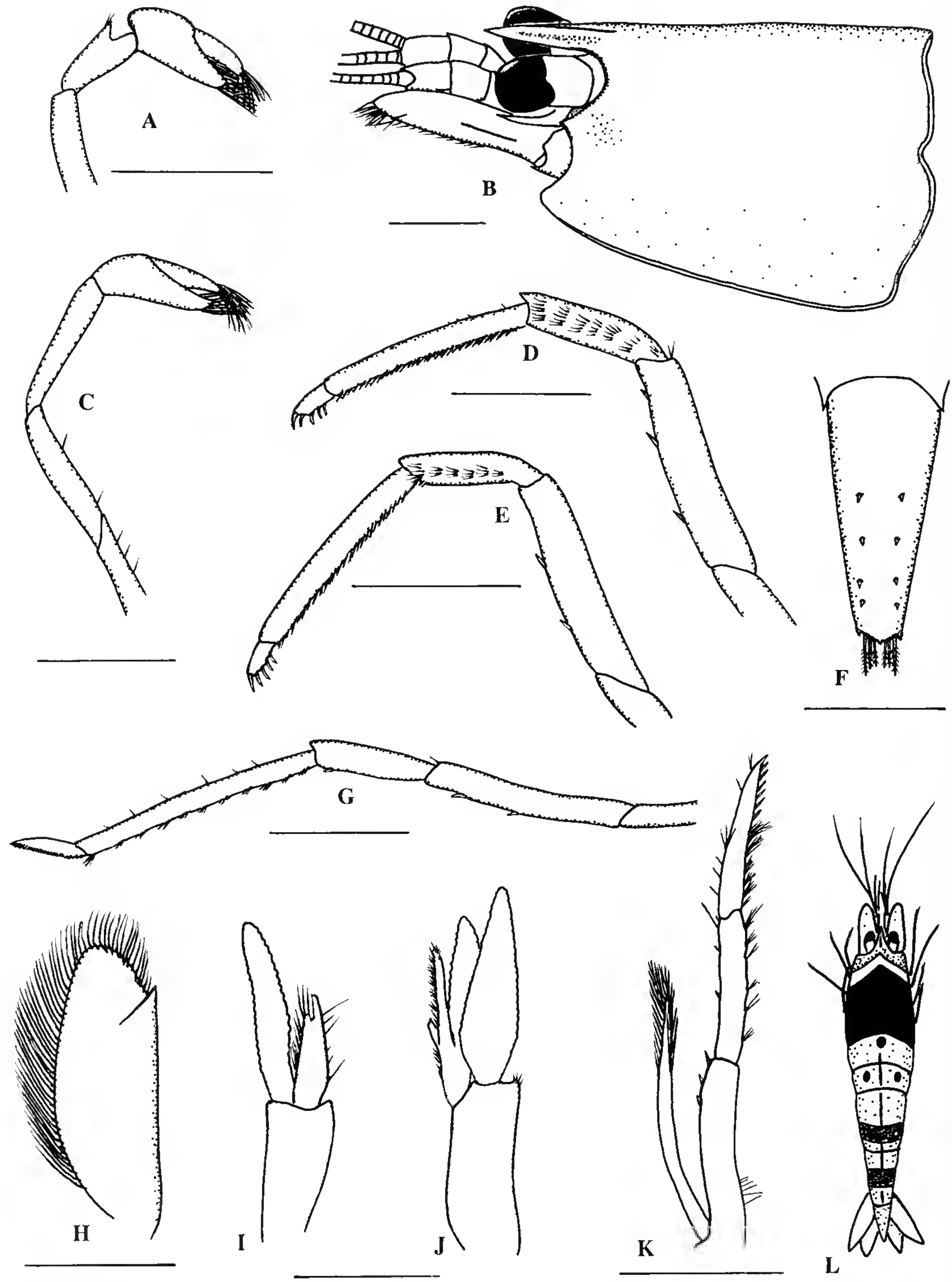

FIG.2. *Caridina zebra* sp.nov., ♂ holotype, A. first pereiopod. B. dorsolateral view of cephalothorax. C. second pereiopod. D. third pereiopod. E. fourth pereiopod. F. telson. G. fifth pereiopod. H. scaphocerite. I. first pleopod. J. second pleopod. K. third maxilliped. L. chromatophore pattern. Scale lines 1 mm.

exopod elongate, ovate. Dorsal telson with four pairs of small, stout hamate setae (4-5 pairs in paratypes) located in distal two-thirds; posterior margin angular, with small acute median projection, laterally spinate, with small inner hamate seta, sublaterally with pair of long pappose setae, submedially with two pairs of shorter pappose setae. Uropods distinctly longer than telson; diaeresis on exopod bearing numerous small hamate setae, 16 setae on diaeresis of right exopod, left exopod damaged (19/16 setae on allotype; paratypes 10-18 setae, $\bar{x}$=14.9, n = 30).

COLOUR

Dorso-anterior carapace with narrow, v-shaped, transverse, white band immediately followed by much broader, transverse, black band terminating at posterior carapace margin; anterior abdomen marked with medial blotch, followed by pair of submedial blotches, posterior abdomen with two broad, well separated, transverse, dark bands. Strength of chromatophore pattern variable; most developed on light-coloured, sandy substrates, poorly developed on dark substrates.

BIOLOGY

Lotic freshwater, low to strong flow, rocks/sand/silt/bedrock substrates, generally with leaf litter and fallen timber, water clarity high, macrophytes absent to abundant, fringing rainforest (complex mesophyll to simple notophyll vine forest) or *Brachiaria mutica* (Para Grass) in anthropically disturbed areas, altitude 400-900 m. Recorded physico-chemical tolerances: pH 5.5, hardness <10 ppm, water temperature 18-20°C, DO_2 5.8-6.0 ppm.

Developed ova large, maximum recorded length 1.1 mm, and few, 55 ova on allotype. Maximum recorded size of males 5.1 mm OCL, 17.3 mm TBL; maximum recorded size of females 5.5 mm OCL, 18.4 mm TBL; minimum recorded size of ovigerous females 3.8 mm OCL, 14.5 mm TBL.

Caridina zebra is active and very conspicuous during daylight, particularly on sandy substrates, where the banded chromatophore pattern is generally most developed. At the most elevated site sampled (c.900 m), fish predators and crustacean competitors appeared to be absent. The

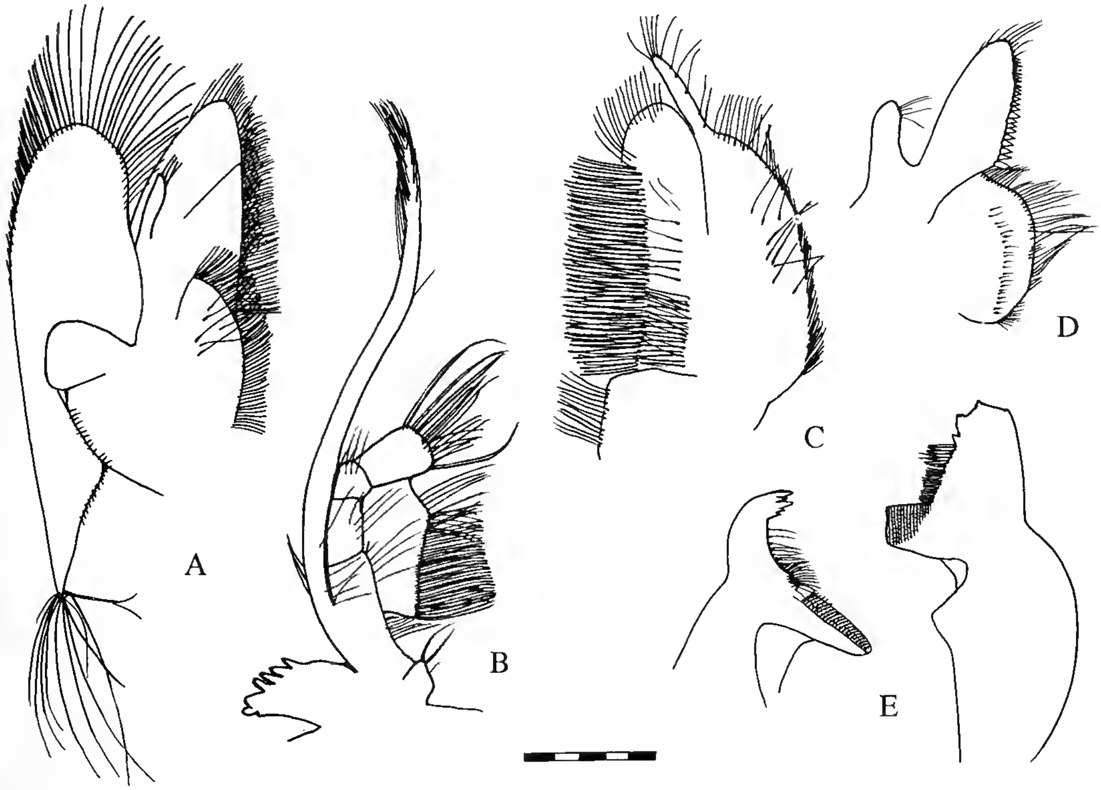

FIG.3. *Caridina zebra* sp.nov., ♂ holotype, A. maxilla. B. second maxilliped. C. first maxilliped. D. maxillula. E. mandibles. Scale divisions 0.1 mm.

population density at this locality was high, around 100 individuals/m^2.

The species appears to be directly associated with lotic, high elevation, rainforest streams. Despite moderately intensive sampling, the species could not be located in Nitchaga Ck, an open forest tributary of the Tully R. above Tully Falls. This stream dries to a series of still pools during severe drought periods (as in November 1992 when sampled) in direct contrast to rainforest tributaries at higher elevations, which have permanent flow.

The striking colour pattern of *C. zebra* and its probable highly-abbreviated or direct development indicates high potential as an aquarium species.

At the type locality *C. zebra* is sympatric with *Cherax parvus* and *Euastacus yigara* (Short & Davie, 1993), and an undescribed species of *Macrobrachium*.

DISTRIBUTION

Recorded from the upper Tully, Herbert (Blunder Ck), Johnstone and Barron R. catchments (Fig.4).

SURVIVAL STATUS

Probably secure. Abundant in pristine, rainforest streams in the headwaters of four separate drainage systems. The species also appears to tolerate anthropic disturbance and occurs in heavily silted, *Brachiaria mutica* (Para Grass) infested streams on the Atherton Tableland.

ETYMOLOGY

Derived from an Abyssinian name for the striped equine of Africa, referring to the black and white banded colour pattern. The specific epithet is to be treated as a noun in apposition.

SYSTEMATIC POSITION

The new species belongs to the *typus* species-group, characterized by a short, dorsally unarmed rostrum. The following characters suggest a close affinity with the wide-ranging, small-egged species, *C. typus* H. Milne Edwards, 1837: appendix interna on the first pleopods; markedly concave postantennal carapace margin; bluntly angular, well-produced, pterygostomial carapace margin; and the absence of a well developed antennal spine.

The new species differs from *C. typus* in the following features: rostrum with an obsolete ventral carina, strongly expanded lateral carinae, and poorly-developed, feebly-convex, dorsal carina; angular posterior telson margin (rather than rounded margin) with three pairs of pappose setae (rather than five); and developed ova large (up to 1.1 mm in length) and few (55 ova on allotype).

DISCUSSION

Caridina zebra is the fourth, high altitude species of *Caridina* described from the Southwest Pacific Region. Other species include: *C. fijiana* Choy, 1983; *C. imitatrix* Holthuis, 1970; *C. nudirostris* Choy, 1984; and *C. devaneyi* Choy, 1991. In common with many high altitude shrimps, the limited number and large size of the developed ova (> 1.0 mm length), suggests direct or abbreviated larval development (Choy, 1991).

Queensland Museum and literature records of Atyidae from the humid tropics are shown in

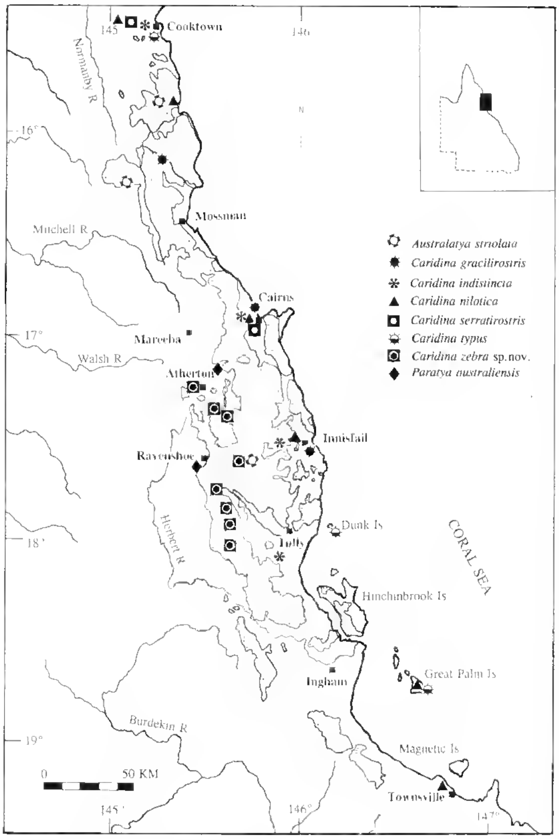

FIG.4. QM and literature records of Atyidae from the humid tropics. Literature records are those of Roux (1926b), Riek (1953), Williams & Smith (1979) and Smith & Williams (1982). Stippling indicates major rainforest areas (Australian Heritage Commission, 1986).

Fig.4. A large part of the region has not been adequately surveyed for atyid shrimps and previous records are largely the result of incidental collecting. Apart from *C. zebra*, only *Australatya striolata* (McCulloch & McNeill, 1923) and *Paratya australiensis* Kemp, 1917, are known from high elevation areas. *C. zebra* is the only species endemic to rainforest of the humid tropics.

ACKNOWLEDGEMENTS

Dr Stuart Bunn and Mr John Marshall, Griffith University brought specimens of *C. zebra* to my attention. Mr Warren Lee Long of the Northern Fisheries Research Centre, Cairns allowed access to the Johnstone Rivers Survey material and donated representative specimens to the QM. Peter Davie encouraged this work and allocated QM resources to the 1992 Tully River expedition. Satish Choy and Peter Davie provided constructive criticism of the manuscript. The photograph was printed by Gary Cranitch.

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TWO NEW SPECIES OF FRESHWATER CRAYFISH (CRUSTACEA: DECAPODA: PARASTACIDAE) FROM NORTHEASTERN QUEENSLAND RAINFOREST

JOHN W. SHORT AND PETER J.F. DAVIE

Short, J.W., & Davie, P.J.F. 1993 12 24: Two new species of freshwater crayfish (Crustacea: Decapoda: Parastacidae) from northeastern Queensland rainforest. *Memoirs of the Queensland Museum* **34**(1):69-80. Brisbane. ISSN 0079-8835.

Two new species of freshwater crayfish, *Cherax parvus*, and *Euastacus yigara*, are described and illustrated from the upper Tully R. catchment in simple notophyll vine forest, on the Cardwell Ra. *C. parvus* sp.nov. has several morphological features unique to the genus, and does not appear closely related to any extant species, suggesting a long period of geographic isolation. *E. yigara* sp.nov. most closely resembles *E. balanensis* Morgan, 1988, known from the nearby Lamb and Bellenden Ker Ranges, and can be distinguished by the morphology of the first chelipeds and carapace. Keys are provided to Queensland species of *Cherax* and *Euastacus*. ☐*Crustacea, Parastacidae, Cherax, Euastacus, Queensland, northeastern Australia, freshwater, rainforest, taxonomy, morphology, biology, biogeography, survival status.*

John W. Short & Peter J.F. Davie, Queensland Museum, PO Box 3300, South Brisbane, Queensland 4101, Australia; 30 August, 1993.

Six species of parastacid freshwater crayfish, all belonging to the genus *Euastacus*, are currently considered endemic to wet highland areas (>800 m elevation) in north and mideastern Queensland (Morgan, 1991). No Australian species of *Cherax* has been considered endemic to wet upland or highland areas and most records have been from elevations less than 400 m (Riek, 1951, 1969; Short, 1991, 1993a). In the highlands of New Guinea a distinctive *Cherax* species-group comprising nine species is endemic to the Wissel Lakes area (Holthuis, 1949, 1950). The discovery of a new species of *Cherax* in an upland/highland, rainforest catchment in northeastern Queensland, occurring sympatrically with an undescribed *Euastacus* and two undescribed freshwater shrimps, is of considerable interest.

Cherax parvus sp.nov. and *E. yigara* sp.nov. were discovered during a Queensland Museum expedition to the upper Tully River area in November 1992. The primary purpose of the expedition was to collect fully-developed, adult males of an undescribed species of *Macrobrachium* (presently being studied as part of a revision of Australian species by J.S.) and obtain habitat data for an undescribed *Caridina* (described as *C. zebra* Short, 1993), previously known from the area. These new shrimps were first collected by Dr S. Bunn and Mr M. Bray, Griffith University, during a limnological study for the proposed Tully-Millstream hydroelectric scheme in 1990.

MATERIAL AND METHODS

All material examined is housed in the Queensland Museum collection unless otherwise stated. Measurements were made using vernier callipers and line drawings with the aid of a camera lucida. Photographs were taken with a 35 mm SLR camera and flashes.

The terms 'cheliped' and 'chela' refer to the first pereiopod unless stated otherwise. *Euastacus* terminology largely follows Morgan (1986), particularly spination and sternal keel characters. Colour patterns, habitats and burrow types for Queensland *Cherax* are derived from the work of Riek (1951, 1969), Horwitz & Richardson (1986) and personal observations by J.S. Rainforest and climatic zone terms follow Webb & Tracey (1981).

Physico-chemical habitat data were obtained using a TPS LC82 dissolved oxygen meter, mercury thermometer, Merck Universalindikator pH 0-14 paper, and an Aquasonic water hardness test kit. Altitudes were estimated from the Australia 1:100 000 topographic survey map series R631.

Abbreviations used in text: QM, Queensland Museum; OCL, carapace length from orbital margin to dorsolateral invagination of posterior margin; T, thoracic sternite, T6, thoracic sternite six etc., imm., immature; P, pereiopod; Pr, sternal keel processes, Pr1, first sternal keel processes, etc; Qld, Queensland; N.T., the Northern Territory.

SYSTEMATICS

Cherax parvus sp.nov.
(Figs 1-4)

MATERIAL EXAMINED

HOLOTYPE: QM W18121, ♂ (22.7 mm OCL), O'Leary Ck, tributary of the Tully R. above Koombooloomba Dam, 17°50.7'S, 145°37.7'E, in short phreatic burrows under rocks, rocks/sand substratum, leaf litter, fallen timber, low to moderate flow, water clarity high, fringing simple notophyll vine forest, pH 5.5, hardness <10 ppm, water temperature 20°C, dissolved oxygen 6 ppm, altitude c. 750 m, water depth 0.1-0.3 m, 06/11/1992, J. Short, P. Davie.

PARATYPES: QM W18123, ♀ (14.0 mm OCL), upper Tully R. near Old Culpa above Koombooloomba Dam, 17°55.5' S, 145°37.6'E, amongst leaf litter, rocks/sand substratum, fallen timber, low to moderate flow, water clarity high, fringing simple notophyll vine forest, pH 5.5, hardness <10 ppm, water temperature 18°C, dissolved oxygen 5.8 ppm, altitude c. 720 m, water depth 1 m, netted, 06/11/1992, J. Short, P. Davie; QM W18133, 6♂♂ (12.4-21.9 mm OCL), 2♀♀ (12.6, 16.0 mm OCL), imm. (9.9 mm OCL), same collection data as holotype except collected from short phreatic burrows under rocks in small, clay bottomed pool above main creek; QM W17494, 10♂♂ (9.0-16.6 mm OCL), 4♀♀ (8.3-14.4 mm OCL), same locality and habitat data as holotype, water depth 0.1-0.5 m, 06/11/1992, J. Short, P. Davie.

DESCRIPTION OF MALE HOLOTYPE

Cephalothorax. Carapace punctate; slender, breadth c. 0.5 X CL (0.5-0.6 in paratypes), depth c. 0.6 X CL (0.5-0.6 in paratypes); cephalon with few tubercles ventrally; branchiostegites uninflated, with few indistinct tubercles along ventral cervical groove.

Rostrum slender, triangular, tapering strongly in distal third, length c. 1.4 X breadth (1.0-1.6 in paratypes), reaching distal penultimate segment of antennular peduncle, dorsally flattened, not recurved distally, punctate along inner margins of lateral carinae, smooth medially, setose distally near acumen; lateral carinae moderately developed, commencing at base of rostrum, terminating at acumen, without tubercles or spines; ventro-lateral margins setose; acumen blunt, upturned (strongly in paratypes).

Post-orbital carinae almost obsolete, unarmed anteriorly, excavated with well separated punctations, commencing close to orbital margin of carapace, medially curved anteriorly, diverging posteriorly; cervical groove setose (setation less developed in smaller paratypes); branchiocardiac grooves obsolete.

Eyes with cornea large, globular, well pigmented; eyestalks largely concealed by rostrum. Scaphocerite length slightly exceeding length of rostrum, broadest at mid-length; lamina broadly rounded mesially, lateral margin terminating in well developed spine. Antennal peduncle setose ventrally, coxocerite acute anteriorly, basicerite without lateral spine (acute in smaller paratypes).

Epistome strongly concave medially, setose anteriorly (densely setose in paratypes), with distinct tubercles laterally, lateral margins entire. Mouthparts without unique features for genus. Branchial formula typical for genus (cf. Holthuis, 1949) with posterior arthrobranch above P4 reduced. Pleurocoxal lappets well developed; operculiform; fringed with long plumose setae; lappet between P4-5 unusually thin, circular, plumose setae very long.

Sternal keel sharp posteriorly, more rounded anteriorly, lateral processes setose, without obvious pores, Pr4 juxtaposed, Pr5 similar.

Chelipeds. First chelipeds large, chela length exceeding carapace length (shorter in juvenile paratypes), distal merus reaching end of scaphocerite (carpus reaching end of scaphocerite in juvenile paratypes), isomorphic.

Outer margin of chela moderately convex; fingers slightly gaping (without gape in undeveloped paratypes); opposing edges densely setose ventrally with pollex setation continuing onto manus, bearing rounded teeth, one tooth large and prominent on dactylus at mid-length, similar slightly smaller tooth on pollex (teeth isomorphic in paratypes); pollex broad basally, evenly tapering; dactylus broadest at mid-length, equal to manus in length; manus moderately broad, breadth equal to length (greater than length in juveniles), dorsum slightly convex longitudinally, strongly convex laterally, mesial margin serrations continuing onto distal half.

Carpus bearing large broad uncinate mesial spine (missing on left cheliped), angle of disto-ventral condyle not produced into spine or tubercle, ventro-mesial angle similar, followed by few tubercles postero-mesially, disto-mesial angle glabrous, disto-dorsal condyle strongly developed, enlarged laterally to form broad sclerotinous plate.

Merus of typical shape, dorsal carina without obvious tubercles or spines (small distal tubercle in paratypes), ventral surface sparsely setose, with numerous strong cuticular processes, one or two larger than remainder.

COLOUR

Body dark brown; first chelipeds dark brown

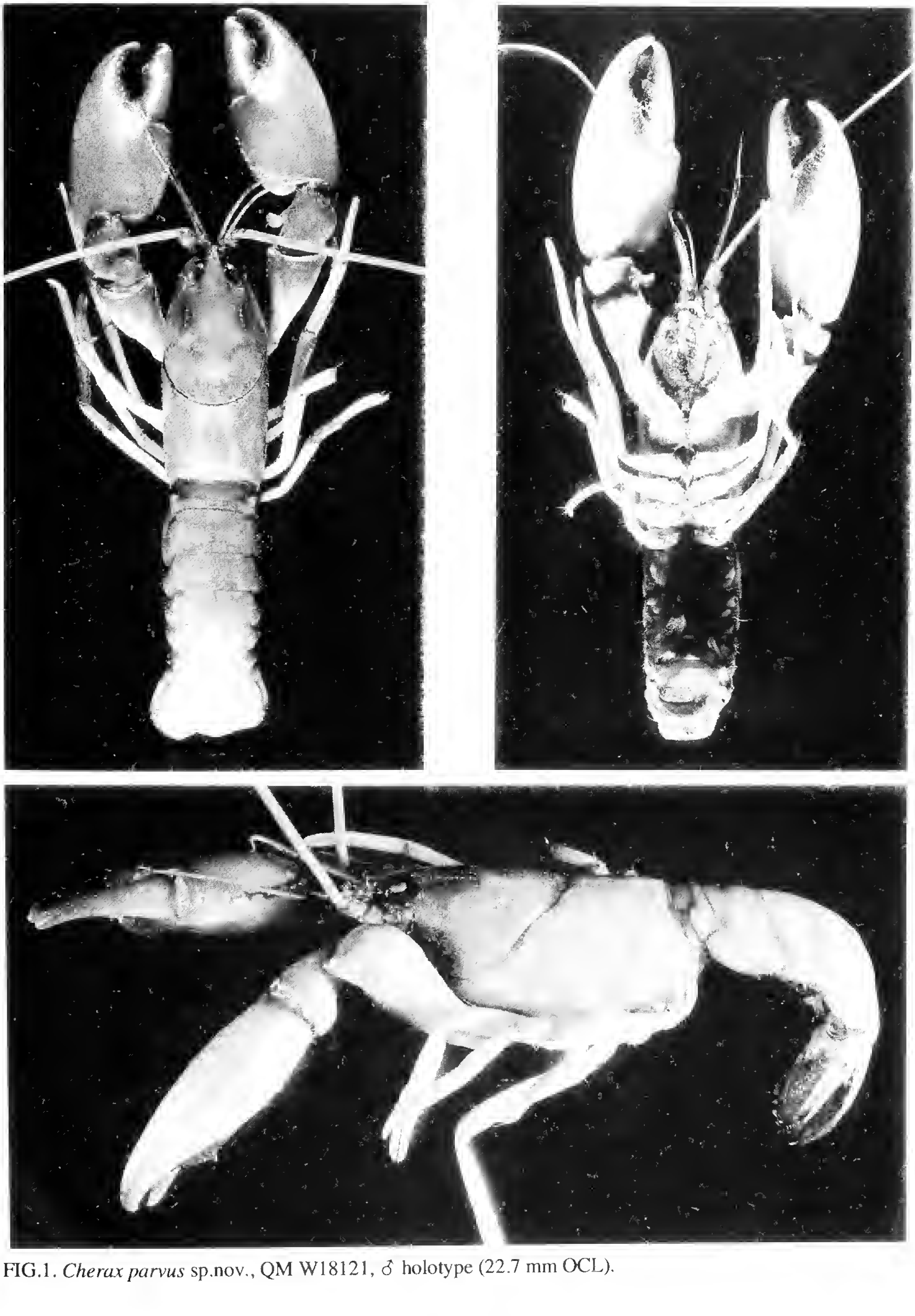

FIG.1. *Cherax parvus* sp.nov., QM W18121, ♂ holotype (22.7 mm OCL).

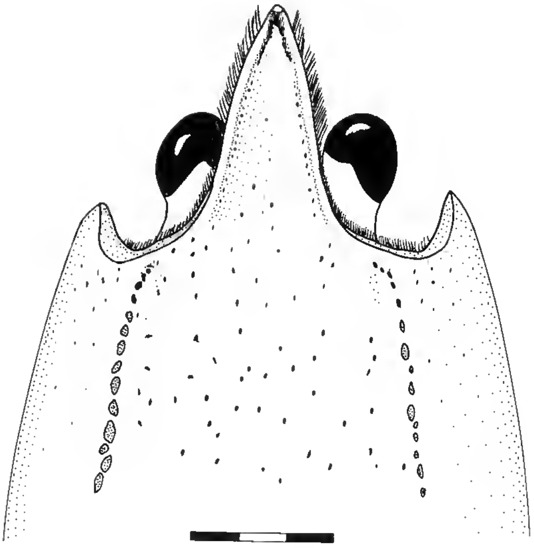

FIG.2. *Cherax parvus* sp.nov., QM W18121, ♂ holotype, anterior carapace and rostrum. Scale bar divisions in millimetres.

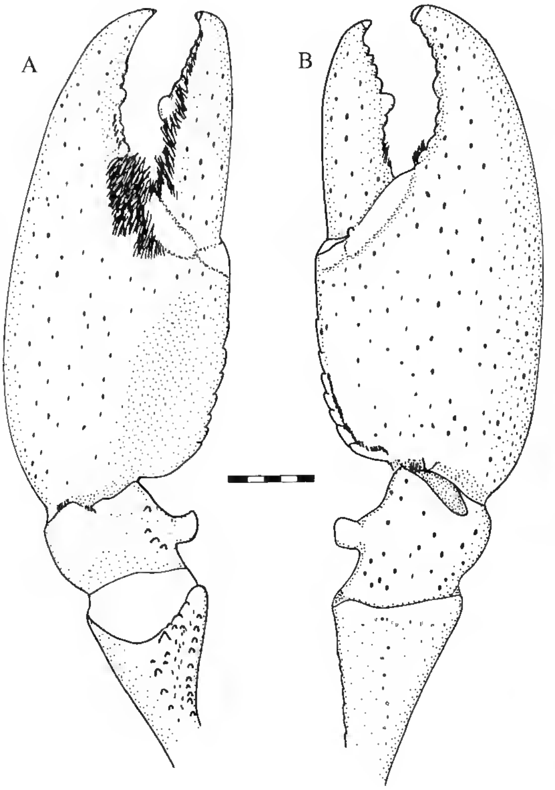

FIG.3. *Cherax parvus* sp.nov., QM W18121, ♂ holotype, A. ventral first right cheliped. B. dorsal first left cheliped. Scale bar divisions in millimetres.

disto-dorsally with reticulated pattern on manus, fingertips orange, proximal merus and ischium orange, ventral manus and fingers cream; second chelipeds and ambulatory legs greenish-cream dorsally, light cream ventrally.

BIOLOGY

Freshwater, short phreatic burrows under rocks or amongst leaf litter in shallow open water (1 m), rocks/sand or clay substrates, fringing simple notophyll vine forest, 720-750 m altitude, zero to moderate flow, water clarity high. Recorded physico-chemical tolerances: pH 5.5, hardness <10 ppm, water temperature 18-20°C, dissolved oxygen 5.8-6.0 ppm.

Close association of this species with rainforest is suggested by its absence in Nitchaga Ck, another tributary of the Tully R., above Tully Falls. This creek drains open sclerophyll forest and dries to a series of pools during extended dry periods (as in November 1992, when sampled). Here it is replaced by a species of the wide-ranging '*depressus*' complex (sensu Riek, 1951).

This is the smallest species so far described in the genus. The holotype, which has a post-orbital body length of only 55 mm and a post-orbital carapace length of 23 mm, shows the robust, broad chelae with an obvious gape, and the well developed dentition on the opposing margins of the fingers, characteristic of a well developed male. Of the 24 paratypes only two exceed 17 mm in post-orbital carapace length.

At the type locality *C. parvus* is sympatric with *E. yigara* sp.nov., *Caridina zebra* Short, 1993, and an undescribed *Macrobrachium*.

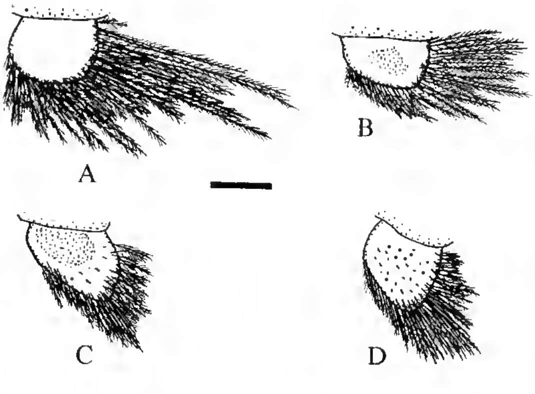

FIG.4. *Cherax parvus* sp.nov., QM W18133, ♂ paratype (17.4 mm OCL), pleurocoxal lappets. A. P4-5. B. P3-4. C. P2-3. D. P1-2. Scale bar 1 millimetre.

DISTRIBUTION

Recorded from the upper Tully R. and its tributary, O'Leary Ck, above Koombooloomba Dam, at 720-750 m altitude, Cardwell Ra., NEQ.

SURVIVAL STATUS

Probably secure. Although abundant at the type locality, more data is required on the distribution of the species and its relative abundance at other sites. Only one specimen was collected in the main Tully R. at Old Culpa where the substrate was clean sand. Two higher elevation sites (c. 900 m), approx. 12 km past O'Leary Ck, travelling east on the main forestry road, failed to produce crayfish, although *C. zebra* Short, 1993, was very abundant. Both sites had a silty sand substratum and the fringing vegetation showed indications of regrowth, possibly as a result of timber logging.

ETYMOLOGY

Latin (adjective), meaning small.

SYSTEMATIC POSITION

The distribution of *Cherax* in the humid tropics of north Queensland is shown in Fig.5. Although records of the new species lie within the broad geographical range of '*C. depressus*' (sensu Riek, 1951), *C. parvus* does not appear closely related to that complex. The following unique features suggest a long period of geographic isolation.

1. The almost obsolete post-orbital carinae commencing very close to the orbital carapace margin.
2. The disto-dorsal condyle on the carpus of the first chelipeds very strongly developed and enlarged laterally to form a broad sclerotinous plate.
3. The pleurocoxal lappet between P4-5 unusually thin and fringed with very long plumose setae.
4. The branchiostegites uninflated in developed specimens.

With regard to the last character, inflated branchiostegites and narrow areolae are generally correlated with the enlargement of the branchial chambers and increased surface area of gills. This is most pronounced in fully grown adults of species living in poorly oxygenated habitats. The relatively small branchial chambers of *C. parvus* may reflect its preference for cool, well-oxygenated, rainforest streams.

In contrast to the unarmed rostrum of *C. parvus*, all highland New Guinean species, except *C. monticola*, have two or more pairs of lateral processes (tubercles or spines) on the rostrum. In *C. monticola* there is generally one or two pairs, but occasionally none or three. This species, however, has two well-defined uncalcified patches on the first cheliped of mature males and is clearly allied to the *quadricarinatus* species-group (Short, 1991).

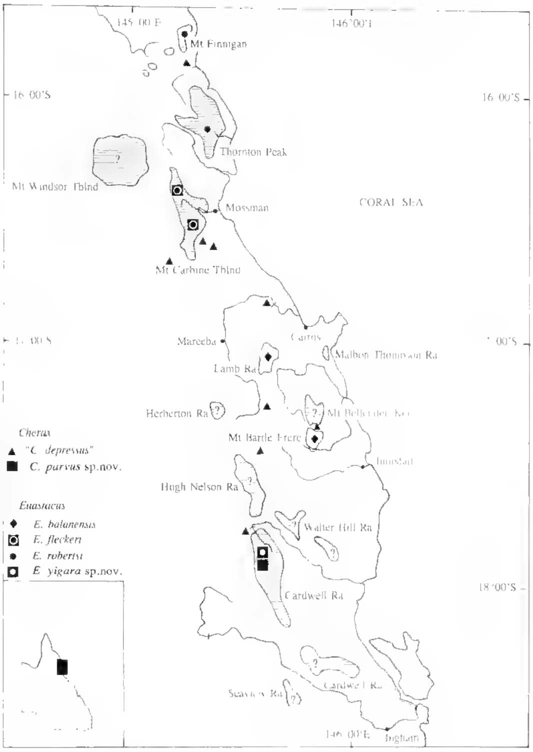

FIG.5. QM locality records of freshwater crayfish in the humid tropics. Hatched areas are cloudy wet mountains inferred as major refugia (Webb & Tracey, 1981). Question marks indicate poorly-sampled refugial areas on which future investigations should focus.

KEY TO QUEENSLAND *CHERAX*

1 Adult rostrum with obvious, well-developed spines on lateral carinae; cervical groove of adults bordered by number of well developed spines 2

— Adult rostrum without well-developed lateral spines, lateral carinae terminating in blunt process or unarmed; cervical groove bordered by blunt tubercles or small spines 4

2(1) Rostrum with 1 pair of lateral spines; lateral pollex of first chelipeds of mature males without uncalcified region......................... *C. dispar* Riek, 1951 [Body bluish or green-grey, chelipeds dark blue in mature specimens, lighter blue ventrally, chelae orange in juveniles. Between Elliot R. & Brisbane R.,SEQ, including large sand islands. Permanent freshwater, including

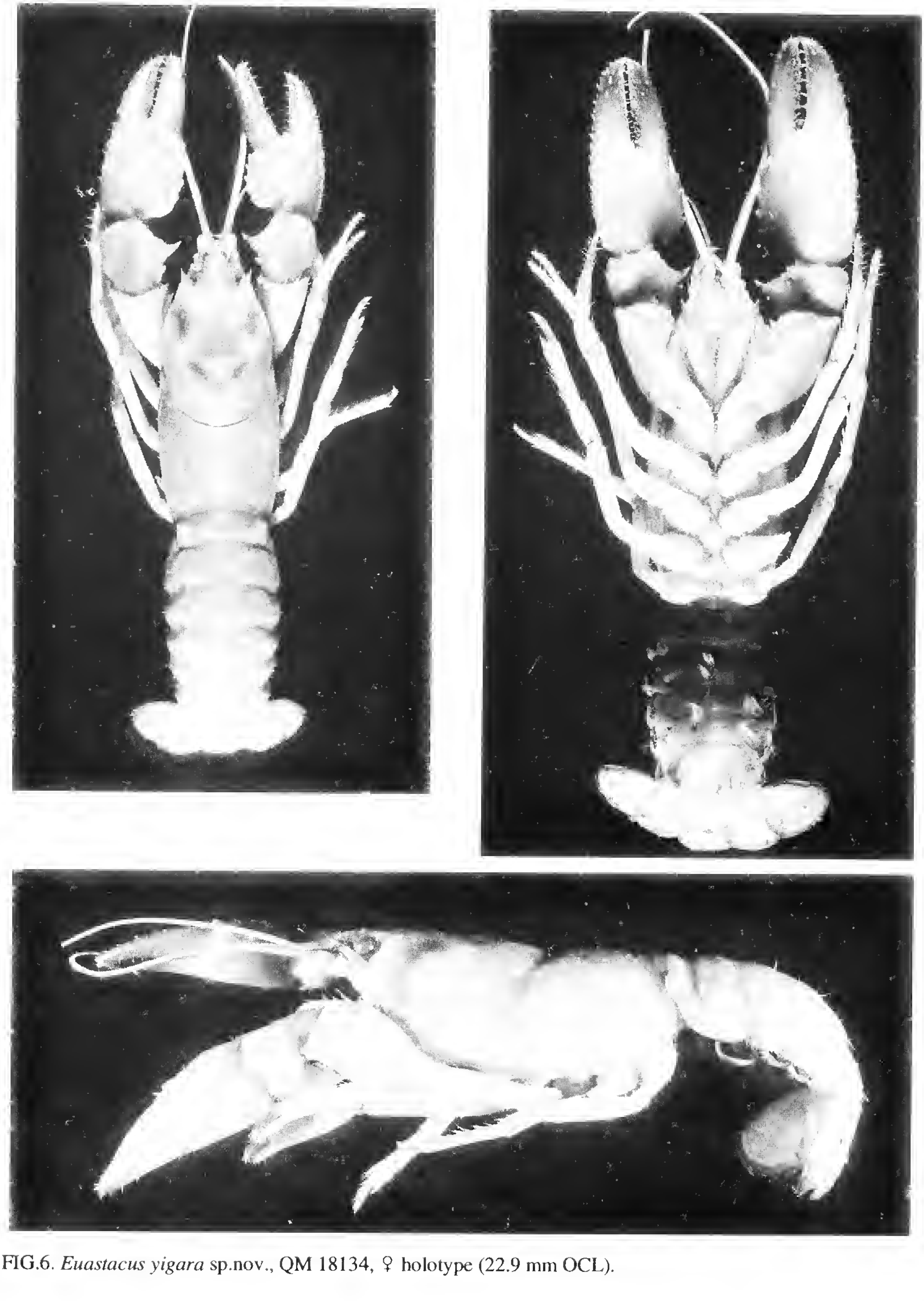

FIG.6. *Euastacus yigara* sp.nov., QM 18134, ♀ holotype (22.9 mm OCL).

acidic perched lakes and large coastal streams. Short burrows in, or connected to open water.]

— Rostrum with 2 or more pairs of lateral spines; lateral pollex of first chelipeds of mature males with distinct uncalcified region (most developed in fully grown males) 3

3(2) Post-rostral carinae short, terminating slightly behind line of post-orbital spines; dorso-medial rostrum slightly concave, lateral carinae moderately elevated .... *C. rhynchotus* Riek ,951
[Body green-brown dorsally, chelipeds similar except lateral chela orange, and uncalcified portion on lateral pollex of mature males peach cream. Northern Cape York Pen. and Badu Is., Torres Strait. Acidic coastal swamps and perched lakes. Burrows connected to open water or water table.]

— Post-rostral carinae long, almost extending to end of post-orbital carinae. Dorso-medial rostrum strongly concave, lateral carinae well elevated .... *C. quadricarinatus* (von Martens, 1868)
[Body colour from light green-blue to almost black, light flecks on lighter specimens, abdomen with purple bands dorso-laterally, chelipeds slightly darker than body, manus patterned dorsally, base of dactylus white, uncalcified portion on pollex of mature males red. Exorheic drainage systems from Daly R. N.T., to Normanby R., NEQ. Permanent freshwater, absent from acidic swamps and perched lakes. Short burrows in, or connected to open water.]

4(1) Antero-dorsal carpus of first chelipeds with condyle developed into long sclerotinous plate; post-orbital carinae commencing very close to carapace margin; adults with branchiostegites not obviously inflated .... *C. parvus* sp.nov.
[Dorsum dark brown, chelipeds dark brown disto-dorsally, patterned on dorsal manus, finger tips orange, proximal segments orange. Upper Tully R. catchment, NEQ. Rainforest streams. Short burrows in open water.]

— Antero-dorsal carpus of chelipeds with condyle typically developed into rounded lobe; post-orbital carinae widely separated from carapace margin; adults with brachiostegites obviously inflated ... 5

5(4) Branchiocardiac grooves well defined on adults, very narrowly separated or confluent anteriorly; mesial margin of manus of cheliped generally very short, much shorter than dactylus .... *C. punctatus* Clark, 1936
[Mary R. catchment, SEQ. Burrows independent of open water or the water table, located on clay hillsides.]

— Branchiocardiac grooves variably defined on adults, when present well separated throughout length; mesial margin of manus of cheliped of moderate length, about equal in length to, or slightly shorter than, length of dactylus 6

6(5) Serrations on manus of chelipeds clearly terminating within proximal half of mesial margin .... *C. cartalacoolah* Short, 1993
[Dorsum blue-grey to rusty brown, venter vivid purple or blue, meral/carpal joint red.Cape Flattery, NEQ. Coastal sand dune wetlands, acid water. Burrows connected to open water or the water table.]

— Serrations on manus of chela terminating at least halfway along mesial margin 7

7(6) Setation on ventral pollex of chelipeds very broad, clearly continuing onto manus .... *C. robustus* Riek, 1951
[Body bluish or purple-grey to black, chelae of similar colour dorsally, ventrally vivid purple or blue, joints red.Fraser Is. and Cooloola to N. Stradbroke Is. SEQ.Coastal sand dune wetlands, acid water. Burrows connected to open water or water table.]

— Setation on ventral pollex of chelipeds restricted to opposing edge, not continuing onto manus 8

8(7) Mesial surface of cheliped carpus usually with well developed setal pubescence; post-orbital processes obsolete..........'*C. destructor*' complex[1]
[Body from pale cream to brown or deep blue, chelipeds slightly darker with dorsal manus patterned, joints red. Wide-ranging inland and southern Australia; endorheic catchments, Murray-Darling system, and the Dawson R., MEQ. Permanent and ephemeral water bodies. Burrows in, or connected to open water.]

— Mesial surface of cheliped carpus without distinct setal pubescence, generally asetose, sometimes with scattered short setae; post-orbital processes moderately developed, spinate in juveniles, blunt in adults ....'*C. depressus*' complex[2]
[Body green-brown to blue-black or dark brown, often mottled in females, dorsal manus of chelae generally patterned, finger tips orange, joints red or orange. The Gold Coast, SEQ to Jardine Swamps, Cape York Peninsula. Ephemeral waters including acidic swamps. Burrows connected to open water or the water table.]

Euastacus yigara sp.nov.
(Figs 6-8)

MATERIAL EXAMINED

HOLOTYPE: QM W18134, ♀ (22.9 mm OCL), O'Leary Ck, 17°50.7'S, 145°37.7'E, freshwater, rocks/sand, leaf litter, fallen timber, fringing simple notophyll vine forest, under rock in pool along edge of creek, pH 5.5, hardness <10 ppm, water temperature 20°C, dissolved oxygen 6 ppm, altitude c. 750 m, water depth 0.1-0.5 m, 07/11/1992, J. Short, P. Davie.
PARATYPE: QM W18125, imm. (11.1 mm OCL), same

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[1] Includes the nominal species, *C. davisi* Clark, 1941 and *C. destructor* Clark, 1936, in Queensland .

[2] Includes the poorly-defined nominal species, *C. depressus* Riek, 1951 and *C. cairnsensis*, *C. gladstonensis*, *C. wasselli* and *C. urospinosus*, all of Riek, 1969.

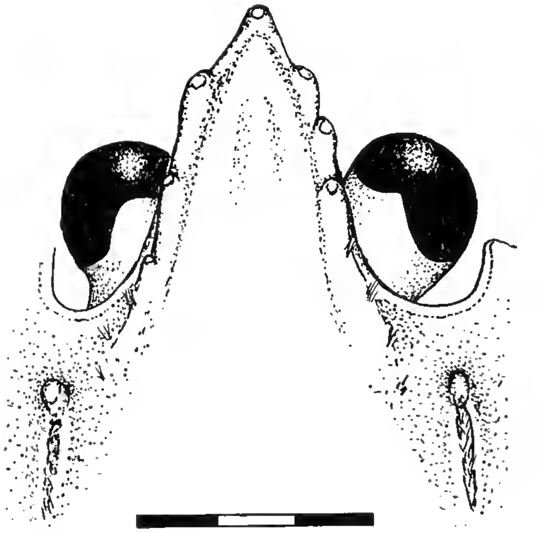

FIG.7. *Euastacus yigara* sp.nov., QM 18134, ♀ holotype (22.9 mm OCL), anterior cephalon and rostrum. Scale bar divisions in millimetres.

locality and habitat data as holotype, 06/11/1992, J. Short, P. Davie.

DESCRIPTION OF FEMALE HOLOTYPE

Cephalothorax. Carapace slender, breadth c. 0.5 X CL; cephalon with low, blunt, anteriorly-directed tubercles anterolaterally, extending in a band ventrally; thorax punctate, punctations bearing short setae, armed with 1-2 low cervical tubercles, otherwise smooth.

Rostrum moderately long, acute, basally broad, length c. 1.2 X breadth, reaching base of antennular flagella; acumen spinous, upturned, sclerotinous at tip; lateral carinae well developed, slightly convex, armed with 3-4 pairs of blunt processes (more prominent and acute in juvenile paratype), processes diminishing in size posteriorly (3 on right side, but with no trace of fourth; on left side second spine missing but fourth present at about level of posterior edge of cornea), extending onto proximal half of rostrum; rostral carinae extending posteriorly to about half distance between posterior margin of orbit and post-orbital spine.

Post-orbital carinae long, sulcate, sulci setose, margins raised, armed with single blunt spine anteriorly. Branchiocardiac grooves distinct, relatively widely separated, areola divergent anteriorly.

Antennal scaphocerite with lateral margin straight, unarmed, apex acute, greatest breadth at mid-length; basicerite spine (suborbital spine) moderately developed; coxocerite with 2 small acute processes (on right), 1 small acute process and 2 more indistinct processes (on left); basal exopod spine (basipodite spine) absent. Epistome (interantennal spine) moderately elongate with weakly scalloped margins, reaching distal end of first segment of antennal endopod.

Sternal keel lacking spines; Pr1 posterior margin sloped, processes apart and parallel; Pr2 apart and open; Pr3 with posterior edges straight, or very slightly rounded; Pr4 with anterior edges angular, posterior borders sharp and convex.

Chelipeds. Moderately stout, dimorphic, left larger and more robust than right; left cheliped

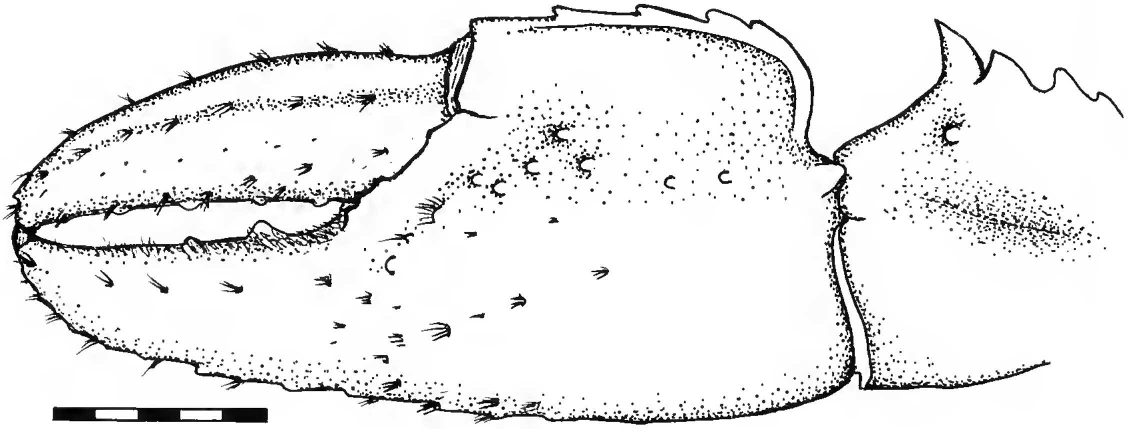

FIG.8. *Euastacus yigara* sp.nov., QM 18134, ♀ holotype (22.9 mm OCL), dorsal left chela. Scale bar divisions in millimetres.

dactyl length c. 0.6 X propodus length; propodus length c. 2.1 X width.

Dactylus without spines above tuberculate opposing edge, bearing small apical mesial spine, mesial basal spines absent, dactylar groove deep.

Propodus with single lateral spine row, spines blunt, becoming more prominent and closer together distally, not formed into distinct ridge; ventral spine row vestigial, single blunt midlateral spine; 5 marginal mesial spines; dorsal apical spines absent; without spines above opposing edge, opposing edge with single prominent rounded tubercle at about proximal quarter; 1 small distinct tubercle and 2 smaller indistinct tubercles on base of dorsal pollex lateral to dactylar base; uneven row of tubercles dorso-medially on manus, ventral pollex with 1-2 tubercles lateral to dactylar base.

Carpus with deep dorso-longitudinal groove; 3-4 mesial spines, distal-most the largest and offset from remainder; minute lateral spine; articulation spine absent; small but prominent dorso-mesial tubercle inside longitudinal groove; minute disto-ventral process medially, 2 ventromesial processes, 1 slightly proximal to distoventral process the other placed below large distal carpal spine (processes much smaller on right cheliped).

Merus with 1-3 (1 on left, 3 on right) small dorsal spines; outer spine absent.

Abdomen. Bearing sparse short tufts of setae, smooth, punctate, second pleurae with 2 indistinct tubercles ventrally. Dorsal telsonic spines absent; surface anterior to small disto-lateral spines coarsely punctate, punctations bearing tufts of setae; posterior surface with fine longitudinal ridging.

COLOUR

General colour greenish-grey.

BIOLOGY

Freshwater, under rocks in shallow water (<0.5m), rocks/sand substratum, fringing simple notophyll vine forest, c. 750m altitude, water clarity high. Recorded physico-chemical tolerances: pH 5.5, hardness <10 ppm, water temperature 18-20°C, dissolved oxygen 5.8-6.0 ppm.

At the type locality *E. yigara* is sympatric with *C. parvus* sp.nov., *Caridina zebra* Short, 1993 and an undescribed *Macrobrachium*.

DISTRIBUTION

Presently known from O'Leary Ck, a tributary of the upper Tully R. above Koombooloomba Dam, Cardwell Ra., NEQ.

SURVIVAL STATUS

Unknown. More data is required on the abundance and distribution of the species. The two type specimens were located during 2 days collecting in the upper Tully area and c. 4 man-hours at the type locality. The species may be more common at higher elevations as other north Queensland species are restricted to altitudes above 800 m (Morgan, 1991).

ETYMOLOGY

The aboriginal word for 'crayfish' in the Djirbal language group of the upper Tully R. area (Dixon, 1972). The specific epithet is to be treated as a noun in apposition.

SYSTEMATIC POSITION

E. yigara sp.nov. most closely resembles *E. balanensis* Morgan, 1988, which is known from the nearby Lamb and Bellenden Ker Ranges. It can be separated from that species by the following features:

1. An obvious tubercle on the disto-mesial carpus inside the longitudinal groove.
2. The presence of 3-5 distinct dorso-medial tubercles in an irregular longitudinal row on the manus, with small setose punctations anteriorly. In *E. balanensis* the dorsal manus is ornamented with broad punctations but is without elevated tubercles.
3. The rostrum armed with blunt marginal tubercles which extend onto the proximal half. On *E. balanensis* they are restricted to the distal half.
4. A relatively wider areola which diverges anteriorly rather than having subparallel margins.

Fifteen species of *Euastacus* are now known from Queensland. The distribution of *Euastacus* species in the humid tropics and their close association with the cloudy, wet, mountain areas, inferred as refugial by Webb & Tracey (1981), is illustrated in Fig. 5. Question marks indicate poorly-sampled refugial areas on which future investigations should focus. Of particular interest are the Walter Hill, Herberton and Hugh Nelson Ranges, between the present distribution of *E. yigara* and *E. balanensis*.

KEY TO QUEENSLAND *EUASTACUS*
(Modified from Morgan, 1991)

1 Well-defined, longitudinal groove on dorsal carpus of cheliped 2

— Without well-defined, longitudinal groove on dorsal carpus of cheliped, at most with broad, shallow depression 14

2(1) Large species with well-developed abdominal spines; large adults usually with distinct spines on thorax and/or telson and 2 spines on mesial carpus of cheliped.. 3

— Small species with reduced or absent abdominal spines; large adults with spines on thorax and telson absent or minute; 3 or more spines on mesial carpus of cheliped.. 6

3(2) No mesial basal spines on cheliped dactylus. .... *E. valentulus* Riek, 1951
[Body deep green or green-brown. From Currumbin Ck SEQ to Clarence R., NSW. Wet sclerophyll forest and rainforest, 0-600m.]

— One or more mesial basal spines on cheliped dactylus 4

4(3) Large adults with dorsal spines absent on thorax and absent or very small on telson. .... *E. sulcatus* Riek, 1951
[Body bright blue, red or brown. East flowing streams from Logan R.,SEQ, to Richmond R., NSW;also the Condamine R. flowing west. Wet sclerophyll forest and subtropical/rainforest, >300 m.]

— Large adults with distinct spines on thorax; spines on telson usually distinct and often large 5

5(4) Large adults with distinct dorsal spine(s) on abdominal somites 2-4. .... *E. suttoni* Clark, 1941
[Body very dark, spines on thorax and abdomen bright red. Severn R. and Dumaresque R., SEQ, flowing west, and Clarence R., NENSW, flowing east. Dry sclerophyll forest and heath, >680 m.]

— Large adults with dorsal spines absent on abdominal somites 2-4...... *E. hystricosus* Riek, 1951
[Body, including spines, deep green. Conondale and Blackall Ranges, SEQ. Wet sclerophyll forest and rainforest, >550 m.]

6(2) Spines above opposing edges of chelae in rows reaching almost full length of fingers; ventral spine row on lateral chclae well developed 7

— Spines above opposing edges of chelae not reaching beyond mid-length of fingers and sometimes absent; ventral spine row on latcral chelae absent or poorly developed (fewer than 4 spines) 9

7(6) Post-orbital spine absent; 1st processes of stcrnal keel well separated and converging anteriorly .... *E. monteithorum* Morgan, 1989
[Body and chelipeds dark brown dorsally except for orange merus, ventral body orange. From Kroombit Ck, Kroombit Tops, Calliope Ra., SEQ. Rainforest, >800 m elevation.]

— Post-orbital spine present; 1st processes of sternal keel close and parallel 8

8(7) Numerous tubercles on dorsal and ventral surfaces of chelae near base of pollex, extending some distance along finger; without dorso-mesial tubercle on carpus of cheliped. .... *E. bindal* Morgan, 1989
[From North Ck, Mt. Elliot, NEQ. Rainforest, 1000 m .]

— Only a few tubercles near base of fingers, these not extending along pollex; dorso-mesial tubercle/s present on carpus of cheliped. .... *E. eungella* Morgan, 1988
[Body green-blue with purple tinges, especially on chelae. Tributaries of Pioneer R, Clark Ra., MEQ. Rainforest, >740 m.]

9(6) First processes of sternal keel apart 10

— First processes of sternal keel close together 11

10(9) Carpus of cheliped with dorsal disto-mesial tubercle, manus with irregular longitudinal row of dorso-medial tubercles; rostrum with marginal processes extending onto proximal half. .... *E. yigara* sp.nov.
[Body green-grey. O'Leary Ck, tributary of upper Tully R, Cardwell Ra., NEQ. Rainforest, 760 m.]

— Carpus of cheliped without dorsal disto-mesial tubercle, manus without dorso-medial row of tubercles; rostrum with marginal processes restricted to distal half. .... *E. balanensis* Morgan, 1988
[Body green-brown or olive, abdominal spines paler brown or green. Lamb and Bellenden Ker Ranges, NEQ. Rainforest, >800 m.]

11(9) Suborbital spine large........ *E. setosus* Riek, 1956
[Body deep red-brown with green on chelae. Mt. Glorious, D'Aguillar Ra., SEQ. Rainforest, >500 m.]

— Suborbital spine medium-sized......................... 12

12(11) Third sternal keel processes parallel. .... *E. urospinosus* Riek, 1956
[Body red-brown with green tinges. Conondale and Blackall Ranges, SEQ. Rainforest, >240 m.]

— Third sternal keel processes not parallel 13

13(12) Adult epistome of moderate length, clearly shorter than first segment of antennal endopod. .... *E. maidae* Riek, 1956
[Body orange-brown, chelipeds similar except for finger tips blue. Upper Currumbin and Tallebudgera Cks, SEQ. Rainforest, >150 m.]

— Adult epistome elongate, reaching to distal end of first segment of antennal endopod or beyond .... *E. jagara* Morgan, 1988
[Flaggy Ck, Mistake Mts, SEQ. Rainforest, 900 m.]

14(1) Lateral ventral spine row on chelae poorly developed, usually 4-5 spines on mesial margin of manus; rostrum U-shaped on large specimens .... *E. fleckeri* (Watson, 1935)

[Body very dark green, thoracic and abdominal spines red. Mt. Carbine Tableland, NEQ. Rainforest, >1000m.]

— Lateral ventral spine row on chelae well developed and reaching apex of pollex; 6-9 spines on mesial margin of manus; rostrum usually triangular. ....*E. robertsi* Monroe, 1977
[Body dull blue-purple. Mt Finnigan and Thornton Peak, NEQ. Rainforest, >1000 m.]

DISCUSSION

The presence of four undescribed freshwater decapods in the upper Tully R. catchment, three of which appear endemic (the two crayfish species described above and an undescribed *Macrobrachium*), suggests something unique about the physiographic/climatic history of the area. Features which may have promoted speciation include:

1. A well-developed, physical, dispersal barrier in the form of Tully Falls, which is a sheer drop of 200 m. Potential crustacean competitors and predatory fish such as *Hephaestus fuliginosus* (Sooty Grunter), *Kuhlia rupestris* (Jungle Perch) and *Tandanus tandanus* (Eel-tail Catfish) are also isolated by this barrier.

2. The high, consistent, annual rainfall (2689 mm average at Koombooloomba Dam) and plateau topography, resulting in an unusually large, upland/highland catchment of permanent streams of high water quality and cool water temperature.

3. A cloudy, wet, rainforest environment which may have acted as a refugium during periods of climatic warming and decreasing rainfall. The Cardwell Ra. was listed by Webb & Tracey (1981) as one of their inferred refugial areas for the humid tropics.

4. The long, stable geological history of the Cardwell Range, which is largely granitic in composition (De Keyser, 1964). Neighbouring granite massifs such as the Lamb and Bellenden Ker Ranges are of Permo-Triassic origin (Wilmott et al, 1988). Unlike the nearby Atherton Tableland, there is presently no evidence of larva flows on the Cardwell Range during the Cainozoic (De Keyser, 1964).

ACKNOWLEDGEMENTS

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THE BIODIVERSITY OF AUSTRALIAN MYGALOMORPH SPIDERS. I. TWO NEW SPECIES OF *NAMIREA* (ARANEAE: DIPLURIDAE).

ROBERT J. RAVEN

Raven, R.J. 1993 12 24: The biodiversity of Australian mygalomorph spiders. I. Two new species of *Namirea* (Araneac:Dipluridae). *Memoirs of the Queensland Museum* **34**(1):81-88. Brisbane. ISSN 0079-8835.

Two new species of *Namirea*, *N. dougwallacei* and *N. johnlyonsi*, are described from northern Australia. This is the first record of males from the region. Males of *N. dougwallacei* appear to pose a phylogenetic dilemma because of homoplasies with *Australothele*. ☐ *Mygalomorphae, Dipluridae, taxonomy, phylogeny, Namirea, biogeography, biodiversity, disturbance, Australia.*

Robert J. Raven, Queensland Museum, PO Box 3300, South Brisbane, Queensland 4101, Australia; 4 July 1993.

The genus *Namirea* was described by Raven (1984) along with other ischnotheline diplurids from Australia. *Namirea* included five new species. The genus is found in areas from Mt Lewis, NEQ, through southeastern Queensland, to the Blue Mountains, NSW. Males of the genus were known only in the southern portion of its range. The most northerly known males of *Namirea* were of *N. planipes* which is widespread in open forest areas and found commonly in roadside embankments in southern Queensland. Here two new species including males from the northern part of the range are described. Their morphology, especially that of males, allows a better understanding of the relationships of the group. Methods are explained in Raven (1984).

SYSTEMATICS

Namirea Raven, 1984

Namirea dougwallacei sp. nov.
(Figs 1-4. Tables 1, 2)

MATERIAL EXAMINED

HOLOTYPE ♂, ALLOTYPE ♀, Mt Archer, summit, 23°21'S 150°35'E, MEQ, D. Wallace, May 1984, QMS19706, 19707.

DIAGNOSIS

Males differ from those of all other *Namirea* with known males in having a mounded spur on tibia I and from *Australothele* in lacking the secondary spine on the spur and the metatarsal thorn on leg II. Females differ from those of *N. eungella* in the spermathecae having three, rather than only two, spiralled loops, a larger basal lobe and longer apical lobe.

Medium-sized; carapace length ca. 5. Preening combs present on metatarsi I, II, IV. Spermathecae two, each an inner long sclerotised spiralled duct with short straight unsclerotised outer lobe. MALES. Tibia I subdistally incrassate with group of strong retrolateral spines; metatarsus I basally incrassate, distally arched; retrolaterally a low but distinct mound, set on retroventral corner, with strong spines almost forming a scoop; a long broad depression defined below by distinct keel from proventral corner proximally rising to upper junction with metatarsi. Leg II, viewed prolaterally, distally a long conical spur capped with short conical megaspine; two long upcurved spines on edge above spur.

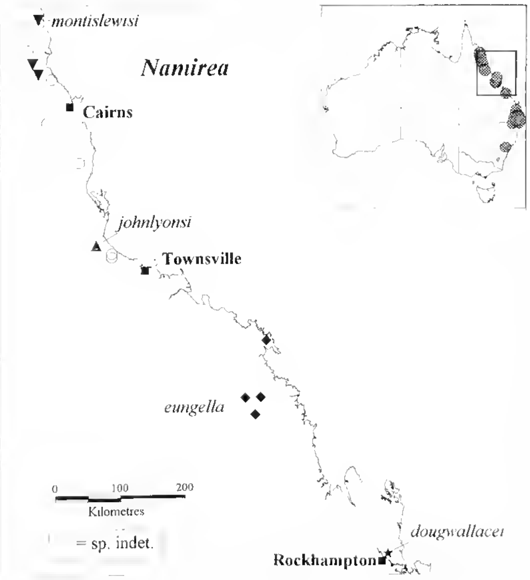

FIG. 1. Records of *Namirea* in north eastern Queensland; inset shows known range.

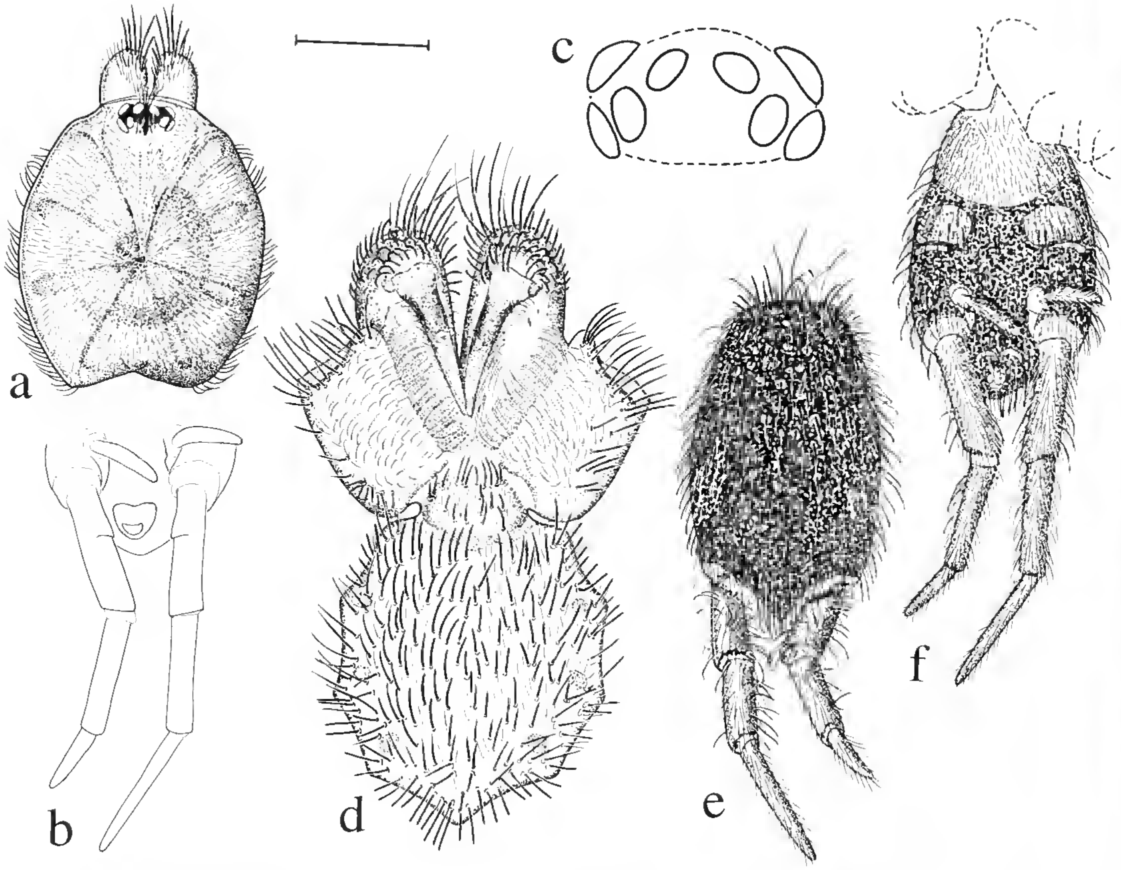

FIG. 2. *Namirea dougwallacei* sp. nov., holotype ♂ (QMS19706). a, carapace & chelicerae, dorsal view; b, spinnerets, ventral view; c, eyes, dorsal view; d, chelicerae, sternum, maxillae & labium, ventral view; e, f, abdomen, dorsal (e), ventral view (f). Scale line =1mm (d); 2mm (a, b, e, f); 0.5mm (c).

ETYMOLOGY

The specific epithet is a patronym in honour of Mr Doug Wallace, renowned arachnologist of Rockhampton, who prepared detailed and thorough arachnid displays for the Queensland Ambulance Service and Rockhampton Botanical Gardens, from which the types were 'rescued'.

DESCRIPTION

Holotype male QMS19706

Carapace 4.88 long, 4.00 wide. Abdomen 4.60 long, 3.20 wide. Total length, 10.

Colour in alcohol. Carapace yellow brown with darker lines posteriorly on caput and beside anteromedial line, chelicerae, and legs yellow brown, none banded. Abdomen dorsally and ventrally dark brown without pattern.

Carapace. Caput low. Pilosity: light cover of fine brown and silver hairs; striae broad, shallow. Bristles: one foveal pair; one very long and few finer on clypeal edge; all other setae slender, similar. Fovea a short, straight transverse pit. Clypeus ca. 0.16 from ALE.

Leg	1	2	3	4	Palp
Femur	3.63	3.44	3.44	4.19	2.19
Patella	2.19	2.19	1.88	2.25	1.50
Tibia	2.31	2.38	2.38	3.25	1.63
Metatarsus	2.56	2.81	3.56	4.50	—
Tarsus	1.19	1.56	1.88	2.06	0.88
Total	11.88	12.38	13.14	16.25	6.20

Table 1. Leg lengths of *N. dougwallacei*, holotype ♂.

Leg	1	2	3	4	Palp
Femur	3.28	3.32	3.24	4.00	2.40
Patella	2.12	2.12	2.00	2.28	1.44
Tibia	2.16	2.20	2.24	2.96	1.60
Metatarsus	2.32	2.48	3.08	4.00	—
Tarsus	1.20	1.32	1.56	1.68	1.76
Total	11.08	11.44	12.12	14.92	7.20

Table 2. Leg lengths of *N. dougwallacei*, allotype ♀.

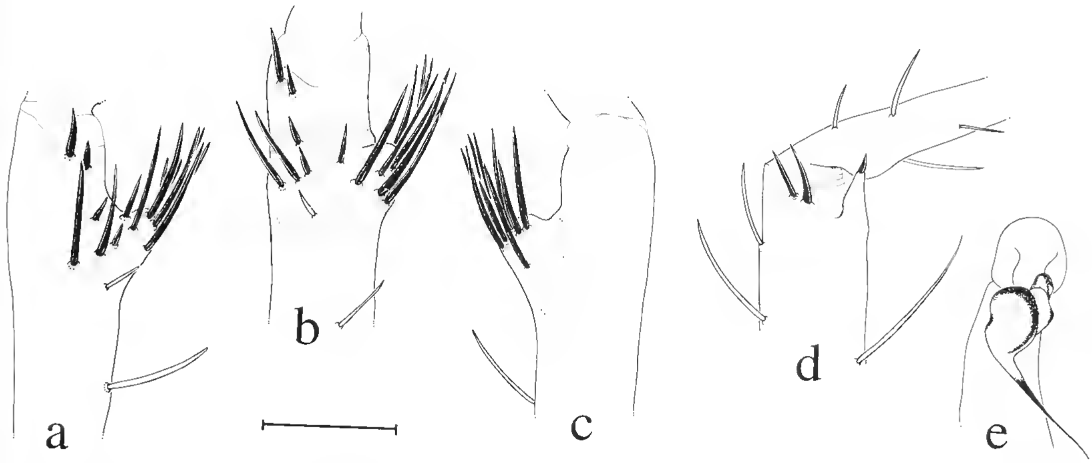

FIG. 3. *Namirea dougwallacei* sp. nov., holotype ♂ (QMS19706). a-c, left tibia I, prolateral (a), ventral (b), retrolateral (c) views; d, tibia & metatarsus II, prolateral view; e, tibia, cymbium & palpal bulb, ventral view. Scale line =1mm.

Eyes. Tubercle distinct. Group occupies 0.50 of head-width; front width, length, 38:18. Front row procurved; back row recurved. MOQ front width, back width, length, 20:30:17. AME:ALE: PME:PLE, 10:11:9:10. Eye interspaces: AME-AME, 0.2; AME-ALE, 0.1; ALE-ALE, 2.0; PME-PLE, 0.1; PME-PME, 1.6; ALE-PLE 0.1.

Chelicerae. Small; wide band of long erect brown bristles prodorsally. Intercheliceral tumescence small, pallid, distinct. Furrow promargin with 5 large mixed with 8 smaller teeth, basomesally no teeth evident.

Labium. 0.50 long, 0.88 wide. Anterior edge pallid, not indented; setae cover uniform, no pattern. Labiosternal suture a narrow continuous groove.

Maxillae. 1.25 long in front, 1.18 long behind, 0.75 wide; anterior edge pallid. Heel truncated; anterior lobe well defined by long groove, lobe small; serrula distinct. No modifications or strong setae on anterior face.

Sternum. 2.50 long, 2.18 wide. Cordate, with strong 'shoulders' lateral of labium; setae on margin not enlarged; covered with long erect brown bristles. All sigilla small, oval with long axis transverse, within one length of margin.

Legs. I: viewed prolaterally, tibia subdistally incrassate with group of strong retrolateral spines evident; metatarsus basally incrassate, distally arched; retrolaterally a low but distinct mound, set on retroventral corner, with few small and 11 long strong spines almost forming a scoop, as in *Australothele*; a long broad depression defined below by distinct keel from proventral corner proximally rising to upper junction with metatarsi. II: viewed prolaterally, distally a long conical spur capped with short conical megaspine; two long upcurved spines on edge above spur; metatarsus basally excavate, then a short incrassate mound quickly reducing to normal leg diameter. Preening combs: I, III, none; II, 1 of 2 weak setae proventrally; 1 of 5 strong setae on retrolateral IV. No scopula.

Spines. Distinction between 'spines' and thickened bristles subtle. Leg 1, fe d7, pa p1, ti p2, v 5 short distal, 3 long slender plus 10 long megaspines in retroventral group and 1 proventrally, me v2; ta, 0. Leg 2, fe d6, pa p4, ti p3, v2 + 3 megaspines, me p2, v5; ta, v4. Leg 3, fe d6, r1, pa p5, d4, r2, ti p3, d3, r3, v6, me p4, r3, v5; ta, p1, v4; leg 4, fe d4, r1, pa p4, r2, ti p3, d2, r3, v6, me p5, r6, v8; ta, p4, r1, v8; palp, fe d5, pa p1, d2, ti p1, r2, ta, 0.

Claws. 8 long teeth in S-shaped line on paired claws of I, IV, unpaired claws bare.

Trichobothria. Two rows, each of ca. 10 for 3/4 of tibiae; ca. 10-15 on metatarsi in line; ca. 10 filiform on tarsi.

Palp. Bulb reniform, quickly tapering to long slender embolus extending past basal tibia; cymbium short, indented, aspinose; tibia basally incrassate with cluster of many long bristles, distally excavate.

Spinnerets. PMS 1.25 long, 0.25 wide, 1.00 apart, and ca. 0.45 of basal PLS in diameter. Basal, middle, apical, total segments of PLS, 1.80, 1.88, 2.00, 5.68 long, respectively.

Allotype female QMS19707

Carapace 4.92 long, 4.08 wide. Abdomen 5.00 long, 3.60 wide. Total length, 11.

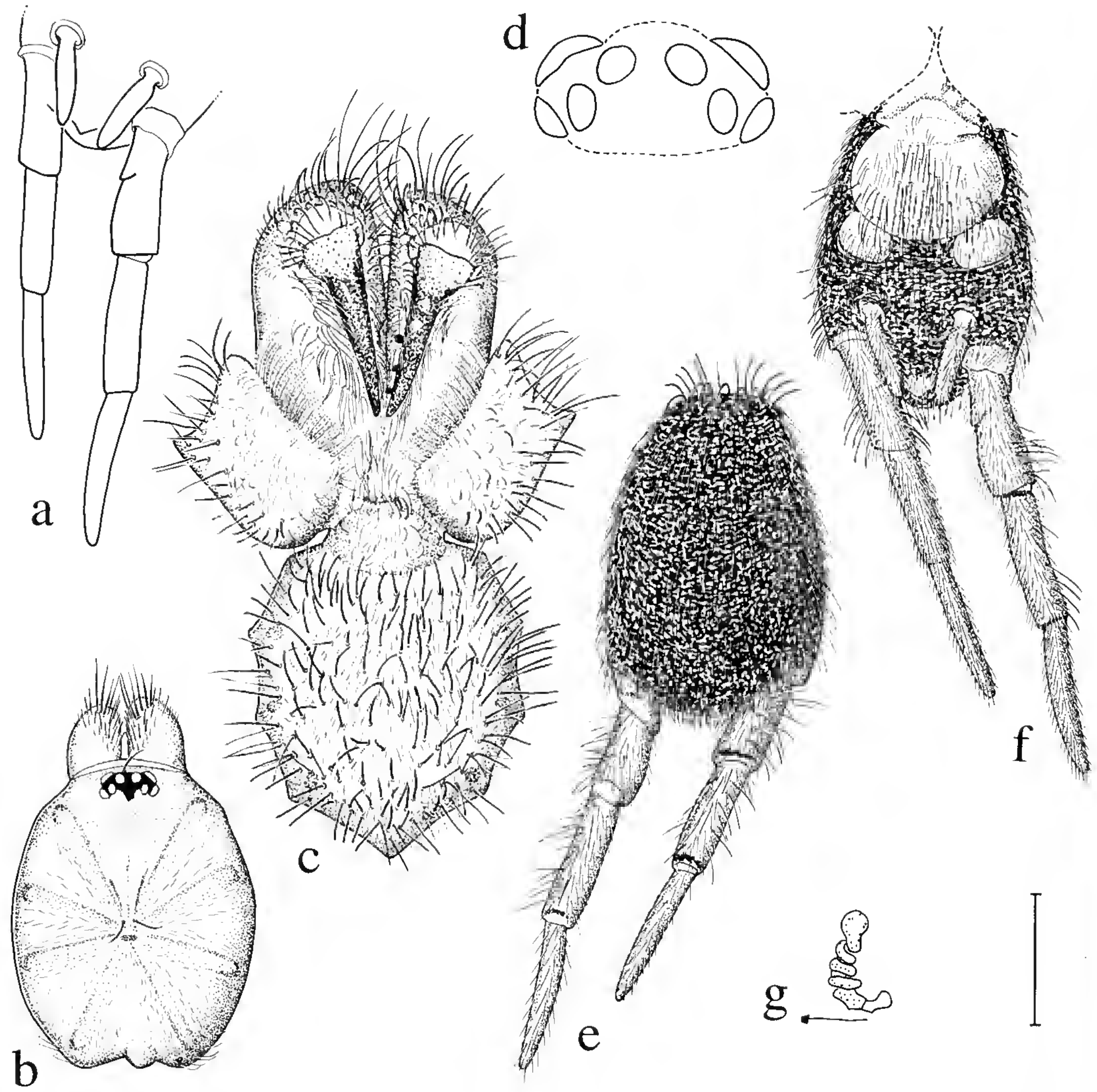

FIG. 4. *Namirea dougwallacei* sp. nov., allotype ♀ (QMS19707). a, spinnerets, ventral view; b, carapace & chelicerae, dorsal view; c, chelicerae, sternum, maxillae & labium, ventral view; d, eyes, dorsal view; e, f, abdomen, dorsal (e), ventral view (f); g, spermathecae. Scale line =2mm (a, b, e, f); 1mm (c); 0.5mm (d, g).

Colour in alcohol. As in ♂.

Carapace. Pilosity: as in ♂ but 2 pairs of foveal bristles. Fovea short, transverse; set 45% of carapace length from back edge. Caput low but sloping down to fovea. Clypeus width, 0.12 to base of tubercle.

Eyes. Tubercle distinct. Front row procurved; back row recurved. Group occupies 0.44 of head-width; front width, back width, length, 38, 38, 18, respectively. MOQ front width, back width, length, 20, 29, 15, respectively. AME:ALE: PME:PLE, 9:12: 7:10. Eye interspaces: AME-AME, 0.3; AME-ALE, 0.2; ALE-PLE, 0.2; PME-PME, 1.9; PME-PLE, 0.1; ALE-ALE, 2.0.

Chelicerae. Geniculate, stout; setation like ♂. Furrow promargin with 4 large mixed evenly with 11 small teeth, basomesally with 4 small teeth.

Labium. 0.55 long, 1.03 wide. Anterior edge indented. Labiosternal suture a narrow continuous groove.

Maxillae. 1.28 long in front, 1.10 long behind, 0.83 wide. Heel truncated; anterior lobe short, with long defining groove.

Sternum. 2.50 long, 2.20 wide. Cordate, widest at coxae I; all sigilla small, distinct, subcircular, marginal. Marginal setae like central.

Legs. Preening combs: 1 of 3 strong setae on proventral I, II; 1 of 5 strong setae on retrolateral IV.

Spines. Leg 1, fe d5w, pa p4w, ti p3, v5, me p1, v6, ta v1; leg 2, fe d5w, pa p4w, ti p3, v5, me p3, v7, ta v3; leg 3, fe d3w, r2w, pa p3w, d2w, r3w, ti p3, d2, r3, v5, me p5, r3, v8, ta v3; leg 4, fe d5w, pa p3w, r2, ti p3, r3, v8, me p4, r3, v9; ta v3; fe d3, pa p2, d1, ti p2, v6, ta v7.

Claws. ca.9 teeth in S-shaped row on paired claws of I, IV; unpaired claw with 1 small tooth; palpal claw with 10 teeth in straight line on medial keel.

Trichobothria. As in ♂.

Spermathecae. Two, each an inner long sclerotised spiralled duct with short straight unsclerotised outer lobe. Epigastric furrow extended in curve from outer edge of anterior booklung cover extending posteriorly to line at about half length of posterior booklung covers.

Spinnerets. PMS 1.42 long, 0.32 wide, 1.20 apart, and ca. 0.50 of basal PLS in diameter. Basal, middle, apical, total segments of PLS, 2.25, 2.15, 2.27, 6.67 long, respectively.

DISTRIBUTION AND HABITAT

Known only from vine thicket on the summit of Mt Archer, MEQ.

PHYLOGENY

The phylogenetic position of this species poses a dilemma. A phylogeny of some Australian Evagrini was implicit in Raven (1984). All *Australothele* males have a secondary spine on the spur of tibia I and distinct thorn on lower metatarsi I. Males of all species, except *A. magna*, which lack spurs on tibia I, have clustered spines on tibia I. Hence, *A. magna* is the sister group of all other species of *Australothele*. Neither the secondary spine nor the metatarsal thorn are found in *Namirea*. In *Namirea*, the first leg lacks a spur but in *N. insularis*, a cluster of spines is present. Also, metatarsus and sometimes also tibia I have a dorsal flat area demarcated by a distinct ridge (Raven, 1984, figs. 201, 202). In *N. dougwallacei*, the form of the spur and spine cluster on tibia I resembles that in some *Australothele*. However, other autapomorphies in *Namirea* override any notion that the spur similarity derives from recent common descent. Equally, the encumbent increase in homoplasies in both *Australothele* and *Namirea* imposed by interposing *N. dougwallacei* between *A. magna* and other *Australothele* species is too severe to be acceptable.

Namirea johnlyonsi sp. nov.

(Figs 1, 5, 6. Tables 3, 4)

MATERIAL EXAMINED

HOLOTYPE ♂, Mt Spec National Park, 19°00'S 146°09'E, NEQ, on embankment at ecotone of rainforest, *Casuarina*, and eucalypt forests, 3 Sep 1988, R. Raven, J. Gallon, T. Churchill, QMS11225; ALLOTYPE ♀, 2 paratype ♀♀, same data as holotype, QMS19704-5.

DIAGNOSIS

Females differ from those of *N. montislewisi* in the narrow form of the spermathecae and males differ from those of *N. dougwallacei* in having a lower spur on tibia I.

Small to medium-sized; preening combs present on legs I, II, IV. Two spermathecae, each a bipartite lobe broadest basally. Tibia I with a ventral mound bearing one long and several smaller megaspines; metatarsus I proximally incrassate, slightly flattened dorsally. Tibia II distoventrally with long single spur tipped with small black megaspine. Palpal bulb long, pyriform with short embolus; cymbium with sclerotised distal edge.

ETYMOLOGY

The specific epithet is a patronym in honour of Mr John Lyons, Chairperson, Management Committee, Museum of Tropical Queenland, a branch of the Queensland Museum.

DESCRIPTION

Holotype male QMS11225

Carapace 3.20 long, 2.92 wide. Abdomen 3.44 long, 2.08 wide. Total length, 7.

Colour in alcohol. Carapace, chelicerae and legs yellow brown, ocular area black, carapace with light mottled brown margins and two long triangles laterally on caput; tibia I orange brown. Abdomen entirely dark brown.

Table 3. Leg lengths of *N. johnlyonsi*, holotype ♂.

Leg	1	2	3	4	Palp
Femur	3.20	3.24	3.52	3.72	2.28
Patella	2.04	2.12	1.80	2.20	1.52
Tibia	2.36	2.28	2.08	3.12	1.68
Metatarsus	2.36	2.44	3.08	3.84	—
Tarsus	1.16	1.28	1.52	1.56	1.68
Total	11.12	11.36	12.00	14.44	7.16

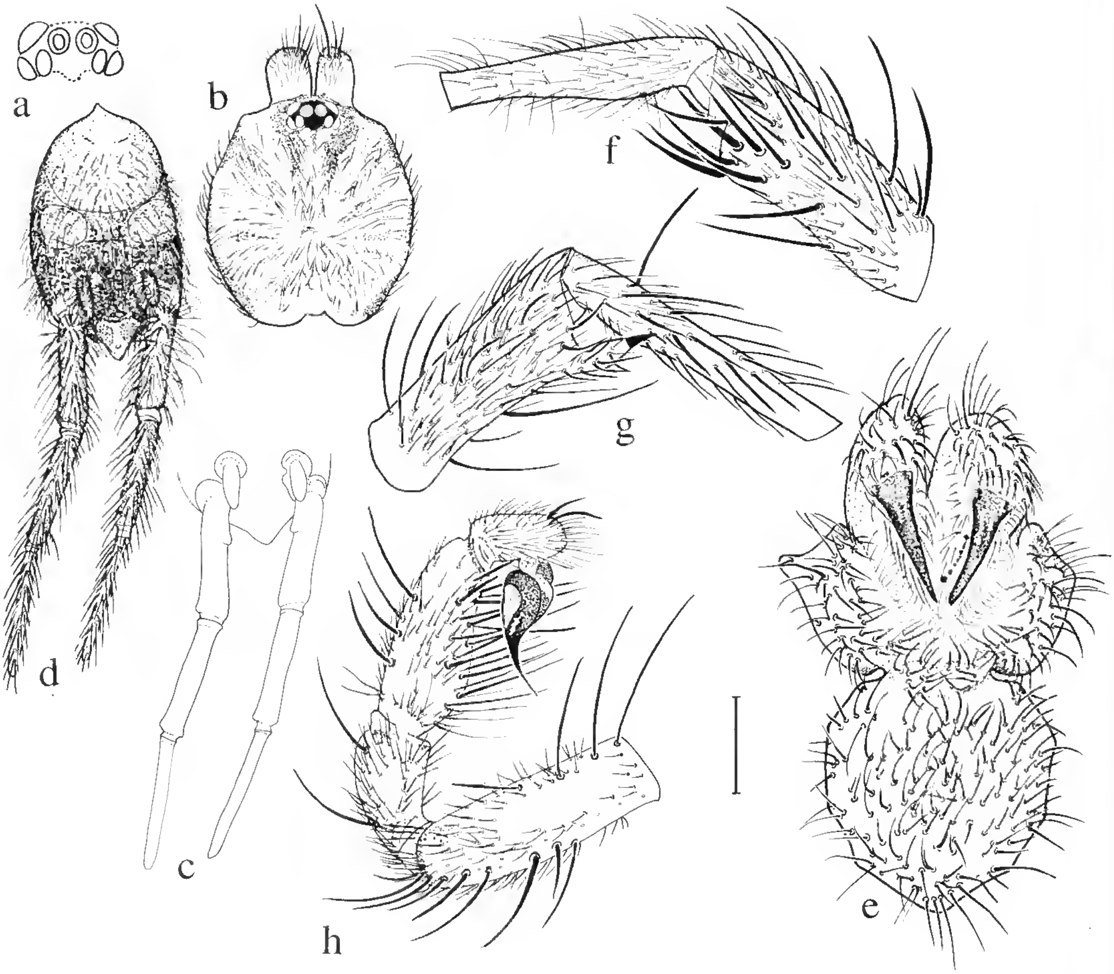

FIG. 5. *Namirea johnlyonsi* sp. nov., holotype ♂ (QMS11225). a, eyes, dorsal view; b, carapace & chelicerae, dorsal view; c, spinnerets, ventral view; d, abdomen, ventral view; e, chelicerae, sternum, maxillae & labium, ventral view; f, tibia I, retrolateral view; g, tibia & metatarsus II, prolateral view; h, palp showing tibia, cymbium & palpal bulb, prolateral view. Scale line =2mm (b-d); 1mm (a, e-h).

Carapace. Pilosity: margins with line of fine brown setae; one pair of foveal bristles; light cover of fine gray hair on caput and interstrial ridges; striae distinct, glabrous. Caput low, flat. Fovea a small open pit. Clypeus absent.

Eyes. Tubercle steep, distinct. Front row slightly procurved; back row recurved. Group occupies 0.49 of head-width; front width, back width, length, 34, 37, 20, respectively. MOQ front width, back width, length, 18, 26, 17, respectively. AME:ALE:PME:PLE, 10:13:9:10. Eye interspaces: AME-AME, 0.3; AME-ALE, 0.2; ALE-PLE, 0.4; PME-PME, 1.6; PME-PLE, 0; ALE-ALE, 1.5.

Chelicerae. Small, rounded, knee-like; with few long and many short curved bristles prodorsally. Intercheliceral tumescence a small pallid area. Furrow promargin with 4 long mixed with 13 smaller teeth, basomesally with 5 teeth.

Labium. 0.40 long, 0.76 wide. Labiosternal suture a shallow continuous groove.

Maxillae. 0.98 long in front, 1.00 long behind, 0.60 wide. Heel rounded; anterior lobe rounded, distinct, serrulate.

Sternum. 1.68 long, 1.54 wide. Cordate with uniform cover of long erect bristles and short hairs. Sigilla six; all small, rounded.

Legs. Tibia I distally incrassate; apically a ventral mound bears one long and several smaller megaspines; metatarsus I proximally incrassate,

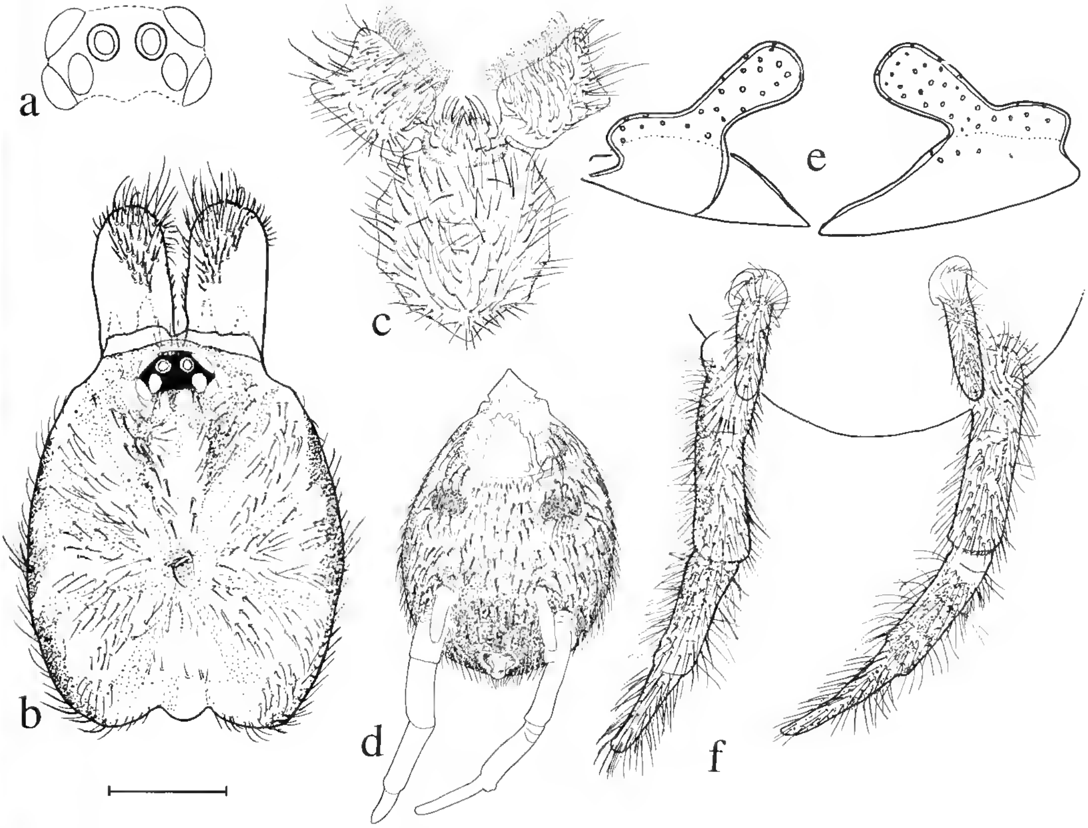

FIG. 6. *Namirea johnlyonsi* sp. nov., allotype ♀ (QMS19704). a, eyes, dorsal view; b, carapace & chelicerae, dorsal view; c, sternum, maxillae & labium, ventral view; d, abdomen, ventral view; e, spermathecae, dorsal view; f, spinnerets, ventral view. Scale line =0.5mm (a, f); 2mm (b, c); 4mm (d); 0.25mm(e).

slightly flattened dorsally. Tibia II distoventrally with long single spur tipped with small black megaspine, passing prolateral when metatarsus II is contracted; metatarsus II proximally excavate distal of which is incrassate area. Preening comb of 4 setae on retroventral IV. Scopula absent but sparse band of erect hairs ventrally on all tarsi.

Spines. Leg 1, fe d5, pa 0, ti p1w, v11, me 0, ta, 0; leg 2, fe d5w, pa p3w, ti p3w, v2 + megaspine, me p2, v5 ta, 0; leg 3, fe d5w, pa p4w, r2w, ti p3w, d2w, r3w, v6, me p3, r3, v5, ta, v2; leg 4, fe d6w, pa p2w, r2w, ti p3, r3, v5, me p3, r3, v5; palp, fe d5w, rest, 0.

Claws. One S-shaped row of 9 (I) to 7(IV) teeth on paired claws; unpaired claw bare.

Trichobothria. Two rows, each of 10 for half length of tibiae; ca. 10 on metatarsi in straight line; ca 8 filiform in line on tarsi.

Palp. Bulb long pyriform with short embolus; cymbium with sclerotised distal edge.

Spinnerets. Australotheline crescent distinct. PMS 0.72 long, 0.16 wide, 0.76 apart, and about 0.50 of basal PLS in diameter. Basal, middle, apical, total segments of PLS, 1.64, 1.60, 1.80, 5.04 long, respectively.

Allotype female QMS19704

Carapace 4.92 long, 4.00 wide. Abdomen 6.48 long, 4.80 wide. Total length, 13.

Colour in alcohol. Carapace and legs light orange brown, caput, lateral margins and interstrial ridges of carapace slightly darker. Abdomen brown.

Carapace. Oval; with uniform cover of fine gray hairs; lateral margins with few longer hairs; one pair of foveal bristles arising deep in fovea. Fovea a small pit with steep front edge forming recurved arc. Striae distinct, glabrous. A line of 4 erect setae on clypeal edge; clypeus narrow but distinct; few hairs between ALE and PME.

Eyes. Front row procurved; back row recurved. Group occupies 0.45 of head-width; front width, back width, length, 48, 52, 28, respectively. MOQ front width, back width, length, 22, 35, 20, respectively. AME:ALE:PME:PLE, 9:15:11:12. Eye interspaces: AME-AME, 0.6; AME-ALE, 0.4; ALE-PLE, 0.6; PME-PME, 2.6; PME-PLE, 0.1; ALE-ALE, 2.7.

Chelicerae. Stout, porrect with ca 20 long black and many shorter setae dorsally. Fangs short. Furrow promargin with 3 large mixed with 13 smaller teeth, basomesally with 7 teeth and 20-30 granules.

Labium. Like ♂, 0.48 long, 1.12 wide.

Maxillae. Rectangular; anterior lobe distinct but with delimiting groove; 1.48 long in front, 1.48 long behind, 0.92 wide; heel indistinct.

Sternum. Like ♂; 2.40 long, 2.24 wide. Sigilla all oval, marginal but anterior pair farthest from margin.

Legs. Covered with long curved setae and fine hair. Scopula absent. Preening combs: 1 of 3 setae on prolateral I, II, none of III; 1 of 4 setae retroventrally on IV.

Spines. Thicker setae scored as weak spines on femora. Leg 1, fe p6w, pa p3w, ti p3, v5, me p1, v5; ta, 0; leg 2, fe d5w, pa p1w, ti p3, v5, me p3, v5, ta, v2; leg 3, fe d5w, pa p3w, r3, ti p3, r3, v5, me p3, r3, v7, ta, v2; leg 4, fe d5w, pa p3, r2, ti p3, d4w, r3, v6, me p3, r3, v7, ta, d1, v3; palp, fe d5w, pa 2w, ti p2,w, v7, ta v9.

Claws. S-shaped line of 15 (I) to 9(IV) teeth on paired claws; 3 on unpaired claws; palpal claw with 12 teeth in one medial line.

Trichobothria. Two rows, each of ca. 10 for half length of tibiae; ca. 18 on metatarsi; ca. 8 on tarsi.

Spermathecae. Two, each a bipartite lobe broadest basally.

Spinnerets. PMS 1.48 long, 0.32 wide, 2.08 apart, and about 0.53 of basal PLS in diameter. Basal, middle, apical, total segments of PLS, 2.56, 2.08, 2.08, 6.72 long, respectively.

DISTRIBUTION AND HABITAT

Known only from Mt Spec NP, NEQ, in a mixed forest ecotone including *Casuarina*, eucalypts, and rainforest. The species was not found at higher altitudes in an evidently highly disturbed rainforest where ground fauna was generally depauperate. Nor was it evident in less disturbed adjacent areas of rainforest. Clearly, the preference of this group for embankments indicates that it will take advantage of the microhabitats provided by road cuttings. (A similar phenomenom was noted by Raven, 1991 in New Caledonian diplurids.) Like many mygalomorphs in Australia, this group is more diverse in open forest habitats.

Table 4. Leg lengths of *N. johnlyonsi*, allotype ♀

Leg	1	2	3	4	Palp
Femur	2.64	2.40	2.60	3.08	1.68
Patella	1.44	1.60	1.36	1.36	0.96
Tibia	1.92	1.92	1.96	2.56	1.36
Metatarsus	1.92	2.12	2.72	3.60	—
Tarsus	1.04	1.32	1.40	1.80	0.72

WEB

The web had bluish white curtains of silk extending 8-10 cms from the overhang of an embankment beside a road. Several corridors lead to a branching main tube extended only 3-4cm into the soil.

ACKNOWLEDGEMENTS

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FUNCTIONAL SIGNIFICANCE OF NEST CONSTRUCTION BY AN AUSTRALIAN RAINFOREST FROG: A PRELIMINARY ANALYSIS

STEPHEN J. RICHARDS

Richards, S.J. 1993 12 24: Functional significance of nest construction by an Australian rainforest frog: a preliminary analysis. *Memoirs of the Queensland Museum* 34(1):89-93 Brisbane. ISSN 0079-8835.

A frog of the *Litoria lesueuri* complex from northeastern Queensland rainforests sometimes deposits its eggs in small basins constructed on sandy banks adjacent to streams. Observations and experiments on nests at Elphinstone Ck showed that basin construction commenced by early September, and that the mortality of embryos from desiccation was extremely high. Embryos removed from basins and placed in the stream suffered no detectable predation, and developmental rates of embryos placed in streams were similar to those left undisturbed in basins. Basin construction may have evolved as a mechanism to secure egg masses to a homogeneous and mobile substrate. ☐ *Anura, Hylidae, aquatic nest, embryo, development, predation, Litoria lesueuri complex.*

S.J.Richards, Zoology Department, James Cook University, Townsville, Queensland 4811, Australia; 20 August, 1993.

A few species of frogs that breed along rainforest streams construct small water-filled basins ('nests') for egg deposition (Duellman & Trueb, 1986). Two hypotheses have been proposed to explain the evolution of this behaviour. It evolved either to exclude potential predators of eggs and embryos, or to take advantage of higher water temperatures to ensure more rapid embryonic development (Crump, 1974; Lammote & Lescure, 1977). There have been few attempts to test these hypotheses, and two recent studies (Caldwell, 1992; Kluge, 1981) reached different conclusions about the functional significance of nests.

Richards & Alford (1992) reported the first example of this reproductive strategy in Australia and speculated on the benefits of nest construction. The species involved here is undescribed but is referred to as *Litoria lesueuri* (Richards & Alford, 1992). I report the results of preliminary experiments designed to test the proposed hypotheses, and propose an additional one to explain the evolution of nest construction in this species.

MATERIALS AND METHODS

I made a series of observations on 12 nests over a 15 day period in September, 1991 at Elphinstone Ck, a lowland stream west of Ingham, NEQ (18° 29'S, 146° 01'E). Each nest was marked with a flag for identification, and information on mortality of eggs and tadpoles was recorded. Each nest was examined for the presence of potential predators. Nests were classified as 'separate' if there was no connection between the stream and the nest, and 'connected' if there was even a small channel between the nest and the stream. Separate nests therefore included those separated from the water only by the nest wall, and some located more than one metre from the stream edge. Only nests separate from the stream were used in the experiments reported below.

To test the hypothesis that water temperatures are higher in nests than in the adjacent stream, and confer an advantage in terms of more rapid embryonic development, I placed a max-min thermometer in each of two nests, and another in a small basin artificially constructed in the stream adjacent to them. Nests and artificial basins were about 5 cm deep, and in each case the thermometer was about 3 cm below the water surface. Approximately 50 eggs were excised from the egg mass in each nest and placed in the artificial basins in the adjacent stream. Maximum, minimum and ambient temperatures were recorded after three days when hatching had commenced. These temperatures were recorded, and the embryos preserved, within a 15 minute period. Between 1400 - 1500 on the afternoon of 6.9.91 ambient temperatures in the 12 nests and adjacent stream were recorded. Temperatures in each nest/stream combination were recorded within 30 seconds.

Dry nests often contained no desiccated tadpoles so, to determine whether tadpoles could escape drying nests, I constructed a moat (about

10 cm deep) around each of four nests that contained embryos and were separate from the stream. As the nests dried the moats (which retained water) were checked for the presence of tadpoles leaving the nests. Water levels in nests were regulated by seepage from the stream so moat construction did not contribute to drying of the nests. The staging tables of Gosner (1960) were employed.

RESULTS

Male *L. lesueuri* (Fig. 1) constructed small circular basins (Fig. 2) in sand banks along Elphinstone Ck (Fig. 3), between September and December, 1991. At the time of the study the area was extremely dry and water levels were falling. No nests were observed after late summer storms flooded the creek in March 1992. Egg masses were never observed away from nests, and in nearby rocky creeks frogs attempted to construct nests amongst coarse pebbles (Fig. 4). Half of the nests observed initially contained a single egg mass; the remainder contained recently hatched, free-swimming tadpoles. Eight of the 12 nests were separate from the stream, two were submerged completely, and two (8 & 12) were connected to the stream by shallow channels.

MORTALITY

Observations on survivorship of embryos in 12 nests over a 15 day period (Table 1) show mortality was extremely high due to desiccation as water levels dropped. Free-swimming tadpoles escaped from only two of the 12 nests (17%) (Table 1). Both of these nests were submerged, and the tadpoles escaped before the nests were separated from the creek by falling water levels. Tadpoles in another nest that was not studied intensively were observed to swim from the nest via a shallow channel, and subsequently return to the nest. As water levels fell these tadpoles died from desiccation.

Moats dug around four nests contained water but no tadpoles when the nests dried up. Three of these nests contained desiccated tadpoles, but one was empty. Ants were observed in dried nests,


FIG. 1. Male nest-building frog *L. lesueuri* .


FIG. 2. Aquatic nest with a single egg mass at Elphinstone Creek.


FIG. 3. The main study site, Elphinstone Ck. Nests were located in the sand banks at the water's edge.


FIG. 4. Nest constructed in a rocky creek near the study site.

TABLE 1. Mortality of embryos and tadpoles in 12 nests at Elphinstone Ck, NEQ. S = nest separate from stream, C = nest connected to stream; T=tadpoles; St = tadpole stages according to Gosner (1960); E = unhatched embryos, tadpoles at stage 24 and above are free-swimming; dry = 100% mortality. Where a stage is not given, the tadpoles have hatched, but data on stage are not available.

	Date			
Nest	6.9.91	9.9.91	12.9.91	20.9.91
1	S,T	dry	—	—
2	S,E	S,St 24	S,St 25	dry
3	S,T, 95% dead	S,St 22	dry	—
4	S,T	dry	—	—
5	S,T	S,T, almost dry	dry	—
6	C,E	C,T escaping	—	—
7	C,T	C, St 25 escaping	—	—
8	C,E	S,T	dry	
9	S,E hatching	S,St 24	S,St 25	dry
10	S,T	S,St 24	S,St 25	dry
11	S,E	S,St 20	S, St 24	dry
12	C,E	S,T	S,T	dry

and egrets and herons were observed along the stream bank. They may have removed tadpoles from some nests.

DEVELOPMENT AND PREDATION

Table 2 summarises information on the temperature regime and tadpole development in two nests and the adjacent stream. Nest 2 became much warmer than nest 1, and the adjacent stream at this site was also warmer than the stream adjacent to nest 1. Both nests were warmer than the adjacent stream during the day, but were slightly colder at night.

On 6.9.91 four shaded nests were 1 - 5°C cooler than the adjacent stream, and four unshaded nests were 4.2 - 7.7°C warmer than the adjacent stream. Four connected nests were 4 - 5.7°C warmer than the adjacent stream.

There was no difference between developmental rates of embryos in nests and in the adjacent artificial basins in the stream over three days at two sites (Table 2). Differences in developmental stages of embryos between sites partly reflected different initial stages of embryos at the two sites, but embryos at the warmer site (nest 2) also appeared to develop faster than those at the cooler site (Table 2).

There were large numbers of fish and conspecific tadpoles in the creek, and large (stage 36-7) conspecific tadpoles were seen in two submerged nests (6 & 7, Table 1) that contained smaller embryos. If egg predation occurred it was minimal. All egg masses, including those in submerged nests, remained intact throughout the study. However it was impossible to determine whether small numbers of eggs were consumed from the surface of the egg masses. Embryos translocated from two nests into the stream successfully hatched at both sites.

DISCUSSION

Mortality of embryos deposited in nests during this study was extremely high. It was attributed primarily to desiccation, although predation may occur as water levels in nests drop. As water levels in the nests are maintained by seepage (Richards & Alford, 1992) falling water levels result in rapidly drying nests. Most nests were separate from the creek, and as water levels dropped their isolation from the stream increased. Isolated nests are unlikely to release tadpoles to

TABLE 2. Temperature regimes in two nests and adjacent stream, with stages (Gosner, 1960) of tadpoles transferred to stream and left in nests, 9.9.91 and 12.9.91. Differences between nests reflect different initial stages of embryos in each nest (nest 1 = stage 19, nest 2 = stage 9). All ambient temperatures taken within fifteen minutes at time of data collection.

NEST 1		NEST 2	
Nest	Stream	Nest	Stream
Temp °C		Temp °C	
Max: 30.0	27.5	34.0	31.0
Min: 14.5	17.5	15.5	17.0
Amb: 30.0	25.0	23.5	26.0
Tadpole stages (Gosner, 1960) (n = 10)			
22	23	20	20
23	23	20	20
23	23	20	20
23	23	20	20
23	23	19	20
23	23	20	20
23	23	20	20
23	23	19	20
23	23	20	20
23	23	20	20

the stream, as tadpoles rely on erosion of the nest wall (presumably from fluctuating water levels) to escape. Tadpoles of the Hispaniolan Frog, *Hyla vasta* were reported by Noble (1927) to wriggle over wet rocks from rocky basins into an adjacent stream, but tadpoles of *L. lesueuri* were unable to escape drying nests. All nests were constructed at the waters edge, (or were submerged) minimising the probability of nests becoming isolated from the stream.

Nests reached much higher temperatures than the adjacent stream during the day, but were cooler at night and appeared to cool more rapidly than the stream when shaded. Nests constructed along rainforest streams may be in shade for most of the day, and thus may be cooler than the adjacent stream much of the time, so explaining the similarity between developmental rates of embryos in and out of nests. Given the apparent spatial heterogeneity of temperature regimes observed at the two nests manipulated during this study, further work is required to determine whether frogs select sunny positions for nest sites rather than shady positions, and whether increased temperature may enhance development.

Although there were large numbers of fish and conspecific tadpoles in the stream, tadpoles from both submerged nests observed escaped into the stream. Embryos translocated from nests into the stream also hatched with no apparent mortality from predation.

My observations differ from those of the most comprehensive study to date on the biology of a nest-building frog: *Hyla rosenbergi* from Panama (Kluge, 1981), where there was little difference between nest and stream temperatures. Nest temperatures were, however, more variable. *H. rosenbergi* embryos were consumed rapidly by a number of predators if they were removed from nests and placed in the adjacent stream. Kluge (1981) argued that predation of embryos by small fish, and hetero-and conspecific tadpoles played a key role in the evolution of nest construction in that species. Although mortality from desiccation was considered insignificant, he suggested that it may be higher in the drier, early wet season.

Caldwell (1992) found that nests of *Hyla boans* in Brazil were warmer than those in the stream, and showed that embryos developed more rapidly in nests. The temperature regime was variable among nests and she found that nests with seepage from the stream were cooler and had embryos with slower development than isolated nests.

Despite this apparent advantage, Caldwell (1992) also found that embryos in nests of *H. boans* suffered extremely high levels of mortality from predation and desiccation. Only two of seven nests observed by Caldwell (1992) produced any surviving tadpoles. In contrast, embryos from all clutches laid by *H. boans* outside nests escaped into the stream (Caldwell, 1992). That study was also conducted during the dry season when water levels were falling.

The functional significance of nest construction appears to vary between localities and species. Both of the hypotheses proposed to explain the advantages of nest construction gain some support from the studies of Kluge (1981) and Caldwell (1992). However the selective advantage of nest construction by *L. lesueuri* is less clear, and additional studies are required to further test the two hypotheses. Further experiments should be conducted to determine predation rates on egg masses by fish and conspecifics, and variability in temperature regimes in nests at many sites also needs to be established. My preliminary results suggest that predation of embryos by aquatic organisms may not be a major cause of mortality. Increased temperatures may not provide benefits in terms of enhanced development because nests may be cooler than the stream for most of the day. Mortality in nests later in the wet season needs to be assessed but observations during 1991-2 suggested that nest construction during monsoon rains may be an ineffective strategy as creeks flood and nests and tadpoles are washed away.

What then, is the functional significance of this strategy? I have observed many submerged nests in streams in northern Queensland. The sandy substrates at many of these sites are uniform and mobile. Egg masses removed from nests and placed in the current are frequently rapidly washed downstream. The evolution of nest construction by this species initially may have been a response to a substrate on which egg deposition was virtually impossible without a depression in which to protect the clutch from the force of the current. The observed benefits of nest construction by several species may in fact be a consequence, rather than the cause of, the evolution of nest construction. A large proportion of nests constructed by *H. boans* in central Amazonia are connected to the stream (Hero, pers. comm.), and the nests of *Rana blythi* from Borneo are completely submerged in the stream (Emerson, 1992).

ACKNOWLEDGMENTS

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RECOGNITION OF *LITORIA EUCNEMIS* (LÖNNBERG) IN AUSTRALIA. *Memoirs of the Queensland Museum 34(1): 94. 1993*:- In 1979, in the McIlwraith Ra., Cape York Peninsula (CYP), one of us (KMcD) recorded the call of a frog in the *Litoria eucnemis* species-group (Tyler & Watson, 1985). The call, a series of short growls, has been confirmed recently (September, 1993, KMcD). It clarifies nomenclature of Australian taxa in the *L. eucnemis* group.

Species of this group occur in New Guinea as well as Australia and three names have been proposed for them — *Hyla eucnemis* Lönnberg, 1900 (described from Sattelberg, Huon Peninsula, PNG); *H. genimaculata* Horst, 1883 ('Gebeh' Is, west of Waigeo Is., West Irian); and *H. serrata* Andersson, 1916 (Malanda, Atherton and Carrington, NEQ).

Australian '*eucnemis*' occur in three discrete populations: southern (Paluma-Big Tableland, 19°01'S 146°12'E-15°42' 145°16', NEQ); middle (McIlwraith Ra.-Iron Ra., 13°50'S 143°17'E-12°46' 143°16', CYP); and northern (Wenlock R.-Ducie R., 12°16'S 141°59'E-12°07' 142°21', CYP). These populations have always been treated as a single taxon, but the names *Litoria serrata, L. genimaculata* and *L. eucnemis* have variously been applied (e.g. Ingram & Covacevich, 1981; Cogger et al, 1983; Tyler & Watson, 1985).

There are, however, at least two taxa in Australia with distinctly different mating calls. Males of the southern population produce a series of soft 'ticks' (SJR, KMcD, GJI, pers. obs.; Fig. 1). Those of the middle population have a series of short growls (Tyler & Watson, 1985). Calls of the northern population have not been recorded.

In New Guinea there are also two taxa with distinct calls: one resembling a short, repeated 'growl' (described as 'waa waa' by Menzies (1976) and as 'groups of low, soft chuckling notes' followed by a 'series with several louder, shorter, pulsed calls' by Zweifel (1980)); the other a series of soft 'ticks'. Both authors also concluded there were two morphologically similar species distinguished primarily by mating call structure, and by slight differences in degree of finger webbing and size. They assigned the name *genimaculata* to the taxon with the 'soft tick'; and *eucnemis* to the other.

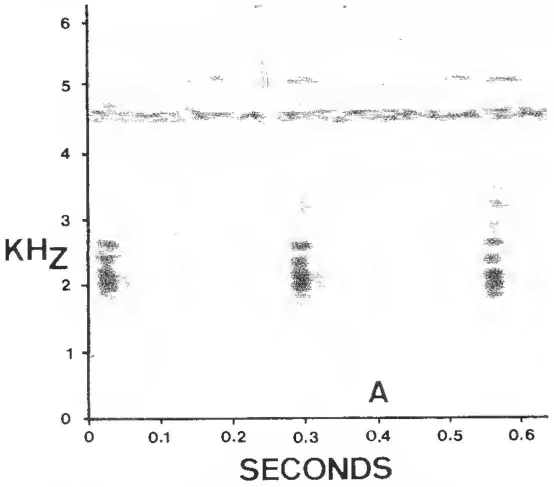

Fig. 1. Sound spectrograph of call of *L. genimaculata* recorded 23 January, 1977, Tully Falls, NEQ, by G.J. Ingram.

Fig 2. *L. eucnemis*, McIlwraith Ra., September, 1993.

Calls of the two Australian taxa closely resemble those of the two New Guinean species. We conclude that the appropriate name for the population between Paluma-Big Tableland is *Litoria genimaculata*; and that for the Iron Ra.-McIlwraith Ra. taxon is *Litoria eucnemis* (Fig. 2). Thus *H. serrata* Andersson, 1916, becomes a junior subjective synonym of *L. genimaculata* (for photograph, see Cogger, 1992: 139). Further, pending investigation of the call of the Ducie R.-Wenlock R. population, it seems reasonable to assign that polulation to *L. eucnemis*.

Acknowledgements

R.G. Atherton, J.W. Winter and D. L. Storch assisted with field work in the McIlwraith Ra. in 1979 and 1993. Research on rainforest frogs was funded by the Wet Tropics Management Authority, Queensland Department of Environment and Heritage, Australian Nature Conservation Agency, Queensland Museum and ARC grants A18715284 and A18931875 to R.A. Alford.

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A REVIEW OF THE LEAF-TAILED GECKOS ENDEMIC TO EASTERN AUSTRALIA: A NEW GENUS, FOUR NEW SPECIES, AND OTHER NEW DATA

P.J. COUPER, J. A. COVACEVICH AND CRAIG MORITZ

Couper, P.J., Covacevich, J.A. & Moritz, C. 1993 12 24: A review of the leaf-tailed geckos endemic to eastern Australia: a new genus, four new species, and other new data. *Memoirs of the Queensland Museum* **34**(1):95-124. Brisbane. ISSN 0079-8835.

Saltuarius gen. nov. is separated from *Phyllurus* by external and internal characters, and by karyotype. To it are assigned *S. cornutus* (Ogilby, 1892); *S. salebrosus* (Covacevich, 1975); *S. swaini* (Wells & Wellington, 1985) and *S. occultus* sp.nov. To *Phyllurus* sensu stricto are assigned *P. caudiannulatus* Covacevich, 1975; *P. platurus* (Shaw, 1790); *P. isis*; *P. nepthys* and *P. ossa* spp. nov. The leaf-tailed geckos (*Saltuarius* spp. and *Phyllurus* spp.) are confined to narrow, isolated patches of rainforest or heathlands in coastal Australia between the McIlwraith Range, far northeastern Queensland (13°45'S, 143°19'E) and the Hawkesbury Sandstone area, near Sydney (33°55'S,151°13'E), mideastern New South Wales. Endemic species lists for several rainforests and lists of rare, endangered or vulnerable species have been changed by this revision. *P.occultus* is recognised as the first reptile species endemic to rainforests of the McIlwraith Ra., FNEQ; *S. cornutus* is no longer a wide-ranging species, but is confined to the Wet Tropics, NEQ; and *P. isis, P. nepthys, P. ossa* spp. nov. and *P. caudiannulatus* join lists of very narrowly endemic rainforest species. ☐ *Saltuarius, Phyllurus , rainforest, endemism, Reptilia, Squamata,Gekkonidae, Australia.*

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Leaf-tailed geckos are well known as being strongly associated with tropical and subtropical rainforests and, to a lesser extent, heaths on sandstones and granites in eastern Australia. Covacevich, 1975 completed a revision of *Phyllurus*, recognising *Phyllurus platurus* (Shaw, 1790), *P. caudiannulatus* Covacevich, 1975 (both small species); *P. cornutus* Ogilby, 1892, and *P. salebrosus* Covacevich, 1975 (both large species). Since then, additional work has been undertaken on *Phyllurus* species, notably by Wells & Wellington (1985) and by Bauer (1990). Further, many new specimens of *Phyllurus* have been added to the reference holdings of the Queensland and Australian Museums. Wells & Wellington (1985) separated *P. swaini* from *P. cornutus*, recognising the specific status of southern and northern forms, previously treated as one species Covacevich (1975). Bauer (1990) confirmed the monophyly of *Phyllurus*, clarified relationships with other carphodactyline geckos, and provided new data on two distinct subgroups within *Phyllurus,* a new key, and new species diagnoses. He did not recognise *P. swaini*.

Rainforest vertebrates in Australia are now generally regarded as being fairly well known, at least in taxonomic terms. However, rainforests of mideastern Queensland are not as well known as those further north. In an attempt to redress that situation, the National Rainforest Conservation Programme funded research in unsurveyed rainforests in this area. Two of the new species of *Phyllurus* from isolated rainforests of mideastern Queensland were collected during this field work. Their discovery prompted this review.

Some 61 specimens of *Phyllurus* have been added to the Queensland Museum's holdings since Covacevich (1975). Most significant are specimens of a new species from far northern Queensland, three new species from isolated rainforest blocks in mideastern Queensland, and specimens from southern Queensland and New South Wales. The last mentioned confirm recognition of *P. swaini* Wells & Wellington (1985) and provide new distributional records and other data.

Bauer's (1990) definition of two subgroups within *Phyllurus* prompted investigation of possible separate generic status for the large species of *Phyllurus*. In particular, we examined the distribution of the diagnostic characters defined by Bauer in our new specimens and added new information from karyology. As a result, we define a new genus, *Saltuarius*, including four species of large leaf-tails-*S. cornutus* (Ogilby 1892), *S. occultus* sp. nov., *S. salebrosus* (Covacevich, 1975) and *S. swaini* (Wells & Wellington, 1985). To *Phyllurus* sensu stricto we assign two previously recognised species - *P. caudiannulatus*

Covacevich, 1975 and *P. platurus* (Shaw, 1790) and three new species - *P. isis, P. nepthys* and *P. ossa* from the rainforests of mideastern Queensland.

Body measurements follow Covacevich (1975) for snout to vent length (SVL); tail length (T), from posterior margin of cloaca to tip of tail; attenuated tip of original tail (TT); head length (HL); head width (HW); snout length (S). Additional measurements include - length of front leg (L1) axilla to tip of longest digit; length of hind leg (L2) groin to tip of longest digit; neck length (NL) axilla to posterior margin of ear.

Morphological characters follow Covacevich (1975) also, with the following modifications - labial scale counts are for both sides of each specimen of newly described species; subdigital lamellae of the 4th toe are for both sides of each specimen (in a sample of 20, 'n' for labial and toe lamellae counts could be a maximum of 40). Skeletal definitions follow Bauer, (1990). Colours are defined subjectively, e.g. cream, rather than according to Ridgway (1912), e.g. cartridge buff. Axillary pits (acarodomatia) are described for both new and previously known species, wherever they are present. As it is not universally agreed that they are useful taxonomic tools (Loveridge, 1951; Arnold, 1986), we use them with caution, only as secondary features, in support of our species definitions.

GENERIC HISTORY

The genus *Phyllurus* has had a fairly stable taxonomic history, save for the successive inclusion in, and exclusion from it of *Underwoodisaurus* spp. *Underwoodisaurus* has been treated as a synonym of *Phyllurus* by Kluge (1967) and Russell (1980), and as distinct from *Phyllurus* by Covacevich (1975) and Bauer (1990). Bauer (1990) provided a 107 character matrix for all carphodactyline taxa and constructed a consensus cladogram of the Australian padless carphodactyline genera from it. His node 5 defined a monophyletic group including *Carphodactylus laevis* with all the then known *Phyllurus* spp. Further, he identified five characters, three of them unique synapomorphies, that confirmed the monophyly of *Phyllurus*. In *Phyllurus*, he recognised two diagnosable subgroups (nodes 7,8). In the former, he placed *P. caudiannulatus* and *P. platurus*. To the latter he referred *P. cornutus* and *P. salebrosus*. This separation of what are essentially the small from the large *Phyllurus* sensu lato, foreshadows the recognition here of a new genus, *Saltuarius*, for the large geckos formerly assigned to *Phyllurus*.

We have examined Bauer's characters for the two phylogenetic divisions in leaf tail geckos (*Phyllurus* sensu lato) in our expanded collection, added new characters and reassessed the evidence using parsimony analysis. One important character, the expansion of the epipubic cartilage, was found to exhibit more variation than recognised by Bauer (1990), with one species of each putative group (*S. occultus* gen. et sp. nov. and *P. nepthys* sp. nov.) having an intermediate condition (Fig. 1). Another significant character used by Bauer was the presence or absence of an anterior process of the interclavicle which, if present, was a narrow spike vs a broad process. Again, we recognize an intermediate state, in *P. nepthys* (Fig. 2).

Important evidence derives from preliminary analysis of karyotypes. Previous studies of *Phyllurus* and related genera of carphodactyline geckos (*Nephurus* and *Carphodactylus*) have reported variation in the number of chromosome arms, but not in the number of chromosomes, all species having the presumed ancestral chromosome number of 2n = 38 (King, 1987). We have obtained new data confirming this result for *S. cornutus* and showing that other species of *Saltaurius* (*S. swaini* and *S. salebrosus*) also have the ancestral condition. Species within *Phyllurus* are unique among carphodactylines in having reduced chromosome numbers. The mideastern Queensland species (*P. caudiannulatus, P. nepthys* and *P. ossa*) have 2n = 28 or 2n = 30 chromo-

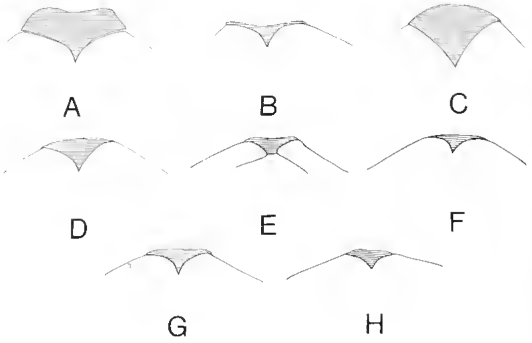

FIG. 1. Variation in size and shape of epipubic cartilage in *Saltuarius* spp. and *Phyllurus* spp. (A) *S. cornutus* - J48178; (B) *S. occultus* - J37037; (C) *S. salebrosus* J33700; (D) *S. swaini* - J8075; (E) *P. caudiannulatus* - J33631; (F) *P. isis* - J53512 (G) *P. nepthys* - J34024; (H) *P. ossa* - J53391. See Bauer (1990) for condition in *P. platurus*.

somes (Fig. 3) with predominantly metacentric or submetacentric chromosomes, suggesting reduction from the 2n = 38 condition via centric fusion. *P. platurus* has an even more reduced chromosome number, 2n = 22. Such dramatic reductions in chromosome number have been reported previously within genera (even 'species' of geckos, e.g. *Nactus*, Moritz, 1987; *Diplodactylus*, King, 1987). Our analysis is limited by small sample size (1-2 specimens per species) and the absence of data for two species, *S. occultus* and *P. isis*. Nonetheless, it provides strong support for the grouping of the species *Phyllurus*.

The chromosome evidence, along with a series of morphological characters (Table 1) were used in a parsimony analysis (using PAUP 3.0s with ordered states and *C. laevis* as an outgroup) to re-evaluate the phylogenetic division proposed within *Phyllurus* sensu lato (Bauer, 1990). Three shortest trees were obtained with the branch and bound search option, and each supported the monophyly of *Saltaurius* and *Phyllurus* (Fig. 4). These major clades were each strongly supported in a bootstrap analysis present in 98% of pseudoreplicates, the former being defined by a minimum of four characters, the latter by six. There was also evidence for grouping of *S. swaini*, *S. cornutus* and *S. salebrosus* to the exclusion of *S. occultus*, although this rests in part on the intermediate state of the epipubic cartilage in *S. occultus*.

The presence of two clearly defined monophyletic lineages within leaf-tailed geckos supports the conclusions of Bauer (1990) and our proposal to recognise *Saltaurius* as a genus.

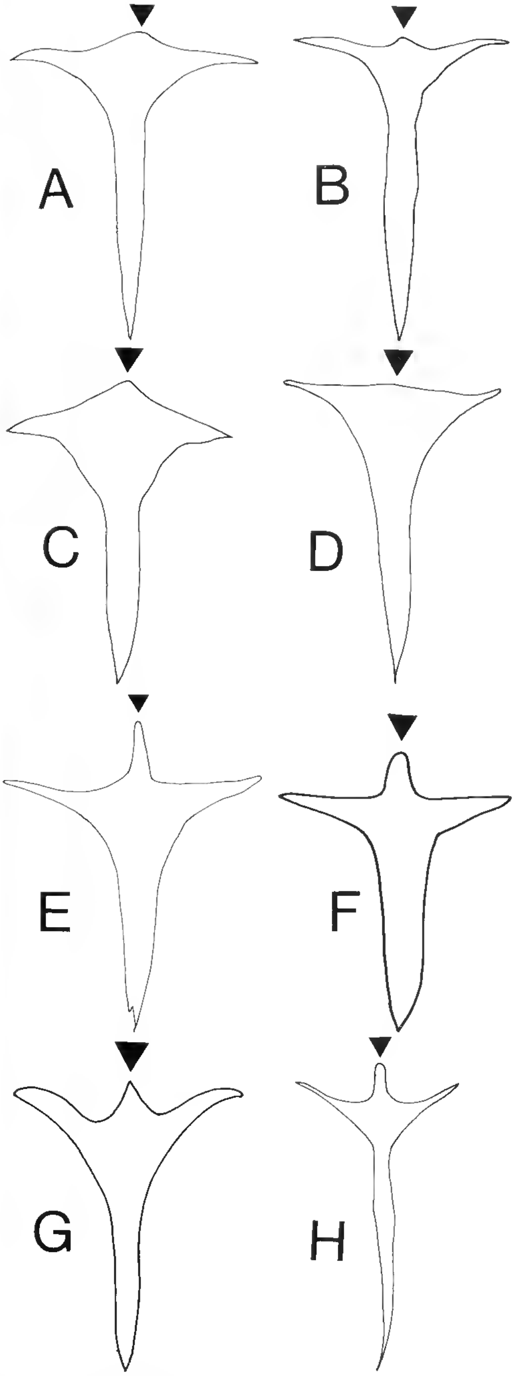

FIG. 2. Condition of the anterior interclavicular extension in *Saltuarius* spp. and *Phyllurus* spp. (A) *S. cornutus* - J48178; (B) *S. occultus* - J37037; (C) *S. salebrosus* - J33700; (D) *S. swaini* - J8075; (E) *P. caudiannulatus* - J33631; (F) *P. isis* - J53512; (G) *P. nepthys* - J34024; (H) *P. ossa* - J53391. See Bauer (1990) for the condition in *P. platurus*.

Saltuarius gen.nov.

See Cogger, et al., 1983; Bauer, 1990.

REFERRED SPECIES

Saltuarius cornutus (Ogilby, 1892); *S. occultus* sp. nov.; *S. salebrosus* (Covacevich, 1975); *S. swaini* (Wells & Wellington, 1985).

DIAGNOSIS

Nostril in contact with rostral (vs not contacting the rostral in *Phyllurus*); anterior margin of interclavicle flat, or forward projecting without distinct process, Fig. 2a-d (vs bearing a distinct process); axilla not, or only very rarely and shallowly, invaginated (vs always, sometimes deeply invaginated); epipubic cartilage moderate to large, wedge-shaped, Fig. 1a-d (vs small - moderate, wedge-shaped); male preanal pores present, Fig. 5a-c, save for one species, Fig. 5d

TABLE 1: Character matrix on which the phylogeny (Fig. 4) for species of *Phyllurus* and *Saltuarius* gen. nov. is based. This analysis includes only the characters that vary within the leaf-tailed geckos. Monophyly of *Saltuarius* and *Phyllurus* with respect to other carphodactyline geckos was demonstrated by Bauer (1990).

CHARACTERS , 1-15	
salebrosus	002110111111010
swaini	0021?0101111010
occultus	0011??01111?01?
corutus	002110111111010
platurus	210001000000111
isis	2100?100000010?
nepthys	1110?1000000101
ossa	2100?1000000101
caudiannulatus	210001000010101
laevis	010110010100000

CHARACTERS

1.Broadened process on anterior interclavicle extension: 0, narrow splint; 1, intermediate; 2, broad
2.Anterior interclavicle extension: 0, absent; 1, present
3.Epipubic cartilage: 0, not expanded; 1, moderate; 2, greatly expanded
4.Supraocular portion of frontal: 0, flat; 1, furrowed
5.Inscriptional ribs: 0, 0-1; 1, 2-4; 2, 5-7 ribs.
6.Postmental scales: 0, enlarged anteriorly; 1, subequal
7.Scales of rosettes: 0, not spinose; 1, spinose
8.Preanal pores: 0, absent; 1, present
9.Rostral contacting nostril: 0, no contact; 1, contact
10.Body size: 0, max SVL <103mm; 1, max SVL >103mm
11.Rostral: 0, not divided or only partially divided; 1, completely divided
12.Tail: 0, simple; 1, elaborate edge flanges
13.Attenuated tip on regrown tail: 0, not elongate; 1, elongate
14.First autotomy septum: 0, 5; 1, 6
15.Chromosome number: 0, 2n=38; 1,2n<38

(vs male preanal pores absent); original tail[1] strongly flared, with an elaborate outer flange, Fig. 6a (vs cylindrical to simply flared, lacking an elaborate outer flange, Fig. 6b); regenerated tail strongly flared, with only a small attenuated tip (vs cylindrical to moderately flared, with a pronounced attenuated tip). Max SVL 108-144mm, medium to large (vs max SVL 76-103mm[2], small - medium); karyotype 2n=38 (vs 2n=30 or 22); rostral completely divided, Fig.

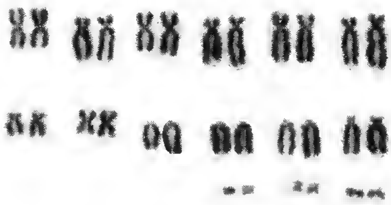

FIG. 3. Karyotype (2n=30) of *Phyllurus nepthys* from Finch Hatton Gorge, MEQ.

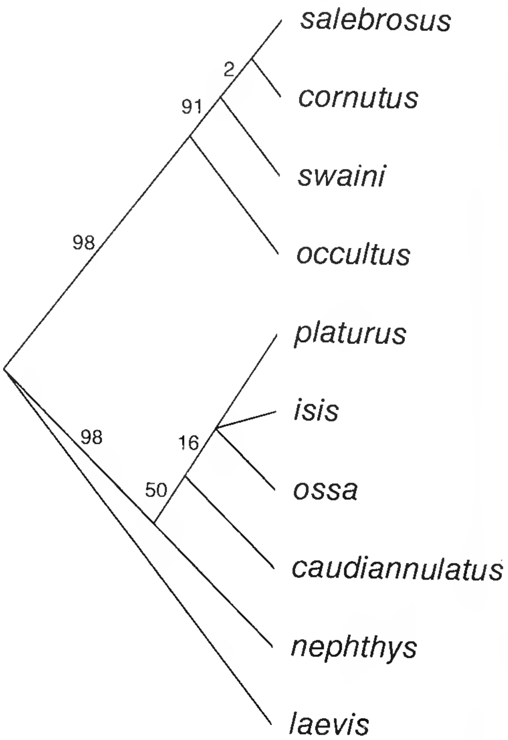

FIG. 4. Phylogenetic hypothesis for species of *Phyllurus* and *Saltuarius* derived from parsimony analysis of morphological characters with ordered character states and 100 bootstrap replicates. The numbers above the branches are the number of replicates in which the group to the right was monophyletic. The analysis provides strong support for the monophyly of species within *Saltuarius* and within *Phyllurus*. The monophyly of the two genera with respect to *Carphylodactylus laevis* is assumed on the basis of Bauer's (1990) analysis.

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[1] The original tail of *S. occultus* is not known, because the species is based on only 4 type specimens, none with original tails.

[2] Bauer (1990) gives SVL 112 mm for one *P. caudiannulatus*. The max SVL for *P. caudiannulatus* here is 91.24 mm. Since Bauer's work, *P. nepthys* has been separated from *P. caudianannulatus*. The max. SVL for *P. nepthys* is 103 mm.

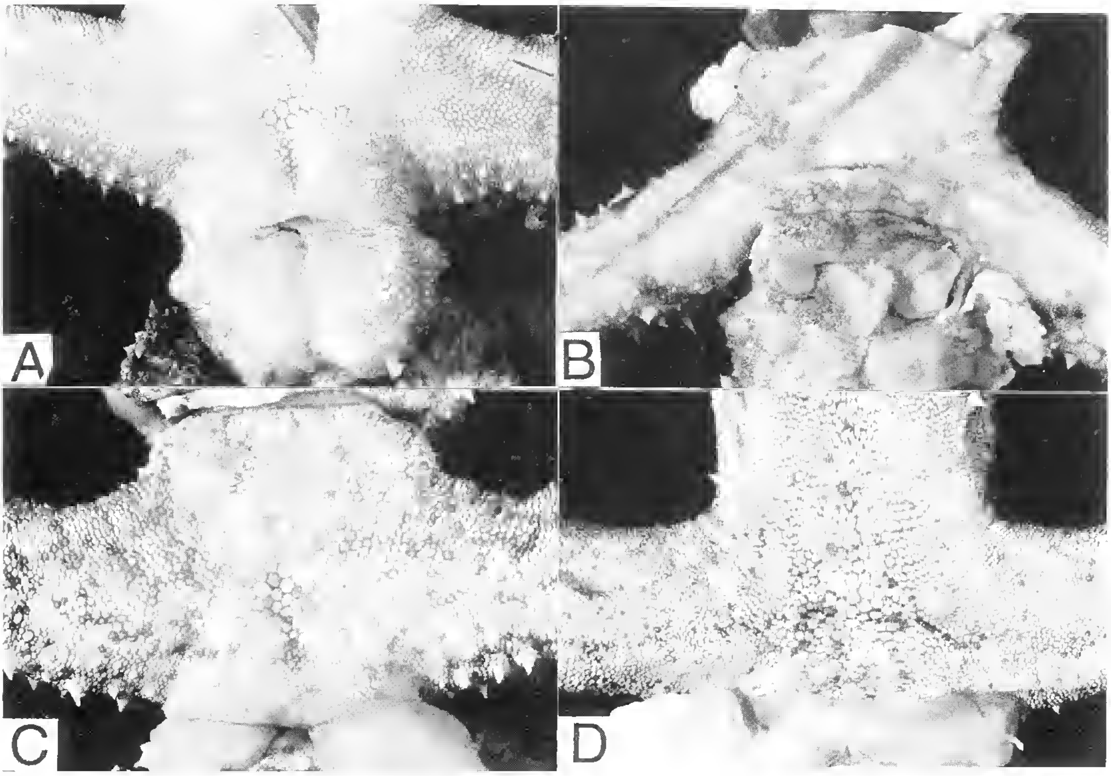

FIG. 5. Presence or absence of preanal pores in *Saltuarius* spp. Preanal pores present (A) *S. cornutus* - J51097, (B) *S. occultus* - J37038, (C) *S. salebrosus* - J33730. Preanal pores absent (D) *S. swaini* - J51639.

7a-d (vs partially divided, Fig. 7e-j, save for one species).

DISTRIBUTION

Eastern Australia: from McIlwraith Ra., Cape York Peninsula, FNEQ, to central coastal NSW (Fig. 8). Individual species accounts contain further details.

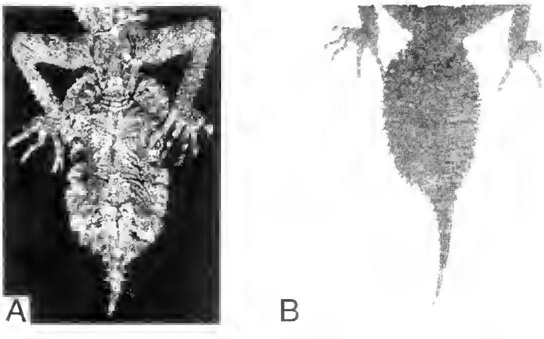

FIG. 6. Original tails of (A) *S. salebrosus* (J33730) - strongly flared with an elaborate outer flange. (B) *P. platurus* (R106497) - simply flared, lacking an elaborate outer flange.

HABITAT

S. occultus and *S. cornutus*, are obligatory rainforest species. *S. salebrosus* occurs in complex notophyll vine forest in Bulburin SF, SEQ, and in araucarian vine thicket in the Goodnight Scrub, SEQ. Throughout the rest of its range, it is found in dry rocky (sandstone) situations. *S. swaini* is found in both rainforest, and in granite-based heathlands.

REPRODUCTION

Oviparous, producing two soft-shelled eggs.

ETYMOLOGY

From the Latin - 'keeper of the forest'.

A key to *Saltuarius*

1.Throat smooth 2
Throat strongly tuberculate.................*S. salebrosus*
2.Lower flank tubercles hooked and surrounded by spinose basal scales (Fig. 9a) ....*S. cornutus*
Lower flank tubercles not as above 3
3.Neck extremely elongate and slender (Fig. 10a) ....*S. occultus*
Neck not as above (Fig. 10b) ....*S. swaini*

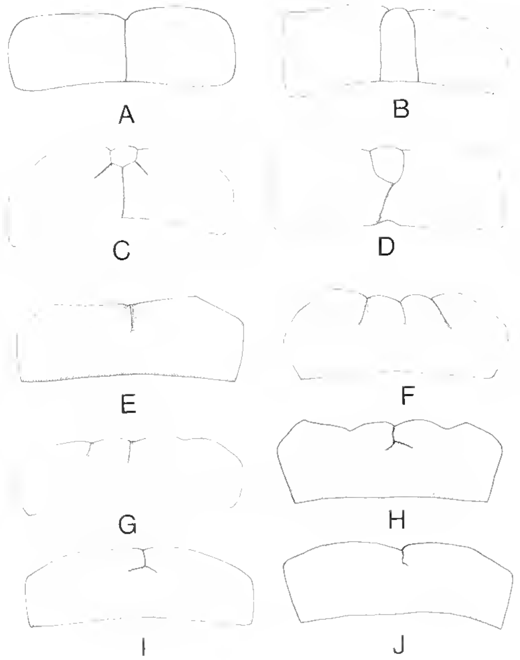

FIG. 7. Variations in rostral grooving (A-D) *S. swaini* (Fig. 7A is the typical condition for all *Saltuarius* spp. and also for *P. caudiannulatus*); (E) *P. isis* (also the condition for *P. nepthys*); (F-H) *P. ossa*; (I-J) *P. platurus*.

Saltuarius cornutus (Ogilby 1892)

(Figs 1a; 5a,d; 7a,b; 9a,b; 11; 12a,b; 13)

Gymnodactylus cornutus Ogilby, 1892.
Phyllurus lichenosus Günther, 1897.
Gymnodactylus spyrurus Barrett, 1950.

Material Examined

Queensland Museum: J25394, Home Rule (15°44', 145°17') NEQ; J27265, Mt Finlay (15°49', 145°21') NEQ; J51631-2, Bell Pk, Malbon Thompson Ra., (17°05', 145° 52') NEQ; J48279, Danbulla SF, Kauri Ck, Mt Haig Rd (17°07', 145°38'); J25373, Atherton Tableland (17°16', 145°29') NEQ; J9532, Atherton, 11km SW Walsh Camp (17°20',145°25') NEQ; J30991, Boonjee, via Malanda (17°22', 145°45') NEQ; J52775, Millaa Millaa, Palmerston Hwy (17°31', 145°37') NEQ; J48254, Ravenshoe SF, near Vine Ck (17°41', 145°31') NEQ; J48178 (alizarin stained), J48179, Koolmoon Ck, S of Ravenshoe (17°44', 145°34') NEQ; J28355, Koombooloomba Dam, via Tully Falls (17°50', 145°36') NEQ; J51096-7, Paluma SF, 2km from turnoff to Paluma Dam (19°01, 146°12') NEQ; J2126, ?Northern Rivers; J149, Queensland. Australian Museum: R26118-9, Evelyn, approx 14.5km from Ravenshoe (17°30', 145°27') NEQ; R128869, El Arish (17°49', 146°00') NEQ; R12935, Queensland.

The original description of *S. cornutus* is accurate. It has been refined by Covacevich (1975) and Bauer (1990). The former recognised three variable, geographically-isolated forms within *S. cornutus* - from rainforests of NEQ; SEQ-MENSW, and the granite-based heaths of the Stanthorpe area, SEQ. The latter recognised four forms of *S.cornutus* - disjunct populations from near Coen, FNEQ; between Cooktown and Townsville, NEQ; from extreme SEQ to MENSW, and the Stanthorpe area, SEQ. Specimens from far northeastern Queensland were collected in 1979, and referred to *S. cornutus* at registration into the Queensland Museum reference collection. Cogger (1992) included them in his distribution map for *Phyllurus* (now *Saltuarius*) *cornutus* and Covacevich & McDonald (1991a) note their collection locality, McIlwraith Ra. FNEQ (13°50', 143°18'), as the northern limit of the range of *Phyllurus* (=*Saltuarius*) *cornutus*.

The far northeastern Queensland specimens of '*P. cornutus*' (which were not included in any of the descriptions of that species) are here

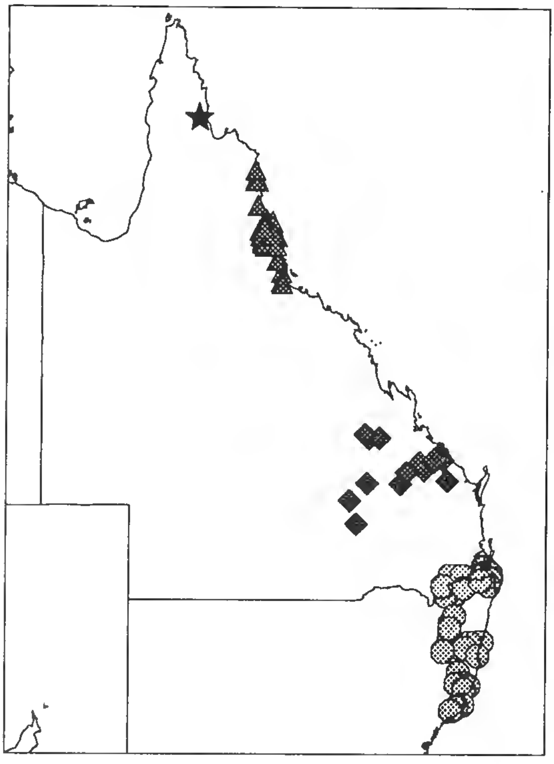

FIG. 8. Distribution of *Saltuarius* spp.

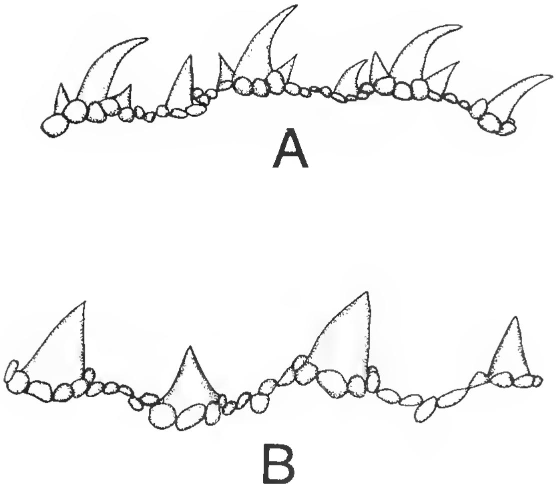

FIG. 9. Flank tubercles of (A) *S. cornutus* (J48254), (B) *S. swaini* (J8183).

described as *S. occultus* . Specimens of '*P. cornutus*' from SEQ- MENSW have been described as *S. swaini* (Wells & Wellington, 1985). The type description is incomplete. It does not include any reference to the features that most readily separate *S. swaini* from *S. cornutus* and does not provide a diagnosis. These, and other deficiencies in the description are redressed under *S. swaini*. The population of '*P. cornutus*' isolated on the Stanthorpe area granites is here referred to *S. swaini*.

With these recent descriptions of new taxa from the wide-ranging former '*P. cornutus*', there are now three species of *Saltuarius* in addition to the nominate species. *S. cornutus* sensu stricto is now confined to the rainforests of the area between Big Tableland and Mt. Spec, NEQ, in the Wet Tropics, one of Australia's World Heritage sites.

Thus, in the light of these changes, data for *S. cornutus* should be modified.

DIAGNOSIS

S. cornutus is a moderately spinose, large *Sal-*

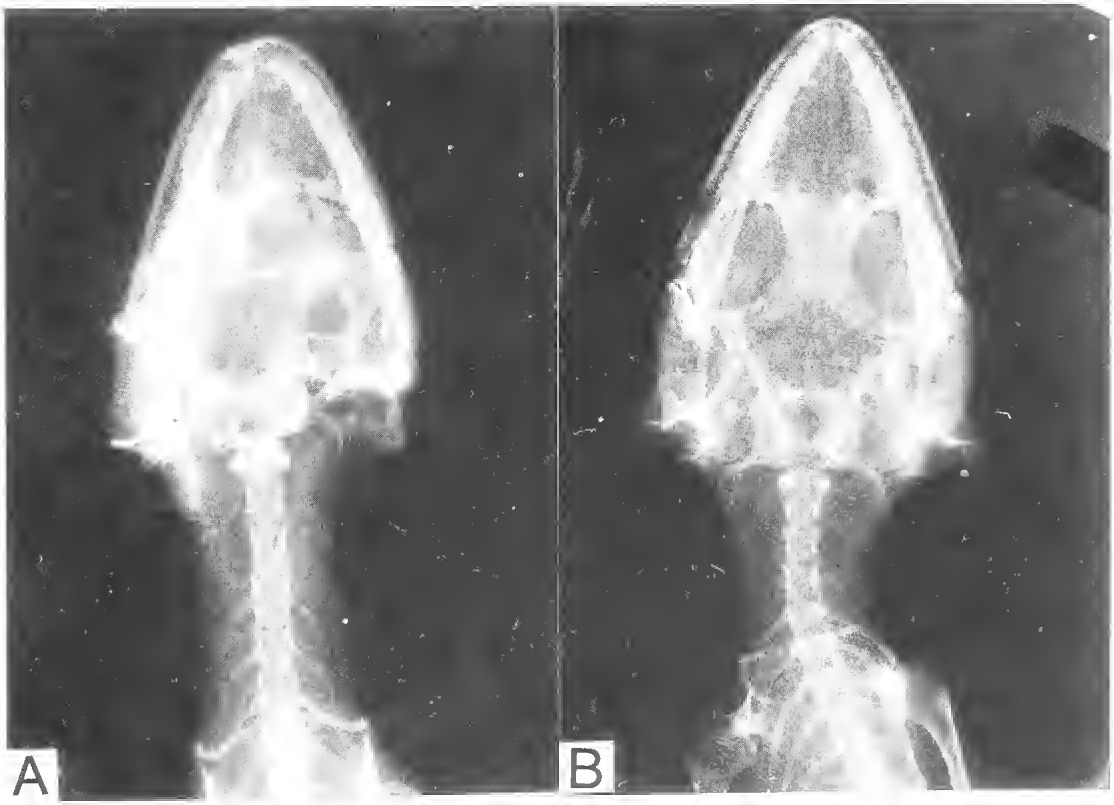

FIG. 10. X-rays showing the cervical vertebrae of (A) *S. occultus* and (B) *S. cornutus*. Elongation of the cervical vertebrae in *S. occultus* results in this species having a proportionately longer neck than other *Saltuarius* spp. Condition (B) is shared with *S. salebrosus* and *S. swaini*.

FIG. 11. *S. cornutus*, Paluma, NEQ (S. Richards).

tuarius (maximum SVL 144mm). It is distinguished from *S. salebrosus* by its chin scalation (smooth, with no raised tubercules vs rough, covered with raised tubercules); from *S. occultus* by flank tubercules (long and hooked - Fig. 9a, surrounded by smaller spines vs not long and hooked and not surrounded by smaller spines), by the number of lumbar vertebrae (2 - Fig. 12a vs 3 - Fig. 12b) and by the size of neck vertebrae (not elongate vs elongate); and from *S. swaini* by flank tubercules (long and hooked, surrounded by smaller spines - Fig. 9a vs not hooked and not surrounded by smaller spines - Fig. 9b). It is further distinguished from *S. swaini* by preanal pores (males with preanal pores - Fig. 5a vs males without preanal pores - Fig. 5d).

DESCRIPTION

With the separation of *S. occultus* and *S. swaini* from *S. cornutus*, the descriptions provided by Covacevich (1975) and Bauer (1990) for this species require minor modification. Bauer (1990) refers to the flank tubercules as being 'enlarged and hooked' (Fig. 9a). We found this character to be confined to NEQ (Big Tableland-Mt Spec) specimens. This character is absent in far NEQ specimens (*S. occultus*) and SEQ through MENSW specimens (*S. swaini*). Bauer's sample (in litt.) was based predominantly on NSW and SEQ specimens from the Australian Museum's collection. This explains why his diagnosis makes no reference to preanal pores, which are present in male *S. cornutus* (Fig. 5a) and absent in male *S. swaini* (Fig. 5d). Covacevich (1975) recognised the difference in the flank tubercules between the NEQ (long hooked spines surrounded by smaller spines - Fig. 9a) and the SEQ-NSW (shorter, unhooked spines - Fig. 9b) populations. At the time she treated this as acceptable variation within a single species. The far NEQ specimens (*S. occultus*) were unknown at the time of her revision. We now regard this feature (long hooked flank tubercules surrounded by smaller spines - Fig. 9a) as key to the diagnosis of *S. cornutus*. Covacevich (1975) and Bauer (1990) provide size ranges for '*P. cornutus*'. Of the three species now recognised from the former *P. cornutus* sensu lato, *S. cornutus* is the largest (maximum SVL 144mm). *S. swaini* has a maximum SVL of 131mm and *S. occultus* (based on the 4 known specimens) has a maximum SVL of 108mm.

The following measurements and characters have not been included in previous descriptions of *S. cornutus*: Proportions as % SVL: L1 43-50 (n18, mean 46.4); L2 53-62 (n17, mean 56.1); S

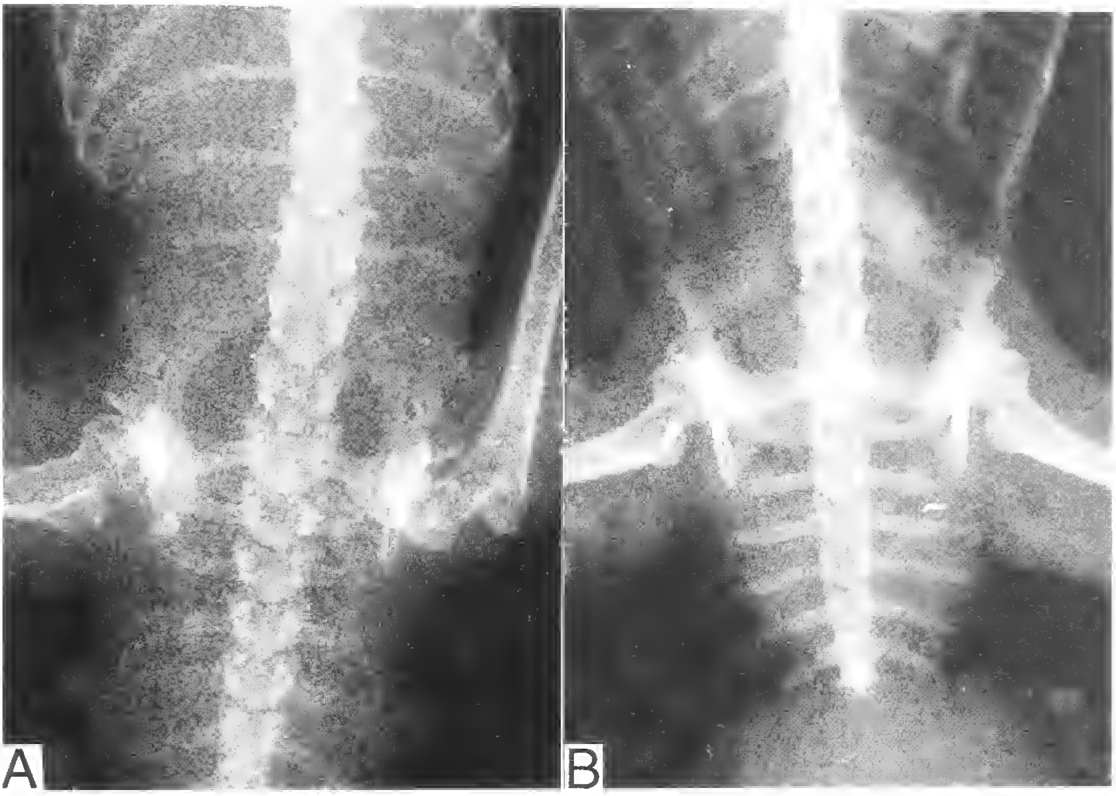

FIG. 12. X-rays showing the number of lumbar vertebrae in (A) *S. cornutus* (J28355), two lumbar vertebrae; (B) *S. occultus* (J37040), three lumbar vertebrae. Condition (A) is shared with *S. salebrosus* and *S. swaini*.

12-15 (n20, mean 13.0); NL 13-21 (n20, mean 17.3). Rostral completely divided by a single vertical groove, Fig. 7a (n18), or by two grooves forming an additional scale and dividing the rostral into three (n2), seen also in *S. swaini*, (Fig. 7b). Axilla not invaginated. Preanal pores present in males (Fig. 5a).

SKELETAL FEATURES

Material examined: (X rays) J28355, J30991, J48254; (alizarin stained) J48178.

Supraocular portion of frontal grooved (n4); anterior process of interclavicle projecting slightly forward, Fig. 2a (n1); epipubic cartilage greatly expanded, Fig. 1a (n1); presacral vertebrae 25-26 (n3, mean 25.3); sacral vertebrae 2 (n3); lumbar vertebrae, 2-Fig. 12a (n3); 1st autotomy septum 6 (n1); abdominal vertebrae bearing reduced ribs 4 (n1); rib free cervicals 3 (n3); cervical vertebrae not enlongate; sternal ribs 3 (n1); mesosternal ribs 2 (n1).

DISTRIBUTION

Big Tableland (15°43', 145°16', sight record, K.McDonald pers. comm.) to Mt Spec (19°01', 146°12') NEQ (Fig. 13). The locality given for QM J212 is '?Northern Rivers', which usually refers to an area in northern NSW. The previous entry in the register (QM J2125) is a specimen of *Nephrurus asper* from the same locality. As neither *S. cornutus* nor *N. asper* occurs in NSW, nor are they sympatric elsewhere, the locality '?Northern Rivers' should probably be regarded as an error.

HABITAT

Tree trunks and rocks, tropical rainforest.

REPRODUCTION

A female from the Malbon Thompson Ra., NEQ laid two oval-shaped eggs on 1 December, 1990 (±3 days). These measured 26.62 x 16.05 mm and 27.24 x 16.44 mm. The eggs took 100±3 days to hatch at a temperature of approximately 24°C. Hatchlings measured (SVL) 50.63mm and 51.41mm.

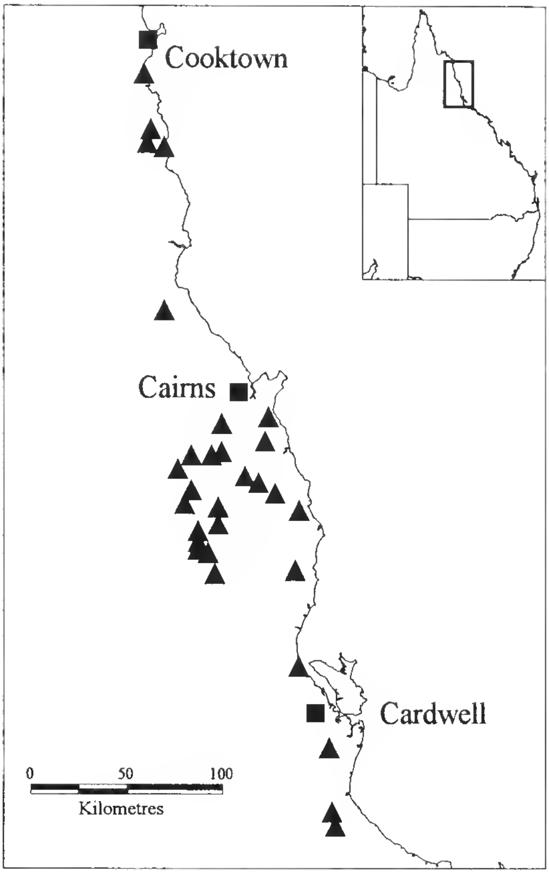

FIG. 13. Distribution of *S. cornutus*.

Diet

A faecal sample from QM J48179 contained fragments of cockroaches, a cricket, and a spider (Blattellidae, Gryllidae and Sparassidae).

Saltuarius occultus sp. nov.

(Figs 1b, 2b, 5a-d, 7a, 10a, 12b, 14, 15)

Material Examined

Holotype: Queensland Museum: J37040 ♀ (with regenerated tail) Peach Ck, McIlwraith Ra., 19km ENE of Mt Croll (13°45', 143°19') FNEQ, J.W. Winter, R.G. Atherton, P.A. Matthew, 7 June 1979. paratypes: Queensland Museum: J37037 (alizarin preparation), J37038-9 summit of McIlwraith Ra., 17km ENE of Mt Croll (13°46', 143°19'), FNEQ.

Diagnosis

S. occultus is a moderately spinose, medium-sized *Saltuarius* (maximum SVL 108mm). An extremely long, thin neck, a function of elongate neck vertebrae (Fig. 10a), mean % NL/SVL 24.2; a series of enlarged, spinose tubercles fringing the regenerated tail; and three lumbar vertebrae (Fig. 12b) separate it from all its congeners.

S. occultus resembles *S. cornutus* and *S. salebrosus* in having male pre-anal pores (Fig. 5a-e). These are not present in *S. swaini* (Fig. 5d). In *S. occultus* they are very pronounced, and form a raised cluster (vs not pronounced, only just visible without magnification, and flat).

Distribution

McIlwraith Ra. (13°45', 143°19'), Cape York Peninsula, FNEQ (Fig. 15).

Habitat

Microphyll / notophyll vine forests, on a variety of substrates, including granite.

Habits

Known from only four specimens, all of which were found at night, on granite boulders in rainforest.

Reproduction

The only females known (J37037, J37040) were found with enlarged vitellogenic follicles between late May and early June, 1974.

Diet

The gut of QM J37038 contained spider fragments.

Etymology

From the Latin - 'hidden' and so, difficult to find.

Description

SVL (mm): 99-108 (n4, mean 102.7). Proportions as % SVL: L1 45-49 (n4, mean 47.1); L2 56-61 (n4, mean 59.0); HL 25-27 (n4, mean 25.8); HW 16-19 (n4, mean 17.2); S 12-14 (n4, mean 13.0); NL 23-27 (n4, mean 24.2).

Head: large, depressed, elongate, shovel-shaped, distinct from neck; covered in small granules which are intermixed with larger conical tubercles (top of snout without larger tubercles); skin of head and skull not co-ossified; rostral divided, bisected by a deep vertical groove (Fig. 7a); rostral contacting nostril; ear opening extremely narrow, elliptical, vertical, much less than half as large as eye; supralabials 19-21 (n8, mean 19.75), infralabials 18-22 (n8, mean 19.5). Neck: long and slender. Body: moderate, depressed, covered in small granules; dorsal granules intermixed with larger conical tubercles;

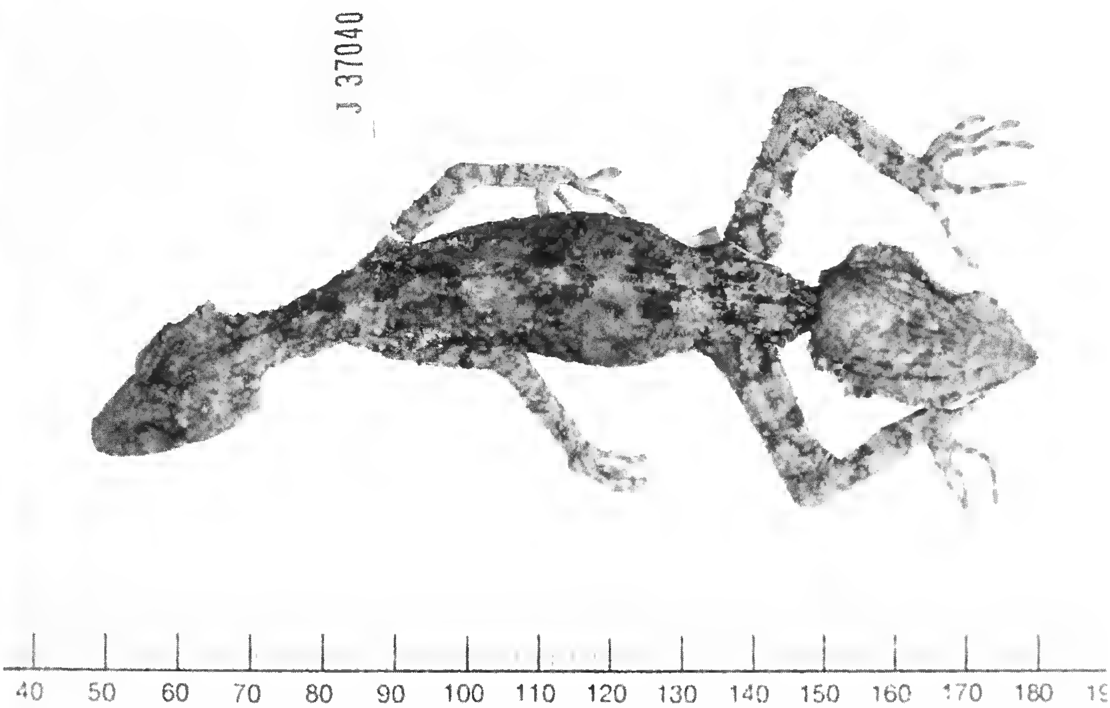

FIG. 14. *S. occultus* (holotype J37040), Peach Ck, McIlwraith Ra., NEQ (B. Cowell).

tubercles moderate on back, small on flanks, no more prominent on sides of neck than back; basal scales surrounding flank tubercles not enlarged; no enlarged tubercles or granules on ventral surface of body. Preanal Pores: present in males, extremely prominent (Fig. 5b). Limbs: long, covered in pointed tubercles dorsally (much more prominent on hind limb); proximal portion of forelimb bearing slightly enlarged tubercules on ventral surface; digits strong, compressed distally; subdigital lamellae (fourth toe) 23-25 (n4, mean 24). Original tail: unknown, because all of the type series have regenerated tails. Regenerated tail: (n4) depressed, broad and leaf-like, contracted at base, not attenuated at tip; lacking spinose tubercles on dorsal surface; edges surrounded by broad spinose tubercles.

SKELETAL FEATURES

Material examined: (X rays) J37038-40; (alizarin stained) J37037. Supraocular portion of frontal grooved (n4); anterior process of interclavicle projecting slightly forward (Fig. 2b) n 1; epipubic cartilage slightly expanded (Fig. 1b) n 1; presacral vertebrae 25 (n3); sacral vertebrae 2 (n3); lumbar vertebrae 3 (Fig. 12b) n 3; 1st autotomy septum 6 (n3); abdominal vertebrae bearing reduced ribs 3 (n1); rib free cervicals 3 (n3); cervical vertebrae greatly enlarged (Fig. 10a); sternal ribs 3 (n1); mesosternal ribs 2 (n1).

PATTERN

In spirit, dorsal base colour tan; heavily marked

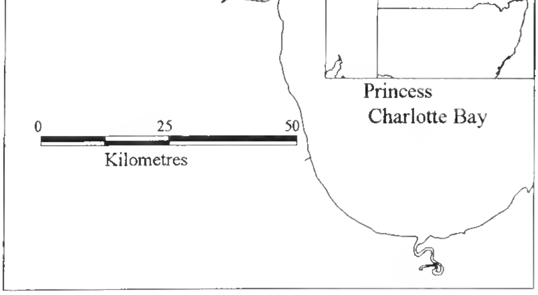

FIG. 15. Distribution of *S. occultus*.

with large distinct, dark brown blotches which form a series of four irregular crossbands between the axilla and groin. Limbs bearing irregular dark brown crossbands. Head marked with less distinct brown blotchings. Ventral surface cream with pale brown mottling on belly, throat and limbs. Labials, mainly dark brown broken by patches of white. Regenerated tail tan to cream, mottled brown dorsally and ventrally.

Saltuarius salebrosus (Covacevich, 1975)
(Figs 7a,b; 16; 17)

MATERIAL EXAMINED
Queensland Museum: J51091-2, Blackdown Tableland, 500m from top (23°46', 149°06') MEQ; J36114, Cania Kroombit goldfield , near Dawes Ra., via Monto (24°38', 150°58') SEQ; J33730-2, Granite Ck. tributary crossing to forestry camp, Bulburin (24°31', 151°29') SEQ; J33700 (alizarin stained), J51090, Bulburin SF (24°31', 151°29') SEQ; J9770, Lowmead (24°32', 151°45') SEQ; J22288, Bulburin SF, Granite Ck, via Many Peaks (24°35', 151°29') SEQ; J8377, Injune (25°51', 148°34') SEQ; J8142, Monto (24°52', 151°07') SEQ; J56919, Bania SF, via Monto (24°57', 150°30') SEQ; J5390, J25360, J28741, Goodnight Scrub, via Wallaville (25°12', 151°55') SEQ; J6198, Burnett R., Goodnight Scrub (25°12', 151°55') SEQ; J28802, J29778, J36115, Robinson Gorge, Taroom (25°17', 149°09'); SEQ; J6382, Cracow, Cracow Ck. (25°18', 150°18') SEQ.

Little that is new can be added to the data on *S. salebrosus*. The type description is accurate and no change to the species definition is warranted following re-examination of the specimens of Covacevich (1975), and examination of those added to museum collections recently.

The following measurements and characters have not been included in previous descriptions of *S. salebrosus*:

Proportions as % SVL: L1 45-50 (n19, mean 47.1); L2 53-61 (n17, mean 57.1); S 11-13 (n20, mean 12.2); NL 15-21 (n20, mean 18.5).

Rostral completely divided by a single vertical groove (Fig. 7a) n 17, or by two grooves forming an additional scale and dividing the rostral into three (n2) seen also in *S. swaini* (Fig. 7b). The axilla is normally not invaginated (n16), but is sometimes slightly invaginated (n4). For skeletal description see Bauer, (1990).

Some modification to distribution of *S. salebrosus* is required following re-examination of

FIG. 16. *S. salebrosus*, Bulburin SF, SEQ (S. Wilson).

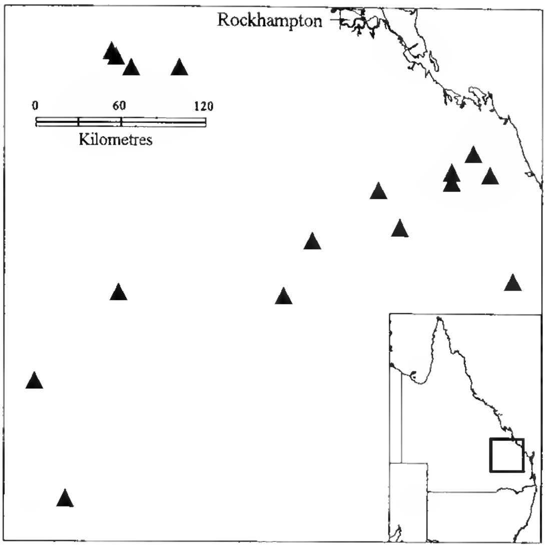

FIG. 17. Distribution of *S. salebrosus*.

data for one specimen originally believed to be from south-central Queensland, remote from the near-coastal range of the species. The record was based on QM J4897 'Coongoola, SCQ'. The specimen in fact comes from Coombooloolaroo Station, a locality well within the near-coastal range of *S. salebrosus*, and quite close to the Blackdown Tableland, an area in which *S. salebrosus* is well known now. In addition to restricting the western range of *S. salebrosus*, new data extends it a little to the north and slightly to the south west of its former range, Fig. 17 (minus the 'Coongoola, SCQ' record). New records since those of Covacevich (1975) include Blackdown Tableland, MEQ, J35400, J35448, J51091-2 (23°46', 149°06'), where specimens of *S. salebrosus* are common in heaths on both sandstones and granites, and Bania State Forest, via Monto, SEQ, J56919, (24°57', 150°30') in rainforest.

REPRODUCTION

New data on breeding by *S. salebrosus* are also available. A young specimen (J51090, SVL 52.8mm) was collected at Bulburin State Forest on 18 May, 1991. This individual is similar in size to newly emerged *S. cornutus* hatchlings (50.63-51.41mm). It seems reasonable to regard it as a newly emerged hatchling. The incubation period recorded for *S. cornutus* is approximately 103 days. Because of close taxonomic affinity, it seems reasonable to suggest that the eggs of *S. cornutus* and *S. salebrosus* would have a similar incubation period. If this is so, the oviposition date for hatchling J51091 would have been early February, 1990.

DIET

The gut of QM J33732 from rainforest, contained one large cockroach and a pygmy grasshopper (Tetrigidae). QM J51092 from open forest, contained fragments of a spider.

Saltuarius swaini (Wells & Wellington,1985)
(Figs 2d; 5a,d; 7a-d; 9a,b; 18a,b; 19)

Phyllurus swaini Wells & Wellington, 1985.

The specimen chosen as the holotype of *S. swaini* was unfortunate considering the many specimens available to the authors. Specimen AM R116978 (formerly AM Field Series no. 16799), the holotype, is extremely faded and all but patternless; has been totally eviscerated; has a badly damaged left lower jaw; and has a separate, regenerated tail. The type description of *S. swaini*, which is based on this specimen and one published photograph, is neither complete nor accurate. Characters key to separating *S. swaini* from *S. cornutus* are not described (i.e. smaller size, lateral tubercles that are neither hooked nor surrounded by at least some spinose basal scales (Fig. 9b), and the absence of preanal pores (Fig. 5d). Further, part of the discussion of this species is erroneous. ... 'Another species occasionally confused with this taxon is *Phyllurus caudiannulatus* of southeast Queensland; Covacevich, 1975, included northeast New South Wales specimens of *P. swaini* in her analysis of *P. caudiannulatus*'.... *P. caudiannulatus* has not been (and could hardly be) confused with *S. swaini*. The former is very distinct in being considerably smaller than *S. swaini*, and in having a distinctly white-banded original tail. It is restricted to the Dawes/Many Peaks Ranges, SEQ. No mention of specimens from northeastern New South Wales is made in the description of *P. caudiannulatus* by Covacevich, (1975) although she does refer to *P. platurus* of ...' more open forest in rocky, especially sandstone areas of mideastern New South Wales'...

This re-description of *S. swaini* is based on a sample of specimens selected from the collections of the Queensland and Australian Museums, to give maximum range in terms of distribution and morphological diversity.

MATERIAL EXAMINED

Australian Museum R116978, holotype, (formerly AM

Field Series no. 16799) Richmond Ra. SF, (28°31', 152°44') NSW. Other Specimens:Queensland Museum: J398, J2409, J2933-34, J3254, J4439, J8183, J8359, J8861, J10440, J12257, J51095 Mt Tamborine, (27°55', 153°10') SEQ; J4819, Mt Tamborine, Eagle Heights (27°55', 153°12') SEQ; J148 Canungra Ck (27°58', 153°09') SEQ; J3215 Canungra (28°01', 153°11') SEQ; J4198, J5690 Mudgeeraba (28°05', 153°22') SEQ; J5649 Flying Fox Valley, Beechmont (28°08', 153°12') SEQ; J3313 Tallebudgera (28°08', 153°26') SEQ; J5382 Lamington NP (28°12', 153°05') SEQ; J8646 Lamington NP Binna Burra (28°12', 153°11') SEQ J23937 near Mt. Ballow, (28°16', 152°37') SEQ; J51094 Mt. Superbus SF, via Warwick, (28°13', 152°28') SEQ; J51639 J51637-40 O'Reilly's, Lamington NP (28°14', 153°08') SEQ; J8074, J8075 (alizarin stained), J8099 Mt Clunie, via Boonah (28°18', 152°32') SEQ; J1143 Tweed R. (28°18', 153°27') NSW; J5757 Chillingham, Murwillumbah (28°19', 153°17') NSW; J10565 Mt Lindesay (28°23', 152°43') SEQ; J35401 Boonoo Boonoo Falls, via Tenterfield (28°48', 152°10') NSW; J24250, J27349 near Girraween (28°50', 151°55') SEQ; J25374 Girraween NP, via Stanthorpe (28°50', 151°55') SEQ; J28648-9 Girraween area, near Wyberba (28°50', 151°55') SEQ; J29115-7 Stanthorpe area, ?Girraween (28°50', 151°55') SEQ; J30677 Stanthorpe, Aztec Temples, near underground river (28°50', 152°05') SEQ; J51093 edge of Girraween NP (28°50', 151°56') SEQ; J51633-6 Girraween NP, Natural Arch track (28°50', 151°55') SEQ; J54847 Bookookoorara, Boonoo SF (28°51', 152°11') NSW J50345 Girraween NP (28°51', 151°55') SEQ; J30420 near Wyberba (28°52', 151°52') SEQ; J53984 Teapot Ck, Narrow Pass Fire Trail, Mann R. Nature Reserve (29°45', 152°02') NSW; J54846 Bray's Ck, Border Ranges NP (28°24', 153°03') NSW; J9054 Bulahdelah, 96km NE Newcastle (32°25', 152°12') NSW; J56894 found on warehouse wall, Brisbane. Australian Museum: R97823 Mt Superbus,(28°13', 152°26') SEQ; R2409 Murwillumbah, Tweed R., (28°20', 153°24') NSW; R110510 Mt. Warning, (28°24', 153°16') NSW; R118601 Huonbrook (28°32', 153°21') NSW; R92121-3 6km NW of Amiens, (28°34', 151°46') SEQ; R98332-3 ca. 1.5km NW of Amiens, (28°34', 151°46') SEQ; R130911 Yabbra SF, (28°37', 152°30') NSW; AM Field No. 41650 Black Ck, 6.1km SE along Black Hole Trail, Curramore SF, (29°30', 152°11') NSW; AM Field No. 41770 Willy's Ck, 300m downstream from Oakwood Fire Trail, (29°53', 152°02') NSW; R43870 33km E of Guyra, (30°15', 152°00') NSW; R69866-7, R81921 Coff's Harbour, (30°18', 153°08') NSW; R43875 Dorrigo, (30°20', 152°43') NSW; R43871-3, R16905, R16989, R17008 Pt Lookout, via Armidale, (30°29', 152°25') NSW; R54071 Brinerville, via Thora, (30°29', 152°33') NSW; R97670-2, R106749 Cogger's property, near Brinerville, (30°29', 152°33') NSW; AM Field No. 41683 first falls below Blue Hole, Gara R. Gorge, (30°36', 151°48') NSW; R6284 Gurravembi, near Macksville on Nambucca R., (30°44', 152°59') NSW; R103031 4.5km N. of Wonders Hill Homestead, (31°16', 152°19') NSW; R71372-3 Comboyne Pk, (31°35', 152°32') NSW; R6247 Bulga Tableland, near Bobin, Manning R., (31°37', 152°15') NSW; R6915 Bulong, via Wingham (31°37', 152°18') NSW; R59313 vicinity of Bird Tree, Middle Brother SF, (31°41', 152°42') NSW; R59314 5km W. of highway on Middle Brother Mt (31°41', 152°42') NSW; R43874 Lansdowne, Manning R., (31°47', 152°32') NSW; R8253 Wallis Lake, Tuneurry, (32°17', 152°29') NSW; R101338 O'Sullivan's Gap Forestry Reserve, Buladelah, (32°20', 152°16') NSW; R15412 Girvan, via Stroud, (32°28', 152°04') NSW; R123490 Tullawudjah Ck, (?) NSW.

DIAGNOSIS

S. swaini is a moderately-spinose, large *Saltuarius* (maximum SVL 131mm). It is distinguished from *S. cornutus* by its flank tubercules (tubercules not hooked and not surrounded by smaller spines, Fig. 9b vs tubercules hooked and surrounded by smaller spines, Fig. 9a); from *S. salebrosus* by its chin scalation (chin lacking tubercles vs chin with tubercles); from *S. occultus* by the colour of its labial scales (labials pale, blotched with grey or brown vs labials dark brown with a few patches of white). It is further distinguished from *S. cornutus* by male preanal pores (males without preanal pores, Fig. 5d vs males with preanal pores, Fig. 5a).

DIET

The gut of QM J51640 contained a large cricket (Gryllacrididae).

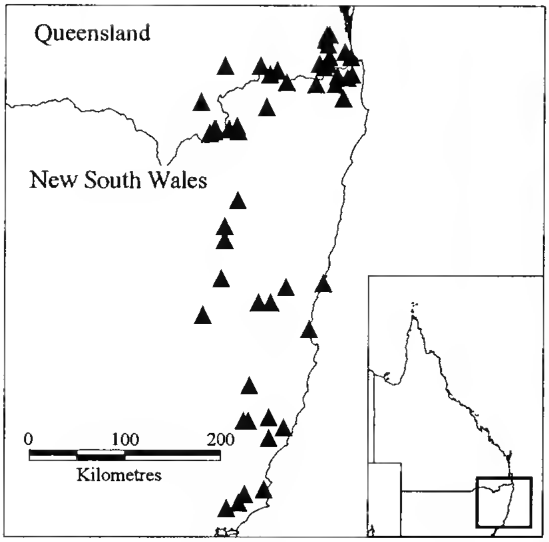

FIG. 18. Distribution of *S. swaini*.

DESCRIPTION

SVL (mm): 41-131 (n101, mean 92.0). Adult SVL (mm): 82-131 (n81, mean 102.6). Proportions as % SVL: L1 37-62 (n83, mean 45.1); L2 50-65 (n81, mean 56.3); T 58-81 (n43, mean 68.1); TT 20-33 (n43, mean 27.8); HL 26-32 (n101, mean 28.1); HW 19-25 (n101, mean 21.5); S 11-14 (n101, mean 12.4); NL 15-23 (n95, mean 19.7).

Head: large, depressed, triangular, distinct from neck; covered in small granules which are intermixed with large rounded to conical tubercles; skin of head co-ossified with skull; rostral completely divided, usually by a single deep groove (n101, for variations see Fig. 7a-d); rostral contacting nostril; ear opening elliptical, vertical, much less than half as large as eye; supralabials 11-20 (n198, mean 14.5); infralabials 9-16 (n192, mean 12.4); Neck: broad; Body: moderate, depressed, covered in small granules; dorsal granules intermixed with larger conical tubercles; tubercles moderate to large on back, flanks and neck; lower flank tubercles small to large, often associated with a lateral flange running from axilla to groin; basal scales surrounding flank tubercles slightly enlarged (Fig. 9b); granules on chest often noticeably larger than adjacent granules. Preanal Pores: Absent (Fig. 5d). Limbs: long, covered in pointed tubercles dorsally; digits strong, compressed distally; subdigital lamellae (fourth toe) 18-26 (n164, mean 21.7). Original tail: (n43) - depressed, broad and contracted at base and attenuated at tip; anterior flared portion surrounded by an undulating flange which bears slender, sharply pointed tubercles around its margin; dorsal surface of tail (except along midline of flared portion) covered in large conical tubercles which are particularly pronounced on the attenuated tip; tubercles extend to tail tip; number of rows of enlarged spinose tubercles across attenuated tip 2-7 (n43, mean 5.3); attenuated tip accounts for 34-45% of total tail length; ventral surface smooth, some specimens with a shallow groove along the midline. Regenerated tail: (n37) depressed, broad and leaf-like, contracted at base and only just attenuated at tip; tail margin is a broad, thin flange which bears minute spinose tubercles around the edges; tail free from spinose tubercles on both dorsal and ventral surfaces; ventral surface without any indication of a shallow groove along the midline.

SKELETAL FEATURES

(X rays)QM J2409, J3313, J4439, J5649, J8359, J28648-9, J51633, J51635-6, J53984; (alizarin stained) J8075, J29115.

Supraocular portion of frontal grooved (n13); anterior process of interclavicle not present, anterior edge flat, Fig. 2d(n2); epipubic cartilage expanded, Fig. 1d (n2); presacral vertebrae 24-25 (n8, mean 24.8); sacral vertebrae 2 (n9); lumbar vertebrae 2 (n7); 1st autotomy septum 6 (n6); abdominal vertebrae bearing reduced ribs 3-4 (n2, mean 3); rib free cervicals 3 (n10); cervical vertebrae not enlongate; sternal ribs 3 (n2); mesosternal ribs 2 (n1).

PATTERN

In spirit, three colour forms are readily distinguished by dorsal colour and pattern - gray to medium brown with both paler and darker blotches in the base colour; these blotches are edged with brown or black lines to give a 'lichen-like' effect (Fig. 19a); often with a pale vertebral streak: gray or mid-dark brown with a pale vertebral streak: heavily blotched with pale gray and black, often with a pale fawn vertebral streak (Fig. 19b). These three forms have cream ventral surfaces, faintly to heavily marked by small clusters of brown scales. Original tails are marked with 'lichen-like' blotches on dorsal surface. Some specimens of the three forms have indistinct light bands across the attenuated tip, sometimes extending to the ventral surface. Ventrally the tails in all three forms are grey to brown, bearing pale blotches and small dark specks. Regenerated tails are pale with cream and brown mottling.

Forms 'lichen-like' (Fig. 19a) and 'gray- mid-dark brown' are the dominant colour morphs in rainforests of southeastern Queensland and New South Wales. Form 'heavily blotched' (Fig. 19b) is dominant in dry eucalypt/granite habitats centred on the Stanthorpe region, SEQ, and the New England Tableland, NSW. However, 'lichen-like' (R98333) and 'gray- mid-dark brown' (R92122) individuals also occur in dry forests near Stanthorpe, and one 'heavily-blotched' individual (R110510) has been collected from rainforest on Mt Warning, NENSW.

Phyllurus Goldfuss, 1820

See Bauer, 1990.

REFERRED SPECIES

Phyllurus caudiannulatus Covacevich, 1975; *P. isis* sp. nov.; *P. nepthys* sp. nov.; *P. ossa* sp. nov.; *P. platurus* (Shaw, 1790).

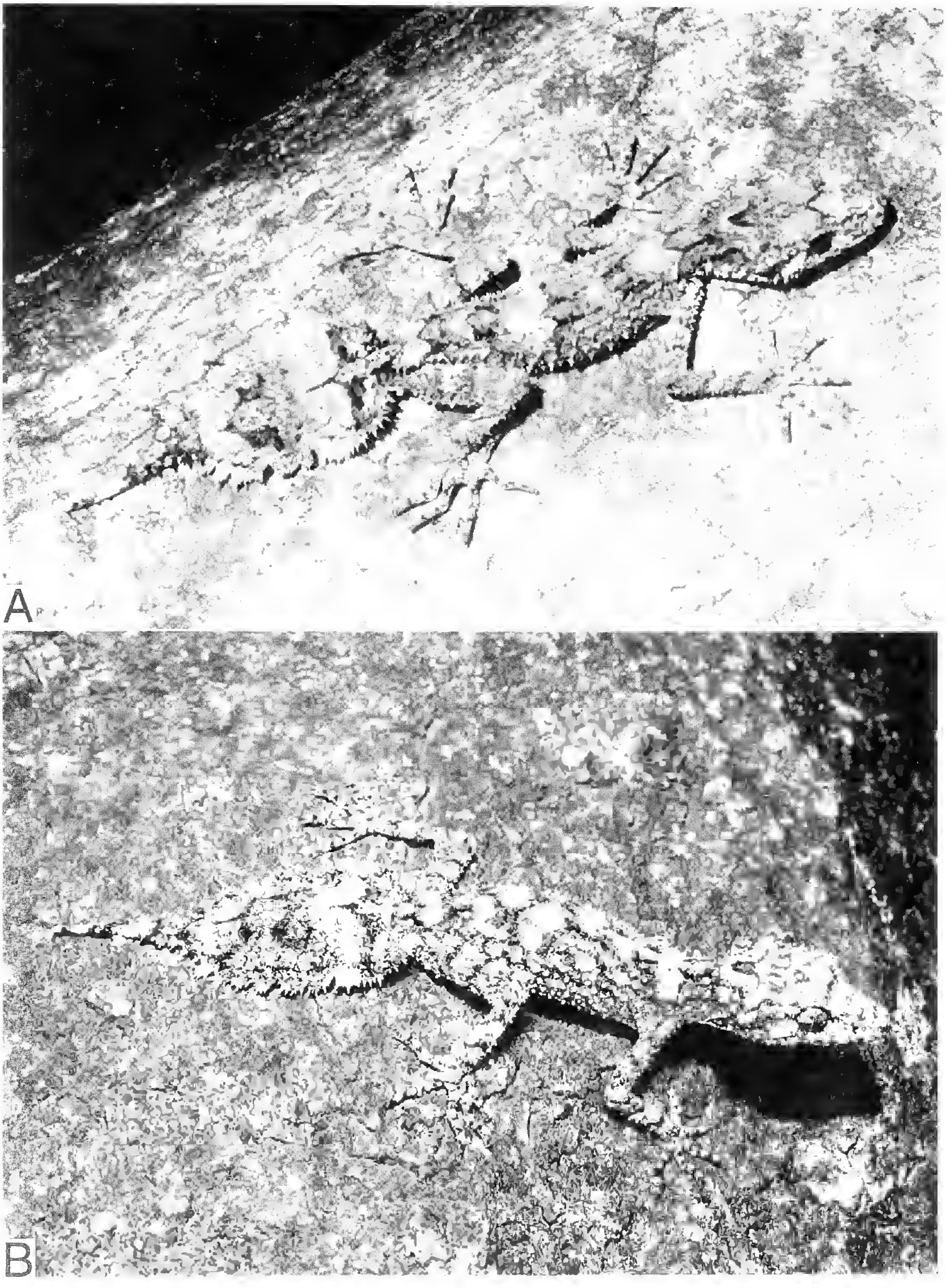

FIG. 19. (A) *S. swaini* (J51094) Mt. Superbus, SEQ (S. Wilson). (B) *S. swaini* Girraween NP, SEQ (S. Wilson.)

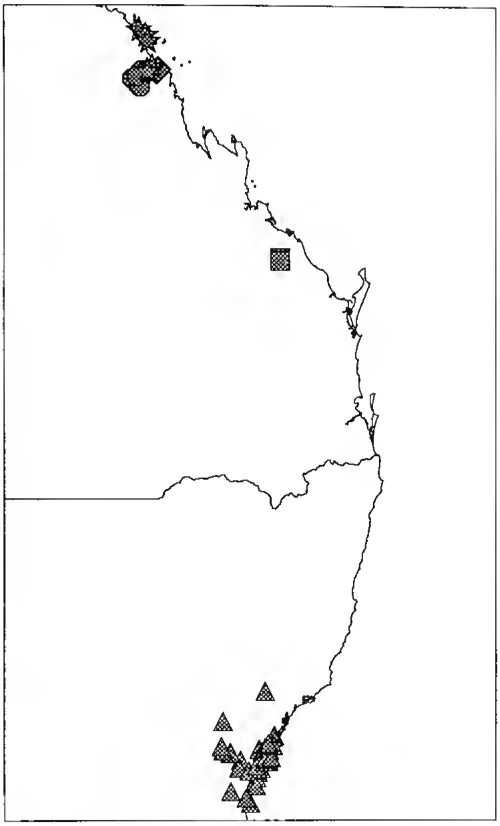

FIG. 20. Distribution of *Phyllurus* spp.

DIAGNOSIS

Nostril not in contact with rostral shield (vs nostril contacts the rostral in *Saltuarius*); anterior margin of the interclavicle with a distinct process, Fig. 2e-h (vs flat or bearing a slight projection, Fig. 2a-d); axilla always, sometimes deeply, invaginated (vs very rarely, invariably shallowly invaginated); epipubic cartilage small - moderate, wedge-shaped, Fig. 1c-h (vs moderate - large, wedge shaped, Fig. 1a-d); male precanal pores absent; original tail cylindrical, without flaring to simply flared, carrot-like (vs strongly flared, with an elaborate spinose outer flange); max SVL 76-103mm, small to medium (vs max SVL 108-144mm, medium to large); karyotype 2n=30 or 22 (vs 2n=38); rostral shield usually partially divided[3], Fig. 7e-j (vs rostral always completely divided, Fig. 7a-d).

DISTRIBUTION

Eastern Australia from the Mackay/ Proserpine district MEQ - to the Sydney district, NSW (Fig. 20).

HABITAT

P. caudiannulatus, *P. isis*, *P. nepthys* and *P. ossa* occur in complex notophyll vine forests on a variety of substrates. *P. platurus* is confined to heaths on sandstones.

REPRODUCTION

Oviparous, producing two soft-shelled eggs.

A KEY TO *PHYLLURUS*

1.Rostral completely divided (Fig. 7a) .... *P. caudiannulatus*
Rostral not as above (Fig. 7e-j) 2
2.Venter distinctly 'peppered' with brown... *P. nepthys*
Venter not as above 3
3.Original tail plain, without light bands......*P. platurus*
Original tail not as above (with light bands)............4
4.Rostral with 2-3 partial divisions (Fig. 7f,g) ..*P. ossa*
Rostral not as above, 1 partial division (Fig. 7e,h). 5
5.Anterior-most white tail marking a broken band... *P. ossa*
Anterior-most white tail marking two narrowly-spaced, midline blotches............................. *P. isis*

Phyllurus caudiannulatus Covacevich, 1975
(Figs 7a,e; 21; 22)

Phyllurus nepthys Couper et al. 1993. In part.

MATERIAL EXAMINED

Queensland Museum: J15619, Holotype, Bulburin SF, 24km SW Miriam Vale (24°31', 151°29') SEQ; J28356, J33631, J33649, J33651, J33684-5, J33692-5, J33703-4, J33709, J51103-4, as for holotype. Australian Museum: R47641, R47654, R47657, R47888, R90205, Bulburin SF (24°31', 151°29') SEQ.

The type description of *P. caudiannulatus* is accurate, but requires modification in light of our separation of *P. nepthys* from it. *P. caudiannulatus* was described from Bulburin SF, SEQ. As the description went to press, a specimen (J25411) apparently similar to *P. caudiannulatus*, came to hand from isolated rainforest of the Eungella NP (Clarke Ra.) MEQ, some 480km north of Bulburin. This was referred to *P. caudiannulatus*, despite recognition of certain differences, notably in the tail, between material from Bulburin SF and Eungella NP. Re-examination of specimens of *P. caudiannulatus*, of the Eungella specimen referred to it, and examination of

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[3] *P. caudiannualtus* is the exception. It has a completely divided rostral, a character of *Saltuarius* gen.nov.

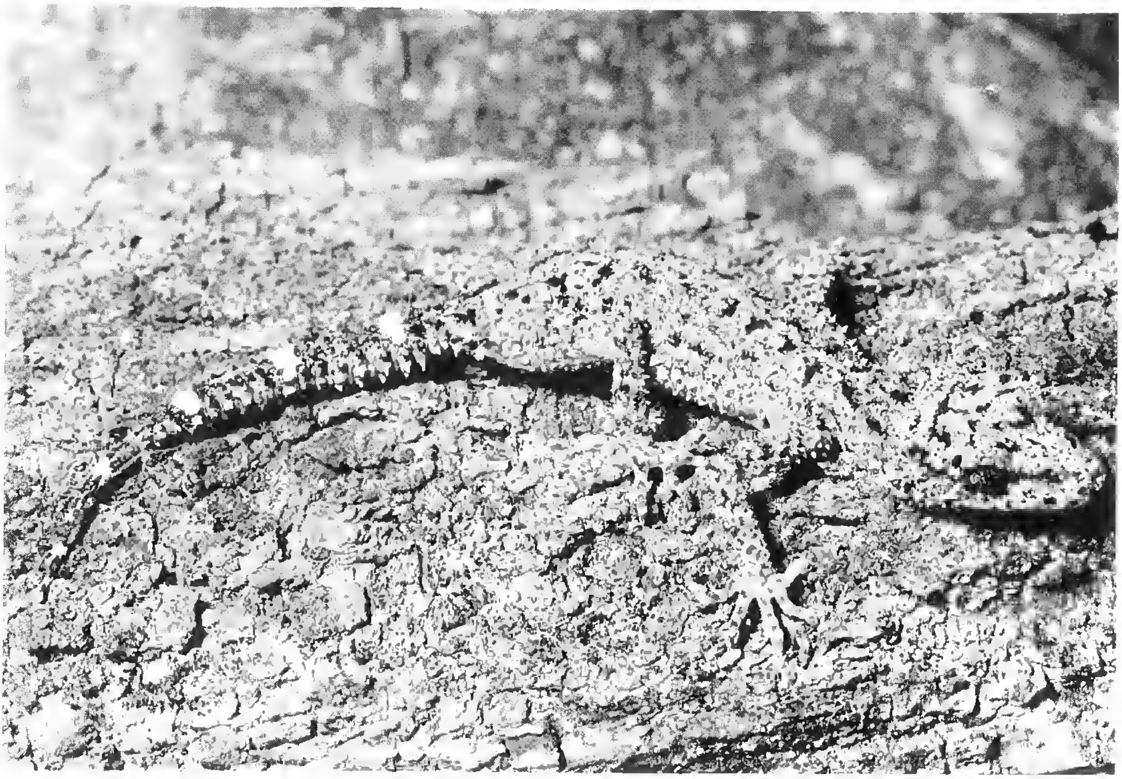

FIG. 21. *P. caudiannulatus*, Bulburin SF, SEQ (B. Cowell).

additional specimens recently collected from both localities, shows that the differences originally observed are consistent and that there are other distinct characters. Thus, we recognise as distinct *P. nepthys* sp. nov. from the Eungella NP and Crediton SF on the Clarke Ra., MEQ.

DESCRIPTION

Now removed from the series of specimens on which the description of *P. caudiannulatus* was based is QM J25411. *P. caudiannulatus* and *P. nepthys* resemble each other in size, body proportions, colour pattern and spinosity. They differ in the condition of the rostral scale (completely divided in *P. caudiannulatus*, Fig. 7a vs partially divided in *P. nepthys*, Fig. 7e). Further differences are given in the description of *P. nepthys*.

The following measurements and characters have not been included in previous descriptions of *P. caudiannulatus*. Proportions as % SVL: L1 37-45 (n20, mean 42.3); L2 46-54 (n20, mean 50.6); S 11-12 (n20, mean 11.6); NL 17-23 (n19, mean 19.5). Rostral completely divided by a single vertical groove - Fig. 7a (n20). Axilla shallowly to deeply invaginated.

DISTRIBUTION

The range of *P. caudiannulatus* is also restricted with the removal from *P. caudiannulatus* of specimens from the Clarke Ra. *P. caudiannulatus* is now narrowly restricted to rainforests of Bulburin SF, on the Dawes Ra. and Many Peaks Ra., SEQ (Fig. 22). Bauer (1990) notes its occurrence 'to the south and west of Brisbane'. This locality is based on an AMNH specimen from Nerang. Given the SVL (112 mm) of this specimen, it seems reasonable to suggest that it is referable to *S. swaini*, which is known to occur in the Nerang area.

DIET

The gut of QM J33709 contained numerous small beetle fragments, and pieces of a large beetle larva (Coleoptera).

SKELETAL FEATURES

Material examined: (X rays) J28356, J33651, J33684-5, J33693, J33695, J33703-4, J33709; (alizarin stained) J33631. Supraocular portion of frontal flat (n9); anterior process of interclavicle distinct(n1); epipubic cartilage not expanded (n1); presacral vertebrae 26 (n9); sacral vertebrae

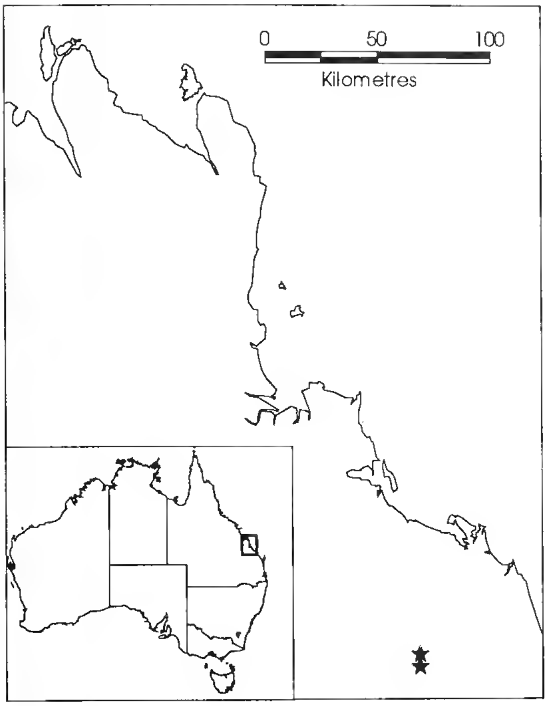

FIG. 22. Distribution of *P. caudiannulatus.*

2 (n9); lumbar vertebrae 2 (n9); 1st autotomy septum 5 (n5); abdominal vertebrae bearing reduced ribs 4 (n1); rib free cervicals 3 (n9); sternal ribs 2 (n1); mesosternal ribs 3 (n1).

Phyllurus isis sp. nov.
(Figs 1f; 2f; 7a,e-h; 23; 24)

MATERIAL EXAMINED

HOLOTYPE: Queensland Museum J 53511 gravid ♀ (with original tail) Mt Blackwood NP (21°02', 148°56'), MEQ, P.J. Couper, J.A. Covacevich, K.R. McDonald, 10 October 1991. PARATYPES: Queensland Museum: J 53485-6; J53518 Coffee Ck, Mt Jukes (21°00' 148°57'), MEQ; J 53480, J53512 (alizarin preparation), J 53591, J53602-3 Mt Blackwood NP (21°02', 148°56'), MEQ.

DIAGNOSIS

P. isis is the least spinose and smallest *Phyllurus* (maximum SVL 76mm). It most resembles *P. ossa*. From *P. ossa* it is distinguished by rostral grooves (a single groove partially dividing the rostral, Fig. 7e vs 2-3 grooves, usually 3, rarely 1, partially dividing the rostral, Fig. 7f-h). It is further distinguished from *P. ossa* by the size of its flank tubercules (small vs moderate). *P. isis* is readily distinguished from *P. caudiannulatus* by the shape of both its original and regrown tail (flared vs cylindrical) and by the nature of the rostral groove (rostral partially divided, Fig. 7e vs rostral fully divided, Fig. 7a); from *P. nepthys* by ventral colour pattern (immaculate vs 'peppered' brown); from *P. platurus* by original tail colour pattern (distinctly banded white vs lacking white bands).

DISTRIBUTION

Mt Blackwood (21°02', 148°56') and Mt Jukes (21°02', 148°57'), Mackay district, MEQ (Fig. 24).

HABITAT

Complex notophyll vine forest, on quartz-syenite and granite.

HABITS

All specimens examined, except QM J53512, were collected during the early evening on rock outcrops. J53512, also active during the early evening, was found sitting on a stick on the forest floor, after light rain.

REPRODUCTION

Gravid females (J53511, J53512, J53602) were present in the population in early October, 1992.

DIET

The gut of QM J53512 contained moth, cockroach and cricket fragments (Lepidoptera, Blattodea; Gryllidae).

ETYMOLOGY

Selected from Egyptian mythology (Mackenzie, 1978). The epithet is to be treated as a noun in apposition.

DESCRIPTION

SVL (mm): 53-76 (n9, mean 69.2). Adult SVL (mm): 68-72 (n8, mean 71.2). Proportions as % SVL: L1 41-45 (n9, mean 42.6); L2 48-56 (n9, mean 52.1); T 73 (n1); TT 40 (n1); HL 28-32 (n9, mean 29.4); HW 22-26 (n9, mean 23.1); S 12-13 (n9, mean 12.2); NL 15-19 (n9, mean 16.8).

Head: large, depressed, triangular, distinct from neck; covered in small granules which are intermixed with larger rounded to conical tubercles; skin of head co-ossified with skull; deep vertical groove partially dividing rostral scale (Fig. 7e); rostral excluded from nostril; ear opening elliptical, vertical, much less than half as large as eye; supralabials 14-18 (n18, mean 15.7); infralabials 13-15 (n18, mean 13.9). Neck: broad. Body:

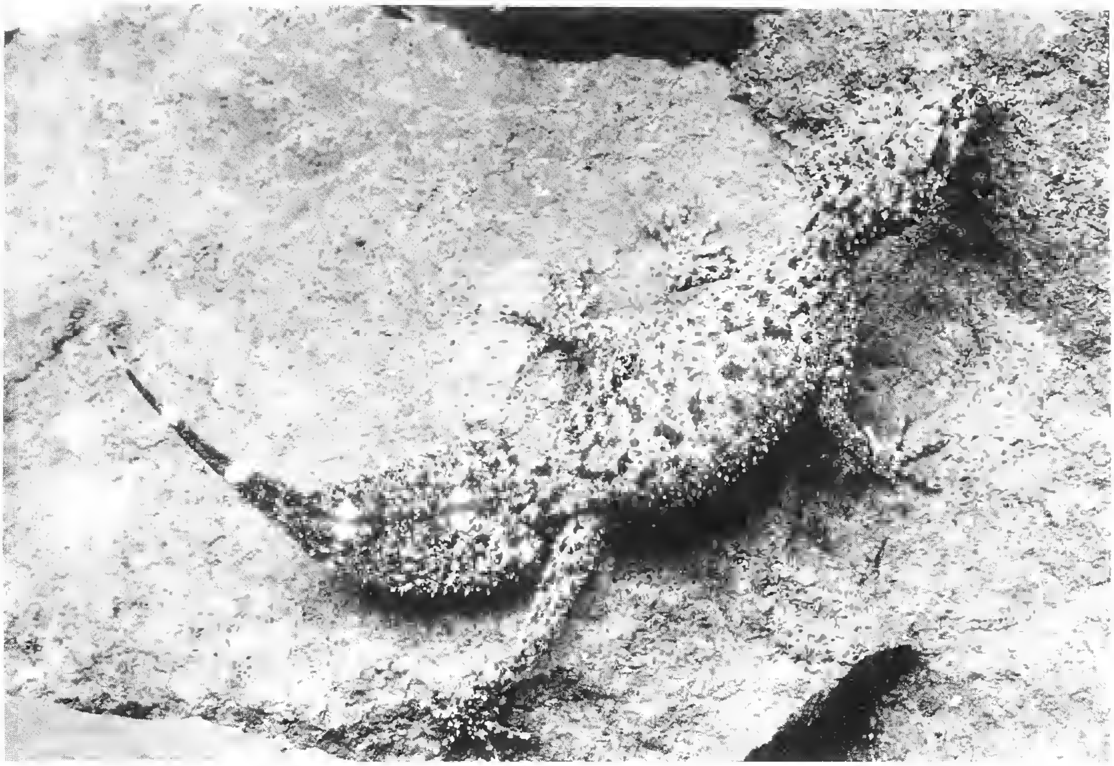

FIG. 23. *P. isis*, Mt Blackwood, MEQ (B. Cowell).

moderate, depressed, covered in small granules; dorsal granules intermixed with larger conical tubercles; tubercles indistinct on back, small on flanks, most prominent on sides of neck; basal scales surrounding flank tubercles not enlarged; no enlarged tubercles or granules on ventral surface of body. Preanal pores: absent. Axilla: Invaginated. Limbs:long, covered in small pointed tubercles dorsally; proximal portion of forelimb bearing enlarged tubercles on ventral surface; digits strong, compressed distally; subdigital lamellae (fourth toe) 18-20 (n9, mean 18.6). Original tail: (n1) depressed, strongly flared, contracted at base and attenuated at tip; without enlarged, spinose edge tubercles; covered dorsally with numerous minute, spinose tubercles; tubercles terminate approximately half-way along the attenuated tip which is long, fine, and terminates with a minute rounded 'knob' distally; dorsal tubercles fail to form clearly defined rows anteriorly across the attenuated tip; attenuated tip accounts for 52% of total tail length; ventral surface smooth, deeply grooved along midline (excluding attenuated tip). Regenerated tail: (n6) depressed, flared, contracted at base and attenuated at tip; lacking spinose tubercles on dor-

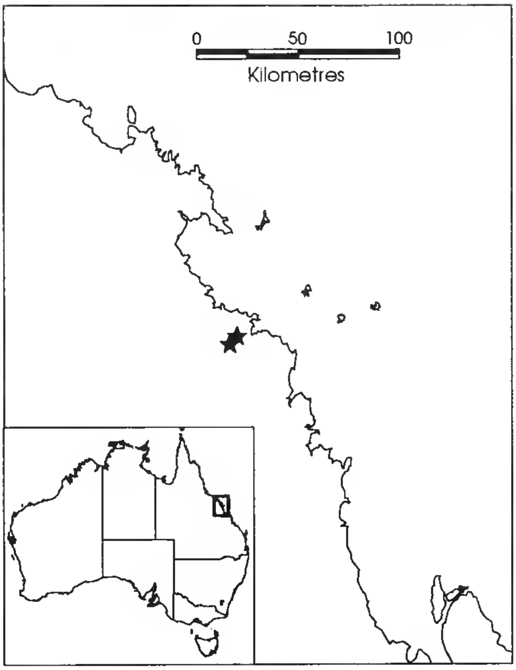

FIG. 24. Distribution of *P. isis*.

sal surface and edges; ventral surface without deep groove along midline.

SKELETAL FEATURES

Material examined: (X rays) J53480, J53485, J53511, J53518, J53591, J53602, J53603; (alizarin stained) J53512.

Supraocular portion of frontal flat (n7); anterior process of interclavicle distinct - Fig. 2f(n1); epipubic cartilage not expanded - Fig. 1f (n1); presacral vertebrae 26 (n7); sacral vertebrae 2 (n7); lumbar vertebrae 2 (n7); 1st autotomy septum 5(n6); abdominal vertebrae bearing reduced ribs 4 (n1); rib free cervicals 3 (n7); sternal ribs 2 (n1); mesosternal ribs 3 (n1).

PATTERN

In spirit, dorsal base colour grey to pale brown; heavily marked with distinct, dark grey to black blotches on head, body and limbs. Body ventrally cream, slightly translucent. Labials pale grey to brown, mottled with white. Original tail dorsally black, indistinctly patterned with irregular grey markings; three distinct creamish bands on attenuated tip, extending to the ventral surface; two broken bands which appear as one irregular blotch on either side of the vertebral line on anterior flared portion; ventrally grey, mottled with white. Regenerated tail totally lacking cream bands; dorsally, grey to brown with obscure creamish blotching; ventrally mottled but paler than dorsal surface.

Phyllurus nepthys sp. nov.

(Figs 1g; 2g; 7a,e,f-h; 25; 26)

Phyllurus caudiannulatus Covacevich, 1975. In part.

MATERIAL EXAMINED

HOLOTYPE: Queensland Museum J34058 ♀ (with original tail) Finch Hatton NP (21°06', 148°38') MEQ, R. Monroe, J.A. Covacevich, P. Filewood, 7-14 April 1975. PARATYPES: Queensland Museum: J50993 Eungella NP, Dalrymple Rd (21°03', 148°34') MEQ; J35128 Thurgood farm, 18km N Dalrymple Hts (21°04', 148°36') MEQ; J34024 (alizarin preparation), J34025, Finch Hatton NP (21°06', 148°38') MEQ; J51098-101 Finch Hatton Gorge (21°06', 148°38') MEQ; J34076-9 Finch Hatton NP (21°06', 148°38') MEQ; J25411 (also a paratype of *P. caudiannulatus*) Broken R. headwaters, Eungella NP (21°08', 148°30') MEQ; J50992 Eungella NP, near Vlasak property (21°10', 148°24') MEQ; J32634-35, J32695 Crediton (21°13', 148°34') MEQ; J32669, J32674-76, J32696, J32733, J32740 Crediton (21°13', 148°34') MEQ; J53330-2 Rocky Dam Ck, via Crediton (21°18', 148°32') MEQ; J53359-62 Rocky Dam Ck, via Crediton (21°19', 148°34') MEQ.
Australian Museum: R47901-14, R47959 Mt William, via Eungella (21°01', 148°36') MEQ; R47512 R47836-49 Eungella (21°08', 148°30') MEQ; R47738-62 Eungella, Dalrymple Hts (21°08', 148°30') MEQ; R47551-6, R47957 Eungella, near Vlasak property (21°10', 148°24') MEQ; R61473 AM building? - no original locality data.

DIAGNOSIS

P. nepthys is an extremely spinose, large *Phyllurus* (maximum SVL 103 mm). A 'peppered' brown venter separates it from all its congeners (with immaculate or mottled venters). *P. nepthys* is further distinguished from *P. caudiannulatus* by its rostral groove (partially divided, Fig. 7e vs completely divided, Fig. 7a); from *P. isis* and *P. platurus* by the depth of its acarodomatia = axillary pits (moderately to deeply invaginated vs shallowly invaginated); and from *P. ossa* by rostral grooves (1 groove partially dividing the rostral, Fig. 7e vs 1-3 grooves, usually 3, only rarely 1 or 2, partially dividing the rostral, Fig. 7f-h).

DISTRIBUTION

Confined to the Clarke Ra., west of Mackay, MEQ. Much of this range is included in the Eungella NP (Fig. 26).

HABITAT

Complex notophyll and mesophyll vine forests on a variety of substrates, including granite.

HABITS

Commonly found in association with both rocks and trees, and also with buildings.

REPRODUCTION

Gravid females (J53332, J53362) were present in the population during late October-late November, 1991.

DIET

The gut of QM J51098 contained a beetle larva (Coleoptera). QM J51099 contained fragments of a fulgoroid leafhopper. QM J51100 contained cockroach and moth fragments (Blattodea and Lepidoptera).

ETYMOLOGY

Selected from Egyptian mythology (Mackenzie, 1978). The epithet is to be treated as a noun in apposition.

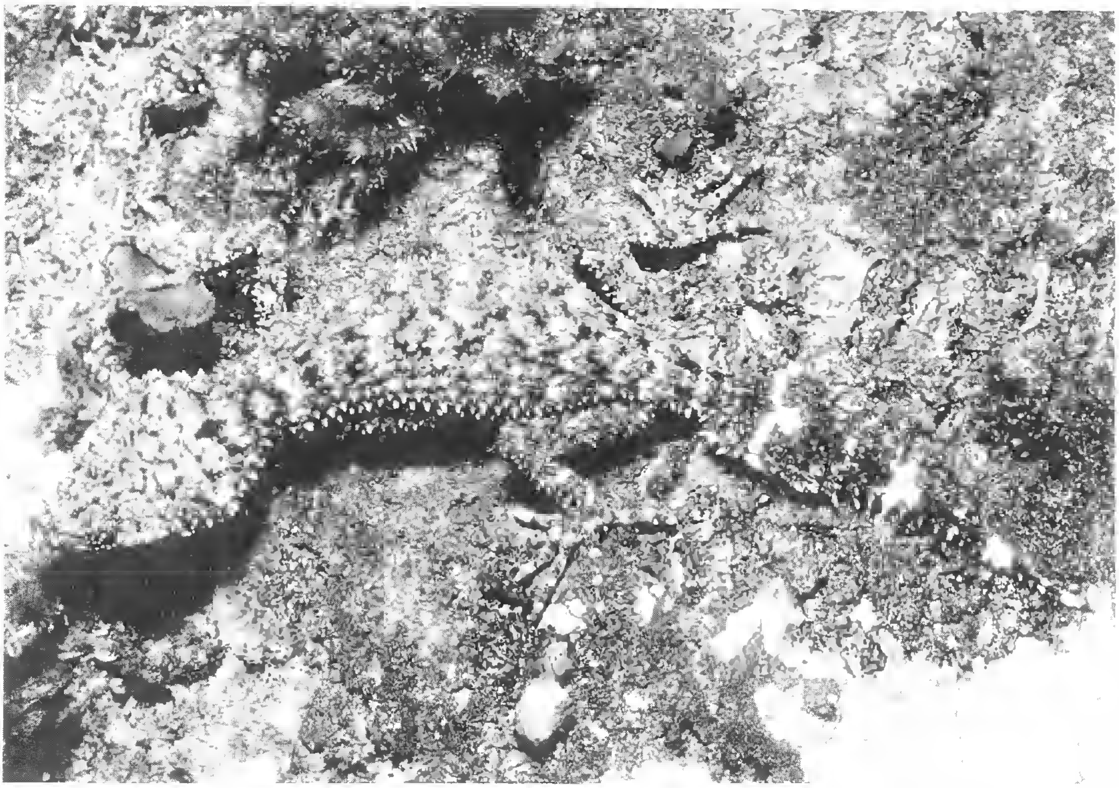

FIG. 25. *P. nepthys*, Eungella, MEQ (T. Helden).

DESCRIPTION

SVL - (mm): 39-103 (n98, mean 91.0). Proportions as % SVL: L1 41-49 (n90, mean 43.7); L2 49-60 (n88, mean - 54.3); T 61-89 (n49, mean 75.5); TT 28-50 (n49, mean 40.9); HL 26-31 (n97, mean 27.9); HW 20-24 (n97, mean 21.5); S 9-13 (n97, mean 11.8); NL 14-24 (n96, mean 18.9).

Head: large, depressed, triangular, distinct from neck; covered in small granules which are intermixed with larger conical tubercles (tubercules extremely prominent on snout); skin of head co-ossified with skull; deep vertical groove partially dividing rostral scale, Fig. 7e; rostral excluded from nostril; ear opening elliptical, vertical, much less than half as large as eye; supralabials 12-20 (n196, mean 15.4); infralabials 10-17 (n195, mean 13.9). Neck: broad. Body: moderate, depressed, covered in small granules; dorsal granules intermixed with larger conical tubercles; tubercles moderate on back, large on flanks and extremely prominent on sides of neck; basal scales surrounding flank tubercles only slightly enlarged; no enlarged tubercles or granules on ventral surface of body. Preanal pores: absent. Axilla: moderately to deeply invaginated. Limbs: long, covered in large pointed tubercles dorsally; without enlarged tubercles on ventral surface; digits strong, compressed distally; subdigital lamellae (fourth toe) 18-24 (n173, mean 20.5). Original tail: (n49) - depressed, flared to carrot-shaped, contracted at base and attenuated at tip; covered with prominent enlarged spinose tubercles over entire dorsal surface; 6-8 rows of enlarged spines across the attenuated portion of the tail; attenuated tip accounts for 45-62% of total tail length; ventral surface smooth, grooved or ungrooved along midline (excluding attenuated tip). Regenerated tail: (n22) depressed, broad and strongly flared, contracted at base and attenuated at tip; covered with spinose tubercles which are most prominent around the edges and on the attenuated tip; ventral surface without groove along midline.

SKELETAL FEATURES

(X rays) QM J32669, J32674-5, J34057, J53331, J53359, J53362; (alizarin stained) J34024. Supraocular portion of frontal flat (n7); anterior process of interclavicle distinct - Fig. 2g;

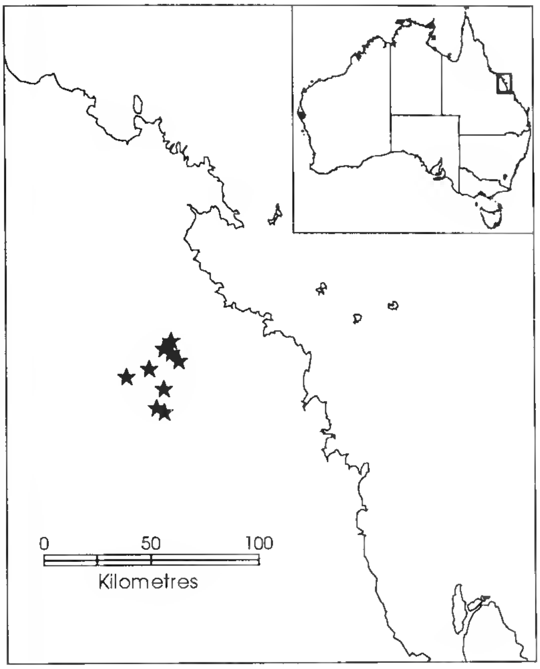

FIG. 26. Distribution of *P. nepthys*.

epipubic cartilage slightly expanded - Fig. 1g; presacral vertebrae 26 (n7); sacral vertebrae 2 (n7); lumbar vertebrae 2 (n7); 1st autotomy septum 5 (n3); abdominal vertebrae bearing reduced ribs 4; rib free cervicals 3 (n7); sternal ribs 2; mesosternal ribs 3.

Pattern

In spirit, dorsal base colour tan to dark brown; marked with irregular dark brown blotches on head, body and limbs. Body and limbs ventrally cream, faintly to heavily peppered with brown specks; labials cream, mottled with dark brown. Original tail dorsally tan to dark brown, marked with irregular dark brown blotches; four or five bold cream bands on tail, only those on the attenuated portion extending to the ventral surface; some specimens exhibit faint, obscure banding between the bold cream bands; ventrally cream, peppered with brown specks. Regenerated tail totally lacking cream bands; dorsally tan to brown, mottled with cream and dark brown blotches; ventrally mottled but paler than dorsal surface.

Phyllurus ossa sp. nov.

(Figs 1h; 2h; 7a,e,f-h,i,j; 27; 28; 29)

Material Examined

Holotype: Queensland Museum: J53444 ♂ (with original tail) Mt Ossa/Ossa Ck, via Mirani (20°56', 148°49') MEQ, P.J. Couper, D. Limpus, M. Cunningham, 20 October 1991. Paratypes: Queensland Museum: J56775, J56791-2, Vine Ck, Mt Dryander (20°15', 148°33') MEQ; J56766-71, Brandy Ck, Conway Ra. (20°21', 148°41'), MEQ; J56772-4, near Little Conway Mtn, Conway SF (20°27', 148°44'), J53443, J53445-7, J53507 Mt Ossa/Ossa Ck, via Mirani (20°56', 148°49') MEQ; J53426-8 St Helen's Gap, via Mt Charlton (21°00', 148°43') MEQ; J53389-90, J53391 (alizarin preparation), J53392-3, J53414, J56311, Mt Charlton foothills, via Mt Charlton (21°01', 148°44') MEQ.

Diagnosis

P. ossa is a moderately-spinose, medium-sized *Phyllurus* (maximum SVL 89mm). *P. ossa* may be distinguished from *P. caudiannulatus* by its rostral shield (rostral partially divided, Fig. 7f-h vs rostral totally divided, Fig. 7a); from *P. isis*, *P. nepthys*, and *P. platurus* by its rostral grooves (usually 3 grooves, sometimes 2, rarely 1, partially dividing the rostral, Fig. 7f-h vs a single groove partially dividing the rostral, Fig. 7e,i,j). It can be distinguished further from *P. nepthys* by its venter (immaculate vs heavily 'peppered' brown); from *P. platurus* by its original tail (with distinct white bands vs lacking white bands); and from *P. isis* by the size of its flank tubercules (moderate vs small).

Distribution

Disjunct populations occur in the Mt Ossa/Mt Charlton area, (21°00', 148°43') north of Mackay, MEQ, in the Conway Ra., (20°27', 148°44') and Mt. Dryander, (20°15', 148° 33'E) via Proserpine, MEQ (Fig. 28).

Habitat

Complex notophyll vine forest on a variety of substrates.

Habits

Usually found on rocks in rainforest or on the trunks of trees that are near rock. At Mt Dryander, *P. ossa* was found on large boulders in a dry creek bed. Activity starts soon after dark. This species appears to be common.

Reproduction

Gravid females were present in the population in October, 1992.

Diet

The gut of QM J53391 contained spider fragments. QM J56768 also contained spider fragments, and pieces of a cricket (Gryllidae).

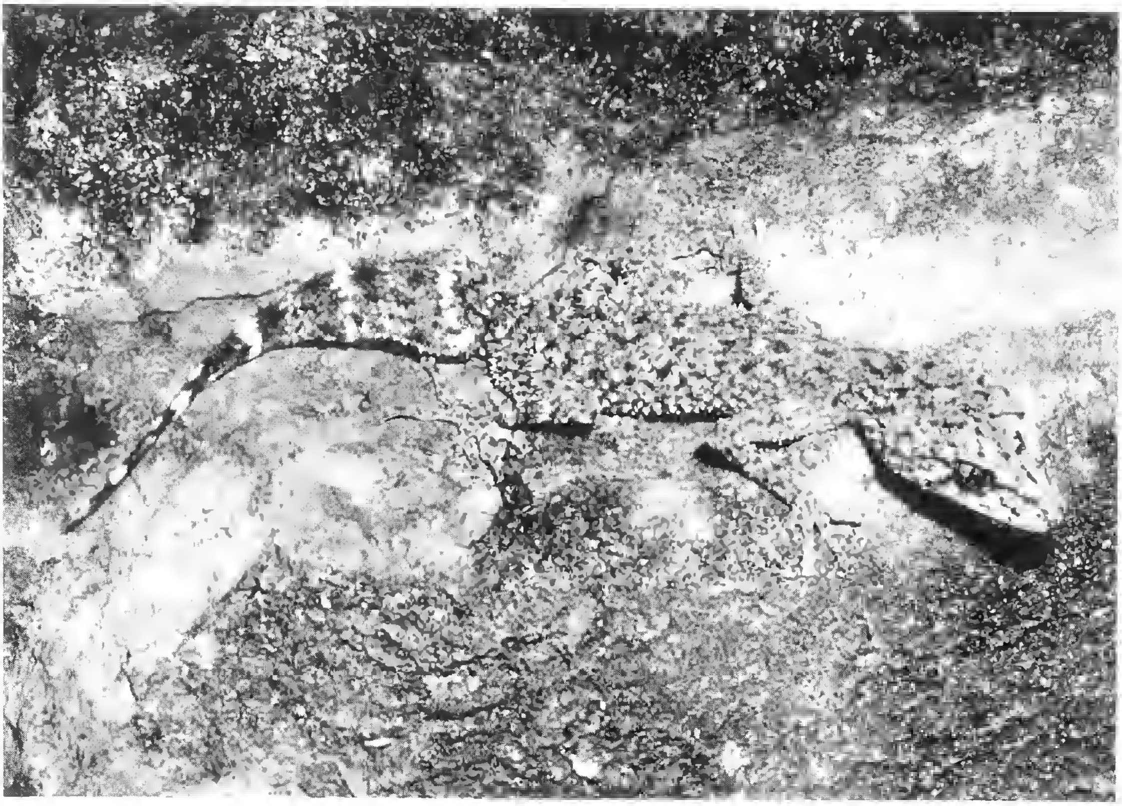

FIG. 27. *P. ossa*, Ossa Ck, MEQ (P. Couper).

ETYMOLOGY

Named for Mt Ossa, the type locality. The epithet is to be treated as a noun in apposition.

DESCRIPTION

SVL (mm): 36-89 (n28, mean 72.9). Adult SVL (mm): 63-89 (n22, mean 78.4). Proportions as % SVL: L1 41-46 (n21, mean 43.2); L2 48-59 (n22, mean 53.6); T 79-93 (n8, mean 86.1); TT 39-53 (n7, mean 48.3); HL 28-32 (n28, mean 29.7); HW 23-26 (n28, mean 24.3); S 11-13 (n28, mean 12.2); NL 14-23 (n28, mean 18.6).

Head: large, depressed, triangular, distinct from neck; covered in small granules which are intermixed with larger conical tubercles; skin of head co-ossified with skull; three deep vertical grooves penetrate dorsal edge of rostral scale (n22), Fig. 7f, two vertical grooves penetrating rostral scale (n5), Fig. 7g; a single inverted 'Y' shaped groove penetrating the rostral scale (n1) (Fig. 7h); rostral excluded from nostril; ear opening elliptical, vertical, much less than half as large as eye; supralabials 13-18 (n56, mean 15.6); infralabials 13-16 (n56, mean 14.3). Neck: broad. Body: moderate, depressed, covered in small dorsal granules intermixed with larger conical tubercles; small on back, moderate on flanks, most prominent on sides of neck; basal scales surrounding flank tubercles slightly enlarged; ventral surface with or without a small patch of enlarged granules on the pectoral region. Preanal pores: absent. Axilla: shallowly to extremely deeply invaginated (Fig.29). Limbs: long, covered in moderate-sized pointed tubercles dorsally; proximal portion of forelimb bearing enlarged tubercles on ventral surface; usually a few enlarged granules on ventral surface of thigh; digits strong, compressed distally; subdigital lamellae (fourth toe) 16-20 (n40, mean18.2). Original tail: (n9) depressed, broad and flared to carrot-shaped, contracted at base and attenuated at tip; with or without an enlarged series of spinose edge tubercles on the anterior flared portion; covered dorsally with numerous moderate-sized, spinose tubercles which become smaller along the vertebral line; tubercles terminate approximately half-way along the attenuated tip which is long, fine and terminates with a minute

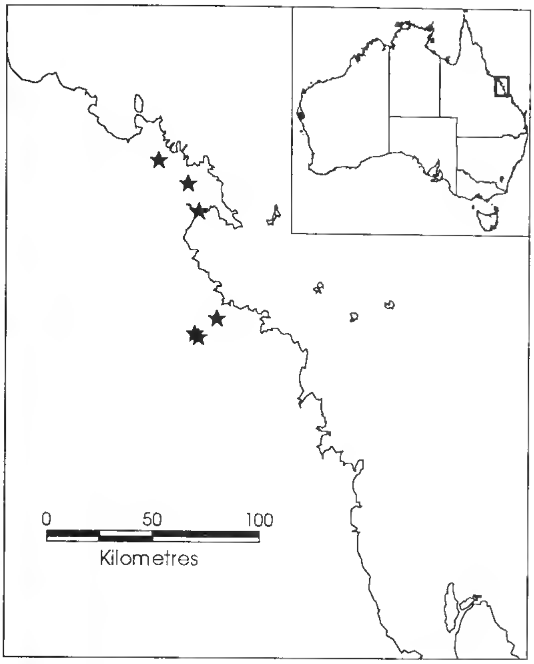

FIG. 28. Distribution of *P. ossa*.

rounded 'knob' distally; dorsal tubercles fail to form clearly defined rows anteriorly across the attenuated tip; attenuated tip accounts for 50-60% of total tail length; ventral surface smooth, lacking a midline longitudinal groove. Regenerated tail: (n17) depressed, broad and flared, contracted at base and attenuated at tip; lacking spinose tubercles on dorsal surface and edges.

SKELETAL FEATURES

(X rays) J53390, J53392, J53426-8, J53443-5, J53447, J56766-8, J56770-4; (alizarin stained) J53391. Supraocular portion of frontal flat (n17); anterior process of interclavicle pronounced - Fig. 2h (n1); epipubic cartilage not expanded - Fig. 1h (n1); presacral vertebrae 26 (n17); sacral vertebrae 2 (n17); lumbar vertebrae 2 (n17); 1st autotomy septum 5 (n12); abdominal vertebrae bearing reduced ribs 4 (n1); rib free cervicals 3 (n9); sternal ribs 3 (n1); mesosternal ribs 2 (n1).

PATTERN

In spirit, dorsal base colour grey to pale brown; heavily marked with distinct, dark grey to black blotches on head, body and limbs; vertebral zone free from darker blotchings; back with or without obscure pale blotches. Body cream ventrally, slightly translucent. Labials pale grey to brown, mottled with white. Original tail dorsally mid-grey, bearing dark grey blotches; attenuated tip black, with three to four distinct creamish bands which extend to the ventral surface; two prominent broken cream bands across the flared anterior portion of the tail (a faint, very obscure band sometimes lies between these two anterior bands); ventrally cream, faintly to boldly mottled with brown. Regenerated tail totally lacking cream bands; cream to pale grey with obscure black blotching or black with cream or tan blotching; ventrally mottled, but paler than dorsal surface.

REMARKS

Populations of *P. ossa* from Conway Ra., MEQ are smaller than the Mt Ossa/Mt Charlton/St Helen's Gap, MEQ populations (adult SVL mm 63-80, n 11, mean 73.7 vs SVL mm 70-89, n 11, mean 83.1). These populations also differ in the depth of their axillary pits. The axilla is extremely deeply invaginated, Fig. 29 (Conway Ra.) vs axilla shallowly invaginated (Mt Ossa/Mt Charlton/St Helen's Gap).

FIG. 29. *P. ossa* from Conway Ra., MEQ, displaying deep axillary pits, acarodomatia (P. Couper).

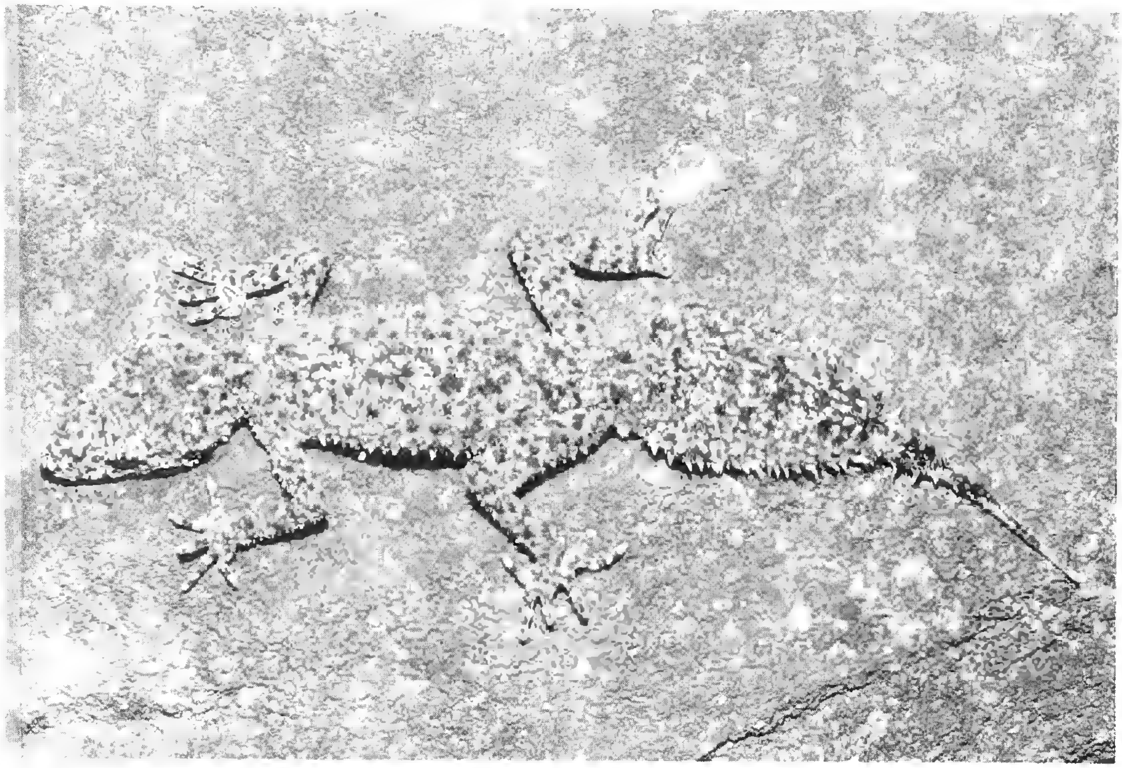

FIG. 30. *P. platurus*, Heathcote, NSW. (S. Wilson).

Phyllurus platurus (Shaw, 1790)
(Figs 7i,j; 30; 31)

See Bauer (1990).

MATERIAL EXAMINED
Queensland Museum: J56880-1, J56895, Marara, via Gosford (33°24', 151°21') MENSW.
Australian Museum: R49185, 28km W, 2km S of Singleton (32°34', 150°51') NSW; R61097, Watagan Ra. (32°57', 151°14') NSW; R55807, Glen Davis (33°08', 150°17') NSW; R106495, Barrenjoey Head (33°35',151°20') NSW; R106609, 10km WNW Mt Ku-ring-gai (33°39',151°02') NSW; R106491, McCarrs Ck, Ku-ring-gai NP (33°40, 151°15') NSW; R107089, Hornsby, Sydney (33°42', 151°06') NSW; R106801, Gordon, Sydney (33°45', 151°09') NSW; R55803, Northbridge, Sydney (33°48', 151°11') NSW; R106497, Dobroyd Head (33°49', 151°16') NSW ; R55808, Heathcote, Sydney (34°05', 151°01) NSW.

The type description, expanded description, and habitat and distribution data of Covacevich (1975) and the rediagnosis of *P. platurus* (Bauer, 1990) need no elaboration.

The following new data on *P. platurus* are based on examination of a sample of 18 specimens from the collections of the Australian and Queensland Museums. QM J9054 from Buladelah, was treated as *P. platurus* by Covacevich (1975), but has been identified as *Saltuarius swaini* here.

REPRODUCTION

Two females from Marara, MENSW each produced a clutch of two oval shaped eggs in late December, 1992. One egg from each clutch was preserved. The second was incubated in vermiculite. The eggs measured 25.03 x 15.85mm, 23.26 x 15.30mm, 20.92 x 15.48mm and 21.83 x 15.28mm. Incubation took 71-72 days at an uncontrolled Brisbane temperature. Hatchlings measured (SVL) 30.28mm and 31.48mm.

DESCRIPTION

The following measurements and characters have not been included in previous descriptions of *P. platurus*. Proportions as % SVL: L1 39-45 (n18, mean 42.9); L2 50-58 (n18, mean 54.0); S 12-14 (n18, mean 13.1); NL 15-21 (n18, mean 18.4).

Rostral only partially divided, by an inverted 'Y' shaped groove, Fig. 7i (n8), by a single verti-

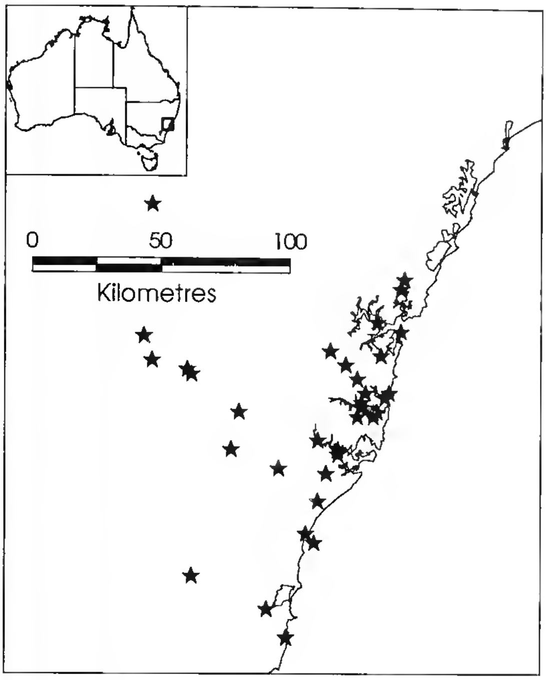

FIG. 31. Distribution of *P. platurus*.

eal line (n8), or by an 'L' shaped groove, Fig. 7j (n2). Axilla shallowly invaginated.

For skeletal details see Bauer, 1990. *P. platurus* stands separate from its congeners in two skeletal features - presacral vertebrae (25 vs 26) and first autotomy septum (6 vs 5).

ZOOGEOGRAPHY

The species of *Saltuarius* and *Phyllurus* are associated with rainforest or heathlands, or both. (*S. occultus* and *S. cornutus* are obligatory rainforest species; *S. salebrosus* and *S. swaini* occur in both rainforests and heathlands. *P. ossa, P. nepthys, P. isis* and *P. caudiannulatus* are obligatory rainforest species; *P. platurus* is a species of heathlands). These associations may reflect the parallel history of the evolution of rainforests and heathlands in Australia. The former evolved on fertile soils, the latter on infertile soils. Each habitat was widely distributed prior the Tertiary (65mya). Tertiary climatic fluctuations account for alternating contractions and fluctuations in their size and for their occurrence as fragmented, coastal and near-coastal narrow strips. Their island-like occurrence in an ocean of sclerophyllous forests is well documented (Kikkawa et al., 1979). With this history of alternating expansion/linking and contraction/separating rainforests and heathlands, it is not surprising that many taxa, some of which have narrow ranges and all of which are endemic to Australia, are 'shared' between rainforest and heathland today.

The recognition of two additional (*S. occultus* and *S. swaini*) species from the formerly very widely distributed *Phyllurus* sensu lato (now *Saltuarius*) *cornutus*, and of three new species of *Phyllurus* (*P. ossa, P. nepthys* and *P. isis*) from a very small area of isolated peaks/ranges in mideastern Queensland is consistent with concepts of separation and isolation of rainforests, and the survival, during such drier periods, of relict patches of rainforest and their faunas. *S. occultus* is a narrowly endemic species, known only from the type series of four specimens, from rainforests of the McIlwraith Ra., FNEQ. Its discovery is interesting zoogeographically. *P. occultus* appears to be one of only five vertebrate species which are confined to the rainforests of Iron-McIlwraith Ranges. (The others are *Antechinus leo* Van Dyck 1980, *Cophixalis crepitans* Zweifel, 1985, *Cophixalis peninsularis* Zweifel, 1985 and *Litoria longirostris* Tyler & Davies, 1977).

The situation where 1/13 rainforest reptile species is endemic to the area (Iron-McIlwraith Ranges) contrasts sharply with that of the rainforest block at the southern part of Cape York Peninsula (the Wet Tropics, between Cooktown, 15°48', 145°15', and Mt. Spec, 18°57', 146°11', NEQ). Here 20/29 rainforest reptile species are endemic. This pattern of Iron-McIlwraith Ranges endemic-species-paucity vs endemic-species-richness in the Wet Tropics is not unique to the reptiles, mammals and frogs. Exact parallels have been observed in heteropodid spiders (V. Davies pers. comm.); land snails (J. Stanisic, pers. comm.); and in carabid and aradid insects (Darlington, 1961; G. Monteith, pers. comm.).

S. cornutus sensu stricto is an addition to the already long list of rainforest reptile species endemic to the Wet Tropics (e.g. Covacevich & McDonald, 1991a,b). This area supports the highest percentage of endemic species known in Australia. A similarly high degree of endemism has been reported also in mammals, birds, frogs, and many invertebrate groups including snails, insects, spiders, crustaceans.

S. salebrosus and *S. swaini* are found in a wide variety of rainforests and heathlands. The former is common from dense, moist, notophyll rainforests to drier semievergreen vine thickets and heathlands, on either granites or sandstones. *S.*

swaini occurs in notophyll rainforests and heathlands. No other vertebrate species share the exact ranges of these two species, although many reptile (and other) species in coastal central and southern Queensland and northern and central New South Wales range between fragments of rainforest and heathland (eg. *Saiphos equalis*, *Hoplocephalus stephensii*, *Tropidechis carinatus*, *Ophioscincus ophioscincus*).

The distribution of *Saltuarius* spp. is paralleled by that of *Antechinus* spp. (Marsupialia: Dasyuridae) with only minor variations. *Antechinus leo* has roughly the same distribution as *Saltuarius occultus*; *A. godmani / S. cornutus; A. flavipes / S. salebrosus; A. stuartii /A. swaini* (S. Van Dyck, pers. comm.).

With the separation of *Saltuarius* from *Phyllurus* sensu lato, *Phyllurus* spp. are confined to the area between mideastern Queensland and mideastern New South Wales. They, too, occur in rainforests (*P. isis, P. nepthys, P. caudiannulatus*) and heathlands (*P. platurus*) and their distributions undoubtedly reflect the parallel evolution of these habitats in eastern Australia. In the Mackay/Proserpine area of mideastern Queensland, three species of *Phyllurus* occur in three localities, all within 100km of each other (Mt Blackwood-Mt Jukes / *P. isis* sp. nov.; Eungella = Clarke Ra./ *P. nepthys* sp. nov.; Mt Charlton, St Helen's Gap, Mt Ossa, Conway / *P. ossa* sp. nov.). Such speciation in a small area appears unusual initially, but can be explained in terms of alternate contraction and expansion of rainforests; the geology of the area; and the probable antiquity of *Phyllurus*. Given the multiple chromosome reduction in these species it is also possible that chromosome changes have contributed to speciation events (Sites & Moritz, 1987).

Rozefelds (1990) has described Oligocene rainforest plant fossils from near Capella, MEQ to the SW of the *Phyllurus* localities. This area is presently extremely dry in comparison with them, and does not now support any vegetation remotely resembling rainforest. He notes of his site '... the area was covered in tropical rainforest communities during the late Oligocene - early Miocene .... the reduction in and/or migration of taxa to refugial rainforest communities along the northeastern Queensland coast can be correlated with the increasing aridity of the Australian climate from the Miocene onwards.... Remnants of Australia's widespread early Tertiary mosaic of rainforest communities are now restricted to *refugia* along the eastern and northern coasts...'. The sequence of the many expansions and contractions of the rainforests has been ably summarised by Archer et al. (1991) who write '... the existence of many now isolated islands of rainforest in Australia is evidence that these ... are remnants of what was once a much wider, more uniformly spread rainforest. Of the islands that remain, those of the tropical and temperate regions are clearly descendants of the ancient, primordial types of rainforest ...'. Genetic studies of reptile species in the Wet Tropics rainforest have revealed major differences attributed to contractions of rainforest in the past (Moritz et al., 1993).

The present species composition of the relict patches of rainforest on Mt Blackwood-Mt Jukes and the occurrence in them of endemic species result from the geological and botanical history of the area. A quartz syenite intrusive (presently Mt Blackwood) formed in the Oligocene (25-40 mya). A second intrusive of granite (presently Mt Jukes) formed, later, but also in the Oligocene. As weathering progressed, the two peaks have been exposed (Champion, 1984). Moist, sheltered pockets have enabled rainforests which have been eliminated from intervening drier areas, to survive. These small islands of rainforest (Mt Jukes-Mt Blackwood, St Helen's Gap-Mt Ossa-Mt Charlton) and the large rainforest islands (Clarke and Conway Ranges) can be viewed as a microcosm of the broader, total present picture of Australia's tropical and subtropical rainforests with their highly endemic, narrowly distributed faunas and floras.

Geckos are poorly known in Australia's fossil record. However, they are present in Oligocene-Miocene deposits (Archer et al., 1991) when rainforest was the dominant vegetation. *Phyllurus* has not been identified from fossil deposits, but Carphodactylini (*Phyllurus*, *Saltuarius* and *Carphodactylus*) which are, today, the only obligatory rainforest geckos in Australia, are regarded as a probable part of the Gondwanic fauna (Covacevich & McDonald, 1991a; Kluge, 1967). An ancestral *Phyllurus* may have occurred widely in the rainforests of the Oligocene-Miocene. Descendants of that ancestral form may have speciated in the 'islands' of rainforest present today.

CONSERVATION STATUS

McDonald et al. 1991 reviewed the conservation status of all Queensland's reptile species. With this review, the following additions to their list of 'rated' species are necessary - *S. occultus* 2 ('... species with a very restricted distribution in Australia and with a maximum geographic distribution of less than 100km...') K ('... poorly known species ...'); *P. caudiannulatus, P. isis, P. nepthys* and *P. ossa* 2R (R, 'species which are rare in Australia .... may be represented by a relatively large population in a relatively restricted area or by smaller populations spread over a wider range ....').

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ECOLOGICAL NOTES ON *CARLIA ROSTRALIS* IN RAINFOREST AND ASSOCIATED HABITAT IN THE SOUTHERN WET TROPICS

J.M. WHITTIER

Whittier, J.M. 1993 12 24: Ecological notes on *Carlia rostralis* in rainforest and associated habitat in the southern Wet Tropics. *Memoirs of the Queensland Museum* 34(1):125-129. Brisbane. ISSN 0079-8835.

A study of *Carlia rostralis* was conducted in November-December, 1988, July, 1990-92, and January-February, 1991-93, between Townsville and Cairns, Queensland, Australia. In this southern portion of its range, *C. rostralis* was locally abundant in vine thickets along creeks as well as in grassy riparian areas in open forest. It was absent from dense rainforest at higher elevations in the Seaview Ra. *C. rostralis* was restricted to the more mesic eastern localities in this southern area. Current and future conservation status of this species is excellent.

Reproductive patterns of *C. rostralis* were investigated at two locations, Waterfall Ck, Waterview Shire, and Waterview Ck, Jourama Falls NP. Adult males and females (> 45.0 mm snout vent length) were highly sexually dimorphic in both colour and maximal body size. Juveniles in their first year resembled females in colouration. Reproduction in *C. rostralis* is seasonal; egg-laying commenced in November-December and continued to February in the study. In each year, nearly all adult females in the populations observed were reproductively active. Reproductive activity coincided with the usual time of the wet season at the two localities, but seasonal rainfall did not appear to regulate the onset or the maintenance of egg-laying. ☐ *Lizard ecology, lizard reproduction, seasonal breeding, Scincidae.*

Joan M. Whittier, Department of Anatomical Sciences, University of Queensland, St. Lucia, Queensland 4072, Australia, 10 September, 1993.

Recent reviews of reproductive patterns in lizards that inhabit tropical environments have found that there is little relationship between seasonal environmental conditions and timing of breeding (Shine, 1985; James & Shine, 1985; Auffenberg & Auffenberg, 1989; Vitt, 1990). There appears to be a lack of general patterns of breeding in tropical lizards, despite early predictions that breeding in these areas would probably be related to seasonal rainfall. The factors that regulate the diverse patterns of breeding in tropical lizards are virtually unknown (Whittier & Crews, 1987; Whittier, 1993).

The genus *Carlia* represents an excellent model group in which patterns of seasonal breeding in tropical areas can be studied. *Carlia* comprises a total of 20+ recognised species endemic to tropical Australia, Papua New Guinea, and nearby islands (Ingram & Covacevich, 1989). No long-term studies of the status and reproductive biology of this group have been conducted previously. A few short-term studies have examined the reproductive and thermal ecology of members of this genus. Reproductive cycles of *C. rhomboidalis* and *C. schmeltzii* (originally identified as *Leiolopisma rhomboidalis* and *Leiolopisma fusca*, respectively; identification checked by examination of Wilhoft's labelled specimens in the Los Angeles County Museum, by JMW), in northeastern Queensland, and *C. bicarinata*, in eastern Papua New Guinea, indicate that these species reproduce during the wet season (Wilhoft 1963a, 1963b; Wilhoft & Reiter, 1965; Zug et al., 1982). Similarly, several species of *Carlia* were reported to breed only in the wet season in the Alligator Rivers region of the Northern Territory, Australia, based on examination of museum specimens (James & Shine, 1985). James & Shine (1985) concluded that taxa such as *Carlia*, with origins in seasonally wet tropical areas, have maintained a historical association between breeding and the occurrence of seasonal rainfall. However, as in other tropical lizards that breed in association with the seasonal onset of rain, the factors that regulate the timing of breeding are not known in *Carlia*.

At the localities where *C. rostralis* were observed in the present study, a large community of reptiles exists at high densities. In this region, the onset and yearly occurrence of the wet season is relatively unpredictable. This is due to the stochastic occurrence of cyclonic rains; in more northern areas rain does occur in most years, but in these more southern areas dry summers occur at irregular intervals, approximately every three to six years. For lizards such as *C. rostralis* that live for one to five years (unpub. data, JMW), a dry summer can be a significant event in the life cycle. Furthermore, the onset of the wet season can vary up to four months, ranging from November to February, although normally commencing in late December or January.

In the Wet Tropics, the limited data available on reproductive patterns suggest that most species of lizards breed in the summer, with the onset of breeding commencing just prior to the start of the wet season (December & January; James & Shine, 1985). The conclusions from these observations have generally been that 'wet season' breeders reproduce in response to increased food availability (insect prey) that accompanies summer rains. These observations suggest that food availability may not play a critical role in the onset of reproduction, but that it may be important for the maintenance of reproduction later in the season.

I became interested in determining whether reproduction in *C. rostralis* in the Wet Tropics was regulated by seasonal rainfall. Of interest was the timing of reproduction in years when the wet season was delayed or did not occur (the latter is associated with the conditions of the Southern Pacific Oscillation, or El Niño). At the same time that the study of reproductive patterns in this species was conducted, the distribution and habitat preferences of *C. rostralis* were surveyed. Known localities obtained from records in the Queensland and Australian Museums (Ingram & Covacevich, 1989) between Townsville and Cairns, NEQ, were visited to establish and confirm the current distribution of this species.

METHODS

A study of *C. rostralis* was conducted in November-December, 1988; July, 1990-92, & January-February, 1991-93 at two field sites, Waterfall Ck, Waterview Shire, Ingham SF District, and at Waterview Ck, Jourama Falls NP, both approximately 60 km north of Townsville, NEQ. Both sites supported lowland vine thicket extending down the water course from rainforest at higher elevations. The vine thicket riparian zone extended approximately 100m to either side of the creek. Surrounding these areas was open sclerophyll forest. Several additional sites between Cairns and Townsville were visited to determine the extent of current distribution of *C. rostralis* in the southern portion of the Wet Tropics. These sites were mainly limited to locations in the vicinity of those published in Ingram & Covacevich (1989).

To assess sex and reproductive condition animals were hand captured using insect lures. On capture, individuals were measured snout to vent (±0.5 mm) and weighed (±0.2 gram). At the two field sites individuals were toe-clipped for long term population studies. Adult males were distinguished from adult females by the presence of a black gular region and bright orange lateral coloration. Minimum size (SVL) at sexual maturity was determined by the observation of the smallest size at which either sex was producing functional gametes. This was indicated by palpation of females in the field and dissection of museum specimens (JMW, unpublished observations). During the winter months, when immature and juvenile (<35-40 mm SVL) individuals were present, coloration was not reliable as a means of determining sex, and individuals with a white throat less than 40 mm SVL were not sexed. Female reproductive condition was assessed by laparotomy or by palpation. Initially palpation followed by laparotomy was used to confirm the presence of previtellogenic follicles (no ovarian masses, < 3 mm in diameter), maturing follicles, (round, firm bodies > 3 mm in diameter), ovulated eggs (oval soft bodies > 5 mm in length), or shelled oviductal eggs (oval hard bodies > 6 mm in length). Subsequently females were palpated only , as this proved to be an accurate method of assessing reproductive condition. Since some females began developing a subsequent clutch, a portion of females had both maturing follicles and oviductal eggs. Most females in the study were recaptured numerous times before, during and after ovulation and after oviposition so that the timing and stage of the ovarian cycle was reconfirmed.

RESULTS

In the southern portion of its range, the current distribution of *C. rostralis* appears to resemble recent historical distribution as indicated by records in the Queensland and Australian Museums, and in Ingram & Covacevich (1989). At only a few sites were no *C. rostralis* found. At the majority, animals were either common or abundant. *C. rostralis* was locally abundant in vine thickets along creeks as well as in grassy riparian areas in open forest. This species was absent from dense rainforest such as that at higher elevations in the Seaview Ra. *C. rostralis* was restricted to the more mesic eastern localities in this southern area. No changes in habitat preference were noted between summer and winter seasons at the intensively studied localities. In the following list of *C. rostralis* sites surveyed, 1988–1993, the data are: (location surveyed; lat/long; habitat; date; status: A-abundant, C-common, U-uncommon, Ab-absent; AM/QM#, recorded locality).

1. Holloway Beach; 16 51/145 45; beach, residential; 7/90;Ab; AM R97693-4; Holloway Beach, via Casuarina St.
2. Davies Creek NP; 17 00/145 34; riparian open forest, rocks; 7/91; A; AM R53904; Davies Creek Rd., 16 miles SE Mareeba.
3. Palmerston NP; 17 36/145 45; rainforest; 12/88; Ab; --;--.
4. Millstream Falls NP; 17 39/145 27; grass in open forest, riparian; 12/88; C; AM R62272; Millstream Falls NP.
5. Murray Falls SF Park; 18 12/145 55; grass in open forest, riparian; 12/88; A; --;--.
6. Wallaman Falls NP; 18 38/145 33; grass in open forest, riparian; 12/88; U; AM R97690-2; 24.1 km ESE Wallaman Falls NP by road.
7. Jourama Falls NP; 18 52/146 07; grass in open forest, riparian vine thicket; 12/88-7/93; A; --; --.
8. Jourama Falls NP, upper drainage of east tributary of Waterview Ck; 18 52/146 07; rainforest; 7/91; Ab; --; --.
9. Waterfall Ck, Waterview Shire; 18 53/146 09; grass in open forest, riparian vine thicket; 12/88-7/93; A; --; --.
10. Waterfall Ck upper drainage, Waterview SF; 18 53/146 08; rainforest; 12/88; Ab; --;--.
11. Birthday Falls, Blackfriars SF; 18 59/146 09; rainforest; 12/88; Ab; --; --.
12. Hencamp Ck northern tributaries, Hinchinbrook SF; 19 01/146 21; rocky dry stream beds, open forest; 12/88; C; QM J27695; QM 32570-32575; Hencamp Creek, 5km N of 1 km E of Rollingstone.
13. Hencamp Ck, Hinchinbrook SF; 19 01/146 21; rocky dry stream bed, vine thicket; 7/93; A; QM J27695; QM 32570-32575; Hencamp Ck, 5km N of 1 km E of Rollingstone. ,
14. Little Crystal Ck, Mt Spec NP; 19 01/146 17; vine thicket, riparian; 12/88; U; AM R97675-6; 10 km W of Bruce Hwy via Paluma Rd.
15. McClellan's Lookout, Mt Spec NP; 19 01/146 12; grass in open forest; 12/88; U; --; --.
16. Cloudy Creek upper drainage , Mt. Spec NP; 19 01/146 12; rainforest; 12/88; Ab; --; --.
17. Pine Ck tributaries, Blackfriars and Kangaroo Hills Shires; 19 01/146 07; dry streams, open forest; 12/88; Ab; --;--.
18. Station Ck, Clemant SF; 19 07/146 26; rocks in dry stream bed, vine thicket; 7/93; A; --; --.

There is a high degree of sexual dimorphism in size in *C. rostralis*. Data from the first and second breeding seasons, in November & December, 1988, and January & February, 1991, are representative. Males were significantly longer and heavier than females and were heavier per unit of body length, except for the largest females (n, mean ± 1SE, of SVL and BW, of males: 21, 61.6 ± 3.5 mm, range, 53.0-69.0 mm; 5.4 ± 1.0 g, range, 4.0-7.0; of females: 21, 56.0 ± 2.8 mm, range, 50.0-60.0 mm; 4.4 ± 0.9 g, range, 3.0-7.0 g). At first breeding season, most of the adult females (12/14) were reproductively active during the study, with either preovulatory, postovulatory or, in one case, both types of follicles present in the reproductive tract. All females examined had two eggs. Two oviductal eggs, 8 x 4 mm, were found in two additional females that were kept as specimens. One of these individuals also had two yolking follicles, 1 mm in diameter, present in the ovary, indicating that females are capable of producing multiple clutches.

Based on direct observation (1988) or indirect inference from the presence of cohorts of hatchlings (1991 & 1992), ovarian recrudescence and egg-laying in this species began in November in all three years of the study. Reproductive activity was maintained through February in at least two years, regardless of the timing of the onset of the rainy season (Table 1). In 1988/89, females began developing mature follicles in early November and the first clutch of eggs was laid in mid-November; hatchlings first appeared in mid-December, suggesting that incubation time under the ambient conditions was 4-5 weeks. The onset of summer rains in 1988/89 occurred earlier than usual, in mid-December. In the second breeding season examined, 1990/91, breeding again commenced in November, as estimated by the presence of two cohorts of hatchlings in the population in mid-January. However, there was no onset of summer rains in this season, due to an occurrence of a severe drought as a result of a persistent Southern Pacific Oscillation. Finally, in the third year of the study, 1991/92, breeding commenced in November, estimated by the presence of three cohorts of hatchlings observed in late January, and continued through February. In mid-February, females ceased developing mature follicles and the reproductive season came to an end. In this year drought conditions persisted through early January, and heavy wet season rains did not occur until mid-February.

DISCUSSION

The current and future conservation status of *C. rostralis* in the southern portion of its range in the

Wet Tropics appears to be excellent. The habitat preferences and distributional requirements of the lizards in this area confirmed previous accounts (Ingram & Covacevich, 1989). *C. rostralis* is often observed basking on the rocky floor of the vine thicket. This heliothermy probably accounts for the species' absence in denser rainforest at higher elevations in the Seaview Ra. *C. rostralis* has a relatively diverse range of habitat preferences, being found also in grassy areas in open sclerophyll forest. However, the animals found in these localities usually are in close proximity to creeks and mesic riparian zones; in drier open forest on the western side of the range the species is absent.

Reproductive observations of *C. rostralis* at two localities (Waterfall & Waterview Cks) indicated that this species attains a large index of sexual dimorphism (1.1; ratio of mean SVL of males to females; Stamps, 1983). In addition, *C. rostralis* has a striking degree of sexual dichromatism that develops in the first year. These patterns of sexual dimorphism, although not uncommon amongst *Carlia* or other Australian scincids, are very different from that found in scincids that have been studied elsewhere, although few species have been studied (Stamps, 1983). This high degree of sexual dimorphism and dichromatism in *C. rostralis* appears to be related to breeding, as males do not usually develop the black gular region and bright orange, black and white markings on the lateral head, neck and thorax until breeding commences in the first year (Whittier & Scott, 1989; Whittier, 1991). These patterns of sexual dimorphism and dichromatism may be related to a highly competitive and ritualistic dominance hierarchy that is exhibited by male *C. rostralis* in both the laboratory and the field (Whittier & Martin, 1991).

Reproduction in *C. rostralis* is seasonal, with egg-laying beginning in November and December, and continuing to February. Egg production and hatchlings were not observed in July. In each year, nearly all adult females in the populations observed were reproductively active, having yolking follicles or oviductal eggs. Multiple clutches appeared to be produced by most females; in nearly every case of a recapture in the summer, developing follicles were detected in females that had previously been gravid. From these observations, I suggest that female *C. rostralis* produce three to four clutches of two eggs each during each breeding season (Whittier & Scott, 1989).

Although the breeding period in *C. rostralis* coincides with the usual time period of the wet season, breeding is not regulated by the onset of seasonal rain. Nor is breeding maintained by any factors such as purported increases in food availability associated with those rains. Although the factors that regulate timing of reproduction in this species are not known, two conclusions can be drawn from the study. First, that the timing of breeding is predictable and regulated in a precise manner, and second, that timing of breeding coincides with the most frequent occurrence of seasonal rain. I speculate that the timing of reproduction in this species is regulated either by seasonal changes in photoperiod or by an endogenous mechanism. These mechanisms would represent the best predictor of favourable conditions over the long term in this unpredictable environment.

Many factors, including physiology, phylogeny, zoogeographic history and life history traits may influence seasonal reproduction in squamate reptiles that inhabit subtropical and tropical environments (Shine, 1985; James & Shine, 1985; Auffenberg & Auffenberg, 1989; Vitt, 1990). From a physiological viewpoint, to understand the patterns of breeding in tropical lizard species and communities, an important consideration is the somatic condition of the female lizards (Bradshaw et al., 1991; Whittier, 1991a; 1993; Whittier & Tokarz, 1992). Patterns of abundance of food resources in the environment, assessed in the context of energy requirements for subsistence, growth, and reproduction of the species need to be considered. Because reptiles, particularly squamates, are limited by the energetic cost of female egg production, the mechanisms by which females assess somatic condition can be co-opted to regulate reproduction directly (Stearns, 1976; Tinkle & Hadley, 1985). Future studies should determine how

TABLE 1. Female egg-laying patterns of *C. rostralis*, NEQ, in relation to the onset of the wet season.

Time	Onset of Rain	Breeding Onset	Breeding Duration
Nov.1988- Dec. 1988	mid-Dec.	mid-Nov.	unknown
Jan. 1992- Feb. 1992	no season	mid-Nov.*	Feb.
Jan. 1993- Feb. 1993	Feb.	mid-Nov.**	Feb.

*Estimated from the presence of two cohorts of hatchlings present in early January.

**Estimated from the presence of three cohorts of hatchlings present in late January.

species such as *C. rostralis* precisely time and maintain reproduction in relatively unpredictable environments like the southern portion of the Wet Tropics.

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VARANUS PRASINUS (THE EMERALD GOANNA) ON MOA ISLAND, TORRES STRAIT, AUSTRALIA.

Memairs of the Queensland Museum 34(1)130. 1993:- A specimen of *Varanus prasinus* (QM transparency NM 791, E. Mattock) was observed in closed mesic forest on Moa Island (10°11'S 142°16'E) recently. This is the only record of this species in Australia this century, and is the southernmost record for the species.

Moa Is., formerly Banks Is., is a relatively large continental island (700km^2 approximately) in the central part of the Torres Strait. There are two small villages on the island. Diverse native vegetation, most of which is undisturbed, predominates. At higher elevations on and around Moa Peak (374m), there is a closed mesic forest. This is now one of the few large patches of closed mesic forest in Queensland in which virtually no herpetological survey work has been done.

Accompanied by Mr T. Moore, Ms E. Mattock and Mrs A. Torenvwek, we climbed Moa Peak on 28 August, 1993. At about 180m, from a rocky outcrop, we saw a specimen of *V. prasinus* basking in bright sunlight on a broken tree top, about 10m from the ground. The specimen was bright green, with black chevrons along its back. It was slender and had a snout-vent length of approximately 30cm. Its long, slender tail was curled, not used to hold on to the tree.

V. prasinus is well known in Papua New Guinea, but is recorded in Australia only from Dauan (formerly Cornwallis) and Mer (formerly Murray) Islands in the Torres Strait (Günther, 1877, 1879; Boulenger, 1885). These two islands are in the northern and eastern portions of the Torres Strait. Cogger (1992) reports *V. prasinus* in the far northern Torres Strait and Papua New Guinea. There are no recent records of *V. prasinus* in Australia. No Australian specimens are held in the collections of the Queensland or Australian Museums (Covacevich & Couper, 1991; R. Sadlier pers. comm.).

Records of *V. prasinus* from the McIlwraith Range area of Cape York, reported by Czechura (1980), have been shown to be based on specimens of *V. teriae* (Sprackland, 1991). Sprackland (1991) also described a new species of tree goanna, *V. telenestes*, from Rossell Island, Papua New Guinea, from material previously treated as *V. prasinus*. This raises the possibility that the specimen we observed on Moa Island may also be an endemic island taxon. Future collection and taxonomic evaluation of the green goanna on Moa Island will clarify this. This observation emphasises the importance of the closed mesic forest on Moa Island.

Acknowledgments

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REPRODUCTIVE BIOLOGY OF THE PRICKLY FOREST SKINK, *GNYPETOSCINCUS QUEENSLANDIAE*, AN ENDEMIC SPECIES FROM NORTHERN QUEENSLAND

MICHAEL CUNNINGHAM

Cunningham, M. 1993 12 24: Reproductive biology of the Prickly Forest Skink, *Gnypetoscincus queenslandiae*, an endemic species from northern Queensland. *Memoirs of the Queensland Museum* **34**(1):131-138. Brisbane. ISSN 0079-8835.

Examination of morphology, reproductive state and skeletochronological markings in specimens of a rainforest skink, *Gnypetoscincus queenslandiae*, in the Queensland Museum, reveals a sex ratio of 1:1.5 (♂♂:♀♀); that the sexes can not be distinguished by any single morphological trait; females mature at about 55 mm (SVL); and immature females produce many small (<2mm diameter) ovarian follicles. As females approach maturity increasingly large ovarian follicles are produced, but in mature females the number of ovarian follicles produced is independent of size. Clutch size increases with size of mature females. The number of vitellogenic follicles produced is significantly correlated with clutch size. Breeding is seasonal on the Atherton Tableland. A suggested reproductive cycle for this viviparous skink on the Atherton Tableland, is presented. A significant linear regression indicates a high correlation between size and the number of haematoxylinophilic lines in transverse sections of the femur. □ *Gnypetoscincus queenslandiae, rainforest ecology, reproduction, skeletochronology, Scincidae.*

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A well preserved museum specimen, accompanied by accurate records of location and date of capture, provides a snapshot of an animal's physical state at a particular time. A collection of these specimens gives a broader picture of seasonal, size related and geographic variation in a population of these animals. In this way museum collections may provide valuable information on the ecology of cryptic or poorly known species.

One such species is the Prickly Forest Skink, *Gnypetoscincus queenslandiae*. This nocturnal, live bearing lizard is endemic to the rainforests of the Australian Wet Tropics (Cogger, 1992; Nix & Switzer, 1991). Because it is found in or under rotting logs, this species is difficult to study in the field. Greer (1989) describes *G. queenslandiae* as 'one of the most ecologically buffered terrestrial reptiles in Australia' and continues 'given this presumably relatively aseasonal microhabitat, one could ask what has happened to those biological activities that are generally seasonal in less buffered species'.

In several areas of the Wet Tropics, especially the Atherton Tableland, much of the original forest has been cleared for agriculture, grazing and settlement (Winter et al., 1987). *G. queenslandiae* is a common inhabitant of the remaining rainforest, and is thus a suitable species for the study of this habitat fragmentation. The aim of this project was to elicit information on the reproductive biology and demography of *G. queenslandiae* for later use in ecological and genetic models of the effects of habitat fragmentation. This was done through the examination of a series of this species in the Queensland Museum. Details of these specimens are available from the Queensland Museum database.

METHODS

G. queenslandiae (n=160) from 24 sites in the Wet Tropics were examined. The majority (n=118) were from 18 sites on the Atherton Tableland (17°10'-17°35'S 145°30'-145°45'E), an undulating plateau with an altitude of 700m-900m. Twenty-nine skinks were collected from upland sites to the north (three sites: n=23) and south (one site: n=6) of the Atherton Tableland. A further thirteen were collected from two lowland sites: one at a similar latitude to the Atherton Tableland (Bellenden Ker: n=6) and one site in the northern Wet Tropics (Daintree: n=7). Skinks had been obtained between 1963 and 1992 in February, April, June, September, November and December. Samples collected from the same site at different times were available from only four sites.

The snout-vent length (SVL) of each skink was measured with electronic callipers. Each specimen was then dissected for examination of the reproductive tract. Males were distinguished from females by the absence of oviducts running forward along the body wall from the gonads, the absence of enlarged ovarian follicles and the presence of a cream coloured epididymis. For each male, only a qualitative assessment of the state (turgid or flaccid) and size (small or enlarged) of the epididymis was recorded. Females were recorded as gravid (possessing oviducal eggs) or not gravid (without oviducal eggs). In addition, the following measurements of reproductive state were recorded for each female: I - Clutch size (the number of oviducal eggs); II number of greatly enlarged (>2 mm diameter) ovarian follicles; III number of enlarged follicles, between 1.5 mm and 2 mm in diameter; IV number of ovarian follicles between 0.5 mm and 1.5 mm in diameter; and V number of small follicles, less than 0.5 mm in diameter.

These classes were determined from the observed size distribution of developing follicles, and correspond to the follicular growth stages described for the Diamond-backed Water Snake, *Natrix rhombifera*, (Betz, 1963) and the latter five classes described for several tropical snakes (Zug, 1979). Oviducal eggs (class I) were a golden yellow colour and always larger than 5 mm; class II follicles were a creamy yellow colour; classes III, IV and V were white. The diameter of each ovarian follicle was determined using a dissecting microscope.

To assess the relationship between size and relative age in *G. queenslandiae* , the left femur from fourteen specimens (representative of the range of sampling locations and size within each sex), was removed for skeletochronological analysis. Each femur was decalcified in formic acid and formalin, and vacuum embedded in wax. Transverse sections were taken from the mid-diaphysis of these bones, mounted on slides and stained for 15 minutes with Delafield's haematoxylin and for 10 seconds with Eosin. These were examined under a compound microscope, to record the number of haematoxylin stained concentric rings in the compact bone of each femur.

ANALYSES

A Chi square test was used to compare the observed sex ratio in the total sample, with an expected 1:1 ratio. Morphological differences between sexes were assessed by Canonical-Discriminant Analysis. This analysis finds the maximum difference between groups (in this case males and females) based on a weighted combination of variable characters, measured on each individual. Canonical-Discriminant Analysis may demonstrate separation among groups that appear indistinguishable in analyses of single variables, due to overlap between groups in the range of each morphological character. A series of meristic measurements (SVL, head length, head width, length of the left tibia, and length of the left fourth toe) and scale counts (lamellae under the left and right fourth toes, left and right supra-ocular scales, para-vertebral scales, and nuchal scales) gathered on these skinks for another study were submitted to the procedure 'CANDISC' in the SAS statistical analysis package (SAS Institute Inc, 1985). In addition to this multi-variate analysis 'CANDISC' provides analysis of variance (ANOVA) comparisons of groups for each morphological variable (SAS institute inc., 1985). These test the hypothesis that differences between the sexes cannot be distinguished from variation within each sex.

Nix & Switzer (1991) report size variation in populations of *G. queenslandiae* from different locations. The SAS procedure 'GLM' (SAS institute inc., 1985) was used to investigate size (SVL) differences between sampling sites by one-way ANOVA. This analysis included only those locations from which five or more samples had been collected. The mean size of gravid females (with oviducal eggs) was compared with that of all other females from the Atherton Tableland, using Student's t-test, generated by the SAS 'TTEST' procedure (SAS institute inc., 1985). This analysis tests the null hypothesis that gravid females do not differ in size from other females.

Pearson product-moment correlation coefficients, generated by the SAS procedure 'CORR' (SAS institute inc., 1985), were used to compare size of female skinks with number of eggs or ovarian follicles carried by those females, for each class defined above. These analyses test the hypothesis that the number of eggs and ovarian follicles is not correlated with SVL. A Chi square test of homogeneity was used to investigate temporal variation in the proportion of gravid females in the Atherton Tablelands samples, and to test the probability that this variation could be due to random sampling.

Finally, the procedure 'REG' in SAS (SAS institute inc., 1985) was used to generate simple linear regressions of the number of femoral bone rings against size, SVL, for all samples and for those from the Atherton Tableland alone. These regressions are used to predict the expected number of femoral bone rings from a skink of known size.

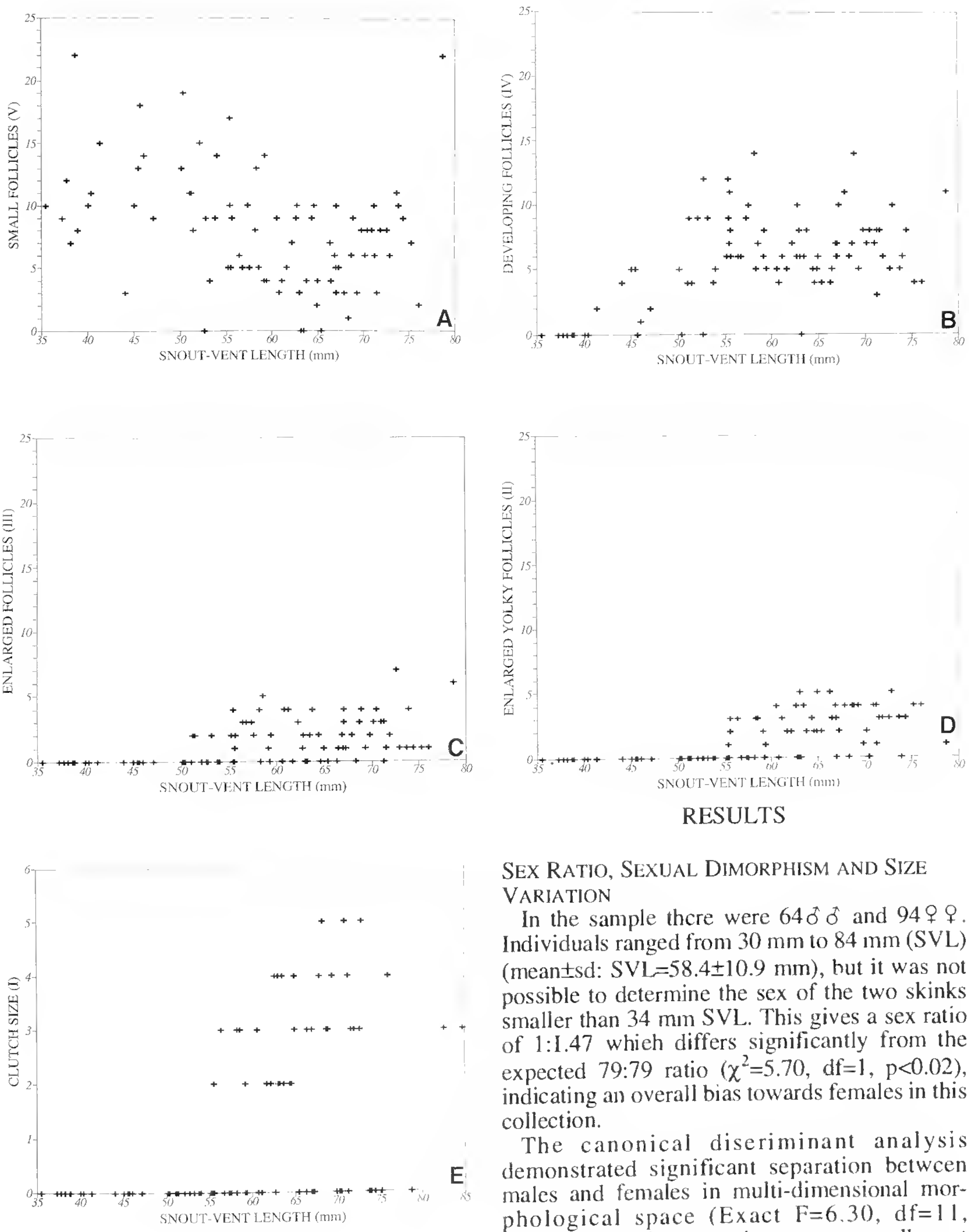

FIG. 1(A-E). Plot of clutch size and number of follicles in each size class against SVL for all females.

RESULTS

SEX RATIO, SEXUAL DIMORPHISM AND SIZE VARIATION

In the sample there were 64♂♂ and 94♀♀. Individuals ranged from 30 mm to 84 mm (SVL) (mean±sd: SVL=58.4±10.9 mm), but it was not possible to determine the sex of the two skinks smaller than 34 mm SVL. This gives a sex ratio of 1:1.47 which differs significantly from the expected 79:79 ratio (χ^2=5.70, df=1, p<0.02), indicating an overall bias towards females in this collection.

The canonical discriminant analysis demonstrated significant separation between males and females in multi-dimensional morphological space (Exact F=6.30, df=11, p<0.0001). This separation was generally not reflected in the univariate tests of sexual dimorphism, with only the number of nuchal scales (NTOT - defined here as the number of scales posterior to, and in contact with, the parietal

Table 1. Correlation between number of oviducal eggs/ovarian follicles and the snout-vent length (SVL) of all females, mature females (SVL > 55 mm) and gravid females (clutch size > 0).

	Sample size (n)	Pearson product-moment correlation co-efficient (r)	Significance probability (p)
ALL FEMALES			
Clutch size(I)	91	0.494	0.0001
Vitellogenic follicles (II)	88	0.622	0.0001
Enlarged follicles(III)	88	0.472	0.0001
Developing follicles (IV)	88	0.508	0.0001
Small follicles (V)	88	-0.349	0.0009
MATURE FEMALES			
Clutch size (I)	61	0.158	NS
Vitellogenic follicles (II)	58	0.257	NS
Enlarged follicles (III)	58	0.130	NS
Developing follicles (IV)	58	-0.042	NS
Small follicles (V)	58	0.124	NS
GRAVID FEMALES			
Clutch size(I)	36	0.390	0.019
Vitellogenic follicles (II)	33	0.299	NS
Enlarged follicles(III)	33	0.115	NS
Developing follicles(IV)	33	-0.021	NS
Small follicles (V)	33	-0.231	NS

scales) showing significant differences between males and females (F=6.11, df=1, p=0.015). Females tend to have fewer nuchal scales (mean±sd, ♀♀: NTOT=16.64±1.83; ♂♂: NTOT =17.43±1.66). However, the ♀ range (NTOT=13 to 21) is contained in that of ♂♂ (NTOT=11 to 21) and, as this is a discrete character, the expected value of NTOT for both is 17.

Although no significant size differences were detected between the sexes in the above analyses, significant SVL differences were found among sample locations in the ANOVA (F=4.39, df=13, p<0.0001). To further explore these differences the mean of each population was compared with that of each other population using Tukey's studentized range tests calculated by the SAS procedure 'GLM' (SAS institute inc., 1985). The overall type 1 error rate for these comparisons (the rate at which results are falsely accepted as significant) was restricted to 0.05. Several samples were found to differ significantly in SVL. The skinks from Dowlings' Fragment (17°23'S 145°41'E) are smaller on average (n=7: SVL=43.6±6.3 mm) than those from other locations, whilst those from Major's Mountain (17°38'S 145°32'E) were generally larger (n=5: SVL=72.9±3.3 mm).

SIZE AND REPRODUCTION

All ♂♂ larger than 50 mm SVL displayed enlarged epididymides (approximately 4.5 mm in diameter), which presumably indicates sexual maturity. None smaller than 45 mm SVL possessed an enlarged epididymis. Among the ♂♂ larger than 50 mm SVL, epididymides were either turgid or flaccid with no clear seasonal or geographic trends. This may indicate a stage in the reproductive cycle, such as the production and storage of sperm, or may be an artefact of collection and fixation.

Of the 71 ♀♀ from the Atherton Tableland, 25 were gravid (mean SVL=66.8±5.0 mm) and 46 were not (mean SVL=55.5±11.9 mm). The smallest gravid skink 55.5 mm (SVL); the largest (non-gravid) was 78.7 mm (SVL). Using an estimate of T, modified to account for unequal variance between groups, gravid ♀♀ were found to be significantly larger than others (modified t=-5.48, df=65.9, p<0.0001). No specimen smaller than 55 mm (SVL) had any class I or II ovarian follicles. Class III follicles were found in only three ♀♀ (12%) smaller than 55 mm (SVL), Fig. 1C.

The correlation analysis was performed on three nested groups: all ♀♀, to investigate general size related trends in reproductive state; only ♀♀ >55 mm SVL, to exclude immature skinks ♀♀; and only gravid ♀♀ (clutch size > 0), to compare skinks in a similar physiological

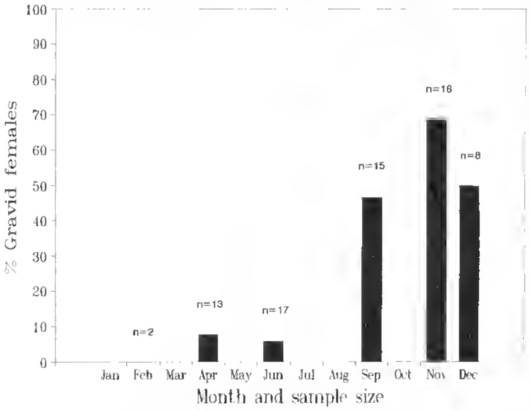

FIG. 2. Temporal variation in percentage of females from the Atherton Tableland carrying oviducal eggs. Sample sizes are given for each month from which collections were available.

condition. Pearson product-moment correlation coefficients for each of these comparisons are presented (Table 1). In the comparisons including all ♀♀, SVL was significantly correlated with clutch size and each class of follicles (Table 1). Clutch size and the numbers of class II, III and IV ovarian follicles increase with SVL, the number of class V follicles decreases with SVL, however, there is considerable variation between similarly sized lizards (Fig. 1A-E). When immature ♀♀ are excluded from the correlation analysis, variation in the number of eggs and follicles appears to be independent of SVL (Table 1). Among gravid ♀♀ clutch size is significantly and positively correlated with SVL (Table 1); large gravid ♀♀ generally carry more eggs than smaller gravid ♀♀ (Fig. 1A). Although the number of vitellogenic follicles (II) was not significantly correlated with SVL in gravid females (Table 1), it was significantly correlated with clutch size (n=33, =0.536, p=0.001).

FEMALE REPRODUCTIVE CYCLE, ATHERTON TABLELAND

At least 50% of ♀♀ collected from sites on the Atherton Tableland in September, November and December were gravid (Fig. 2). Neither of the two ♀♀ collected in February were gravid. Only one of thirteen ♀♀ collected in April, and one of seventeen ♀♀ collected in June, were gravid (Fig. 2). The Chi square test of homogeneity indicates statistically significant temporal variation in the proportion of gravid females (χ^2=22.628, p=0.000).

A temporal trend was also evident in the development of eggs within gravid females. The single gravid specimen collected in June carried small eggs (average egg length 6.0 mm). Several non-gravid ♀♀ collected in June carried very large, class II, follicles (between 4 mm and 6 mm), which were of similar size to small oviducal eggs and were not found in females collected at other times. In gravid ♀♀ collected in September, eggs were larger (average length =10.7±1.2 mm) but showed no obvious signs of fertilisation. Eggs in gravid females collected in November and December were of a similar size to those in September (average egg length 11.8±1.7 mm) and carried developing embryos, up to 5 mm long, surrounded by yolk. The gravid female from April (J31057) was the only individual in the entire sample carrying well developed young, and the only gravid individual to have a clutch size of one. The single foetus found in this female appeared to be fully developed and, although still encased in the egg membrane, was not surrounded by yolk. This unborn skink had a SVL of 25.9 mm, which was 4 mm smaller than the smallest juvenile skink examined in this study.

This apparent seasonality of reproduction suggests temporal variation in the average size of *G. queenslandiae* on the Atherton Tableland, resulting from an annual pulse of recruitment. The average SVL of *G. queenslandiae* collected from the Atherton Tableland and examined here, shows no such pattern, being highest in April and November, and lowest in September. In some seasonally breeding species the observed sex ratio varies with the reproductive cycle, as gravid females are often more obvious than other individuals (Schwarzkopf & Shine, 1992; Simbotwe, 1985). In this study the observed proportion of females varies between 50% in February and 73% in December, however, both months have small sample sizes (n=4 and n=11 respectively). A chi square test of homogeneity shows that there is no evidence for temporal variation in the sex ratio (χ2=1.28 df=5 p=0.937).

BONE HISTOLOGY AND SKELETOCHRONOLOGY

The bone structure of *G. queenslandiae* is similar to that of other squamates (Castilla & Castanet, 1986; Ricqles, 1976; Enlow, 1969). At mid-diaphysis a weakly vascular or non-vascular cortex of periosteal bone surrounds an almost hollow medullary cavity lined with endosteal bone. The periosteal bone consists of a series of peripherally deposited lamellae, among which are regularly arranged, haematoxylinophilic rings or 'rest lines'. Endosteal bone results from the resorption and reworking of the inner cortex and so the amount of endosteal increases with the diameter of the femur. The process of erosion of periosteal bone and substitution with endosteal bone results in the obliteration of some rest lines.

Linear regressions, predicting the number of rest lines from SVL, were statistically significant for both the total sample and for the seven individuals from the Atherton Tableland alone (all samples - R^2=0.76, p=0.0001; Atherton samples - R^2=0.77, p=0.01) (Fig 3).

DISCUSSION

The results of this study allow broad estimates of parameters which are vital to the successful application of population models, and which would be difficult to measure under field conditions. These factors include the sex ratio, the clutch size produced, the size at which maturity

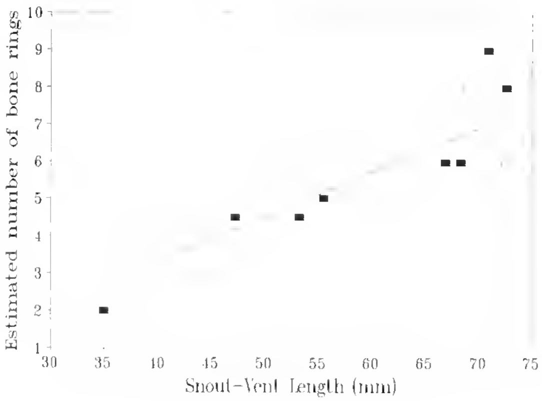

FIG. 3. Plot of estimated number of haematoxylin stained femural bone rings against SVL for individuals from all locations. Open symbols = ♂♂; closed symbols = ♀♀. The least squares regression for all individuals (bone rings = $0.12 \pm 0.02 \times \text{SVL} - 1.49 \pm 1.19$) depicted above is significant ($R^2 = 0.76$, $p < 0.001$). The regression including only samples from the Atherton Tableland was also significant (bone rings = $0.09 \pm 0.02 \times \text{SVL} + 0.13 \pm 1.3$, $R^2 = 0.77$, $p < 0.01$).

is attained and the relationship between size and age. These results and others, such as the degree of sexual dimorphism and spatial variation in size, would complement ecological and genetic studies of *G. queenslandiae*.

SEX RATIO

There appears to be a slight bias in the sex ratio towards females. As there is distinct temporal variation in the proportion of gravid females, albeit on small numbers, but no similar variation in the sex ratio, it seems that this observed sex ratio bias can not be attributed to the capture of more gravid females than other individuals. The sex ratio of *G. queenslandiae* would be difficult to determine in the field as there do not appear to be any clear morphological differences between the sexes, although one possible method is the eversion of male hemipenes described by Schwarzkopf (1992).

VARIATION IN SIZE

Significant size differences were found between several populations. Although these may be the result of non-random sampling, it does appear that skinks from the southern Atherton Tableland, particularly from Majors Mountain, are larger than those elsewhere. No significant size differences were found between latitudinally separated upland populations or between upland and lowland populations, however, the small sample sizes from areas other than the Atherton Tableland may be insufficient to detect such differences. Considerable genetic variation has also been detected between geographically separated populations of *G. queenslandiae* (Moritz et al., 1993). The degree of congruence between this genetic variation and morphological variation could not be examined because of limited sample sizes from matched sites and possible collector bias.

REPRODUCTIVE BIOLOGY

Sexual maturity in females is attained at approximately 55 mm SVL. Males probably mature at a slightly smaller size. Skinks smaller than 50 mm were uncommon in this collection. This may reflect collection bias, rapid growth to maturity, that juvenile skinks are more difficult to locate than mature animals, or a combination of these. In mature females ovarian follicles are always present but vitellogenesis is seasonal. Developing follicles greatly outnumber the number of oviducal eggs, presumably with the remaining vitellogenic follicles being resorbed after the breeding season. According to Shine (1977) the production of more vitellogenic follicles than are ovulated is of adaptive value, allowing an individual to adjust clutch size according to environmental conditions at the time of ovulation. These additional enlarged follicles may also allow multiple clutches

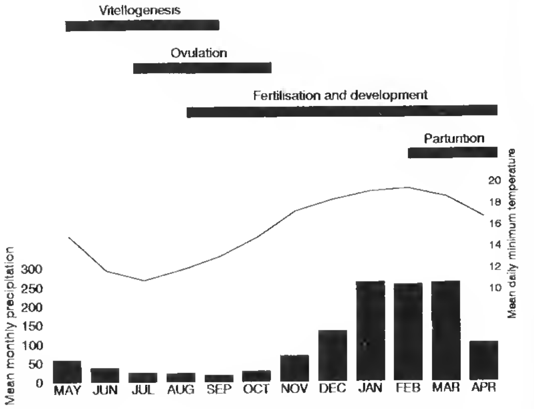

FIG. 4. Reproductive cycle of *G. queenslandiae* on the Atherton Tableland. Vitellogenesis peaks early in the mild, dry season, and is followed by ovulation and fertilisation mid-year. Development of young occurs late in the dry season and throughout the warm wet season, with parturition late in the wet season.

within a breeding season. The latter suggestion is supported by the observed correlation between clutch size (I) and the number of vitellogenic follicles (II).

The correlations between the numbers of ovarian follicles and SVL, when all females are considered, and the lack of any correlations with SVL when only females larger than SVL=55 mm are considered, indicates that the number of enlarged follicles (III & IV) produced by immature females increases with size until maturity. The negative correlation between the number of small follicles (V) and SVL, when immature females are included, suggests that the total number of follicles is relatively constant throughout life. As females grow towards maturity some class V follicles become enlarged, and so the number of follicles that remain small decreases.

As in studies of other squamates (Schwarzkopf, 1992; Simbotwe, 1985; Shine, 1977), clutch size in *G. queenslandiae* is correlated with size of females. Life history theory predicts that females should maximise lifetime reproductive output, and that it may be advantageous for a female to use energy reserves for growth rather than breeding, if the probability of survival is high and additional growth will substantially increase future clutch sizes (Schwarzkopf & Shine, 1992). The relationship between clutch size and SVL (Fig. 1A) is consistent with this prediction in that larger females produce either small or large clutch sizes whilst smaller females only produce small clutches. In each of the samples of *G. queenslandiae* considered here a proportion of 'mature' females (SVL>55 mm) were not gravid. In the related seasonally breeding, viviparous skink *Eulamprus tympanum*, Schwarzkopf (1992) found that variability in reproductive output per year was expressed as variation in offspring size, and possibly the proportion of non-breeding females, whilst the average clutch size remained constant across years. The lack of replicate samples from the same sites precluded such an analyses of between-year variation in this study.

SUGGESTED REPRODUCTIVE CYCLE

The skinks considered in this study were collected not only in different months, but also in different years, so it is not possible to distinguish within-year patterns from between-year variation. The predictable climate of the Atherton Tableland and the pattern of temporal variation in the proportion of gravid females and egg development suggest the following seasonal reproductive cycle in *G. queenslandiae* (Fig. 4). Active vitellogenesis becomes apparent in June and is followed by ovulation in June and July. Fertilisation and development of foetuses occurs between September and January. Parturition occurs between February and April and is probably accompanied by regression of the vitellogenic follicles that were not ovulated. The time at which mating occurs could not be inferred from the results of this study, as females may store sperm for a considerable time before fertilisation (Fitch, 1982), in this case ovulation.

Reproductive cycles in other tropical skinks are highly variable both between and within species (Fitch, 1982). The primary determinant of seasonality of reproduction in tropical skinks appears to be the seasonality of precipitation (Fitch, 1982). Precipitation on the Atherton Tablelands is distinctly seasonal with average rainfall over 250 mm in January, February and March, and below 50 mm in June, July, August, September and October (measured at Kairi experimental station; AGPS 1988). Temperature is also seasonal on the Atherton Tableland and varies between a mean daily minimum of 10.9°C, with occasional frost, in July, and a mean daily minimum of 19.5°C in February (Kairi experimental station; AGPS 1988). In the reproductive cycle outlined above, embryonic development on the Atherton Tableland would occur during the warm, rainy season, with parturition occurring just before the onset of the mild, dry weather (Fig. 4). In other parts of the Wet Tropics, particularly the Bellenden Ker Ra. immediately to the east of the Atherton Tableland, precipitation and temperature are less distinctly seasonal and populations of *G. queenslandiae* from these areas may have different reproductive cycles.

SKELETOCHRONOLOGY

The number of 'rest lines' in the femurs of *G. queenslandiae* shows a clear relationship with size which is roughly approximated by: rest lines = 0.1 × SVL (Fig. 3). Although these rest lines can not be assumed to represent a true index of age as a result of remodelling of the bone, they may be a useful measure of age differences between skinks (Enlow, 1969). Mature individuals had at least five rest lines and no more than nine. If it is assumed that the intervals between rest lines represent constant periods of growth, these results suggest that maturity in *G. queenslandiae* is delayed until quite late in life.

In other species, mainly those from temperate regions, rest lines are formed semi-annually or annually but not less frequently (Castanet et al., 1988). The observed number of rest lines in *G. queenslandiae* could be used in demographic models as a rough estimate of maximum age, where skinks reach maturity at five years of age and live a maximum of ten years. A sex ratio of 1:1.5 could be used in this model with 75% of mature females breeding each year (maximum number of gravid females with SVL>55 mm) and each gravid female producing a clutch size of (3.11=average clutch size). Field studies of size specific mortality and population density would be required to complete this basic model.

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TAXONOMY AND DISTRIBUTION OF THE SCINCID LIZARD *SAPROSCINCUS CHALLENGERI* AND RELATED SPECIES IN SOUTHEASTERN AUSTRALIA

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Sadlier, R.A., Colgan, D.J. & Shea, G.M. 1993 12 24: Taxonomy and distribution of the scincid lizard *Saproscincus challengeri* and related species in southeastern Australia. *Memoirs of the Queensland Museum* 34(1):139-158. Brisbane. ISSN 0079-8835.

The skink *Saproscincus challengeri* is here recognised as comprising three species on the basis of allozymic and morphological variation. *S. challengeri* is redefined and restricted to the McPherson Range region, southeastern Queensland. The names *Saproscincus galli* Wells & Wellington (1985) and *Saproscincus rosei* Wells & Wellington (1985) apply to two widespread species. All species occur almost exclusively in closed forest. *Mocoa spectabilis* De Vis, 1888 is shown to be a senior synonym of *Saproscincus basiliscus* (Ingram & Rawlinson, 1981). ☐ *Scincidae, Saproscincus, taxonomy, electrophoresis, distribution, rainforest.*

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As our knowledge of the taxonomy and relationships of the Australian scincid lizard fauna has been refined in the past two decades, a number of widespread species have been found to be composite. One such example is the species *Lygosoma challengeri* Boulenger (1887), which was formerly regarded as widespread in closed forests of northern New South Wales and Queensland (Worrell, 1963; Dale, 1973; Cogger, 1975). This taxon has variably been assigned to the genus *Leiolopisma* (Cogger, 1975), *Lampropholis* (Greer, 1974) and the *challengeri* species group within *Lampropholis* (Greer & Kluge, 1980). The latter species group was regarded as generically distinct by Greer (1980) and subsequently given the generic name *Saproscincus* by Wells & Wellington (1984). Greer (1980) and Greer & Kluge (1980) listed two additional species in the complex from the northern end of the distribution. One of these, *Lampropholis tetradactyla*, was a new discovery (only two records were known prior to 1974), while the other, which Greer & Kluge diagnosed but left undescribed, represented northern populations previously assigned to *L. challengeri* (Worrell's 1963 diagnosis of *challengeri* was at least partly based on the northern taxa). The second species was subsequently described as *Lampropholis basiliscus* (Ingram & Rawlinson, 1981), with a third northern species in the *challengeri* group, *Lampropholis czechurai*. Consequently the name *challengeri* was restricted to southern (SEQ-NENSW) populations within the complex, although no author had redefined that species.

The possibility of the restricted *S. challengeri* being composite was suggested by Wells & Wellington (1985), who named two additional species, *S. galli* and *S. rosei*, both from single specimens, and by Wilson & Knowles (1989), who figured several distinctive morphotypes from SEQ. Neither gave evidence to distinguish these taxa at the species level.

An undescribed member of the *challengeri* species group from the Sydney region has been known for many years (e.g. Griffiths, 1987). Several specimens of the same taxon (one figured by Wilson & Knowles, 1988, pl.502) were collected (RAS) in the Bellingen region, NENSW, in 1983, a northern extension of the known distribution of over 400km. The discovery of this species in regional sympatry with what was then considered typical *S. challengeri* initiated the investigations reported here.

MATERIALS AND METHODS

The species recognized are identified by possessing unique combinations of both morphological and electrophoretic characters, and their species-level distinction is supported by field observations relating to distribution, habitat preferences, and the occurrence of sympatry between species.

Electrophoretic procedures: Electrophoresis of liver samples was performed on 'Titan III' (Helena, Austin) cellulose acetate gels according to standard procedures (Hebert & Beaton, 1989). Gels were run for 60 minutes, with a constant potential drop of 200V between electrodes. Twenty-one enzyme systems encoded by 24 loci were scored. Staining protocols were adapted from Harris & Hopkinson (1977) and Hebert & Beaton (1989). Fluorescence methods were used for esterase and negative stains for superoxide dismutase. The enzymes stained, abbreviations used herein, Enzyme Commission numbers, running buffer and number of presumptive genetic loci are given in Table 1. Tissue was ground in 1 volume of tissue to 1 volume of homogenising buffer (100ml tris-HCl, pH 7.0, 1mM Na_2EDTA, 0.5mM NADP and 50µl/100ml β-mercaptoethanol) in hand-held glass homogenisers. Allozymes are designated in order of their relative anodal mobility, as are different loci encoding the same enzyme. Results were analysed using the BIOSYS-1 package of Swofford & Selander (1981).

Morphological studies: All specimens of *S.challengeri* in the Australian and Queensland Museums were examined. Specimen registration numbers for Australian Museum (AMS) specimens are prefixed R and Queensland Museum (QM) specimens, J. From this material 23 series of specimens, corresponding to most of the samples analysed biochemically, but in some cases enlarged by the addition of specimens from the same or nearby localities, were examined for the full suite of characters listed below. Measurements (axilla to groin, hindlimb, and tail lengths) are expressed as percentages of snout to vent length (SVL) in the taxon accounts.

The following characters were scored for each specimen where possible: Axilla to groin distance (AGL). Hindlimb length (HLL) - measured from groin to tip of fourth toe including nail. Tail length (TL) - measured from caudal edge of anal scales to tip of tail, on complete original tails only. Supraciliaries (SCIL) - first row of enlarged scales above eye posterior to prefrontal scales and bordering supraocular scales. Last scale in series is that abutting the posterior edge of the fourth supraocular. Midbody scale rows (MB) - number of longitudinal scale rows around body counted midway between axilla and groin. Paravertebral scales (DSR) - number of scales in a paravertebral row from first scale posterior to parietal scale to last scale anterior to level of vent opening. Fourth finger (FS) and toe (TOES) scales - number of dorsal scales on fourth digit of foot and hand. Distal scale contains claw and basal scale broadly contacts adjacent basal scale of third finger or toe. Fourth finger (FL) and toe (TOEL) lamellae - number of ventral scales on fourth digit of foot and hand. Distal scale contains claw and basal scale is last largely undivided scale at a point level with intersection of third and fourth digits.

TABLE 1. Enzymes stained (1), abbreviations (2), Enzyme Commission numbers (3), running buffer (4) and number of presumptive genetic loci (5).

1	2	3	4	5
Adenylate kinase	AK	2.7.4.3	TEM 50	1
Aspartate aminotransferase	AAT	2.6.1.1	TC 100	2
Esterase	EST	3.1.1.1	TEM 50	2
Fructose bisphosphatase	FBP	3.1.3.11	TEM 50	1
Fumarate hydratase	FH	4.2.1.2	TEM 50	1
Glucosephosphate isomerase	GPI	5.3.1.9	TEM 50	1
Glucose-6-phosphate dehydrogenase	G6PD	1.1.1.49	TC 100	1
Glyceraldehyde phosphate dehydrogenase	GA-3-PDH	1.2.1.12	TEM 50	1
β-Glycerophosphate dehydrogenase	GPD	1.1.1.8	TEM 50	1
Isocitrate dehydrogenase	IDH	1.1.1.42	TEM 50	2
Lactate dehydrogenase	LDH	1.1.1.27	TC 100	1
Malate dehydrogenase	MDH	1.1.1.37	TEM 50	2
Mannosephosphate isomerase	MPI	5.3.1.8	TEM 50	1
Peptidase (leu-ala substrate)	PEP-la	3.4.11	TEM 50	1
Peptidase (leu-gly-gly substrate)	PEP - lgg	3.4.11	TEM 50	1
Peptidase (phe-pro substrate)	PEP - pp	3.4.11	TEM 50	1
Phosphoglucomutase	PGM	2.7.5.1	TEM 50	1
6-Phosphogluconate dehydrogenase	6-PGDH	1.1.1.44	TEM 50	1
Superoxide dismutase	SOD	1.15.1.1	TEM 50	1
Triosephosphate isomerase	TPI	5.3.1.1	TEM 50	1
UDP glucose pyrophosphorylase	UDPG	2.7.7.9	TC 100	1

Bilaterally scorable characters (SCIL, FS, FL, TOES, TOEL) were scored on both sides and the mean value used.

Apart from tail length, which was not subjected to analysis, all characters had significant geographic variation using one-way analysis of variance. The metric characters AGL and HLL both showed allometric growth in comparison to SVL. To remove the effects of varying size and allometric growth the values for these two variables were log-transformed and adjusted to the values they would assume at a constant SVL using the formula (Thorpe, 1975)

$$\hat{Y}=e^{\ln(yi)-a(\ln(xi)-\ln(x))}$$

where $\hat{y}$ is the adjusted dependent variable, yi is the raw dependent variable, xi is the SVL for that individual, x is the mean SVL across all samples and a the allometric coefficient from the regression $\ln(y) = a*\ln(x)+b$.

Values were adjusted to mean SVL 49.287mm. As an estimate of a the mean value of the allometric coefficients for the three best sampled populations (populations 6, 9, and 23 corresponding to the three putative biochemical species) was used: 1.127 for AGL and 0.778 for HLL.

Canonical variates analyses were run with the nine characters, adjusted AGL, adjusted HLL, SCIL, MB, DSR, FS, TOES, FL, and TOEL, using SYSTAT (Wilkinson, 1987). Four analyses were run. In the first analysis, all twenty-three samples were treated as a priori groups (operational taxonomic units). In the second analysis, the three putative species were used as groups. The final two analyses treated males and females separately, again using the three putative species as groups. In total, 210 animals were run in the first two analyses, while 88 males and 120 females were run in the last two analyses.

Two features of osteology were also surveyed but because of the more limited samples examined were not included in the main analysis above. These were number of presacral vertebrae (anterior to sacrum), and postsacral vertebrae (posterior to sacrum).

RESULTS

The results of combined electrophoretic and morphological analyses on 27 populations identified three major groups. The presence of one or more fixed allelic differences between regionally sympatric populations of each group was regarded as clear evidence of species level differentiation. Regional sympatry is here defined as species occuring in the same general vicinity but not necessarily within the same habitat or altitudinal range. From among these 27 populations sampled for electrophoretic analysis regional sympatry was observed between all possible pairings of the three major groups at one or more localities. On this basis, three species are recognised to which the following names apply: *S. challengeri* from the McPherson Ranges, SEQ and hinterland far NENSW; *S. rosei* from the eastern edge of the Great Dividing Range and associated ranges, NENSW and SEQ; and *S. galli* from isolated areas of the central and northern coast and adjacent ranges, NSW, and the McPherson Ra., SEQ.

INTERSPECIFIC VARIATION

1. Electrophoresis: The electrophoretic results are presented in Table 2. A phenogram based on Nei's unbiased genetic distance is shown in Fig. 1. Three main groups of populations (separated at the 0.2 distance) can be recognised. There are fixed allozymic differences between all of these, including cases of sympatry or near sympatry, for each pair of groups.

All populations of *S. challengeri* and *S. galli* examined electrophoretically, including two instances where populations of each species occurred in ecological sympatry (syntopy), show fixed allelic differences for the *Ak*, *G-6-pdh* and *Idh-1* loci, and nearly fixed differences in *Est-1* and *Gpi*. In addition *S. challengeri* has only one observable *Mdh* locus, whereas *S. galli* and in-

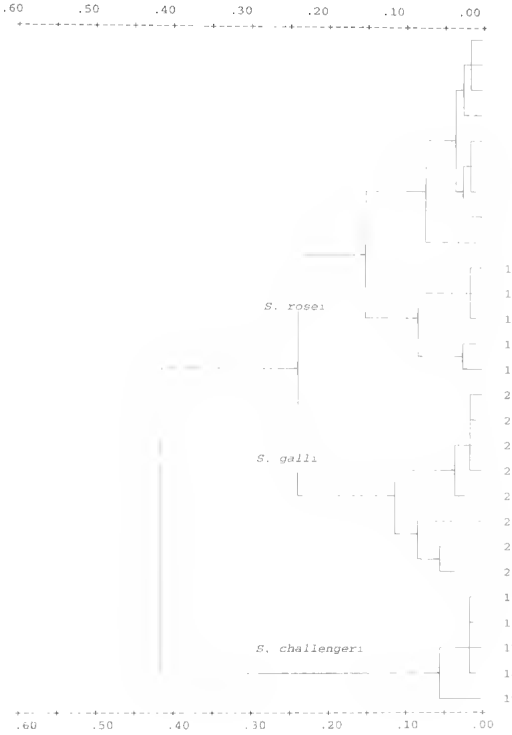

FIG. 1. Phenogram of genetic similiarity based on Nei's unbiased genetic distance, populations 1-14 *S. rosei*, populations 15-19 *S. challengeri*, populations 20-27 *S. galli*.

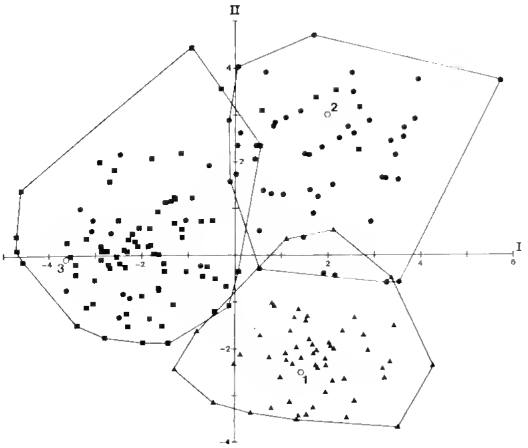

FIG. 2. Canonical variates analysis of 23 *Saproscincus* populations. Ordination of 23 populations on first two canonical variates. Points represent individuals as follows: dots = *S. galli*; squares = *S. rosei*; triangles = *S. challengeri*; open circles represent type specimens (1 = *S. challengeri*; 2 = *S. galli*; 3 = *S. rosei*). Polygons enclose scatter of points for each taxon.

	Population																			Population							
Allozyme	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
AK	4	5	3	1	4	5	3	1	10	4	3	1	8	4	3	4	8	5	5	5	4	2	2	2	4	3	5
A															1.000	1.000	1.000	1.000	1.000								
B							.333													.800	1.000	1.000	1.000	1.000	.500	.333	1.000
C	1.000	1.000	1.000	1.000	1.000	1.000	.667	1.000	1.000	1.000	1.000	1.000	1.000	1.000						.200					.500	.667	
AAT-1	4	5	3	1	4	5	9	6	12	4	3	1	8	4	4	5	9	5	8	7	4	5	4	2	4	3	9
A							.056																				
B	1.000	1.000	1.000	1.000	1.000	1.000	.944	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
AAT-2	4	5	3	1	4	5	9	6	12	4	3	1	8	4	4	4	9	5	8	7	4	5	4	2	4	3	9
A	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
EST-1	4	3	3	1	4	5	3	1	10	4	3	1	8	4	3	4	8	5	5	6	4	1	2	2	3	3	5
A										1.000	1.000			1.000						.167	.250	1.000	.500	1.000	.667	1.000	.100
B	.750	.500	.500	1.000			.667																				
C		.167										.500	1.000							.750	.750		.500				.800
D	.250	.333	.500		.125	.400	.333		.350																		
E												.500			.833	.625	.813	.600	.500	.083					.333		.100
F					.625	.400		1.000	.650																		
G															.167	.375	.188	.400	.500								
H					.250	.200																					
FBP	2	3	1	1	4	1	9	6	10	4	3	1	8	4	1	4	9	5	8	4	4	3	2	2	4	3	9
A							.167																				
B	1.000	1.000	1.000	1.000	1.000	1.000	.833	1.000	1.000	1.000	1.000	1.000	.875	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
FUM	4	5	3	1	4	5	9	6	12	4	3	1	8	4	2	4	9	5	8	4	4	3	2	2	4	3	9
A	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
G6PDH	1	2	1	1	4	3	3	1	7	4	3	1	8	4	4	4	5	3	6	5	4	1	2	2	2	2	4
A		.250																									
B	1.000	.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000						1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
C															1.000	1.000	1.000	1.000	1.000								
GPI	4	5	3	1	4	5	6	3	12	4	3	1	8	4	4	4	9	5	8	6	4	4	3	2	4	3	6
A										.750	.500		.125	.250													
B															1.000	1.000	1.000	1.000	1.000					.500			.083
C	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.250	.500	1.000	.875	.750						1.000	1.000	1.000	1.000	.500	1.000	1.000	.917
GA3PD	4	5	3	1	4	5	7	4	12	4	3	1	8	4	4	4	9	5	8	6	4	5	4	2	4	1	9
A																		.200									
B	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.800	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
GPD	4	4	3	1	4	5	3	2	6	4	3	1	7	4	4	5	5	5	6	6	4	4	4	2	4	1	4
A															.125												
B	.875	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.875	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
C	.125																										
IDH-1	4	5	1	1	4	5	8	6	12	4	3	1	8	4	4	5	9	5	9	4	4	4	4		2	3	8
A															1.000	1.000	1.000	1.000	1.000								
B	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000						1.000	.875	1.000	1.000			1.000	1.000
C																					.125				.750		
D																									.250		
IDH-2															4	5	9	5	9	1	3	1	3		1	1	1
A																		.200									
B															1.000	1.000	.833	.700	.944		.167					1.000	
C																	.167	.100	.056	1.000	.167		1.000		1.000		
LDH	4	3	3	1	4	5	9	6	10	4	3	1	8	4	4	5	7	5	9	7	4	4	2	2	4	3	7
A																		.200									
B	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.800	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MDH-1	4	5	3	1	4	5	9	6	12	4	3	1	8	4	3	5	9	5	7	4	4	3	2	2	4	1	9
A																		.200									
B	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.800	1.000	1.000	.875	1.000	1.000	1.000	1.000	1.000	1.000
C																					.125						
MDH-2	4	5	3	1	4	5	7	4	12	4	3	1	8	4						4	4	3	2	2	4	1	8
A	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000						1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
MPI	4	4	3	1	4	5	7	6	10	4	3	1	8	4	3	5	8	5	4	5	4	3	2	2	4	3	7
A	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000													
B															1.000	1.000	.875	.900									
C																	.125	.100	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PEPLA	4	5	3	1	4	5	5	3	8	4	2	1	8	4	4	5	5	5	4	4	4	5	4	2	4	3	6
A										.250	.250	1.000	.938	.500													
B	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000						1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
C										.750	.750		.063	.500													
PEPLG	4	5	3	1	4	5	6	4	8	4	3	1	8	4	4	5	6	5	5	5	4	5	4	2	4	3	7
A	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PEPPP	4	5	3	1	4	5	5	3	8	4	3	1	8	4	2	3	1	3	3	3	4	3	3	2	4	3	6
A																									.250		
B	.875	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.833					1.000	.750	1.000	
C																			.167								
D																				1.000	1.000	1.000	1.000				1.000
E	.125																										
PGM	4	5	3	1	4	5	9	6	12	4	3	1	8	4	4	5	9	5	9	7	4	5	4	2	4	3	9
A	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.938	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
B													.063														
6PGDH	4	5	3	1	4	5	9	6	12	4	3	1	8	4	3	4	9	5	8	4	4	3	2	2	4	3	9
A					.125																						
B	1.000	1.000	1.000	1.000	.875	1.000	1.000	1.000	1.000																		
C															1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
D										1.000	1.000	1.000	1.000	1.000													
SOD	4	4	3	1	4	5	9	5	10	4	3	1	8	4	3	4	8	5	8	5	4	2	2	2	4	3	8
A	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TPI	4	5	3	1	4	5	9	6	10	3	2	1	8	4	4	5	9	5	8	7	4	5	4	2	4	3	9
A	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
UDPG	4	3	3	1	4	5	2	1	7	4	2	1	8	4	2	4	2	2	3	5	4	4	4	2	4	3	4
A	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000												
B							1.000									1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

TABLE 2: Gene frequencies in the studied *Saproscincus* populations. Populations 1 - 14 are *S. rosei*, 15 - 19 are *S. challengeri* and 20 - 27 are *S. galli*. Population identifications are given in the text. Numbers in the same row as locus identifications indicate sample sizes. Where no frequency is listed for IDH-2 or MDH-2, the locus is not present in the population.

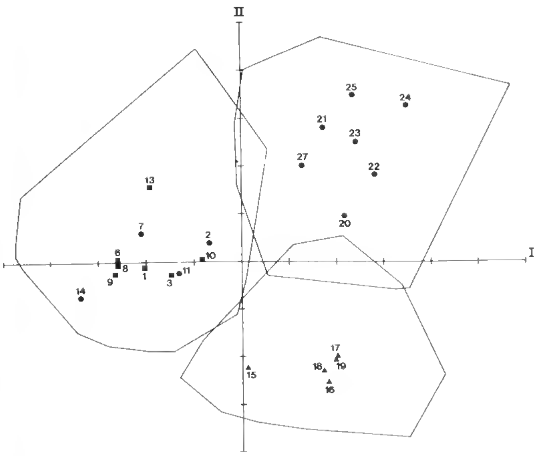

FIG. 3. Canonical variates analysis of *Saproscincus* populations. Same axes and polygons as Fig. 2. Group centroids (numbered) of populations. Dots = *S. galli*; squares = *S. rosei*; triangles = *S. challengeri*. Populations 4-5, 12 and 26 analysed biochemically but not included in canonical variates analysis.

deed all other examined *Saproscincus* taxa have two.

S. challengeri (populations 17-19) and regionally sympatric *S. rosei* from NENSW (population 12 separated by less than 10km from population 17) and SEQ (population 13) showed fixed allelic diferences at the *Ak*, *G-6-pdh*, *Gpi*, *Idh-1*, *Mpi*, *Pep-la* and *6-Pgdh* loci, in addition to the absence of a scorable *Mdh-2* from *S. challengeri* and a scorable *Idh-2* from *S. rosei*. With the exception of *Pep-la*, the differences listed above also distinguish *S. challengeri* from allopatric *S. rosei*.

S. galli and *S. rosei* show fixed allelic differences for the *Mpi* and *6-Pgdh* loci for all populations examined, including three instances of regional sympatry between *S. galli*. and *S. rosei*.

2. Morphology: The initial canonical variates analysis, using populations as OTUs, identified three largely distinct groups of populations on the first two functions (Figs 2-3; Table 3). These three groups corresponded exactly with the groupings determined biochemically. Factor 1 separated two clusters of populations (groups 1+2 and group 3) largely on the basis of subdigital lamellae (FL, TOEL) while factor 2 separated a third population (group 2 from group 1) largely on the basis of midbody scale rows, supraciliaries, and supradigital scales (MB, SCIL, TOES; Table 3). Canonical scores for primary type specimens (see below) of the available names within the *S. challengeri* complex were calculated using the functions: the lectotype of *S. challengeri* was placed among group 1; the holotype of *S. galli* lay among group 2; and the holotype of *S. rosei* lay among group 3. One other name has been previously placed in the synonomy of *S. challengeri* (Cogger et al., 1983). *Mocoa spectabilis* De Vis (1888) was described from specimens from Gympie, SEQ. Of the four identifiable types in the Queensland Museum (Covacevich, 1971; Cogger et al., 1983) one (QM J244) (Fig. 4) is *S. galli*, while the other three (QM J255, J19742-43) agree in all respects with *S. basiliscus* (Ingram & Rawlinson, 1981), a species not known from further south than the Mackay district, MEQ. Diagnostic characters of the latter species shown by these three specimens include the presence of a divided nuchal scale bordering the parietal and two tertiary temporals bordering the posterior edge of the lower secondary temporal scale. Designation of J19743 (Fig. 5) as lectotype by Wells & Wellington (1985) means that *Mocoa spectabilis* becomes a senior synonym of, and the available name for the taxon previously known as *Saproscincus basiliscus*.

Treating the three species as OTUs in the second canonical variates analysis resulted in 96.2% of specimens being correctly identified (96.7%, n=63 of *S. challengeri*; 98.2%, n=58 of *S. galli*; and 94.8%, n=101 of *S. rosei*). Canonical coefficients and loadings for characters for the two functions extracted are given in Table 4. Group classification coefficients are presented in Table 5, allowing unknown specimens to be assigned to species.

TABLE 3. Standardised discriminant function coefficients (and correlations with discriminant functions) for the first seven discriminant functions of nine characters from the *Saproscincus challengeri* complex. Twenty-three of the 24 populations biochemically sampled are used as a priori groups. Group 12, represented by a single individual, not used in determining functions.

Variable	I	II	III	IV	V	VI	VII
AGL (adj)	0.049(0.012)	0.162(0.164)	-0.119(0.004)	-0.037(0.097)	0.482(0.408)	-0.007(0.032)	0.551(0.646)
HLL (adj)	0.151(0.216)	-0.234(-0.173)	0.162(0.170)	0.359(0.357)	-0.617(-0.601)	0.305(0.323)	-0.137(-0.061)
MB	-0.159(-0.131)	-0.609(-0.484)	0.267(0.383)	0.204(0.158)	0.128(0.159)	0.196(0.105)	0.288(0.347)
DSR	-0.215(-0.138)	0.215(0.145)	0.605(0.659)	0.267(0.312)	-0.175(-0.045)	-0.665(-0.629)	0.059(0.123)
SCIL	-0.254(-0.106)	0.577(0.487)	-0.135(-0.125)	-0.164(-0.231)	-0.529(-0.522)	-0.036(0.003)	0.292(0.376)
FL	0.403(0.715)	0.032(0.117)	-0.284(0.029)	0.135(0.066)	0.209(0.109)	-0.536(-0.350)	-0.492(-0.251)
FS	0.065(0.311)	0.079(0.200)	0.641(0.664)	-0.788(-0.525)	0.080(0.107)	0.254(0.256)	-0.192(-0.173)
TOEL	0.685(0.856)	-0.170(0.068)	0.055(0.141)	-0.068(-0.012)	-0.206(-0.133)	0.039(-0.052)	0.640(0.386)
TOES	-0.020(0.272)	0.581(0.547)	0.102(0.299)	0.648(0.461)	0.242(0.287)	0.497(0.429)	-0.133(-0.111)

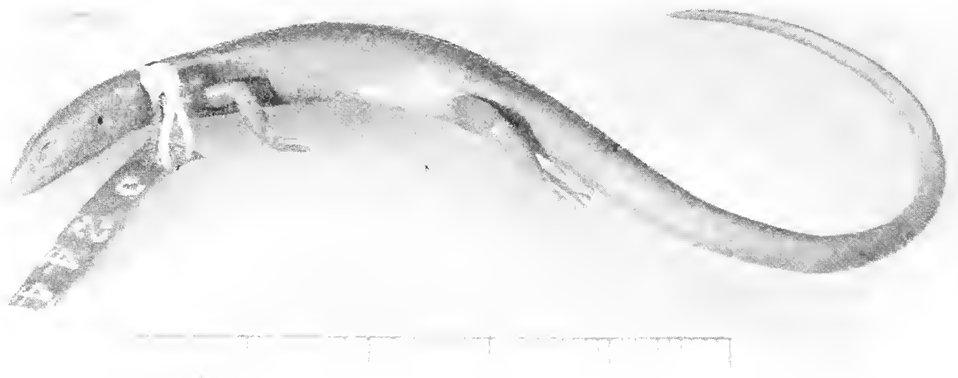

FIG. 4. QM J244 syntype of *Mocoa spectabilis* De Vis, a specimen of *S. galli*.

Treating both sexes seperately did not offer any noticeable improvement in resolution. Overall, 96.6% of males and females were correctly assigned to groups.

INTRASPECIFIC VARIATION

1. Electrophoresis: The electrophoretic results clearly demonstrate that there are at least three species level taxa in the *S. challengeri* group. The Nei distances separating lineages within these groups are, however, quite high, the distances approaching, in the case of *S. galli*, the figure of 0.15 which has been suggested (Thorpe, 1982; Nei, 1987) as a criterion for determining the specific status of a population when this is otherwise unresolvable. This figure is probably too low for lizards, as sister species in this group, with the exception of some iguanids (Gorman & Kim, 1976; Adest, 1977; Case & Williams, 1984), generally exhibit Nei distances of more than 0.2 (Kim et al., 1983; Milton et al., 1983; Busack, 1986; Daugherty et al., 1990). Nevertheless, the possibility of taxonomic structuring within *S. rosei*, *S. galli*, and *S. challengeri* should be considered .

On the basis of genetic (Nei distance) similarity two subgroups of *S. rosei* are recognised. One includes populations from central eastern and NENSW, the other populations from SEQ. Included in the SEQ subgroup are distinctive regionally restricted high altitude populations in the eastern border ranges. The first subgroup has fixed differences from the second for *Pep-la* and *6-Pgdh*, and a nearly fixed difference for *Est*. Another distinguishing feature of the SEQ subgroup is the presence, at a relatively high frequency of the GPI A allozyme, which is absent from the central-eastern and north-eastern subgroup of

FIG. 5. QM J19743 syntype of *Mocoa spectabilis* De Vis designated as lectotype for the species by Wells & Wellington, 1985.

TABLE 4.Standardised discriminant function coefficients (and correlations with discriminant functions) of nine characters from the *Saproscincus challengeri* complex. The three putative species based on biochemical data used as a priori groups.

	Discriminant Function	
Variable	I	II
AGL (adjusted)	-0.131(-0.075)	0.247(0.165)
HLL (adjusted)	0.290(0.290)	-0.305(-0.109)
MB	0.146(0.060)	-0.683(-0.537)
DSR	-0.363(-0.146)	-0.040(-0.039)
SCIL	-0.485(-0.306)	0.472(0.419)
FL	0.283(0.607)	0.272(0.423)
FS	0.048(0.177)	0.028(0.180)
TOEL	0.725(0.732)	0.126(0.418)
TOES	-0.254(0.059)	0.431(0.435)

S. rosei. Within the SEQ subgroup of *S. rosei* there is a fixed difference for *Est* between the high altitude populations in the eastern Border Ranges and those populations to the west and north. In these high altitude populations the GPI A and PEP-LA C allozymes are found in low frequencies but occur at frequencies of more than 50% in other populations of the SEQ subgroup of *S. rosei*.

Two subgroups of *S. galli* were identified, separated at a Nei unbiased distance of about 0.1. One subgroup comprises the populations from the Dorrigo region in the central part of the species range, the other subgroup, separated by several hundred kilometres from the first, comprises the northern and southern populations. No morphological differences were observed to support differentiation of the Dorrigo populations of *S. galli* from those to north or south. The electrophoretic differentiation is due to a fixed difference between the subgroups for *Pep-pp* and the relatively high frequencies of allozymes AK C, IDH-1 C and D, and GPI B which are found at lower levels in other *S. galli*. The *Pep-pp* B allozyme which distinguishes Dorrigo *S. galli* from other populations of this species is fixed in *S. rosei* and nearly fixed in *S. challengeri*. The presence of the allozyme may be due to its retention in Dorrigo *S. galli* rather than evolution *in situ*. The frequency differences for other allozymes may be due to local adaptations or genetic drift but do not suggest that the Dorrigo *S. galli* is greatly genetically isolated from other populations of this species.

TABLE 5.Fisher group classification function coefficients for the three species in the *Saproscincus challengeri* complex. Individual animals are assignable to the taxon with the highest function value.

	challengeri	*galli*	*rosei*
AGL (adjusted)	11.352	12.269	11.895
HLL (adjusted)	18.156	16.279	16.614
MB	20.325	17.051	19.114
DSR	10.064	10.304	10.805
SCIL	43.111	50.560	49.498
FL	13.693	14.325	12.654
FS	0.264	0.311	-0.047
TOEL	0.555	-0.063	-1.773
TOES	-2.373	0.803	-0.376
Constant	-1124.175	-1130.669	-1112.650

The populations of *S. challengeri* showed little genetic variation across their range, a notable exception being the fixation of the MPI D allozyme in the Mt Warning population, this form being at low frequencies elsewhere. The range of the species is, however, small in comparison to that of *S. galli* or *S. rosei* so the same degree of genetic structuring should not be expected.

2. Morphology: Within each of the three major species there was little additional resolution of populations on subsequent discriminant functions in the first analysis. Factor 3 partially separated the regionally restricted high altitude populations of *S. rosei* (Population 13 - Toolong Falls) in the eastern McPherson Range from other populations of *S. rosei*, although much overlap remained.

Presacral and postsacral vertebrae number was surveyed for a sample of individuals (n=88) representing most of the populations examined. *S. challengeri*, *S. galli*, and populations of *S. rosei* from central eastern and NENSW usually had 27, rarely 28 or 26 presacral vertebrae, while populations of *S. rosei* from SEQ (including population 13) usually had 28, occasionally 29 presacral vertebrae.

SPECIES DESCRIPTIONS

Saproscincus challengeri (Boulenger, 1887)

Figs 6-8

Lygosoma challengeri Boulenger, 1887: 575.

Type material. Lectotype BMNH 1946.8.16.55 (Fig. 6), Paralectotype BMNH 1946.8.16.56 Queensland.

SPECIMENS EXAMINED

The following specimens were used in the description, and include those used in the canonical variates analysis and electrophoretic analysis (morphological analysis only *; electrophoretic analysis only !).

Border Ranges NP, Lophostemon Falls on Brush Box Falls track (population 17), 28.24'S, 153.04'E (R133463-66; R133467-71*, R138062-66); Mt Warning NP (population 19), 28.'24S, 153.18'E (R133450*; R133451-53; R133454-56*; R133457; R133458-61*; R138005-06*, R138017-18; R138019*,R138020!; R138021-22; R138023-24*, R138026*, R138028-30*); Nightcap NP, vicinity of Terania Ck picnic area (population 18), 28.34'S, 153.18'E (R138077-78; R138079-82*; R138083-

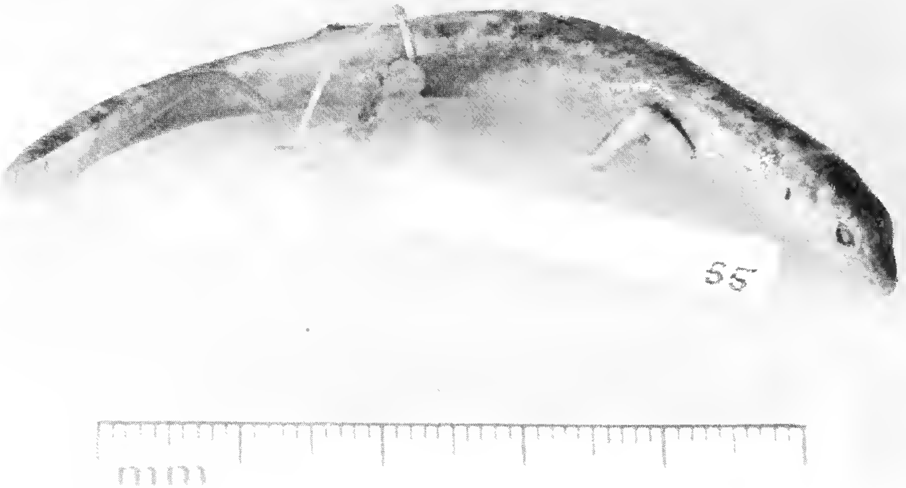

FIG. 6. BMNH 1946.8.16.55 syntype of *Lygosoma challengeri* Boulenger designated as lectotype for the species by Wells & Wellington, 1985.

87*); Dome Mt. area, Yabbra SF (population 16), 28.28'S, 152.40'E (R135469, R135471); 28.27'S, 152.39'E (R135470); 28.27'S, 152.34'E (R135472-73); Tooloom Ra., Yabbra SF (population 15), 28.38'S, 152.29'E (R135461-62; 135465-66); 28.35'S, 152.29'E (R135459-60*); 28.34'S, 152.29'E (R135463*, R135468*).

Other specimens used to map the distribution of this species, *S. galli* and *S. rosei* are listed in appendix1.

DIAGNOSIS

The following features in combination generally distinguish *S. challengeri* from other members of the *S. challengeri* species group: maximum adult size 57mm; supraciliaries usually 6; lamellae beneath fourth finger 15-19; lamellae beneath fourth toe 22-27; presacral vertebrae usually 27; postsacral vertebrae 45-48; dorsal surface uniform brown; ventral surface with irregular brown spotting; dorsal surface of tail usually with several moderately large, pale vertebral blotches anteriorly; abdomen of adult males uniformly cream or with a pale yellow wash.

The first, fourth, and ninth characters will distinguish *S. challengeri* from *S. rosei* which reaches a greater adult size (maximum SVL 64mm), usually has fewer fourth toe lamellae (17-24), and lacks moderately large tail blotches. The fifth and eighth characters will also distinguish *S. challengeri* from regionally sympatric northern populations of *S. rosei* which have 28-29 presacral vertebrae and the markings on the ventral surface faint and regularly aligned.

The second, and sixth to tenth characters will distinguish *S. challengeri* from *S. galli* which usually has 7 supraciliaries, 48-53 postsacral vertebrae, a mottled dorsal colour, the markings on the ventral surface regularly aligned, pale markings on the dorsal surface of the tail present as isolated spots a single scale in size, and the abdomen of adult males a bold lemon yellow.

DESCRIPTION

Measurements: Maximum SVL 57mm; TL 137-168% of SVL (x=155.8%, n=27); AG 51-59% of SVL (x=55.6%, n=62); HL 36-44% of SVL (x=41.3%, n=60).

Scalation: Nasals widely separated; prefrontals moderately to narrowly separated; supraciliaries 6-7 (x=6.0, sd=0.16, n=63); upper labials 6, rarely 7; midbody scale rows 23-26 (x=24.6, sd=1.0, n=63); paravertebral scales 54-63 (x=57.6, sd=1.6, n=63), fourth finger scales 9-11 (x=10.0, sd=0.3, n=63); fourth finger lamellae 15-19 (x=17.3, sd=0.9, n=63); fourth toe scales 11-13 (x=11.2, sd=0.4, n=63); fourth toe lamellae 22-27 (x=24.3, sd=1.0, n=63).

Osteology: Presacral vertebrae 27-28 (x=27.1, sd=0.3, n=16); postsacral vertebrae 45-48 (x=46.8, sd=1.1, n=12).

Colour and pattern: The populations of *S. challengeri* are generally similar. Two forms of sexual dichromatism, both at low frequencies, occur in certain populations. Dorsal surface usually overall mid brown (occasionally lighter or darker), uniform or with scattered pale brown scales. Dorsolateral region with dark flecking along scale rows 3 and 4 forming a rough-edged stripe at least anteriorly, and variably extending partly or wholly along the body and basal portion of the tail. Where dark dorsolateral markings continue to level of hindlimb these may occasionally be bordered above by a pale, poorly defined, brown to russet hip stripe. Head with a bold dark brown loreal streak between nares and eye, becoming narrower and obscure behind eye and generally not continuous with dark dorsolateral stripe. Dorsal and lateral surfaces of tail similar to body, usually marked with several moderately large, pale vertebral blotches anteriorly, rarely uniform, and occasionally defined by a continuation of the fine dark dorsolateral flecking on scale rows 3 and 4 of body. Dark lateral and pale ventral surfaces of tail in bold contrast and the ventrolateral margin of tail defined by a fine but obvious black stripe. Ventral surface white with sparse to heavy scattering of mid brown spots positioned in either the centre or edge of the individual ventral scales. In life adults males generally have a pale yellow wash to the posterior half of the abdomen, occasionaly extending to the underside of hindlimbs and basal portion of tail, whereas adult females generally lack such colour or only occasionally have a very weak yellow flush to the posterior half of the abdomen.

Two colour patterns were observed in females of this species. A small proportion of females (approximately 10-20%) from all populations had a uniform mid brown dorsal surface bordered by a smooth, well defined, pale edged, dark dorsolateral stripe continous along the body and tail and contrasting with the darker brown lateral colour to the body and tail. In the Nightcap Range population a small percentage of females had a relatively plain mid brown dorsal surface and boldly contrasting uniformly darker brown upper lateral surface bordered below by a broad, bold white stripe which occupied most of the mid and lower lateral region, particularly in the region of the forelimb. One of these 'white-striped' specimens had the dorsal and lateral surfaces further distinguished by a narrow, pale brown laterodorsal stripe along the entire length of the body and basal portion of the tail.

DISTRIBUTION, HABITAT

S. challengeri is restricted to the McPherson Ra. and its hinterland (Fig. 8). In NSW it occurs in the ranges of the Mt Warning caldera (Mt Warning, Nightcap Ra.), southern edge of the McPherson Ra., and the Tooloom and Richmond Ras. In SEQ it occurs throughout the McPherson Ra. from its eastern margin west to Cunningham's Gap and adjacent Mt Tambourine, and has been recorded from coastal lowland at Beenleigh and Scotts Is. in the lower reaches of the Tweed R.

Throughout most of its range it inhabits closed gully forest from sea level to 500 m. *S. challengeri* is a conspicuous, surface active, diurnal species that inhabits the forest floor and edges of streams in closed forest, where it can be relatively abundant. It is sympatric with *S. galli* at two localities, Breakfast Ck at Mt Warning and Sheepstation Ck in the border ranges. Both

FIG. 7. *S. challengeri*, Lamington Plateau, SEQ.

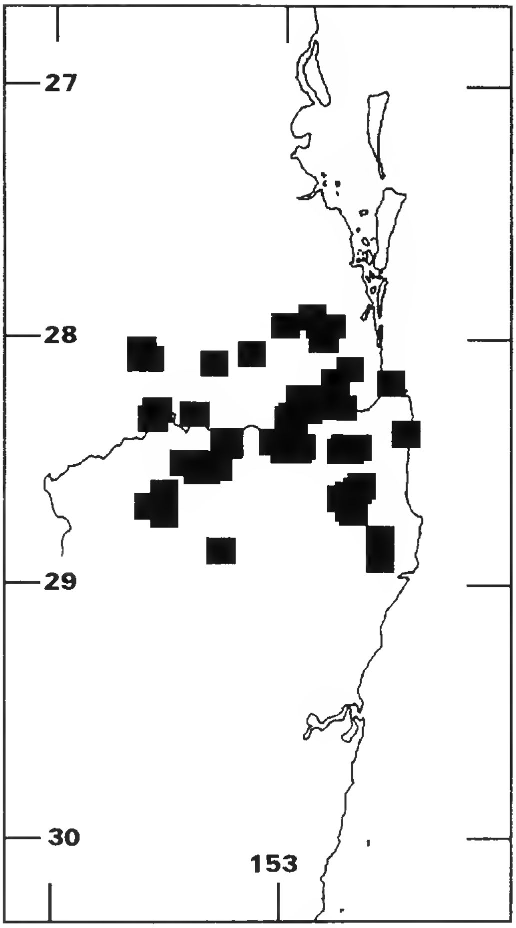

FIG. 8. Distribution of *S. challengeri* (closed squares).

localities are small gully creeks running through closed forest at mid to low (<500 m) altitude. At these sites *S. challengeri* is widespread and moderately abundant on the forest floor bordering and adjacent to the streams, whereas *S. galli* is rarely encountered away from the stream and, in contrast, difficult to observe, tending to shuttle between sheltering sites and remain secretive, rarely appearing to bask in the open.

Saproscincus galli Wells & Wellington, 1985
Figs 9-12

Saproscincus galli Wells & Wellington, 1985:37. Holotype: AMS R116964 (AMH 16800) (Fig. 9)

SPECIMENS EXAMINED

The following specimens were used in the description, and include those used in the canonical variates analysis and electrophoretic analysis (morphological analysis only *; electrophoretic analysis only !).

Lamington NP, Toolona Gorge area on Toolona Falls track (population 21-part), 28.15'S, 153.10'E (R140660-62); Lamington NP, Toolona Falls (population 21-part), 28.15'S, 153.10'E (R140667, R140674); Border Ras NP, vicinity of Brindle Ck rest area (population 22), 28.22'S, 153.03'E (R138031-33, R138042; R138043-44*); Mt Warning NP, vicinity of Breakfast Ck carpark (population 20), 28.23'S, 153.17'E (R133456!; R133458!; R138000-01*, R138007-09, R138016*, R138070, R138072); Border Ras NP, Lophostemon Falls on Brush Box Falls track (population 23), 28.24'S, 153.01'E (R138047-48, R138049*; R138050-51); Twelve Sixty Flora Reserve, Coffs Harbour district (population 26), 30.07'S, 152.55'E (R138207!, R138409-10!); Mobong Falls, Wild Cattle SF (population 25), 30.10'S, 152.47'E (R134986-87, R138191-92); Dorrigo NP, Never Never picnic area (population 24), (R138174*; R138175-76); Cooper's Park, Bellevue Hill, Sydney (population 27), 33.51'S, 151.17'E (R71622-26*, R71628*, R71709-14*, R93768-69*, R132041-44; R132045*; R132046, R138404-07; R138408*).

DIAGNOSIS

The following features in combination generally distinguish *S. galli* from other members of the *S. challengeri* species group: maximum adult size 59mm; supraciliaries usually 7; lamellae beneath the fourth finger 16-21; lamellae beneath the fouth toe 22-28; presacral vertebrae usually 27; postsacral vertebrae 48-53; dorsal surface a mosaic of lighter and darker scales; ventral surface with regularly aligned faint brown spotting tending to form longitudinal rows; lateral and dorsal surfaces of tail barely differentiated, the markings tending to be a continuation of the overall dorsal colour pattern; abdomen of adult males bold lemon yellow.

The second, and sixth to tenth characters will distinguish *S. galli* from *S. challengeri* as outlined in the diagnosis of *S. challengeri*.

The first, third to fourth, and tenth characters will distinguish *S. galli* from all populations of *S. rosei* which reach a greater adult size (maximum SVL 64mm), generally have fewer lamellae beneath the fourth finger and toe, and lack bold ventral colour. Characters seven and eight further distinguish *S. galli* from sympatric southern populations of *S. rosei* which have a more more uniformly coloured dorsal surface and the ventral surface marked with irregular brown spots. Characters five and nine will further distinguish *S. galli* from sympatric northern populations of *S. rosei* which have more presacral vertebrae and in subadults and females a bold russet hipstripe which define the dorsal and lateral surface of the

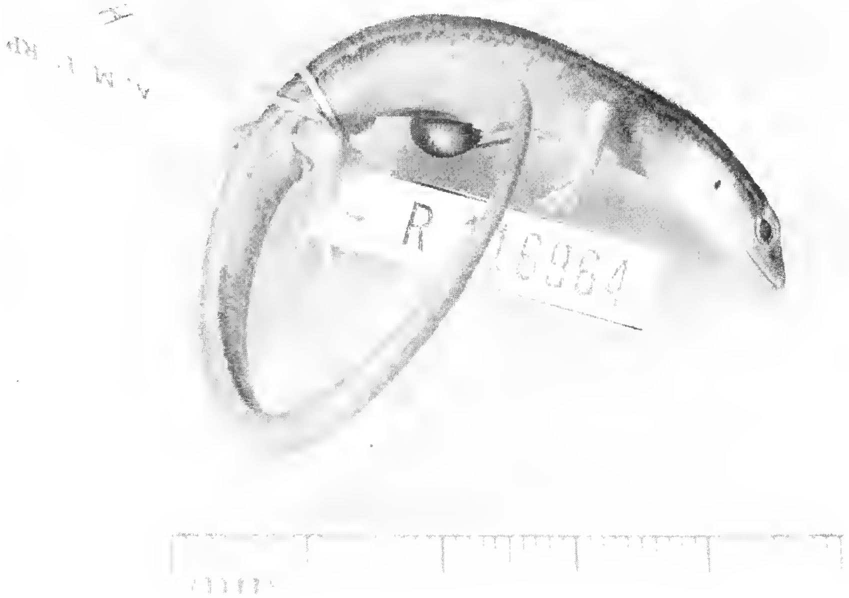

FIG. 9. AMS R11694 holotype of *S. galli* Wells & Wellington.

tail anteriorly, this latter character though present in subadult and female *S. rosei* from southern populations is less bold.

DESCRIPTION

Measurements: Maximum SVL 59mm; TL 139-192% of SVL (x=165.0%, n=28); AG 53-62% of SVL (x=56.8%, n=58); HL 35-44% of SVL (x=39.7%, n=57).

Scalation: Nasals widely separated; prefrontals moderately to narrowly separated; supraciliaries 6-8 (x=6.8, sd=0.3,n=58); upper labials 6, rarely 7; midbody scale rows 22-24 (x=22.7, sd=0.9, n=58); paravertebral scales 54-61 (x=57.9, sd=1.7, n=58), fourth finger scales 9-11 (x=10.2, sd=0.4, n=57); fourth finger lamellae 16-21 (x=17.9, sd=1.0, n=57); fourth toe scales 11-14 (x=12.3, sd=0.9, n=58); fourth toe lamellae 22-28 (x=24.8, sd=1.4, n=58).

Osteology: Presacral vertebrae 26-28 (x=27.0, sd=0.3, n=41); postsacral vertebrae 48-53 (x=50.3, sd=1.2, n=31).

FIG. 10. *S. galli*, ♂ Lamington Plateau, SEQ.

FIG. 11. *S. galli*, ♀, with white midlateral stripe, Border Ranges, NENSW.

Colour and pattern: The various populations of *S. galli* are similar in colour and pattern (Fig. 10).

Dorsal surface mid to dark brown with numerous scattered pale brown to cream scales. Dorsolateral region with dark flecking along scale rows 3 and 4 forming a rough-edged stripe at least anteriorly, and variably continuing partly or wholly along the body and basal portion of the tail. Lateral and dorsal surfaces of tail barely differentiated, the markings tending to be a continuation of the overall dorsal colour pattern. Ventral surface of tail pale with scattered brown spotting, contrasting with darker lateral surface but tending to grade into it at the ventrolateral margin. Head with a bold dark brown loreal streak between the naris and eye and continuous past the eye with the dark dorsolateral stripe. Ventral surface white with sparse to dense brown flecks which are generally aligned along the edge of the individual ventral scales, giving the appearance of rough longitudinal streaks on boldly marked individuals. In life adult males have a bold lemon yellow enamel flush to the abdomen.

A low frequency of two forms of sexual dichromatism occurs in females of this species, the combinations of which vary between populations. In populations from the Sydney region a small proportion (10-20%) of females have a uniform mid brown dorsal surface bordered by a smooth, well defined, pale edged, dark dorsolateral stripe continuous along the body and tail, contrasting with a darker brown lateral colour of the body and tail. In the McPherson Ranges a small percentage of females have a relatively plain mid brown dorsal surface and boldly contrasting uniformly darker brown upper lateral surface bordered below by a moderately broad, bold white, midlateral stripe (Fig. 11).

DISTRIBUTION, HABITAT

Saproscincus galli, although widespread is known from a limited number of sites over much of its range. It extends from Mt Tambourine and the McPherson Ra., SEQ to the Sydney region, NSW (Fig. 12). In the northern and central parts of its range it has been recorded mainly from closed forest in gullies. At only one locality in the central part of its range, Bellinger Is., has *S. galli* been recorded on the coastal plain. In the Sydney region this species is found in remnant patches of low, closed forest in the sandstone hills adjacent to Port Jackson, one of the more densely populated areas in the region. It is also known from urban gardens in near suburbs.

Saproscincus rosei Wells & Wellington
Figs 13-21

Saproscincus rosei Wells & Wellington, 1985:38. Holotype: AMS R116963 (AMH 16801) (Fig. 13)

SPECIMENS EXAMINED

The following specimens were used in the description, and include those used in the canonical variates analysis and electrophoretic analysis (morphological analysis only *; electrophoretic analysis only !).

Conondale Ra., Booloumba Ck xing ca 15km by rd from SF camp (population 14), (R140655-56; R140657*; R140658-59); Mt Glorius, 5.6km N village (population 10), 27.16'S, 152.45'E (R140651-54); Mt Nebo, 1.5km N village (population 11), 27.33'S, 152.48'E (R140645-46*; R140647-49); Lamington NP, Toolona Falls (population 13), 28.15'S, 153.10'E (R140665; R140666*, R140668-70, R140672-73, R140676-77); Border Ras NP, Tweed Valley Lookout (population 12), 28.22'S, 153.05'E (R133485); Washpool NP, Coombadjha Ck, Coachwood Pool (population 1-part), 29.28'S, 152.18'E (R138098-100; R139101*; R138102); Washpool SF, 5.0km S Hayden's trig (population 1-part), 29.19'S, 152.18'E

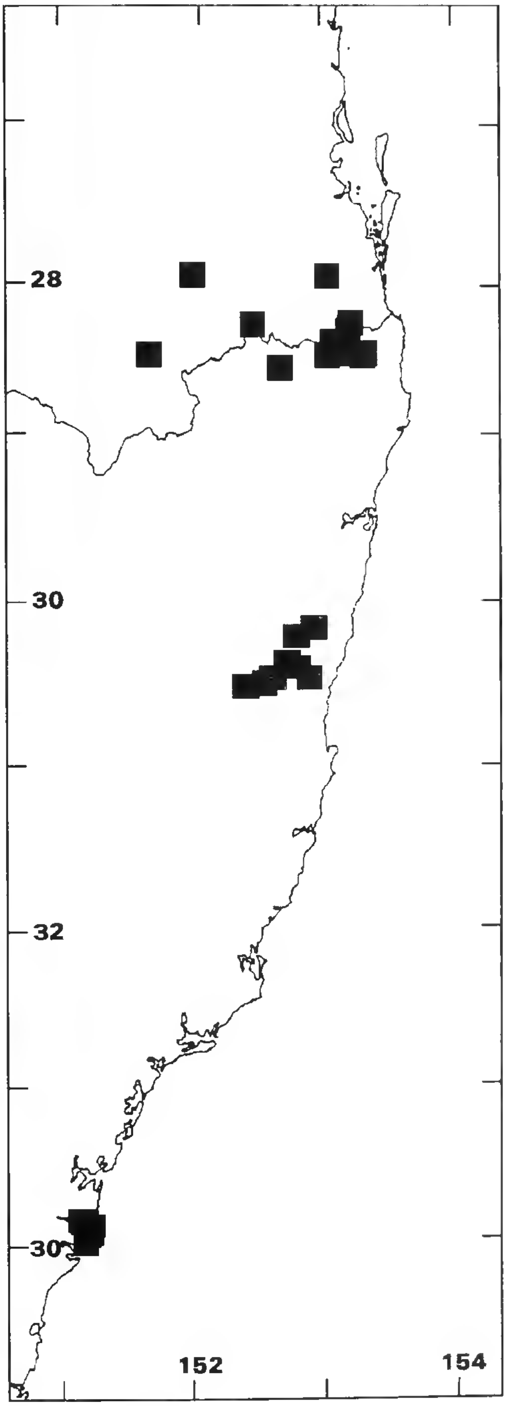

FIG. 12. Distribution of *S. galli*.

(R96793*); Lionsville fire trail, 6km N The Sugarloaf, Washpool SF (population 1-part), 29.23'S, 152.22'E (R96827*, R96877*, R96923-24*); Washpool SF, btn forks of Oorowin road 4km N The Sugarloaf (population 1-part), 29.24'S, 152.23'E (R96878-79*, R96921*); Washpool SF, off Old Coombadjha road, 9.5km N The Summit (population 1-part), 29.25'S, 152.21'E (R96803*); Gibraltar Ras NP, Cedar Valley (population 1-part), 29.28'S, 152.20'E (R96792*, R96888*, R96930*); Gibraltar Ras NP, Hakea picnic area (population 1-part), 29.28'S, 152.21'E (R96808*); Washpool, 29.30'S, 152.22'E (R92911*); Bruxner P, Coffs Harbour district (population 4), 30.15'S, 153.06'E (R138208!); Wild Cattle Ck SF, Measuring Hut rd, 1-6km N Cascade (population 5-part), 30.10'S, 152.47'E (R138218!); Dorrigo NP, Never Never picnic area (population 2), 30.21'S, 152.48'E (R138163-67; R138168*); Dorrigo NP, The Glades picnic area (population 3-part), 30.22'S, 152.43'E (R138184-86); Dorrigo NP, Crystal Shower Falls track (population 3-part), 30.23'S, 152.43'S (R138180)*; Chaelundi SF (population 5-part), (R135281-83!); Styx R. SF, Softwood rd (population 7), 30.32'S, 152.19'E (R130029-33; R130034*; R130035-36, R130038-39*, R138198-99); Plateau Beech, Werrikimbe NP (population 6), 31.10'S, 152.15'E (R130019-22); Mt Banda Banda Flora Reserve (population 8), 31.10'S, 152.25'E (R130023-27); Williams R., nr Barrington House (population 9), 32.10'S, 151.31'E (R130069-71, R130780-82; R130783, R130786-90; R130791*; R138092; R130793*; R130794-95.

DIAGNOSIS

The following features in combination generally distinguish *S. rosei* from other members of the *S. challengeri* species group: maximum adult size 64mm; supraciliaries usually 7, occasionally 6; lamellae beneath the fourth finger 14-18; lamellae beneath the fouth toe 17-24; presacral vertebrae 27-29 (usually 27 in southern populations and usually 28 in northern populations); postsacral vertebrae 46-54; dorsal surface uniform brown (southern populations) or with a mosaic of lighter and darker scales (northern populations); ventral surface with irregular brown spotting (southern populations) or regularly aligned faint brown spotting tending to form longitudinal rows (northern populations); dorsal surface of tail of subadults and adult females with a bold, russet dorsolateral hipstripe; abdomen of adult males usually with a pale yellow wash.

See accounts for *S. challengeri* and *S. rosei* for direct comparison between *S. rosei* and these species.

DESCRIPTION

Measurements: Maximum SVL 64mm; TL 137-192% of SVL (x=168.1%, n=31); AG 46-61% of SVL (x=57.1%, n=97); HL 34-44% of SVL (x=38.2%, n=97).

Scalation: Nasals widely separated; prefrontals

FIG. 13. AMS R11693 holotype of *S. rosei* Wells & Wellington.

FIG. 14. *S. rosei*, ♂, Mt Glorious, SEQ.

FIG. 15. *S. rosei*, ♀, Mt Glorious, SEQ.

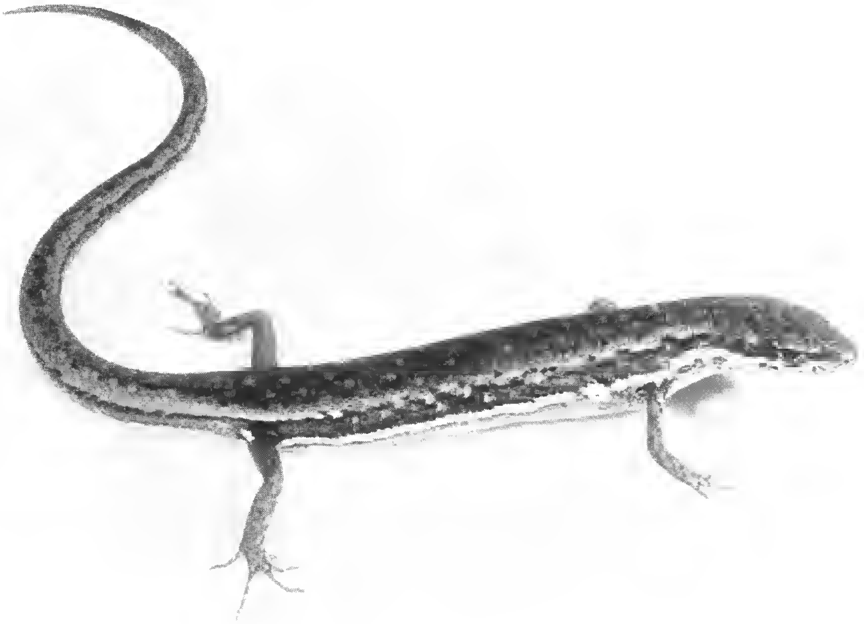

FIG. 16. *S. rosei*, ♀, with white midlateral stripe, Mt Nebo, SEQ.

moderately to narrowly separated; supraciliarics 5-8 (x=6.6, sd=0.5, n=101); upper labials 6, rarely 7; midbody scale rows 22-26 (x=24.1, sd=0.9, n=101); paravertebral scales 55-67 (x=58.8, sd=2.2, n=101), fourth finger scales 8-11 (x=9.7, sd=0.8, n=100); fourth finger lamellae 14-18 (x=15.3, sd=0.9, n=100); fourth toe scales 10-14 (x=11.2, sd=0.6, n=100); fourth toe lamellae 17-24 (x=21.0, sd=1.2, n=100).

Osteology: Presacral vertebrae 27-29 (x=27.7, sd=0.7, n=31); postsacral vertebrae 46-53 (x=49.6, sd=2.3, n=20).

Colour and pattern: The following description applies to populations of *S. rosei* from MENSW (i.e. Bellinger R. region south to the Williams R.) including the type locality for *S. rosei*. Variation in colour and pattern elsewhere throughout the species range are discussed with respect to differences from the type population.

In specimens from MENSW the dorsal surface is usually overall mid brown (occassionally lighter or darker), uniform or with a few scattered pale brown scales. Dorsolateral region with dark flecking along scale rows 3 and 4 forming a broken, rough-edged stripe along the body and basal portion of the tail. Females with a poorly defined pale brown to russet hip stripe. Head with a bold dark brown streak between the naris and eye, becoming narrower and obscure behind the eye and generally not continuous with the dark dorsolateral stripe. Dorsal and lateral surfaces of tail in males generally similar, tending to be broken only by fine dark dorsolateral flecking where scale rows 4 and 5 overlap. The darker lateral and pale ventral surfaces of tail are in bold contrast, and defined by an obvious black stripe along the ventrolateral margin. Ventral surface white, with sparse to heavy scattering of mid brown spots. In life adult males generally have a pale yellow flush to the posterior half of the abdomen and a similiar or bolder yellow flush to the underside of hindlimbs and basal portion of tail, whereas adult females generally lack such colour or only occasionally have a very weak yellow flush to the very posterior edge of the abdomen, underside of hindlimbs and basal portion of tail. A low frequency of sexual dichromatism occurs in populations around the Dorrigo-Bellinger region. Some females had a relatively plain mid brown dorsal surface and boldly contrasting uniformly darker brown upper lateral surface bordered below by a broad, bold white mid lateral stripe. A narrow, pale brown laterodorsal stripe further defined the dorsal and lateral surfaces of the body.

Specimens from the Clarence River region north to the NSW-QLD border are intermediate in coloration between MENSW populations and those from SEQ. The dorsal surface is usually marked with a mosaic of lighter and darker scales;

FIG. 17. *S. rosei,* ♀, with dark vertebral stripe, Lamington Plateau, SEQ.

the russet hip-stripe is bold and well defined and the ventral surface is marked with regularly aligned faint brown spotting tending to form longitudinal rows. Adult ventral colour in life similar to MENSW populations.

A colour photograph of an adult female *S. rosei* from Mt Glorious, SEQ is figured by Wilson & Knowles (1988). The russet hip stripe of subadult and adult females tends to dominate the dorsal coloration. The ventral surface is marked with regularly aligned faint brown spotting tending to form longitudinal rows rather than with sparse to heavy scattering of mid brown spots (Figs 14-16). Adult ventral colour in life similar to central eastern NSW populations.

A low frequency of sexual dichromatism occurs in most SEQ populations. Some females have a relatively plain mid brown dorsal surface and boldly contrasting uniformly darker brown upper lateral surface bordered below by a broad, bold white mid lateral stripe. A narrow, pale brown laterodorsal stripe further defines the dorsal and lateral surfaces of the body.

Four coloration forms are recorded on the E McPherson Ra. population (Figs 17-20). The most common variant occurs in both sexes where darker flecking on the dorsal surface tends to concentrate down the middle of the body to form a rough, dark vertebral stripe (Fig. 17). The pale ventral surface is marked with regularly aligned faint brown spotting tending to form longitudinal rows. The yellow ventral colour in live adult males is more prominent than in other populations being present as a moderate to pale flush over the posterior part of the venter, underside of hindlimbs, and basal portion of tail (where it is boldest), and sometimes extending over most of the venter. It is similarly well developed in live adult females being present as a pale yellow wash to most of the venter in all but one individual.

A low frequency of two forms of sexual dichromatism was observed in females and one in males. One female had a relatively plain grey-brown dorsal surface (Fig. 18) the other a mid-dark brown dorsal surface with a mosaic of lighter and darker scales (Fig. 19). Both had boldly contrasting uniformly darker brown upper lateral surfaces bordered below by a broad, bold white mid lateral stripe, and bold, russet dorsolateral hip stripes which tend to dominate the dorsal coloration. A colour photograph of one of these forms from Lamington NP, SEQ is figured by Wilson & Knowles (1988). One male was completely patternless, being uniform grey-brown (Fig. 20).

DISTRIBUTION, HABITAT

S. rosei has a broad distribution extending from just south of Gympie (26°11'S), SEQ, to the Barrington Tops region (32°10'S) in central eastern NSW (Fig. 21). Over much of its range *S. rosei* occurs along the eastern edge of the Great Dividing Ra. and its associated near coastal ranges, but is noticeably absent from most of the McPherson Ra. and adjacent Richmond and Tweed Ranges, except for two isolated high altitude populations in the eastern McPherson Ra.

In SEQ, *S. rosei* occurs on the Great Dividing Ra. along the western edge of the Brisbane R. drainage, and north of the Brisbane R. drainage from the D'Aguilar, Conondale and Jimna Ranges and associated near coastal ranges. It is not known from the more inland Bunya Mts on the Great Dividing Ra., or from ranges south of the Brisbane R. drainage, except for the two isolated populations in the McPherson Ra.

S. rosei is a conspicuous, surface active, diurnal species that inhabits the edge of closed forest or open, sunlit, patches in the forest. It tends to be more abundant in the former situation where it is commonly observed basking among debris piles.

FIG. 18. *S. rosei*, ♀, with uniform dorsal surface and white midlateral stripe, Lamington Plateau, SEQ.

FIG. 19. *S. rosei*, ♀, with dark flecked dorsal surface and white midlateral stripe, Lamington Plateau, SEQ.

FIG. 20. *S. rosei*, ♂, with uniformly coloured dorsal and lateral surface, Lamington Plateau, SEQ.

In MENSW it has been recorded regionally sympatric with *S. galli* at a number of locations in the Dorrigo region. On the western edge of the McPherson Ra., SEQ. *S. rosei* has been recorded regionally sympatric with *S. challengeri* (Cunningham's Gap) and with *S. galli* (Mt Superbus). In the eastern McPherson Ra. it is restricted to high altitude closed forest, being found in creekside vegetation at the headwaters of Toolong Ck, where it was sympatric with *S. galli*, and from beside a foot-track through closed forest on a ridge on the adjacent Tweed Ra.

KEY

1. Supraciliaries usually 6; dorsum uniform brown; venter with irregular brown spotting; dorsal surface of tail usually with several moderately large, pale vertebral blotches anteriorly .....*S. challengeri*
   Supraciliaries usually 7; dorsum uniform brown or with a mosaic of lighter and darker scales; venter with irregular brown spotting or regularly aligned faint brown spotting tending to form longitudinal rows; dorsal surface of tail without several moderately large, pale vertebral blotches anteriorly 2
2. Dorsum uniform brown; venter with irregular brown spotting; abdomen of adult males usually with a pale yellow wash .....*S. rosei* southern populations
   Dorsal surface of body with a mosaic of lighter and darker scales; ventral surface with regularly aligned faint brown spotting tending to form longitudinal rows 3
3. Lamellae beneath the fourth toe 22-28; abdomen of adult males bold lemon yellow; lateral and dorsal surfaces of both sexes undifferentiated........*S. galli*
   Lamellae beneath the fourth toe 17-24; abdomen of adult males usually with a pale yellow wash; dorsal surface of tail of subadults and adult females with a bold, russet dorsolateral hipstripe........................ .... *S. rosei* northern populations

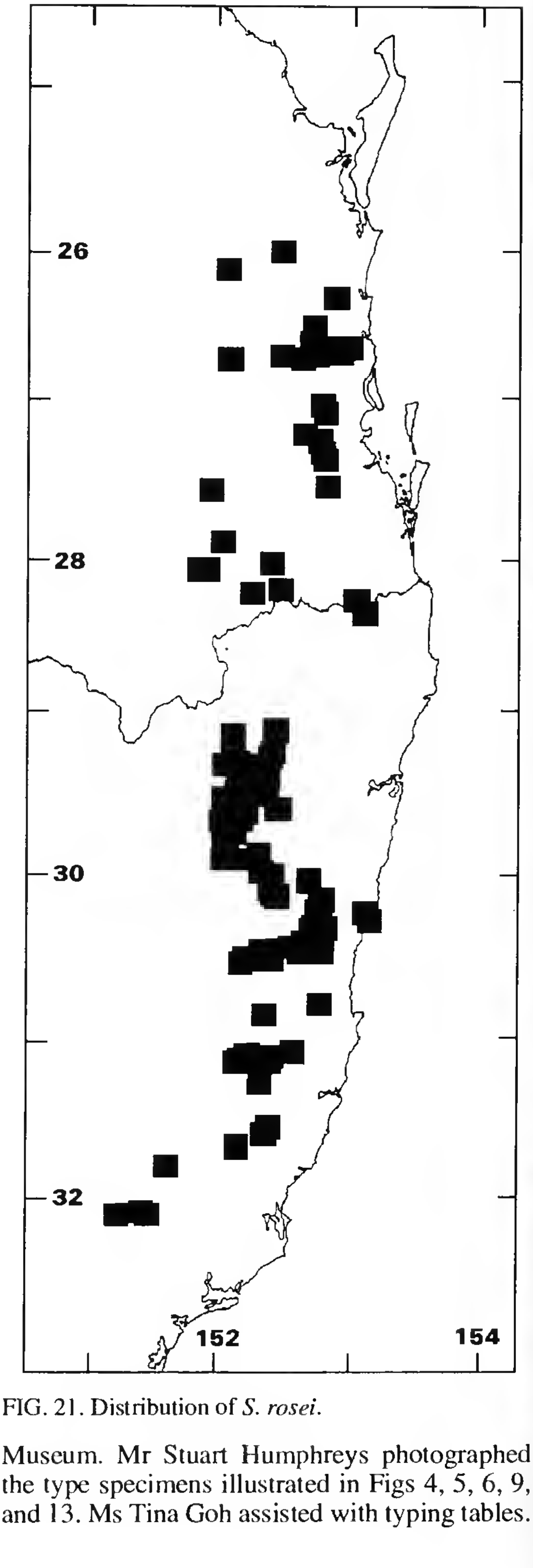

FIG. 21. Distribution of *S. rosei*.

ACKNOWLEDGEMENTS

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APPENDIX 1

Specimens examined (AM and QM) to prepare the distribution maps of *S. challengeri, S. galli,* and *S. rosei.*

Saproscincus challengeri Queensland Museum specimens: J3037-40; J3042; J7497; J12143-44; J12151-57; J12161-70; J13362-63; J13635; J16456; J18020; J18023; J21997; J22224; J22941-42; J24836; J24910; J26032-33; J26681-85; J26723; J27705-06; J27769-71; J27840-42; J28297-99; J30808; J32274-75; J34951-56; J34978-86; J35258-59; J42434-37; J49629; J49632; J49636; J49641; J49649; J49662; J49664; J49667; J49686; Australian Museum specimens: R8780; R15747-48; R18299; R18301-02; R18726; R20513-15; R52745-50; R55088-90; R85947-48; R87048-50; R92131-32; R95382; R96440-43; R97819-21; R97885; R104104; R111207; R130855; R130857; R130865; R130867; R130881; R130905; R131869-80; R132436-37; R132450; R132460-61; R132464; R133462; R135464; R138003-04; R138027; R138062-69; R138088-89; R138092-94; R138265-68; R138272-78; R139124-25; R139514-15; R139521-22; R140640-44. *Saproscincus galli* Queensland Museum specimens: J3041; J3043; J13636; J30564-67; J30569-74; J30671-72; J32276. Australian Museum specimens: R16997; R18540-44; R18565; R20319; R53742; R54341; R64519; R71627; R71629-32; R76549; R85724; R90604; R90614; R92133; R95613; R96588-96; R97817; R97836-46; R104284-87; R104304; R111737-40; R118999-119000; R127378; R130018; R132033-37; R132047-48; R132434; R132462; R133448-49; R138002; R138010-15; R138034-41; R138052-61; R138071; R138073-75; R138177; R138193-94; R138411-12; R139551; R140663-64; R140675. *Saproscincus rosei* Queensland Museum specimens: J1581; J3754; J12254; J14318; J16915; J18022; J20229; J20655; J21409; J22471; J22684; J24049-50; J24334-35; J24346; J25534; J26501; J26679;J26911; J28278; J29035; J29944; J30575; J30809; J32189; J32277;J36919; J36958; J37934; J42122; J49663; J49735; J51620; J51983. Australian Museum specimens: R16996; R17002; R43738; R43750; R49173-77; R52730-44; R53746; R54470-71; R54622-23; R54890-91; R61167-68; R61303; R62786; R85938-46; R90603; R96893; R97818; R99475; R103007-08; R103012; R103024-26; R103066; R104110; R104113; R107678; R108693-97; R108705-06; R108738; R108752; R111566-69; R112253-59; R112273; R130037; R130784-85; R130796-97; R132000-28; R132049-72; R132826; R137685; R137704; R137711; R137715-16; R137727; R137753; R137760; R137763-64; R137868-71; R138162; R138169; R138251-52; R138269-71; R138279-96; R138356; R138413-17; R139031; R139054-56; R139063; R139076; R139079; R139081; R139097; R139112; R139138; R139217; R139220; R139226-27; R139234; R139236-42; R139271; R139275-77; R139282; R139284; R139313-15; R139341; R139346-49; R139366-67; R139484-85; R139489; R139499; R139511; R139558-63; R139680-81; R139702-03; R139786; R139791; R140650; R140671; R141050; R141071; R141395; R141437; R141463; R141544; R141552-54; R141556; R141622; R141653.

A NEW SKINK, *NANGURA SPINOSA* GEN. ET SP. NOV., FROM A DRY RAINFOREST OF SOUTHEASTERN QUEENSLAND

J.A. COVACEVICH, P.J. COUPER AND C. JAMES

Covacevich, J.A., Couper, P.J. & James, C. 1993 12 24: A new skink, *Nangura spinosa* gen. et sp. nov., from a dry rainforest of southeastern Queensland. *Memoirs of the Queensland Museum* **34**(1):159-167. Brisbane. ISSN 0079-8835.

Nangura spinosa gen. et sp. nov. is a very distinct member of the *Sphenomorphus* group. It resembles *Gnypetoscincus queenslandiae* superficially in being very spiny. It is, however, larger than *G. queenslandiae*, has supratemporal fossae (absent in *G. queenslandiae*), and a karyotype 2n=28 (vs 30). It also has an interparietal which totally separates the parietals. *Nangura spinosa* is the first reptile species known to be confined to the remnant dry rainforests (= semievergreen vine thickets) of southeastern Queensland. It is known only from Nangur State Forest (Figs 1a,b), which is now, like most semievergreen vine thickets in southeastern Queensland, in the care of the Queensland Forest Service. ☐ *Nangura spinosa, Sphenomorphus group, dry rainforest, Scinidae, southeastern Queensland.*

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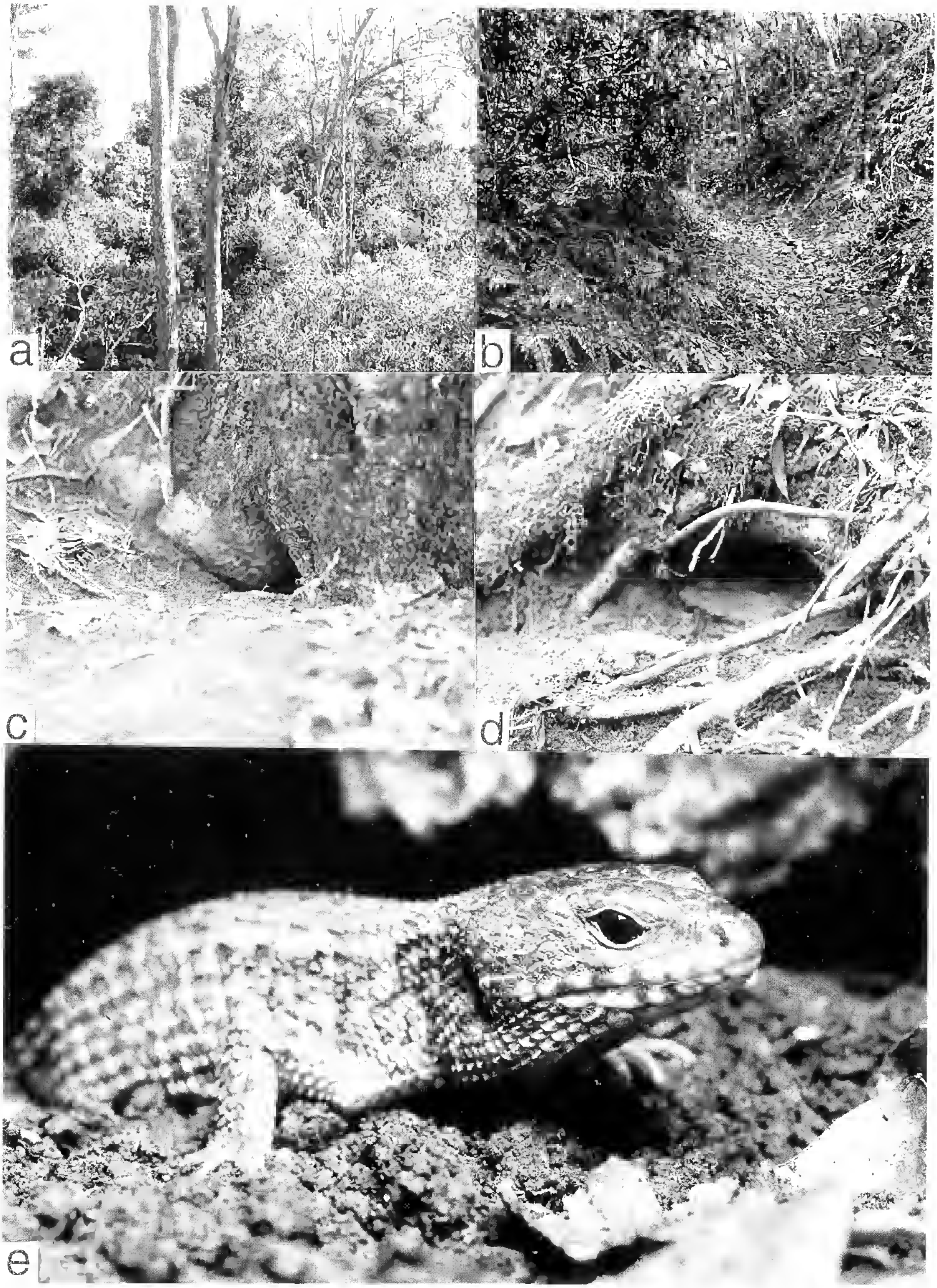
The reptiles of the tropical and subtropical moist rainforests (=micro, meso and notophyll vine forests) of Queensland are now relatively well known as far as species and broad distributions are concerned (Covacevich & McDonald, 1991). These species have been the subject of intense taxonomic research in the last decade or so. No less than 11 species have been described from Queensland's moist rainforests since 1980. Many of these species are endemic to Australia and have extremely narrow ranges. By contrast, the reptiles of the dry rainforests (=semievergreen vine thickets, inter alia, Webb, 1978) are not well known. Semievergreen vine thickets occur in a broken band to the west of the better-known moist rainforests of the near coastal uplands and plains. Some reptile surveys were undertaken in semievergreen vine thickets in the mid 1970s (Anonymous, 1976; Queensland Museum, 1977). They form an important habitat for some recently described species from north and mid-eastern Queensland (e.g. *Anomalopus brevicollis* Greer & Cogger 1985; *Glaphyromorphus cracens* (Greer 1985); and *Lerista vittata* Greer et al., 1985), but endemism is not a feature of their reptile (and other vertebrate) fauna. The reptiles from semievergreen vine thickets surveyed to date are either wide-ranging species recorded from moist rainforests to sparse, open woodlands (e.g. *Varanus varius, Rhinoplocephalus nigrescens, Boiga irregularis*), or from purely open forests (e.g. *Carlia mundivensis, Carlia schmeltzii, Heteronotia binoei, Lialis burtonis*).

In southern Queensland, '.... vineforests ... include a number of vegetation communities that are known by a variety of names, including rainforest scrub, hoop-pine scrub, vine scrub, vine thicket and softwood scrub. These communities have been largely cleared in southern Queensland because of their rich soils and value for agriculture. The remaining stands are remnants ... 'of less than 1 hectare to large stands of up to 3000 ha, however most are small and less than 100 ha in size' .... (Forster et al., 1991). Nangur State Forest (Fig. 1a-b) is a patch of semievergreen vine thicket near Murgon, SEQ, only 250km northwest of Brisbane. Survey work on the vertebrates of this and other similar forests was undertaken in 1992. The results of those surveys are reported in this volume (Covacevich et al., 1993; Horsup et al., 1993). In June, 1992, one of us (C.J.), working with Mr Mark Fletcher, excavated a burrow 'which looked as if it might have been made by a lizard'. A very distinct, spiny skink, here described as *Nangura spinosa* gen. et sp. nov., was found in a small chamber about 60cm from the burrow entrance. *N. spinosa* is only the second reptile species known to be confined to semievergreen vine thicket. (The other is *Lerista vittata*). It is a large, distinctive skink. That it remained unknown till 1992 and has been discovered close to Brisbane, where the reptiles are generally well-known, is remarkable.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N.spinosa 'fits' closely, but not perfectly, into the definition of Greer (1979) for members of the *Sphenomorphus* group. It has 8 premaxillary teeth; an open Meckel's groove; each parietal bordered posterolaterally by the temporals; enlarged medial preanals; two rows of scales on the basal half of the dorsal part of the fourth digit; an iris and pupil which are equally dark; a thin bilobed hemipenis. It lacks pterygoid teeth and a postorbital bone. (The latter is present in some members of the *Sphenomorphus* group, e.g. *Eulamprus* spp. and absent in others, e.g. *Ctenotus* spp. Its presence is regarded as primitive for the group, Greer, 1979; Hutchinson, pers. comm. In *N.spinosa* the former postorbital has been incorporated in the postfrontal. A short, incomplete suture is the only remaining trace of this bone.) *N.spinosa* is secretive, has a scaly eyelid and fully-developed pentadactyl limbs, and appears not to be sexually dimorphic/dichromatic (our sample size is of five specimens only). The latter suite of characters used also by Greer (1989) for the *Sphenomorphus* group are primitive characters for all skinks, and are generally true for the *Sphenomorphus* group (M. Hutchinson, pers. comm.). *N.spinosa* has greatly enlarged preanal scales, an iris virtually as dark as its pupil, and a bifurcate hemipenis - a combination present only in members of the *Sphenomorphus* group (Hutchinson, pers. comm.).

In two characters *N.spinosa* is unusual amongst members of the *Sphenomorphus* group. *Nangura* is the only member of the *Spenomorphus* group karyotyped to date that has 2n=28. (Genera karyotyped include *Anomalopus*, *Calyptotis*, *Ctenotus*, *Eremiascincus*, *Glaphyromorphus*, *Gnypetoscincus*, *Hemiergis*, *Lerista*, *Lipinia*, *Lobulia*, *Notoscincus*, *Papuascincus*, *Prasinohaema*, *Saiphos* and *Sphenomorphus*). All, except *Lipinia* (which has 2n=42), have 2n=30 (which is seen also in *Scincella laterale* of the USA). Karyotype thus strongly emphasises the uniqueness of *N.spinosa* in comparison with *Gnypetoscincus queenslandiae* and *Eulamprus* spp. with which it shares some characters (Donnellan, 1985; Donnellan, pers. comm.). Further, its parietal scales are totally separated by the interparietal. This character is present in only one species group (*Eulamprus quoyii*) of the *Sphenomorphus* group. It seems more reasonable to expand definitions of Greer (1979, 1989) slightly to include *N.spinosa* in the *Sphenomorphus* group, than to separate it from the group because of these distinctive features.

The most striking feature of *N.spinosa* is the presence of well-defined spines all over its dorsum. In this feature and in general body proportions, it bears some resemblance to *G. queenslandiae* (of the *Sphenomorphus* group) and to some of the *Egernia* species (of the *Mabuya* group). In the *Sphenomorphus* group, Greer (1989) recognises two subdivisions based on ecology, surface-dwelling species (e.g. *Ctenotus* spp.) and semi-fossorial or fossorial species (e.g. *Coeranoscincus* spp.). He notes the unique case of *G. queenslandiae* which, despite its surface-dwelling habits, is a sedentary lizard that spends much of its life under rotting rainforest logs. He places it with semi-fossorial or fossorial species.

The following characters are used: snout to vent length (SVL); tail length (T); length of front leg (L1); length of hind leg (L2); head length (HL); head width (HW). Character definitions and measurements follow Couper et al., 1993.

Nangura gen. nov.

Head scales rugose. Most other dorsal and lateral scales keeled, and not, or only just overlapping. Keels on the tail are most pronounced, almost pyramidal. Dorsal keels form longitudinal lines. Axillal and inguinal scales bead-like to granular. Ventral scales weakly carinate. Iris very dark, almost as dark as the pupil which is black.

Rostral in broad contact with the frontonasal, which thus separates the nasals widely. Prefrontals large, moderately spaced. Frontal elongate, almost 1.5 times as long as broad. Fronto-parietals in broad contact, and in contact with supraoculars 2, 3 and 4. Interparietal elongate, almost rectangular, about twice as long as broad, and about as long as the parietals. Parietals widely separated by the interparietal and bordered by two temporals. Supraoculars 4. Supraciliaries 5-7. Suboculars in a distinct row, in contact with supralabials and granules of the lower eyelid. Lower eyelid scaly, without a disc. Loreal scales 2, the posterior one the larger. Ear opening large, about three times as long as wide; vertical, lacking lobules, and with a superficial tympanum.

FIG. 1a Nangur State Forest from the track bisecting it, showing low, closed canopy of typical semievergreen vine thicket.b Bed of small unnamed creek in Nangur State Forest. All known specimens of *N.spinosa* have been collected or seen on the banks of this creek.c-d Entrances of burrows of *N.spinosa*. e *N.spinosa* (J57247).

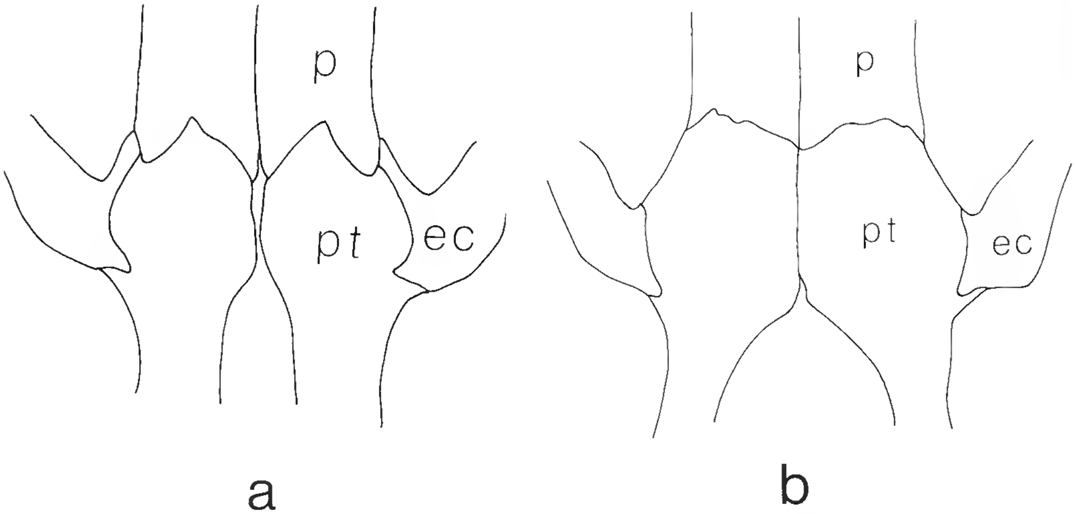

FIG.2 Ectopterygoid, pterygoid and palatine contacts in (a) *N.spinosa* (J57247), (b) *Gnypetoscincus queenslandiae* (J56824).

Medial pairs of preanal scales greatly enlarged. Dorsal scales of the fourth toe paired basally.

Palatine bones in broad medial contact. Palatal rami of the pterygoid bones narrowly separated. Ectopterygoid bones contacting both the palatines and the pterygoids (Fig. 2a). No postorbital. Supratemporal fossae present. Eight conical teeth on the premaxilla. Pterygoid without teeth. Meckel's groove open (Fig. 3).

Karyotype 2n=28.

Hemipenis smooth, bilobed.

Nangura spinosa sp. nov.
(Figs 1-5)

MATERIAL EXAMINED

HOLOTYPE: QMJ55424 ♀, Nangur State Forest (SF74), 26°07', 151°58') SEQ, C. James & M. Fletcher, 5 June 1992.

PARATYPES: QMJ56029 ♀, J56031 , J57246-7 , Nangur State Forest, SEQ.

DIAGNOSIS

N.spinosa is distinguished from other members of the *Sphenomorphus* group (except some *Eulamprus* spp., all of which lack keels)by the state of the parietal shields (parietals not in contact behind the interparietal vs parietals in contact behind the interparietal). It is distinguished from *G. queenslandiae*, the species to which it bears most resemblance, by midbody scale count (28-30 vs 32-36, Cogger 1992); and by karyotype 2n (28 vs 30);degree of caudal keeling (very pronounced vs not pronounced); degree of lateral scale overlap(some vs none); supratemporal fossae (present vs absent); contact between ectopterygoid, palatine and pterygoid bones (ectopterygoid contacting both vs contacting only the pterygoid, Fig 2a,b); and size (max SVL 95.10 mm vs 90.80 mm). As *Nangura* and *Gnypetoscincus* are monotypic, the characters which separate them generically also separate them at the species level. (The latter was redefined by Ingram, 1985, following separation of the Australian '*Tropidophorus*' *queenslandiae* from Southeast Asian *Tropidophorus* spp., as *Gnypetoscincus queenslandiae*, Wells and Wellington, 1985).

DISTRIBUTION

Known only from the type series. All specimens were collected in Nangur SF (SF74), approximately 20km north of Murgon, SEQ.

HABITAT

Semievergreen vine thicket on dark, basaltic soils. Forster et al., 1991 describe Nangur State Forest as having 'canopy intact, exotic weeds present ....'. Estimates of the size of the forest range from < 500 ha (Forster et al., 1991) to 822 ha (P. Flower, pers. comm.).

HOLOTYPE

SVL (mm): 88.9. Proportions as % SVL: T = 85.0, L1 =30.2, L2 =38.1, HL = 24.5, HW = 16.9.

Very spinose, dorsal and lateral scales, save those of the head (which are rugose) and of the axillal and inguinal area (which are bead-like to

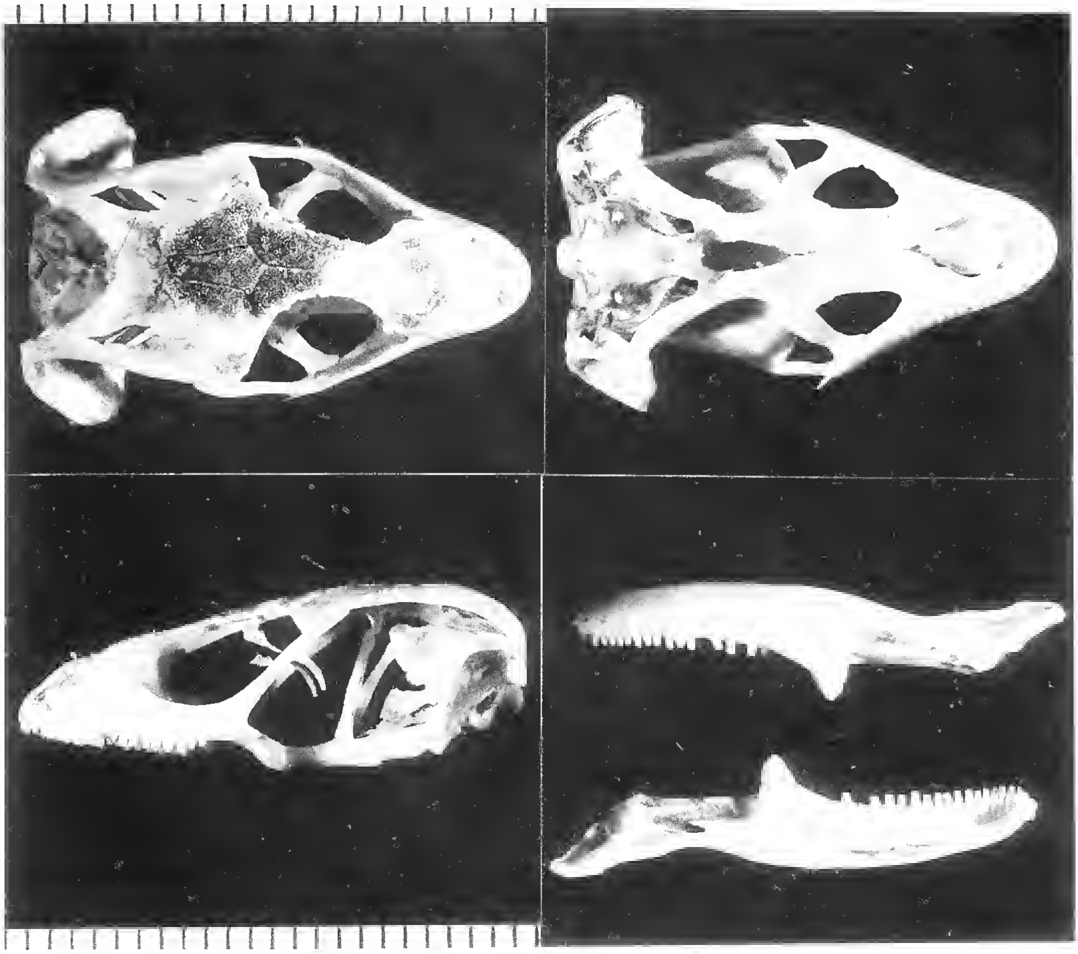

FIG. 3 Skull of *N. spinosa* (J57247).

granular), keeled.(Fig. 5). Keels most pronounced, almost pyramidal, laterally at the base of the tail; strongly developed dorsally and laterally (including the limbs); forming pronounced dorsal longitudinal ridges. Scales of the venter weakly carinate. Midbody scale rows, 30. Paravertebral scales, 40. Preanal scales 4, the middle two greatly enlarged.

Head: moderate, with rugose scalation on dorsal and lateral surfaces; parietals not in contact behind interparietal; interparietal free, elongate; frontoparietals paired, in broad contact; frontonasal single; prefrontals large, moderately spaced; frontal elongate, almost 1.5 times as long as broad; nasals separated by broad rostral/frontonasal contact; supralabials 6; infralabials 4, 2nd largest; supraoculars 4, 2nd largest; supraciliaries 6/7; loreals 2, 2nd largest; presuboculars, 1; subocular scales between the supralabials and scales of the lower eyelid, 3; temporals, an irregular series of small scales; eye dark, pupil not clearly defined; lower eyelid scaly, lacking palpebral disc; ear opening large, vertical without lobules; tympanum superficial, 1st and 2nd chin shields enlarged, 3rd chin shields divided

Limbs: well developed, markedly overlapping when adpressed; plantar scales rounded, slightly keeled; 4th toe markedly longer than 3rd toe; subdigital lamellae, 16/17, bluntly keeled.

Tail: cylindrical, tapering to a point; subcaudal scales slightly enlarged in relation to those adjoining them; vertebral scales not enlarged.

Colour: dorsal surface brown with irregular black crossbands from nape to base of tail; venter cream; lips pale, heavily barred with black; upper lateral zone predominantly black, broken by cream bars; flanks cream with dark flecks.

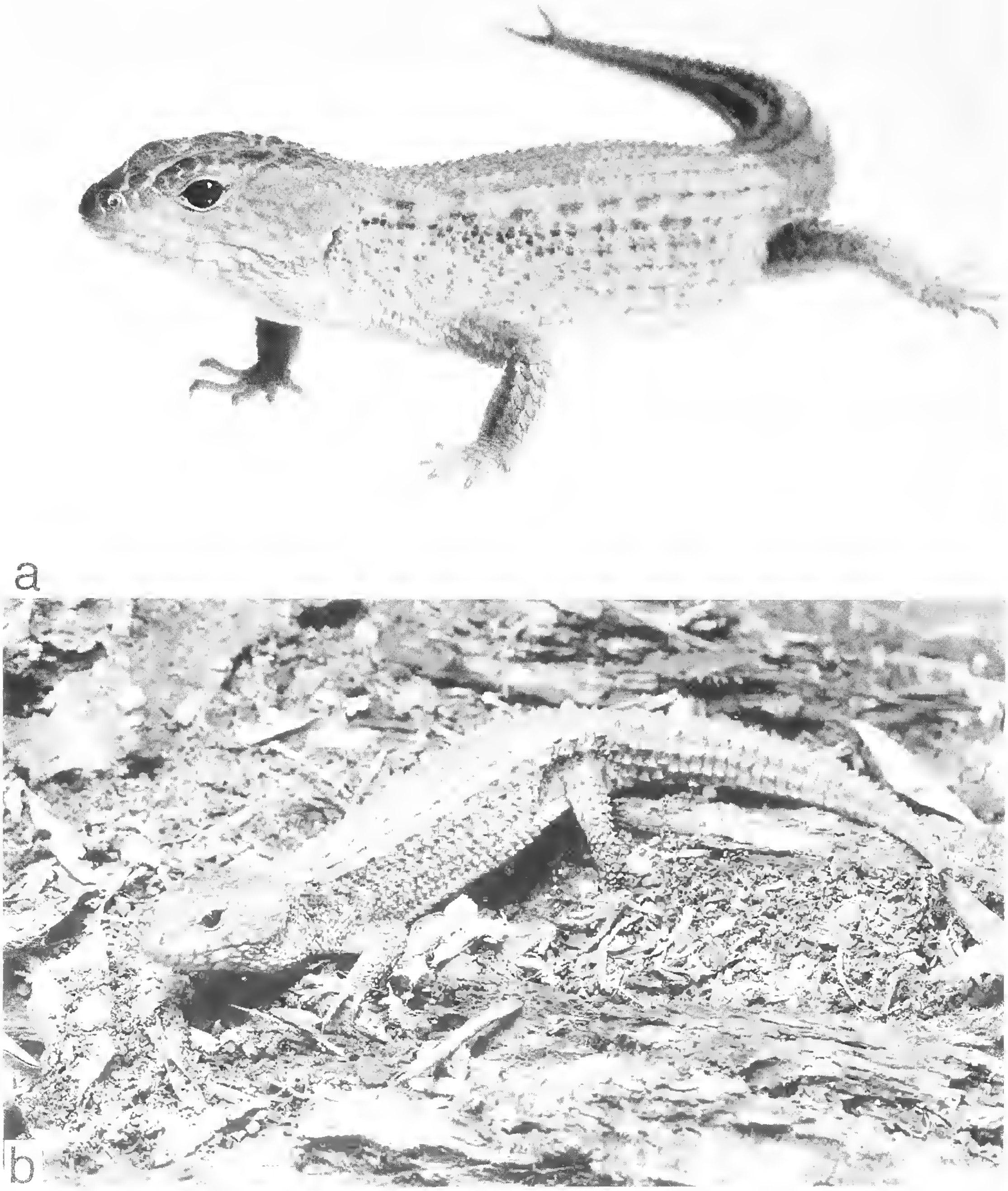

FIG. 4 a-b *Nangura spinosa*. (J57246, J57247)

PARATYPES

SVL (mm): 84.2-95.1. Proportions as % SVL: T 88-94 (n3, mean 89.8); L1 30-33 (n4, mean 31.9), L2 37-42 (n 4, mean 39.7), HL 24-29 (n4, mean 26.8), HW 17-20 (n4, mean 18.7). Midbody scale rows, 28 (J57246-7), 29 (J56031), paravertebral scales, 38 (J57247), 41 (J56029).

Head: infralabials 3, right side only, 3rd largest

(J57246); supraciliaries 5, right side only (J56031); subocular scales between the supralabials and scales of the lower eyelid 2, right side only (J56029, J56031); 2, left side only (J57246).

Limbs: subdigital lamellae, 15/15 (J56029), 18/17 (J56031), 16/16 (J57246), 15/13 (J57247); lamellae broadly callose (J56031, J57246).

FIELD NOTES

All known *N.spinosa* specimens have been collected from burrows in dry, hard, black, basaltic soil. J57246 was taken from a burrow 33.5cm long, with a diameter of roughly 2.0cm. Other burrows excavated have ranged to 60cm. The entrances of burrows are concealed generally by association with tree bases or surface roots (Fig. 1c,d). One (the first found and excavated by C.J. and M. Fletcher) was in the open, several metres from any cover. Two of four burrows excavated terminated in an oval chamber with a length of about 5cm.

N.spinosa occurs in small colonies. The type locality has been searched methodically and extensively. All burrows known lie on the gently sloping bank of a seasonal, unnamed small creek, above what we surmise to be the wet season water flow level, but close to it in one case. Two colonies of solitary or near solitary specimens were found 500 metres apart. (All but one burrow housed only one adult *N.spinosa*. The exception was 'home' to two specimens - an adult observed, and a neonate 'fished' from the burrow using a meal worm as bait and a cotton thread as line, 14 April 1993. This specimen was released after being measured, SVL 4.1cm, T 3.4cm. It retained an 'umbilical' scar). Burrows located are roughly 20-30 m apart. In June, 1992, and April, 1993 the ground was dry and very hard. No sign of digging was seen, and each burrow appeared to have a smooth resting platform of about 6x4cm. The platforms appear to be compacted. In November, 1992, C.J. observed that burrows appeared to be 'active'. Small screes of friable soil near burrow entrances suggested digging was either current or very recent. With each burrow there is a defecation site about 30cm from the burrow entrance. As well as faeces, fragments of shed *N.spinosa* skin were found on these sites.

Faeces found in April, 1993, contained hemipteran abdomen, thorax, other remains, coreid (*Pachycolpura*) remains; coleopteran legs, scarab elytra, carabid beetles (*Notonomus* sp., *Craspedophorus* sp.), dung beetle (*Canthonosoma* sp., *Cephalodesminus* sp.) remains, ground weevil remains, click beetle remains, a large cricket head; large ant remains, a wasp head; millipede remains, spider legs. Dr. G.B. Monteith who identified the remains, notes '.... The sample was of a diverse range of well-chewed anthropod remains. No plant material was present. Most common were remains from beetles and spiders, with fewer from bugs, millipedes, ants and a cricket. The largest animal in the sample is the cricket which would have measured 3-4cm. Some of the prey animals have very distasteful defence secretions (e.g. millipedes; carabid beetles; and the coreid bug, *Pachycolpura* sp.). Some of the animals found would be expected to be nocturnal (e.g. *Canthonosoma* sp., *Notonomus* sp. and the cricket). All taxa represented in the sample are forest-floor dwellers.....'. All would be wanderers and thus susceptible to ambush by *N.spinosa* (G. Monteith, pers. comm.).

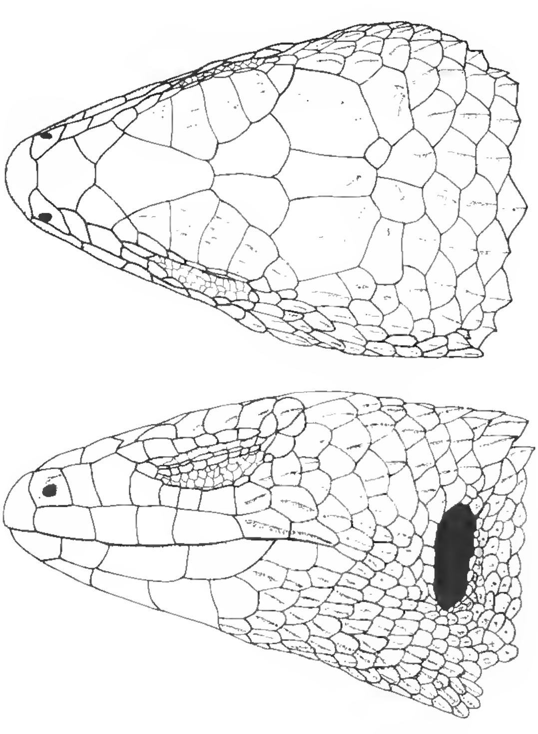

FIG 5. Head scales of the holotype (J55424) of *Nangura spinosa*.

Of the two females, J55424 collected in winter (June, 1992), has slightly enlarged follicles. J56029 collected in spring (September, 1992) also has enlarged follicles. These are larger than those of J55424. Members of the *Sphenomorphus* group are both egg-layers (many *Glaphyromorphus* spp.) and live-bearers (all 8 spp. of *Eulamprus* examined and *G. queenslandiae*), Greer, 1989. *N.spinosa* is not typical of the *Sphenomorphus* group. It has some features in common with the latter, and the combination of burrow-dwelling habits and a very young specimen in a burrow with an adult suggest that *N.spinosa* is probably a live-bearer.

CONSERVATION

By any standard, a species known from only five type specimens from a single locality, which is a remnant of a forest type previously widely distributed, is in need of special conservation/management attention. Under the system devised by Thomas & McDonald (1989) and applied to all then-known species of reptiles in Queensland by McDonald et al. 1991, *N.spinosa* is a 'species known only from the type collection'(1), and is 'rare in Australia, but not currently considered endangered or vulnerable....'(R).

N.spinosa has already received special attention. Nangur State Forest is protected from further clearing. In addition, following the discovery of *N. spinosa* , the Queensland Forest Service took action to 'minimise disturbance to the animal's habitat...' (T. Ryan, in litt., 23 September, 1993) by restricting access, applying special precautions regarding fire prevention, and advising staff to strive to locate more colonies of *N.spinosa.* Like all other reptiles in Queensland, *N.spinosa* is fully protected under the The Nature Conservation Act of 1992 and The Nature Conservation Regulations, 1993.

Two different approaches can be followed regarding the conservation of *N.spinosa.* A non-interventionist approach is based on the fact that this species has survived much alteration to its habitat. (It is an extremely secretive species, virtually impossible to see accidentally and this undoubtedly accounts for its remaining unrecognised till 1992). Nangur State Forest has been subjected to many assaults, which *N.spinosa* has survived. Much of the original Nangur semi-evergreen vine thicket was cleared for agriculture, leaving only a core area of about 500ha. This has been bisected by a road, grazed by cattle, and altered on a smaller scale by fires, timber-getting and invasion by *Bufo marinus*, *Sus scrofa*, and many weeds.

The second approach could evolve from recognition of a second important fact about *N.spinosa.* It is, at least as far as present knowledge is concerned, rare and extremely narrowly restricted. Should research effort to extend knowledge of its ecology with a view to devising an 'active management' scheme be treated as a matter of urgency? Rare, endangered and threatened species research is a very popular field at present (along with research on rainforest taxa). *N.spinosa* qualifies on both fronts for a special place in the current hierarchy of 'worthwhile' research projects. Perhaps it can be considered extra 'worthy', because semievergreen vine thickets are a very poorly known type of rainforest, herpetologically and otherwise. We favour a thorough documentation of the life history, occurrence and habitat requirements of this species, along with continued measures to ensure total protection of its habitat.

ACKNOWLEDGEMENTS

We have received generous assistance in the field from Terry Beutel, and Steve Wilson; in the laboratory from Anita Heideman and Lauren Keim; and in discussion about the status of *N.spinosa* or its habitat from Michael Cunningham, Steve Donnellan, Alan Horsup, Mark Hutchinson and Glen Ingram. Photographs for this description were taken by Bruce Cowell, Gary Cranitch and Jeff Wright. Identifications of insect remains in the faeces of *N.spinosa* were provided by Geoff Monteith. The karyotype was determined by Craig Moritz. Most of the field work for this description was funded by the National Rainforest Conservation Programme, administered by the Queensland Department of Environment and Heritage.

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THE ULTRASTRUCTURE OF SPERMATOZOA OF *NANGURA SPINOSA* (SCINCIDAE, REPTILIA)

B.G.M. JAMIESON AND D.M. SCHELTINGA

Jamieson, B.G.M. & Scheltinga, D.M. 1993 12 24: The ultrastructure of spermatozoa of *Nangura spinosa* (Scincidae, Reptilia). *Memoirs of the Queensland Museum* **34**(1):169-179 Brisbane. ISSN 0079-8835.

Spermatozoa of *Nangura spinosa* are filiform, and approximately 85 μm long. The acrosome vesicle in the form of an elongate hollow, concentrically zoned cone is compressed near its tip, and basally overlies a subacrosomal cone. Axial within the acrosome vesicle is a slender rod, the putative perforatorium. The subacrosomal cone is paracrystalline and invests the tapered anterior end of the nucleus. The perforatorium is a slender, slightly oblique rod extending anteriorly from the subacrosomal material. A conspicuous laminated structure forming a wing-like projection on each side of the proximal centriole contacts with the first of the dense 'ring structures' of the midpiece. The midpiece contains four dense ring structures in longitudinal succession, posterior to which lies the much smaller annulus, all being separated by mitochondrial regions. The mitochondria mostly form 12 or more elongate, sinuous columnar structures, with numerous predominantly longitudinal cristae. Nine peripheral dense fibres are associated with the 9 triplets of the distal centriole and the doublets of the axoneme. However, within the midpiece, only those peripheral fibres adjacent to doublets 3 and 8 remain conspicuous to the level of the annulus, each as a double structure associated with the annulated fibrous sheath. All peripheral fibres are absent from the principal piece. Similarity to the sperm of *Ctenotus* supports placement of *Nangura* in the *Sphenomorphus* group. Comparisons with other amniote sperm are made. ☐ *Nangura spinosa, Scincidae, spermatozoon, ultrastructure, phylogeny.*

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Published descriptions of the male gametes of the Scincidae are limited to a description of the mature spermatozoon of *Chalcides ocellatus tiligugu* by Furieri (1970); an account of spermiogenesis, with some description of mature, epidydimal sperm, in the same subspecies (Carcupino et al., 1989); and a very brief account of the development of the midpiece in *Eumeces laticeps* by Okia (1990). A description of the spermatozoon of the newly described genus and species, *Nangura spinosa* (see Covacevich et al., 1993), allows the addition of morphological characters from the spermatozoon to the description of this species and extends knowledge of skink spermatozoa. Comparison with the sperm of other reptiles will be limited chiefly to that necessary to determine which characters or character states appear to be, from the small sample, distinctive of the Scincidae and of this species. Although the Reptilia is an invalid, paraphyletic grouping (e.g. Jamieson & Healy, 1992), the term 'reptile' is here retained for convenience.

The ultrastructure of spermatozoa or spermiogenesis has been studied in the major groups of squamate reptiles, in addition to skinks: Lacertidae - Butler & Gabri (1984), Courtens & Depeiges (1985), Furieri (1970); Agamidae - Al-Hajj et al. (1987), Dehlawi et al. (1992), Charnier et al. (1967); Chameleonidae - Tuzet & Bourgat (1973); Iguanidae - Furieri (1974), Saita et al. (1988a); Anolidae - Clark (1967); Gekkonidae - Furieri (1970), Phillips & Asa (1993); Teiidae - Del Conte (1976), Newton & Trauth (1990, 1992); Tropiduridae - Da Cruz-Landim & Da Cruz-Höfling (1977), Furieri (1974); and Serpentes - Austin (1965), Boissin & Mattei (1965, 1966), Furieri (1970), Hamilton & Faweett (1968), Saita et al. (1988b), Phillips & Asa (1993).

Non-squamate reptiles which have been investigated are: Chelonia - De et al. (1987), Furieri (1970), Hess et al. (1991), Sprando et al. (1988), Yasuzumi & Yasuda (1968), Yasuzumi et al. (1971); Sphenodontida - Healy & Jamieson (1992), Jamieson & Healy (1992); and Crocodilia - Saita et al. (1987).

MATERIAL AND METHODS

Small pieces of testis were taken from a single specimen of *Nangura spinosa* Covacevich, Couper and James, 1993, collected from Nangur State Forest, near Murgon, SEQ. These samples were diced into 1-2mm^3 portions, and fixed for transmission electron microscopy (TEM), in 3% glutaraldehyde in 0.1M sodium phosphate buffer (pH 7.2), at 4°C for 2 hours and agitated for the first hour. The material was then rinsed in 0.1M phosphate buffer; post-fixed for 80 min in similarly buffered 1% osmium tetroxide; rinsed in buffer; dehydrated through an ascending ethanol series; and infiltrated and embedded in Spurr's epoxy resin. Sections were cut with diamond knives, on an LKB 2128 UM IV microtome. Thin sections, 50-80 nm thick, were collected on carbon stabilized, colloidin-coated, 200 µm mesh copper grids, rinsed in distilled water, stained for 30 s in Reynold's lead citrate, then in 6% aqueous uranyl acetate for 4 min and for a further 2 min in lead citrate before final rinsing. Electron micrographs were taken on an Hitachi 300 electron microscope at 75 kV and a JEOL 100-s electron microscope at 60 kV. Light microscopic observations of spermatozoa, from glutaraldehyde-fixed tissue squashes, were made under Nomarski contrast using an Olympus BH2 microscope.

RESULTS

Spermatozoa of *Nangura spinosa* (Fig. 1) are filiform, and approximately 85 µm long (mean of 10 = 85.4 µm, S.D = 2.8). A cytoplasmic droplet seen in some sperm, by light microscopy and by transmission electron microscopy, is located immediately behind or slightly overlapping the base of the nucleus. Dimensions (for one or two sperm) are: 5.5 µm for the length of the acrosome complex; 6.6 µm for the nucleus posterior to the acrosome;7.6 µm for the midpiece, from transmission electron microscopy, and, from light microscopy 66 µm for the flagellum behind the midpiece (principal piece). The head (acrosome and nucleus), and often the midpiece and flagellum, is curved (Fig. 2A). As a result of this curvature it has not been possible to obtain a complete longitudinal section through the head. The sperm is circular in cross section with the exception of the acrosome. Although the acrosome is circular at its base, anterior to this it develops a unilateral ridge and anterior to the tip of the subacrosomal cone it becomes increasingly compressed and elliptical in transverse section (Figs 2D-I).

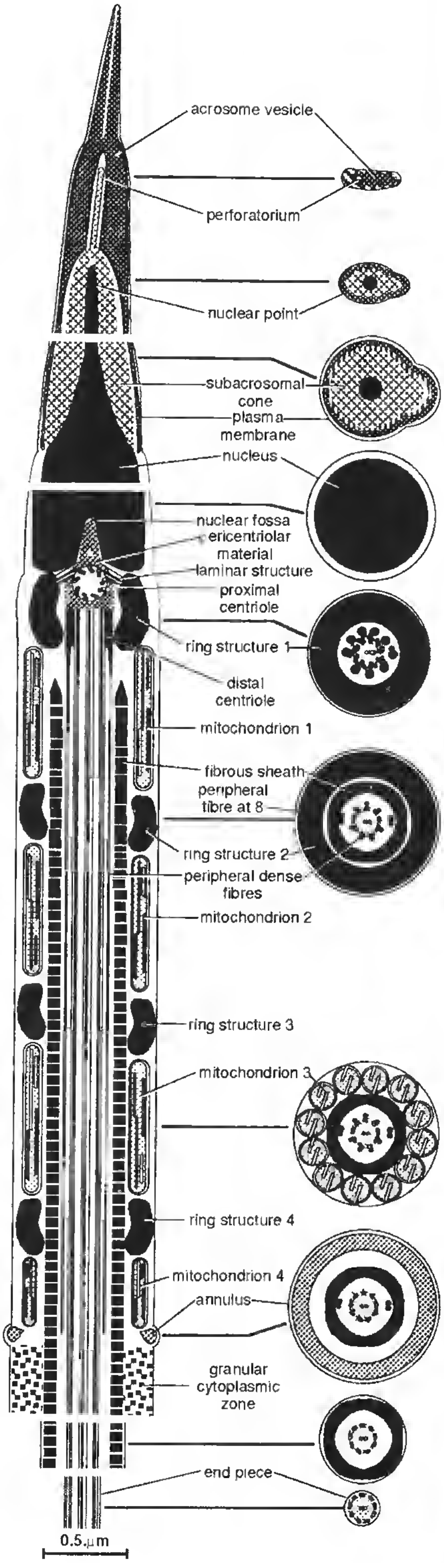


FIG. 1 *Nangura spinosa*. A diagrammatic summary of the spermatozoon viewed in longitudinal section, with the corresponding transverse sections.

ACROSOME COMPLEX

The acrosome complex consists of an acrosome vesicle in the form of an elongate hollow cone, an underlying subacrosomal cone and, axial within the acrosome vesicle, a slender rod, the putative perforatorium. The acrosome complex is 5.5 µm long (Fig. 4A). The anterior end of the vesicle, comprising slightly less than half its total length, forms a thick walled hollow cone with a narrow lumen housing the perforatorium (Fig. 2B). The longer, posterior region of the vesicle is a thin walled continuation of this hollow cone, the vesicle here being no more than a sleeve-like investment (acrosome sleeve) of the subacrosomal material, as seen in longitudinal (Figs 2B, K, 4A) or transverse section (Figs 2F-I). The underlying subacrosomal material forms a thick relatively pale layer.

The material of the subacrosomal cone is paracrystalline, its matrix having fine obliquely longitudinal and less distinct transverse striations, indicating that it forms a fine lattice (Fig. 2C). For most of its length, from its posterior end anteriorly, the subacrosomal cone invests the tapered anterior end of the nucleus (nuclear point). Although corresponding with the subacrosomal cone of other amniote and amphibian sperm, it is not strictly conical but consists of material with a poorly defined outer border which fills the posterior space within the acrosomal sleeve (Figs 2B, C, F-H, K). The nuclear point terminates within the anterior limit of the subacrosomal material at an epinuclear electron lucent region (Fig. 2K).

The perforatorium is a slender, moderately electron dense rod, with some signs of internal longitudinal fibres. It extends anteriorly from the subacrosomal material, lying in a narrow lumen internal to the inner acrosome membrane (Figs 2B, D, 4A). It has been observed to extend through approximately the posterior half of the thick walled part of the acrosomal vesicle. Whether or not a pale, central axial tube-like structure which extends to the tip of the acrosome and displays some internal longitudinal fibres is a forward continuation of the perforatorium has not been determined (Fig. 2B). The perforatorium makes contact at its posterior end with the subacrosomal material. Even allowing for the pronounced curvature of the acrosome, the longitudinal axis of the perforatorium appears to be slightly oblique relative to that of the acrosome vesicle (Figs 2B, D, 4A).

In transverse sections of the acrosome vesicle through the nuclear point and perforatorium (Figs 2D-I), the vesicle is seen to have a concentric zonation which in sequence from the perforatorium outwards is: a narrow space around the perforatorium; a wide, dense, homogeneous zone; a narrow zone with radial striations; a thin, dense, homogeneous layer apposed to the plasma membrane.

NUCLEUS

The nucleus is curved and tapers to a point within the basal region of the acrosome (acrosome sleeve). The transition from the tapered region (nuclear point) to the much longer cylindroid region is abrupt but the 'shoulders' seen in many other reptile sperm are represented only by a gentle curvature on each side. The length of the nucleus from the base of the acrosome vesicle to the base of the nucleus is 6.6 µm with a further 2.9 µm for the nuclear point which is surrounded by the subacrosomal cone (Fig. 2K). The nucleus is almost parallel sided, showing only a slight increase in width posteriad, from 0.7 to 0.9 µm, reaching its greatest width shortly before its posterior end. The cross section of the nucleus is circular throughout (Figs 2F-J, 3C). The chromatin is condensed and strongly electron dense. Basally the nucleus has a compact conical fossa which houses dense material extending from the proximal centriole (Figs 3A, C, L, 4B, D).

NECK REGION

The neck region (Figs 3A, L, 4B, D) is the region where the nucleus joins the midpiece and is here recognized by virtue of its internal components although the anterior end of the midpiece, as here defined, directly abuts the posterior end of the nucleus. The neck region includes the proximal and distal centrioles and associated densities, including the first of the ring structures of the midpiece. Each centriole consists of 9 triplets. The proximal centriole lies immediately anterior to the distal centriole and with its long axis at slightly less than a right angle to it (Fig. 4B). The long axis of the distal centriole, which forms the basal body of the flagellum, is in the long axis of the axoneme. The centrioles do not lie in the basal nuclear fossa but the proximal centriole, immediately behind this, is surmounted by a hollow conical density (dense cone) which conforms in shape with the nuclear fossa which it occupies. An electron lucent space separates it from the wall of the fossa (Figs 3C, L, 4B, D). Compact dense material extends from the base of the dense cone to cover the more axial end of the proximal centriole and insinuates itself as a large mass between the proximal and distal centrioles (Figs 3A, L, 4B, D). The two central singlets of the axoneme extend anteriad at least into the region of transition between the distal centriole and the axoneme. In this region there is a density connecting triplet 3 with the adjacent central singlet in addition to the peripheral dense fibre connected to each triplet or doublet (Fig. 3D). The peripheral dense fibre at doublet 3 is detached in some sections, indicating the commencement of the corresponding longitudinal column.

A conspicuous stratified laminar structure forms a wing-like projection on each side of the proximal centriole, near its anterior limit and is continuous around its axial pole (Figs 3A, L, 4B, C, D). It is therefore seen in some longitudinal profiles of the sperm, which are parallel to but not through the long axis of the axoneme, as a continuous wide lamina spanning much of the width of the nucleus behind the nuclear fossa (Fig. 4C). It is deduced, therefore, that the lamina forms a thick disc around the proximal centriole but that the disc is interrupted at the peripheral end of the proximal centriole. Evidence for this interpretation is also seen in some transverse sections of the neck through the proximal centriole (Fig. 4E). The outer edges of the laminar structure make contact with the first of the dense 'ring structures' of the midpiece, described below (Figs 3A, L, 4B, C, D) as does the peripheral end of the proximal centriole (Figs 4B, E).

MIDPIECE

The midpiece includes the neck, described above. It consists of mitochondria, ring structures and the contained axoneme with its fibrous sheath and ends posteriorly with the annulus.

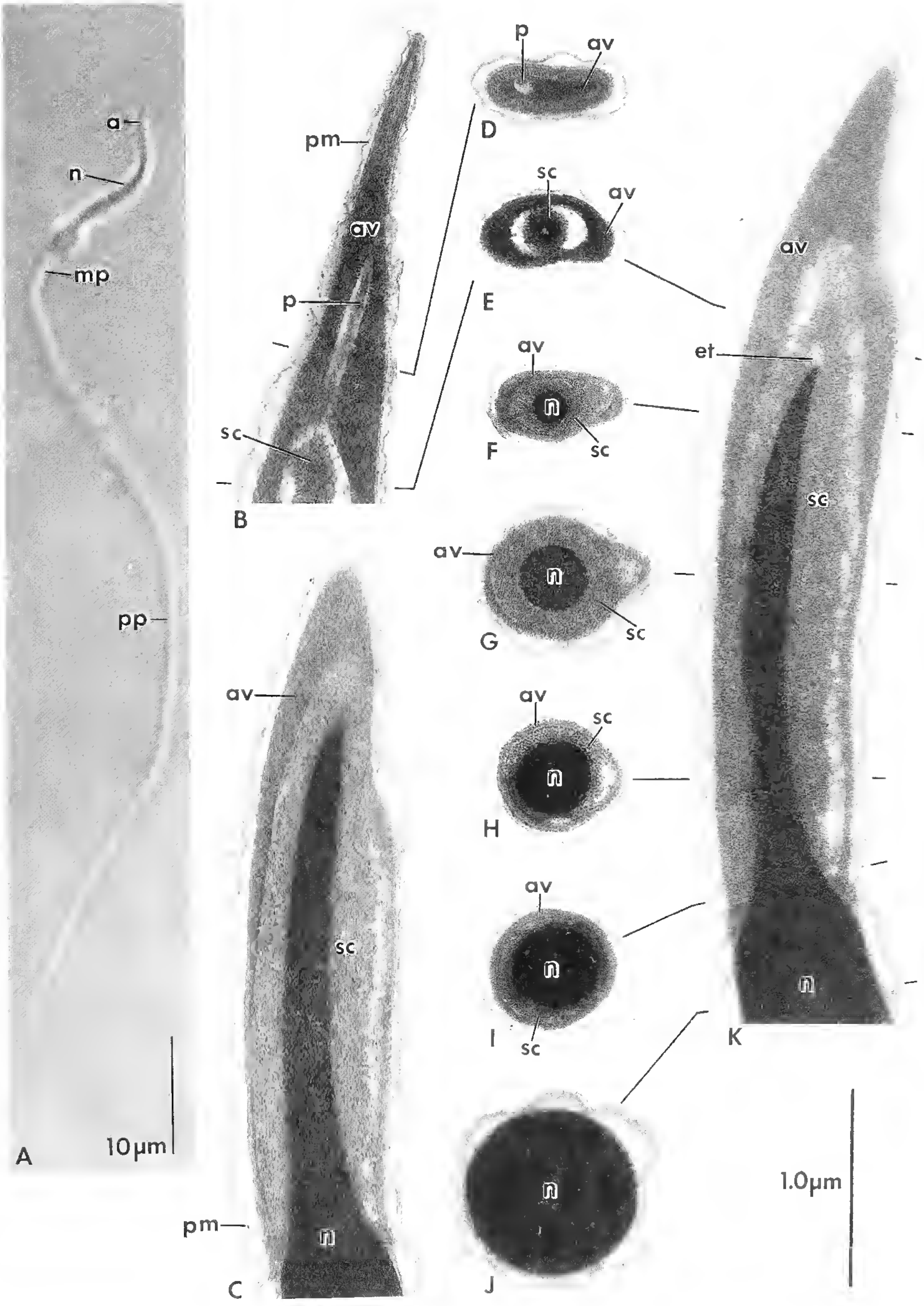
There are four ring structures (rs 1-4) in longitudinal succession, posterior to which lies the much smaller annulus (an). The ring structures, with the annulus, are separated by mitochondrial regions (mi 1-4). In terms of the pattern recognized for the teiid lizard *Cnemidophorus* by Newton and Trauth (1992), the formula for *Nangura* is rs1/mi1, rs2/mi2, rs3/mi3, rs4/mi 4, an. Each ring structure appears in longitudinal section as an approximately kidney-shaped density on each side of the fibrous sheath of the axoneme (Figs 3A, N, 4D). The profile on one side is staggered relative to that on the other, though always overlapping it, but in transverse section the ring is complete, however, when sectioned near its anterior or posterior borders interruption to the ring can be seen (Figs 3E, 4F). This indicates that each structure is a ring which is tilted relative to the axonemal axis.

The mitochondria mostly form elongate, sinuous columnar structures, with numerous predominantly longitudinal cristae, each of which extends from one ring structure to the next (Figs 3A, B, N, 4D). There are 12 or more around the axoneme as seen in transverse section (Fig. 3F). Occasional single, ovoid mitochondria are seen. A few small mitochondrial profiles are sometimes present lateral to the ring structures, the outer surface of which may be scalloped by them (Figs 3E, 4F).

The axoneme has the usual 9+2 pattern. Each doublet has two dynein arms. The A subtubule is occluded by dense material. Around the axoneme almost as far anteriorly as its junction with the distal centriole, there is a fibrous sheath. In longitudinal section (Figs 3A, B, M, N, 4D) the fibrous sheath exhibits rather regularly arranged, approximately square dense blocks which, from glancing longitudinal sections (Figs 3L, N) and transverse sections (Figs 3E-I) are shown to form rings around the axoneme. They show a tendency to tilt relative to the axonemal axis and there are interruptions in the cross sections but that they form a spiral is questionable. Occasional anastomoses of adjacent rings are seen in tangential longitudinal sections.

Nine large peripheral dense fibres are associated with the transition between the distal centriole and the axoneme (Fig. 3D) and continue posteriorly, though much narrower, along the axoneme into the midpiece (Figs 3E, F, 4D). One is attached externally to each triplet or doublet. Within the midpiece, at an undetermined level, all but two of the peripheral fibres become greatly

FIG. 2 *Nangura spinosa*. A. Whole spermatozoon (Nomarski contrast light microscopy). B. Longitudinal section (L.S) through the apical end of the acrosome showing the perforatorium. C. L.S through the basal region of the acrosome showing the nuclear point and paracrystalline matrix of the subacrosomal cone. D-I. A series of transverse sections (T.S) through the acrosome. Note that anteriorly, in D and E, the acrosome is compressed in transverse sections, while further posteriorly, in F-H, it is unilaterally ridged, and at its posterior limit, in I, it is circular. J. T.S through the nucleus. K. L.S through the basal region of the acrosome showing the epinuclear electron lucent region. B-K to the same scale, as indicated. Abbreviations a = acrosome; av = acrosome vesicle; et = epinuclear electron lucent region; mp = midpiece; n = nucleus; p = perforatorium; pm = plasma membrane; pp = principal piece; sc = subacrosomal cone.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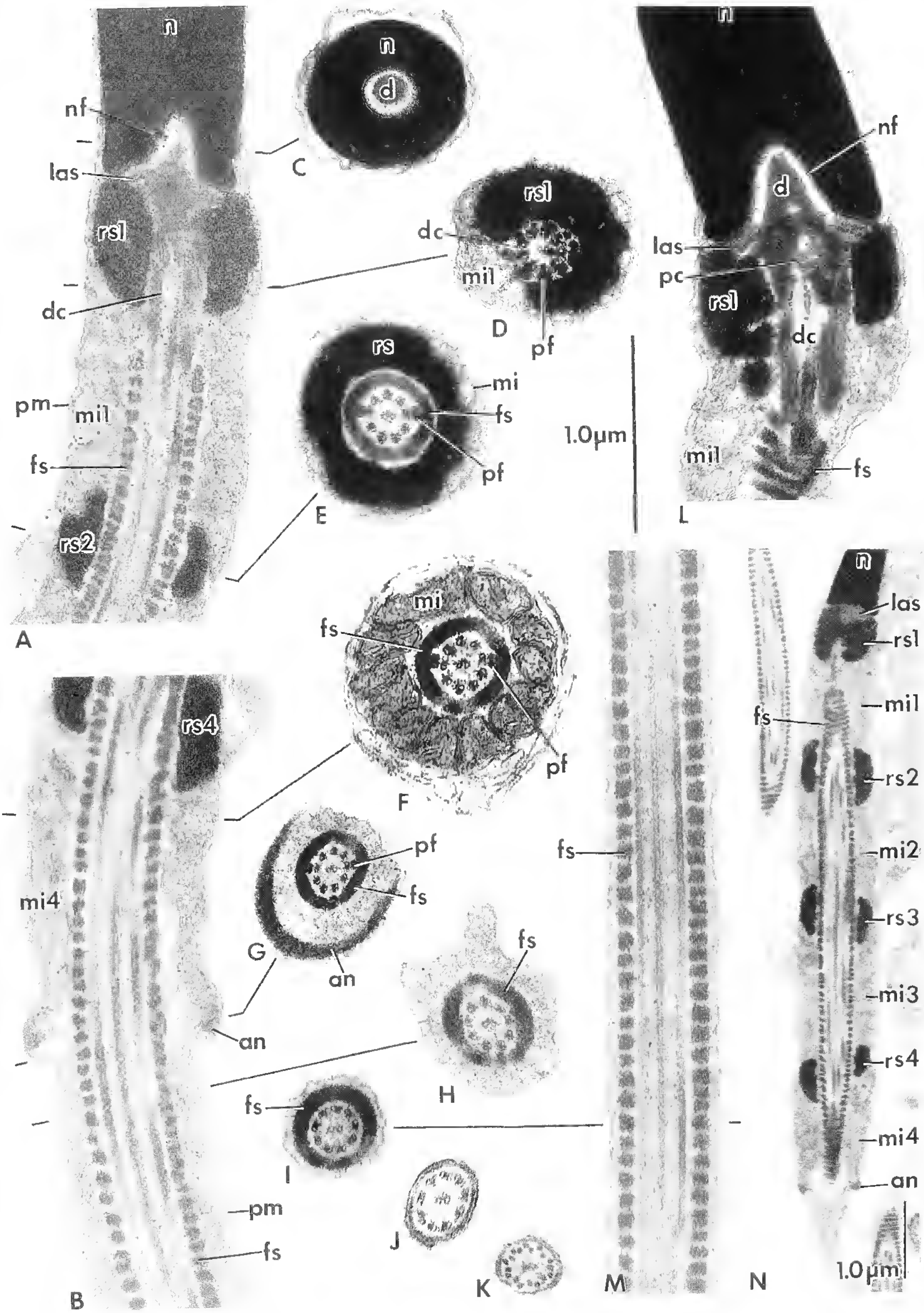
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reduced in size. Only peripheral fibres adjacent to doublets 3 and 8 remain conspicuous, as a double structure nearer the fibrous sheath than it is to its doublet (Figs 3E-G). An unspecified peripheral fibre is seen in longitudinal section at the centriolar end of the axoneme to be cross striated (Fig. 4D). The only well developed, though small, peripheral fibres at the level of the annulus are the double fibres at doublets 3 and 8 (dense columns in Fig. 1). At the beginning of the principal piece all nine dense fibres are already vestigial or absent (Figs 3G, H). They are absent from the remainder of the principal piece (Fig. 3I).

The annulus (Figs 3B, G, N) is a small dense ring with an irregular oval cross section. It is closely applied to the inner surface of the plasma membrane.

PRINCIPAL PIECE

The principal piece, the longest part of the spermatozoon, consists of the continuation, behind the midpiece, of the axoneme with its surrounding fibrous sheath and plasma membrane. It begins, immediately behind the annulus, with a short region in which a wide zone of cytoplasm intervenes between the fibrous sheath and the plasma membrane (Figs 3B, H). The cytoplasm is finely granular, giving the region some resemblance to a glycogen piece but the presence of glycogen has not been determined. Posterior to this the plasma membrane is closely approximated to the fibrous sheath (Figs 3I, M).

ENDPIECE

The axoneme projects behind the fibrous sheath as an endpiece of undetermined length (Figs 3J, K).

DISCUSSION

Extension of the fibrous sheath into the midpiece in the sperm of *N. spinosa* is an autapomorphy of the Squamata, unknown in the sperm of other reptiles (Healy & Jamieson, 1992; Jamieson & Healy, 1992) or other amniotes. Newton & Trauth (1992) are incorrect in suggesting that in *Tropidurus* sperm (Da Cruz-Landim & Da Cruz-Hofling, 1977), the fibrous sheath does not extend into the midpiece.

Nangura is placed by Covacevich et al. (1993) in the *Sphenomorphus* group of Greer (1979) which also includes *Ctenotus*. Sperm of *Ctenotus robustus* and *C. taeniolatus* have been examined by Jamieson & Scheltinga (in preparation). In the *Eugongylus* group of Greer (1979), Oliver & Jamieson (unpublished data) have examined the sperm of *Cryptoblepharus virgatus*, in the *Eugongylus* subgroup, and *Lampropholis delicata* and *Carlia pectoralis*, in the *Lampropholis* subgroup. The sequence of ring structures in the midpiece of *Nangura* make it more similar to *Ctenotus* than it is to any other examined reptile. Species of the *Eugongylus* group differ in having scattered intermitochondrial bodies (considered homologous with the ring structures) in the form of small dense irregular spheres, tortuous rods or large plates (Oliver & Jamieson, unpublished data). The sperm of *Chalcides ocellatus* examined by Furieri (1970) resemble *Nangura* in having four regularly placed intermitochondrial rings but, unlike *Nangura*, each ring consists of a circlet or small juxtaposed spherules rather than a continuous ring. *Varanus gouldii flavirufus* also has 4 dense intermitochondrial structures in longitudinal sequence. However, each 'ring' is made of many loosely aggregated large granules that do not form a continuous ring (Oliver & Jamieson, unpublished data).

In all amniote classes the acrosome plesiomorphically forms an elongate, narrow cone symmetrically located on the tip of the nucleus which it overlaps and constricts. The acrosome vesicle, with this form, encloses a similarly shaped subacrosomal cone the margins of which are poorly defined in *Nangura*. The pointed form of the acrosome, presence of the subacrosomal cone,

FIG. 3 *Nangura spinosa*. A. Longitudinal section (L.S) through the neck region showing, as a squamate autapomorphy, that the fibrous sheath penetrates the midpiece almost to the junction between the axoneme and the distal centriole. B. L.S through the midpiece-principal piece junction showing the annulus. C. Transverse section (T.S) through the nuclear fossa. D. T.S through the distal centriole-axonemal transition showing the 9 peripheral fibres associated with the triplets or doublets. E. T.S through a ring structure. F. T.S through the midpiece showing 12 mitochondria surrounding the axoneme. G. Oblique T.S through the annulus. H and I. T.S through the principal piece. J and K. T.S through the endpiece. L. L.S through the neck region showing the dense cone occupying the conical nuclear fossa. M. L.S through the principal piece. N. L.S through the midpiece showing the four ring structures and annulus separated by four sets of columnar mitochondria. A-M to the same scale, as indicated. Abbreviations an = annulus; d = dense cone; dc = distal centriole; fs = fibrous sheath; las = laminar structure; mi = mitochondria; n = nucleus; nf = nuclear fossa; pc = proximal centriole; pf = peripheral fibre; pm = plasma membrane; rs = ring structure.

and constriction of the nuclear tip are seen in the Chelonia, Crocodilia, *Sphenodon*, Squamata (as in *Nangura*), non-passerine birds (the subacrosomal cone is lost in ratites), and monotremes. These states are also seen in the Lissamphibia, including the primitive frog *Ascaphus* (Jamieson et al., 1993) and presumably characterized the common ancestor of Amphibia and Amniota.

A paracrystalline substructure of the subacrosomal cone, as in *Nangura*, has been recognized in other squamates (Butler & Gabri, 1984; Carcupino et al., 1989; Furieri, 1970), including *Ctenotus* (Jamieson & Scheltinga, in preparation). It is probably a synapomorphy, and autapomorphy, of the Squamata.

All classes of amniotes possess one or more endonuclear canals, containing one or more perforatoria, which penetrate the anterior end of the nucleus to varying depths. This condition is also seen in basal lissamphibians: urodeles (Picheral, 1967) and primitive anurans (see Jamieson et al., 1993; Sandoz, 1970). There are also endonuclear canals in *Latimeria*, and *Neoceratodus* (see Jamieson, 1991), therefore the presumed common ancestor of Amphibia and amniotes probably possessed one or more endonuclear canals. Absence of endonuclear canals is a synapomorphy of the squamates and a homoplasy of these with non-passerines and monotremes (Jamieson & Healy, 1992). However, squamates, including *Nangura*, retain a perforatorium anterior to the nucleus.

The nucleus is an elongate cylinder narrowly constricted within the base of the acrosome in some members of all amniote classes (Jamieson & Healy, 1992). This form, also seen in *Ascaphus* and urodeles (Jamieson et al., 1993), is clearly plesiomorphic for amniotes. It is widespread in reptiles, including *Nangura*.

Representation of the basal nuclear fossa is variable in amniotes. It is poorly developed in the sperm of the caiman, and is small and compact in turtles, *Sphenodon* (tuatara), rooster, guinea fowl, and squamates excepting the skinks. In skinks it

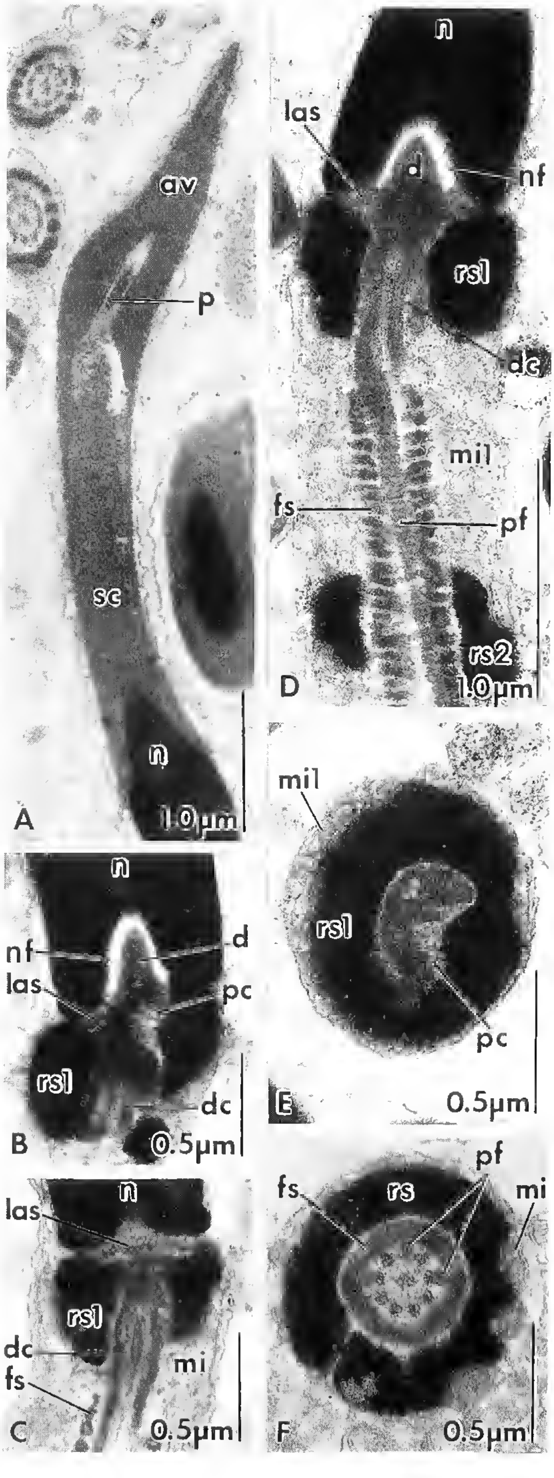

FIG. 4 *Nangura spinosa*. A. Longitudinal section (L.S) through the full length of the acrosome. B-D. L.S through the neck region showing, B, the oblique angle of the proximal centriole relative to the distal centriole, C, the laminar structure, and D, a cross striated peripheral fibre. E. T.S through the proximal centriole showing that the microtubules of the proximal centriole make contact with the ring structure. F. T.S through a ring structure showing the outer surface scalloped by small mitochondria. Abbreviations av = acrosome vesicle; d = dense cone; dc = distal centriole; fs = fibrous sheath; las = laminar structure; mi = mitochondria; n = nucleus; nf = nuclear fossa; p = perforatorium; pc = proximal centriole; pf = peripheral fibre; rs = ring structure; sc = subacrosomal cone.

is narrowly funnel-shaped or conical, as in *Nangura*. In the ratites it has a triple profile. The small and compact form may be plesiomorphic for amniotes (Jamieson & Healy, 1992).

A dense ring, the annulus, at the posterior end of the midpiece is a feature of many metazoan sperm and is clearly plesiomorphic for amniotes. It has been demonstrated, inter alia, in turtles, crocodile, tinamou, rhea, rooster, guineafowl, tuatara and monotremes. Squamates were considered exceptional in absence or at most negligible development of an annulus (Jamieson & Healy, 1992). However, an annulus has been demonstrated for *Lacerta vivipara* by Courtens & Depeiges (1985), *Cnemidophorus sexlineatus* by Newton & Trauth (1992) and for *Nangura*, and may be more widely present in squamates than previously suspected.

The number of mitochondria seen in transverse section of the midpiece, where possible near its anterior end, is very variable in amniotes. The number in chelonians, here considered the most basal amniotes, is six. A trend towards reduction to four in birds and monotremes has been observed. There are eight or nine in the tuatara, the caiman and the skink *Chalcides ocellatus* (Jamieson & Healy, 1992). In the teiid *Cnemidophorus sexlineatus* there are 8 to 10 (Newton & Trauth, 1992). In snakes, the number shows apomorphic increase to as many as 14. The number, approximately 12 in *Nangura*, is also apomorphically high.

The predominantly linear arrangement of cristae in the mitochondria of *Nangura* sperm is a usual feature of amniotes, including most reptiles. Only turtles, caiman and the tuatara, are known to be exceptional. The mitochondrial cristae in these three taxa are concentric and usually surround a large central dense body. In all other amniotes, excepting the Wooly opossum which also has concentric cristae, the cristae have a 'conventional' appearance, being linear or curved but never concentric, and do not surround a dense body. The concentric arrangement around a dense body is here considered to be an apomorphy acquired early in amniote evolution, as evidenced by its occurrence in Chelonia but later lost (Jamieson & Healy, 1992).

The intermitochondrial rings, 'ring structures' in *Nangura*, which are limited to squamates are regarded as derivations of the dense bodies of basic amniotes (Jamieson & Healy, 1992). Carcupino et al. (1989), independently concluded that the rings in *Chalcides ocellatus tiligugu*, were mitochondrial derivatives. Origin of intermitochondrial material from mitochondria has been confirmed by demonstration ontogenetically in the sperm of some squamates by Oliver & Jamieson (in preparation).

The distal centriole, forming the basal body of the axoneme, is plesiomorphically short in vertebrates, including the Lissamphibia, as in most Metazoa, and in *Nangura*. In contrast, the distal centriole extends the entire length of the long midpiece in the tuatara, turtles, crocodiles, and ratites, an apparent basal synapomorphy of amniotes. The shorter, though still elongate distal centriole in the rooster and the somewhat shorter centriole in guinea fowl, the short centriole in squamates, and the vestigial, possibly absent, centriole in monotremes possibly represent secondary reduction in length of the centriole (Healy & Jamieson, 1992).

A cross striated dense body lateral to the proximal centriole, represented by the laminated structure in *Nangura*, appears to be a basal synapomorphy of amniotes but its homology across the various groups requires confirmation. It is seen in tuatara, and the caiman where homology with the striated columns of eutherian sperm has been suggested (Healy & Jamieson, 1992). It has not been reported for sperm of birds or monotremes and the squamates but in view of its presence in *Nangura* further examination of squamates is needed.

The annulated, dense fibrous sheath seen in *Nangura* must have developed in the earliest amniotes as it is present in all amniote classes (though it is absent in some birds). Occasional anastomoses of adjacent rings are seen in tangential longitudinal sections and similar 'branching' in the snake *Lampropeltis getulus*, led Austin (1965) to propose that the annuli are linked together along one or both sides of the tail. A fibrous sheath is absent from amphibian sperm.

The isolated peripheral fibres 3 and 8 in amniotes may well be homologous with columns at this point in other sarcopterygians, the coelacanth, *Latimeria*, and Dipnoi. However, such modifications at doublets 3 and 8, which are approximately in the plane of the two central singlets, could be independent acquisitions as they presumably are in chondrichthyan sperm (references in Jamieson, 1991). In contrast with reptiles, in eutherian mammals the outer coarse fibres at 3 and 8 are the smallest and they terminate first, their place being occupied throughout most of the length of the principal piece by inward prolongations of the dorsal and ventral portions of the fibrous sheath (Hamilton & Fawcett, 1968).

Nine longitudinal dense fibres peripheral to the 9 axonemal doublets, as in *Nangura*, are a fundamental feature of amniote sperm, being found in all classes. They are an autapomorphy and simultaneous symplesiomorphy of the amniotes. The peripheral dense fibres are small in most amniotes investigated: turtles, the caiman, tuatara, squamates and monotremes. The peripheral fibres are described as 'tiny' for the rhea. They are present in suboscine and the more apomorphic oscine passerines, being larger in the latter. They are large and diverse in shape in marsupials above the didelphids, and in eutherian mammals. There thus appear to be trends to enlargement of the peripheral fibres in passerines and non-monotreme mammals, with diversification in the latter.

The peripheral fibres are usually situated in the midpiece with some extension into the principal piece as in turtles, the caiman, non-passerines, tuatara, and monotremes. In eutherians and marsupials they extend far into the principal piece. However, in *Nangura*, as in other squamates, the only well developed, though small, peripheral fibres at the level of the annulus are the double fibres at doublets 3 and 8 and by the beginning of the principal piece all nine dense fibres are already vestigial or absent. In non-passerine birds the fibres may be restricted either to the midpiece or to the principal piece or occur in both or, as in doves, are absent (Jamieson & Healy, 1992; Asa & Phillips, 1987; Jamieson, unpublished data).

In turtles, the tuatara and the skinks *Nangura* and *Chalcides* see Furieri (1970), the nine peripheral dense fibres are partly displaced from the radii of the doublets into the gaps between adjacent doublets. Their exact radial position is unknown in the crocodile and in most squamates. In contrast, the peripheral dense fibres lie in the same radius as the doublets in the rhea, at least some non-passerines (turkey) and monotremes (Jamieson & Healy, 1992).

ACKNOWLEDGEMENTS

We are grateful to Mr P.J. Couper for giving us the opportunity to obtain testicular material from a specimen of *N. spinosa*. Mrs Lina Daddow and Mr Tom Gorringe are thanked for excellent technical assistance.

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TWO NEW SPECIES OF STRIPED BLINDSNAKES

G.J INGRAM AND J.A. COVACEVICH

Ingram, G.J. & Covacevich, J.A. 1993 12 24: Two new species of striped blindsnakes. *Memoirs of the Queensland Museum* **34**(1):181-184. Brisbane. ISSN 0079-8835.

Ramphotyphlops silvia sp.nov. occurs in sand in rainforest mostly within the Great Sandy Region, SEQ. It is striped to black-and-white with 20 midbody scale rows and differs from *R. minimus* (midbody scale rows 16) and *R. chamodracaena* sp.nov (18). *R. broomi* also has 20 midbody scale rows, but has a nasal cleft that distinguishes it from *R. silvia* sp.nov. *R. chamodracaena* sp.nov. is a striped blindsnake found in the west and far north of Cape York Peninsula. Midbody scale count separates it from other striped species. ☐ *Reptilia, Serpentes, Typhlopidae, Ramphotyphlops, new species, blindsnake, Queensland, Australia.*

Glen Ingram & Jeanette Covacevich, Queensland Museum, PO Box 3300, South Brisbane, Queensland 4101, Australia; 24 September, 1993.

Blindsnakes are usually dull, virtually patternless snakes. However, some species are strongly marked, sometimes striped, e.g. *Ramphotyphlops minimus* (Kinghorn, 1929) and *R. broomi* (Boulenger, 1898). To these we add *R. silvia* sp.nov. and *R. chamodracaena* sp.nov. Striped blindsnakes are found mainly in woodlands of northern Australia. The latter new species is from northern woodlands. *R. silvia* sp.nov., however, inhabits rainforests on sand, southeastern Queensland. Measurements (mm) and scale counts here follow Storr (1981). Specimens prefixed by 'J' and 'R' are housed in the Queensland and Australian Museums respectively. Regions for Queensland follow Ingram & Raven (1991).

Ramphotyphlops silvia sp.nov.
(Figs 1, 2)

MATERIAL EXAMINED

HOLOTYPE: J27387 Seary's Scrub, Cooloola NP (25°58'S, 153°07'E), SEQ. Collected by J. Covacevich & P. Filewood, 3-6 February, 1976.

PARATYPES: J31579 Fraser Is., NP HQ; J31576-7 Fraser Is. NP, HQ on 'A' rd; J35872 Tuan SF, Firetower 6; J27386 Seary's Scrub, Cooloola NP; J43785 Cooloola NP; J23620 Cooloola, on Freshwater rd, 5km from junction; J46128 Pomona, 25km N, on rd to Rainbow Beach; J8521 Nambour. All localities in SEQ.

DIAGNOSIS

A small (maximum total length 175), striped or black-and-white *Ramphotyphlops* with 20 midbody scale rows. The nasal cleft extends up from the nostril, to about the level of the eye and nearly divides the nasal (Fig. 1).

DESCRIPTION

Total length: 72-175 (N 10, mean 143.6). Length of tail (% of total length): 2-5 (N 10, mean 3.6). Rostral (from above) elliptic, a little longer than wide, about half as wide as head and extending back to just in front of, or just between, the level of the eyes. Nasals narrowly separated behind rostral. Frontal smaller than prefrontal. Snout rounded in profile. Nostrils inferior, closer to rostral than preocular. Nasal cleft proceeding from second labial (close to the juncture of the 1st and 2nd labial) and extending vertically from nostril to about the level of eye, nearly dividing the nasal. Midbody scale rows 20 (N 10). Ventrals 272-320 (N 9, mean 293.9). Subcaudals 14-21 (N 9, mean 17.6). Dorsal and lateral surfaces with 11 thick, purplish brown stripes along body on a creamy yellow background. Mostly however, the stripes merge and and the dorsal and lateral surfaces appear evenly purplish black. Ventral surface cream to creamy yellow — one specimen has two black bands across the throat. The ventral colour contrasts strongly with the lateral colour (Fig. 2).

DISTRIBUTION

Coastal rainforest on Quaternary sands, from Fraser Is. to Noosa NP, SEQ (S. Wilson, pers. comm.), except for an old specimen from Nambour, SEQ.

ETYMOLOGY

There are two allusions. Rhea Silvia was the mother of Romulus and Remus, legendary founders of Rome. Hannah Sylvia Ingram is the mother of one of us.

REMARKS

R. silvia appears to be endemic to the Quaternary sands of coastal SE Queensland and most of its distribution falls within the Great Sandy Region. For discussions of these faunas see Kikkawa et al. (1979) and Dwyer et al. (1979).

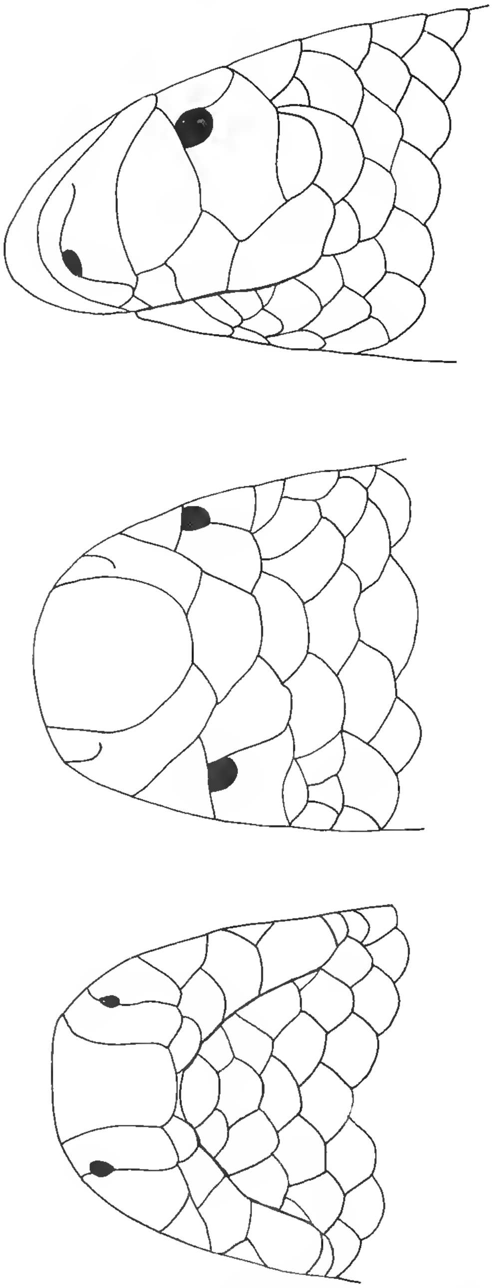

FIG. 1. *Ramphotyphlops silvia* sp.nov. (paratype J23620). Above: dorsal view of head. Centre: lateral view of head. Below: ventral view of head.

Ramphotyphlops chamodracaena sp.nov.
(Fig. 3)

1992 *Ramphotyphlops* sp. Cameron & Cogger, p.60, pl.25.

MATERIAL EXAMINED

HOLOTYPE: J40233 N Camp 'Beagle', ca.40km N Aurukun (13°05'S, 141°59'E), Cape York Peninsula. Collected by G. Ingram & P. Webber, 18 March, 1982.

PARATYPES: J31963 Weipa, Andoom Mine; J41550 Weipa; R91631 Rocky Pt, Weipa; R93164 Weipa; J28082 Lockhart R. Settlement; J39673 N Camp 'Beagle', 15km from camp on rd to Watson R.; J51980 Inkerman Stn. All localities are on Cape York Peninsula.

DIAGNOSIS

A small (maximum total length 210), striped *Ramphotyphlops* with 18 midbody scale rows. The nasal cleft extends diagonally up from nostril to terminate about halfway between nostril and rostral (Fig. 3).

DESCRIPTION

Total length: 114-210 (N 8, mean 164.3). Length of tail (% of total length): 1-3 (N 8, mean 1.8). Rostral (from above) elliptic, a little longer than wide, about half as wide as head and extending back to just in front of, or just between, the level of the eyes. Nasals narrowly separated behind rostral. Frontal smaller than prefrontal. Snout rounded in profile. Nostrils inferior, closer to rostral than preocular. Nasal cleft proceeding from second labial and extending diagonally up from nostril to terminate shortly about halfway between nostril and rostral. Midbody scale rows 18 (N 8). Ventrals 464-523 (N 7, mean 486.1). Subcaudals 14-16 (N 8, mean 15.1). Dorsal, lateral and ventral surfaces usually totally striped (18 stripes along body, but one specimen has 16). Stripes are dark to light brown on a yellowish cream to off-white background. Tail black and, in some specimens, the head is black. For a colour photograph, see Cameron & Cogger (1992, pl.25).

DISTRIBUTION

Western Cape York Peninsula from Weipa south to Inkerman Station. Also recorded from Lockhart R. Settlement on the east coast. Inhabits woodland, but Cameron & Cogger (1992) also note that its occurrence on lawns after watering.

ETYMOLOGY

'Chamodracaena' (earth snake) was one of the 12½ names of the female demon Gello (Stoneman, 1991).

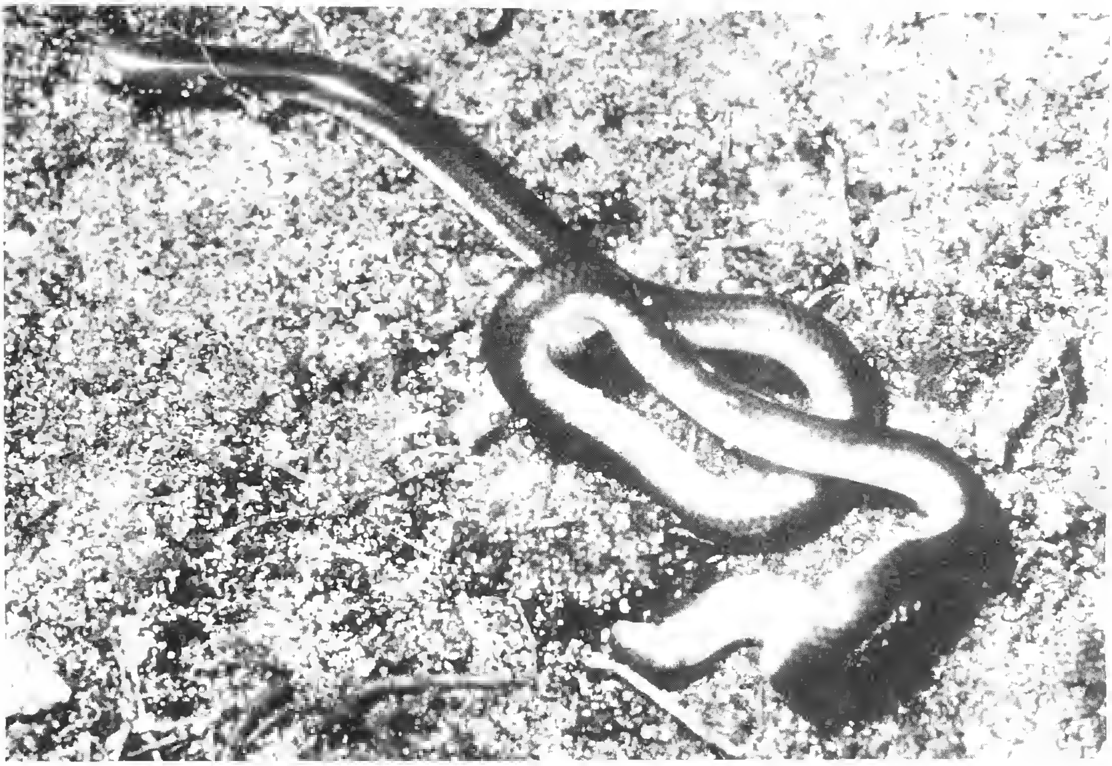

FIG. 2. *Ramphotyphlops silvia* sp.nov. Pile Valley, Fraser Is., August, 1993 (S. Wilson).

REMARKS

Most of the publications on Australian blindsnakes have followed Waite (1918). His paper was an important beginning, but his 'species' are sometimes not easily recognised. It is also difficult to recheck his work, because no registration numbers are given for his specimens and there are no data on where they are housed.

The identity of *R. broomi* (Boulenger, 1898) is a case in point. Waite examined five specimens and referred them to Boulenger's taxon. These came from Queensland, Victoria and Western Australia. However, Storr (1981) made no mention of *broomi*, or any other striped species, in his revision of the Western Australian blindsnakes. As well, we cannot be confident that we have examined any specimens of Waite's *broomi*. Thus we are unsure of his concept of the taxon.

Even so, in northeastern Queensland, there is a small blindsnake known only from the area between the western edge of the Atherton Tableland and Cooktown. It matches Boulenger's description ('20 scales round the body. Pale buff above, with 11 brown streaks following the series of scales, white beneath') and is found near the type locality of *R. broomi*, Muldiva, NEQ. However, we cannot be completely sure of the identity until the holotype of *Typhlops broomi* in the Natural History Museum, London, can be examined. For this paper, we have assumed that this taxon is *R. broomi*. If it is, considering the localities Waite gave, we are confident that none of his specimens were *broomi*, because that species appears to be restricted to the dry belt along the western edge of the Wet Tropics. The confusion with the identity of *R. broomi* is evident in Wilson & Knowles (1988). Their '*R. broomi*' (pl.827) is not *R. broomi* as we understand it. However, their photograph of *Ramphotyphlops* sp. (pl.847) appears to be true *R. broomi*. This is J47254 from Cooktown — S. Wilson, pers. comm.

R. chamodracaena is most similar to *R. broomi* and *R. minimus*. However, besides the smaller number of midbody scale rows (18 vs 20), *R. chamodracaena* is usually striped all round the body while *R. broomi* is not striped ventrally (number of stripes 16-18 vs 11-15). Cameron & Cogger (1992) have discussed the similarities and differences between *R. chamodracaena* (as *Ramphotyphlops* sp.) and *R. minimus*, a species with 16 midbody scale rows.

OTHER MATERIAL EXAMINED

R. broomi: J46849 Cooktown, James Cook Museum Building; J47254 Cooktown; J20315 Mt Molloy; J2953-4, 47503 Atherton Tblds, Stannary Hills, nr Herberton; J53305 Mt Rosey, 15 mile Ck camp; R128220 Mandalee, Innot Hot Springs. All localities in Cape York Peninsula and NEQ. *R. minimus*: R9692 Groote Eylandt, NT (holotype); R9693, R61025-6 (paratypes) same data as holotype.

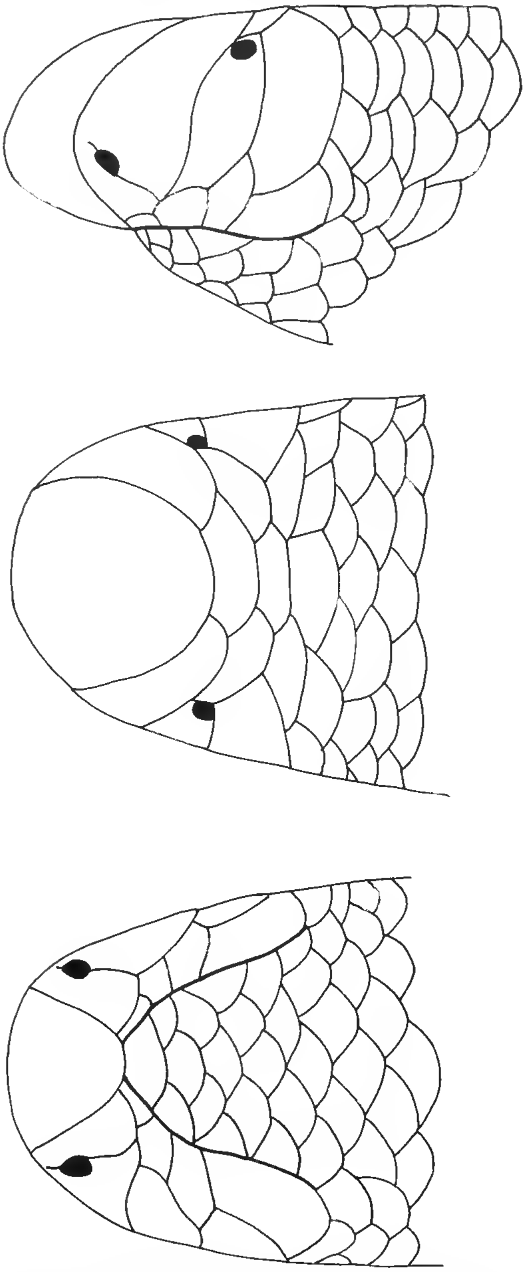

FIG. 3. *Ramphotyphlops chamodracaena* sp.nov. (paratype J39673). Above: dorsal view of head. Centre: lateral view of head. Below: ventral view of head.

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NEW REPTILE RECORDS FROM RAINFORESTS OF SOUTH AND MIDEASTERN QUEENSLAND

J. A. COVACEVICH, P.J. COUPER AND G.J. INGRAM

Covacevich, J.A., Couper, P.J. & Ingram, G.J. 1993 12 24: New reptile records from rainforests of south and mideastern Queensland. *Memoirs of the Queensland Museum* **34**(1):185-187. Brisbane. ISSN 0079-8835.

Recent surveys of 13 previously unsurveyed small rainforests of south and mideastern Queensland have refined knowledge of the distribution of many reptile species. *Nangura spinosa* gen. et sp.nov., *Lygisaurus zuma* sp. nov., *Phyllurus isis*, *P. nepthys* and *P. ossa* spp. nov. have been described largely as a result of this survey. ☐ *Survey, reptiles, rainforest, Queensland, Australia.*

J.A. Covacevich, P.J. Couper & G.J. Ingram, Queensland Museum, PO Box 3300, South Brisbane, Queensland 4101, Australia; 17 July, 1993.

Following a decade of fairly intense research, moist, near-coastal rainforest reptiles are now probably better known than those of other habitats in Queensland. Many new species have been described from Queensland's notophyll and mesophyll vine forests, and revisionary work on several rainforest genera has now been completed or is nearly so. Nowhere has the product of well-organized rainforest research been more evident than in the Wet Tropics, recently (1988) placed on the World Heritage Register. Since 1979, 13 of the 20 reptile species endemic to those rainforests have been described (Covacevich, in press). From recent descriptions and revisions, from reference collections (notably of the Queensland and Australian Museums), and from the earlier literature, it has been possible to review distributions of many rainforest species, at least to the extent of defining their north-south limits and commenting on aspects of their zoogeography and conservation (Covacevich & McDonald, 1991; Covacevich, in press).

Much is known as a result of collecting undertaken either randomly or in surveys in the large rainforests. Major surveys (e.g. Anonymous, 1976; Broadbent & Clark, 1976; Queensland Museum, 1977) have focussed on larger tracts of rainforest. In these studies mideastern Queensland rainforests have not generally received the same attention as those further north or south, so their reptile species are not so well known. In south and mideastern Queensland, there are many small, isolated rainforests about which nothing herpetological is known. Semievergreen vine thickets, particularly, are poorly known and have been reduced by clearing for agriculture (Forster, et al., 1991).

In 1991, our proposal to the National Rainforest Conservation Programme to make small collections of reptiles in previously unsurveyed rainforests of south and mideastern Queensland was approved for funding. The object was to add to knowledge of the distribution of rainforest reptiles, particularly the less well-known species. Our study sites were selected from areas from which there were no museum records of reptiles. No attempt was made to ensure the sites were comparable in terms of size, soil type, aspect, season or survey time, because our interest in the reptile species was purely discovery. Replication was not considered necessary. Four-ten 'man' days were spent collecting reptile specimens at most sites, using conventional methods of rolling logs and rocks, and peeling bark and 'working' sun patches. Spotlighting was undertaken at all sites. At some very small rainforests (e.g. Warriwillah, a remnant of the now-cleared Isis Scrub) only one day was spent. In the species list (Table 1) the number of 'man' days spent at each is indicated in brackets. These records are not, and are not intended to be complete. Rather, they are a small contribution to knowledge of the distributions of some of the species of reptiles.

For most species, voucher specimens have been lodged in the Queensland Museum. A species name not accompanied by a 'J' number is based on sight record only, always by at least one of us. Collection sites are arranged north to south.

NEW INFORMATION

This work to improve the accuracy of distribution data for reptiles in south and mideastern Queensland has made returns beyond our expec-

TABLE 1. Some small, previously-unsurveyed rainforests of south and mideastern Queensland: reptile records from October, 1991 to April, 1993.

MT OSSA 20°56' 148°49', MEQ (6) notophyll vine forest: *Phyllurus ossa* (J53443-7, J53507), *Oedura ocellata* (J53463), *Carlia rhomboidalis* (J53456-61), *Eulamprus amplus* (J53465, J53531-2), *E. tenuis* (J53466), *Lampropholis adonis* (J53452-4, J53462), *Saproscincus spectabilis* (J53508), *Physignathus lesueurii* (J53533), *Morelia spilota*, *Boiga irregularis*, *Dendrelaphis punctulata* (J53442), *Demansia psammophis* (J53440-1).

COFFEE CREEK, MT JUKES 21°00' 148°57', MEQ (10) notophyll vine forest: *Phyllurus isis* (J53485-6, J53518), *Anomalopus verreauxi* (J53600), *Carlia rhomboidalis* (J53562-4, J53576-81), *Eulamprus amplus* (J53523), *E. quoyii*, *Lampropholis adonis* (J53565, J53570-5, J53608-10), *Saproscincus spectabilis* (J53566-7, J53582-4, J53611-2), *Physignathus lesueurii* (J53595), *Morelia spilota* (J53593), *Dendrelaphis punctulata* (J53515), *Cacophis squamulosus* (J53516), *Demansia psammophis* (J53487, J53585).

ST HELEN'S GAP, VIA MT CHARLTON 21°00 148°43', MEQ (3) notophyll vine forest: *Phyllurus ossa* (J53426-8), *Carlia rhomboidalis* (J53429-31), *Eulamprus amplus* (J53471-2), *E. tenuis* (J53473), *Lampropholis adonis* (J53432-4), *Saproscincus spectabilis* (J53435-9), *Varanus varius*, *Boiga irregularis* (J53425).

MT CHARLTON (foothills) 21°01' 148°44', MEQ (9) notophyll vine forest: *Oedura* cf. *tryoni* (J53412), *Phyllurus ossa* (J53389-90, J53414), *Carlia rhomboidalis* (J53402-7, J53415), *Eulamprus amplus* (J53399-400, J53828-30), *E. tenuis* (J53401, J53416) *Lampropholis adonis* (J53410-11, J53417-21),*Saproscincus spectabilis* (J53408-9, J53422-4) *Varanus varius*, *Morelia spilota*, *Demansia psammophis*.

MT BLACKWOOD NATIONAL PARK 21°02' 148°56', MEQ (9) notophyll vine forest: *Oedura ocellata* (J53479), *Phyllurus isis* (J53480, J53511-2, J53591, J53602-3), *Carlia rhomboidalis* (J53474-5, J53514, J53559-60), *Eulamprus amplus* (J53485, J53513), *Lampropholis adonis* (J53476-8, J53483, J53558), *Saproscincus spectabilis* (J53481), *Morelia spilota* (J53606), *Boiga irregularis* (J53510, J53522), *Cacophis harriettae* (J53526), *Rhinoplocephalus nigrescens* (J53607).

ROCKY DAM CREEK via Crediton Site 1 21°18' 148°32', MEQ (4) notophyll vine forest: *Oedura ocellata* (J53333), *Phyllurus nepthys* (J53330-2), *Eulamprus tenuis* (J53334-5), *Lampropholis adonis* (53336-50) *Varanus varius*. Site 2 21°19', 148°34' (3) notophyll vine forest: *Phyllurus nepthys* (J53359-62), *Carlia rhomboidalis* (J53352-4, J53363-6), *Eulamprus amplus* (J53358, J53827), *E. tenuis* (J53356-7), *Lampropholis adonis* (J53355, J53367-78), *Saproscincus spectabilis*, *Physignathus lesueurii*, *Varanus varius*, *Dendrelaphis punctulata* (J53351),

EAST FUNNEL CREEK 21°36' 149°12', MEQ (8) notophyll vine forest: *Carlia rhomboidalis* (J53489-91, J53496, J53501-2), *Eulamprus quoyii* (J53534), *Lampropholis adonis* (J53492-3, J53498, J53500, J53503-6, J53613), *Saproscincus spectabilis* (J53497, J53601, J53614), *Physignathus lesueurii* (J53494), *Morelia spilota* (J53319), *Boiga irregularis* (J53509), *Demansia psammophis* (J53524).

WEST HILL CREEK headwaters, Connors Range 22°51' 149°18', MEQ (2) notophyll vine forest: *Carlia rhomboidalis* (J53537-8), *Lampropholis adonis* (J53539-50), *Boiga irregularis* (J53530).

KA KA MUNDI/SCRUBBY CREEK 24°50' 147°25', SCQ (6) semievergreen vine thicket: *Gehyra catenata*, *Lialis burtonis*, *Anomalopus brevicollis* (J56037-41), *A. leuckartii* (J56042-3, J56061), *Carlia pectoralis* (J56035, J56046), *Cryptoblepharus virgatus* (J56034), *Ctenotus taeniolatus* (J56044, J56062) *Eulamprus martini* (J56065-6, J56083-4), *Lerista fragilis* (J56063), *L. punctatovittata* (J56090), *Gemmatophora nobbi* (J56060), *Morelia maculosa* (J56071), *Dendrelaphis punctulata*, *Rhinaplocephalus nigrescens* (J56052).

KA KA MUNDI, PACKSADDLE SPRING 24°50' 147°27', SCQ (1) semievergreen vine thicket: *Gehyra catenata* (J56057), *G. dubia* (J56058-9), *Anomalopus leuckartii* (J56055), *Lerista fragilis* (J56056).

WARRIWILLAH, via Cordalba 25°06' 152°13', SEQ (1) notophyll vine forest (riverine): *Calyptotis scutirostrum* (J57242-3), *Lygisaurus foliorum* (J57244), *Ophioscincus cooloolensis* (J57240-1) *Physignathus lesueurii*, *Boiga irregularis*, *Tropidonophis mairii*.

NANGUR STATE FOREST 26°07' 151°58', SEQ (9) semievergreen vine thicket: *Anomalopus verreauxii* (J55996), *Calyptotis scutirostrum* (J56001-8) *Carlia vivax* (J56009), *Ctenotus arcanus* (J56024), *Lampropholis amicula* (J57245), *Nangura spinosa* (J56029, J56031, J57246, J57247), *Morethia taeniopleura* (J56028), *Saiphos equalis* (J55997-600, J56027, J56030), *Gemmatophora nobbi* (J56025),*Varanus varius*, *Dendrelaphis punctulata*, *Rhinoplocephalus nigrescens* (J56026).

MISTAKE MOUNTAINS 27°55' 152°20', SEQ (2) notophyll vine forest: *Cautula zia* (J31320), *Coeranoscincus reticulatus* (J54646-50), *Lampropholis delicata* (J54436), *Saproscincus challengeri* (J32276-7), *Physignathus lesueurii* (J54438), *Morelia spilota* (J54437), *Hemiaspis signata* (J54439), *Tropidechis carinatus* (J54434).

tations. New species have been collected; new data published on *Coeranoscincus reticulatus* and *Morelia spilota*; and the range of *Eulamprus amplus* has been extended. Most significant was the discovery of *Nangupa spinosa*, a distinct spiny lygosomid, by Cameron James and Mark Fletcher in Nangur State Forest, a remnant patch of semievergreen vine thicket (Covacevich et al., 1993). Most of the type specimens of *Lygisaurus zuma* Couper, 1993 were collected at Boulder Creek, near Mt Charlton, MEQ, in open forest during this survey; *Phyllurus isis* and *P. ossa* Couper et al., 1993 were described from specimens discovered in this survey, and *P. nepthys* Couper et al., 1993 has been described following re-examination of existing material and of new specimens found on this survey.

Coeranoscincus reticulatus is a rare skink (McDonald et al., 1991) occurring narrowly in southeastern Queensland and northeastern New

South Wales rainforest. As a result of work on the Mistake Mountains, Couper et al. (1992) have described the nest, eggs and young of this species.

Morelia spilota is a well-known predator of mammals and birds. In October, 1991 at East Funnel Creek, 21°37', 149°12', near Sarina MEQ, Covacevich & Couper (1992) found a large male *M. spilota* dead, following ingestion of a large specimen of the Cane Toad, *Bufo marinus*. *M. spilota* does not prey upon *B. marinus* under normal conditions. This discovery confirms previous anecdotal accounts.

Eulamprus amplus was described (Covacevich & McDonald, 1980) from two populations - Eungella and Conway National Parks, via Mackay and Proserpine, MEQ. It has been rated as 'rare' (McDonald et al., 1991). It is now known to occur in several intervening areas of rainforest, although its conservation status remains unchanged by the new records.

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POSSUM ASSEMBLAGES IN RAINFOREST OF THE CARBINE UPLANDS, NEQ, WITH SPECIAL REFERENCE TO *HEMBELIDEUS LEMUROIDES*. *Memoirs of the Queensland Museum 34(1):188. 1993:-* Four ringtail possum (Pseudocheiridae) species are confined to the upland rainforests of northeastern Queensland's Wet Tropics. These are the Lemuroid Possum (*Hemibelideus lemuroides*), Green Possum (*Pseudochirops archeri*), Daintree Ringtail (*Pseudocheirus cinereus*) and Herbert River Ringtail (*P. herbertensis*). At least five other, wider-ranging species (the Long-tailed Pygmy Possum, *Cercartetus caudatus*; Striped Possum, *Dactylopsila trivirgata*; Common Ringtail, *P. peregrinus*; Sugar Glider, *Petaurus breviceps* and Coppery Brushtail, *Trichosurus vulpecula johnstonii*) are also regularly encountered. These high altitude rainforests are not uniformly distributed. Mountainous terrain divides the area into discrete blocks, montane subregions (sensu Winter et al., 1984; Winter, 1991). A major altitudinal discontinuity exists between the Atherton Tableland and the Carbine Uplands. Geographic separation is evident for upland obligate fauna unable to negotiate the relatively low altitude Black Mountain rainforest corridor connecting them. With isolation, allopatric speciation has occurred. This is reflected in the separation of *P. cinereus*, of the Carbine Uplands (Murray et al., 1989), from *P. herbertensis* of the Atherton Tableland. The former was known as the ashen-coloured race or subspecies of *P.herbertensis* .

Vehicular spotlight runs were conducted along the Mt Lewis Forestry Rd (approximately 110km NW Cairns, NEQ) during the summers of 1986/87 and 1987/88. Altitudes between 500-1200 m were surveyed during 13 spotlight traverses, averaging approximately 6km and 2 hours duration. Most of this survey was undertaken at altitudes exceeding 900m (19.75 hours) with only 6.75 hours of survey carried out below this. Only when possums could be positively identified were they accepted and recorded. Altitudes were recorded by altimeter. This method was employed to detect changes in possum density and community make-up with changes in altitude along the traverse. In addition, it was anticipated that a sufficient number of *H. lemuroides* sightings could be obtained to estimate the relative proportion of leucist individuals within the population, and provide evidence to support or refute the suggested lower altitudinal limit of 900m (Winter et al., 1984) of the Carbine population. Results of the survey are summarised in Table 1.

While only four possum species were recorded during the period of the survey (Table 1), an additional two species are known to occur in rainforests of the Carbine Uplands. The species *C. caudatus* and *P. breviceps* are recorded only occasionally. The numerically dominant species within all altitudinal bands between 501-1100 was *P. cinereus*. Above 1100m, more *H. lemuroides* were recorded. A general trend of increasing possum abundances with increasing altitude was partially due to this sudden appearance of *H. lemuroides* at the higher elevations. The lowest elevation at which *H. lemuroides* was recorded was 1070m. If such a lower altitudinal limit is consistent for the entire northern population isolate of this species, it may indicate a restricted relictual distribution and lengthy separation from the population on the Atherton Tableland. The incidence of leucism among this population was high, 31.56% of individuals recorded.

TABLE 1. Possums on Mt Lewis Rd, Carbine Uplands.

Altitude (m)	*P.cinereus*	*H.lemuroides* (dark/pale)	*P.archeri*	*D.trivirgata*	Total per spotlight hour
1101-1200	65	98 (66/32)	1		16.40
1001-1100	34	3(3/0)	2	1	7.27
901-1000	18		1	1	4.71
801-900	13		2		5.00
701-800	4		1		2.00
601-700	2				2.67
501-6002					4.00
Totals	138	101 (69/32)	7	2	9.36

The rainforest possum assemblage of the Carbine Uplands differs in several ways from that of the Atherton Tableland. Replacement of *P. herbertensis* with *P. cinereus*, and absence of *T. vulpecula johnstonii* from the Carbine Uplands are significant differences. Leucism in the Atherton population of *H. lemuroides* is also a rarity. One biologist noted only three pale individuals in thousands of records made over a period of 6 years of upland possum research on the Atherton Tableland (N. Goudberg, pers. comm.). Further, the suggested lower altitudinal limit of 480m (Winter et al., 1984) is substantially lower for Atherton Tableland *H. lemuroides* than both the suggested Carbine Uplands lower limit of 900m (Winter et al.,1984) and 1070m, which was the lowest record made in this survey. (Many hours of traverse prior and subsequent to those reported here have failed to reveal any *H. lemuroides* at lower elevations). These observations suggest investigation of the taxonomic status of animals from the northernmost population would be worthwhile.

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DISTRIBUTION AND CONSERVATION OF FROGS AND REPTILES OF QUEENSLAND RAINFORESTS

J.A. COVACEVICH AND K.R. McDONALD

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Forty-six species of frogs and 95 species of reptiles are now known from the wet and dry rainforests of Queensland. Close to 70% of frog species and 63% of reptile species are well protected; nearly 20% of frog and reptile species are still either poorly or not protected in reserves.
Conservation programmes for Queensland's rainforest frog and reptile species must address the following problems: unexplained declines in frog populations; survey of moist rainforest on Moa Is.; protection of moist rainforest at Somerset and the McIlwraith Ra., FNEQ, and of dry rainforests; and the paucity of ecological data on most species.
Many new species of frogs and reptiles have been described in the last decade, and the herpetofauna of Queensland's rainforests is now well-known taxonomically. It is important that research on this group not consume an excessive proportion of the research resources, to the detriment of the futures of other taxa and habitats. ☐ *Australia, rainforest, frogs, reptiles, declining frogs, conservation, Wet Tropics, distribution.*

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A review of patterns of occurrence and conservation of frog and reptile species restricted to tropical and subtropical moist rainforests of eastern Australia has been published recently (Covacevich & McDonald, 1991). That review was based essentially on museum specimens and references available in the early 1980s, and submitted for publication in 1984. The period 1984-1990 was a very active one for research on Queensland's rainforest frogs and reptiles and, while some up-dating was possible while the paper was in press, much that was new could not be included.

This work is both narrower and broader than the previous study. Here, we confine ourselves to Queensland rainforests, because most of what is new regarding rainforest frog and reptile species has been discovered in Queensland. However, in addition to obligate rainforest species we include all species recorded in rainforests. Further, we have adopted a broader definition of rainforest, including both 'wet rainforests' (vine forests and fern forests of all types) and 'dry rainforests' (= deciduous and semi-deciduous vine thickets).

As well as incorporating data on facultative rainforest species (along with the obligate rainforest species), this review includes data of Greer et al., 1983 (*Lerista vittata*); Greer, 1985 (*Sphenomorphus cracens*); Wells & Wellington, 1985 (many spp., including *Cacophis churchilli* and *Saltuarius swaini*); Greer & Cogger, 1985 (*Anomalopus* and *Ophioscincus* spp.); Zweifel, 1985 (microhylid frogs); Davies et al., 1986 (*Litoria xanthomera*); Corben & Ingram, 1987 (*Mixophyes fleayi*); Ingram & Covacevich, 1988 (*Lygisaurus* spp.); Ingram & Covacevich, 1989 (*Carlia* spp.); Ingram, 1991 (*Lampropholis* spp.); Sprackland, 1991 (*Varanus teriae*); McDonald, 1992 (conservation of northern rainforest frogs); Greer, 1992 (*Eulamprus tenuis* group); Couper et al., 1993 (*Saltuarius* spp. and *Phyllurus* spp.); Covacevich et al., 1993 (*Nangura spinosa*); and Sadlier et al., 1993 (*Saproscincus challengeri* species complex); Richards et al., 1993 (*Litoria eucnemis, L. genimaculata*). Since the 1980s the results of frog/reptile surveys in previously unknown or poorly known rainforests have been published (e.g. Horsup et al., 1993; Covacevich et al., 1993). These are incorporated, along with additional records compiled incidentally by one of us (KMcD).

New data has been combined with that known previously into a list of frog and reptile species recorded from Queensland's rainforests sensu lato (Table 1). For each species are provided: ranges in both latitude and altitude; notes on habitat; conservation status; and level of habitat protection.

DISTRIBUTION

In assessing the species for inclusion in Table 1, three categories of reptiles and frogs occurred only occasionally in rainforest and are not considered further: open vegetation species which were using patches of rainforest or gallery forest as dry season refugia (e.g. *Bufo marinus, Limnodynastes ornatus, Litoria bicolor, L. gracilenta, L. nigrofrenata, L. rothii, Sphenophryne gracilipes, Glaphyromorphus pumilus, Lygisaurus macfarlani, L. sesbrauna)*; species occurring on rainforest margins or utilising natural openings such as rock faces and scree slopes (e.g. *Heteronotia binoei, Oedura rhombifer, Dendrelaphis calligastra, D. punctulatus, Tropidonophis mairii, Demansia torquata, Morelia maculosa*); species entering rainforest which has been disturbed by roads, logging, mining or real estate (e.g. *Bufo marinus, Litoria nasuta, Limnodynastes peronii, Litoria nigrofrenata, Lialis burtonis, Heteronotia binoei, Oedura rhombifer, Carlia longipes, C. rostralis, C. pectoralis, Tropidonophis mairii, Morelia maculosa, Demansia psammophis, D. torquata*).

Conservation status was determined using the definitions of Thomas and McDonald, 1989. Level of habitat protection is defined: well protected (recorded from several conservation reserves, or all or most of the population in reserves); moderately protected (found in more than two reserves); poorly protected (only recorded from one or two reserves); unprotected (not on any reserves).

Table 1. Frog and reptile species recorded from Queensland's wet and dry rainforests, based largely on records of the Queensland Museum, the literature and observations by KMcD.

FROGS

Myobatrachidae

Adelotus brevis (Gunther 1863): Eungella NP, MEQ; Byfield, MEQ -Grove Ck, NSW; 21° 00'S, 148° 35'E - 21° 11', 148° 35'; 22° 50', 150° 41' - 33° 50', 148° 23'; sea level - 1000+m; subtropical vine forest, also heaths, moist forests and moist sandstone gorges of sub-coastal upland areas; secure; well protected.

Assa darlingtoni (Loveridge 1933): Conondale Ra., SEQ - Gibraltar Ra., NENSW; 26° 37'S, 152° 35'E - 29° 36', 152° 13'; usually above 1000m, infrequently to 300m; subtropical vine forest; rare; moderately protected.

Kyarranus kundagungan Ingram & Corben, 1975: Mistake Mtns - Mt Superbus, SEQ; 27° 55'S, 152° 20'E - 28° 12', 152° 29'; 300 - 1000m; subtropical vine forest; rare; well protected.

Kyaranus loveridgei (Parker, 1940): McPherson Ra., SEQ - Mt Warning, NENSW; 28° 15'S, 153° 15'E - 28° 24', 153° 16'; above 750m; subtropical vine forest; rare; well protected.

Lechriodus fletcheri (Boulenger, 1890): Cunningham's Gap, SEQ - near Gosford, NSW; 27° 58'S, 152o 25'E - 33° 25', 151° 20'; above 750m; subtropical vine forest; secure; well protected.

Mixophyes fasciolatus Günther, 1864: Eungella NP, MEQ; 20° 50'S, 148° 28'E - 21° 11', 148° 32'; Kroombit Tops, MEQ - Gosford, NSW; 24° 24',151° 00' - 33° 25', 151° 17'; sea level - 1100m; subtropical vine forest, adjacent moist open forests; secure; well protected.

Mixophyes fleayi Corben and Ingram, 1987: Conondale Ra., SEQ - Tooloom Scrub, NSW; 26° 30'S, 152° 37'E - 28° 40', 152° 30'; 620m+; subtropical vine forest; insufficiently known; poorly protected.

Mixophyes iteratus Straughan, 1968: Conondale Ra., SEQ - Narooma, NSW; 26° 37'S, 152° 35'E - 36° 13', 150° 09'; 100 - 1000m; subtropical vine forest; insufficiently known; poorly protected.

Mixophyes schevilli Loveridge, 1933: Big Tblnd - Mt Halifax, NEQ; 15° 42'S, 145° 16'E - 19° 07', 146° 22'; sea level - 1500m; monsoon vine forest; secure; well protected.

Rheobatrachus silus Liem, 1973: Blackall and Conondale Ra., SEQ, Booloumba Ck - Kilcoy Ck, SEQ ; 26° 37'S, 152° 35' - 26° 47', 152° 38'; 400 - 800m; subtropical vine forest; endangered, ? extinct; poorly protected.

Rheobatrachus vitellinus Mahony, Tyler & Davies, 1984: Eungella NP, Clarke Ra., MEQ; 20° 50'S, 148° 33'E - 21° 07', 148° 33'; 400 - 1000m; subtropical vine forest; endangered, ? extinct; well protected.

Taudactylus acutirostris (Andersson, 1916): Big Tblnd - Mt Graham, NEQ; 15° 42'S, 145° 16'E - 18° 24', 145° 52'; 300 - 1500m; monsoon vine forest; endangered; well protected.

Taudactylus diurnus Straughan & Lee, 1966: Blackall and Conondale Ras, Mt Glorious, SEQ; 26° 37'S, 152° 35'E - 27° 23', 152° 47'; 400 - 800m; subtropical vine forest; endangered, ? extinct; poorly protected.

Taudactylus eungellensis Liem & Hosmer, 1973: Cathu SF - Eungella NP, Clarke Ra., MEQ; 20° 50'S, 148° 33'E - 21° 07', 148° 33'; 200 - 1000m; subtropical vine forest; endangered; well protected.

Taudactylus liemi Ingram, 1980: Cathu SF, Clarke Ra. - Crediton SF, MEQ; 20° 51'S, 148° 34'E - 21° 11', 148° 35'; 250 - 1000m; subtropical vine forest; rare; well protected.

Taudactylus pleione Czechura, 1986: Kroombit Tops SF, SEQ; 24° 24'S, 150° 59'E; 900m; subtropical vine forest; insufficiently known; poorly protected.

Taudactylus rheophilus Liem & Hosmer, 1973: four allopatric populations on Thornton Pk, Carbine Tblnd, Lamb

Ra., Bellenden Ker Ra., NEQ; 16° 10'S, 145° 22'E - 17° 16', 145° 22'; 900m - 1500m; monsoon vine forest; endangered; well protected.

Ranidae

Rana daemeli (Steindachner, 1868): Cape York tip - Rollingstone, NEQ; extralimital in PNG; 10° 42'S, 142° 32'E - 19° 03', 146° 23'; sea level - 640m, mostly < 100m; monsoon vine forest, usually from open forests, entering rainforest along roads & clearings, Cape York populations from riparian rainforest; secure; well protected.

Hylidae

Litoria caerulea (White, 1790): throughout Q, extralimital in WA, NT, SA, NSW; sea level - 800m. Predominantly associated with open vegetation, entering disturbed rainforest & dry vine thickets; secure; well protected.

Litoria chloris (Boulenger, 1893): Conway Ra. NP - Eungella NP, MEQ; Bulburin SF, MEQ - Gosford, NSW; 20° 24', 148° 35' - 21° 08', 148° 30'; 24° 15', 151° 24' - 33° 26', 151° 20'; sea level - 1000m; subtropical vine forest; secure; well protected.

Litoria eucnemis (Lönnberg, 1900): Ducie R. - Wenlock R.; Iron Ra. - McIlwraith Ra., FNEQ; 12° 07'S, 142° 21'E - 12° 16', 141° 59'; 12° 46', 143° 16' - 13° 50', 143° 17'; sea level - 20m; monsoon vine forest; secure; poorly protected.

Litoria genimaculata (Horst, 1883): Big Tblnd - Paluma, NEQ; 15° 42'S, 145° 16'E - 19° 01', 146° 12'; sea level - 1300m; monsoon vine forest; secure; well protected.

Litoria infrafrenata (Gunther, 1867): Cape York tip, FNEQ - Mutarnee, NEQ; Extralimital in PNG; 10° 42', 142° 32' - 19° 00', 146° 20'; sea level - 580m; monsoon vine forest, usually from open forests enters riparian rainforest & rainforest edges; secure; well protected.

Litoria lesueurii (Duméril & Bibron, 1841): Cooktown, NEQ - Victoria; 15° 25'S, 145° 05'E-V; sea level - 1200m; monsoon, dry, subtropical vine forests & moist open forests; secure; well protected.

Litoria longirostris Tyler & Davies 1978: Leo Ck - Station Ck, FNEQ; 13° 42'S, 143° 18'E - 13° 57', 143° 19'; 400 - 820m; monsoon vine forest; rare; not protected.

Litoria lorica Davies & McDonald, 1979: Alexandra Ck - Hilda Ck, Thornton Pk NEQ; 16° 07', 145° 20' - 16° 10', 145° 23'; 640 - 1000m; monsoon vine forests; vulnerable; well protected.

Litoria nannotis (Andersson, 1916): Big Tblnd-Mt. Halifax, NEQ; 15° 42'S, 145° 16'E- 19° 11'S 146° 27'E; 80-1300m; monsoon vine forest; vulnerable; well protected.

Litoria nyakalensis (Liem, 1974): McDowall Ra. - Douglas Ck, Kirrama Ra., NEQ; 16° 07'S, 148° 20'E - 18° 13', 145° 48'; 380 - 1020m; monsoon vine forest; endangered; well protected.

Litoria pearsoniana (Copland, 1961): Kroombit Tops, SEQ - Lismore, NSW; 24° 24'S, 151° 01'E - 28° 50', 153° 01'; 200 - 1000m; subtropical vine forest, sometimes along perennial, densely vegetated streams in open forest adjacent to rainforest; insufficiently known; well protected.

Litoria revelata Ingram, Corben & Hosmer, 1982: three allopatric populations; Atherton Tblnd, NEQ; Clark Ra., MEQ; Mt Tamborine, SEQ - Smith's Lake, NSW; 17° 23'S, 145° 42'E - 17° 36', 145° 29'; 21° 01', 148° 36' - 21° 07', 148° 31'; 27° 55', 153° 10' - 32° 23', 152° 29'; 400 - 900m; monsoon and subtropical vine forests, open forests, and pastures; secure; moderately protected.

Litoria rheocola (Liem, 1974): Amos Bay - Broadwater Ck, NEQ; 15° 41'S, 145° 19'E - 18° 23', 145° 57'; sea level - 1180m; monsoon vine forest; vulnerable; well protected.

Litoria xanthomera Davies, McDonald & Adams, 1986: Big Tblnd -Bluewater Ra., NEQ; 15° 42'S, 145° 17'E - 19° 07', 146° 23'; 20 - 1300m; monsoon vine forest; secure; well protected.

Nyctimystes dayi (Gunther, 1897): Big Tblnd - Paluma, NEQ; 15° 42'S, 145° 16'E - 19° 01', 146° 13'; sea level - 1200m; monsoon vine forest, along densely vegetated perennial streams adjacent to rainforest; vulnerable, well protected.

Microhylidae

Cophixalus bombiens Zweifel, 1986: Shipton's Flat - Mt Lewis, NEQ; 15° 47'S, 145° 14'E - 16° 35', 145° 16'; 200 - 1300m; monsoon vine forest; rare; well protected.

Cophixalus concinnus Tyler, 1979: Mt Finnigan - Mt Lewis, NEQ; 15° 49'S, 145° 17'E - 16° 35', 145° 16'; 560 - 1300m; monsoon vine forest; rare; well protected.

Cophixalus crepitans Zweifel, 1985: McIlwraith Ra., FNEQ; 13° 44'S, 143° 20'E; 380 - 540m; rare; unprotected.

Cophixalus exiguus Zweifel & Parker, 1969: Big Tblnd - Mt Finnigan, NEQ; 15° 42'S, 145° 16'E - 15° 49', 145° 16'; 180 - 1120m; monsoon vine forest; rare; moderately protected.

Cophixalus hosmeri Zweifel, 1985: Mt Spurgeon - Mt Lewis, NEQ; 16° 27'S, 145° 12'E - 16° 35', 145° 16'; 960 - 1370m; monsoon vine forest; rare; moderately protected.

Cophixalus infacetus Zweifel, 1985: Crystal Cascades - Dalrymple Gap, NEQ; 16° 58'S, 145° 40'E - 18° 24', 146° 05'; 40 - 800m; monsoon vine forest; secure; well protected.

Cophixalus mcdonaldi Zweifel, 1985: Mt Elliot, Bowling Green Bay NP, NEQ; 19° 30'S, 146° 58'E; 900+ m; monsoon vine forest; rare; well protected.

Cophixalus neglectus Zweifel, 1962: Mt Bellenden Ker and Mt Bartle Frere, NEQ; 17° 16'S, 145° 49'E - 17° 24', 145° 51'; 900 - 1600m; monsoon vine forest; rare; well protected.

Cophixalus ornatus (Fry, 1912): Mt Spurgeon - Bluewater Ra., NEQ; 16° 27'S, 145° 23'E - 19° 12', 146° 22'; sea level - 1520m; monsoon vine forest; secure; well protected.

Cophixalus peninsularis Zweifel, 1985: Leo Ck, McIlwraith Ra., FNEQ; 13° 44'S, 143° 20'E; 520-540m; monsoon vine forest; insufficiently known; unprotected.

Sphenophyme fryi Zweifel, 1962: Big Tblnd - Lamb Ra. NEQ; 15° 42'S, 145° 16'E - 17° 08', 145° 36'; sea level - 1300m; monsoon vine forest; secure; well protected.

Sphenophyme pluvialis Zweifel, 1965: Gap Ck, Cedar Bay NP - Mt Fox SF, NEQ; 15° 49'S, 145° 19'E - 18° 35', 145° 49'; sea level - 1300m; monsoon vine forest; secure; well protected.

Sphenophyme robusta (Fry, 1912): Lamb Ra. - Bluewater Ra., NEQ; 17° 06'S, 145° 36'E - 19° 12', 146° 23'; 360 - 1520m; monsoon vine forest; secure; well protected.

Reptiles

Gekkonidae

Carphodactylus laevis (Günther, 1897): Big Tblnd - Douglas Ck, Kirrama, NEQ; 15° 42'S, 146° 16'E - 18° 12', 145° 47'; 300 - 1400m; monsoon vine forest; secure; well protected.

Cyrtodactylus louisiadensis (de Vis, 1892): two disjunct populations: McIlwraith Ra., FNEQ; Cape Flattery, NEQ - Chillagoe, NEQ; extralimital in PNG; 12° 30'S, 143° 16'E; 15° 01', 145° 13' - 17° 16', 144° 37'; sea level - 600m; monsoon vine forest, also occurs in moist open forests on Cape York; secure; moderately protected.

Phyllurus caudiannulatus Covacevich, 1975: Bulburin SF; 24° 31' 151° 30'; 200 - 600m; subtropical vine forest; rare; unprotected.

Phyllurus isis Couper, Covacevich & Moritz, 1993: Mt Blackwood -Mt Jukes, MEQ; 21° 02'S, 148° 56'E - 21° 02', 148° 57'; 250 - 500m; monsoon vine forest; rare, well protected.

Phyllurus nepthys Couper, Covacevich & Moritz, 1993: Clarke Ra., MEQ; 21° 01'S, 148° 36'E - 21° 19', 148° 34'; 250 - 1000+ m; subtropical vine forest; rare; well protected.

Phyllurus ossa Couper, Covacevich & Moritz, 1993: Mt Dryander, Conway NP - Mt Charlton, MEQ; 20° 15'S, 148° 33'E - 21° 01', 148° 44'; 200 - 400m; monsoon vine forest; rare; well protected.

Saltuarius cornutus (Ogilby, 1892): Big Tblnd - Paluma, NEQ; 15° 42'S, 146° 16'E - 19° 01', 146° 14'; 100 - 1100m, mostly above 600m; monsoon vine forest; secure; well protected.

Saltuarius occultus Couper, Covacevich & Moritz, 1993: Peach Ck, McIlwraith Ra., FNEQ; 13° 45', 143° 19' - 13° 46', 143° 19'; 500 -800m; monsoon vine forest; insufficiently known; unprotected.

Saltuarius salebrosus (Covacevich, 1975): Blackdown Tblnd, MEQ -Cracow, SEQ; 23° 46'S, 149° 06'E - 25° 18', 150° 18'; sea level - 1000m; dry vine thickets, often associated with sandstone uplands & gorges, open forest; secure; moderately protected.

Saltuarius swaini (Wells & Wellington, 1984): Mt Tambourine, SEQ - Girvan, NSW; 27° 55'S, 153° 10'E - 32° 28', 152° 04'; 750m - 1000m; subtropical vine forest; secure; well protected.

Rhacodactylus australis (Günther, 1877): Horn, Prince of Wales and Wednesday Is, Torres Strait; McDonnell-Cockatoo Ck, Heathlands - Lankelly Ck, FNEQ; 10°37'S 142° 17'E, 10° 41'S 142° 09 E, 10° 32'S 142° 19'E; 11° 35'S, 142° 22'E - 13° 52', 143° 15'; sea level - 550m; monsoon vine forests, open forest & woodland; secure; moderately protected.

Scincidae

Anomalopus brevicollis Greer & Cogger, 1985: Finch Hatton Gorge, Eungella NP - Cracow, MEQ; 21° 04'S, 148° 38'E - 25° 18'; 150° 18'; 250 - 1000m; dry vine thicket, predominantly associated with open vegetation; secure; moderately protected.

Anomalopus gowi Greer & Cogger, 1985: Mt. Mulligan - Woodstock, NEQ; 16° 52'S, 145° 52'E - 19° 35', 146° 54'; 60 - 800m; dry vine thicket, also open forest and woodlands; insufficiently known; poorly protected.

Anomalopus pluto Ingram, 1977: vicinity of Heathlands, FNEQ; 11° 33'S, 142° 26'S -11° 45'S, 142° 41'; sea level - 100m; monsoon vine forest, also in adjacent heaths, woodlands; rare; unprotected.

Anomalopus verreauxii Duméril & Duméril, 1851: Proserpine, MEQ -Red Rock, NSW; 20° 24'S, 148° 35'E - 29° 59', 153° 12'; sea level - 900m; dry vine thickets, predominantly from open vegetation; secure; well protected.

Bartleia jigurru (Covacevich, 1984): Mt Bartle Frere, NEQ; 17° 23'S, 145° 48'E; 1500m+; monsoon vine forest; rare; well protected.

Calyptotis lepidorostrum Greer, 1983: Eungella, MEQ - Conondale Ra., SEQ; 21° 09'S, 148° 29'E - 26° 45', 152° 50'; 200 - 920m; subtropical vine forest; secure; moderately protected.

Calyptotis scutirostrum (Peters, 1873): Gympie, SEQ - Dorrigo, NSW; 26° 11'S, 152° 40'E - 30° 20', 152° 43'; 20 - 750m; subtropical vine forest, coastal heathlands and moist sclerophyll forests; secure; moderately protected.

Calyptotis temporalis Greer, 1983: Finch Hatton Gorge, Eungella NP, MEQ - Byfield, SEQ; 21° 05'S, 148° 35'E - 23° 05', 150° 40'; 20 - 685m; subtropical vine forests; secure; moderately protected.

Calyptotis thorntonensis Greer, 1983: Thornton Pk, NEQ; 16° 11'S, 145° 24'E; 640m; monsoon vine forests; insufficiently known; well protected.

Carlia coensis (Mitchell, 1953): Birthday Mt - 13km SW Coen, FNEQ; 13° 33'S, 143° 09'E - 14° 01', 143° 06'; 220 - 550m; monsoon vine forest, woodland, usually on rocks; rare; unprotected.

Carlia longipes (Macleay, 1877): Darnley Is - Gordonvale, NEQ, extralimital NT & PNG; 9° 35'S, 143° 46'E - 17° 06', 145° 48'; sea level - 600?m; monsoon vine forest; secure; moderately protected.

Carlia mundivensis (Broom, 1898): Chillagoe, NEQ - Chinchilla, SEQ; 17° 09'S, 144° 31'E - 26° 45', 150° 38'; 100 - 800m; dry vine thicket, invariably with rocks, predominantly from open forest; secure; poorly protected.

Carlia rhomboidalis (Peters, 1869): Magnetic Is., NEQ - East Funnel Ck, MEQ; 19° 08'S, 146° 50'E - 21° 36', 149° 12'; 0 - 1000m; secure; well protected.

Carlia rubrigularis Ingram & Covacevich, 1989: Big Tblnd - Bluewater Ra., NEQ; 15° 42'S, 145° 16'E - 19° 07', 146° 22'; sea level - 1200m; secure; well protected.

Cautula zia (Ingram & Ehmann, 1981): Cunningham Gap, SEQ - Styx R. SF, NSW; 27° 58'S, 152° 25'E - 30° 36', 152° 19'; 560 -1300m; subtropical vine forests; secure; moderately protected.

Coeranoscincus frontalis (de Vis, 1888): Mt Sorrow - Mt Elliot, NEQ; 16° 05'S, 145° 26'E - 19° 29', 146° 58'; 20 - 1000m; monsoon vine forests; secure; well protected.

Coeranoscincus reticulatus (Günther, 1873): Cooloola, SEQ - Richmond Ra., NSW; 25° 58'S, 153° 06'E - 29° 41', 152° 56'; 20 - 1000m; subtropical vine forest; vulnerable; well protected.

Cyclodomorphus gerrardi (Gray, 1845): Whitfield Ra., NEQ - Blue Mtns, NSW; 16° 56'S, 145° 42'E - 33° 36', 150° 15'; 20 - 700m; subtropical & monsoon vine forests, moist and dry sclerophyll forests; secure; well protected.

Egernia frerei Günther, 1897: Murray Is., Torres Strait, FNEQ - Coffs Harbour, NSW; 9° 56'S, 144° 02'E - 30° 17', 153° 08'; sea level - 1000m; subtropical & monsoon vine forests; secure; well protected.

Egernia major (Gray, 1845): Gympie, SEQ - Gosford, NSW; 26° 11'S, 152° 40'E - 33° 26', 151° 20'; sea level - 1000m subtropical vine forest; secure; well protected.

Egernia striolata (Peters, 1870): Forty Mile Scrub NP, NEQ - SA; 18° 08'S, 144° 43'E -SA; 20 - 800m; subcoastal vine thickets, predominantly from open forests; secure; moderately protected.

Emoia longicauda (Macleay, 1877): Darnley Is., Torres Strait - McIlwraith Ra., FNEQ; extralimital in PNG; 9° 35'S, 143° 46'E - 13° 33', 143° 28'; sea level - 250m; monsoon vine forest; secure; poorly protected.

Eroticoscincus graciloides (Lönnberg & Andersson, 1913): Fraser Is. - Pine Mtn, near Ipswich, SEQ; 24° 48'S, 153° 13'E - 27° 32', 152° 43'; sea level - 600m; subtropical vine forests, wet sclerophyll forests; rare; poorly protected.

Eugongylus rufescens (Shaw 1802): Darnley Is., Torres Strait - Lockerbie, FNEQ; extralimital in PNG; 9° 35'S, 143° 46'E - 10° 47', 142° 30'; sea level - 50m; monsoon vine forest; secure; poorly protected.

Eulamprus amplus (Covacevich & McDonald, 1980): Brandy Ck, Conway Ra. - Eungella NP, MEQ; 20° 55'S, 148° 44'E - 21° 06', 148° 29'; 150 - 1100m; subtropical & monsoon vine forest; rare; well protected.

Eulamprus brachysoma (Lönnberg & Andersson, 1915): Coen, NEQ - Lever's Plateau, nr Lamington NP, SEQ; 13° 56'S, 143° 12'E - 28° 20', 152° 52'; sea level - 1100m; monsoon & subtropical vine forest; secure; well protected.

Eulamprus frerei Greer, 1992: Mt Bartle Frere, NEQ; 17° 24'S, 145° 48'E; 1600m; monsoon vine forest; insufficiently known; well protected.

Eulamprus luteilateralis (Covacevich & McDonald, 1980): Mt William & Mt Dalrymple area, Eungella NP, MEQ; 21° 08'S, 148° 30'E; above 900m; subtropical vine forests; rare; well protected.

Eulamprus martini Wells & Wellington, 1985: Homevale, MEQ - Coffs Harbour, NSW; 21° 23'S, 148° 32'E - 30° 20', 153° 07'; sea level - 1000m; dry vine thickets, usually from open forests; secure; well protected.

Eulamprus murrayi (Boulenger, 1887): Conondale Ra., SEQ - Barrington Tops, NSW; 26° 37'S, 152° 35'E - 32° 02', 151° 24'; 300 - 1000+m; subtropical vine forest; rare; moderately protected.

Eulamprus quoyii (Dumeril & Bibron, 1839): Daintree, NEQ - Budawang, NSW; 16° 15'S, 145° 19'E - 30° 18',153° 08'; sea level -1000m; subtropical & monsoon vine forest; secure; well protected.

Eulamprus sokosoma Greer, 1992: Taravale, NEQ - Injune, MEQ; 19° 07'S, 146° 04'E - 25° 51', 148° 34'; 20 - 800m; dry vine thickets; rare; poorly protected.

Eulamprus tenuis (Gray, 1831): Holbourne Is., MEQ - Bega, NSW; 19° 43'S, 148° 22'E - 36° 40', 149° 55'; sea level - 750m; dry vine thickets, subtropical vine forest; secure; well protected.

Eulamprus tigrinus (De Vis 1888): Shipton's Flat - Smoko Ck, NEQ; 15° 48'S, 145° 14'E - 18° 09', 145° 37'; sea level - 1600m; monsoon vine forest; secure; well protected.

Glaphyromorphus cracens (Greer, 1985): Mt Mulligan - Wyandotte Ck, NEQ; 16° 50'S, 144° 51'E - 18° 35', 144° 33'; 400 - 1000m; dry vine thickets, predominantly from open forests; secure; poorly protected.

Glaphyromorphus fuscicaudis (Greer, 1979): Big Tblnd - Bluewater Ra., NEQ; 15° 42'S, 145° 16'E - 19° 15', 146° 29'; 40 - 1160m; monsoon vine forest; secure; well protected.

Glaphyromorphus mjobergi (Lönnberg & Andersson, 1915): Mount Carbine Tblnd - Vine Ck, NEQ; 16° 34'S, 145° 15'E - 17° 36', 145° 29'; above 650m; monsoon vine forest; rare; well protected.

Glaphyromorphus punctulatus (Peters, 1871): Kaban, NEQ - Mt Walsh NP, SEQ; 17° 31'S, 145° 25'E - 25° 35', 152° 03'; sea level - 1000m; dry vine thicket, predominantly from open forests; secure; well protected.

Gnypetoscincus queenslandiae (De Vis, 1890): Big Tblnd - Mt Thorn, NEQ; 15° 42’S, 145° 16’E - 18° 16’, 145° 48’; 40 - 1200m; monsoon vine forest; secure; well protected.

Lampropholis adonis Ingram, 1991: Conway NP, MEQ - Maleny, SEQ; 20° 15’S, 148° 32’E - 26° 47’, 152° 49’; 20 - 980m; monsoon & subtropical vine forest; secure; moderately protected.

Lampropholis amicula Ingram & Rawlinson, 1981: Kroombit Tops, SEQ - Karuah SF, NSW; 24° 22’S, 150° 59’E - 32° 36’, 151° 56’; 20 - 900m; subtropical vine forest; secure; moderately protected.

Lampropholis coggeri Ingram, 1991: Big Tblnd - Mt Elliot, NEQ; 15° 42’S, 145° 16’E -19° 29’, 146° 58’, sea level - 1500m; monsoon vine forest; secure; well protected.

Lampropholis colossus Ingram, 1991: Bunya Mtns, SEQ; 26° 53’S, 151° 37’E; 1000 -1200m; subtropical vine forest; rare; well protected.

Lampropholis couperi Ingram, 1991: Byfield, MEQ - Mt Glorious, SEQ; 22° 50’S, 150° 41’E - 27° 25’, 152° 50’; 40 - 700m; subtropical vine forest; insufficiently known; poorly protected.

Lampropholis mirabilis Ingram & Rawlinson, 1981: Magnetic Is. - Mt Elliot, NEQ; 19° 08’S, 146° 50’E - 19° 29’, 146° 58’; sea level - 1234m; monsoon vine forest & dry vine thicket; rare; well protected.

Lampropholis robertsi Ingram, 1991: Thornton Pk - Mt Bartle Frere, NEQ; 16° 10’S, 145° 23’E - 17° 23’, 145° 48’; 600 - 1520m; monsoon vine forest; secure; well protected.

Lerista colliveri Couper & Ingram, 1992: Battery Stn - Hughenden, NEQ; 19° 26’S, 145° 52’E - 20° 51’, 144° 12’; 300 - 400m; dry vine thickets, predominantly from open forests; secure; poorly protected.

Lerista vittata Greer, McDonald & Lawrie, 1983: Mt Cooper Stn, NEQ; 20° 31’S, 146° 55’E; 250 - 300m; dry vine thickets; vulnerable; unprotected.

Lygisaurus laevis Ingram & Covacevich, 1988: Amos Bay - Bramston Beach, NEQ; 15° 41’S, 145° 19’E - 17° 21’, 146° 01’; sea level - 950m; monsoon vine forest; secure; moderately protected.

Lygisaurus tanneri Ingram & Covacevich, 1988: McIvor R., Starcke Stn - Endeavour R., NEQ; 15° 03’S, 145° 08’E - 15° 27’, 145° 08’; sea level - 100m; monsoon vine forest; insufficiently known; unprotected.

Nangura spinosa Covacevich, Couper & James, 1993: Nangur SF, SEQ; 26° 07’S, 151° 58’E; 300m approx.; semievergreen vine thicket; rare; moderately protected.

Ophioscincus cooloolensis Greer & Cogger, 1985: Aldoga, nr Gladstone - Cooloola, SEQ; 23° 48’S, 151° 04’E - 25° 58’, 153° 07’; sea level - 900m; subtropical vine forest; rare; moderately protected.

Ophioscincus ophioscincus (Boulenger, 1887): Bulburin SF - Brisbane, SEQ; 24° 31’S, 151° 33’E - 27° 28’, 153° 0’; sea level - 500m; subtropical vine forest, heathlands; rare; moderately protected.

Ophioscincus truncatus (Peters, 1876): Coolum, SEQ - Way Way SF, NSW; 26° 33’S, 153° 05’E - 30° 47’, 152° 56’; sea level - 800m; subtropical vine forest; adjacent open forests; rare; moderately protected.

Saiphos equalis (Gray, 1825): Kroombit Tops, SEQ - Wollongong, NSW; 24° 20’S, 151° 01’E - 34° 35’, 150° 52’; sea level - 1100m; subtropical vine forest, coastal heathland and moist sclerophyll forests; secure; moderately protected.

Saproscincus challengeri (Boulenger, 1887): McPherson Ra., area, SEQ & NENSW; 28° 03S, 152° 24’E - 28° 24’, 153° 04’; sea level -500m; rainforest, moist coastal lowland forest; secure; well protected.

Saproscincus czechurai Ingram & Rawlinson, 1981: Big Tblnd - Walter Hill Ra., NEQ; 15° 42’, 145° 16’ - 17° 47’, 145° 49’; 500 - 1000m; monsoon vine forest; secure; well protected.

Saproscincus galli Wells & Wellington, 1985: Mt Tamborine, SEQ - Sydney area, MENSW; 27° 58’S, 153° 11’E, 33° 53’, 151° 13’; sea level - 1000m; rainforest, low closed remnant forest; secure; well protected.

Saproscincus rosei Wells & Wellington, 1985: Gympie, SEQ - Barrington Tops, MENSW; 26° 11’, 152° 40’E - 32° 10’, 151° 26’; sea level - 1000m; rainforest, moist riverine forest; secure; well protected.

Saproscincus spectabilis (de Vis, 1888): Mt Webb - Mt Elliot, NEQ and Mt Dryander - East Funnel Ck, MEQ; 15° 04’S, 145° 08’E - 19° 29’, 146° 58’; 20° 15’, 148° 38’ - 21° 36’, 149° 12’; sea level - 1000m; monsoon & subtropical vine forest; secure; well protected.

Saproscincus tetradactyla Kluge & Greer, 1979: Mossman Gorge, Daintree NP - Paluma, NEQ; 16° 28’S, 145° 16’E - 19° 00’, 146° 12’; 50 - 1000m; monsoon vine forest; secure; well protected.

Agamidae

Hypsilurus boydii (Macleay, 1884): Big Tblnd - Paluma, NEQ; 15° 42’S, 145° 17’E - 19° 01’, 146° 14’; 20 - 1160m; monsoon vine forests; secure; well protected.

Hypsilurus spinipes (Duméril & Duméril, 1851): Gallangowan, SEQ - Ourimbah, NSW; 26° 26’S, 152° 17’E - 33° 32’, 151° 22’; 50 - 680m; subtropical vine forests; secure; well protected.

Physignathus lesueurii (Gray, 1831): Big Tblnd - Victoria; 15° 42’S, 145° 16’E - V; sea level - 700m; subtropical & monsoon vine forest; secure; well protected.

Varanidae

Varanus prasinus (Schlegel, 1839): Moa Is., Torres Strait; 10° 11’S, 142° 16’E; 180m; ‘closed mesic forest’; rare; unprotected. (Whittier & Moeller, 1993).

Varanus scalaris Mertens, 1941: Heathlands, FNEQ - Paluma, NEQ; 11° 50’S, 142° 39’E - 19° 01’, 146° 13’; sea level - 900m; monsoon vine forests, open forests; secure; well protected.

Varanus teriae Sprackland, 1991: Buthen Buthen - Lankelly Ck, FNEQ; 13° 21'S, 143° 27'E - 13° 53', 143° 17'; 100 - 500m; monsoon vine forest; rare; unprotected.

Varanus varius (White & Shaw, 1790): Shipton's Flat, NEQ - Victoria; 15° 48'S, 145° 14'E -V; sea level - 700m; subtropical & monsoon vine forests, usually from open forests; secure; well protected.

Colubridae

Boiga irregularis (Merrem, 1802): Badu Island, Torres Strait - NSW; 10° 07'S, 142° 07'E - NSW; sea level - 1100m; dry vine thickets; monsoon & subtropical vine forests, also in open forests; secure; well protected.

Stegonotus cucullatus (Duméril, Bibron & Duméril, 1854): Badu Is, Torres Strait, FNEQ - Rollingstone, NEQ; extralimital in PNG; 10° 42'S, 142° 32'E - 19° 03', 146° 23'; sea level - 250m; monsoon vine forests; secure; well protected.

Elapidae

Cacophis churchilli Wells & Wellington, 1985; Thornton Pk - Palm Is.; 16° 10'S, 145° 23'E - 18° 40', 146° 33'; sea level - 1000m; monsoon vine forest; secure; well protected.

Cacophis krefftii Gunther, 1863: Broken R. - Crediton, MEQ; Cooran Plateau, SEQ -Gosford, NSW; 21° 10'S, 148° 31'E - 21° 13', 148° 30'; 26° 20', 152° 50' - 32° 26'· 151° 21'; sea level - 720m; subtropical vine forests, moist & dry sclerophyll forests; secure; well protected.

Cacophis squamulosus (Duméril, Bibron & Duméril, 1854): Mt William, Eungella NP, MEQ - Wollongong, NSW; 21°02'S, 148°32'E - 34°26', 150°53'; sea level - 1000m; subtropical vine forests; secure; well protected.

Hemiaspis signata (Jan, 1859): Thornton Pk - Mt Spec, NEQ; Miriam Vale, SEQ - SCNSW; 16° 11'S, 145° 20'E - 18° 57', 146° 11'; 24° 00', 151° 34' - SNSW; sea level -1200m; subtropical vine forest, moist sclerophyll forest & heathlands; secure; well protected.

Hoplocephalus stephensii Krefft, 1869: Kroombit Tops, SEQ - Gosford, NSW; 24° 20'S, 151° 01'E - 32° 26', 151° 20'; 300 - 1000m; subtropical vine forests, heathlands; secure; moderately protected.

Notechis scutatus (Peters, 1861): Mt Moffat section, Carnarvon NP; Ocean L., Fraser Is - V; 24° 55'S, 148° 03' - 24° 58', 148° 08'; 24° 55', 153° 16' - V; sea level - 1000+m; subtropical vine forest, usually from open forests; secure; well protected.

Pseudechis porphyriacus (Shaw, 1794): Big Tblnd - Blue Water Ra., NEQ; Mt Dryander, Conway NP - Crediton, MEQ; Gladstone, SEQ - Victoria; 15° 42'S, 145° 17'E - 19° 14', 146° 24'; 20° 16', 148° 35' - 21° 13', 148° 32'; 23° 51', 151° 16' - V; sea level -1000+m; monsoon & subtropical vine forests; secure; well protected.

Rhinoplocephalus nigrescens (Günther, 1862): Big Tblnd - V; 15° 42'S, 145° 16'E - V; sea level - 1100+m; subtropical & monsoon vine forests and adjacent moist open vegetation; secure; well protected.

Tropidechis carinatus (Krefft, 1863): Thornton Pk - Mt Spec, NEQ; Fraser Is., SEQ -Barrington Tops, NSW; 16° 10'S, 145° 23'E - 18° 57', 146° 11'; 24° 48', 153° 13' - 32° 02', 151° 24'; sea level - 1374m; subtropical & monsoon vine forests, heaths and moist open forests; secure; well protected.

Boidae

Morelia amethistina (Schneider, 1801): Cape York P., FNEQ - Townsville, NEQ; 11° 48'S, 142° 21'E - 19° 20', 146° 30'; sea level - 1100m; monsoon vine forests and open forests, extralimital in NG and adjoining islands; secure; well protected.

Morelia spilota (Lacépède, 1804): throughout Q; sea level - 1100m; dry vine thickets, monsoon & subtropical vine forest & open forests; secure; well protected.

Morelia viridis (Schlegel, 1872): Claudie R. - Rocky R., FNEQ; extralimital in PNG; 12° 46'S, 143° 17'E - 13° 49', 143° 28'; sea level - 400m; monsoon vine forest; rare; poorly protected.

Typhlopidae

Ramphotyphlops nigrescens (Gray, 1845): Kroombit Tops, SEQ - Victoria; 24° 24'S, 150° 59'E - V; sea level - 800m; subtropical vine & moist open forests; secure; moderately protected.

Ramphotyphlops polygrammicus (Schlegel, 1839): islands of Torres Strait;Cockatoo Ck, Heathlands, FNEQ -Eungella NP, MEQ; 10° 23's 142° 02'E;11° 39', 142° 37' - 21° 10', 148° 30'; sea level - 900m; monsoon vine forest; secure; moderately protected.

Ramphotyphlops silvia Ingram & Covacevich, 1993: Fraser Is. NP -Rainbow Beach area, SEQ; 24° 52'S, 153° 16'E - 26° 10', 152° 55'; sea level - 100m; subtropical vine forest; rare; well protected.

CONSERVATION

Most of Australia's rainforests are in Queensland and, in general terms, are now well-protected. They present one of the success stories in the history of the Australian conservation movement. The Rainforest Conservation Society Inc., formed in 1982, played the major role in heightening public awareness of rainforests, converting this to political will to increase protection of rainforests and to provide finance to increase research to understand them better. Rainforests of the Wet Tropics, which have the highest frog-reptile species endemism known for any part of Australia, were placed on the World Heritage register in 1988; much of the moist rainforest of mideastern Queensland is now protected in National Parks; moist rainforests of most of southeastern Queensland have been nominated for inclusion on the World Heritage List (Government of Australia, 1992); remnants of the dry rainforests of the southern part of Queensland, too, are now protected from further clearance by the Forest Service (Forster et al., 1991), although most are not declared national parks or other specially protected reserves, and there is thus no legislative protection for them. Not protected or not well-protected are major moist rainforests in the far north of the state (on Moa Is., at Somerset and in the McIlwraith Ra.); dry rainforests north of the Carnarvon Ra., MEQ; and small, isolated patches of dry rainforest on the western side of Cape York Peninsula.

Gazettal as National Park, the highest level of protection possible for a forest in Queensland, cannot guarantee protection. The Forty Mile Scrub near Mt Garnet, NEQ, has been National Park since 1970. This is a semievergreen vine thicket. Here, following disturbance of the ground by feral pigs, there has been an invasion by *Lantana camara*, which has created a rich understorey. This, in turn, has created a fire hazard in a forest which was previously highly fire resistant; and fire has destroyed substantial portions of this forest (R. Fensham, pers. comm.). Moist rainforest on Moa Is., although not safe in terms of special protective status by legislation, is in excellent condition and, at least for the foreseeable future, safe by default. Moa Islanders are sea-farers, and have thus made virtually no incursions into the rainforest on the high part of their island (J. Whittier, pers. comm.). Dry rainforest (= vine forest and vine thicket) on the western side of Cape York Peninsula, near Weipa, NWQ, has recently been surveyed (Cameron & Cogger, 1992). They note these habitats are small and fragmented and that their frog-reptile fauna is depauperate, a feature they share with other rainforests on the Cape. (Species paucity in northern Cape York Peninsula rainforests vs extraordinarily high species diversity in southern Peninsula rainforests has been discussed many times, most recently by Covacevich, in press. Those of the north have had '... a discontinuous history because of climatic fluctuations during the Quaternary.'..., Cameron & Cogger, 1992).

Protection of habitat is fundamental to protecting frog and reptile (and other) species, but it does not guarantee their survival. The alarming case of unexplained declines in populations of numerous species of rainforest frogs attests to this. First signs of declines in rainforest frog populations were reported in the late 1970s. (Winter & McDonald, 1986) who noted possible problems with *Rheobatrachus vitellinus* and *Taudactylus eungellensis* at low altitudes in the Eungella NP, MEQ. McDonald (1990) undertook special surveys of *R. vitellinus*, *T. eungellensis* and *T. liemi* in the area. His work showed that *R. vitellinus* disappeared in March, 1985; that *T. eungellensis* had disappeared in June, 1986; and that *T. liemi* appeared safe. *T. eungellensis* has been found once since then (Couper, 1992) giving a glimmer of hope for this species. In southeastern Queensland the congeners of these highly specialised frogs have not been seen, despite intensive searching, since 1979 (Czechura & Ingram, 1990).

The depressing state of affairs with populations of several tropical rainforest frog species in various degrees of decline has been reviewed recently (Richards et al., 1993). Two species (*Litoria nyakalensis* and *T. rheophilus*) were not seen in 1991-2 surveys; the former being seen last in November, 1990, the latter in January, 1990. For other species (*L. nannotis*, *L. rheocola*, *L. lorica*, *Nyctimystes dayi*, *T. acutirostris*) grave fears are held. Populations of some of these in some well-documented sites have disappeared; others are clearly in decline across their whole range.

Although natural population fluctuations are well known for frog species (e.g. Peachmann et al., 1991), these can be difficult to distinguish from true declines. Richards et al. (1993) conclude that the declines they report are 'real'; those reported by Czechura and Ingram (1990) certainly appear 'real', if a 14-year absence has any meaning. Several explanations have been advanced to explain declines in frog populations elsewhere. These are summarized and excluded as relevant to the problem in the Wet Tropics frogs by Richards et al. (1993). Factors which do not appear to be relevant to these declines in the Wet Tropics and southeastern Quieensland are: destruction of habitat; historic uses of sites for timber-gathering or mining; other direct human factors (collecting, road mortality); acid-rain; heavy metal, pesticide or other water pollution; drought-induced lowering of the water table; and flooding. Damage to stream habitats by feral pigs had increased at one study site and could be neither discounted nor verified as a causal factor. Similarly, the role of climatic change could not be fully assessed and was neither blamed nor discounted.

By any standard the habitats of all these frog species are extremely well-protected and have been for considerable time. Declines in other taxa in these habitats have not been observed, but that does not, of course, mean they have not taken place. Nor have they been reported in frog species from habitats other than rainforest, with one exception. (The exception is *Litoria aurea*, a southern species from open forests, generally at low altitudes, G. Ingram, pers. comm.). There is at present no clear reason to account for the declines or disappearances documented and, obviously, no clear course to follow to attempt to save the frogs. The words of Czechura and Ingram (1990) are as accurate and worrying now as they were when written '... it is very difficult to decide whether or not the missing frogs are extinct. Extinction is not easy to prove. If the missing frogs *are* extinct, their passing was not a slow process. Rather it appears to have been a catastrophic event that could not have been anticipated or prevented.'

The fauna authority in Queensland (Department of Environment & Heritage), Australian Nature Conservation Agency, James Cook University, the Wet Tropics Management Agency, the University of Queensland and the University of Newcastle are supporting the following projects under an umbrella study of declining frogs of Queensland and New South Wales (McDonald): survey of the distribution and status of *Litoria longirostris* (McDonald); monitoring declining frog populations of the Wet Tropics Biogeographic Region (McDonald); genetic study of several threatened frog species of the Wet Tropics (Moritz & Cunningham); intensive survey of tadpole populations of streams in different catchments of the Wet Tropics (Trenerry); study of mortality rates of semi-captive populations of *T. acutirostris* and *T. rheophilus* (Mahoney & Dennis); captive breeding of two species of threatened stream-dwelling frogs in the Wet Tropics (Richards & Alford); preliminary survey of diseases of Wet Tropics frogs (Speare); community ecology of Eungella stream-dwelling frogs (Hero, McDonald, Alford); survey of distribution and abundance of rare or threatened stream-dwelling frogs, SEQ (McDonald & Ingram); survey to assess the status of *T. pleione* (McDonald & Hero).

In addition, the Wet Tropics Management Agency will fund a 3-year study of the ecology and conservation of declining frogs (Wet Tropics Management Agency, in litt.) and the Endangered Species Program will fund a survey of declining frogs in New South Wales. From these studies it is hoped that it will be possible to devise remedial strategies.

Since January, 1984, 8 new species of frogs and 24 new species of reptiles have been described from Queensland's rainforests. Increased public interest in rainforests has spearheaded a dramatic increase in research on rainforest fauna in recent years. This has led to a rate of discovery and description of new taxa that equals or surpasses the previous great eras of discovery of frog and reptile species between 1960-80, and pre-1900. For many rainforest taxa, especially invertebrates, only a small proportion of the species are described. For the frogs and reptiles, however, the stage has been reached where the species and their broad limits of occurrence are fairly well-known. There are notable exceptions to this suggestion. Cryptic species are known within *Mixophyes schevilli* (M. Mahoney, pers. comm.)and *Gnypetoscincus queenslandiae* (C. Moritz, pers. comm.) as they are presently defined; remote, as yet unexplored, specialized habitats may yet yield new species; and, amongst the burrowing forms, there are probably undescribed taxa.

Notwithstanding the facts that much is now known about rainforest frog and reptile species and that many are now secure and moderately to well protected (Table 2), much remains to be learnt. Several species remain endangered or vulnerable, and either poorly protected or unprotected (Table 2).

Several species from the McIlwraith Ra., FNEQ urgently need protection in reserves (e.g. *L. eucnemis, L. longirostris, C. crepitans, C. peninsularis* and *S. occultus*, all of which are either rare or insufficiently known and poorly or not protected). Precise details of their distribution are lacking, as are any data on breeding or other habits for most species. Further, there are some rainforests in which no herpetological work has been undertaken. One example is Nangur SF, only 250km NW of Brisbane. In late 1992, this semievergreen vine thicket was investigated herpetologically for the first time. *N. spinosa*, a distinct member of the *Sphenomorphus* group has since been described from there (Covacevich et al., 1993). No survey work has been undertaken in the Moa Is. moist rainforest and in many other semievergreen vine thickets of both southern and northern Queensland.

In Queensland much of the research money spent in recent years on vertebrates has been used on either rare and threatened species or on those from rainforests. From this, valuable data have been published, and there are now reliable data for some species. Reasonable decisions regarding

Table 2. Conservation status and levels of protection of Queensland's rainforest frog and reptile species.

LEVEL OF PROTECTION	CONSERVATION STATUS					TOTAL
	E	V	R	S	IK	
Well	5(0)	4(1)	7(10)	16(43)	1(2)	33(56)
Moderately	0(0)	0(0)	3(5)	1(17)	0(0)	4(21)
Poor	2(0)	0(0)	0(3)	1(5)	3(2)	6(11)
Unprotected	0(0)	0(1)	2(5)	0(0)	1(2)	3(8)

E (endangered); V (vulnerable); R (rare); S (secure); IK (insufficiently known): unbracketed = frogs; bracketed = reptiles.

plans for future conservation of rainforest frogs and reptiles can now be made.

With finite resources it is important to remember that rainforest is not the only important habitat in Queensland and that rainforest frogs and reptiles are, generally, reasonably well-researched taxonomically and well-protected. Few ecological data are available, however, for most species, and lack of data is a major problem. Efforts must continue towards solving the disappearing frogs' problem and others that may occur, and building a store of knowledge about the ecology of rainforest species. There is now, however, a reasonable case to be made for some shift of emphasis to other species in other habitats more vulnerable and less well-known (e.g. deserts, black soil plains, heaths and grasslands).

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A NEW REPRODUCTIVE MODE FOR AN AUSTRALIAN HYLID FROG. *Memoirs of the Queensland Museum 34(1)200. 1993* :- The rare frog, *Litoria longirostris*, was described (Tyler & Davies, 1977) from six specimens collected from the headwaters of the Rocky R., McIlwraith Ra., Cape York Peninsula, FNEQ. Collectors of the type series observed a clump of 'bluish-gray eggs' 30 cm above water level on a tree buttress, but did not know whether or not they were eggs of *L. longirostris*.

As part of a survey to determine the status of declining and possibly declining frogs, we visited the McIlwraith Ra., from 14 - 18 September, 1993. On the banks of Peach Ck (13° 44'S, 143° 20'E) and Leo Ck (13°22'S, 143° 22'E), in a notophyll vine forest, we found nests, eggs and embryos of *L. longirostris*. Four nests were guarded by *L. longirostris* which straddled the nests. Eggs and embryos were lime green.

Twenty three egg masses were found on dry substrate above the water, on trunks of Water Gum (*Tristaniopsis exciliflora*) (7); Rainforest Satinash (*Syzigium* sp.) (2); on granite rocks in Leo Ck (8); under leaves of rainforest shrubs (2), a living *Licuala ramsayi* palm frond (1); dead *L. ramsayi* fronds (2); and on the upper surface of a frond of *Cyathea rebeccae* (1). Eggs had been laid from 4.5 - 117.5 cm above the water (mean 26.36, SD 26.54, n 22) in areas where water depth immediately below egg masses varied from 2.0 - 71.0 cm (mean 22.26, SD 18.69, n 20). All but one were associated with still water pools. Pool depths ranged from 15.5 - 120.0 cm (mean 49.74, SD 36.06, n 17). The exception (on the *C. rebeccae* frond) hung over gently flowing water. Size of pools ranged from 0.5 m adjacent to fast flowing streams, to approximately 10 m in streams with gentle (<1°) gradients.Streams varied from gently sloping (<1°) with numerous pools and sandy substrate (upper Peach Ck) to fast flowing rocky streams (Leo Ck). Conductivity of the waters of the creeks ranged from 48.2 - 79.2 µS/cm (n 6) ; pH from 6.05 - 6.59 (n 6).

Egg masses were laid with the longest axis vertical for all clutches (range 29 - 45 mm, mean 35.9, SD 4.925, n 20) and the width at the widest section ranged from 8.5 - 25.0 mm (mean 16.43, SD 3.27, n 20). The height of the egg mass with developing embryos ranged from 0.9 - 1.2mm (n 10) and with recently laid eggs, 5mm (n 1). Egg numbers ranged from 29 - 60 (mean 40.86, SD 6.896, n 22). The diameter of 10 eggs laid the night before measurement ranged from 2.0 - 2.4 mm (mean 2.16, SD 0.126). The clear, jelly-like capsule surrounding the egg was approximately 6 mm deep.

Amplexus was not observed. Females near calling males were observed with lime coloured eggs visible through the groin skin. Hatching tadpoles were light yellow, with areas of brown on the dorsum and lime green yolk in the abdomen.

L. longirostris (♂♂) called from leaves over water, or occasionally from vegetation within 2m of the water. Calling sites were from 33.0 - 211.0 cm (mean 100.84, SD 50.79, n 45) above the substrate. Two males were heard calling from the upper surface of the frond of *L. ramsayi* at estimated heights of 3.5 and 5.0 m.

L. longirostris was located with *L. eucnemis* and *Rana daemelii* near streams. *Sphenophryne gracilipes* and *Cophixalus crepitans* occurred in leaf litter in adjacent areas.

This mode of reproduction is unique amongst Australian frogs (Tyler, 1985). Similar reproductive modes have been described from New Guinea and South America (Duellman & Trueh, 1986).

Acknowledgments

Bruce Gray, CSIRO, Atherton provided information on previous observations of *L. longirostris*. Mike Delaney and staff of the Queensland Department of Environment and Heritage, Coen provided assistance in the field.

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A MITOCHONDRIAL DNA PERSPECTIVE ON THE HISTORICAL BIOGEOGRAPHY OF MIDEASTERN QUEENSLAND RAINFOREST BIRDS

LEO JOSEPH, CRAIG MORITZ AND ANDREW HUGALL

Joseph, L., Moritz, C. & Hugall, A. 1993 12 24: A mitochondrial DNA perspective on the historical biogeography of mideastern Queensland rainforest birds. *Memoirs of the Queensland Museum* **34**(1):201-214. Brisbane. ISSN 0079-8835

We approach the historical biogeography of the isolated mideastern Queensland (MQ) rainforests using mitochondrial DNA (mtDNA) phylogeography in three bird species present in rainforests of MQ, northeastern Queensland (NEQ) and southeastern Queensland and northeastern New South Wales (SE): the Large-billed Scrubwren *Sericornis magnirostris*, White-browed Scrubwren *S. frontalis* and Eastern Whipbird *Psophodes olivaceus*. We ask whether patterns of genetic diversity in these species, which we infer from restriction fragment length polymorphisms and sequence analyses, conform to a model of isolation by distance having operated prior to physical isolation of the NEQ, MQ and SE rainforests, or to a vicariance model whereby the dry woodland between Townsville and Bowen (the Burdekin Gap) first separated the NEQ rainforests from those of MQ and SE, which were isolated from each other later. In the Large-billed Scrubwren and Eastern Whipbird nucleotide diversities and sequence divergences are greatest in comparisons between NEQ and either SE or MQ or both, and phylogenetic analyses similarly cluster NEQ populations apart from those of MQ and SE. At the DNA sequence level in the cytochrome *b* gene, the strong sequence similarity (almost 100%) between SE and MQ populations of the Large-billed Scrubwren was especially noteworthy. These observations all suggest that the vicariance model has operated in these two species and that isolation of MQ rainforest from SE is much more recent than that of NEQ rainforests from MQ and SE. No clear trends were discernible in the White-browed Scrubwren and we attribute this to the species' high habitat plasticity, which, by facilitating gene flow, may have prevented the development of phylogeographic structure to mtDNA diversity. We further suggest that the biogeographical peculiarities of MQ rainforests (i.e. presence of a number of endemic species and subspecies coupled with the absence of other prominent rainforest endemics present in NEQ and SE rainforests) might be explained simply if MQ and SE rainforests have long been connected not by large tracts of unbroken rainforest but by scattered patches of a habitat such as vine thicket. ☐ *Rainforest, Sericornis, Psophodes, birds, mtDNA, historical biogeography, Queensland.*

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Of the rainforests scattered along Australia's eastern periphery (Fig. 1), those of mideastern Queensland (MQ) in the Mackay-Eungella-Clarke Range area are of particular biogeographic interest. Their affinities variously have been placed either with rainforests in northeastern Queensland (NEQ) (e.g. Schodde & Calaby, 1972) or, more often, with the subtropical rainforests of southeastern Queensland and northeastern New South Wales (SE, e.g. Webb & Tracey 1981; Cracraft, 1991). Although the MQ rainforests form a minor centre of endemism (Table 1), a number of taxa essentially confined to rainforest and present in rainforests to the north and south enigmatically are absent from them. Examples of the latter are the fig-parrots *Cyclopsitta* spp., logrunners *Orthonyx* spp., riflebirds *Ptiloris* spp., catbirds *Ailuroedus* spp., and Yellow-throated Scrubwren *Sericornis citreogularis*;and among the skinks *Coeranoscincus* spp. Further interest derives from some species complexes having isolated populations in MQ rainforest and other populations in SE or NEQ or both. Analyses of morphological variation in some of these (e.g. Boles, 1983 for the Brown Thornbill, *Acanthiza pusilla*), suggest some MQ isolates are more closely related to SE populations than to those of geographically closer NEQ. In other complexes having undifferentiated MQ isolates there are clear affinities with NEQ (e.g. the skinks *Saproscincus basilicus* and *Carlia rhomboidalis*) or with SE (e.g. the skink *Lampropholis delicata* – Mather, 1990; Mather & Hughes, 1992). Still other MQ isolates are of uncertain affinity because they are morphologically intermediate between conspecifics in north-

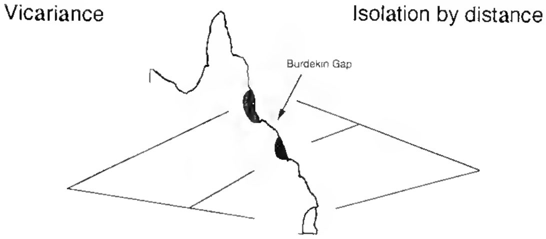


FIG. 1. Location of mideastern Queensland rainforests, their isolation from rainforests of northeastern Queensland and south-central eastern Australia, and the location of the Burdekin Gap. Superimposed on this are the two models of phylogenetic relationships among populations of species inhabiting rainforests tested here.

eastern and southeastern Queensland (e.g. Boles & Longmore, 1983 for the White-throated Treecreeper *Cormobates leucophaea intermedia*). Molecular analyses bearing on phylogenetic affinities of MQ populations at present are few and limited in extent (e.g. Christidis & Schodde, 1991).

Given these observations and analyses, we chose to investigate the historical biogeography of MQ rainforest birds and the evolutionary connections between populations in MQ, SE and NEQ rainforests. We have used an approach that integrates phylogenetic and geographical patterns of diversity in mitochondrial DNA (mtDNA). Such patterns are increasingly being used to explore interactions between phylogeny, ecology and biogeography. Mitochondrial DNA is well-suited to this type of analysis for reasons that have been discussed by a number of authors (Avise et al., 1987; Moritz et al. 1987). Analyses of mtDNA can be used to trace within-species phylogenetic patterns and to place them in the context of a species' geographical distribution. This has created a bridge between systematics and population genetics that Avise et al. (1987) called intraspecific phylogeography, and which we are using to analyse the biogeographical history of NEQ rainforests (e.g. Moritz et al., 1993). Phylogeography has also been used to interpret the biogeographical history of several species assemblages and faunas in the United States (Bermingham et al., 1992; Lamb et al., 1992; Avise, 1992).

From palynological and climatological analyses, it has been established that rainforest fluctuated in extent at specific sites in eastern Australia during the Pleistocene, with eucalypt-dominated habitats replacing rainforest for periods of several thousands of years (e.g. Walker, 1990; Kershaw, 1986). Less clear are the dynamics of rainforest's extent on the broader geographical scale in eastern Australia, although rainforest is known to have extended well into southeastern Australia during the Tertiary (Truswell, 1990). In this paper we test hypotheses concerning the presence and absence of connections among rainforests of MQ, SE and NEQ by examining mtDNA phylogeography of birds inhabiting those rainforests (Fig. 1). Notwithstanding what might be considered the null hypothesis of there being no geographical structure in within-species mtDNA diversity, we ask whether geographical patterns of mtDNA diversity in these species reflect either the effects of isolation by distance prior to the isolation of the NEQ, MQ and SE populations, or historical effects of vicariance induced by the dry, sparsely wooded corridor between Townsville and Bowen (the Burdekin Gap — Ford, 1986; Winter, 1984; Galbraith, 1969). In applying an isolation by distance model to a continuously distributed species with limited dispersal, one expects that the degree of genetic differentiation between two individuals will increase with increasing distance between the sites of sampling. Under this model, we would expect MQ populations to have closest phylogenetic affinity with populations geographically closest to them (i.e. those from NEQ). Under a vicariance model, MQ populations would be expected to be closer to SE populations if the Burdekin Gap has operated for an evolutionarily long period.

We focus on three bird species that occur in MQ, SE and NEQ rainforests: Large-billed Scrubwren, *Sericornis magnirostris*, White-browed Scrubwren, *S. frontalis* and Eastern Whipbird, *Psophodes olivaceus*. Populations of the Large-billed Scrubwren in the three areas are isolated from one another with the NEQ birds recognized as *S. m. viridior* due to minor differentiation in plumage (Christidis et al., 1988). The White-browed Scrubwren is continuously distributed between NEQ and SE rainforests and its NEQ populations have been separated as *S. f. herbertoni* although this subspecies is not currently recognized (Christidis & Schodde, 1991; Ford, 1985; Storr, 1984). The NEQ populations of the Eastern Whipbird are geographically isolated and recognized as *P. o. lateralis* (Blakers et al., 1984; Storr, 1984). All three species occur in a range of forested habitats. The Large-billed Scrubwren and Eastern Whipbird favour rainforest and wetter temperate forests, whereas the White-browed Scrubwren is far less specialized,

MQ endemic taxa	Presumed closest relative(s)	Distributions	Reference
Mammals			
*Petrogale persephone**	*?P. xanthopus*	inland SE Australia	Maynes, 1982; Edridge et al., 1992
Birds			
Meliphaga hindwoodi	*M. chrysops**	SE Australia (non-breeding migrant to NEQ)	Longmore & Boles, 1983
	M. frenata	NEQ	Longmore & Boles, 1983
Acanthiza pusilla mcgilli	*A.p. pusilla*	SE Australia	Boles, 1983
Cormobates leucophaea intermedia	*?C.l. leucophaea*	SE Australia	
Reptiles			
Phyllurus spp. (*caudiannulatus, isis, nepthys, ossa*)	*P. platurus**	Hawkesbury sandstone, NSW	Couper et al., 1993
Eulamprus amplus	?	–	
E. luteilateralis	*E. murrayi*	SEQ, NE NSW	Covacevich & McDonald, 1980
*Lygisaurus zuma**	?	–	Couper, 1993
*Anomalopus brevicollis**	*A. gowi**	NEQ	Greer & Cogger, 1985
Amphibians			
Rheobatrachus vitellinus	*R. silus*	SEQ	Mahony et al., 1984
Taudactylus eungellensis	*T. diurnus*	SEQ	Ingram, 1980
T. liemi	?	–	Ingram, 1980

TABLE 1. Summary table of taxa endemic to mideastern Queensland with presumed closest relatives and their distributions. See Stanisic (1990) and Dyne (1991) for some invertebrate groups. An * indicates a species not normally found in rainforest.

occurring also in shrubby undergrowth in drier areas (Crome, 1990, table 1).

MATERIALS AND METHODS

RESTRICTION SITE ANALYSIS

Restriction endonucleases are used to sample nucleotide sequence variation. Information from several restriction enzymes is combined to define different alleles or 'haplotypes' of mtDNA present in different individuals. We have described the method in more detail elsewhere (Dowling et al., 1990; Joseph & Moritz, 1993a). Our comparisons are based on mapped or unambiguously inferred restriction sites, mostly using enzymes that recognize sequences of six bases, and extend our previous analyses of restriction site variation (Joseph & Moritz, 1993b). In addition, we present new evidence from DNA sequences.

From a survey of restriction fragment length polymorphism (RFLP) of the entire mtDNA genome in each species we derive proportions of shared restriction sites and from these obtain sequence divergence estimates within and among individuals from NEQ, MQ and SE populations by the maximum likelihood method of Nei & Tajima (1983). Nucleotide diversity, a measure of the average difference between any two mtDNAs, was derived either with the the REAP package of McElroy et al. (1992) using the GENERATE, D and DA functions, or calculated manually (e.g. Quinn & White, 1987); nucleotide diversity values in comparisons between two populations have been corrected for within-population variation. Phylogenetic relationships among haplotypes in the three populations were derived from the same data using parsimony from PAUP Version 3.0s (Swofford, 1991) and MacCLADE Version 3 (Maddison & Maddison, 1992). The significance of branching points was assessed with 500 randomized replicates using the exhaustive search option of PAUP. Hedges (1992) urged that a minimum of 2,000 replicates be performed unless computing time is prohibitive. In view of this and with reference to Fig. 1 of Hedges (1992), we contend that given the relatively simple data sets obtained here with small numbers of taxa, 500 replicates are adequate.

DNA SEQUENCING

Next, we sought finer resolution of the patterns obtained from RFLP with direct sequencing of approximately 270 bp of the cytochrome *b* gene using templates generated by the polymerase chain reaction (PCR). To minimize the chance of amplifying nuclear DNA copies of mtDNA sequences, most sequences (23 of 29) were amplified from mtDNA that had been purified by ultracentrifugation in a CsCl density gradient (Dowling et al., 1990); one outgroup sequence, that of the Grey-crowned Babbler, *Pomatostomus temporalis*, was obtained from the literature. The

TABLE 2. Numbers of individuals examined by RFLP and sequence analysis for three species studied and in three rainforest blocks NEQ, MQ and SE of eastern Australia. South-east* indicates southeastern Queensland and northeastern New South Wales. Locality details for the scrubwren samples are in Joseph & Moritz (1993a, b) and voucher specimens of the scrubwrens are held mostly in the Queensland Museum, Brisbane. For the whipbird samples, details of collection localities and field identification numbers of specimens used in RFLP analysis are in the caption to Table 4. The following were used for sequence analysis: SE: L 226, C 291, Ps 1; MQ: C 529; NEQ:C 564, Ps 7 (Atherton Tableland). All whipbird specimens are lodged with the Australian National Wildlife Collection, Canberra or Museum of Victoria, Melbourne except Ps 1, which is lodged at the Queensland Museum. Only a blood sample was available from Ps 7.

	Restriction Fragment Length Polymorphism Analysis			*Cytochrome b* Sequence Analysis		
	North-east Queensland	Middle Eastern Queensland	South-east*	North-east Queensland	Middle Eastern Queensland	South-east*
Large-billed Scrubwren *Sericornis magnirostris*	15	3	9	6	3	3
White-browed Scrubwren *S. frontalis*	3	2	10	3	4	2
Eastern Whipbird *Psophodes olivaceus*	1	1	6	2	1	3

six samples obtained by PCR amplification of total cellular DNA were AQ 8, SK 14, SF 35, SF 37, Ps 7 and SM 111 and these showed no signs of involving a nuclear copy. The initial PCR involved 30 cycles of denaturing at 93°C for 35s, annealing at 48°C for 1 m and extension at 72°C for 1 m. PCR products were then purified and sequences obtained by cycle sequencing (Murray 1989; 25 cycles of denaturing at 94°C, annealing at 58°C and extension at 70°C, each for 30 secs) using only minor modifications of the commercially available BRL kit. Primers used were based on those of Kocher et al. (1989) and were:

Light strand:

`cyt b1: 5'- TACCCGGGGATCCCCATCCAACATCTCAGCATGATGAAA - 3'`

Heavy strand:

`cyt b2: 5' - CCGGATCCCCGGCCCTCAGAATGATATTTGTCCTCA - 3'`

Sequences initially were obtained from both strands in at least one individual for each species from NEQ, MQ and SE. Subsequent sequencing was done only on the light strand except to verify further polymorphisms where necessary.

For sequence analyses, we used any further MQ samples available and, if possible, at least five individuals from SE and NEQ (Table 2). Sequence divergences were calculated by direct count and nucleotide diversities calculated and phylogenetic analyses done as for the RFLP data. Most methods are described in Hillis & Moritz (1990).

RESULTS

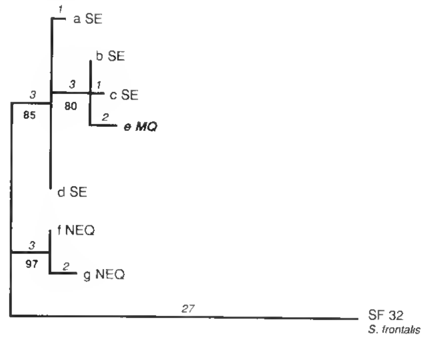
For the scrubwrens we present a summary of RFLP data, most of which have been presented in full in Joseph & Moritz (1993b). For the whipbird and all sequence analyses we offer more complete presentations.

LARGE-BILLED SCRUBWREN

Previous RFLP analyses revealed one common haplotype in northeastern Queensland (present in 8 of 15 individuals surveyed) with several other very similar haplotypes (sequence divergences 0.2% ± 0.2 to 0.7% ± 0.4) separated from it by small numbers of site changes. A similar situation applied to SE samples. Sequence divergence between SE and NEQ samples ranged from 1.2 ± 0.6 to 1.7 ± 0.7% but inclusion of further restriction sites not considered in the earlier study saw the divergences rise (e.g. to 2.2% ± 0.6 between the most common SE and NEQ haplotypes). All three MQ individuals had the same haplotype, which differed by 0.8 ± 0.5% from the common SE haplotype and by 2.6 ± 0.8% from the common NEQ one. Nucleotide diversities showed a similar pattern with the values in comparisons between NEQ and either MQ or SE (0.021 in both) being up to an order of magnitude greater than between SE and MQ or within either NEQ, MQ or SE (Table 3). Together, these values indicate that mtDNA diversity in this species was most strongly structured geographically between NEQ on one hand and MQ/SE on the other. The phylogenetic analysis of Joseph & Moritz (1993b), designed to investigate relationships between species of *Sericornis*, was extended to study the phylogenetic structure within this species by including all SE haplotypes and the

Large-billed Scrubwren *Sericornis magnirostris*

a) 50% Majority rule consensus tree from RFLP data with branch lengths above and bootstrap values (500 replicates) below



b) shortest tree (56 steps) from *cytochrome b* sequence data with branch lengths above and bootstrap values (500 replicates) below

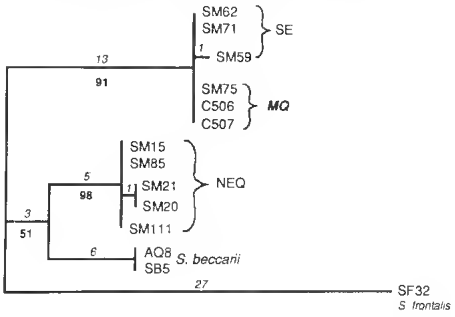


FIG. 2. Trees produced from analysis of RFLP (a) and sequence data (b) in the Large-billed Scrubwren showing bootstrap values and branch lengths. Though not central to the aims here, the Tropical Scrubwren *S. beccarii* has been included. Its position in the analysis reinforces the findings of Joseph & Moritz (1993b). The letters a to g in (a) correspond to the haplotypes shown in Appendix 1.

White-browed Scrubwren as an outgroup (Appendix 1). In a 50% majority rule consensus tree (42 steps in length), the MQ haplotype consistently clustered with all SE ones (85% of 500 randomized pseudoreplicates) and the two NEQ haplotypes aligned with each other (97% of 500 pseudoreplicates) (Fig. 2a). This provided a better explanation for six characters when compared with a tree constrained to place MQ with NEQ; the latter better explained only one character and was five steps longer.

Sequence for the cytochrome *b* gene was obtained from 12 individuals all of which except one (SM 111) had also been assayed for RFLP. 279 bp were sequenced in most individuals with a minimum of 256 bp (Fig. 3). Nineteen nucleotide sites were polymorphic. NEQ individuals were polymorphic at one third codon position and the SE and MQ individuals were identical except for one site change present in a single SE individual. Together, the MQ/SE individuals were 6.9% divergent from the common NEQ sequence. Nucleotide diversities showed a similar pattern with the diversities for the comparisons between NEQ and either MQ or SE being an order of magnitude greater than all other comparisons within and among populations (Table 3). Phylogenetic analysis of the cytochrome *b* sequence data, which included the White-browed Scrubwren as an outgroup, emphasized the close relationship between MQ and SE individuals suggested from RFLP patterns (Fig. 2b). In the shortest tree (56 steps) all SE and MQ individuals clustered together and apart from all north-eastern individuals. Among the NEQ individuals, SM 20 and 21 were united by a shared site change but SM 111 separated because of uncertain base assignment at one site. This tree was 12 steps shorter than the shortest tree that could be produced under the constraint of MQ and NEQ individuals being monophyletic. It provided significantly better explanations for twelve characters compared with zero better explained by the constrained tree (chi-squared = 12, *d.f.* = 1, $p < 0.001$).

WHITE-BROWED SCRUBWREN

In a previous RFLP analysis (Joseph & Moritz, 1993b), MQ, SE and NEQ haplotypes essentially formed a single cluster with sequence divergences mostly 0.5% or less and nucleotide diversities consistently low (< 0.003) in all comparisons within and among populations (Table 3). The relationships of the common SE haplotype and single NEQ and MQ haplotypes were poorly resolved (Joseph & Moritz, 1993b). Further analysis using an additional five haplotypes defined by RFLP from 14 restriction endonucleases, and with the Atherton Scrubwren, *S. keri* as an outgroup, still could not produce a well resolved phylogeny in this species (data not shown).

In sequence analyses, 276 bp were obtained with a minimum of 238 bp (Fig. 4). Only five nucleotide sites varied and all base changes were silent transitions at third base positions. Sequence divergences ranged from zero between SF 5 from NEQ and all MQ samples, to 1.2% between SF 3 and SF 30 from NEQ and SE, respectively. Nucleotide diversities were also low in all com-

	Within SE	Within NEQ	SE-MQ	NEQ-MQ	SE -NEQ
Large-billed Scrubwren					
RFLP	0.006 (8)	0.003 (15)	0.004 (11)	0.021 (18)	0.021 (22)
cyt b	0.003 (3)	0.003 (5)	0.000 (6)	0.030 (8)	0.037 (8)
White-browed Scrubwren					
RFLP	0.002 (10)	0.00 (3)	0.003 (12)	0.002 (6)	0.001 (13)
cyt b	0.016 (2)	0.015 (3)	0.000 (6)	0.001 (7)	0.000 (5)
Eastern Whipbird					
RFLP	0.007 (6)	0.00 (1)	0.009 (7)	0.028 (2)	0.009 (7)
cyt b	0.011 (3)	0.01 (2)	0.004 (4)	0.009 (3)	0.0054 (5)

TABLE 3. Nucleotide diversities estimated from RFLP and sequence data within and among populations of NEQ, MQ and SE for the three species. Sample sizes are shown in brackets. Values shown for between population comparisons have been corrected for within-population diversity.

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Large-billed Scrubwren Sericornis magnirostris cytochrome b sequence starting from position 14862
relative to the complete human mtDNA sequence

NEQ a - north-eastern Queensland, individuals SM 20, 21
NEQ b - north-eastern Queensland, individuals SM 15, 85, 111
MQ - middle eastern Queensland, individuals SM 75, C506, C507
SE a - south-eastern Queensland, individuals SM 62, 71
SE b - south-eastern Queensland, individual SM 59

                     Ile Cys Leu Met Thr Gln Ile Ile Thr Gly Leu Leu Leu Ala Met His Tyr Thr
NEQ a                ATC TGC CTA ATA ACT CAA ATC ATC ACA GGC CTC CTG CTA GCC ATA CAC TAC ACG
NEQ b                ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
MQ                   ..T ... ... ... ... ... ... ... ... ... ... ..A ... ... .C. ... ... ..A
SE a                 ..T ... ... ... ... ... ... ... ... ... ... ..A ... ... .C. ... ... ..A
SE b                 ..T ... ... ... ... ... ... ... ... ... ... ..A ... ... .C. ... ... ..A


         Ala Asp Thr Thr Leu Ala Phe Ser Ser Val Ala His Met Cys Arg Asn Val Gln Phe Gly Trp
NEQ a    GCA GAC ACT ACA CTA GCC TTC TCC TCT GTC GCT CAT ATA TGC CGA AAC GTC CAA TTC GGC TGA
NEQ b    ... ... ... ..C ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
MQ       ..G ... ..C ..C ... ... ..T ... ..C ... ... ... ..G ... ... ... ... ... ... ... ...
SE a     ..G ... ..C ..C ... ... ..T ... ..C ... ... ... ..G ... ... ... ... ... ... ... ...
SE b     ..G ... ..T ..C ... ... ..T ... ..C ... ... ... ..G ... ... ... ... ... ... ... ...

         Leu Ile Arg Asn Leu His Ala Asn Gly Ala Ser Phe Phe Phe Ile Cys Ile Tyr Leu His Ile
NEQ a    CTC ATC CGC AAC CTC CAT GCA AAC GGG GCT TCA TTC TTC TTT ATC TGC ATC TAC CTT CAC ATC
NEQ b    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
MQ       ... ... ... ... ... ..C ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SE a     ... ... ... ... ... ..C ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SE b     ... ... ... ... ... ..C ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...

         Gly Arg Gly Phe Tyr Tyr Arg Ser Tyr Leu Asn Lys Glu Thr Trp Asn Val Gly Val Ile Leu
NEQ a    GGA CGA GGA TTC TAC TAC GGC TCC TAC TTG AAC AAA GAA ACC TGA AAC GTC GGA GTT ATC CTC
NEQ b    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
MQ       ... ... ... ... ... ... ... ... ... C.A ... ... ... ... ... ..T A.. ..G ... ... ...
SE a     ... ... ... ... ... ... ... ... ... C.A ... ... ... ... ... ..T A.. ..G ... ... ...
SE b     ... ... ... ... ... ... ... ... ... C.A ... ... ... ... ... ..T.A.. ..G ... ... ...

         Leu Leu Ala Leu Met Ala Thr Ala Phe Val Pro Met
NEQ a    CTC CTG GCC CTT ATA GCA ACT GCT TTC GTA CCT ATG
NEQ b    ... ... ... ... ... ... ... ... ... ... ... ...
MQ       ... ..A A.T ... ... ... ...
SE a     ... ..A A.T ... ... ... ... ...
SE b     ... ..A A.T ... ... ... ...
```

FIG. 3. Sequence of part of the cytochrome *b* gene in the Large-billed Scrubwren in individuals from NEQ, MQ and SE. In this and Figs 4 and 7, the amino acid sequence is included for the purposes of a) verifying that true mtDNA sequence and not non-functional nuclear copies have been obtained and b) making the amino acid sequence itself available for any subsequent phylogenetic analyses at that level.

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White-browed Scrubwren Sericornis frontalis cytochrome b sequence starting from position 14855
relative to the complete human mtDNA sequence


                Leu Gly Ile Cys Leu Met Thr Gln Ile Ile Thr Arg Leu Leu Leu Ala Met His Tyr Thr
SF 3 NEQ      A CTA GGT ATC TGC CTA ATA ACT CAA ATC ATC ACA GGC CTT CTA CTG GCC ATA CAC TAC ACA
SF 4 NEQ                                            ... ... ... ... ... ... ... ... ... ...
SF 5 NEQ                                            ... ... ... ... ... ... ... ... ... ...
SF 32 MQ                                            ... ... ... ... ... ... ... ... ... ...
SF 33 MQ                      . ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 35 MQ                      . ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 37 MQ                      . ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 2  SE                                            ... ... ... ... ... ... ... ... ... ...
SF 30 SE      . ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ..T ... ...

            Ala Asp Thr Thr Leu Ala Phe Ser Cys Val Ala His Met Cys Arg Asn Val Gln Phe Gly Trp
SF 3 NEQ    GCA GAC ACC ACC CTA GCT TTC TCT TCC GTT GCC CAC ATA TGC CGA AAC GTC CAA TTT GGC TGA
SF 4 NEQ    ... ... ... ... ... ... ... ..C ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 5 NEQ    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 32 MQ    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 33 MQ    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 35 MQ    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 37 MQ    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 2  SE    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 30 SE    ... ... ... ... ... ... ... ..C ... ... ... ... ... ... ... ... ... ... ... ... ...

            Leu Ile Arg Asn Leu His Ala Asn Gly Ala Ser Phe Phe Phe Ile Cys Ile Tyr Leu His Ile
SF 3 NEQ    CTT ATC CGC AAC CTT CAC GCA AAC GGA GCC TCA TTC TTT TTT ATC TGC ATC TAC CTC CAC ATC
SF 4 NEQ    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 5 NEQ    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 32 MQ    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 33 MQ    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 35 MQ    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... .
SF 37 MQ    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 2  SE    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 30 SE    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...

            Gly Arg Gly Phe Tyr Tyr Gly Ser Tyr Leu Asn Lys Glu Thr Trp Asn Val Gly Val Ile Leu
SF 3 NEQ    GGA CGG GGC TTT TAC TAC GGC TCC TAC CTA AAC AAA GAA ACC TGA AAC GTC GGA GTA ATC CTC
SF 4 NEQ    ..G ... ... ..C ... ... ..T ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 5 NEQ    ..G ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 32 MQ    ..G ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ..
SF 33 MQ    ..G ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 37 MQ    ..G ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... .
SF 2  SE    ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SF 30 SE    ..G ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...

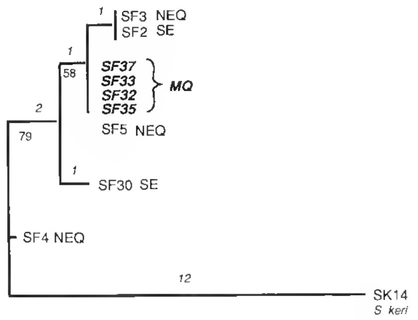

            Leu Ser Ser Pro His Ser Asn Cys Leu
SF 3 NEQ    CTC TCT AGC CCT CAT AGC AAC TGC CTT
SF 4 NEQ    ... ... ... ... ... ... ... ..
SF 5 NEQ    ... ... ... ... ... ... ... ..
SF 33 MQ    ... ... ..
SF 2  SE    ... ... ... ... ... ... ... ..
SF 30 SE    ... ... ... ... ... ... ... ... ...
```

FIG. 4. Sequence of part of the cytochrome *b* gene in the White-browed Scrubwren in individuals from NEQ, MQ and SE.

parisons within and among populations reaching 0.01 only within NEQ and within SE. As was the case with RFLP analysis, phylogenetic analysis of the small number of informative sites in the sequence data showed no consistent pattern of relationships among the three areas SE, MQ and NEQ (Fig. 5).

EASTERN WHIPBIRD

In the RFLP analysis, between 46 and 51 sites unambiguously were inferred after digesting the mtDNA genomes with the same 17 restriction endonucleases as used for *Sericornis* (Appendix 2, Table 4). The MQ sample was identical with one from southeastern Queensland, both of which in turn were very similar to the individuals from New South Wales (sequence divergences 0.2 ± 0.2% to 1.1 ± 0.4%). In contrast, in comparisons between MQ/SE and the individual from NEQ divergences reached between 2.5 ± 0.7% and 2.8 ± 0.8% (Table 5). Nucleotide diversities suggested a similar pattern, being 0.007 within SE (only single individuals were available from MQ and NEQ) and 0.009 between MQ and SE but 0.028 in comparisons between MQ and NEQ and 0.009 between SE and NEQ (Table 3). Structuring of mtDNA diversity in the limited sample of this species was most strongly suggested between NEQ and MQ/SE combined. No RFLP data were available for use as an outgroup in phylogenetic analysis for this species so an unrooted phylogenetic network linking all haplotypes was constructed using only unambiguous characters (Fig. 6a). In a tree 21 steps in length the single NEQ individual was on a branch separate from all other samples while those from south-eastern and middle eastern Queensland, which were the same haplotype, were aligned with one of the New



White-browed Scrubwren *Sericornis frontalis*

-shortest tree (17 steps) with branch lengths above and bootstrap values (500 replicates) below; MQ individuals italicized

FIG. 5. Tree produced from analysis of sequence data in the White-browed Scrubwren showing bootstrap values and branch lengths.

South Wales samples. Placing MQ with NEQ produced a tree one step longer that better explained only one character compared with two better explained in the tree aligning MQ with SE.

In sequence analyses, up to 264 bp were sequenced in six individuals with a minimum of 228 bp (Fig. 7). Seven nucleotide sites varied across NEQ, MQ and SE. Among all the MQ and SE individuals, divergence ranged from zero (between C529 and Ps 1 from middle eastern and south-eastern Queensland, respectively) to 0.9% and 1.1% in comparisons among SE individuals. Between SE/MQ and NEQ individuals divergences ranged from 1% to 3% while divergence between the two NEQ individuals was 0.9%. Nucleotide diversities weakly suggested structuring to the diversity with between population values being generally lower than those within populations but with the highest value being in the NEQ-MQ comparison (Table 3). Though few phylogenetically informative characters were available, phylogenetic analysis was done using sequence from the Grey-crowned Babbler (Edwards et al., 1991) as an outgroup. A shortest tree 33 steps in length was produced that grouped the two NEQ individuals apart from all SE and MQ individuals (Fig. 6b). Placing the single MQ individual with NEQ did not better explain any characters and resulted in a tree two steps longer.

DISCUSSION

mtDNA PHYLOGEOGRAPHY

To shed light on the historical biogeography of MQ rainforests we have looked at the phylogeographic structure of mtDNA diversity in three bird species common to MQ, SE and NEQ rainforests and asked whether the structures are consistent with isolation by distance or vicariance models. The patterns revealed by RFLP and sequence analyses in the three species in general were concordant in that where geographic structuring was present, the patterns were the same. In this regard, the identity between MQ and SE individuals at the sequence level in the Large-billed Scrubwren was striking, although RFLP assays did reveal some variation in other parts of the mtDNA genome. These patterns strongly suggest that in the Large-billed Scrubwren and, to a lesser extent the Eastern Whipbird, mtDNA diversity is apportioned between SE and MQ populations on one hand and NEQ on the other. For these two species, we can favour the hypothesis of a vicariance event about the Burdekin Gap having isolated MQ and SE populations from NEQ ones. If isolation by distance has operated in these species, then its effects are minor compared with those of vicariance induced by the Burdekin Gap. This in turn implies that the Burdekin Gap has been a long-standing biogeographical barrier, a conclusion consistent with geographical patterns of morphological variation as expressed in existing subspecific taxonomy in these two species.

In the White-browed Scrubwren, however, there was no clear geographic structure despite substantial variation in RFLP analyses and the phylogenetic relationships among the mtDNA alleles seem poorly resolved; the greatest divergence was between some SE haplotypes. The situation in this species is consistent with neither the isolation by distance nor the vicariance model and we suggest that this species has not evolved a stable phylogeographic structure in mtDNA diversity among its Queensland populations; the situation is at present less clear with regard to morphological diversity (Ford, 1985). This may be attributable to the species' far greater habitat diversity relative to the other two species studied, as this probably facilitates rapid and widespread dispersal. Christidis & Schodde (1991) argued from allozyme data that a zone of secondary intergradation in the White-browed Scrubwren occurs about the latitude of Rockhampton, which is south of the MQ rainforests. Unfortunately,

	Ava I	*Bam III*	*Bcl I*	*Bgl II*	*Dra I*	*Eco 0109*	*Eco RI*	*Eco RV*	*Hind III*	*Nco I*	*Nhe I*	*Pvu II*	*Spe I*	*Hinp I*	*Hinf I*	*Msp I*
New South Wales																
D750	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
L226	.	.	.	.	?	.	.	.	.	.	.	?	.	.	.	.
L255	.	.	.	.	.	.	.	.	B	.	.	.	.	.	.	.
B840	.	.	.	.	B	B	.	.	.	B	.	B	.	.	.	B
C291	.	.	.	.	B	B	.	.	.	B	.	B	.	.	.	B
South-East Queensland																
Ps I	.	B	B	.	B	B	.	.	.	C	.	.	B	A?	A?	A?
Middle Eastern Queensland																
C529	.	B	B	.	B	B	.	.	.	C	.	.	B	--	A?	?
North-East Queensland																
C564	.	B	C	B	C	C	B	.	C	D	B	C	C	B	A?	C

D750: Nowra, NSW
L226: Kiola, NSW
L255: Kangaroo Valley, NSW
B840: Cambridge Plateau, NSW
C291: Mebbin State Forest, NSW
Ps 1: Conondale Ranges, South-East Queensland
C529: Cathu State Forest, Middle Eastern Queensland
C564: Mission Beach, North-East Queensland

TABLE 4. Restriction fragment profiles in the Eastern Whipbird. Question marks indicate uncertain typings.

they were only able to analyse NEQ populations for one locus (*AlD*) and further analysis of allozymes in northeastern Queensland populations would be desirable.

The mtDNA data, then, provide a basis for suggesting that isolation of the MQ and SE rainforests from each other is very recent compared with that of the NEQ rainforests from those of SE and MQ. Further, we may conclude that vicariance induced by the Burdekin Gap has been a major force in shaping patterns of genetic diversity within rainforest birds such as the Large-billed Scrubwren and Eastern Whipbird as well as in shaping species distributions. The White-browed Scrubwren, however, is a species for which mtDNA diversity and geographical range appear not to have been so affected; its broader habitat range and likely greater dispersal abilities may act to override the evolution of any phylogeographic structure.

SPECULATIONS ON MQ BIOGEOGRAPHY

The mtDNA evidence indicates recent connections between SE and MQ rainforests. These connections could have been either of two types: (i) continuous tracts of rainforest only recently broken into present disjunct isolates or, (ii)scattered patches of a habitat such as vine thickets or dry rainforest that could have existed for much of the Pleistocene. Either interpretation would be consistent with the patterns of genetic diversity we have reported here, but the second is more consistent with both the absence in MQ of several highly specialized rainforest species of SE and NEQ rainforests, and the presence of less specialized species such as we have studied here in each of SE, MQ and NEQ rainforests. Further, the lack of substantial rainforest connections could have promoted the evolution of MQ rainforest endemics (Table 1). What remains to be explained is the initial absence from MQ of several rainforest species found in both NEQ and SE rainforests. As suggested by Winter (1988) to explain the dearth of rainforest specialists among the mammals of SE rainforests, it could be that MQ rainforests contracted to an area too small to support obligate rainforest species during the driest period of the Pleistocene glacials. However, the absence of the Yellow-throated Scrubwren *S. citreogularis*, a species now capable of occupying wet sclerophyll as well as rainforest habitats, remains difficult to understand. The mtDNA divergence between the SE and NEQ populations is at least as great as that between those of the Large-billed Scrubwren (Joseph & Moritz, 1993b) so they might be expected to have reacted similarly to habitat changes and vicariance events.

A prediction from the second suggestion is that the endemic species of MQ rainforests are des-

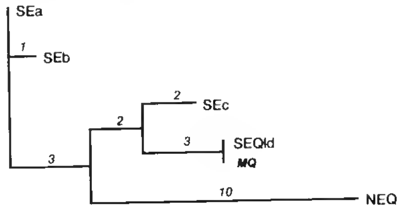
	D 750, L 226 (NSW)	L 255 (NSW)	B 840, C 291 (NSW)	Ps 1 (SE Qld), C 529 (MQ)	C 564 (NEQ)
D 750, L 226 (NSW)	49	48	46	47	41
L 255 (NSW)	0.2 ± 0.2	48	45	46	40
B 840, C 291 (NSW)	0.9 ± 0.4	1.1 ± 0.4	48	47	40
Ps 1 (SE Qld), C 529 (MQ)	1.0 ± 0.4	1.2 ± 0.4	0.9 ± 0.4	51	41
C 564 (NEQ)	2.5 ± 0.7	2.7 ± 0.8	2.7 ± 0.8	2.8 ± 0.8	46

TABLE 5. Matrix of sequence divergence values between different haplotypes in the Eastern Whipbird. Numbers of sites inferred in each haplotype are on the leading diagonal, while numbers of shared sites and sequence divergence values and their standard deviations are above and below the diagonal, respectively.

cendants of lineages that were either capable of surviving in small rainforest patches or that were non-rainforest forms. This could be tested by placing habitat preference of MQ endemics, especially the most narrowly distributed ones with rainforest specialization, and their close relatives in a framework of the phylogenetic affinities among the species themselves. One could then argue whether habitat shifts from eucalypt to rainforest have occurred and, if so, whether MQ rainforest endemics are likely derived from non-rainforest inhabiting ancestral lineages. The leaf-tailed geckoes *Phyllurus* spp., which include narrowly distributed rainforest endemics in MQ and other species showing varying degrees of dependence on rainforest, are an example of such a group (Couper et al., 1993). The Eungella Honeyeater of MQ rainforests (Table 1) would provide a further useful test as its closest relative is either the Yellow-faced Honeyeater *M. chrysops* of eastern Australian eucalypt forests or the Bridled Honeyeater *M. frenata* endemic to NEQ rainforests (Longmore & Boles, 1983). Habitat shifts from rainforest to eucalypt habitats have long been considered to have been involved in the evolution of the Australian biota but the reverse has rarely, if ever, been proposed. MQ rainforests provide an opportunity to test for such shifts.

Eastern Whipbird *Psophodes olivaceus*

a) unrooted phylogenetic network from RFLP data showing branch lengths



b) shortest tree from sequence data with branch lengths

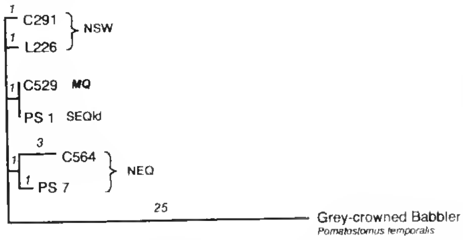


FIG. 6. Trees produced from analysis of RFLP (a) and sequence data (b) in the Eastern Whipbird to show bootstrap values and branch lengths. The letters a to c in (a) correspond to the haplotypes shown in Appendix 2.

The existence between MQ and SE of a number of very narrowly distributed species endemic to small, isolated patches of rainforest and wetter forest types would be consistent with long-term habitat connections between MQ and SE rainforests having been through scattered habitat patches rather than continuous rainforest. Examples are especially prominent in the Kroombit Tops region from where the day frog *Taudactylus pleione* Czechura, 1986 and a number of charopid land snails (Stanisic, 1990) are known. The recently discovered and most distinctive scincid genus *Nangura* from near Murgon (Covacevich et al., 1993) is a further example.

In conclusion, we submit that mtDNA intraspecific phylogeography offers increased resolution over that available so far in studies of the historical biogeography of middle eastern Queensland rainforests. However, more insight may be forthcoming from the other species listed in Table 1. Phylogenetic analyses of groups with narrowly distributed MQ endemics (e.g day frogs

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Eastern Whipbird Psophodes olivaceus cytochrome b sequence starting from position 14868 relative
to the human sequence

NEQ a - north-eastern Queensland, individual C 564
NEQ b - north-eastern Queensland, individual Ps 7
MQ - middle eastern Queensland, individual C 529
SE a - south-eastern Queensland, individual Ps 1
SE b - eastern New South Wales, individual C 291
SE c - eastern New South Wales, individual L 226

                              Leu Ile Thr Gln Ile Ile Thr Gly Leu Leu Leu Ala Met His Tyr Thr
NEQ a                               C ACA CAA ATC ATC ACA GGC CTC CTC CTA GCC ATA CAT TAC ACA
NEQ b                         CTA GT. ... ... ... ... ... ... ..T ... ... ... ... ... ... ...
MQ                            ... ... ... ... ... ..T ... ... ..T ... ... ... ..G ... ... ...
SE a                          ... ... ... ... ... ..T ... ... ..T ... ... ... ..G ... ... ...
SE b                          ... A.. ... ... ... ... ... ... ..T ... ... ... ..G ... ... ...
SE c                          ... ... ... ... ... ... ... ... ..T ... ... ... ... ... ... ...

          Ala Asp Thr Asn Leu Ala Phe Ser Ser Val Ala His Met Cys Arg Asn Val Gln Phe Gly Trp
NEQ a     GCA GAC ACC AAC CTA GCC TTC TCC TCT GTA GCC CAC ATA TGC CGA AAT GTA CAA TTC GGA TGA
NEQ b     ... ... ... .C. ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
MQ        ... ... ... .C. ... ... ... ... ..C ... ... ... ... ... ... ..C ... ... ... ... ...
SE a      ... ... ... .C. ... ... ... ... ..C ... ... ... ... ... ... ..C ... ... ... ... ...
SE b      ... ... ... .C. ... ... ... ... ..C ... ... ... ... ... ... ..C ... ... ... ... ...
SE c      ... ... ... .C. ... ... ... ... ..C ... ... ... ... ... ... ..C ... ... ... ... ...

          Leu Ile Arg Asn Leu His Ala Asn Gly Ala Ser Phe Phe Phe Ile Cys Ile Tyr Phe His Ile
NEQ a     CTA ATC CGA AAC CTA CAT GCA AAC GGA GCT TCA TTC TTC TTC ATT TGT ATC TAC TTC CAC ATT
NEQ b     ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
MQ        ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SE a      ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SE b      ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SE c      ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...

          Gly Arg Gly Ile Tyr Tyr Gly Ser Tyr Leu Asn Lys Glu Thr Trp Asn Val Gly Val Ile Leu
NEQ a     GGA CGA GGA ATC TAC TAC GGA TCA TAC CTA AAC AAA GAA ACC TGA AAC GTC GGA GTC AT
NEQ b     ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ..
MQ        ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ..C CTC
SE a      ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SE b      ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...
SE c      ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... ...

          Leu Leu Thr Leu Met Ala Thr Ala Ser
MQ        CTA CTA ACC CTC ATG GCA ACT GCT TCG
SE a      ... ... ... ... ... ... ... ... .
SE b      ... ... G.. ... ... ... ...
SE c      ... ... ... ... ... ... ...
```

FIG. 7. Sequence of part of the cytochrome *b* gene in the Eastern Whipbird in individuals from NEQ, MQ and SE.

Taudactylus spp. and leaf-tailed geckos *Phyllurus* spp.) or those with representatives in the rainforests of all major eastern Australian rainforest blocks (e.g. the White-throated Treecreeper and Brown Thornbill complexes) are likely to be especially fruitful.

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APPENDIX 1. Restriction site matrix for the Large-billed Scrubwren.

Appendix 1. Matrix of restriction sites from RFLP data in the Large-billed Scrubwren *Sericornis magnirostris*. a - haplotype 1 - individuals SM2, 59, 60, 68; b - SM 71; c - SM1; d SM 66; e - SM75; f - SM 79; g - SM105; SF32 - *Sericornis frontalis* a - dare from south-eastern Queensland; e is from middle eastern Queensland; f and g are from north-eastern Queensland.

	Ava I	*Bam* HI	*Bcl* I	*Bgl* II	*Dra* I	*Eco* RI	*Eco* RV	*Nhe* I	*Pvu* II	*Sac* II	*Hind* III
a	1111110	111010000	111100	1100	1111	110	1	1100	1011000	11	111111100
b	1111110	111000000	111100	1100	1111	111	1	1100	1111100	11	111111100
c	1111110	111010000	111100	1100	1111	111	1	1100	1111100	11	111111100
d	1111110	111000000	111100	1100	1111	110	1	1100	1011000	11	111111100
e	1111110	111011000	111100	1100	1111	111	1	1100	1111100	11	111111100
f	1111100	111101000	101100	1000	1111	110	1	1110	1011000	11	111111100
g	1101100	111101000	101100	1000	1111	110	1	1110	1011000	11	111111101
SF32	1111101	110000111	000011	0011	1110	111	0	1001	0000011	11	111100010

APPENDIX 2. Restriction site matrix for the Eastern Whipbird.

Appendix 2. Matrix of restriction sites from RFLP data in the Eastern Whipbird *Psophodes olivaceus*. a - haplotype 1 field collection numbers D750, L226 (NSW); b - L255 (NSW); c - B840, C291 (NSW); d - Ps1 (SE Qld) and C529 (MQ); e- C564 (NE Qld)

	*Ava*I	*Bam* HI	*Bcl* I	*Bgl* II	*Dra* I	*Eco* 0109	*Eco* RI	*Eco* RV	*Hind* III	*Nco* I	*Nhe* I	*Pvu* II
a	11111	110111	101111	101	11111	10101	1110111	11	111111	10101	111	1111
b	11111	110111	101111	101	11111	10101	1110111	11	101111	10101	111	1111
c	11111	110111	101111	101	10101	10111	1110111	11	111111	11101	111	1011
d	11111	111111	111111	101	10101	10111	1110111	11	111111	10111	111	1111
e	11111	111111	101100	111	10111	11101	1111111	11	111011	01101	101	0110

VERTEBRATES OF DRY RAINFOREST OF SOUTH AND MIDEASTERN QUEENSLAND

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Horsup, A., James, C. & Porter, G. 1993 12 24: Vertebrates of dry rainforest of south and mideastern Queensland. *Memoirs of the Queensland Museum* **34**(1):215-228. Brisbane. ISSN 0079-8835.

In 1992, the Queensland Department of Environment and Heritage undertook a series of surveys of vertebrates of dry rainforests of south and mideastern Queensland. Eighteen sites were surveyed between Rockhampton and Gympie, west to Monto and Biloela. Sites were surveyed twice, six monthly, to examine seasonal variations. Generally, faunal diversity was low. Diversity was affected by the proximity of other rainforest or undisturbed forests; the presence of permanent water; size, type, and degree of disturbance from logging, cattle grazing or weed infestation. Seasonal variation at some sites was considerable. The new skink, *Nangura spinosa* (Covacevich et al., 1993) at Nangur SF, near Murgon, SEQ was the most important discovery. ☐ *Dry rainforest, surveys, frogs, Bufo marinus, reptiles, birds, mammals, conservation.*

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With few exceptions, vertebrates of dry rainforests of south and mideastern Queensland, between Rockhampton and Gympie, are poorly known. Although this is the most common rainforest there, little is protected. Much has been cleared, and grazing is common in remaining patches. These rainforests are recognised as important refuges for populations of several temperate and tropical vertebrate species. In the early 1970's, *Potorous tridactylus* was found at Granite Ck SF, a 200km northern extension of its range (J. Toop, pers. comm.), and *Trichosurus caninus* and *Thylogale thetis* have been located at Kroombit Tops, 200km and 300km north of their previous known distributions (Woodall, 1986).

METHODS

All available information on the vertebrate fauna of the study area was collated by searching the literature (e.g. Ingram & Raven, 1991) and accessing the Queensland Museum and RAOU Bird Atlas Scheme databases. Rainforests were selected to cover a range of vegetation types and if they were of more than 50 ha, of less than secure tenure, of interest for acquisitional purposes by DEH, or linked with other areas of significant rainforest; or threatened by clearing, grazing or fire.

Most sites were surveyed twice to take into account seasonal variations. Each was surveyed over a four day period by the rapid fauna survey method (Denny, 1984).

Sites were sampled by the gradsect method of Gillison & Brewer (1985). Two transects were sampled per site. The main axis of each transect was laid out at right angles to the prevailing slope or moisture regime. Over 4 days and nights, fauna records were collected by trapping (200 Elliott, 28 cage, 40 pit-trap, and 40 break-back trap nights), dawn and dusk observations, intensive searches (log-rolling, leaf litter searching), spotlighting, mist-netting, recording bat calls using an electronic detector, and identifying tracks and traces. Voucher specimens of species were lodged in the Queensland Museum wherever possible.

RESULTS

STUDY SITES

The sites (Table 1, Fig. 1) ranged from 50 to 3000 ha and included six vegetation types (Table 1). Sites included freehold and crown land (NP, SF and TR). Bania SF and Granite Ck SF, contain large tracts of wet rainforest. Bania SF is situated at the head of the Burnett R., S Burnett Ra., and contains the largest stand outside a NP in southeastern Queensland. Smaller sites were selected to cover many rainforest types. Two were surveyed at Granite Ck SF to repeat the Australian-Queensland Museum's study (Broadbent & Clark, 1976). Little information was available previously on the vertebrate species of the sites chosen. There are species lists for Granite Ck SF (Broadbent & Clark, 1976), Dan Dan SF (Queensland Forest Service), Goodnight Scrub (Robinson, 1977), and Rundle Ra. (Stock et al., 1988).

AMPHIBIANS

Nineteen species of native frogs (myobatrachids, hylids), and the introduced Cane Toad, *Bufo marinus*, were recorded (Appendix 1). All occur widely elsewhere in Australia. None can be considered endangered or threatened. The amphibians encountered in this study are typically northern tropical (8 species) and eastern regional (6), with a minor inland (3) and southern (2) element.

Generally, frog species diversity was low (mean, 3.8 species per site). No native frogs were found at Coominglah SF and, at three sites, only one native species was found. The highest number of frog species was recorded at Boogooramunya (9). The most commonly encountered and widespread frogs were *Litoria caerulea* (11 of 18 sites), *Limnodynastes ornatus*, *L. latopalmata*, and *L. lesueuri* (all recorded at 7 of 18 sites). *B. marinus* was widespread, and recorded at all sites except Coongara Rock.

As expected, more species and more individuals were recorded in the wet season surveys than in those of the dry season. Twelve of the 19 native frog species were found in both seasons. The other seven species were found only in the wet seasons, and all were recorded at only one site. For example, at Oakview SF, seven native species were recorded in the wet season, none in the dry season. Oakview is a small rainforest (150 ha), with permanent water only 200m from its edge. In contrast, at Bania SF, a large patch of rainforest (>3000 ha), five species were recorded in the wet season, four in the dry season.

Thirteen frog species were recorded at the four AMVF sites (mean, 5.5 per site), 10 species at the seven SEVT sites (mean, 2.4 per site), and eight species at the three CNVF (mean, 3.0 per site). These differences are partly due to the SEVT sites being situated generally in the drier northern and western areas, while AMVF sites were more on the wetter coastal ranges (Fig.1). *L. latopalmata* and *L. rubella* were the most widespread native species, occurring in five of the six vegetation types.

REPTILES

Forty-nine species of reptile (agamids, gekkonids, pygopodids, scincids, varanids, boids, colubrids and elapids) were recorded (Appendix 1). All are native to Australia and, except for *Nangura spinosa*, occur widely elsewhere. Nineteen reptile species are eastern with predominantly coastal distributions from NNSW to NEQ. Nine are endemic to coastal areas of MEQ and SEQ. Of these, *Phyllurus caudiannulatus*, *Ophioscincus ophioscincus*, *Calyptotis lepidorostrum*, *Lampropholis adonis*, and *L. couperi*, are restricted to rainforest and wet sclerophyll forests, and *N. spinosa* is restricted to one patch of semievergreen vine thicket (Covacevich et al., 1993). Three species endemic

Table 1. Survey sites, tenure (NP=National Park, TR=Timber Reserve, SF=State Forest, F=Freehold), site number (after Forster et al., 1991) vegetation, size, and time(1992).

Mt Etna Caves NP, (1), SEVT, semievergreen vine thicket, 300 ha, Mar.
Rundle Range NP (10), semievergreen vine thicket, 500 ha, Apr/Oct.
Mt Larcom F, (14), semievergreen vine thicket, 250 ha, Apr.
Spring Creek F, (17), semievergreen vine thicket, 250 ha, Aug/Dec.
Dan Dan SF 53, (18), semievergreen vine thicket, 835 ha, Mar/Aug.
Coominglah SF 28, (38), semievergreen vine thicket, 1674 ha, Mar/Aug.
Nangur SF 74, (92), semievergreen vine thicket, 500 ha, Jun/Nov.
Deep Creek TR 581, (61), SEVT/AMVF, semievergreen vine thicket/Araucarian microphyll vine forest, 180 ha, May/Nov.
Coongara Rock SF 1344, (69), semievergreen vine thicket/Araucarian microphyll vine forest, 50 ha, Feb/Jul.
Mt Coulston TR 471, (20), AMVF, Araucarian microphyll vine forest, 700 ha, May/Nov.
Goodnight Scrub SF 169, (46), Araucarian microphyll vine forest, 250 ha, May/Oct.
Boogooramunya SF 465, (77), Araucarian microphyll vine forest, 180 ha, Jun/Nov.
Wrattens SF 546, (107), Araucarian microphyll vine forest, 210 ha, Mar/Sep.
Bania SF 54, (39), AMVF/ANVF, Araucarian microphyll vine forest/Araucarian notophyll vine forest, 3000 ha, Apr/Nov.
Oakview SF 220, (99), ANVF, Araucarian notophyll vine forest, 150 ha, Mar/Sep.
Eurimbulah NP, (BB), CNVF, complex notophyll vine forest, 100 ha, Apr/Aug.
Boyne Logging Area SF 391, (30), complex notophyll vine forest, 3000 ha, Jun/Dec.
Dawes Range SF 391, (33), complex notophyll vine forest, 3000 ha, Jun/Dec.

to MEQ and SEQ are not restricted to wetter forests: *Glamphyromorphus punctulata* (tall woodland and seasonally dry forests), *P. salebrosus* (dry rocky scrublands to moister closed forest), and *L. amicula* (open forest and heath). Reptiles were recorded during the study with equal probability in either season: 39 in both wetter and drier surveys.

By far the highest reptile diversity was recorded at the AMVF and SEVT sites, with 42 and 36 species, respectively, while only 15 species were recorded at CNVF sites. Overall, AMVF-ANVF had the highest mean number of species per site (16), mainly because this rainforest type was present at only one very large site, Bania SF (>3000 ha). There was little difference in the mean number of species per site for the other rainforest types: AMVF (11.8), SEVT (10.6), SEVT-AMVF (12.5), CNVF (7.3).

BIRDS

A total of 169 bird species were recorded during the study (Appendix 1). This represents approximately 25% of the total number of birds known to breed in or regularly migrate to Australia. Of these, 79 were commonly recorded in rainforest, 75 were recorded more often in adjacent drier open forests (but were also found along the ecotone between rainforest and open forest), and 15 are shorebirds or waterbirds. Rainforest bird species which were expected, but were not sighted are: Double-eyed Fig Parrot (race *coxeni*), Striated Thornbill, Little Bronze Cuckoo, Rufous Bronze Cuckoo, White-browed Robin, Southern Log Runner, Large-billed Warbler, Bell Miner, and Black Butcherbird. The three species listed first have been recorded previously at Granite Ck SF in the late 1970's (E. Zillman, pers. comm.).

Fifty-seven families were recorded. Dominant were the Muscicapidae (19 species), Meliphagidae (14 species), Columbidae, Acanthizidae, Accipitridae and Falconidae (all 11 species). Most species were recorded at sites in both surveys. The exceptions include the Dollarbird, Superb Fruit-dove, cuckoos, monarchs, flycatchers, and whistlers. These species move seasonally with food availability and breeding.

All bird species recorded occur naturally in Australia and none are restricted to the study area. Fifty-eight species are primarily northern in distribution (e.g. Brown Cuckoo-dove, Spectacled Monarch); 42 are southern (e.g. Eastern Yellow Robin, White-browed Scrubwren); 21 have a regional coastal affinity (e.g. Satin Bowerbird, White-headed Pigeon); 42 are widespread across Australia (e.g. Brown Goshawk, Grey Shrike-Thrush); and 6 have an inland affinity (e.g. Emu, Galah). The ranges of 25 of these birds species terminate in or near the boundaries of the study area. Southern species whose ranges terminate in the study area include the Green Catbird, Paradise Riflebird and Eastern Whipbird (nominate race); northern species whose ranges terminate in the study area include the Fairy Gerygone and Bar-breasted Honeyeater.

Of the 79 bird species recorded primarily in rainforests, most were recorded at the AMVF sites (71 species), followed by the SEVT and CNVF sites (62 and 60 species). When the mean number of species per site was compared, the SEVT sites were lower (32.2 species/site) than the other two rainforest types (AMVF 48.3, CNVF 45.3). This may be explained partly by the northern location of five of the seven SEVT sites which places them north of the distribution of several bird species (e.g. the Green Catbird, Paradise Riflebird, and Pale-yellow Robin). Birds which were recorded at AMVF but not SEVT sites include: Green Catbird, Paradise Riflebird, Black-breasted Button-quail, Crimson Rosella, and Yellow-tailed Black-cockatoo. Conversely, several northern species recorded at SEVT sites were not recorded at AMVF sites because their distribution terminates within the study area: Satin Flycatcher, Large-tailed Nightjar, and Oriental Cuckoo. Relative to the SEVT sites, CNVF and AMVF sites generally contained more fruit-eating birds (F. Columbidae), more insect-eating birds (F. Acanthizidae and Muscicapidae), and more birds of prey (F. Accipitridae).

The rainforest species most frequently recorded were Lewin's Honeyeater and Torresian Crow (all 18 sites), Australian Brush-turkey, Southern Boobook, Australian King-parrot, Rainbow Lorikeet, Emerald Dove, Varied Triller, Rufous Fantail, White-browed Scrub-wren (17 sites), and Australian Owlet-nightjar, Fan-tailed Cuckoo, Little Shrike-thrush, Grey Fantail, Spangled Drongo, Pied Currawong (16 sites).

MAMMALS

Twenty-three species of bats were recorded during the study (Appendix 1). Six were recorded only electronically. One was very distinct (*Mormopterus* sp.), and is probably undescribed (M.C. de Oliveira, pers. comm.). The 23 species comprise 35% of the known Australian bat fauna. Species encountered most frequently were *Mini-*

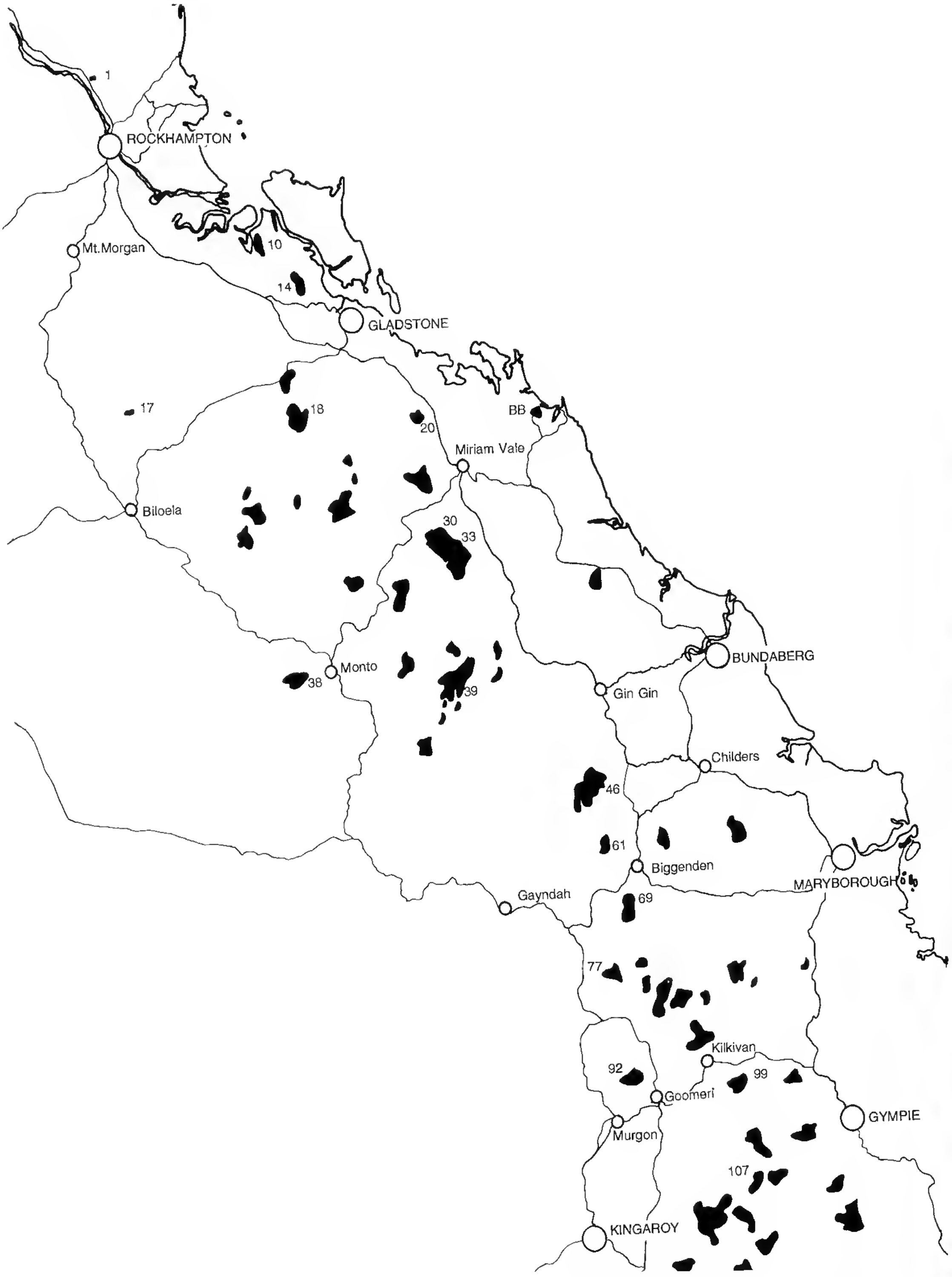

FIG. 1. Location of significant areas of rainforest in the study area, and of major cities, towns and roads. Numbers for study sites correspond with those in Table 1.

opteris schreibersii (9 sites), *M. australis* (8 sites), and *Chalinolobus gouldii* (7 sites).

Thirty-three species of terrestrial and arboreal mammal were recorded (Appendix 1). Thirty-one species were recorded in the dry seasons, 23 in the wet seasons. Nineteen native species were recorded in rainforests. Five of these species are either endemic to, or closely associated with, rainforests: *Melomys cervinipes*, *Rattus fuscipes*, *Antechinus flavipes*, *Thylogale thetis*, and *Wallabia bicolor*.

The geographic affinities of the native terrestrial and arboreal mammal fauna area are primarily eastern (15 species) and northern Australian (6). The occurrence of *Trichosurus caninus* at Dan Dan SF was a 20km extension of the northern limit of its known range (Kroombit Tops, SEQ, Woodall, 1986). Another species, *T. thetis*, is also near the northern limit of its distribution, and *Petrogale inornata* reaches its southern limit in the study area.

When the nine non-rainforest species are excluded, the AMVF, SEVT, and CNVF sites had by far the most diverse mammal faunas, with 24, 21, and 17 species, respectively. The remaining three forest types supported only 7 terrestrial and arboreal mammal species. The patterns become clearer when these rainforest species are divided into groups based on size and taxonomy.

Bats: Twelve species recorded during the study have generally northern distributions; four are eastern regionals; three are widespread; two have mainly southern distributions; one has a mainly inland distribution; and the unidentified *Mormopterus* sp. is probably also northern, given that the calls of southern species are generally well known. The number of species recorded was approximately related to the sampling intensity and the number of sites sampled in each vegetation type: 16 species at seven SEVT sites, 12 at four AMVF sites, nine at two SEVT-AMVF sites, seven at one AMVF-ANVF site, and five each at three CNVF sites and one ANVF site.

Most of the bat species recorded, especially the insectivorous bats, are habitat generalists. None are rainforest endemics, although several species roost in closed forests. *Nyctimene robinsoni* was captured at dusk in rainforest at Dan Dan SF, and was probably emerging to feed on *Eucalyptus* species which were flowering at the rainforest edge. The sheathtail bats (F. Emballonuridae) were represented by only one species, *Saccolaimus flaviventris*, which was recorded at Mt Coulston and Bania. This species is regarded as rare, possibly because it flies high and fast and is difficult to capture, and because it may be restricted to roosting in hollows of aged emergents. *Myotis adversus*, recorded at Eurimbulah, is comparatively rare throughout its range because it is found usually only close to water, where it skims insects from the water surface.

Rodents, dasyurids and bandicoots: Ten small mammal species were recorded during the study. The most frequently encountered species was *M. cervinipes* (10 of 18 sites), which was recorded at all AMVF and CNVF sites, but at only two of the seven SEVT sites. It was typical of structurally complex rainforests where there was a ground cover of leaf litter and logs. The next most frequently encountered small mammal was *R. fuscipes* (5 sites), which was recorded at all CNVF sites, one AMVF site, and none of the SEVT sites. It was found where shelter was available in the form of fallen trees, or a good undergrowth of shrubs and ferns. *A. flavipes*, a habitat generalist, was recorded at only three sites in three vegetation types: AMVF, CNVF, and ANVF. It was found only in sites where epiphytes and logs provided shelter and moss and lichens indicated a moist environment. There was a paucity of small mammals at the SEVT sites.

Possums:Three species were recorded with little difference between rainforest type in the number or composition of species. The most frequently encountered species were *Pseudocheirus peregrinus* and *Trichosurus caninus* (12 and 11 sites, respectively). The former species prefers a variety of vegetation types where shrubs form dense tangled foliage, and was recorded in all CNVF sites and 3 of 4 AMVF sites. *T. caninus* is at the northern limit of its range in the study area and prefers tall open to closed forest. It was recorded in 2 of 3 CNVF sites and 3 of 4 AMVF sites. Both species were recorded in less than half of the seven SEVT sites, although the five northern and coastal SEVT sites are outside the known range of *T. caninus*. *T. vulpecula*, a habitat generalist, was recorded at 8 sites in all vegetation types.

Macropods: Eight species were recorded. Those most frequently encountered in closed forests were *W. bicolor* and *Macropus dorsalis*, which were both recorded at 10 sites evenly across all vegetation types. *T. thetis*, which prefers rainforest and denser vegetation, was recorded at only one site, Dawes Range. Two rock-wallaby species were recorded in rocky habitats in closed forests during the study: *Petrogale inornata*, Mt Etna, and *P. herberti*, Coominglah and Deep Ck.

Other species: Both monotreme species were recorded. *Tachyglossus aculeatus* was identified at Rundle Range (SEVT) from bones. At Mt Coulston an echidna was observed foraging on the edge of the AMVF, but took refuge inside it when disturbed. *Ornithorhynchus anatinus* was observed at Dan Dan (SEVT), in Futter Ck on the forest edge. Dingos were recorded at nine sites.

DISCUSSION

This study has added to knowledge of the distribution of many vertebrate species, and can easily be repeated to examine future patterns of occurrence. The most significant discovery was *N. spinosa*, a new skink, at Nangur SF (Covacevich et al., 1993). This is remarkable in SEQ, which is relatively well known herpetologically. The study also produced some anomalous results which probably relate more to the weather preceding each survey, and to brevity of survey, than to real faunal distribution patterns. It is generally recognised that to sample small mammal species, a minimum of four nights trapping is required (Denny, 1984), and to adequately sample the amphibian fauna, sampling must be carried out following significant rains, and preferably near water. Reptiles are easier to find in warmer weather. Birds also have seasonal patterns of distribution and abundance, with some species (e.g. cuckoos), migrating north in winter. Because of prolonged drought in much of the study area, some sites (e.g. Spring Ck, where no rain fell between both surveys) were effectively sampled in two dry seasons.

The vertebrates of the rainforests of the study area are only moderately diverse. When compared with adjacent open woodlands, however, they support an unique and highly diverse fauna. Removal of the rainforests would result in the disappearance of many species, notably fruit-eating birds, and small mammals such as *M. cervinipes* and *R. fuscipes*.

The relationship between rainforest type and species diversity is complicated by many factors including size, proximity of other rainforests, climate, soils, site moisture regime, and degree of disturbance. Nevertheless, some general patterns are evident from the records. The fauna of SEVT was consistently less diverse than of the other two major rainforest types, AMVF and CNVF. AMVF and CNVF sites supported on average at least 50% more bird and small mammal species than SEVT sites. AMVF also supported around twice as many amphibian species as SEVT and CNVF sites.

The 19 native amphibian species recorded during the survey represent only 10% of the native amphibian fauna of Australia. No permanent or temporary water was present at some sites and, with prolonged drought, this result is not surprising. The Australian Museum expeditions to Granite Ck SF in 1975 recorded 5 other amphibians, *Adelotus brevis*, *Limnodynastes ornatus*, *Litoria caerulea*, *L. nasuta*, and *L. chloris* (Broadbent & Clark, 1976), all relatively widespread species. In rainforest at Kroombit Tops, 50 km from Granite Creek SF, 21 species of frog have been recorded in a variety of habitats from wet rainforest to open woodland, including *Taudactylus pleione*, a rainforest species endemic to the area (Czechura, 1986).

Reptile diversity differed little between rainforest types, although AMVF and SEVT sites were nearly twice as diverse as their CNVF counterparts. Two of the three CNVF sites were at Granite Ck SF which probably explains the lower reptile diversity in this rainforest type. The first survey at Granite Creek SF was conducted in very cold conditions in June, 1992; the second in wet and cool conditions in December, 1992. In the Australian Museum surveys in 1975, 11 additional species were recorded at Granite Creek: *Oedura tryoni*, *Anomalopus verreauxi*, *Egernia frerei*, *Lampropholis adonis*, *Eulamprus quoyi*, *Boiga irregularis*, *Dendrelaphis punctulata*, *Cacophis squamulosus*, *Pseudechis porphyriacus*, *Hemiapsis signata*, and *P. salebrosus* (Broadbent & Clark, 1976).

A large proportion of the rainforest birds expected to occur in the study area were recorded. Notable exceptions were the Double-eyed Fig Parrot, Little Bronze Cuckoo, and Rufous Bronze Cuckoo. The rainforest fauna included a large proportion of fruit-eating species which are important in maintaining and regenerating rainforests by dispersing seed in these rainforests.

The bat fauna of the study area was particularly diverse, with the electronic detector increasing the number of species recorded by 35%. None of the species recorded is a rainforest endemic. However, species such as *N. robinsoni* roost in closed forests, and many of the fruit-eating bats are important dispersers of rainforest fruit. In contrast to the other vertebrate groups, the bat fauna was more diverse at the SEVT sites. This may be because the SEVT sites were more often adjacent to open woodland where more species were recorded.

The terrestrial and arboreal mammal fauna of these rainforests is moderately diverse. Most small mammals expected were recorded. Exceptions were *Dasyurus hallucatus* and *D. maculata*, which have undergone major range contractions; *Phascogale tapoatafa*, which has also undergone a range contraction; and *A. stuartii*, which prefers wetter, denser forests. Of special significance was the record of *T. caninus* at Dan Dan SF, which extends the known northern range of the species by 20 km. *Acrobates pygmaeus* was not recorded during this study. It was recorded at Granite Creek SF by Broadbent & Clark (1976), and has recently been sighted there (Hobcroft & Flower, pers. comm.). Another possum which may occupy closed forests, *Petaurus norfolcensis*, was not recorded but has been recently reported for Boogooramunya SF (Hobcroft & Flower, pers. comm.).

When comparing terrestrial and arboreal mammals by rainforest type, the occurrence of those species requiring structurally complex forests differed most. *M. cervinipes*, *R. fuscipes*, and *P. peregrinus* were conspicuously absent from many of the SEVT sites, suggesting that those SEVT sites surveyed generally did not meet their habitat requirements. The macropod fauna of the closed forests of the study area is diverse, with five species recorded and another two, *T. stigmatica* and *P. tridactylus*, known to occur in the area. Of the five species recorded, only *T. thetis* could be considered a true rainforest species, and it was recorded only once, at Dawes Range, a CNVF site. *T. stigmatica*, which prefers wet sclerophyll forest and rainforest, was reported from Granite Ck SF by Broadbent & Clark (1976).

Introduced and feral mammals did not figure highly at any of the sites. Rabbits, cattle, house mice, and feral cats were recorded at only two sites.

The dry rainforests of south and midcastern Queensland are poorly conserved. In the past they have attracted little scientific interest. Those under the control of the Queensland Forest Service (QFS) can be considered to be relatively safe from major disturbance. Although cattle grazing continues in many sites, current QFS policy is that there will be no further logging. Cattle open up the forest, destroy the lower stratum, and disturb the soil and humus layer. In so doing they can destroy the habitat of small mammals, reptiles, and amphibians, while encouraging invasion by weeds, particularly *Lantana camara*. Fire, which is a common management tool of most graziers, continues to be a threat to many small rainforest patches by 'eating away' the edges and, thus, progessively reducing them.

We expected high diversity at larger rainforest sites, but this was not generally the case. This may be due to the presence of permanent water, and proximity to or connection with other rainforest patches.

We recommend that remaining dry rainforests be conserved. They are important refuges for a wide range of species and with the discovery of *N. spinosa*, are known now to support at least one endemic species.

ACKNOWLEDGEMENTS

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APPENDIX 1. Vertebrate species recorded in dry rainforests in south and mideastern Queensland.

BANIA SF 54

Amphibians F. Myobatrachidae: *Adelotus brevis; Limnodynastes ornatus; L. terraeginae; Pseudophryne major;* F. Hylidae: *Litoria rubella*; F. Bufonidae: *Bufo marinus.*

Reptiles F. Agamidae: *Physignathus lesueurii*; F. Gekkonidae: *Diplodoctylus steindachneri; D. vittatus; Oedura tryoni*; Phyllurus salebrosus; F. Varanidae: *Varanus varius;* F. Scincidae: *Anomalopus verreauxi; Calyptotis lepidorostrum; C. scutirostrum; Carlio pectoralis*; *Ctenotus taeniolatus; Eulamprus tenuis*; *Lampropholis adonis; L. amicula; L. couperi; L. delicata.*

Birds F. Anatidae: *Chenonetta jubata*; F. Accipitridae: *Accipiter fasciotus; Aquila audax; Aviceda subcristata*; F. Megapodiidae: *Alectura lathami;* F. Turnicidae: *Turnix varia;* F. Columbidae: *Chalcophaps indica; Geopelia humeralis; G. placida; Leucosarcia melanoleuco; Macropygia amboinensis; Ptilinopus magnificus; P. regina;* F. Cacatuidae: *Cacatua galerita*; *Calyptorhynchus funereus; C. magnificus*; F. Loriidae: *Glossopsitta pusilla; Trichoglossus chlorolepidotus; T. haematodus;* F. Polytelitidae: *Alisterus scapularis;* F. Platycercidae: *Platycercus adscitus;* F. Cuculidae: *Chrysococcyx lucidus; Cuculus pyrrhophanus; C. variolosus; Eudynamis scolopacea; Scythrops novaehollandiae;* F. Strigidae: *Ninox novaeseelandiae*; *N. strenua;* F. Podargidae: *Podargus strigoides;* F. Aegothelidae: *Aegotheles cristatus*; F. Apodidae: *Hirundapus caudacutus;* F. Alcedinidae: *Dacelo novaeguineae; Halcyon macleayii;* F. Pittidae: *Pitto versicolor*; F. Campephagidae: *Coracina novaehollandiae*; *C. papuensis*; *C. tenuirostris; Lalage leucomela;* F. Muscicapidae: *Colluricincla harmonica*; *C. megarhyncha; Eopsaltria australis*; *Falcunculus frontatus; Microeca leucophaea*; *Monarcha leucotis; M. melanopsis; M. trivirgatus; Myiagra cyanoleuca; Pachycephala pectoralis*; *P. rufiventris*; *Rhipidura fuliginosa; R. leucophrys; R. rufifrons;* F. Orthonychidae: *Psophodes olivaceus;* F. Timaliidae: *Pomatostomus temporalis;* F. Maluridae: *Malurus lamberti; M. melanocephalus;* F. Acanthizidae: *Acanthiza pusilla; A. reguloides*; *Gerygone mouki; G. olivacea; Sericornis frontalis; S. magnirostris;* F. Neosittidae: *Daphoenositta chrysoptera;* F. Climacteridae: *Climocteris leucophaea; C. picumnus;* F. Meliphagidae: *Entomyzon cyanotis; Lichenostomus chrysops; Manorina melanocephala; Meliphaga lewinii; Melithreptus albogularis; M. lunatus; Myzomela obscura; M. sanguinolenta; Philemon corniculatus*; F. Pardalotidae: *Pardolotus punctatus;* F. Zosteropidae: *Zosterops lateralis;* F. Ploceidae: *Emblema temporalis*; F. Oriolidae: *Oriolus sagittatus*; F. Dicruridae: *Dicrurus hottentottus;* F. Paradisaeidae: *Ailuroedus crassirostris; Ptiloris paradiseus*; *Sericulus chrysocephalus;* F. Grallinidae: *Grallina cyanoleuca;* F. Cracticidae: *Cracticus nigrogularis; C. torquatus; Gymnorhina tibicen; Strepera graculina;* F. Corvidae: *Corvus orru.*

Mammals: F. Phascolarctidae: *Phascolarctos cinereus*; F. Petauridae: *Petaurus australis;* F. Pseudocheiridae: *Petauroides volans;* F. Phalangeridae: *Trichosurus caninus; T. vulpecula;* F. Emballonuridae: *Saccolaimus flaviventris;* F. Rhinolophidae: *Rhinolophus megaphyllus;* F. Vespertilionidae: *Chalinolobus gouldii; Miniopteris australis; Nyctophilus gouldii; Scotorepens greyii;* F. Muridae: *Melomys cervinipes*; F. Canidae: *Canis familiaris dingo.*

BOOGOORAMUNYA SF 465

Amphibians: F. Myobatrachidae: *Limnodynastes ornatus; L. Crinia parasignifera; C. signifera; Pseudophryne major*; F. Hylidae: *Litoria caerulea; L. lotopalmata; L. lesueurii; L.rubella*; F. Bufonidae: *Bufo marinus.*

Reptiles: F. Gekkonidae: *Heteronotia binoei*; Oedura monilis; F. Scincidae: *Anomalopus verreauxi*; *Calyptotis scutirostrum*; *Carlia pectoralis; Cryptoblepharus virgatus; Ctenotus taeniolatus; Eulamprus tenuis; Lampropholis adonis; L. amicula; Lygisaurus foliorum;* F. Elapidae: *Rhinoplocephalus nigrescens.*

Birds: F. Ardea: *Ardea novaehollandiae;* F . Accipitridae: *Accipiter cirrhocephalus; A. fasciatus; Aviceda subcristata*; F. Falconidae: *Falco cenchroides*; F. Megapodiidae: *Alectura lathami;* F. Phasianidae: *Coturnix australis;* F. Turnicidae: *Turnix varia*; F. Columbidae: *Chalcophaps indica; Geopelia humeralis; Leucosarcia melanoleuca; Ptilinopus regina;* F. Cacatuidae: *Cacatua galerita; Calyptorhynchus funereus;* F. Loriidae: *Glossopsitta pusilla; Trichoglossus haematodus*; F. Polytelitidae: *Alisterus scapularis;* F. Platycercidae: *Platycercus adscitus*; F. Cuculidae: *Centropus phasianinus; Chrysococcyx basalis; Cuculus pyrrhophanus; Eudynamis scolopacea; Scythrops novaehollandiae;* F. Strigidae: *Ninox novaeseelandiae; N. strenua*; F. Podargidae: *Podargus strigoides*; F. Aegothelidae: *Aegotheles cristatus;* F. Alcedinidae: *Dacelo novaeguineae; Halcyon sancta;* F. Meropidae: *Merops ornatus;* F. Coraciidae: *Eurystomus orientalis;* F. Pittidae: *Pitta versicolor;* F. Campephagidae: *Coracina novaehollandiae; C. papuensis; C. tenuirostris; Lalage leucomela;* F. Muscicapidae: *Colluricincla harmonica; C. megarhyncha; Eopsaltria australis; Monarcha leucotis, M. melanopsis; Myiagro rubecula; Pachycephala pectoralis; P. rufiventris; Petroica rosea; Rhipidura fuliginosa; R. leucophrys; R. rufifrons;* F. Orthonychidae: *Psophodes olivaceus;* F. Timaliidae: *Pomotostomus temporalis;* F. Maluridae: *Malurus melanocephalus;* F. Acanthizidae: *Acanthiza pusilla; A. reguloides*; *Gerygone olivacea; Sericornis frontalis; S. magnirostris; Smicrornis brevirostris;* F. Neosittidae: *Dophoenositta chrysoptera;* F. Climacteridae: *Climacteris leucophaea*; F. Meliphagidae: *Lichenostomus chrysops; Manorina melanocephala; Meliphaga lewinii; Melithreptus albogularis; Myzomela sanguinolenta;* F. Pardalotidae: *Pardalotus punctatus; P. striatus;* F. Zosteropidae: *Zosterops lateralis;* F. Ploceidae: *Emblema temporolis; Poephila bichenovii; Emblema temporolis;* F. Oriolidae: *Oriolus sagittatus; Sphecotheres viridis;* F. Dicruridae: *Dicrurus hottentottus;* F. Corcoracidae: *Corcorax melanorhamphos*; F. Cracticidae: *C. torquatus*; *Gymnorhina tibicen; Strepera graculina*; F. Corvidae: *Corvus orru.*

Mammals: F. Dasyuridae: *Planigale maculata;* F. Peramelidae: *Perameles nasuta;* F. Phascolarctidae: *Phascolarctos* *cinereus;* F. Pseudocheiridae: *Pseudocheirus peregrinus;* F. Phalangeridae: *Trichosurus caninus; T. vulpecula*; F. Macropodidae: *Macropus dorsalis; M. giganteus; Wallabia bicolor;* F. Molossidae: *Mormopterus beccarii; Nyctinomus australis;* F. Rhinolophidae: *Rhinolopus megaphyllus;* F. Vespertilionidae: *Chalinolobus gouldii; C. nigrogriseus; Eptesicus pumilis; Miniopterus australis; M. schreibersii; Nyctophilus geoffroyi Scotorepens greyii;* F. Muridae: *Melomys butoni; M. cervinipes*; F. Canidae: *Canis familiaris dingo*; F. Leporidae: *Oryctolagus cuniculus.*

BOYNE LOGGING AREA SF 391

Amphibians: F. Hylidae: *Litoria lesueurii;* F. Bufonidae: *Bufo marinus.*

Reptiles: F. Gekkonidae: *Phyllurus caudiannulatus;* F. Varanidae: *Varanus varius;* F. Scincidae: *Calyptotis scutirostrum; Hemisphaeriodon gerrardii; Lampropholis adonis; Ophioscincus ophioscincus.*

Birds: F. Accipitridae: *Accipiter novaehollandiae; Aquila audax; Aviceda subcristata; Lophoictinia isura;* F. Megapodiidae: *Alectura lathami;* F. Columbidae: *Chalcophaps indica; Columba leucomela; Leucosarcia melanoleuca*; *Lopholaimus antarcticus; Macropygia amboinensis; Ptilinopus magnificus; P. regina; P. superbus;* F. Cacatuidae: *Calyptorhynchus funereus; C. magnificus;* F. Loriidae: *Trichoglossus haematodus;* F. Polytelitidae: *Alisterus scapularis;* F. Cuculidae: *Chrysococcyx lucidus; Cuculus pyrrhophanus;* F. Strigidae: *Ninox novaeseelandiae;* F. Tytonidae: *Tyto tenebricosa;* F. Aegothelidae: *Aegotheles cristatus;* F. Apodidae: *Apus pacificus; Hirundapus caudacutus;* F. Alcedinidae: *Ceyx azurea; Dacelo novaeguineae; Halcyon sancta;* F. Pittidae: *Pitta versicolor;* F. Campephagidae: *Coracina lineata; C. tenuirostris; Lalage leucomela*; F. Muscicapidae: *Colluricincla harmonica; C. megarhyncha; Eopsaltria australis; Monarcha melanopsis; M. trivirgatus; Pachycephala pectoralis; Petroica rosea; Rhipidura fuliginosa; R. rufifrons;* F. Orthonychidae: *Psophodes olivaceus;* F. Acanthizidae: *Acanthiza pusilla; Gerygone mouki; Sericornis frontalis; S. magnirostris*; F. Climacteridae: *Climacteris leucophaea;* F. Meliphagidae: *Acanthorhynchus tenuirostris; Meliphaga lewinii; Myzomela obscura; M. sanguinolenta;* F. Zosteropidae: *Zosterops lateralis;* F. Ploceidae: *Emblema temporalis;* F. Oriolidae: *Sphecotheres viridis;* F. Paradisaeidae: *Ailuroedus crassirostris; Ptiloris paradiseus; Sericulus chrysocephalus;* F. Artamidae: *Artamus cinereus*; F. Cracticidae: *Strepera graculina;* F. Corvidae: *Corvus orru.*

Mammals: F. Dasyuridae: *Planigale maculata;* F. Pseudocheiridae: *Pseudocheirus peregrinus;* F. Phalangeridae: *Trichosurus caninus;* F. Pteropodidae: *Pteropus poliocephalus; Syconycteris australis;* F. Muridae: *Melomys cervinipes*; *Rattus fuscipes;* F. Bovidae: *Bos taurus.*

DAWES RANGE SF 391

Amphibians: F. Myobatrachidae: *Litoria lesueuri;* F. Bufonidae: *Bufo marinus.*

Reptiles: F. Gekkonidae: *Phyllurus caudiannulatus;* F. Scincidae: *Calyptotis scutirostrum; Eulamprus tenuis; Lampropholis adonis; Ophioscincus ophioscincus;* F. Boidae: *Morelia spilota; Rhinoplocephalus nigrescens.*

Birds: F. Accipitridae: *Accipiter novaehollandiae;* F. Megapodiidae: *Alectura lathami*; F. Columbidae: *Chalcophaps indica; Columba leucomela; Leucosarcia melanoleuca; Lopholaimus antarcticus; Macropygia amboinensis; Ocyphaps lophotes; Ptilinopus magnificus; P. regina;* F. Cacatuidae: *Calyptorhynchus magnificus;* F. Cuculidae: *Cuculus pyrrhophanus;* F. Loriidae: *Trichoglossus haematodus;* F. Polytelitidae: *Alisterus scapularis;* F. Cuculidae: *Cuculus pyrrhophanus;* F. Strigidae: *Ninox novaeseelandiae;* F. Tytonidae: *Tyto tenebricosa;* F. Aegothelidae: *Aegotheles cristatus*; F. Apodidae: *Apus pacificus;* F. Alcedinidae: *Dacelo novaeguineae;* F. Pittidae: *Pitta versicolor;* F. Campephagidae: *Coracina novaehollandiae; Lalage leucomela*; F. Muscicapidae: *Colluricincla harmonica; C. megarhyncha; Eopsaltria australis; Monarcha leucotis; M. melanopsis; Pachycephala pectoralis; Petroica rosea; Rhipidura fuliginosa; R. rufifrons;* F. Orthonychidae: *Psophodes olivaceus*; F. Acanthizidae: *Acanthiza nana; A. pusilla; Gerygone mouki; Sericornis frontalis; S. magnirostris;* F. Climacteridae: *Climacteris leucophaea*; F. Meliphagidae: *Lichenostomus chrysops;. Lichmera indistincta; Meliphaga lewinii; Myzomela sanguinolenta;* F. Zosteropidae: *Zosterops lateralis;* F. Ploceidae: *Emblema temporalis;* F. Oriolidae: *Sphecotheres viridis;* F. Paradisaeidae: *Ailuroedus crassirostris; Ptiloris paradiseus; Sericulus chrysocephalus;* F. Grallinidae: *Grallina cyanoleuca;* F. Cracticidae: *Cracticus nigrogularis; Gymnorhina tibicen; Strepera graculina;* F. Corvidae: *Corvus orru.*

Mammals: F. Dasyuridae: *Antechinus flavipes;* F. Peramelidae: *Perameles nasuta;* F. Pseudocheiridae: *Petauroides volans*; *Pseudocheirus peregrinus;* F. Phalangeridae: *Trichosurus caninus;* F. Macropodidae: *Macropus dorsalis*; *Thylogale thetis; Wallabia bicolor*; F. Muridae: *Melomys cervinipes; Rattus fuscipes.*

COOMINGLAH SF 28

Amphibians: F. Bufonidae: *Bufo marinus.*

Reptiles: F. Gekkonidae: *Diplodactylus vittatus; Heteronotia binoei; Oedura tryoni; Underwoodisaurus milii;* F. Agamidae: *Pogona barbata;* F. Varanidae: *Varanus varius;* F. Scincidae: *Anomalopus verreauxi; Carlia pectoralis; C. schmeltzii; Cryptoblepharus virgatus; Ctenotus taeniolatus; Eulamprus quoyii; E. tenuis; Lampropholis amicula:* F. Elapidae: *Rhinoplocephalus nigrescens.*

Birds: F. Accipitridae: *Aquila audax;* F. Megapodiidae: *Alectura lathami;* F. Columbidae: *Chalcophaps indica; Geopelia humeralis; G. placida; Leucosarcia melanoleuca; Ocyphaps lophotes;* F. Cacatuidae: *Cacatua galerita; C. roseicapilla; Calyptorhynchus magnificus*; F. Loriidae: *Glossopsitta pusilla; Trichoglossus haematodus;* F. Polytelitidae: *Alisterus scapularis;* F. Platycercidae: *Platycercus adscitus;* F. Cuculidae: *Chrysococcyx lucidus; Cuculus pyrrhophanus;* F. Strigidae: *Ninox novaeseelandiae*; F. Podargidae: *Podargus strigoides;* F. Aegothelidae: *Aegotheles cristatus;* F. Alcedinidae: *Dacelo novaeguineae*; F. Meropidae: *Merops ornatus;* F. Pittidae: *Pitta versicolor;* F. Campephagidae: *Coracina novaehollandiae; C. papuensis; Lalage leucomela;* F. Muscicapidae: *Colluricincla harmonica; Eopsaltria australis; Pachycephala pectoralis; P. rufiventris; Rhipidura fuliginosa; R. leucophrys; R. rufifrons;* F. Orthonychidae: *Psophodes olivaceus;* F. Timaliidae: *Pomatostomus temporalis;* F. Maluridae: *Malurus lamberti;* F. Acanthizidae: *Acanthiza pusilla; A. reguloides; Gerygone mouki; G. olivacea; Sericornis frontalis; S. magnirostris; S. saggitatus;* F. Neosittidae: *Daphoenositta chrysoptera;* F. Climacteridae: *Climacteris leucophaea;* F. Meliphagidae: *Lichenostomus chrysops; Manorina melanocephala; Meliphaga lewinii; Melithreptus lunatus; Myzomela sanguinolenta; Philemon citreogularis;* F. Pardalotidae: *Pardalotus punctulatus; P. striatus;* F. Zosteropidae: *Zosterops lateralis;* F. Ploceidae: *Emblema temporalis;* F. Oriolidae: *Sphecotheres viridis;* F. Dicruridae: *Dicrurus hottentottus;* F. Grallinidae: *Grallina cyanoleuca;* F. Cracticidae: *Cracticus nigrogularis; Strepera graculina;* F. Corvidae: *Corvus orru.*

Mammals: F. Dasyuridae: *Planigale maculata;* F. Phascolarctidae: *Phascolarctos cinereus;* F. Pseudocheiridae:

Petauroides volans; Pseudocheirus peregrinus; F. Macropodidae: *Macropus dorsalis; M. giganteus; Petrogale herberti; Wallabia bicolor;* F. Molossidae: *Mormopterus loriae*; F. Vespertilionidae: *Chalinolobus gouldii; C. nigrogriseus; Miniopteris schreibersii; Scoteanax rueppellii; Scotorepens greyii;* F. Muridae: *Melomys cervinipes;* F. Canidae: *Canis familiaris dingo;*

COONGARA ROCK SF 1344

Amphibians: F. Myobatrachidae: *Adelotus brevis; Mixophyes fasciolatus;* F. Hylidae: *Litoria caerulea; L. gracilenta.*

Reptiles: F. Scincidae: *Calyptotis scutirostrum; Carlia pectoralis; Cryptoblepharus virgatus; Ctenotus robustus; Eulamprus quoyii; E. tenuis; Lampropholis adonis; L. amicula;* F. Colubridae: *Boiga irregularis;* F. Elapidae: *Pseudechis porphyriacus.*

Birds: F. Ardeidae: *Nycticorax caledonicus;* F. Accipitridae: *Accipiter novaehollandiae; Aquila audax; Aviceda subcristata;* F. Megapodiidae: *Alectura lathami;* F. Phasianidae: *Coturnix australis;* F. Turnicidae: *Turnix varia;* F. Rallidae: *Gallinula olivacea;* F. Columbidae: *Chalcophaps indica; Geopelia humeralis; G. placida; Leucosarcia melanoleuca; Macropygia amboinensis; Ptilinopus regina;* F. Cacatuidae: *Cacatua galerita*; F. Loriidae: *Glossopsitta pusilla; Trichoglossus haematodus;* F. Polytelitidae: *Alisterus scapularis;* F. Platycercidae: *Platycercus adscitus;* F. Cuculidae: *Centropus phasianinus; Chrysococcyx lucidus; Cuculus pyrrhophanus; Eudynamis scolopacea;* F. Strigidae: *Ninox novaeseelandiae*; F. Aegothelidae: *Aegotheles cristatus;* F. Alcedinidae: *Dacelo novaeguineae*; F. Meropidae: *Merops ornatus;* F. Coraciidae: *Eurystomus orientalis;* F. Pittidae: *Pitta versicolor;* F. Campephagidae: *Lalage leucomela;* F. Muscicapidae: *Colluricincla harmonica; C. megarhyncha; Eopsaltria australis; Monarcha leucotis; M. melanopsis; M. trivirgatus; Pachycephala rufiventris; Petroica rosea; Rhipidura fuliginosa;* F. Orthonychidae: *Psophodes olivaceus;* F. Maluridae: *Malurus melanocephalus;* F. Acanthizidae: *Acanthiza pusilla; Sericornis frontalis; S. magnirostris*; F. Meliphagidae: *Lichmera indistincta; Meliphaga lewinii; Myzomela sanguinolenta; Philemon corniculatus;* F. Pardalotidae: *Pardalotus punctulatus; P. striata;* F. Ploceidae: *Emblema temporalis; Poephila bichenovii;* F. Dicruridae: *Dicrurus hottentottus;* F. Cracticidae: *Cracticus nigrogularis; Gymnorhina tibicen; Strepera graculina;* F. Corvidae: *Corvus orru.*

Mammals: F. Pseudocheiridae: *Pseudocheirus peregrinus;* F. Phalangeridae: *Trichosurus caninus;* F. Molossidae: *Mormopterus loriae;* F. Rhinolophidae: *Rhinolophus megaphyllus;* F. Vespertilionidae: *Chalinalabus gouldii; Miniopteris australis; M. schreibersii; Scoteanax rueppellii;*

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Amphibians: F. Myobatrachidae: *Limnodynastes ornatus*; Pseudophryne major; F. Hylidae: *Litoria caerulea*; *L. gracilenta*; *L. lesueurii*; *L. rubella*; F. Bufonidae: *Bufo marinus.*

Reptiles: F. Agamidae: *Diporiphora australis;* F. Scincidae: *Anomolapus verreauxi*; *Carlia pectoralis; C. schmeltzii; C. vivax; Cryptoblepharus virgatus; Ctenotus taeniolatus;* F. Boidae: *Morelia spilata*; F. Colubridae: *Dendrelaphis punctulata.*

Birds: F. Ardeidae: *Ardea pacifica; Nycticorax caledonicus;* F. Accipitridae: *Accipiter cirrhocephalus; Aquila audax;* F. Falconidae: *Falco berigora;* F. Megapodiidae: *Alectura lathami;* F. Phasianidae: *Coturnix australis;* F. Columbidae: *Chalcophaps indica; Geopelia humeralis; G. placida; Leucosarcia melanoleuca; Lopholaimus antarcticus; Macropygia amboinensis; Ptilinopus magnificus; P. regina;* F. Cacatuidae: *Cacatua galerita; Calyptorhynchus magnificus;* F. Loriidae: *Trichoglossus chlorolepidotus; T. haematodus;* F. Polytelitidae: *Alisterus scapularis*; F. Platycercidae: *Platycercus adscitus;* F. Cuculidae: *Centropus phasianinus; Chrysococcyx lucidus; Cuculus pyrrhophanus; Scythrops novaehollandiae*; F. Strigidae: *Ninox novaeseelandiae;* F. Podargidae: *Podargus strigoides;* F. Aegothelidae: *Aegotheles cristatus;* F. Caprimulgidae: *Caprimulgus macrurus;* F. Apodidae: *Apus pacificus; Hirundapus caudacutus;* F. Alcedinidae: *Ceyx azureo; Dacelo novaeguineae; Halcyon sancta*; F. Meropidae: *Merops ornatus;* F. Coraciidae: *Eurystomus orientalis;* F. Campephagidae: *Coracina tenuirostris; Lalage leucomela;* F. Muscicapidae: *Colluricincla harmonica; C. megarhyncha; Eopsaltria australis; Monarcha leucotis; M. melanopsis; M. trivirgatus; Myiagra rubecula; Pachycephala pectoralis; P. rufiventris; Rhipidura fuliginosa; R. rufifrons;* F. Orthonychidae: *Psophodes olivaceus;* F. Maluridae: *Malurus lamberti;* F. Acanthizidae: *Acanthiza nana; A. pusilla; Sericornis frontalis; S. magnirostris;* F. Meliphagidae: *Manorina melanocephala; Meliphaga lewinii; Melithreptus albogularis; Myzomela obscura; M. sanguinolenta; Philemon citreogularis; P. corniculatus*; F. Dicaeidae: *Dicaeum hirundinaceum;* F. Pardalotidae: *Pardalotus striatus;* F. Zosteropidae: *Zosterops lateralis;* F. Ploceidae: *Emblema temporalis;* F. Oriolidae: *Oriolus sagittatus; Sphecotheres viridis;* F. Dicruridae: *Dicrurus hottentottus;* F. Paradisaeidae: *Ptilonorhynchus violaceus; Sericulus chrysocephalus;* F. Corcoracidae: *Corcorax melanorhamphos;* F. Cracticidae: *Cracticus nigrogularis; Gymnorhina tibicen; Strepera graculina*; F. Corvidae: *Corvus orru.*

Mammals: F. Ornithorynchidae: *Ornithorhynchus anatinus;* F. Phascolarctidae: *Phascolarctos cinereus;* F. Pseudocheiridae: *Petauroides volans;* F. Phalangeridae: *Trichosurus caninus; T. vulpecula;* F. Macropodidae: *Wallabia bicolor;* F. Pteropodidae: *Nyctimene robinsoni; Pteropus alecto;* F. Vespertilionidae: *Chalinolobus gouldii; Miniopteris schreibersii; Scoteanax rueppellii;* F. Muridae: *Hydromys chrysogaster; Rattus fuscipes;* F. Felidae: *Felis catus.*

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Amphibians: F. Myobatrachidae: *Limnodynastes ornatus; L. peronii; Pseudophryne major;* F. Hylidae: *Litoria caerulea; L. latopalmata;* F. Bufonidae: *Bufo marinus.*

Reptiles: F. Gekkonidae: *Gehyra dubia; Heteronotia binoei; Oedura tryoni;* F. Scincidae: *Calyptotis scutirostrum; Carlia pectoralis; C. schmeltzii; C. vivax; Cryptoblepharus virgatus; Eulamprus tenuis; Lampropholis adonis; L. amicula; Ophioscincus ophioscincus;* F. Boidae: *Morelia spilota;* F. Elapidae: *Pseudechis porphyriacus; Pseudonaja textilis.*

Birds: F. Ardeidae: *Ardea novaehollandiae;* F. Anatidae: *Anas superciliosa*; F. Accipitridae: *Aquila audax;* F. Falconidae: *Falco berigora*; F. Megapodiidae: *Alectura lathami;* F. Turnicidae: *Turnix varia;.* F. Columbidae: *Chalcophaps indica; Geopelia humeralis; Lopholaimus antarcticus; Macropygia amboinensis;* F. Cacatuidae: *Calyptorhynchus magnificus; Cacatua roseicapilla;* F. Loriidae: *Trichoglossus haematodus;* F. Polytelitidae: *Alisterus scapularis;* F. Platycercidae: *Platycercus adscitus;* F. Cuculidae: *Centropus phasianinus; Chrysococcyx lucidus; Cuculus pyrrhophanus; Eudynamis scolopacea; Scythrops novaehollandiae;* F. Strigidae: *Ninox novaeseelandiae*; F. Aegothelidae: *Aegotheles cristatus;* F. Alcedinidae: *Dacelo novaeguineae;* F. Meropidae: *Merops ornatus;* F. Pittidae: *Pitta versicolor*; F. Campephagidae: *Coracina novaehollandiae; C. tenuirostris; Lalage leucomela;* F. Muscicapidae: *Colluricincla hormonica; C. megarhyncha; Eopsaltria australis; Monarcha leucotis; M. melanopsis; M. trivirgatus; Pachycephala pectoralis; P. rufiventris; Rhipidura fuliginosa; R. rufifrons;* F. Orthonychidae: *Psophodes olivaceus;* F. Timaliidae: *Pomatostomus temporalis;* F. Maluridae: *Malurus melanocephalus;* F. Acanthizidae: *Acanthiza pusilla; A. reguloides; Gerygone olivacea; G. palpebrosa; Sericornis frontalis; S. magnirostris;*

F. Neosittidae: *Daphoenositta chrysoptera;* F. Climacteridae: *Climacteris leucophaea;* F. Meliphagidae: *Manorina melanocephala; Meliphaga lewinii; Myzomela sanguinolenta; Philemon corniculatus;* F. Dicaeidae: *Dicaeum hirundinaceum;* F. Pardalotidae: *Pardalotus striatus;* F. Ploceidae: *Emblema temporalis;* F. Oriolidae: *Sphecotheres viridis;* F. Dicruridae: *Dicrurus hottentottus;* F. Cracticidae: *Cracticus nigrogularis; C. torquatus; Gymnorhina tibicen; Strepera graculina;* F. Corvidae: *Corvus orru.*

Mammals: F. Pseudocheiridae: *Pseudocheirus peregrinus;* F. Phalangeridae: *Trichosurus caninus; T. vulpecula;* F. Macropodidae: *Macropus dorsolis; M. parryi; Petrogale herbeti;* F. Pteropodidae: *Pteropus scapulatus;* F. Rhinolophidae: *Rhinolophus megaphyllus;* F. Vespertilionidae: *Chalinolobus nigrogriseus; Miniopterus australis;* F. Canidae: *Canis familiaris dingo;*

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Amphibians: F. Myobatrachidae: *Adelotus brevis; Limnodynastes terraereginae;* F. Hylidae: *Litoria caerulea; L. latopalmata; L. rubella;* F. Bufonidae: *Bufo marinus.*

Reptiles: F. Gekkonidae: *Oedura tryoni;* F. Varanidae: *Varanus varius;* F. Scincidae: *Carlia pectoralis; Cryptoblepharus virgatus; Eulamprus tenuis;* F. Elapidae: *Cacophis horrietae; Rhinoplocephalus nigrescens.*

Birds: F. Anatidae: *Anas superciliosa;* F. Accipitridae: *Accipiter novaehollandiae; Aquila audax; Aviceda subcristata; Haliaeetus leucogoster; Haliastur indus;* F. Megapodiidae: *Alectura lathami;* F. Laridae: *Larus novaehollandiae;* F. Columbidae: *Chalcophaps indica; Geopelia humeralis; G. placida; Leucosarcia melanoleuca; Macropygia amboinensis; Ptilinopus regina;* F. Cacatuidae: *Cacatua galerita; Calyptorhynchus magnificus;* F. Loriidae: *Trichoglossus haematodus;* F. Polytelitidae: *Alisterus scapularis;* F. Cuculidae: *Chrysococcyx lucidus; Cuculus pyrrhophanus;* F. Strigidae: *Ninox novoeseelandiae; N. strenua;* F. Podargidae: *Podargus strigoides;* F. Aegothelidae: *Aegotheles cristatus;* F. Alcedinidae: *Dacelo novaeguineae; Halcyon macleayii;* F. Meropidae: *Merops ornatus;* F. Pittidae: *Pitta versicolor;* F. Hirundinidae: *Hirundo neoxena;* F. Campephagidae: *Coracina novaehollandiae; C. tenuirostris; Lalage leucomela;* F. Muscicapidae: *Colluricincla megarhyncha; Eopsaltria australis; Monarcha leucotis; M. melanopsis; M. trivirgatus; Myiagra cyanoleuca; M. rubecula; Pachycephala pectoralis; P. rufiventris; Rhipidura fuliginosa; R. rufifrons;* F. Maluridae: *Malurus melanocephalus;* Acanthizidae: *Gerygone polpebrosa; Sericornis frontalis; S. magnirostris;* F. Meliphagidae: *Acanthorhynchus tenuirostris; Lichmera indistincta; Manorina melanocephala; Meliphaga lewinii; Myzomela obscura; M. sanguinolenta; Philemon citreogularis;* F. Dicaeidae: *Dicaeum hirundinaceum;* F. Zosteropidae: *Zosterops lateralis;* F. Oriolidae: *Oriolus sagittatus; Sphecotheres viridis;* F. Dicruridae: *Dicrurus hottentottus;* F. Cracticidae: *Cracticus nigrogularis;* F. Corvidae: *Corvus orru.*

Mammals: F. Peramelidae: *Perameles nasuta;* F. Petauridae: *Petaurus breviceps;* F. Pseudocheiridae: *Pseudocheirus peregrinus;* F. Phalangeridae: *Trichosurus vulpecula;* F. Macropodidae: *Macropus dorsalis; M. giganteus;* F. Pteropidae: *Nyctimene robinsoni; Pteropus poliocephalus; Syconycteris australis;* F. Rhinolophidae: *Rhinolopus megaphyllus;* F. Vespertilionidae: *Myotis adversus;* F. Muridae: *Melomys cervinipes; Rattus fuscipes;* F. Canidae: *Canis familiaris dingo;* F. Felidae: *Felis catus.*

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Amphibians: F. Myobatrachidae: *Adelotus brevis; Mixophyes fasciolatus;* F. Hylidae: *Litoria caerulea; L. latopalmata; L. lesueurii;* F. Bufonidae: *Bufo marinus.*

Reptiles: F. Gekkonidae: *Heteronotia binoei; Oedura tryoni;* F. Agamidae: *Physignathus lesueurii; Pogona barbata;* F. Pygopodidae: *Lialis burtonis;* F. Varanidae: *Voranus varius;* F. Scincidae: *Calyptotis scutirostrum; Carlia pectoralis; Ctenotus robustus; C. taeniolatus; Eulamprus quoyii; Lampropholis amicula;* F. Elapidae: *Rhinoplocephalus nigrescens.*

Birds: F. Phalacrocoracidae: *Phalacrocorax varius;* F. Ardeidae: *Ardea novaehollandiae;* F. Anatidae: *Anas superciliosa;* F. Accipitridae: *Accipiter cirrhocephalus; Aviceda subcristata;* F. Falconidae: *Falco berigora;* F. Megapodiidae: *Alectura lathami;* F. Turnicidae: *Turnix varia;* F. Charadriidae: *Vanellus miles;* F. Columbidae: *Chalcophaps indica; Geopelia humeralis; Geopelia placida; Leucosarcia melanoleuca; Macropygia amboinensis; Ocyphaps lophotes;* F. Cacatuidae: *Cacatua galerita; Calyptorhynchus magnificus;* F. Loriidae: *Trichoglossus chlorolepidotus; T. haematodus;* F. Polytelitidae: *Alisterus scapularis;* F. Platycercidae: *Platycercus adscitus;* F. Cuculidae: *Centropus phasianinus; Cuculus pyrrhophanus; Eudynamis scolopacea; Scythrops novaehollondiae;* F. Strigidae: *Ninox novaeseelandiae; N. strenua;* F. Caprimulgidae: *Caprimulgus guttatus; C. mystacalis;* F. Alcedinidae: *Ceyx azurea; Dacelo novaeguineae; Halcyon macleayii;* F. Coraciidae: *Eurystomus orientalis;* F. Pittidae: *Pitta versicolor;* F. Hirundinidae: *Hirundo neoxena;* F. Campephagidae: *Coracina lineata; C. novaehollandiae; C. tenuirostris; Lalage leucomela;* F. Muscicapidae: *Colluricincla harmonica; C. megarhyncha; Eopsaltria australis; Monarcha leucotis; M. trivirgatus; Myiagra rubecula; Pachycephala pectoralis; Petroica rosea; Rhipidura fuliginosa; R. rufifrons;* F. Orthonychidae: *Psophodes olivaceus;* F. Acanthizidae: *Acanthiza pusilla; Gerygone mouki; G. olivacea; Sericornis frontalis; S. magnirostris;* F. Climacteridae: *Climacteris leucophaea;* F. Meliphagidae: *Manorina melanocephala; Meliphaga lewinii; Melithreptus albogularis; Myzomela obscura; M. sanguinolenta; Philemon corniculatus;* F. Dicaeidae: *Dicaeum hirundinaceum;* F. Pardalotidae: *Pardalotus striatus;* F. Zosteropidae: *Zosterops lateralis;* F. Ploceidae: *Emblema temporalis;* F. Oriolidae: *Oriolus sagittatus; Sphecotheres viridis;* F. Dicruridae: *Dicrurus hottentottus;* F. Paradisaeidae: *Sericulus chrysocephalus;* F. Corcoracidae: *Corcorax melanorhamphos;* F. Cracticidae: *Cracticus nigrogularis; C. torquatus; Gymnorhina tibicen; Strepera graculina;* F. Corvidae: *Corvus orru.*

Mammals: F. Tachyglossidae: *Tachyglossus aculeatus;* F. Phascolarctidae: *Phascolarctos cinereus;* F. Pseudocheiridae: *Pseudocheirus peregrinus;* F. Phalangeridae: *Trichosurus caninus;* F. Macropodidae: *Macropus dorsalis; Wallabia bicolor;* F. Pteropodidae: *Pteropus scapulatus;* F. Vespertilionidae: *Miniopterus australis;* F. Muridae: *Melomys cervinipes;* F. Canidae: *Canis familiaris dingo;* F. Equidae: *Equus caballus.*

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Amphibians: F. Myobatrachidae: *Limnodynastes peroni;* F. Hylidae: *Litoria fallax; L. lesueurii; L. nasuta; L. rubella;* F. Bufonidae: *Bufo marinus.*

Reptiles: F. Gekkonidae: *Gehyra dubia; Oedura monilis; O. tryoni;* F. Agamidae: *Diporiphora bilineata;* F. Scincidae: *Anomalopus verreauxi; Calyptotis lepidorostrum; Carlia pectoralis; C. schmeltzii; Ctenotus taeniolatus; Eulamprus E. tenuis; Glaphyromorphus punctulatus; Hemisphaeriodon gerrardii; Lampropholis adonis;* F. Colubridae: *Dendrelaphis punctulata;* F. Elapidae: *Pseudechis porphyriacus.*

Birds: F. Ardeidae: *Ardea novaehollandiae;* F. Plataleidae: *Threskiornis spinicollis*; F. Anatidae: *Anas superciliosa;* F. Accipitridae: *Accipiter fasciatus*; *Haliaeetus leucogaster*; F. Falconidae: *Falco berigoru; F. cenchroides;* F. Megapodiidae: *Alectura lathami*; F. Phasianidae: *Coturnix australis;* F. Rallidae: *Gallinula tenebrosa*; F. Gruidae: *Grus rubicundus;* F. Charadriidae: *Vanellus miles*; F. Columbidae: *Chalcaphaps indica; Geopelia humeralis; Lopholaimus antarcticus; Macropygia amboinensis; Ocyphaps lophotes; Ptilinopus regina;* F. Cacatuidae: *Calyptorhynchus magnificus;* F. Loriidae: *Trichoglossus haematodus*; F. Polytelitidae: *Alisterus scapularis;* F. Platycercidae: *Platycercus adscitus;* F. Cuculidae: *Centropus phasianinus*; *Chrysacoccyx basalis; Eudynamis scolopacea;* F. Strigidae: *Ninox novaeseelandiae;* F. Caprimulgidae: *Caprimulgus guttatus; C. mystacalis;* F. Alcedinidae: *Dacelo leachii; D. novaeguineae; Halcyon macleayii; H. sancta;* F. Meropidae: *Merops ornatus;* F. Pittidae: *Pitta versicolar;* F. Motacillidae: *Anthus novaeseelandiae;* F. Motacillidae: *Anthus novaeseelandiae*; F. Campephagidae: *Coracina lineata; Lalage leucomela;* F. Muscicapidae: *Colluricincla megarhyncha; Eopsaltria australis*; *Monarcha leucotis; M. melanopsis; M. trivirgatus; Pachycephala pectaralis; Rhipidura fuliginosa*; *R. leucophrys; R. rufifrons;* F. Orthonychidae: *Psophodes olivaceus;* F. Maluridae: *Malurus melanocephalus;* F. Acanthizidae: *Acanthiza nana*; *A. pusilla; Gerygone palpebrosa; Sericornis frontalis; S. magnirostris*; F. Meliphagidae: *Entomyzon cyanotis; Lichmera indistincta; Manorina melanocephala; Meliphagu lewinii; Myzomela obscura; M. sanguinolenta;* F. Dicaeidae: *Dicaeum hirundinaceum;* F. Zosteropidae: *Zosterops lateralis;* F. Ploceidae: *Emblema temporulis; Poephila bichenovii;* F. Oriolidae: *Sphecotheres viridis;* F. Dicruridae: *Dicrurus hottentottus*; F. Paradisaeidae: *Sericulus chrysocephalus;* F. Grallinidae: *Grallina cyanoleuca;* F. Cracticidae: *Cracticus nigrogularis; Gymnorhina tibicen; Strepera graculina;* F. Corvidae: *Corvus orru.*

Mammals: F. Peramelidae: *Isoodon macrourus;* F. Macropodidae: *Wallabia bicolor*; F. Vespertilionidae: *Miniopterus schreibersii*; F. Muridae: *Melomys cervinipes.*

MT ETNA NP

Amphibians: F. Myobatrachidae: *Limnodynastes salmini;* F. Hylidae: *Litoria cuerulea;* F. Bufonidae: *Bufo marinus.*

Reptiles: F. Gekkonidae: *Gehyra dubia; Heteronotia binoei;* F. Scincidae: *Carlia pectoralis; Ctenotus taeniolatus; Eulamprus tenuis*; F. Boidae: *Morelia spilota.*

Birds: F. Accipitridae: *Accipiter fasciatus; Aviceda subcristata;* F. Faleonidae: *Falco berigora; F. cenchroides;* F. Megapodiidae: *Alectura lathami;* F. Phasianidae: *Coturnix australis;* F. Columbidae: *Chalcophaps indica; Geopelia humeralis; Leucosarcia melanoleuca; Ptilinopus regina;* F. Cacatuidae: *Calyptorhynchus magnificus;* F. Loriidae: *Trichoglossus haematodus;* F. Polytelitidae: *Alisterus scapularis;* F. Cuculidae: *Centropus phasianinus; Cuculus pyrrhophanus;* F. Strigidae: *Ninox novaeseelandiae;* F. Coraciidae: *Eurystomus orientalis;* F. Alaudidae: *Mirafra javanica;* F. Motacillidae: *Anthus novaeseelandiae;* F. Campephagidae: *Lalage leucomela;* F. Muscicapidae: *Colluricincla megarhyncha; Eopsaltria australis; Monarcha leucotis; Rhipidura rufifrons;* F. Maluridae: *Malurus melanocephalus;* F. Acanthizidae: *Sericornis frontalis;* F. Meliphagidae: *Meliphaga lewinii;* F. Dicaeidae: *Dicueum hirundinaceum;* F. Ploceidae: *Lonchura castaneothorax;* F. Dieruridae: *Dicrurus hottentottus;* F. Cracticidae: *Cracticus nigrogularis;* F. Corvidae: *Corvus orru.*

Mammals: F. Maeropodidae: *Petrogale inornata; Wallabia bicolor;* F. Megadermatidae: *Macroderma gigas;* F. Rhinolophidae: *Rhinolophus megaphyllus.*

MT LARCOM

Amphibians: F. Myobatrachidae: *Pseudophryne coriacea*; F. Bufonidae: *Bufo marinus.*

Reptiles: F. Gekkonidae: *Oeduru monilis; O. tryoni;* F. Scincidae: *Carlia schmeltzii; Cryptoblepharus virgatus; Lampropholis adonis; Lygisaurus foliorum.*

Birds: F. Ardeidae: *Ardea novaehollandiae; Egretta alba;* F. Accipitridae: *Aquila audax;* F. Megapodiidae: *Alectura lathami;* F. Columhidae: *Chalcophaps indica; Geopelia humeralis; Macropygia amboinensis; Ptilinopus regina;* F. Cacatuidae: *Calyptorhynchus magnificus;* F. Cuculidae: *Centropus phasianinus; Cuculus pyrrhophanus; Scythrops novaehollandiae;* F. Aegothelidae: *Aegotheles cristatus;* F. Alcedinidae: *Dacelo novaeguineae; Halcyon macleayii;* F. Muscicapidae: *Monarcha trivirgatus; Pachycephala rufiventris; Rhipidura fuliginosa; R. leucophrys; R. rufifrons;* F. Acanthizidae: *Acanthiza nana;* F. Meliphagidae: *Meliphaga lewinii; Melithreptus albogularis;* F. Pardalotidae: *Pardalotus striatus;* F. Oriolidae: *Sphecotheres viridis;* F. Dicruridae: *Dicrurus hottentottus;* F. Cracticidae: *Cracticus nigrogularis; Gymnorhina tibicen; Strepera graculina;* F. Corvidae: *Corvus orru.*

Mammals: F. Phalangeridae: *Trichosurus vulpecula;* F. Macropodidae: *Wallabia bicolor;* F. Pteropodidae: *Pteropus alecto;* F. Vespertilionidae: *Chalinolobus gouldii; C. nigrogriseus; Eptesicus pumilis; Miniopteris australis; M. schreibersii.*

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Amphibians: F. Myobatrachidae: *Limnodynastes ornatus;* F. Hylidae: *Litoria caerulea; L. latopalmata;* F. Bufonidae: *Bufo marinus.*

Reptiles: F. Gekkonidae: *Oeduru tryoni;* F. Agamidae: *Gemmatophora nobbi;* F. Scincidae: *Anomalopus verreauxi; Calyptotis scutirostrum; Carlia pectoralis; Cryptoblepharus virgatus; Ctenotus taeniolatus; Egernia cunninghami; Lygisaurus foliorum; Menetia greyii; Nanguru spinosa; Saiphos equalis;* F. Varanidae: *Varanus varius.*

Birds: F. Accipitridae: *Accipiter fasciatus; Aquila audax;* F. Falconidae: *Falco berigora;* F. Megapodiidae: *Alectura lathami;* F. Phasianidae: *Coturnix australis;* F. Columbidae: *Chalcophaps indica; Geopelia humeralis; Leucosarcia melanoleuca; Macropygia amboinensis;* F. Cacatuidae: *Cacatua roseicapilla;* F. Loriidae: *Trichoglossus chlorolepidotus; T. haematodus;* F. Polytelitidae: *Alisterus scapularis;* F. Platycercidae: *Platycercus adscitus;* F. Cuculidae: *Centropus phasianinus; Chrysococcyx lucidus; Cuculus pyrrhophanus; Eudynamis scalopacea; Scythrops novaehollandiae;* F. Strigidae: *Ninox connivens; N. novaeseelandiae;* F. Podargidae: *Podargus strigoides;* F. Aegothelidae: *Aegotheles cristata;* F. Apodidae: *Apus pacificus; Hirundapus caudacutus;* F. Alcedinidae: *Dacelo novaeguineae; Halcyon sancta;* F. Meropidae: *Merops ornatus;* F. Coraciidae: *Eurystomus orientalis;* F. Pittidae: *Pittu versicolor;* F. Campephagidae: *Coracina lineata; C. tenuirostris; Lalage leucomela;* F. Muscicapidae: *Colluricincla harmonicu; C. megarhyncha; Eopsaltria australis; Monarcha leucotis; M. melanopsis; M. trivirgatus; Myiagra rubecula; Pachycephala pectoralis; P. rufiventris; Petroica rosea; Rhipidura fuliginosa; R. rufifrons;* F. Orthonychidae: *Psophodes olivaceus;* F. Maluridae: *Malurus cyaneus; M. melanocephalus;* F. Acanthizidae: *Acanthiza pusilla; A. reguloides; Sericornis frontalis; S. magnirostris;* F. Neosittidae: *Daphoenositta chrysoptera;* F. Climacteridae: *Climacteris leucophaea;* F. Meliphagidae: *Lichenostomus chrysops; Manorina melanocephala; Meliphaga lewinii; Melithreptus al-*

bogularis; Myzomela sanguinolenta; Philemon corniculatus; Ramsayornis fasciatus; F. Dicaeidae: *Dicaeum hirundinaceum;* F. Pardalotidae: *Pardalotus punctatus; P. striatus;* F. Zosteropidae: *Zosterops lateralis;* F. Ploceidae: *Emblema temporalis; Poephila bichenovii;* F. Oriolidae: *Oriolus sagittatus; Sphecotheres viridis;* F. Dicruridae: *Dicrurus hottentottus;* F. Paradisaeidae: *Sericulus chrysocephalus;* F. Artamidae: *Artamus cinereus;* F. Cracticidae: *Cracticus nigrogularis; Gymnorhina tibicen; Strepera graculina;* F. Corvidae: *Corvus orru.*

Mammals: F. Dasyuridae: *Planigale maculata;* F. Peramelidae: *Isoodon macrourus; Perameles nasuta;* F. Phascolarctidae: *Phascolarctos cinereus;* F. Pseudocheiridae: *Pseudocheirus peregrinus;* F. Phalangeridae: *Trichosurus caninus; T. vulpecula;* F. Macropodidae: *Macropus dorsalis;* F. Molossidae: *Mormopterus beccarii; M. planiceps;* F. Vespertilionidae: *Miniopteris australis; M. schreibersii;* F. Leporidae: *Oryctolagus cuniculus;* F. Canidae: *Canis familiaris dingo.*

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Amphibians: F. Myobatrachidae: *Limnodynastes peroni; Mixophyes fasciolatus;* F. Hylidae: *Litoria latopalmata; L. lesueurii; L. peroni; L. rubella;* F. Bufonidae: *Bufo marinus.*

Reptiles: F. Agamidae: *Physignathus lesueurii; Pogona barbatus;* F. Scincidae: *Calyptotis lepidorostrum; Eulamprus tenuis; Glaphyromorphus punctulatus; Lampropholis adonis; Ophioscincus ophioscincus;* F. Varanidae: *Varanus varius;* F. Colubridae: *Dendrelaphis punctulata.*

Birds: F. Accipitridae: *Accipiter novaehollandiae; Aquila audax; Aviceda subcristata;* F. Falconidae: *Falco berigora;* F. Turnicidae: *Turnix varia;* F. Columbidae: *Chalcophaps indica; Columba leucomela; Leucosarcia melanoleuca; Lopholaimus antarcticus; Macropygia amboinensis; Ptilinopus magnificus; P. regina;* F. Cacatuidae: *Calyptorhynchus funereus; C. lathami;* F. Loriidae: *Trichoglossus haematodus;* F. Polytelitidae: *Alisterus scapularis;* F. Cuculidae: *Centropus phasianinus; Chrysococcyx lucidus; Cuculus pyrrhaphanus;* F. Strigidae: *Ninox novaeseelandiae;* F. Aegothelidae: *Aegotheles cristatus;* F. Caprimulgidae: *Caprimulgus mystacalis;* F. Alcedinidae: *Dacelo novaeguineae;* F. Meropidae: *Merops ornatus;* F. Pittidae: *Pitta versicolor;* F. Campephagidae: *Coracina papuensis;* F. Muscicapidae: *Colluricincla harmonica; C. megarhyncha; Eopsaltria australis; Monarcha trivirgatus; Myiagra inquieta; M. rubecula; Pachycephala pectoralis; Rhipidura fuliginosa; R. rufifrons; Tregellasia capito; Zoothera heinei;* F. Orthonychidae: *Psophodes olivaceus;* F. Maluridae: *Malurus lamberti;* F. Acanthizidae: *Acanthiza pusilla; Gerygone mouki; Sericornis frontalis; S. magnirostris;* F. Climacteridae: *Climacteris leucophaea;* F. Meliphagidae: *Lichenostomus chrysops; Meliphaga lewinii; Melithreptus lunatus; Myzomela sanguinolenta; Philemon corniculatus;* F. Pardalotidae: *Pardalotus punctatus;* F. Zosteropidae: *Zosterops lateralis;* F. Ploceidae: *Emblema temporalis;* F. Oriolidae: *Sphecotheres viridis;* F. Dicruridae: *Dicrurus hottentottus;* F. Paradisaeidae: *Ailuroedus crassirostris; Ptiloris paradiseus; Sericulus chrysocephalus;* F. Cracticidae: *Strepera graculina;* F. Corvidae: *Corvus orru.*

Mammals: F. Dasyuridae: *Antechinus flavipes; Sminthopsis murina;* F. Phascolarctidae: *Phascolarctos cinereus;* F. Pseudocheiridae: *Pseudocheirus peregrinus;* F. Phalangeridae: *Trichosurus caninus; T. vulpecula;* F. Vespertilionidae: *Chalinolobus gouldii; C. nigrogriseus; Eptesicus pumilis; Miniopteris australis; M. schreibersii;* F. Muridae: *Melomys cervinipes; Rattus fuscipes;*

RUNDLE RANGE NP

Amphibians: F. Myobatrachidae: *Limnodynastes ornatus; Uperoleia fusca;* F. Hylidae: *Litoria caerulea;* F. Bufonidae: *Bufo marinus.*

Reptiles: F. Gekkonidae: *Heteronotia binoei;* F. Scincidae: *Anomalopus verreauxi; Calyptotis lepidorostrum; Carlia pectoralis; C. schmeltzii; C. vivax; Cryptoblepharus virgatus; Ctenotus robustus; C. taeniolatus; Glaphyromorphus punctulatus; Lygisaurus foliorum; Menetia greyii;* F. Varanidae: *Varanus varius.*

Birds: F. Dromaiidae: *Dromaius novaehollandiae;* F. Ardeidae: *Egretta alba; E. garzetta;* F. Accipitridae: *Accipiter fasciatus; Aviceda subcristata; Haliastur indus*; F. Megapodiidae: *Alectura lathami;* F. Phasianidae: *Coturnix australis;* F. Laridae: *Sterna bergii;* F. Columbidae: *Chalcophaps indica; Geopelia humeralis; Leucosarcia melanoleuca; Ptilinopus regina;* F. Cacatuidae: *Calyptorhynchus lathami; C. magnificus;* F. Loriidae: *Trichoglossus chlorolepidotus; Trichoglossus haematodus;* F. Polytelitidae: *Alisterus scapularis;* F. Platycercidae: *Platycercus adscitus;* F. Cuculidae: *Centropus phasianinus; Chrysococcyx lucidus; Cuculus pyrrhophanus; C. saturatus; Eudynamis scolopacea; Scythrops novaehollandiae;* F. Strigidae: *Ninox novaeseelandiae;* F. Podargidae: *Podargus strigoides;* F. Aegothelidae: *Aegotheles cristatus;* F. Caprimulgidae: *Caprimulgus macrurus;* F. Alcedinidae: *Dacelo novaeguineae; Halcyon chloris;* F. Meropidae: *Merops ornatus;* F. Coraciidae: *Eurystomus orientalis;* F. Pittidae: *Pitta versicolor;* F. Campephagidae: *Coracina novaehollandiae; C. tenuirostris; Lalage leucomela;* F. Muscicapidae: *Colluricincla harmonica; C. megarhyncha; Eopsaltria australis; Monarcha leucotis; M. trivirgatus; Myiagra rubecula; Pachycephala rufiventris; Rhipidura rufifrons;* F. Sylviidae: *Acrocephalus stentoreus;* F. Maluridae: *Malurus lamberti; M. melanocephalus;* F. Acanthizidae: *Acanthiza reguloides; Sericornis frontalis;* F. Meliphagidae: *Lichmera indistincta; Manorina melanocephala; Meliphaga lewinii; Philemon corniculatus;* F. Dicaeidae: *Dicaeum hirundinaceum;* F. Ploceidae: *Emblema temporalis;* F. Oriolidae: *Sphecotheres viridis;* F. Dicruridae: *Dicrurus hottentottus;* F. Cracticidae: *Cracticus torquatus; Gymnorhina tibicen; Strepera graculina;* F. Corvidae: *Corvus orru.*

Mammals: F. Ornithorhynchidae: *Tachyglossus aculeatus;* F. Peramelidae: *Isoodon macrourus;* F. Pseudocheiridae: *Petauroides volans;* F. Pseudocheiridae: *Petauroides volans;* F. Macropodidae: *Macropus dorsalis;* F. Molossidae: *Mormopterus planiceps;* F. Canidae: *Canis familiaris dingo*

SPRING CREEK

Amphibians: F. Myobatrachidae: *Limnodynastes ornatus;* F. Hylidae: *Litoria caerulea;* F. Bufonidae: *Bufo marinus.*

Reptiles: F. Gekkonidae: *Diplodactylus williamsi; Heteronotia binoei; Oedura monilis; O. tryoni;* F. Scincidae: *Carlia mundivensis; C. pectoralis; C. schmeltzii; Cryptoblepharus virgatus; Ctenotus robustus; C. taeniolatus; Morethia taeniopleura;* F. Elapidae: *Demansia psammophis.*

Birds: F. Anhingidae: *Anhinga melanogaster;* F. Ardeidae: *Ardea novaehollandiae;* F. Anatidae: *Anas superciliosa;* F. Accipitridae: *Aquila audax;* F. Falconidae: *Falco berigora; Falco cenchroides;* F. Megapodiidae: *Alectura lathami;* F. Charadriidae: *Vanellus miles;* F. Columbidae: *Geopelia humeralis; Geopelia placida; Ocyphaps lophotes; Ptilinopus superbus;*F. Cacatuidae: *Cacatua galerita; Calyptorhynchus magnificus;* F. Loriidae: *Trichoglossus chlorolepidotus; T. haematodus;* F. Polytelitidae: *Alisterus scapularis; Aprosmictus erythropterus;* F. Platycercidae: *Platycercus adscitus;* F. Cuculidae: *Centropus phasianinus; Eudynamis scolopacea; Scythrops novaehollandiae;* F. Strigidae: *Ninox novaeseelandiae;* F. Podargidae: *Padargus strigoides;* F. Caprimulgidae *Caprimulgus guttatus;* F. Alcedinidae: *Dacela novaeguineae; Halcyon macleayii;* F. Meropidae: *Merops ornatus;* F. Motacillidae: *Anthus novaeseelandiae;* F. Campephagidae: *Lalage leucomela; Lalage sueurii;* F. Muscicapidae: *Colluricincla megarhyncha; Monarcha leucotis; Myiagra cyanoleuca; Pachycephala pectoralis; Pachycephala rufiventris; Petroica rosea; Rhipidura fuliginosa; R. leucophrys; Rhipidura rufifrons;* F. Maluridae: *Malurus melanocephalus;* F. Acanthizidae: *Acanthiza nana; Acanthiza pusilla; Sericornis frontalis;* F. Meliphagidae: *Meliphaga lewinii;* F. Dicaeidae: *Dicaeum hirundinaceum;* F. Pardalotidae: *Pardalotus striatus;* F. Zosteropidae: *Zosterops lateralis;* F. Ploceidae: *Poephila bichenovii;* F. Oriolidae: *Sphecotheres viridis;* F. Dicruridae: *Dicrurus hottentottus;* F. Corcoracidae: *Corcorax melanorhamphos;* F. Artamidae: *Artamus cinereus;* F. Cracticidae: *Cracticus nigrogularis; Gymnorhina tibicen; Strepera graculina;* F. Corvidae: *Corvus orru.*

Mammals: F. Pteropidae: *Pteropus alecto;* F. Emballonuridae: *Saccolaimus flaviventris;* F. Pseudocheiridae: *Pseudocheirus peregrinus;* F. Phalangeridae: *Trichosurus vulpecula;* F. Potoroidae: *Aepyprymnus rufescens;* F. Macropodidae: *Macropus dorsalis; Wallabia bicolor.*

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Amphibians: F. Myobatrachidae: *Adelotus brevis;* F. Hylidae: *Litoria caerulea; L. latopalmata;* F. Bufonidae: *Bufo marinus.*

Reptiles: F. Agamidae: *Physignathus lesueurii;* F. Varanidae: *Varanus varius;* F. Scincidae: *Anomalapus verreauxi; Lampropholis adonis; L. delicata;* F. Elapidae: *Demansia psammophis.*

Birds: F. Accipitridae: *Accipiter novaehollandiae; Aviceda subcristata;* F. Megapodiidae: *Alectura lathami;* F. Turnicidae: *Turnix melanogaster; T. varia;* F. Burhinidae: *Burhinus magnirostris;* F. Charadriidae: *Vanellus miles;* F. Columbidae: *Chalcophaps indica; Columba leucomela; Leucosarcia melanoleuca; Lopholaimus antarcticus; Macropygia amboinensis; Ptilinopus magnificus; P. regina;* F. Cacatuidae: *Cacatua galerita; Calyptorhynchus funereus; C. magnificus;* F. Loriidae: *Trichoglossus haematodus;* F. Polytelitidae: *Alisterus scapularis;* F. Platycercidae: *Platycercus elegans;* F. Cuculidae: *Centropus phasianinus; Chrysococcyx lucidus; Cuculus pyrrhophanus;* F. Strigidae: *Ninox novaeseelandiae;* F. Podargidae: *Podargus strigoides;* F. Aegothelidae: *Aegotheles cristatus;* F. Caprimulgidae: *Caprimulgus mystacalis;* F. Alcedinidae: *Dacelo novaeguineae;* F. Meropidae: *Merops ornatus;* F. Pittidae: *Pitta versicolor;* F. Campephagidae: *Lalage leucomela;* F. Muscicapidae: *Colluricincla harmonica; C. megarhyncha; Eopsaltria australis; Monarcha leucotis; M. melanopsis; M. trivirgatus; Myiagra rubecula; Pachycephala pectoralis; Petroica rosea; Rhipidura fuliginosa; R. rufifrons; Tregellasia capito;* F. Orthonychidae: *Psophodes olivaceus;* F. Maluridae: *Malurus lamberti;* F. Acanthizidae: *Acanthiza pusilla; Gerygone mouki; Sericornis citreogularis; S. frontalis; S. magnirostris;* F. Meliphagidae: *Lichenostomus chrysops; Meliphaga lewinii; Melithreptus lunatus; Myzomela sanguinolenta; Philemon corniculatus; Phylidonyris novaehollandiae;* F. pardalotidae: *Pardalotus punctatus;* F. Zosteropidae: *Zosterops lateralis;* F. Ploceidae: *Emblema temporalis;* F. Oriolidae: *Sphecotheres viridis;* F. Paradisaeidae: *Ailuroedus crassirostris; Ptiloris paradiseus; Sericulus chrysocephalus;* F. Cracticidae: *Cracticus torquatus; Gymnorhina tibicen; Strepera graculina;* F. Corvidae: *Corvus orru.*

Mammals: F. Dasyuridae: *Antechinus flavipes; Planigale maculata;* F. Peramelidae: *Perameles nasuta;* F. Phascolarctidae: *Phascolarctos cinereus;* F. Petauridae: *Petaurus australis;* F. Pseudocheiridae: *Petauroides valans; Pseudocheirus peregrinus;* F. Phalangeridae: *Trichosurus caninus;* F. Macropodidae: *Macropus dorsalis; Wallabia bicolor;* F. Molossidae: *Mormopterus loriae; Miniopterus schreibersii;* F. Muridae: *Melomys cervinipes; Rattus fuscipes;* F. Canidae: *Canis familiaris dingo.*

CONSERVATION STRATEGIES FOR RARE AND THREATENED VERTEBRATES OF AUSTRALIA'S WET TROPICS REGION

GARRY L. WERREN

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In September 1992, 50 specialists gathered to evaluate the conservation status and management needs of vertebrates of the Wet Tropics Region. Participants agreed that 12 vertebrate species (3 mammals, 2 birds, 6 frogs and 1 fish) warranted urgent restorative action, while others required a 'watching brief', and sensitive and coordinated management of their habitats. Of highest priority were the critically endangered regional endemic mammals *Petaurus gracilis* and *Bettongia tropica*, and six species of frogs, *Taudactylus acutirostris, T. rheophilus, Litoria nannotis, L. nyakalensis, L. rheocola* and *Nyctimystes dayi*. ☐ *Rare species, threatened species, Wet Tropics Region, vertebrates, conservation status, management, rainforests, Queensland.*

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The Wet Tropics Region is an area of high biodiversity. It supports over 500 species of rare and/or threatened plants and animals (Switzer, 1991), and has more rainforest-dependent endemic vertebrates than any other area in Australia. Most of these are confined to cool, wet forests above 400 m. A significant proportion of the region has been accorded World Heritage status in recognition of its biological values. Accordingly, there is now an international obligation, to maintain biodiversity. This involves targeting taxa which, by virtue of their restricted distributions, scarcity and/or susceptibility to threatening processes, may be vulnerable to extinction. It also involves the identification of recurring and/or common threatening processes and threatened habitats or places. The process of fine-tuning various conservation efforts which have been initiated at the national or state level in the Wet Tropics context required the input of essential local knowledge. In order to design an effective meld of conservation strategies, 'the World-Wide Fund for Nature (Australia) instigated a process of consultation, and secured necessary funding from the Wet Tropics Management Authority, to bring together experts on the region's flora and fauna. Fifty specialists met in Cairns, 2-4 September, 1992, to discuss approaches to rare and threatened species conservation (Werren, 1992). The workshop's purpose was to identify taxa, populations, assemblages and habitats requiring special conservation attention, and means to optimise efforts to ensure their survival.

The Wet Tropics biogeographic province of Australia (Stanton & Morgan, 1977) is located in the northeastern coastal region of Queensland, between Cooktown and Townsville and is roughly bounded landward by the 1000mm p.a. rainfall isohyet (Werren et al., in press). The province covers over 16000km^2. It contains the most extensive continuous tracts of rainforest in Australia. Regional species diversity is enriched by the occurrence of non-rainforest vegetation, including sclerophyllous open forest and grassy woodland, sclerophyllous swamp forest and sedgelands, mountain heathlands, saline coastal herbfields and mangrove forests.

REGIONAL CONSERVATION STATUS

The workshop attendees compiled current information on the conservation status of each vertebrate taxon. For many taxa, it must be recognised that knowledge is inadequate. Reference to these taxa is consistent with the scientific nomenclature recognised by the Queensland Museum (Ingram & Raven, 1991), except for bats. For this group names used by G.Richards & L . Hall, pers. comm., have been followed. Common names follow Strahan, 1983 for mammals; Royal Australasian Ornithologists Union, 1978 for birds; Ingram et al., 1993 for frogs; Wager, 1993 for fish. For reptiles, common names are few, but follow Cogger (1992).

While the basic taxonomic unit considered was the species, attention was also given to subspecies and/or population isolates. This was to optimise the chances of maintaining maximum genetic diversity and to avoid overlooking undescribed species or subspecies, and populations of organisms which are genotypically or behaviourly (if not phenotypically) distinct. It allowed identification of threatening processes and threatened sites from direct field knowledge of the regional biota.

Establishing the conservation status of the region's vertebrate fauna required the assignment of generally understood codes for each taxon (e.g. Thomas & McDonald, 1987). Conservation management application necessitated determining priorities for action. The lack of precise quantitative data generally precludes the use of complex systems such as those developed by Millsap et al. (1990) and Mace & Lande (1991). It meant that this part of the exercise was intuitive, rather than quantitatively reliable. However, it was systematic and in keeping with the principles applied by Goosem & Young (1989).

A number of subgroups were convened to focus on particular vertebrate groups. Each subgroup systematically considered each taxon and addressed the question - 'does this organism require any special conservation management attention above and beyond the cautious general ongoing requirements for the maintenance of biodiversity in this region - and, if so, what is it?'. In focussing on single species or groups of taxa (guilds), it was considered important that those remaining should also receive management and research attention.

As a result of these considerations, several general management categories were devised: priority 1 - critically endangered taxa urgently requiring the immediate removal of threatening processes and the rapid implementation of recovery plans; priority 2 - endangered taxa requiring rapid implementation of recovery plans; priority 3 - vulnerable taxa requiring intensive study and possible interventionist management; priority 4 - taxa of special conservation concern requiring close monitoring and possible interventionist management.

Threatened taxa belonging to the first, along with the various status assessments previously ascribed, are listed in Table 1. Local knowledge sometimes prompted determinations different from those devised at the national/international level (e.g. omission of 8 of 12 critically endangered species from the CONCOM list - Hicks, 1991), and to a lesser extent, at the state level (e.g. elevation of the Southern Cassowary, *Casuarius casuarius johnstonii* from 'V' of Ingram & Raven, 1991, to 'E'; and inclusion of the Golden Bowerbird, *Prionodura newtoniana* as a vulnerable species in the regional assessment).

CONSERVATION ASSESSMENT

MAMMALS

Of the 90+ species recorded from the Wet Tropics Region, 11 species of mammal (1 antechinus, 4 ringtail possums, 1 glider, 1 rat-kangaroo, 2 tree-kangaroos, 1 bettong, 1 mosaic-tailed rat), are restricted to this area. The known Australian distributions of two other species (Long-tailed Pygmy-possum, *Cercartetus caudatus*; Flute-nosed Bat, *Murina florium*) are the Wet Tropics and New Guinea, and the Wet Tropics and Southeast Asia respectively. There are nine endemic subspecies of mammals, many of which have populations to the south. This indicates that the Wet Tropics has the highest mammalian endemism of any region in Australia (Winter, 1991). Three species appear on the 'CONCOM List of Endangered Vertebrate Fauna' (Hicks, 1991), and 20 are listed by Van Dyck (1991) as being of special conservation concern.

Most of the endemic mammals are non-volant upland rainforest species. Most have either restricted ranges or isolated populations (e.g. Atherton Antechinus, *Antechinus godmani*; Lemuroid Ringtail Possum, *Hemibelideus lemuroides*; Daintree River Ringtail, *Pseudocheirus cinereus*; Herbert River Ringtail, *P. herbertensis*, Green Ringtail Possum, *Pseudocheirops archeri*; and Thornton Peak Mosaic-tailed Rat, *Melomys hadrourus*). This attaches to them conservation management problems associated with fragmentation and small populations (Kennedy, 1992). Others (Bennett's Tree-kangaroo, *Dendrolagus bennettianus*; Lumholtz's Tree-kangaroo, *D. lumholtzi*; Musky Rat-kangaroo, *Hypsiprymnodon moschatus*) occur at all altitudes. Another Wet Tropics endemic species, the Mahogany Glider (*Petaurus gracilis*), has been rediscovered only recently, and is restricted to limited tracts of lowland open forest/woodland between Ingham and Tully (Van Dyck, 1993).

For the volant mammals, the Wet Tropics, along with Cape York Peninsula, is an area of high species diversity (Richards, 1990a; 1991). At least 35 species of bats, about half of Australia's total, occur in the region (Rainforest Conservation Society of Queensland, 1986). This group comprises species which play pivotal roles in ecosystem processes such as plant pollination and dispersal, particularly in rainforest systems.

TABLE 1. Wet Tropics rare and threatened vertebrate species warranting highest priority conservation management

	Taxon	CONCOM status (April 1991)	Ingram & Raven (1991)	Workshop determination (September, 1992)
MAMMALS	*Petaurus gracilis*, Mahogany Glider	not listed	2E	critically endangered
	Murina florium, Flute-nosed Bat	not listed	3RC+	threatening processes not established
	Bettongia tropica, Tropical Bettong	endangered	2EC	endangered, threatening processes possibly increasing
BIRDS	*Casuarius casuarius johnstonii*, Southern Cassowary	vulnerable	3VC+	Australian endemic subspecies considered endangered
	Prionodura newtoniana, Golden Bowerbird	not listed	–	appears to be in decline
FROGS	*Taudactylus acutirostris*, Sharp-snouted Dayfrog	endangered	3EC	massive & rapid range contraction; critically endangered
	T. rheophilus, Northern Tinkerfrog	not listed	3EC	not recorded for 2 years; critically endangered
	Litoria nannotis, Waterfall Frog	not listed	–	declining; critically endangered
	L. nyakalensis, Mountain Mistfrog	not listed	–	no recent records; critically endangered
	L. rheocola, Common Mistfrog	not listed	–	declining; critically endangered
	Nyctimystes dayi, Australian Lace-lid	not listed	–	declining; critically endangered
FISH	*Melanotaenia eachamensis*, Lake Eacham Rainbowfish	endangered	not assessed	extinct in the wild; captive population

Many are restricted to particular foraging areas (e.g. aquatic foraging over still pools by the Large-footed Mouse-eared Bat, *Myotis adversus*) or to specialised foods (e.g. spider gleaning by the Golden-tipped Bat, *Kerivoula papuensis*; the pale rainforest fruit preferences of the Spectacled Flying-fox, *Pteropus conspicillatus*, Richards, 1990b). Others have morphological characters which indicate habitat specialisation (e.g. wing-folding to shed water and water repellent pelage of *M. florium*, allowing foliage roosting in cloudy upland rainforests, Richards, 1983). Others require particular roosting and reproductive sites (e.g. stenothermic/stenohydric roost sites of the Eastern Horseshoe-bat, *Rhinolophus megaphyllus* or Horseshoe-bats, *Hipposideros* spp., and preference for sea caves by the mangrove-foraging North-eastern Sheathtail-bat, *Taphozous australis*). Such specialisation is reflected in the fact that about 60% of the total Australian bat fauna is considered to be rare/uncommon, and that 16 of the 35 species recorded for the Wet Tropics are ascribed special conservation status (3 endangered, with *M. florium* listed as critically endangered; 2 vulnerable; 4 rare; and 7 insufficiently known, Richards & Hall, pers. comm).

Five groups of mammal species with different management needs were defined: 1. critically endangered (*P. gracilis, M. florium, B. tropica*, Table 1.): 2. endangered, but presumed not critically so (Ghost Bat, *Macroderma gigas* and *K. papuensis*); 3. vulnerable restricted endemics (*D. bennettianus, D. lumholtzi*), and sparse or declining taxa (northern subspecies of the Spotted-tailed Quoll, *Dasyurus maculatus gracilis*; northern subspecies of the Red-cheeked Dunnart, *Sminthopsis virginiae virginiae*; north-eastern subspecies of the Yellow-bellied Glider, *Petaurus australis reginae*; Greater Wart-nosed Bat, *Hipposideros semoni*; *P. conspicillatus*; Water Mouse, *Xeromys myoides*[1]); 4. remaining Wet Tropics endemic taxa (*A. godmani, P. herbertensis, P. cinereus, P. archeri, H. lemuroides, H. moschatus, M. hadrourus*, Common Dunnart, *S. murina tatei*, Coppery Brushtail Possum, *Trichosurus vulpecula johnstonii*; Swamp Rat, *Rattus lutreolus lacctus*) and other taxa which are restricted Wet Tropics population isolates, poorly known and/or suspected to be declining (White-footed Dunnart, *S. leucopus*; Squirrel Glider, *Petaurus norfolcensis*; *C. caudatus*; Feathertail Glider, *Acrobates pygmaeus*; Bare-backed Fruit-bat, *Dobsonia moluccense*; Large-eared Horseshoe-bat, *Rhinolophus philippinensis*;

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[1] Not recorded in the Wet Tropics, but found to the south and northwest. As extensive habitat suitable for *X. mygoides* occurrs in the area, it was considered useful to include this species in discussions (S. Van Dyck, pers. comm.)

Rhinolophus sp. *maros* form; *T. australis*; Diadem Horseshoe-bat, *H. diadema*; Little Bentwing Bat, *Miniopterus australis*; *M. adversus*; Naked-rumped Sheathtail Bat, *Saccolaimus saccolaimus*; Greater Broad-nosed Bat, *Scoteanax rueppellii*; Little Brown Cave-bat, *Vespadelus pumilus*; north-east Queensland subspecies of the Black-footed Tree Rat, *Mesembriomys gouldii rattoides*; Prehensile-tailed Rat, *Pogonomys mollipilosus*); and, 5. widespread species occurring in restricted or vulnerable habitats in the Wet Tropics (Platypus, *Ornithorhynchus anatinus*; Koala, *Phascolarctos cinereus adustus*; north-eastern subspecies of the Swamp Wallaby, *Wallabia bicolor mastersii*; Water Rat, *Hydromys chrysogaster*). Other taxa were flagged for attention in special conservation efforts and inventory programs. The latter will be concentrated in special habitats (e.g. lowland sclerophyll open forest/woodland, tall open forest, freshwater wetlands, mangroves and remnant lowland rainforest and riparian communities).

Changes in habitat floristics and structure, fragmentation, increased incursion by 'edge' species, barriers to animal movement, and competition or predation by alien species impact on mammals of the Wet Tropics. *P. gracilis* is endangered due to clearing of lowland sclerophyll open forest-/woodland in the southeast of the region (Van Dyck, 1993). Lowland habitat loss may also threaten species such as *S. v. virginiae* and the Long-tailed Planigale, *Planigale ingrami*.

B. tropica has suffered habitat loss and modification through grazing and changes to long-standing fire regimes, increased predation from dogs, and may suffer increased predation from the European Red Fox (*Vulpes vulpes*). There are historic records of this exotic canid (e.g. 1962 at McKenzie's Pocket, Black Mountain corridor - K. Sanderson, pers. comm.). These may indicate its lengthy presence in the region. However, they appear to be isolated records of possible escapees or vagrants. Stanton (pers. comm.) has a long familiarity with the region and reports seeing a fox first in 1990, a roadkill at Home Hill, NEQ. Then, in 1991, M.Davis (pers. comm.) recorded a live animal at Mt Carbine, and more recently, (1993) M. Trenerry and M. Prociv (pers. comm.) noted two road-killed foxes (and collected hair samples) in 2km of the Kennedy Hwy, near Kuranda. The former is near the two northerly population isolates of *B. tropica*, while the latter is in the vicinity of Lamb Ra. population. The regional presence of *P. australis reginae* is threatened by loss, fragmentation and modification of its tall open forest habitat on the western fringe of the rainforested uplands.

The continued loss and degradation of mangrove habitat is of concern. This is predicted to impact on populations of taxa such as the Common Brushtail (*T. vulpecula*) and Common Ringtail (*Pseudocheirus peregrinus*) Possums, as well as *X. myoides*, which has a CONCOM rating of 'vulnerable' (Hicks, 1991). Additional fragmentation and disruption of lowland rainforest and associated communities is destructive for species such as the *H. moschatus*, particularly by opening areas up to marauding domestic and feral dogs.

The loss and disruption of roosting and maternity sites through cave or mine collapse, quarrying operations and tourist visitation is significant to a sizeable proportion of the region's bat fauna. Species so affected include *M. gigas*. Endangering processes affect this species extra-regionally. In the Wet Tropics *M. gigas* occurs in the Black Trevethan Ra. area and appears secure. Also affected are *H. semoni*, *H. diadema* and *R. philippinensis*. A colony of the latter near Mt Molloy has been severely reduced over the last decade (Richards & Hall, pers. comm).

Direct human predation, colony disruption, tick infestations and loss of lowland and upland rainforest have increased pressure on *P. conspicillatus* (Richards, 1990b). Destruction of *Pteropus* specimens or habitat stems from concern associated with loss of fruit from orchards and gardens. With the expansion of fruit-growing activities and settlement about Cooktown, the regionally rare *D. moluccense* may be subjected to similar pressures (Richards & Hall, pers. comm).

BIRDS

Of the 360+ bird species recorded for the Wet Tropics, 13 are endemic to this province. Nine of these are restricted to the more temperate uplands (Crome & Nix, 1991). Ten other bird species have subspecies confined to the area and a further eight rainforest species have a major part of their ranges within this area. There are 10 subspecies endemic to the Wet Tropics. Nine of the 13 endemic species are confined to the upland rainforests (Crome & Nix, 1991). All the endemic birds have close relatives in Papua-New Guinea, but many of the endemic subspecies are representative of species which are Australian endemics with essentially southeastern Australian ranges. The region also is the stronghold of a number of species - e.g. Red-necked Crake (*Rallina tricolor*), Papuan Frogmouth (*Podargus papuensis*), White-rumped Swiftlet (*Collocalia spodiopygia*) and Metallic Starling (*Aplonis metallica*).

Discussions revealed the importance of two 'priority 1' taxa warranting rapid recovery action plans. These are the Southern Cassowary (*C. casuarius johnsonii*), which has the bulk of its distribution in the Wet Tropics and Golden Bowerbird (*P. newtoniana*), which is endemic to the region. The former already receives attention, particularly in the Mission Beach area. Survey, monitoring and a comprehensive community-driven campaign designed to raise the bird's conservation requirements in the regional planning context, to inform the public of the bird's plight and to encourage protective action are underway (Werren & Goosem, in press). *P. newtonia* is of special concern due to its natural sparseness in parts of its range. Its bowers have 'disappeared' from The Crater and Butcher's Ck areas of the Atherton Tableland in the past 2-3 years, and it has been the target of ecotourism activities. These may be disrupting its leks and reducing its reproductive success.

There are a number of other species whose ranges extend into the Wet Tropics which are regarded as endangered, rare and threatened or declining. These are predominantly raptors and finches and include the endangered Gouldian Finch (*Erythrura gouldiae*[2]) and eastern subspecies of the Star Finch (*Neochmia ruficauda ruficauda*), the vulnerable Red Goshawk (*Erythrotriorchis radiatus*), the rare and declining Square-tailed Kite (*Lophoictinia isura*) and the white-rumped subspecies of the Black-throated Finch (*Poephila cincta cincta*), as well as the Plumed Frogmouth (*Podargus plumiferus*). Conservation of these species is a national rather than regional issue. Efforts expended on them in this region must contribute within this wider context. Accordingly, it is difficult to assign any of these highly mobile animals to the general management categories applied to other groups. The Beach Thick-knee (*Burhinus neglectus*) is also regarded as vulnerable (a more appropriate category may well be 'endangered'). This species is so sparsely distributed along beaches in the Wet Tropics and extralimitally, that it is difficult to envisage how efforts might be focussed to determine its status and environmental requirements to effect recovery.

A common theme to the discussions concerning the conservation of the Wet Tropics avifauna emanated from the view that certain guilds of birds play key functional roles in ecosystems. *C. casuarius johnstonii*, is a 'keystone' species (Crome & Moore, 1988) as a dispersal vector of many large-fruited rainforest plants. Frugivorous pigeons, the Barred Cuckoo-Shrike (*Coracina lineata*), *A. metallica*, Figbird (*Sphecotheres viridis*) the Orioles (*Oriolus flavicinctus, O. sagittatus*) and honeyeaters are important as plant dispersers or pollinators.

Loss of habitat, particularly in the lowland systems and coastal wetlands, remains an ongoing threat to the regional conservation status of some bird species. The Wet Tropics bird specialist group identified various taxa which are restricted to, or have their strongholds in restricted localities or in habitats which are rare and/or where threats from development and ongoing landuse practices are severe. These are birds of the coastal lowlands and foothills, mangroves, freshwater wetlands and riparian forest. Loss of habitat integrity due to disturbance or through foraging activities of domestic pets and feral animals such as pigs, presents a problem for the survival of the regional avifauna.

Fire is associated with decline of some bird species in other tropical regions (Woinarski, 1990). Late dry season fires can cause a reduction in breeding sites for species such as hollow-breeders, may increase vulnerability to predation of ground-breeders and have affected the survival prospects of *E. radiatus* chicks (Aumann & Baker-Gabb, in Garnett, 1992a). Changes in fire regimes which allow proliferation of fire weeds, or reduce variety in a habitat mosaic, can also disadvantage *C. casuarius johnstonii* (Stanton, in Garnett 1992a).

Avian diseases also appear to be implicated in declines of some taxa. *Tuberculosis* infections have been reported increasingly in the Southern Cassowary (L. Moore, pers. comm.), raising concern about the spread of disease to stock. Avian pathologies are probably connected with declines observed in finch population (Tidemann et al., in press).

Displacement of native species by introduced birds such as Indian Mynahs (*Acridotheres tristis*), House Sparrows (*Passer domesticus*) and the Spice Finch (*Lonchura punctulata*) is also threat to some taxa. While the former two species are essentially restricted to intensively settled areas, the latter is widespread.

Illegal bird collecting appears to be a greater problem on Cape York Peninsula and in semi-arid

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[2] Not normally regarded as part of the avifauna of the Wet Tropics, although old records of this species from the area exist.

habitats than in the Wet Tropics. However, vigilance is required to protect such sought-after birds such as the Fig Parrot (*Cyclopsitta diophthalma macleayana*), the vulnerable *P. cincta* and the rare Blue-faced Parrot Finch (*Erythrura trichroa sigillifer*).

REPTILES

Over thirty rainforest-dependent reptile species occur in disjunct rainforests of the Wet Tropics (Covacevich, in press). Also restricted to the Wet Tropics are *Nactus galgajuga*, *Carlia scirtetis*, *Ctenotus terrareginae*, *Delma mitella* and *Cacophis churchilli*.

Many Wet Tropics reptiles have very narrow geographic ranges. This makes them vulnerable if significant portions of their restricted ranges are disrupted. Such species are regarded as 'R' taxa (species which are rare in Australia, but not currently considered endangered or vulnerable). They may be represented by a relatively large population in a restricted area or by smaller populations spread over a wider range, or some intermediate combination of distribution patterns (Ingram & Raven, 1991). Most occur in conservation reserves. None is known to be threatened. For other species, however, including some whose ranges are peripheral to the region, more information on their conservation status is required. Ten species (*D. mitella, Anomalopus gowi, Ctenotus eutaenius, C. hypatia, C. monticola, C. nullum, C. quinkan, C. terrareginae, Lerista zonulata, Lygisaurus tanneri* and *Simoselaps warro*) are rated as 'K' (McDonald et al., 1991), indicating they are 'poorly known species...'.

While there is the need for more systematic distribution and autecological information for at least 11 species of reptile which occur in or near the Wet Tropics, there was consensus that there is no immediate need for interventionist management of reptiles of the Wet Tropics.

No known widespread threats to the regional reptile fauna were identified. Global warming may prompt a reappraisal of this determination with respect to the summit zone endemic species. Feral pigs were considered likely to threaten local populations through direct predation and through habitat disturbance. The Queensland Department of Environment and Heritage's policy to remove Estuarine Crocodile (*Crocodylus porosus*) specimens from some sites was considered to be affecting the species' regional survival. *C. porosus* also has a high international conservation ranking (Perran Ross, 1992). Illegal collecting and road traffic may also be threatening local populations of some snake species.

FROGS

Of the 210 Australian frog species (Tyler, 1992), 53 occur in the Wet Tropics Region. Twenty-two of these occur nowhere else. The greatest number of rainforest-obligate/dependent endemic frog species (at least 20 of the 22 described species, including three myobatrachids, six hylids, and at least 11 microhylids) occur in the region (McDonald, 1992; Covacevich & McDonald, 1993). Several species are also yet to be described.

Given the world-wide phenomenon of frog 'disappearances' (Heyer, et al., 1988; Weygoldt, 1989; Blaustein & Wake, 1990; Tyler, 1992), the loss of frog species of the genera *Taudactylus* and *Rheobatrachus* in south and mideastern Queensland, and other species in the southeast of the continent (Richards et al., 1993), there is grave concern for the survival of species in the Wet Tropics. The narrowly restricted microhylids are not the focus of this concern. Populations of lotic stream-dwellers from the rainforest uplands are declining dramatically.

There are at least six species (*Taudactylus acutirostris, T. rheophilus, Litoria nannotis, L. nyakalensis, L. rheocola, Nyctimystes dayi* - Table 1) which have undergone recent population crashes (Richards, et al., 1993). A seventh species, the Armoured Mistfrog (*L. lorica*), is poorly known, but is suspected, due to its lotic breeding habit in upland rainforest streams, to belong to this declining group.

Outcomes of the discussions of the Wet Tropics herpetofaunal specialist group included the identification of four groups of species warranting special consideration. The group of six endemic upland lotic frog species mentioned above was considered to require immediate, 'priority 1' attention. The urgency of recovery action and research with respect to these species was accepted as a major workshop recommendation (Werren, 1992).

Another group (*L. lorica*; the Whirring Treefrog, *L. revelata*; the Windsor Nursery-frog, *Cophixalus bombiens*; Tapping Nursery-frog, *C. concinnus*; Bloomfield Nursery-frog, *C. exiguus*; Pipping Nursery-frog, *C. hosmeri*; Southern Nursery-frog, *C. mcdonaldi*; Tangerine Nursery-frog, *C. neglectus*; and Boulder Nursery-frog, *C. saxatilis*) was regarded of secondary consideration ('priority 3' taxa). These are narrow Wet Tropics endemics (apart from *L. revelata*, which has a disjunct distribution and is narrowly restricted in this region) from land which currently has a secure conservation tenure.

All remaining endemics (Covacevich & McDonald, 1993) were regarded as a third group requiring monitoring to ensure their continued survival.

A fourth group, which included species with extralimital distributions (the Northern Sedgefrog, *L. bicolor*; Green Treefrog, *L. caerulea*; Eastern Sedgefrog, *L. fallax*; Graceful Treefrog, *L. gracilenta*; White-lipped Treefrog, *L. infrafrenata*, which are often collected for the pet trade), was also of conservation concern. This group, together with the remaining endemics, fall into the 'priority 4' category.

Factors responsible for the 'disappearances' of some taxa, and the range contraction and declines in abundance of others are far from understood. What is known has been reviewed by Richards et al. (1993). Tyler (1992) comments that 'there is indeed a number of disappearances that at present cannot be explained'. He cites the cases of population crashes experienced by the Northern Platypusfrog (*Rheobatrachus vitellinus*) and Eungella Dayfrog (*T. eungellensis)* in mideastern Queensland that 'simply defy any reasonable explanation'.

Collecting colourful tree frog species is responsible for the local decline of some taxa and is of concern elsewhere (Tyler, 1992). This problem is being addressed with the present Schedules of Listed Fauna and in the Nature Conservation Act (Queensland) 1992, where frogs are now included as 'native fauna' and have the same protection as other vertebrates, except fish.

FRESHWATER FISH

The significance of the Wet Tropics Region to Australia's freshwater fish fauna is highlighted by the fact that 69 of the 188 Australian species (37% of the total fauna) occur in the region's streams (R. Wager, 1993). This represents the greatest regional diversity in Australia (Trenerry & Werren, 1991). A significant portion of this fauna has attracted special conservation interest (Wager, 1993).

Any treatment of the region's freshwater fish is greatly constrained by poor taxonomic and distributional knowledge. There is a relatively small endemic component, with three described and a further two undescribed species noted for the area (Trenerry & Werren, 1991; Wager, 1993). These include the Roman-nosed Goby, *Awaous crassilabrus*; Mulgrave Goby, *Glossogobius* sp.; *Scortum* sp.; Cairns Rainbowfish, *Cairnsichthys rhombosomoides*; and Lake Eacham Rainbowfish, *Melanotaenia eachamensis*. The last is presumed to have occurred only in Lake Eacham, a small crater lake on the Atherton Tableland. Introduction of predatory fish led to its extinction in the wild (Barlow, et al., 1987; Trenerry & Werren, 1991). In addition, there is one vulnerable species (Macculloch's Rainbowfish, *M. maccullochi*). None is rare, but 27 species are poorly known and suspected to belong to one of the other conservation status categories. The poorly known component amounts to 44% of the regional fauna or 90% of species which are ascribed special conservation status. The view was expressed that many of these may be threatened taxa. Just over one half of the region's fish fauna is regarded as secure (Wager, 1993).

In any assessment of the status and conservation requirements of the region's fish, two points must be stressed. 1. Fish populations are highly variable, both spatially and temporally, and assessment of population status must recognise this; and, 2. occurrence in a protected area cannot guarantee survival.

M. eachamensis requires high priority remedial attention, and, given that its continued existence is dependent on the maintenance of vulnerable captive populations, it is ascribed the status of 'endangered' (Wager, 1993, erected the category of 'presumed extinct in the wild' to accommodate this taxon). Questions about its taxonomic status, are under investigation (C. Moritz, pers.comm).

M. maccullochi, has declined in some of its Wet Tropics range. Although adjudged to be common/secure by Wager (1993), this species was considered 'vulnerable' within the region, deserving attention as a 'priority 3' taxon.

Of the 27 species requiring more information before their conservation status can be precisely determined, particular priority should be assigned to those which, on the basis of current information, are endemics or are recorded from restricted localities within the region. These constitute 'priority 4' taxa.

A complex suite of known threatening processes to freshwater fish was identified. Most are associated with catchment modification (e.g. removal/alteration of riparian vegetation, increases in sedimentation and pollution runoff associated with catchment clearing and landuse) and stream flow regime regulation (e.g. increases in water abstraction associated with the growing regional resident and visitor population, hydroelectricity generation, barriers to along-stream fish movement). A further threat to the native freshwater fish assemblages and to survival ability of some species is the introduction of exotics. A variety of ornamental species kept by aquarists has become naturalised in streams of the region. These include a significant number of live-bearers such as the Guppy (*Poecilia reticulatus*), Swordtail (*Xiphophorus helleri*), the Platy (*X. maculatus*) and a species used for insect pest control, the Mosquito Fish (*Gambusia holbrooki*), mouth-breeders such as two Tilapias (*Tilapia mariae, Oreochromis mossambicus*). These fish modify competition and predation dynamics, usually to the detriment of native species. Other threats include translocation of non-local native species, direct exploitation of some species for recreational fishing and, to a lesser extent, aquarium trade, proliferation of ponded pasture species such as *Brachiaria mutica* which chokes channels and disrupts flows, invasion and destruction of riparian vegetation by exotic weeds such as *Thunbergia grandiflora* which changes water temperatures, and the disturbance of stream stretches due to feral pig activities.

CONSERVATION STRATEGIES

Conservation of species is totally reliant on the conservation of their habitats. The maintenance of maximum variety in the landscape is the essential objective of any exercise aimed at the conservation of species. Particular assemblages or ecosystem types can be lost unless there is an attempt to remove threatening processes. Also, with conservation of tracts of habitat, species conservation can be additive and compounding (e.g. with the assignment of protective tenure on stands of lowland sclerophyll forest/woodland between Cardwell and Tully, the survival chances of the critically endangered *P. gracilis* may be significantly advantaged. In addition, the survival chances of other species of small mammals and birds, possibly some restricted fish taxa as well as a host of rare and threatened terrestrial and epiphytic orchids, other higher plants, a myriad of invertebrates and lower plants, will be significantly enhanced).

Despite the diverse professional interests of participants, there was unanimity of purpose, concern and approach to the task of conserving the Wet Tropics biota. There was recognition of the need for integrated and biologically explicit management planning, based soundly on detailed local knowledge. A conceptual framework through which this integrated and informed management can be achieved has been expounded by Hopkins & Saunders (1987). They argue for the adoption of an organisational structure which accepts that management must proceed concurrently with the gathering of data for the purpose of improving management decisions. The process is ongoing and must be incorporated into management systems. This provides for an enhancement of management capability of a nature conservation agency through the clear articulation of directions and the means through which objectives will be achieved. However, much uncertainty remains in the realm of non-conservation agency activity within the region.

The actions of essential service agencies, local government agencies and the entire gamut of private landholders, non-government institutions and structures, impact on the regional biota. They are thus responsible for endangering processes.

There was agreement to press for (i) the adoption of the primacy of protecting rare and/or threatened species as the cardinal principal guiding regional planning; (ii) the need for government agencies operating in the region to produce medium-term (five year) plans for their operations; (iii) an insistence on thorough scrutiny of infrastructure provisioning and development proposals which impinge on rare and/or threatened species during EIS/EIA review; (iv) the need to enact provisions of robust state conservation legislation to protect rare and threatened species when the situation arises; and (v) the forging of clear agreements with private landholders for the protection of rare and/or threatened species and their habitats.

Various taxa, systems and localities have been identified as worthy of immediate high priority interventionist management attention through implementation of recovery plans. Target taxa are detailed in Table 1. The systems of the lowlands, including poorly protected open sclerophyll communities, remnant rainforest, riparian communities, freshwater wetlands and mangroves warrant special conservation attention. In addition, tall open forest communities on the western fringe of the rainforested uplands and summit zones were viewed as deserving of same. Various localities also were considered vital for the conservation of rare and/or threatened species and systems. With respect to vertebrate conservation, the most significant of these was part of the Tully-Ingham lowlands, the habitat of *P. gracilis* (Van Dyck, 1993).

Other species and systems of concern were specified. For these the best protection was afforded by threat abatement mechanisms in the context of careful regional planning and development proposal review, together with the fostering of integrated catchment management.

It was also considered imperative that day-to-day conservation management enshrine the protection of rare and/or threatened species and systems as a central tenet. Negotiation with landholders to enhance conservation efforts on lands beyond the conservation reserves and the promotion of active public participation in conservation efforts and monitoring programs was deemed essential also.

The ultimate conservation management objective is to diminish the numbers of threatened systems and taxa through threat abatement, and to address the particular conservation requirements of target taxa which have become imperilled due to human activity. It is appropriate at the regional level to focus on the total number of taxa when setting such conservation management objectives (Hopkins & Saunders, 1987).

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SIZE AND DIET OF *BUFO MARINUS* IN RAINFOREST OF NORTHEASTERN QUEENSLAND. *Memoirs of the Queensland Museum 34(1):240. 1993:-* The widespread occurrence of the exotic *Bufo marinus* in open habitats and its feeding strategies there are well documented (e.g. Freeland, 1984). Not studied so well are patterns of occurrence and diet of *B.marinus* in rainforest.

Between Dec., 1985 and Jan., 1986, at two predominantly rainforested sites, we collected, measured and examined gut contents of 257 specimens of *B.marinus*. Site 1,'Carbine Uplands' is a traverse of 22.4km through notophyll vine forest along the Mt Lewis Forestry Rd. Site 2, 'Daintree Lowlands' is the 52.4km road from Noah Ck to Bloomfield (incorporating the years old section from Cape Tribulation to Bloomfield). This runs mainly through mesophyll vine forest, but includes cleared and open-forested tracts. At site 1, 102 specimens were obtained; at site 2, 155. Size-class distribution and gut contents (Table 1) of *B. marinus* collected from the two sites during 235 person-hours (between 2000 and 0350hrs) are compared.

A comparison of frequency distributions of snout-urostyle length reveal differences between samples from the two sites. The Carbine Uplands sample was essentially normally distributed around a mean adult length <10cm, suggesting an established population which is in equilibrium with its resource base, along the lower section of traverse to an upper altitudinal limit of ca 900m. That from site 2 clearly exhibited a positive skew around a mean length >10cm and indicates greater numbers of large adult toads (usually females - the largest measuring 19.8cm). Because the second site comprised a 52.4km traverse, of which 32.4km was the new Cape Tribulation-Bloomfield section, this difference can be interpreted as evidence of an invading or pioneering population, where larger sizes are attained due to exploitation of resources that had not been utilised formerly by toads. This is consistent with the work of Freeland (1984) in the Gulf of Carpentaria lowlands. It also supports the view that the newly constructed road acted as a route of 'infection', for toads (with other exotics) into rainforest.

Analysis of stomach contents confirms previous work (eg, Mungomery, 1936; van Beurden, 1980; Strussmann et al., 1984; Freeland et al., 1986), showing consumption of a wide range of invertebrates, but a clear preference for ants and beetles. Notable also is the ingestion of arachnids (both spiders and scorpions), and scolopendromorph centipedes, indicating resilience of *B. marinus* to their venoms. A Chi^2 test (at $p_{crit.}$ = 0.001), shows significant differences between diets of toads at the two sites (more oligochaetes, diplopods, collembolans and curculionids in the upland rainforest vs more slugs, orthopterans and homopterans in the lowlands). Both populations appear to be foraging similarly, largely as predators of arthropods and other invertebrates. In so doing, *B. marinus* is a competitor of native anurans and other small vertebrates. Only one instance of vertebrate prey (a road-killed *B.marinus* being cannibalised) was recorded during the survey. This was one of only three such instances in surveys over 4 summers, between 1985-1989. The others were specimens of *Ramphotyphlops* sp., and *Rana daemeli*, a juvenile.

TABLE 1.Diet of *Bufo marinus* from two rainforest sites, NEQ.

Prey Item	Percentage of stomachs containing prey items			
	Site 1	Site 2	Total	Sig. Diff. p>0.001
Earthworms	12.7	3.9	7.4	yes
Snails	11.8	5.8	8.2	—
Slugs	0.9	11.6	7.4	yes
Scorpions	1.9	4.5	3.4	—
Spiders	12.7	17.4	15.6	—
Harvestmen	11.8	10.9	11.3	—
Slaters	4.9	3.9	4.3	—
Millipedes	36.3	21.3	27.3	yes
Centipedes	11.8	12.3	12.1	—
Springtails	11.8	1.9	5.8	yes
Cockroaches	10.8	22.6	17.9	—
Crickets/Katydids	22.5	36.1	30.7	yes
Earwigs	4.9	8.4	7.0	—
Termites	6.8	4.5	5.4	—
Bugs	3.9	7.1	5.8	—
Leafhoppers/Cicadas	0.9	6.5	4.2	yes
Butterfly/Moth larvae	9.8	11.6	10.9	—
Beetles (excl. weevils)	86.2	67.7	75.1	—
Weevils	52.9	30.9	39.7	yes
Ants (other)	79.4	73.5	75.9	—
Bull Ants	26.5	—	10.5	—
Green Tree Ants	—	22.5	13.6	—
Vertebrates	—	0.6*	0.4	—
Mineral	56.9	26.5	38.5	yes
Plant	60.8	67.7	65.0	yes
(Nematode parasitism)	7.8	12.9	10.9	—
Number	102	155	257	—

* single record, road-killed *B. marinus*

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