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TRANSACTIONS OF THE ROYAL SOCIETY OF SOUTH AUSTRALIA

INCORPORATED

ADELAIDE

PUBLISHED AND SOLD AT THE SOCIETY'S ROOMS
KINTORE AVENUE, ADELAIDE

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By A. JEFFERIS TURNER, M.D., F.R.E.S.

Summary

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STUDIES IN AUSTRALIAN LEPIDOPTERA

By A. JEFFERIS TURNER, M.D., F.R.E.S.

[Read 13 April 1944]

I am indebted to Mr. T. Bainbridge Fletcher for pointing out that we have been using some generic names which have been preoccupied, and for which new names must be substituted. For instance, *Macraeola* Meyr. (Tineidae 1893) must give place to *Tenaga* Clem. (1862). He has also substituted *Thalamarchella* for *Thalamarchis*.

I propose the following changes:—

for *Palaeoneura* Turn. 1923 (Tineidae). *Archaeoneura*.
Lophozancla Turn. 1933 (Gelechiidae). *Phaeotypa*. (φαιοτυπος, with dark markings.)
Idiozancla Turn. 1936. (Oecophoridae). *Phobetica*. (φοβητικος, timid.)
Stenophara Turn. 1940. (Oecophoridae.) *Ischnophara*.

Fam. NOTODONTIDAE

Gallaba diplosticha n. sp.

διπλοστιχος, with double lines.

♂, 40-44 mm.; ♀, 35-40 mm. Head and thorax grey-whitish sprinkled with fuscous; face whitish. Palpi whitish, outer surface of second joint except apex dark fuscous. Antennae grey-whitish; pectinations in male 6, in female 1½. Abdomen whitish-grey. Legs whitish sprinkled with fuscous; inner surface and tarsal rings of anterior and middle pairs dark fuscous. Forewings sub-oblong, narrow, costa in male slightly sinuate, in female slightly arched, apex sub-rectangular, termen rounded, slightly oblique; grey mixed with whitish and sparsely sprinkled with fuscous; markings fuscous; a double line from base to one-sixth costa; another from one-third costa to one-fourth dorsum, slightly waved, indented above dorsum; a single sinuate median transverse line; a double wavy line from two-thirds costa to two-thirds dorsum; an interrupted subterminal line; orbicular and reniform represented by white spots partly outlined with fuscous, the former round, the latter elongate, almost linear, on the posterior edge of median line; cilia grey, apices whitish. Hindwings of male very broad, rounded, with a tuft of long hairs from near base of costa, in female moderate with apex pointed and termen sinuate; 6 and 7 coincident in male, stalked in female; pale fuscous with whitish suffusion towards base; cilia whitish, bases pale fuscous. In one female there is an irregular blackish subdorsal streak from base.

Western Australia: Margaret River in October; Albany in March; Denmark in November and April; Perth; seven specimens, of which three are in the Queensland Museum.

Fam. OENOCHROMIDAE

Taxeotis homoeopa n. sp.

ὁμοιωπος, similar.

♂, 19-22 mm. Head grey; face blackish. Palpi 1¼; blackish, sharply white towards base beneath. Antennae grey; ciliations one-half. Thorax, abdomen, and legs grey. Forewings triangular, costa nearly straight, apex pointed, termen straight, oblique; grey with a few scattered fuscous scales; markings fuscous; dark costal spots at one-third and two-thirds; a dorsal dot at one-fourth, and another in disc midway between this and first costal; a small medium discal dot; a subterminal series of spots more or less connected and obscured by fuscous irroration and preceded by a parallel line not reaching costa of ferruginous dots with fuscous centres; terminal edge pale with a series of dark fuscous dots; cilia grey with fuscous points. Hindwings with termen rounded; colour, terminal dots, and cilia as forewings; a short transverse fuscous line from three-fifths dorsum.

♀, 19-24 mm. Palpi $1\frac{3}{4}$. Forewings with apex acute; markings much more obscure and often partly obsolete.

Most nearly resembling *T. blechra* Turn. from Western Australia, but the male differs in the darkly suffused subterminal line preceded by ferruginous dots on forewings. The female of *T. blechra* often has minute transverse strigulae over both wings.

Queensland: Cunnamulla in October; six specimens.

PHRATARIA Wlk.

Walker 1862, **35,** 1700.

Westwood (1841) made the genus *Epidesmia* for *tricolor* Westw. Walker (1862) made *Phrataria* for *replicataria* Wlk., **35,** 1700. Meyrick (1890) sank Walker's genus to *Epidesmia,* and at the same time described *Satraparchis* for *bijugata,* overlooking the fact that these species agreed in neuration. The genus *Phrataria* must be restored. It differs from *Epidesmia* essentially in the stalking of 3 and 4 of the forewings, and contains *replicataria* Wlk.? *transcissata* Wlk., *bijugata* Wlk., and the following species.

Phrataria V-album n. sp.

V-album, marked with a white V.

♂, 24 mm. Head, palpi and thorax fuscous. Antennae fuscous; pectinations in male, four. Abdomen grey. Legs fuscous. Forewings triangular, costa moderately arched, apex pointed, termen sinuate; fuscous; veins streaked with whitish-ochreous; a broad straight white line from just beneath midcosta to tornus, edged with dark fuscous, its dorsal portion preceded and followed by very fine whitish parallel lines; a white line from apex to termen just above tornus, obtusely bent inwards above middle; a slender white terminal line; cilia fuscous. Hindwings with termen rounded; grey; a slightly darker straight postmedian line; a faint whitish subterminal line from apex to tornus; a slender white terminal line; cilia grey.

Queensland: Milmerran in October; one specimen received from Mr. J. Macqueen.

Fam. SYNTOMIDAE

SYNTOMIS APERTA Wlk. 1864

Walker 1864, Cat. **31,** 72.

Hydrusa nesothetis Meyr. 1886, Proc. Linn. Soc. N.S.W., 783.

Syntomis melitospila Turn, 1905, *ibid.,* 853; Hmps. 1914, Suppl. 1, 20, pl. ii, fig. 2.

Queensland: Gladstone, Eidsvold, Gayndah, Toowoomba, Dalby, Injune, Milmerran, Inglewood, Cunnamulla. New South Wales: Murrurundi, Hay.

Eressa strepsimeris Meyr. 1886

Meyr. 1886, *ibid.*, 786.

Eressa xanthostacta Hmps. 1903, Ann. Mag. Nat. Hist., (7), **11**, 339.

Eressa stenothyris Turn. 1933, Trans. Roy. Soc. S. Aust., **57**, 160.

North Queensland: Cape York, Cairns, Mount Mulligan, Townsville, Bowen, Queensland: Yeppoon.

Eressa megalospila Turn 1922

Turn. 1922, Proc. Roy. Soc. Vict., 28.

Eressa strepsimeris Hmps. 1914, Suppl. i, 47, *nec* Meyr. 1886, *ibid.*, 786.

North Australia: Darwin, Daly River.

Fam. ARCTIIDAE

Heliosia perichares n. sp.

περιχαρης, cheerful.

♂ ♀, 18 mm. Head and palpi orange-yellow. Antennae pale grey, towards base yellowish; ciliations in male 1. Thorax, anterior half orange-yellow, posterior half blackish. Forewings suboblong, costa moderately arched, apex rounded, termen oblique; orange-yellow with three blackish fasciae; first small, basal; second moderate, from one-third costa to mid-dorsum, margins wavy or straight, anterior edge with a slight prominence above middle, posterior leaving a narrow orange-yellow terminal strip, which may or may not extend to tornus; cilia blackish, towards apex of wing yellowish. Hindwings with termen rounded; 3 and 4 coincident; orange-yellow; a broad blackish terminal band; cilia blackish. Very similar to *H. charopa*, which has different neuration of hindwings, no basal fascia in forewings, and subterminal fascia differently shaped.

Queensland: Milmerran in October, November and December; three specimens received from Mr. J. Macqueen.

Halone nephobola n. sp.

νεφοβολος, overcast with clouds.

♂, 27-30 mm. Head and thorax fuscous sprinkled with whitish-ochreous. Palpi dark fuscous. Antennae fuscous; in male with tufts of moderate ciliations (1). Abdomen grey mixed with whitish-ochreous; tuft and underside ochreous. Legs ochreous with fuscous tarsal rings; posterior tibiae ochreous. Forewings triangular, costa strongly arched, apex round-pointed, termen nearly straight, oblique; whitish-ochreous sprinkled and suffused with fuscous, darker in central area; markings dark fuscous; a basal costal spot, from which proceeds a curved line ending on fold and enclosing a pale spot; shortly followed by a suffused line also from costa to fold; antemedian irregularly dentate from one-third costa to three-fifths dorsum; a pale-centred discal spot outlined with fuscous; postmedian from two-thirds costa, dentate, with a broad quadrangular projection from beneath costa to below middle; a broadly suffused interrupted subterminal line; cilia fuscous mixed with pale ochreous. Hindwings with termen gently rounded; orange-yellow; a fuscous apical spot; cilia yellow, on apex partly fuscous.

Allied to *H. sinuata* and *H. coryphaea*, but larger, differing in details of forewing markings, and without fuscous terminal line on hindwings.

Tasmania: Hobart in October (Dr. V. V. Hickman); two specimens taken at rest on the wall of the University. The larvae feed on lichens and pupate in crevices between the stones.

Philenora malthaca n. sp.

μαλθακος, gentle.

♀, 20 mm. Head whitish. Palpi and antennae fuscous. Thorax fuscous with anterior and posterior whitish spots. Abdomen grey. Legs fuscous; posterior pair whitish-ochreous. Forewings elongate-triangular, costa nearly straight, apex pointed, termen oblique; whitish suffused with fuscous, appearing grey; a transverse elongate whitish basal spot, separated by a fuscous line from a whitish fuscous-edged dorsal blotch, which extends nearly to middle; upper edge of blotch nearly straight, subcostal, posterior edge deeply indented, forming median and dorsal obtuse projections; an oblique fuscous line from midcosta to upper angle of blotch; a second oblique line from three-fourths costa to three-fourths dorsum, the costal portion of area between these lines whitish; an irregular subterminal fuscous fascia, indented posteriorly above middle, containing a whitish dorsal triangle, its apex produced to middle of disc; cilia fuscous with whitish bars. Hindwings broad, termen rounded; pale ochreous; a pale fuscous apical blotch tolerably well defined; cilia pale ochreous, on blotch fuscous.

New South Wales: Newport, near Sydney, in September; one specimen received from Mr. J. Macqueen.

Fam. NOCTUIDAE

Subfam. MELANCHRINAE

MELIANA SCOTTI Butl. 1886

Butl. 1886, Trans. Ent. Soc., 391; Hmps. 1905, **5**, 95, pl. xcv, fig. 22.
Leucania melanopasta Turn. 1902, Proc. Linn. Soc. N.S.W., 81.
Borolia microsticta Turn. 1909, *ibid.*, 341.

Male with mid-tibiae densely clothed throughout with long hairs on ventral surface. Lateral hair-tufts on penultimate abdominal segment. Antennae with short ciliations (one-half) and longer bristles (1). Both sexes with posterior tibiae smooth.

North Australia: Darwin. Queensland: Cape York to Brisbane. North-west Australia: Wyndham.

MELIANA LEWINII Butl. 1886

Butl. 1886, Trans. Ent. Soc., 390; Hmps. 1905, **5**, 556.
M. similis Butl. 1886, *ibid.*, 392.
M. xylogramma Meyr. 1897, Trans. Ent. Soc., 367.

Peak Downs to Sydney.

Subfam. ACRONYCTINAE

Acronycta anceps n. sp.

anceps, two-headed.

♂, 32-40 mm. Head and thorax fuscous-brown mixed with whitish; thorax with a slender fuscous transverse antemedian line. Palpi reaching vertex, terminal joint short, obtuse; fuscous-brown. Antennae fuscous; in male shortly ciliated (one-half). Abdomen grey. Legs fuscous-brown with whitish tarsal rings. Forewings elongate-triangular, costa nearly straight, apex rounded, termen rounded, oblique; fuscous-brown with some whitish suffusion; markings fuscous; an ill-defined sub-basal line; a slender blackish sub-dorsal line from near base to one-fourth; orbicular obsolete; reniform outlined with whitish, narrow, oblique, its lower extremity connected by an inwardly curved line with two-thirds dorsum; a suffused oblique line from midcosta to lower extremity of reniform, thence outwards, blackish, and soon dividing into two heads, running respectively to dorsum above tornus and termen below middle; three whitish costal dots beyond middle; some whitish subapical suffusion; subterminal line obsolete or indicated by some blackish dots; cilia fuscous with slender whitish bars. Hindwings with termen rounded, slightly wavy; 5 obsolescent from below middle of cell (one-third); fuscous with a large suffused whitish basal blotch; cilia fuscous, becoming whitish towards tornus.

North Queensland: Kuranda in March; two specimens received from Mr. F. P. Dodd.

Namangana eugraphica n. sp.

εὐγραφικος, well inscribed.

♂, 35 mm. Head, palpi, thorax, and abdomen pale grey. Antennae grey-whitish; in male bipectinate almost to apex, pectinations 2. Leg, grey-whitish; anterior tarsi dark fuscous with whitish rings. Forewings elongate-triangular, costa almost straight, apex rounded-rectangular, termen rounded slightly oblique; grey-whitish; markings fuscous, very clear and distinct; four strigules on basal fifth of costa; a sub-basal median dot; a double wavy transverse line at one-fifth; claviform long, U-shaped; orbicular outlined, broadly oval; reniform outlined, large, connected with dorsum by a dentate line; a dot on mid-costa; postmedian line double, finely dentate, from two-thirds costa outwards, curved beneath costa to become transverse, ending on dorsum near tornus; a finely dentate subterminal line; a terminal series of blackish dots; cilia grey-whitish with two faintly darker lines. Hindwings with termen gently rounded; white; a slender fuscous terminal line; cilia white.

Queensland: Cunnamulla in April; one specimen received from Mr. N. Geary.

NAMAGANA HOROLOGA (Meyr. 1897)

Meyr. 1897, Trans. Ent. Soc., 367 (*Orthosia*).

Prometopus horologa Hmps. 1909, 8, 369, pl. cxxxi, fig. 7.

I think this species is best placed here.

Eidsvold to Melbourne, Clermont, Scone, Charleville.

Barybela n. gen.

βαρυβελος, with heavy palpi.

Tongue strong. Face not projecting. Palpi ascending, rather long, clothed with appressed scales; second joint much thickened, reaching middle of face; terminal joint moderate, obtuse. Thorax with a moderate posterior bifid crest. Abdomen with dorsal crest on basal segment. Posterior tibiae mostly smooth but with short hairs on dorsum. Hindwings with 5 obsolescent from well below middle. Apparently allied to *Namangana*, but with different palpi.

Barybela chionostigma n. sp.

χιονοστιγμος, with white spots.

♀, 30 mm. Head and thorax dark fuscous with a few whitish scales. Palpi 2; dark fuscous, bases of second and terminal joints and a few scales whitish. Antennae dark fuscous. Abdomen whitish heavily sprinkled with fuscous. Legs dark fuscous; apices of tibiae and tarsal joints white. Forewings elongate-triangular, costa straight, apex rectangular, termen slightly rounded, scarcely oblique; dark fuscous with a few whitish scales towards costa, markings white, a mid-basal spot; three or four minute costal dots beyond middle, orbicular a snow-white dot at one-third; reniform a snow-white ring incomplete on costal edge; cilia dark fuscous with obscure grey bars. Hindwings with termen rounded; grey; cilia grey, bases whitish.

Western Australia: Yanchep, in November; one specimen.

MACROPRORA Turn. 1941

Turn. 1941 (June), Mem. Qld. Mus., **12,** 48.

Conocrana Turn. 1941 (August), Proc. Roy. Soc. Qld., **72** (type C. *ochthera* Turn., *ibid.*).

A characteristic feature of this genus, not mentioned in my description, is the large erect dorsal crest on the fourth abdominal segment. Type, *M. chionobola* Turn., *ibid.* To this genus should be referred *M. oostigma* Turn. 1929, Trans. Roy. Soc. S. Aust., **53,** 302, and *M. symprepes,* both of which were described as of the genus *Crypsiprora,* Trans. Ent. Soc., 1902, 29.

The genus *Conocrana* becomes a synonym.

MACROPRORA CHIONOBOLA Turn. 1941

Turn. 1941 (June), Mem. Qld. Mus., **12,** 48.

Conocrana ochthera Turn. 1941 (August), Proc. Roy. Soc. Qld.

EUPRORA Hmps. 1926

New Gen. and Sp. Noct. 1926, 88.

Tongue strong. Face with moderate smooth rounded prominence. Palpi porrect, slender; second joint reaching to facial prominence, shortly rough-scaled; terminal joint short. Thorax and abdomen not crested. Tibiae hairy. Forewings elongate, narrow at base, posteriorly dilated; 2 from three-fourths, 7, 8, 9 stalked from areole, which is short and broad. Hindwings with 5 from middle of cell, weakly developed except towards termen, 12 anastomosing with cell near base. Type, *E. lichenophora.*

This genus should be referred to the Acronyctinae. It agrees in wing-shape and is probably akin to the following genus, which differs in palpi, neuration of forewings, and smooth legs.

EUPRORA LICHENOPHORA Low. 1902

Low. 1902, Trans. Roy. Soc. S. Aust., **26,** 224.

Victoria: Gisborne.

Litoscelis n. gen.

λιτοσκελις, smooth-legged.

Tongue strong. Face with moderate smooth rounded prominence. Palpi smooth, porrect; second joint very much thickened; terminal joint minute. Thorax and abdomen not crested. Tibiae smooth. Forewings elongate, strongly dilated; 2 from two-thirds, areole short and broad, 7 arising from it separately. Hindwings with 5 obsolescent from middle of cell, 12 closely approximated to cell to beyond middle.

LITOSCELIS TANYPHYLLA Turn. 1929

Turn. 1929, Trans. Roy. Soc. S. Aust., **53,** 304.

North Queensland: Cairns, Atherton.

EREMAULA Turn. 1941

Proc. Roy. Soc. Qld., 74.

My definition needs amendment. In the type specimen the thorax was abraded, but in another I find a moderate smooth rounded posterior crest. There is also a small crest on the first abdominal segment. The origin of 5 of the hindwings from below the middle is correct for the type, but in two other examples it is median.

EREMAULA MINOR (Butl. 1886)

Butl. 1886, Trans. Ent. Soc., 397; Hmps. 1909, **8,** 547, pl. cxxxvi, fig. 31 (*Crambodes*).

This species cannot be referred to *Namangana* (Staud. 1888, Ent. Zeit., **49,** 28; Hmp., **8,** 541). *E. ptilopleura* Turn. 1941 is a synonym.

Queensland: Peak Downs; Injune; Cunnamulla.

Bathytricha aethalion n. sp.

αἰθαλιων, dusky.

♂, 38 mm. Head, palpi, thorax, abdomen, and legs fuscous. Antennae grey; pectinations in male 1. Forewings elongate-triangular, costa nearly straight, apex rounded, termen rounded, oblique; dark grey with dark fuscous dots; three dots in a transverse line at one-third; a series of dots in a sinuate line at three-fourths; a supramedian dot displaced inwards; a terminal series of dots; cilia dark grey. Hindwings with termen sinuate; cilia grey-whitish with a darker median line. Closely similar with *B. truncata* Wlk., except that in the hindwings vein 5, which is weakly developed, is not approximated at base to 4, but straight and arising from middle of cell.

Victoria: Orbost; the larvae feeding on maize stems (W. V. Ludbrook); one specimen.

Ariathisa

Wlk. 1865 **33,** 747; Hmps., Cat. Lep. Phal., 1909, **8,** 383.

Tongue strong. Face not projecting. Palpi ascending, second joint thickened with appressed scales, somewhat rough anteriorly; terminal joint short, obtuse. Thorax with a small bifid posterior crest; tegulae rather large. Abdomen without crests but with lateral tufts of hair directed towards middle. Posterior tibiae hairy. Neuration normal.

To this genus I refer all the species formerly included by me in *Caradrina*, Trans. Roy. Soc. S. Aust., 1920, **44,** 154, except *C. obtusa* Hmps., Ill. Het. B.M., **8,** 29, pl. cxlv, fig. 6, and *C. maculatra* Low. 1891, Proc. Linn. Soc. N.S.W., 1902, 657. Two species, including the type, are known from Africa, one from New Zealand and one from Fiji, but there are many in Australia. Their discrimination is often difficult. In addition to a certain amount of variability some show sexual differences. Much work remains to be done before the species are accurately known. *Thoracolopha* Turn., Proc. Roy. Soc. Qld., 1939, 13, is a synonym.

Ariathisa loxonephra n. sp.

λοξονεφρος, with oblique reniform.

♂, 30 mm. Head whitish; face grey. Palpi whitish, sparsely sprinkled with fuscous. Antennae fuscous; in male serrate with fascicles of short cilia (1). Thorax whitish sprinkled with fuscous and pale ochreous. Abdomen whitish, on dorsum faintly ochreous-tinged. Legs whitish sprinkled with fuscous; tarsi except posterior pair with dark fuscous rings. Forewings elongate-triangular, costa almost straight, apex rounded-rectangular, termen rounded, slightly oblique, whitish partly ochreous-tinged, with fuscous markings; costa barred throughout; subcostal, median, and plical streaks from base to antemedian line; antemedian sharply angled inwards on fold, obsolete towards costa; postmedian from two-thirds costa to three-fifths dorsum, sharply dentate, costal half nearly transverse, dorsal half inwardly oblique; median area between lines mostly suffused with fuscous; orbicular a longitudinal oval whitish ring with fuscous centre; reniform large, oblique, two-lobed, edged with whitish except on costal aspect, closely followed by postmedian line; beyond this fine streaks on veins; a terminal series of dark fuscous lunules, cilia fuscous with slender whitish bars. Hindwings with termen rounded, crenulate; white with grey terminal suffusion; an interrupted fuscous terminal line; cilia white.

Western Australia: Tammin in October; one specimen.

Ariathisa desertorum n. sp

desertorum, living in the wilderness.

♂, 28 mm. Head, thorax, and palpi grey or pale ochreous sprinkled with fuscous. Antennae fuscous; in male shortly and evenly ciliated (one-half). Abdomen whitish-ochreous with some fuscous scales. Legs fuscous with whitish-ochreous rings; posterior pair mostly whitish-ochreous. Forewings rather narrow, posteriorly dilated, costa straight, apex rounded-rectangular, termen slightly rounded, slightly oblique; whitish-ochreous or grey more or less suffused with fuscous; markings dark fuscous; a sub-basal line from costa to fold; a slightly dentate line from one-fourth costa to one-third dorsum; an ochreous or pinkish line or suffusion on fold; orbicular a small pale circular spot; reniform dark fuscous, irregularly oblong, its angles sometimes produced, anterior and posterior edges pale and sometimes pinkish-tinged; median line dentate, incomplete or blurred; postmedian slender finely dentate from two-thirds costa, first outwardly curved, bent inwards below middle and indented above dorsum; an apical fuscous suffusion sometimes extended towards dorsum, a submarginal series of pale spots sometimes pinkish-tinged; a terminal line; cilia grey mixed sometimes with fuscous and whitish. Hindwings with termen rounded; whitish sometimes with grey suffusion on apex and termen; cilia whitish.

South Australia: Ooldea in October (W. H. Matthews); three specimens.

Subfam. ERASTRIINAE

NARANGODES GLYCYCHROA (Turn. 1904)

Micrapatetis glycychroa Turn. 1904, Trans. Roy. Soc. S. Aust., **28,** 218; Hmps., **9.** 453, pl. cxlvi, fig. 20.

Darwin; Thursday Island; Cape York; Cairns; Yeppoon; Duaringa.

Eublemma hapalochroa n. sp.

ἁπαλοχροος, softly coloured.

♂ ♀, 15-18 mm. Head and thorax ochreous-brown. Palpi fuscous. Antennae fuscous; ciliations in male minute. Abdomen ochreous. Legs fuscous with ochreous rings. Forewings elongate-triangular, costa gently arched, apex pointed, termen slightly rounded, oblique; ochreous; a fuscous spot on base of costa prolonged on costal edge; a broad postmedian purple-fuscous band, edged with fuscous, and containing a small ochreous discal spot, anterior edge at two-fifths, slightly outwardly curved, posterior edge from two-thirds costa to dorsum before tornus, with subcostal and median obtuse projections; a purple-fuscous apical suffusion, broadest on costa; cilia purple-fuscous. Hindwings with termen rounded; grey; cilia pale grey.

Queensland: Thargomindah in April; two specimens received from Mr. N. Geary.

EUSTROTIA MACROSEMA (Lower 1903)

Xanthoptera macrosema Low. 1903, Trans. Roy. Soc. S. Aust., **27,** 48.
Nanaguna albirena Hmps. 1909, **8,** 557, pl. cxxxvii, fig. 9.
Eustrotia macrosema Hmps. 1910, **10,** 605, pl. clxvii, fig. 1.
Euprora crypsichlora Turn. 1931, Proc. Linn. Soc. N.S.W., 341.

Queensland: Brisbane; Toowoomba; Bunya Mountains; Carnarvon Ranges.

E. cyclospila Turn, 1932, Trans. Roy. Soc. S. Aust., **56,** 178, and *E. eremotropha* Turn., *ibid.,* 177, are allied species.

Subfam. EUTELIINAE

Phlegetonia bathroleuca n. sp.

βαθρολευκος, white at the base.

♀, 32 mm. Head grey. Palpi with second joint nearly reaching vertex, terminal joint one-half; ochreous-whitish, outer surface sprinkled with fuscous, towards base wholly dark fuscous. Antennae fuscous. Thorax greenish-grey mixed with fuscous. Abdomen fuscous; tuft fuscous-whitish. Legs fuscous; tarsi with ochreous-whitish rings. Forewings elongate-triangular, costa straight, apex rounded-rectangular, termen crenulate, slightly curved to vein 3, there bowed, and thence oblique to tornus; basal area to one-third fuscous with waved pale transverse lines each edged with dark fuscous; thence grey; reniform narrow, constricted in middle, greenish, preceded by a dark fuscous spot, and followed by a pale suffusion, which is traversed by an S-shaped fuscous line ending in dorsum beyond middle; postmedian double, fuscous, strongly sinuate, interrupted above middle by a thick blackish streak, which curves to below midtermen; a dentate sinuate subterminal line; an apical fuscous suffusion; a fuscous tornal spot; cilia fuscous, on middle of termen barred with greenish-grey. Hindwings with termen rounded; fuscous, a basal white blotch deeply incised in middle; cilia fuscous.

North Queensland: Tully, near Innisfail, in June; one specimen.

Subfam. SARRHOTHRIPINAE

Neocleta n. gen.

νεοκλητος, newly chosen.

Tongue well developed. Face not projecting. Palpi rather long, porrect; second joint much thickened especially at apex, where there is a broad rounded dorsal tuft; terminal joint minute, depressed. Thorax not crested. Abdomen with a minute crest on basal segment. Posterior tibiae smooth. Forewings without areole, 7, 8, 9, 10 stalked, 11 anastomosing with 12. Hindwings with 3 and 4 coincident, 2 and 5 equidistant from 3, 12 anastomosing to middle of cell.

Near *Microthripa* Hmps., **11**, 226, but with 11 and 12 anastomosing, an unusual feature in this group, and with different palpi.

Neocleta empyra n. sp.

ἐμπυρος, scorched, carbonised.

♂. Head and thorax blackish. Palpi one and a half; blackish. Antennae dark fuscous; ciliations in male one-half. Legs dark fuscous; posterior tibiae mostly grey-whitish. Forewings suboval, costa strongly arched, apex round-pointed, termen oblique; fuscous with blackish markings; a costal streak from base almost to middle; a dorsal streak from base to two-thirds, a suffused fascia interrupted in middle connecting apices of these streaks; a fine line from apex of costal streak beneath costa to two-thirds, there bent in a right angle to below middle, where it is again angled and inwardly curved to dorsal streak; a whitish dot in disc at three-fifths; cilia fuscous. Hindwings and cilia whitish. Adapted for concealment on blackened tree trunks.

Western Australia: Merredin in September; one specimen.

Calathusa anisocentra n. sp.

ἀνισοκεντρος, with unequal spurs.

♀, 32 mm. Head grey mixed with white on crown; face with strong anterior tuft. Palpi 3, obliquely ascending; second joint strongly expanded towards apex, especially on dorsum; terminal joint one-fourth; grey mixed with whitish.

Antennae grey. Thorax grey. Abdomen ochreous-grey-whitish. Legs fuscous sprinkled with white; posterior pair white; posterior tibiae with outer spurs very short. Forewings elongate, narrow, posteriorly dilated, costa slightly arched, apex rounded, termen obliquely rounded; grey unevenly suffused with white except in median area; a slender fuscous antemedian line from one-fourth costa obliquely outwards to fold, there acutely angled inwards to end on dorsum near base; outer edge of median area sharply defined, indented in middle, above dorsum, and on dorsum; dark fuscous discal dots with raised scales at two-fifths and three-fifths; a third dot at four-fifths almost connected with a wavy streak from dorsum before tornus; all veins partly streaked with fuscous; a terminal series of longitudinal elongate fuscous dots; cilia grey with some fuscous bars. Hindwings with termen slightly sinuate; whitish with grey terminal suffusion broadest at apex; cilia white. This species presents some structural peculiarities of minor importance.

Queensland: Milmerran in August; one specimen received from Mr. J. Macqueen.

Calathusa englypta n. sp.

ἐγγλυπτος, indented.

♂, ♀, 28-30 mm. Head and thorax fuscous. Palpi 2; fuscous. Antennae fuscous; ciliations in male 2. Abdomen fuscous; basal segment whitish; tuft ochreous-whitish. Legs fuscous; posterior pair whitish. Forewings elongate-oval, costa slightly arched, apex rectangular, termen rounded, slightly oblique; fuscous unevenly sprinkled with whitish; markings dark fuscous; an incomplete dentate sub-basal line; antemedian line from one-third costa to one-third dorsum, indented in middle with a posterior tooth above and beneath; postmedian from before two-thirds costa to two-thirds dorsum with a posterior rectangular projection indented in middle, thence incurved, preceded by a short line from costa; fine streaks on veins in terminal area; sometimes a short whitish submedian suffusion; an irregular dentate whitish subterminal line; cilia grey with fuscous bars. Hindwings with termen slightly bisinuate; grey, towards base suffused with whitish; cilia whitish.

Queensland: Milmerran in March; two specimens received from Mr. J. Macqueen.

Subfam. ACONTIINAE

Verz., 164; Hmps., **11**, 326.

The genus *Eligma* Hb. should be placed in this subfamily next to *Cacyparis* Wlk., **26**, 1.572; Hmps., **11**, 461.

Subfam. OPHIDERINAE

Eremnophanes n. gen.

ἐρεμνοφανης dark.

Tongue present. Face with strong rounded prominence. Palpi long, porrect, shortly rough-scaled; terminal joint long, stout, obtuse. Thorax with a strong posterior crest. Abdomen with crests on first two segments. Forewings with areole present, 10 arising from it separately. Hindwings with 5 approximated to 4, 6, and 7 connate, 12 anastomosing to beyond middle of cell.

Eremnophanes apicinota n. sp.

apicinotus, with apical mark.

♀, 20 mm. Head, antennae, and thorax dark fuscous. Palpi 3; fuscous. Abdomen whitish; crests dark fuscous. Legs fuscous. Forewings narrowly triangular, costa nearly straight, apex pointed, termen obliquely rounded, crenulate; dark fuscous; markings blackish, obscure, partly edged with whitish; a short white streak from base of costa edged blackish posteriorly; antemedian line from one-third costa to dorsum near middle, angled on fold; orbicular a small whitish ring; a median transverse line projecting obtusely in middle and above dorsum; reniform large, outlined with blackish, whitish towards costa; a broad white streak from costa near apex to median line, traversing reniform; cilia fuscous, extreme bases whitish. Hindwings with termen rounded; whitish with some fuscous terminal suffusion; cilia white.

Queensland: Cunnamulla in February; two specimens recieved from Mr. N. Geary.

Stenoprora triplax n. sp.

τριπλαξ, threefold.

♂, 21 mm. Head and thorax grey sprinkled with dark fuscous. Palpi 3, second joint much exceeding face, terminal joint short, truncate; grey sprinkled with dark fuscous, lower edge white towards base. Antennae grey; ciliations in male one-half. Abdomen whitish-grey; basal crest dark fuscous. Legs fuscous sprinkled with white; anterior coxae and posterior tibiae and femora white. Forewings narrow, posteriorly dilated, costa almost straight, apex round-pointed, termen slightly rounded, slightly oblique; grey; markings and some irroration dark fuscous; a sub-basal line from costa to fold; sharply angled inwards beneath costa and outwards above fold; antemedian from one-third costa to one-third dorsum, double, slightly waved; orbicular and reniform outlined with dark fuscous, large, closely applied; orbicular semilunar with convexity anterior; reniform about twice as large, transversely oval with median constriction; a line from inner edge of orbicular below middle almost enclosing a large circle, then angled to two-thirds dorsum; a slight whitish suffusion from upper end of reniform to apex; four whitish dots on posterior half of costa; an irregular subterminal line incised in middle; a crenulate terminal line; cilia grey with fuscous bars. Hindwings with termen gently rounded; whitish; a fuscous terminal suffusion; cilia white.

Queensland: Cunnamulla in October; one specimen.

Capelica n. gen.

καπηλικος, misleading.

Tongue developed. Face with strong anterior tuft of scales. Antennae in male minutely ciliated. Palpi obliquely ascending, reaching vertex; second joint moderately thickened with appressed scales; terminal joint short, obtuse. Thorax with erect expansile anterior tuft. Abdomen without crests but with first segment clothed dorsally with long hairs. Posterior tibiae hairy on dorsum. Forewing neuration normal. Hindwings with 5 well developed from near angle; 12 anastomosing with cell near base.

Capelica oxylopha n. sp.

ὀξυλοφος, sharp--crested.

♂, 36 mm. Head, palpi, and thorax pale ochreous-grey. Abdomen fuscous. Legs fuscous with narrow whitish tarsal rings; posterior pair grey. Forewings elongate-triangular, costa nearly straight, apex rounded, termen nearly straight, slightly oblique; glossy ochreous-grey; a blackish dot on lower posterior angle of cell, closely followed by a whitish dot; three blackish dots on fold, and several between veins representing a subterminal line; cilia grey. Hindwings with termen rounded, grey; cilia pale grey. On casual inspection this would be taken for one of the Melanchrinae or Acronyctinae.

Western Australia: Yanchep in September; one specimen.

Oglasa prionosticha n. sp.

πριονοστιχος, with serrate lines.

♀, 38 mm. Head, thorax, and abdomen whitish-ochreous. Palpi ascending, reaching vertex; second joint thickened with smoothly appressed scales; terminal joint short, stout, pointed; whitish-ochreous, lower two-thirds of external surface of second joint blackish. Antennae fuscous, towards base whitish-ochreous. Legs fuscous (posterior pair missing). Forewings elongate-triangular, costa slightly arched, apex round-pointed, termen slightly rounded, slightly oblique; whitish-ochreous slightly brownish-tinged; a blackish triangle on mid-costa, its apex acute and reaching lower edge of cell; a blackish dot midway between this and dorsum; a sub-quadrate blackish blotch on costa before apex; a blackish dot on one-sixth costa giving origin to a slender sharply dentate fuscous line to one-third dorsum; a slender fuscous line from median triangle beneath costa almost to subapical blotch, then curved, strongly sinuate, and minutely dentate to two-thirds dorsum; a fuscous costal dot just before apex; cilia pale brownish. Hindwings with termen rounded; grey; a faint dentate fuscous postmedian line; cilia whitish-ochreous.

North-west Australia: Wyndham; one specimen received from Mr. L. J. Newman.

Artigisa anomozancla n. sp.

ἀνομοζαγκλος, with unusual sickles.

♂, 30 mm. Head and thorax fuscous sprinkled with whitish-ochreous. Palpi in male very long (6); terminal joint as long as second, with a dense mass of long expansile scent-hairs on inner surface; fuscous, scent-hairs and irroration whitish-ochreous. Antennae fuscous; in male bipectinate to near apex, each pectination (one and a half) terminating in a longer bristle. Abdomen fuscous; tuft ochreous-grey. Legs dark fuscous with ochreous-whitish rings; posterior pair paler. Forewings triangular, costa nearly straight, apex pointed, termen bowed on vein 3, slightly oblique; ochreous-whitish suffused with grey, veins mostly whitish; markings dark fuscous, an irregular sub-basal line from costa to fold, edged ,with whitish posteriorly; a small triangular spot on one-fourth costa emitting a fine waved line to one-third dorsum; orbicular a whitish dot beneath one-third costa, margined with fuscous; a broad median costal triangle; reniform immediately following this, a whitish oval ring indented posteriorly, partly edged with whitish; closely beneath and following are several irregular dots; a grey postmedian shade at one-third, angled outwards, its inner margin crenulate; a terminal series of triangular interneural dots; cilia whitish-ochreous, bases sprinkled with fuscous. Hindwings with termen rounded; fuscous, suffused darker antemedian and double dentate postmedian lines; terminal dots and cilia as forewings.

Queensland: Macpherson Range (3,000 ft.) in January; one specimen received from Mr. E. J. Dumigan.

Rhapsa occidentalis n. sp.

occidentalis, western.

♂, ♀, 34-38 mm. Head and thorax grey, sometimes brownish-tinged. Palpi extremely long (8), porrect or ascending; laterally compressed, second joint very long, thickened with loosely appressed scales; posterior two-thirds of dorsal edge rough-scaled; terminal joint moderate, similarly thickened, its apex hidden in a terminal quadrangular tuft; grey sprinkled with fuscous. Antennae grey-whitish; ciliations in male one and a half. Abdomen grey-whitish. Legs ochreous-whitish, more or less sprinkled with fuscous; anterior pair darker. Forewings triangular, costa slightly arched, apex acute, termen sinuate beneath apex, bowed in middle, scarcely oblique; in male with a broad costal fold beneath extending to middle and enclosing a tuft of scent-hairs; grey, sometimes brownish-tinged except in terminal area; markings and some sparsely scattered scales fuscous; a dot in disc at one-fourth, rarely obsolete; two discal dots in middle, placed transversely, rarely white-centred; sometimes an obscure line from four-fifths costa to two-thirds dorsum; a terminal series of dots; cilia ochreous-whitish with a grey basal line, apices sometimes fuscous. Hindwings with termen rounded; grey, towards base whitish-grey; a whitish subterminal line edged on both sides with grey; cilia as forewings but without fuscous apices.

Western Australia: Margaret River in October and November; two male and five female examples.

Zethes hemicyclophora n. sp.

ἡμικυκλοφορος, carrying a half-circle.

♀, 63 mm. Head grey, mixed on crown with fuscous. Palpi long (5), porrect; second joint greatly expanded with rough scales towards apex; terminal joint short, stout, truncate; grey-whitish sprinkled with fuscous. Antennae grey-whitish; in female with minute cilia and long bristles (one and a half). Thorax grey; anteriorly fuscous. Abdomen pale grey sprinkled with fuscous. Forewings triangular, costa slightly arched, apex rounded, termen excavated beneath apex, with rounded median prominence; grey; markings and a few scattered scales fuscous; a basal costal spot; an antemedian band, towards costa grey except in margins, containing a small white semi-circular crescent; anterior edge of band curved, dentate, from one-fourth costa to one-third dorsum, posterior edge from two-fifths costa to mid-dorsum, strongly sinuate; two median blackish discal dots placed transversely; postmedian line slender, sinuate, dentate, from three-fifths costa to four-fifths dorsum; a waved line of submarginal dots, the second from costa larger; cilia grey, apices dark fuscous. Hindwings with termen dentate, rounded; colour as forewings; slender median and postmedian lines not reaching costa; an interrupted dentate subterminal line ochreous with dark fuscous edge thickened near tornus; submarginal dots and cilia as forewings.

Queensland: Macpherson Range (3,000 feet) in January; one specimen received from Mr. E. J. Dumigan.

Subfam. HYPENINAE

Gn. Delt. & Pyr., 41; Hmps. 1895, Fauna Brit. Ind., Moths, 3, 98; Meyr. 1927, Rev. Hbk. Brit. Lep., 164.

Hypenodes

Gn. Delt. & Pyr., 41.

I think *T. demonias* Meyr., Tr. Ent. Soc., 1902, 39, and *T. asthenopa* Meyr., *ibid.*, 40, ascribed to *Tipasa* Wlk. should be referred here, and with them the species ascribed by Hampson, *ibid.*, 95, 97, to *Chusaris* Wlk. 1858, Cat. 16. *Hypenodes* has normally 8, 9, 10 of forewings stalked, but 9 may be absent.

Hypenodes costistrigalis Stph.

Meyr. 1927, *ibid.*, 165.

Western Australia: Yanchep in September. A European species, which occurs also in Australia; no doubt artificially introduced.

Hypenodes porphyritica Meyr. 1902

Meyr. 1902, Trans. Ent. Soc., 40.

South Australia: Wirrabara.

Hypenodes micropa Meyr. 1902

Meyr. 1902, *ibid.*, 41.

Queensland: Brisbane. New South Wales: Sydney.

Hypenodes ptocas n. sp.

πτωκας, shy.

♂, 16 mm. Head and thorax grey. Palpi 3; grey. Antennae grey; in male shortly ciliated (1). Abdomen pale grey. Legs fuscous with whitish tarsal rings. Forewings elongate-triangular, costa nearly straight, apex pointed, termen slightly rounded, oblique; grey; markings fuscous, obscure; a series of minute costal dots, towards apex of wing separated by ochreous-whitish dots; twin discal dots at three-fifths; a terminal series of dots; cilia grey. Hindwings with termen rounded; pale grey; cilia pale grey.

New South Wales: Ebor in December; two specimens.

Camptocrossa n. gen.

καμπτοκροσσος, with bent margin.

Tongue developed. Palpi long, straight, obliquely ascending, second joint very long, thickened with scales, smooth beneath, but forming a rough ridge above, terminal joint short, stout, acute. Legs smooth. Forewings without areole, 2 from two-thirds, 3, 4, 5 separate, 4 from angle, 7, 8, 9, 10 stalked, 11 connate. Hindwings with 2 from middle, 3 and 4 connate, 5 from well above angle (one-third), 6 and 7 stalked. Type, *N. selenotypa*. Near *Philogethes* Turn. 1930, Proc. Roy. Soc. Qld., 149, from which it differs in the absence of the areole; also near *Camptocheilus* Hmps. from India, but lacks the tuft on terminal joint of palpi, and 5 of the hindwings does not arise from angle.

Camptocrossa selenotypa n. sp.

σεληνοτυπος, moonstruck.

♂, 20 mm. Head, thorax, and abdomen fuscous. Palpi 5, second joint strongly expanded towards apex; fuscous. Antennae fuscous; in male with minute ciliations and short bristles (one-half). Legs fuscous with whitish tarsal rings; posterior pair mostly whitish. Forewings triangular, costa straight, apex rounded, termen angled on vein 4, concave above and straight beneath angle; fuscous partly mixed with ochreous-whitish; a semilunar patch on costa from middle to near apex, mostly ochreous-whitish, strongly margined with dark fuscous; a suffused transverse dark fuscous line at one-third; an oblique suffused dark fuscous line from middle of semilunar patch to mid-dorsum; on its outer edge a whitish dot above dorsum, and a whitish line beneath costa; a series of whitish costal dots from middle to apex; a subterminal line of whitish dots edged with dark fuscous posteriorly; cilia fuscous. Hindwings with termen crenulate and with a short tooth on vein 4; colour and markings as forewings but with costal and median areas largely suffused with white, a subterminal dark line edged posteriorly with whitish dots; subterminal dots and cilia as forewings.

North Queensland: Atherton Plateau (Lake Barrine) in June; one specimen.

Camptocrossa acrocausta n. sp.

ἀκροκαυστος, scorched at the apex.

♂, 18 mm. Head and thorax pale grey. Palpi 4; pale grey with some fuscous sprinkling, and a penultimate ring on terminal joint; fuscous. (Antennae missing.) Abdomen fuscous-brown; apices of segments and tuft pale grey. Legs whitish-ochreous. Forewings triangular, costa straight, apex rectangular, termen angled on vein 4, concave above, straight beneath; ochreous-whitish sprinkled with grey; an oblong apical blotch from apex to mid-termen, fuscous-brown edged with whitish; three or four fuscous dots on costa; some brown irroration above tornus; a crenulate dark fuscous terminal line; cilia ochreous-whitish, on blotch mostly fuscous. Hindwings with termen rounded; ochreous-whitish, suffused with purple-brown towards costa and termen; a faint postmedian line; a crenulate fuscous terminal line; cilia ochreous-whitish.

North Queensland: Tully, near Innisfail, in June; one specimen.

Esthlodora acosmopa n. sp.

ἀκοσμωπος, unadorned.

♀, 18 mm. Head, antennae, thorax, and abdomen grey. (Palpi missing.) Legs fuscous with whitish tarsal rings. Forewings elongate-triangular, costa straight to near apex, apex pointed, termen strongly bowed in middle, above concave, beneath straight; grey with fuscous markings; a slender, outwardly curved line at one-fourth, slightly dentate; an outwardly oblique blackish mark on mid-costa, joined at an angle by a slender line to mid-dorsum; before this angle a small circle representing orbicular, and beyond it another representing reniform; a triangular mark on costa before apex, its lower part blackish, edged by a whitish line; from this mark proceeds a slender sinuate slightly dentate line to three-fourths dorsum, and another to tornus; a terminal line; cilia fuscous, bases whitish-ochreous. Hindwings with termen rounded, broadly excavated at tornus; grey; a blackish discal dot; three obscure wavy transverse lines; cilia grey.

Queensland: Brisbane; one specimen.

Fam. LASIOCAMPIDAE

Aproscepta n. gen.

ἀπροσκεπτος, unforseen.

Eyes smooth. Palpi short, not exceeding frontal tuft, densely hairy. Forewings with 2 from near middle, 3 from three-fourths, 4 and 5 approximated from angle, 6 from upper angle connate with 7, 8, which are long-stalked, 9 and 10 long-stalked, 11 from two-thirds. Hindwings with 4 and 5 approximated from angle, 6 and 7 connate from upper angle, 11 well developed, running not far from base into 12, which is widely separated from cell; no pseudoneuria. The neuration differs from that of any genus known to me, but comes nearest to that of *Perna* Wlk., **5**, *1,127*, which has a much larger accessory cell in the hindwing, while that of *Endromis*, which I refer to the Lasiocampidae, is still smaller.

Aproscepta amblopis n. sp.

ἀμβλωπις, dull.

♀, 40 mm. Head ochreous. Palpi pale fuscous. Antennae fuscous; pectinations in female one and a half. Thorax pale fuscous. Abdomen dark fuscous; bases of segments whitish. Legs pale fuscous. Forewings elongate-triangular, costa nearly straight, apex rounded, termen long, rounded, oblique; pale fuscous; markings slightly darker, obscure; a subcostal spot at one-third and another before two-thirds; a sinuate suffused line from three-fourths costa to three-fourths dorsum; a roughly parallel similar subterminal line; cilia pale fuscous. Hindwings short, termen rounded; colour as forewings, but without markings.

Queensland: Milmerran in January; one specimen received from Mr. J. Macqueen.

THE SIMPSON DESERT EXPEDITION, 1939 - SCIENTIFIC REPORTS NO. 1, BIOLOGY - SCORPIONS AND SPIDERS

By V. V. HICKMAN, Ralston Professor of Biology, University of Tasmania

Summary

Dr. C. T. Madigan has kindly sent me for examination the scorpion and spiders collected during his recent expedition across the Simpson Desert. I am indebted to him for the opportunity of studying the collection. My thanks are also due to the Trustees of the John Ralston Bequest under whose auspices the work was carried out, and to Mr. A. Musgrave of the Australian Museum for literature not available in Tasmania.

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[Read 13 April 1944]

Plates I to III

Dr. C. T. Madigan has kindly sent me for examination the scorpion and spiders collected during his recent expedition across the Simpson Desert. I am indebted to him for the opportunity of studying the collection. My thanks are also due to the Trustees of the John Ralston Bequest under whose auspices the work was carried out, and to Mr. A. Musgrave of the Australian Museum for literature not available in Tasmania.

Our knowledge of the spiders of Central Australia is based mainly on four collections. The first of these was made by the Horn Expedition in 1894 and was described by H. R. Hogg (1896, 309). The specimens forming the second collection were found by Herr von Leonhardi in 1910 and forwarded to the Senckenberg Museum. They were described by E. Strand (1913, 599). The third collection was made by Capt. S. A. White during an "expedition into the Interior of Australia" in 1913, and a list of the species found has been published by R. H. Pulleine (1914, 447). The fourth collection was made in 1914, also by Capt. S. A. White, from the north-western regions of South Australia. This collection was described by W. J. Rainbow (1915, 772).

In the list of 18 spiders published by R. H. Pulleine (1914, 447) the name *Hemicloea longipes* Koch is attributed to the wrong author and should be *Hemicloea longipes* R. H. Hogg. *Storena graeffei* Keys. should be *Storena graeffei* L. Koch. *Carepalxis monticulo* is probably meant for *Carepalxis montifera* L. Koch. *Miturga lineata* Koch should be *Miturga lineata* Thorell and *Lycosa arenosa* Koch may be intended for *Lycosa arenaris* Hogg.

The present collection contains 1 scorpion and 105 spiders. The spiders are distributed over 14 families and comprise 28 species, 14 of which are new. All the specimens were collected by Mr. H. O. Fletcher and members of the Simpson Desert Expedition.

The following are the species recorded in the present publication. The number of specimens of each species is shown in brackets.

Scorpiones

Urodacus yaschenkoi (A. Birula) (1)

Araneae

Aganippe simpsoni n. sp.	(1)
Aname sp. (immature)	(1)
Dinopis unicolor L. Koch	(1)
Ixeuticus senilis (L. Koch)	(31)
Pardosa eyrei n. sp.	(2)
Pardosa pexa n. sp	(1)
Lycosa abmingani n. sp.	(3)
Lycosa burti n. sp.	(1)
Lycosa finkei n. sp.	(1)
Lycosa fletcheri n. sp.	(1)
Lycosa goyderi n. sp.	(1)
Lycosa halei n. sp.	(1)
Lycosa madigani n. sp.	(5)
Lycosa halei n. sp.	(1)
Lycosa sp. (immature)	(5)
Oxyopes elegans L. Koch	(1)
Storena toddi n. sp.	(1)
Latrodectus hasseltii Thorell	(1)
Argiope protensa L. Koch	(8)
Araneus transmarinus (Keyserling)	(6)
Nephila imperatrix L. Koch	(11)
Odo australiensis n. sp.	(2)
Isopeda pessleri (Thorell)	(8)
Pediana horni (Hogg)	(1)
Pediana regina (L. Koch)	(1)
Olios inframaculatus (Hogg)	(1)
Tharpyna simpsoni n. sp.	(1)
Miturga lineata Thorell	(6)
Saitis lacustris n. sp.	(1)
Ocrisiona sp. (immature)	(1)

The collection is too small for one to draw any definite conclusions in regard to the relative abundance of the different species. *Nephila imperatrix* L. Koch, *Argiope protensa* L. Koch, *Araneus transmarinus* (Keys.), *Isopeda pessleri* (Thorell) and *Miturga lineata* Thorell were collected at many different localities and appear to be well distributed throughout Central Australia. Two species, **Odo australiensis** n. sp. and **Lycosa madigani** n. sp. were found at the centre of the Simpson Desert, while **Pardosa eyrei** n. sp. and **Saitis lacustris** n. sp. were taken on the salt-crust surface of Lake Eyre two and a half miles from shore.

The widely distributed poisonous spider, *Latrodectus hasseltii* Thorell, has been recorded from Central Australia on three previous occasions.

Order **SCORPIONES**

Family SCORPIONIDAE

Sub-Family URODACINAE

Genus Urodacus Peters, 1861

Urodacus yaschenkoi (A. Birula)

(Pl. I, fig. 1-6)

Hemihoplopus yaschenkoi A. Birula 1903, Ann. Mus. Zool. Acad. Sci., St. Petersbourg, **8**, xxxiii-xxxiv.

Urodacus yaschenkoi K. Kraepelin 1908, Fauna Südwest-Australiens, Jena, **2**, 89-95.

Urodacus yaschenkoi K. Kraepelin 1916, Arkiv för Zoologi, Stockholm, **10**, 1-43.

Urodacus yaschenkoi L. Glauert 1925, Trans. Roy. Soc. S. Aust., Adelaide, **49**, 85-87

Birula's type specimen of this scorpion is from Killalpaninna on Cooper Creek, which flows into Lake Eyre. Two other specimens from Cooper Creek and Miller's Creek are recorded and briefly described by Glauert (1925, 87). Birula does not mention the sex of the type specimen but Kraepelin considers that it is probably a female. The two specimens recorded by Glauert are stated to be females.

The single specimen in the present collection comes from 17 miles north of Andado Station in the Northern Territory. From its smaller size, longer tail and bisected genital operculum it appears to be a male. Its description is as follows:

Total length, 63·0 mm.; length of carapace, 8·9 mm.; length of tail, 35·0 mm.

Colour is a fairly uniform clay-yellow. The fingers, however, together with the fifth caudal segment and vesicle are dark brown. A longitudinal stripe on each side of the vesicle and a pair of similar stripes on its ventral surface are yellowish.

Anterior margin of carapace with a median notch furnished with a pair of setae. Distance from the notch to the median eyes is 3·60 mm. Diameter of a median eye, 0·58 mm. The interocular groove is continued behind to the posterior triangular depression, and in front to the marginal notch. Anteocular area furnished with a few coarse granulations, the rest of the carapace being smooth except for a few minute scattered granules. The two lateral eyes of each side are mounted on a common tubercle. The diameter of the anterior eye is 0·46 mm., that of the posterior eye 0·29 mm. The two eyes are separated by a space equal to the diameter of the posterior eye. There is a conspicuous seta below and slightly behind the lateral eyes and another seta in front of them and somewhat towards the middle.

The first six tergites of the preabdomen are smooth except for minute granulation on their posterior half. The seventh tergite has, on each side, a pair of short longitudinal granular keels.

The sternum has the form shown in pl. I, fig. 1, and possesses a median longitudinal depression. On each side of the depression are six small hairs, and in front of it about eight. The genital operculum is oval and bisected longitudinally but, owing to the hardness of the specimen, I am not certain whether the two halves are entirely free from each other. Behind the operculum is a pair of small median apophyses (pl. I, fig. 1).

The marginal area of the pectines is composed of three sclerites. The middle area is indistinctly divided into three or four sclerites, the left side differing from the right (pl. I, fig. 1). The number of teeth is 15 on both sides. The sternites are smooth and shining.

The segments of the postabdomen or tail have the following measurements in millimetres:

Segment:	I	II	III	IV	V
Length	3·77	4·06	4·52	4·99	7·25
Width	3·77	3·65	3·48	3·19	3·25

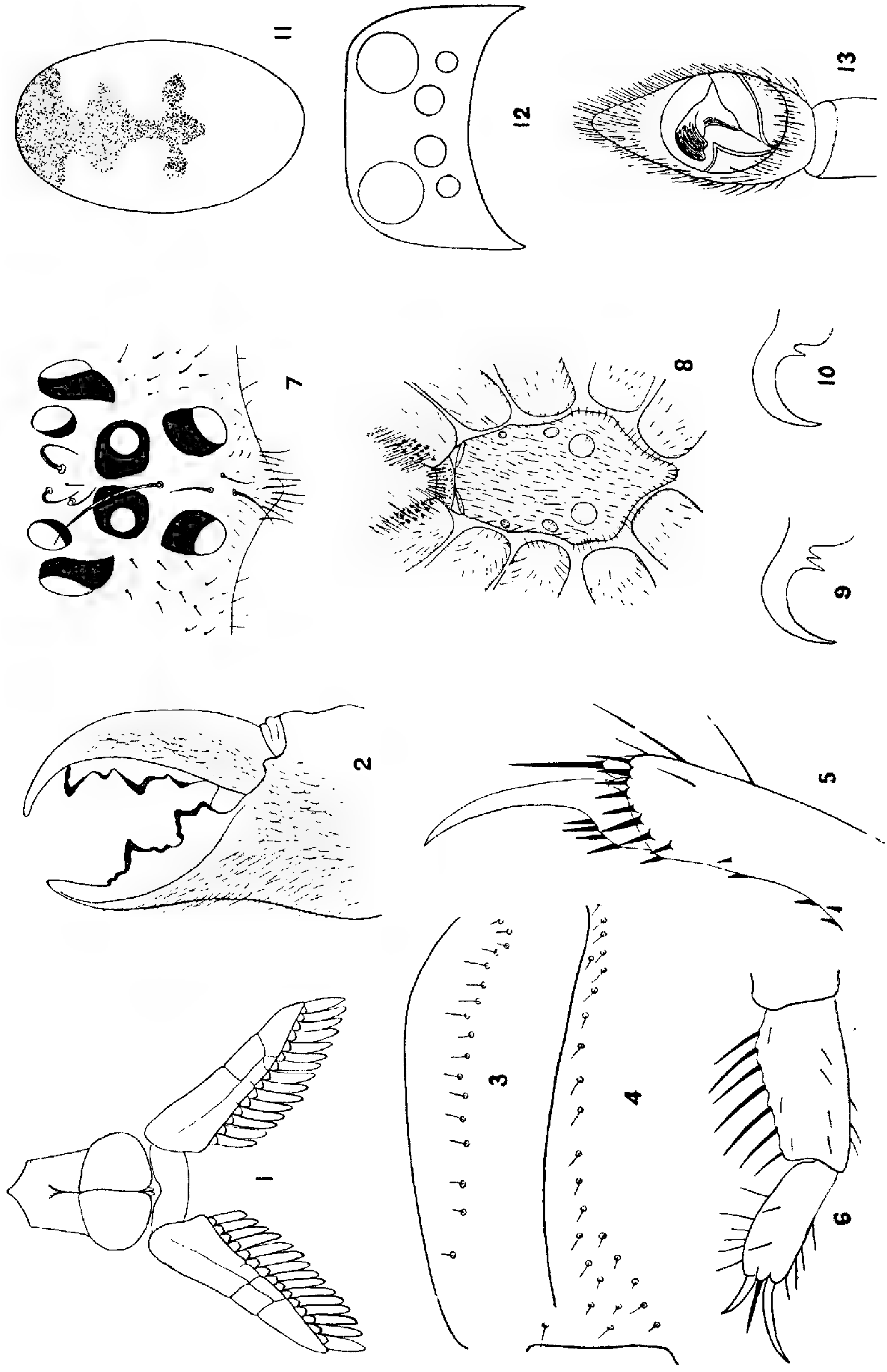
The superior keels of the first four caudal segments are subdenticulate and end behind in a moderately large tooth. The supero-lateral keels are granular and the three ventral keels smooth. The fifth caudal segment is without a dorsal sulcus, except towards the base. Its keels are denticulate and the supero-lateral keels about two-thirds the length of the segment. The ventral surface of the segment is coarsely granular between the keels, the sides and dorsal surface smooth. Apical margin is toothed laterally and ventrally. The vesicle is large and oval, 3·25 mm. wide. The aculeus sharp and well curved. Ventral surface and sides of vesicle granulate. Dorsal surface smooth.

Chelicerae about 5·6 mm. long. Fingers with teeth on upper margin only, the lower margin being smooth. The fixed finger has a large conical tooth near the middle and a large bicuspid tooth nearer the base. The movable finger has two large teeth separated by a small tooth, and there is another small tooth near the base (pl. I, fig. 2). The dorsal surface of the movable finger is furnished with about six setae and there is a transverse row of about four setae near the base of the fixed finger. The ventral surface of the chelicerae densely clothed with fine hairs.

Pedipalpi moderately strong. Humerus measures 6·5 mm. long. Its keels are coarsely granular and there are a few smaller granules on upper and lower surfaces. The brachium is 8·0 mm. long and is smooth except for the upper and lower keels bordering its anterior surface. The ventral surface lacks a keel but is furnished with a longitudinal row of 17 trichobothria (pl I, fig. 3). The hand is 16·1 mm. long and 5·9 mm. wide. The movable finger is 9·2 mm. long. The dorsal surface of the hand is very slightly granular and furnished with two very weak and smooth finger keels. The keel of the under-hand is also smooth and on its inner side, in the case of the left padipalp, there are 25 trichobothria arranged as shown in pl. I, fig. 4. In a similar position on the right pedipalp there are about 29 trichobothria.

The legs are smooth. Tarsal claws very unequal. In the first and second tarsi the outer claw is about twice the length of the inner claw. In the third and fourth tarsi the inner claw is minute and appears like a small papilla in the fourth tarsi (pl. I, fig. 5). First and second metatarsi with a dorsal row of seven strong spines (pl. I, fig. 6). On the outer side of the tarsal claws there are three or four black spines, and on the inner side about seven.

Locality—Seventeen miles north of Andado Station, Northern Territory. Coll. 519 (1 ♂ ? with second and fourth legs of right side slightly damaged).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Order **ARANEAE**

Sub-Order **MYGALOMORPHAE**

Family CTENIZIDAE

Sub-Family CTENIZINAE

Genus AGANIPPE Cambridge 1877

Aganippe simpsoni n. sp.

(Pl. I, fig. 7-10)

♀—Total length, 23·0 mm. Length of carapace, 9·0 mm. Width of carapace, 7·0 mm. Length of abdomen, 11·0 mm. Width of abdomen, 7·0 mm.

The colour of specimen (in alcohol) is light brown, and there is no distinct pattern on the abdomen.

Carapace convex. Thoracic region lightly clothed with dark brown woolly hair and the head region with fine setae. Thoracic groove distinctly procurved. A median row of coarse black bristles extends from the eyes half-way to the thoracic groove. There is a group of five black bristles, which curve towards the front, immediately behind the AME. In a median position in front of the AME is a single large bristle. Between the ALE there is a group of four setae which curve backwards.

The eight eyes are arranged in three rows, as shown in pl. I, fig. 7. Ratio of eyes, AME : ALE : PME : PLE = 8 : 10 : 9 : 12. The quadrangle formed by the four anterior eyes is wider in front than behind in ratio 31 : 24, and wider in front than long in ratio 31 : 26. The posterior row of eyes is wider than the front row in ratio 51 : 31. The ALE are separated from each other by 15/10 of their diameter, and from AME by 12/10 of their diameter. The AME are separated from each other by 11/8 of their diameter and from PLE by 13/8 of their diameter. The hind margins of the eyes of the posterior row are in an almost straight line. The PME are separated from each other by 19/9 of their diameter and from PLE by 6/9 of their diameter. The ALE are separated from the margin of the clypeus by about 6/10 of their diameter.

Chelicerae clothed in front with coarse black bristles and provided with a rastellum. Promargin of furrow with six teeth and retromargin also with six teeth. A median row of five very small teeth in the furrow. Fang strong and provided with coarse serrations. Labium wider than long in ratio 22 : 9, devoid of spinules, submerged and almost hidden by the maxillae. The maxillae with a reddish scopula and numerous spinules in a group at the base near the inner angle. The sternum is convex, longer than wide in ratio 8 : 5. Three pairs of sigilla are arranged as shown in pl. I, fig. 8. In front of the sternum and behind the labium is a pair of sclerites resembling sigilla.

Legs: 4.1.2.3. Clothed with black bristles. The first and second tarsi scopulate. Third and fourth tarsi without scopula. Trichobothria in two rows on each tibia, in an irregular group near the distal end of each metatarsus and on the distal half of each tarsus. On the dorsal side of the first and second tarsi and metatarsi, but not on the third and fourth, are brushes of stiff, erect, black setae. These setae have small barbs near the tip. Three tarsal claws are present. The upper claws of the first and second tarsi with two teeth near base (pl. I, fig. 9), those of third and fourth tarsi with one tooth near base (pl. I, fig. 10). The third claw small and without teeth. The palpus is scopulate on the end segment and its claw has two teeth near the base. The segments of the legs and palpi have the following measurements in millimetres:

Leg		Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	....	5·91	3·42	2·90	2·90	1·80	16·93
II	....	5·16	3·20	2·61	2·72	1·86	15·55
III	....	4·35	3·19	2·61	2·96	2·15	15·26
IV	....	5·91	4·35	4·41	4·60	2·61	21·88
Palpi	....	4·70	2·67	2·90	—	3·48	13·75

The spines on the legs and palpi are arranged as follows: *First leg*—Femur 0. Patella 0. Tibia with numerous coarse black bristles on prolateral and retrolateral sides. Metatarsus: ventral 1 – 2 – 1 – 4, elsewhere 0. Tarsus with an irregular group of about 14 small spines on ventral side near claws. *Second leg*—Femur 0. Patella 0. Tibia with prolateral and retrolateral bristles. Metatarsus: ventral 2 – 2 – 1 – 4, elsewhere 0. Tarsus with a ventral group of about 23 small spines near claws. *Third leg*—Femur 0. Patella with eleven spines in an irregular group on prolateral side, elsewhere 0. Tibia: dorsal 0, prolateral 1 – 1, retrolateral 1 – 1, ventral 3 at apex. Metatarsus: dorsal 0, prolateral 1 – 1 – 1 – 1 – 1, retrolateral 1 – 1 – 1 – 1 – 1, ventral 2 with 4 at apex. Tarsus with a ventral group of about 16 small spines near claws, elsewhere 0. *Fourth leg*—Femur 0. Patella 0. Tibia with 1 spine on ventral side at apex, elsewhere 0. Metatarsus: ventral 1 – 2 – 2 – 1 – 4, elsewhere 0. Tarsus with a ventral group of about 17 small spines on distal half of segment. *Palpus*—Femur 0. Patella 0. Tibia: dorsal 0, prolateral 3 near apex, retrolateral numerous black bristles, elsewhere 0. Tarsus: dorsal 0, prolateral 1 – 1 on basal half, retrolateral 1 – 1 – 1 on basal half, ventral a group of 2 – 2 – 2 close to claw.

Abdomen oval, clothed with fine hairs and long slender bristles. Spinnerets four. Inner pair small, being only 0·81 mm. long. Outer pair 2·61 mm. long, stout and three-segmented. The basal segment is nearly four times the length of the second segment. The third segment is dome-shaped and sunken in the end of the second segment.

Locality—Eleven miles east of Hale River, Simpson Desert. Coll. 549 (1 ♀).

In some respects this species resembles *Aganippe pelochroa* Rainbow and Pulleine (100, 1918). The latter, however, is said to have the front eyes "just touching edge of clypeus." There is also a difference in the dentition of the chelicerae.

Family DIPLURIDAE

Sub-Family DIPLURINAE

Genus ANAME L. Koch 1873

ANAME sp.

The specimen is too immature for the species to be determined.

Locality—Camp, 23. Thirty miles north-west of Birdsville, Queensland. (1 pullus.)

Sub-Order **DIPNEUMONOMORPHAE**

Family DINOPIDAE

Genus DINOPIS MacLeay 1839

DINOPIS UNICOLOR L. Koch 1879

Locality—Hale River, 20 miles up stream from junction with Todd River, Coll. 548 (1 adult ♀).

This species has also been recorded from Western Australia.

Family AMAUROBIIDAE

Sub-Family IXEUTICINAE

Genus IXEUTICUS Dalmas 1917

IXEUTICUS SENILIS (L. Koch)

Locality—Indinda Well, near Andado Station, Northern Territory (2 adult ♂♂, 8 adult ♀♀, and 21 pullus).

This spider was originally described by L. Koch under the name *Amaurobius senilis.* Comte de Dalmas (p. 329, 1917) has shown, however, that most of the Australian species placed in the genus *Amaurobius* possess a calamistrum composed of a single line of curved hairs, whereas the European species have a calamistrum composed of two parallel lines of curved hairs. He has therefore established the genus *Ixeuticus* for the Australian forms. *Ixeuticus senilis* has been recorded from Queensland, Victoria and Tasmania.

Family LYCOSIDAE

Sub-Family PARDOSINAE

Genus PARDOSA C. Koch 1848

Pardosa eyrei n. sp.

(Pl. I, fig. 11-13)

♂—Total length, 17·0 mm. Length of carapace, 8·0 mm. Width of carapace, 6·0 mm. Length of abdomen, 9·0 mm. Width of abdomen, 6·0 mm.

Caput of specimen in alcohol black with white hairs and brown setae. Thoracic region dark brown, densely clothed with recumbent brown hairs in the middle region and white hairs round the margin. Chelicerae, maxillae, labium, sternum and coxae dark brown. Basal two-thirds of ventral surface of femora dark brown. First and second metatarsi and distal half of first and second tibiae also dark brown. Other parts of legs yellowish-brown. Palpi yellowish-brown except tarsal segment, which is dark brown. Dorsal surface of abdomen yellow with a median dark brown patch, having the form shown in pl. I, fig. 11. Ventral surface of abdomen very dark brown, almost black, nearly to spinnerets. Spinnerets yellow.

Head with straight sides. Thoracic groove longitudinal. Front row of eyes shorter than second row (pl. I, fig. 12). Ratio of eyes AME : ALE : PME : PLE = 8 : 6 : 17 : 15. AME separated from each other by 5/8 of their diameter, from ALE by 4/8 of their diameter, and from PME by 3/8 of their diameter. PME separated from each other by 16/17 of their diameter, and from PLE by 18/17 of their diameter. PLE separated from each other by 52/15 of their diameter. The quadrangle of the posterior eyes wider than long in ratio 70 : 46. Face densely clothed with white hairs. Six long slender bristles on clypeus below AME. Clypeus in front of AME equal to 6/8 of their diameter. Near the dorsal margin of each PLE there is a group of long slender bristles projecting outwards over the eye. The space between the PME is furnished with a number of bristles which project forward. There are no bristles near the thoracic groove.

Chelicerae clothed in front with white hairs and black bristles. Condyles well developed. Promargin of furrow with three teeth, of which the median is the largest and the distal the smallest. Retromargin with three equal teeth. A brown scopula on promargin. Labium wider than long in ratio 22 : 19. Maxillae wider in front than at the base. Front margin rounded. Scopula brown. Serrula well developed. Ventral surface of maxillae clothed with long slender erect black setae. Sternum oval, pointed behind, longer than wide in ratio 60 : 50, clothed with fine erect black setae.

Legs: 4.2.1.3. Clothed with white hairs and long erect brown bristles. First and second tarsi and metatarsi scopulate to base. Third and fourth tarsi also scopulate to base but their scopulae divided by a longitudinal band of setae. All scopulae very light. Trichobothria in two rows on tibiae and tarsi, in one row on metatarsi. Three tarsal claws. Upper claws with ten teeth, lower claw without teeth. The form of the palpus is shown in pl. I, fig. 13. The segments of the legs and palpi have the following measurements in millimetres:

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	8·2	2·9	6·0	7·0	2·9	27·0
II	8·0	3·0	6·0	8·0	3·0	28·0
III ...	7·3	2·9	5·1	8·1	2·9	26·3
IV	9·0	3·0	6·0	10·0	3·8	31·8
Palpi	3·8	1·7	2·3	—	2·6	10·4

The spines on the legs and palpi are arranged as follows: *First leg*—Femur: dorsal 1 – 1 – 1, prolateral 2 near end, retrolateral 1 – 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia: dorsal 1 – 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2 – 2. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 3. *Second leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1 – 1, ventral 0. Patella, tibia, and metatarsus armed as in first leg. *Third leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1 – 1, ventral 0. Patella, tibia and metatarsus armed as in first leg. *Fourth leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1 – 1 – 1, retrolateral 1 – 1 – 1 – 1, ventral 0. Patella and tibia armed as in first leg. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 1 – 2 – 2 – 3. *Palpus*—Femur: dorsal 1 – 1 – 1 – 1, prolateral 1 near end, retrolateral 1 near end, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1 bristle, elsewhere 0.

Abdomen clothed on dorsal surface and sides with short white hairs. A few setae at front of brown patch on dorsal surface but elsewhere none. The dark brown colouration of the ventral surface includes the lung-covers and extends from the petiolus almost to the spinnerets, there being a thin yellowish line immediately in front of the spinnerets. Hairs on ventral surface short and black. Spinnerets yellow, the anterior pair with black hairs towards the apex.

Locality—Surface of North Lake Eyre two and a half miles from the shore. Coll. 669 (1 adult ♂ and 1 pullus).

Pardosa pexa n. sp.

(Pl. II, fig. 14)

♂—Total length, 10·7 mm. Length of carapace, 5·39 mm. Width of carapace, 4·23 mm. Length of abdomen, 5·51 mm. Width of abdomen, 3·82 mm.

Carapace very dark brown (in alcohol) and densely clothed with grey hairs. Chelicerae also very dark brown and clothed in front with white hairs. Labium brown with white hairs on its basal half. Sternum brown, densely clothed with grey hairs. Maxillae, legs and palpi yellowish, the legs being marked with indistinct transverse bands of brown on dorsal side. Abdomen yellow above with a median longitudinal patch of brown on front half and several transverse brown markings on posterior half. Sides of abdomen pale yellow with brown spots. Ventral surface pale yellow and without pattern. Lung-covers brown. Spinnerets yellow.

Carapace is pyriform in outline. Sides of head slightly inclined, the dorsal surface being rather flat. Thoracic groove longitudinal. Front row of eyes procurved and shorter than the second row in ratio 31 : 44. Ratio of eyes AME : ALE : PME : PLE = 8 : 6 : 19 : 14. AME separated from each other by about 2/8 of their diameter, from ALE by 1/8 of their diameter and from PME by 2/8 of their diameter. PME poised obliquely and separated from each other by 11/19 of their diameter and from PLE by 17/19 of their diameter. PLE separated from each other by 36/14 of their diameter. The quadrangle of the posterior eyes is wider behind than in front in ratio 52 : 44 and its length is shorter than its width in front in ratio 39 : 44. The clypeus in front of AME is equal to 5/8 of their diameter. Front and sides of head clothed with grey silky hairs. Dorsal surface of head clothed with grey hairs and brown setae which point forward.

Condyles of chelicerae brown and well developed. The promargin of furrow armed with three teeth, of which the median is the largest. Retromargin with three subequal teeth. Fang dark brown and moderately long. Scopula brown and on promargin only. Labium truncate in front, excavated on each side near the base and slightly longer than wide in ratio 13 : 12. Front edge fringed with a row of black setae. Maxillae parallel and clothed with grey hairs on outer side. Scopula brown. Sternum oval, longer than wide in ratio 42 : 32.

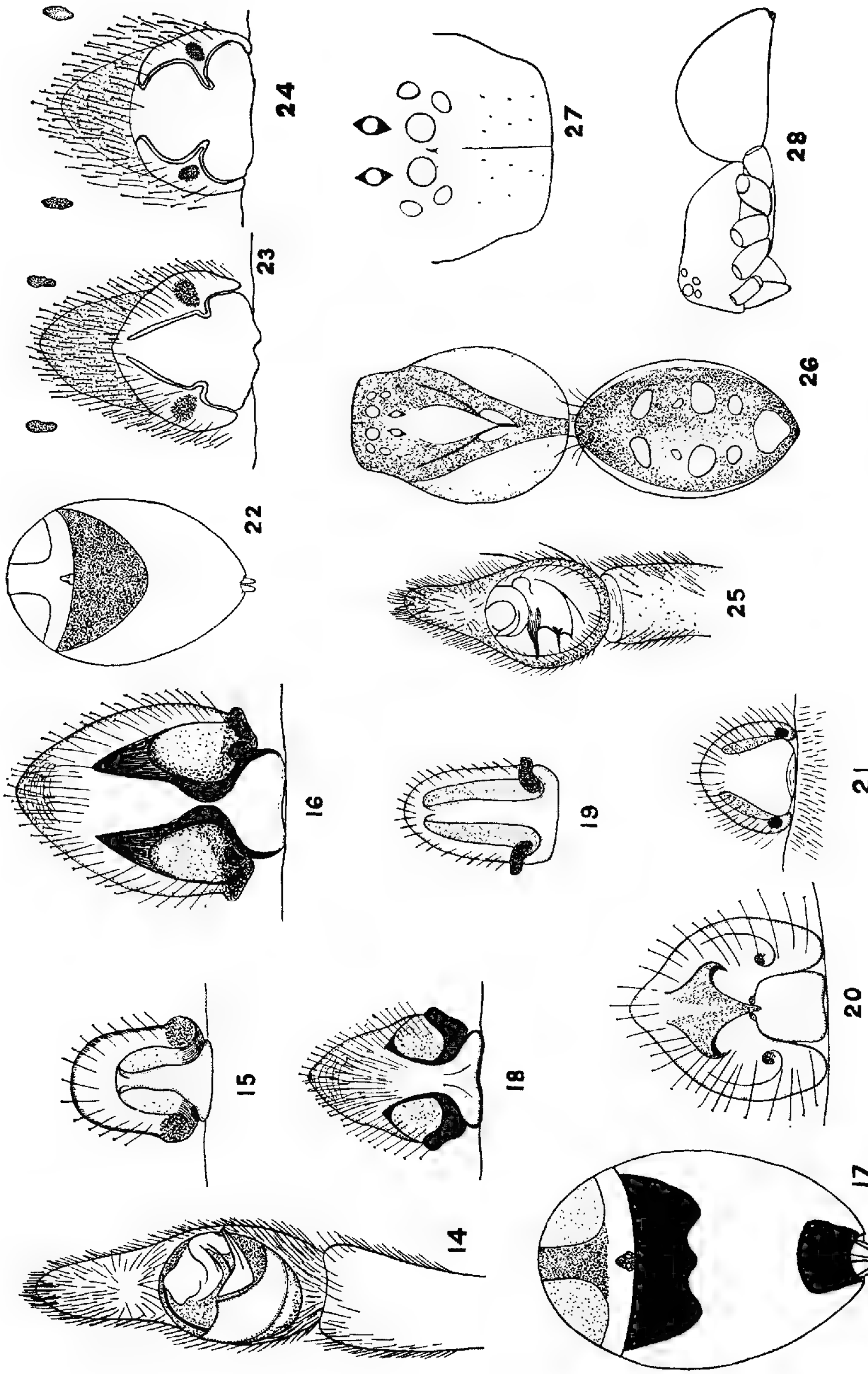
Legs: 4.1.2.3. Clothed with grey hairs and setae. First and second tarsi and metatarsi scopulate to base, the scopula being composed of rather long hairs. Third and fourth metatarsi without scopula. Third tarsus missing on both sides. Fourth tarsi with a light scopula bisected by a longitudinal band of setae. Trichobothria in two rows on tibiae and tarsi, in one row on metatarsi. Upper claws of first leg with about four teeth, those of fourth leg with seven teeth. Third claw small and bare. The dorsal surface of the tarsal segment of the palpi is densely clothed with white hairs. The form of the palpus is shown in pl. II, fig. 14. The segments of the legs and palpi have the following measurements in millimetres:

Leg		Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	....	4·64	2·32	4·46	5·04	2·61	19·07
II	....	4·52	2·20	3·94	4·46	2·49	17·61
III	....	4·06	2·03	3·13	4·46	lost	?
IV	....	5·16	2·15	4·58	7·02	3·07	21·98
Palpi	....	2·03	0·98	1·16	—	1·91	6·08

The spines on the legs and palpi are arranged as follows: *First leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 2, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia: dorsal 1 – 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2 – 2. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 3. *Second leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella, tibia and metatarsus are armed as in the first leg. *Third leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella, tibia and metatarsus are armed as in first leg. *Fourth leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella and tibia armed as in first leg. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 1 – 2 – 2 – 3. *Palpus*—Femur: dorsal 1 – 1 – 2, prolateral 1 near end, retrolateral 1 near end, ventral 0. Patella: dorsal 1 – 1 bristles, prolateral 1 bristle, retrolateral 0, ventral 0. Tibia: dorsal 1 bristle, prolateral 1 – 1 bristles, elsewhere 0. Tarsus: 4 spines on ventral side near apex.

Abdomen densely clothed with grey hairs. Anterior spinnerets cylindrical, the second segment being sunk in the apex of the first. The posterior spinnerets distinctly two-segmented and projecting beyond the anterior pair.

Locality—Burt's Waterhole, South Australia, 55 miles south of Birdsville. Coll. 645 (1 adult ♂ lacking portions of the third pair of legs).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Sub-Family LYCOSINAE

Genus Lycosa Latreille 1804

The collection contains eighteen specimens belonging to the genus *Lycosa*. Five of these are too young to be identified with certainty. The others represent seven new species. It is unfortunate that in most cases only one sex is available for description. The seven new species may be distinguished by the following key:

1	Retromargin of chelicerae with two teeth.		2
	Retromargin of chelicerae with three teeth.		3
2	First femur with three retrolateral spines.	*L. madigani* n. sp	
	First femur with no retrolateral spines.	*L. goyderi* n. sp.	
3	First and second patellae with no lateral spines.		4
	First and second patellae with a prolateral spine.		6
4	Third tibiae with two dorsal spines.		5
	Third tibiae with no dorsal spines.	*L. abmingani* n. sp.	
5	Ventral surface of abdomen with a transverse black band.	*L. finkei* n. sp.	
	Ventral surface of abdomen yellow-brown, without markings.	*L. burti* n. sp.	
6	Second and third metatarsi equally long.	*L. fletcheri* n. sp.	
	Second metatarsus shorter than third.	*L. halei* n. sp.	

Lycosa abmingani n. sp.

(Pl. II, fig. 15)

♀—Total length, 13·0 mm. Length of carapace, 6·5 mm. Width of carapace, 4·6 mm. Length of abdomen, 7·2 mm. Width of abdomen, 4·1 mm.

Carapace yellow (in alcohol) with a longitudinal brown band extending from the sides of the head to posterior margin. Radial grooves dark brown. Legs and sternum brownish-yellow. Tarsal scopulae dark brown. Labium and maxillae brown. Chelicerae and fang dark reddish-brown. Dorsal surface of abdomen yellowish-brown clothed with dark brown hairs and black bristles. A median longitudinal dark brown patch on anterior half, followed by two pairs of black spots. Ventral surface yellowish, clothed with white hairs and fine black setae.

Head with slanting sides. Thoracic groove longitudinal. On the lower edge of the brown band at each side of the head is a row of about six black bristles. There is also a row of five bristles extending from the lower edge of PLE to lower edge of PME. Numerous erect bristles occupy the interocular space and also the area extending from the eyes to the thoracic groove. There are a few bristles at the sides of the groove. On each side near the posterior end of the groove is a radial row of four bristles, extending about half-way to the margin of the carapace.

First row of eyes shorter than the second in ratio 21 : 25, slightly curved downwards. The ratio of eyes AME : ALE : PME : PLE = 5 : 4 : 10 : 8. AME separated from each other by 2/5 of their diameter, from PME by the same distance, and from ALE by half that distance. PME separated from each other by 7/10 of their diameter. PLE separated from each other by 20/8 of their diameter and from PME by 10/8 of their diameter. The quadrangle of the posterior eyes wider behind than long in ratio 31 : 25. Clypeus 6/5 of diameter of AME. A single long bristle between AME and a transverse row of four black bristles on the clypeus below AME. On each side there is also a small group of bristles on the margin near the condyles of the chelicerae.

Chelicerae reddish-brown clothed in front with long black bristles and white hair. Lateral condyles yellow. Promargin of furrow with three teeth, of which the median is the largest and close to the distal one which is the smallest. Retromargin with three equal teeth. Scopula on promargin only. Lip as wide as long. Maxillae with brown scopula and clothed with black bristles. Sternum oval, truncate in front and longer than wide in ratio 50 : 34. It is lightly clothed with erect black bristles.

Legs: 4.1.2.3. Clothed with black bristles. Scopula dense and entire on first and second tarsi and metatarsi, bisected by a longitudinal band of setae on third and fourth tarsi. The scopula on the third and fourth metatarsi is very light. Trichobothria in two rows on tibiae and tarsi, in one row on metatarsi. There are also a few lateral trichobothria on the tibiae. Tarsal claws three. Upper claws on first tarsi with four teeth, on fourth tarsi with eight teeth. Third claw bare. Palpi yellow, clothed with black bristles. Palpal claw with four teeth. The segments of the legs and palpi have the following measurements in millimetres:

Leg		Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	....	4·2	2·5	3·1	3·0	2·2	15·0
II	....	3·8	2·3	2·8	2·9	2·1	13·9
III	....	3·5	1·8	2·9	3·5	2·1	13·8
IV	....	4·9	2·4	3·9	5·6	2·7	19·5
Palpi	....	2·0	1·0	1·3	—	1·7	6·0

The spines on the first two pairs of legs are small, those on the ventral surface of the first and second metatarsi being almost hidden by the scopula. On the ventral surface of the first and second tibiae the basal and middle spines are represented by small bristles. The arrangement of the spines on the legs and palpi is as follows: *First leg*—Femur: dorsal 1 – 1 – 1, prolateral 2 near end, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, elsewhere 0. Tibia: dorsal 0, prolateral 1 small spine near middle, retrolateral 0, ventral 2 – 2 – 2, the basal and middle pairs being bristles. Metatarsus: ventral 2 – 2 – 3 small spines, elsewhere 0. *Second leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 0. Patella, tibia and metatarsus armed as in first leg. *Third leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia: dorsal 0, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2 – 2. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 3. *Fourth leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 0. Patella and tibia armed as in third leg. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 1 – 2 – 2 – 3. *Palpus*—Femur: dorsal 1 – 1 – 2, prolateral 1 near end, retrolateral 1 near end, ventral 0. Patella: dorsal 1 – 1 bristles, prolateral 1 bristle, elsewhere 0. Tibia: dorsal 0, prolateral 2 bristles, elsewhere 0. Tarsus: dorsal 0, prolateral 2 – 1 bristles, retrolateral 1 bristle, ventral 0.

Abdomen oval. Spinnerets yellow. Form of epigynum is shown in pl. II, fig. 15.

Locality—Finke River, 25 miles from Abminga, South Australia; Coll. 520 (1 adult ♀). Goyder's Lagoon Bore, South Australia; Coll. 647 (1 adult ♀ and 1 immature ♀).

Lycosa burti n. sp.

(Pl. II, fig. 16)

♀—Total length, 18·0 mm. Length of carapace, 8·0 mm. Width of carapace, 6·0 mm. Length of abdomen, 11·0 mm. Width of abdomen, 7·0 mm.

Carapace brown (in alcohol) and densely clothed with grey hairs. A grey longitudinal band extends from eyes to posterior margin. Lateral margin grey. Dorsal surface of legs greyish-brown. Ventral surface of legs from apical third of tibia to end of tarsus much darker. Chelicerae black. Maxillae brown. Labium, sternum and coxae very dark brown. Dorsal surface of abdomen fawn with a median brown patch on front half. An indistinct pattern of transverse bars on posterior half. Sides of abdomen fawn. A dark brown, almost black, shield covers the ventral surface and extends from the epigastric furrow to the spinnerets. The middle area of the shield is somewhat lighter in colour and marked by a pair of indistinct longitudinal fawn stripes. The front margin of the epigastric furrow and the region immediately surrounding the epigynum are light brown. Further towards the front the ventral surface, including the lung-covers, is dark brown.

Sides of head slanting. Thoracic groove longitudinal. A median row of weak bristles extends from front of head almost to the thoracic groove. There is a pair of setae behind each PLE. A fringe of grey hairs above each of the four posterior eyes. A circlet of setae round each PME and a row of setae between the lower edge of PME and PLE. First row of eyes shorter than second row in ratio 25 : 36. The ratio of eyes AME : ALE : PME : PLE = 5 : 4 : 15 : 12. The AME separated from each other by 3/5 of their diameter and by the same distance from ALE and PME. PME separated from each other by 9/15 of their diameter, and from PLE by 14/15 of their diameter. PLE separated from each other by 28/12 of their diameter. The quadrangle formed by the posterior eyes wider behind than in front in ratio 45 : 36, its length being equal to its width in front. Clypeus equal to the diameter of AME. A transverse row of four strong setae on front edge of clypeus.

Chelicerae black, clothed in front with dense grey hair and long black bristles. Lateral condyles large and yellowish-brown. Promargin with three teeth. Retromargin with three teeth. Scopula dark brown and on promargin only. Labium slightly longer than wide in ratio 20 : 19, and with lateral excavations at base. Front of labium slightly emarginate. Maxillae wider in front than at base and nearly twice the length of the labium. Scopula brown. Sternum oval and longer than wide in ratio 57 : 44. It is clothed with brown hair and long black setae. Fourth coxae contiguous.

Legs: 4.1.2.3. Clothed with grey hairs and black setae. All tarsi and metatarsi scopulate to base. In the third and fourth legs the scopula is bisected by a band of setae. In the first two pairs of legs the tibiae have a light scopula on the apical two-thirds of the ventral surface. Trichobothria in two rows on tibiae and tarsi, in one row on metatarsi. There are also a few lateral trichobothria on the sides of the tibiae near the base. Upper tarsal claws of front legs with six teeth, of hind legs with seven teeth. Lower claw small and bare. Palpal claw with about four teeth. The segments of the legs and palpi have the following measurements in millimetres:

Leg		Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	....	5·68	2·96	4·35	4·47	2·78	20·24
II	....	5·10	2·73	3·94	4·12	2·90	18·79
III	....	4·99	2·32	3·60	4·81	2·55	18·27
IV	....	6·84	2·90	5·45	8·12	3·36	26·67
Palpi	....	2·61	1·57	1·51	—	2·32	8·01

The spines on the legs and palpi are arranged as follows: *First leg*—Femur: dorsal 1 – 1 – 1, prolateral 2 near end, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, elsewhere 0. Tibia: dorsal 0, prolateral 1 – 1, retrolateral 1 very short spine near end on left leg, 0 on right, ventral 2 – 2 – 2. Metatarsus: ventral 2 – 2 – 3, elsewhere 0. *Second leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, elsewhere 0. Tibia: dorsal 0. prolateral 1 – 1, retrolateral 0, ventral 2 – 2 – 2. Metatarsus: ventral 2 – 2 – 3. *Third leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia: dorsal 1 – 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2 – 2. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 3. *Fourth leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 near end, ventral 0. Patella, tibia and metatarsus armed as in third leg. *Palpus*—Femur: dorsal 1 – 1 – 2, prolateral 1 near end, retrolateral 1 near end, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1 bristle, elsewhere 0 . Tibia: prolateral 2 bristles, elsewhere 0. Tarsus: prolateral 1 – 1, elsewhere 0.

Abdomen oval, clothed with black setae and grey hairs. The form of the epigynum is shown in pl. II, fig. 16.

Locality—Burt's Waterhole, South Australia, 55 miles south of Birdsville. Coll. 645 (1 adult ♀).

Lycosa finkei n. sp.

(Pl. II, fig. 17-18)

♀—Total length, 15·0 mm. Length of carapace, 6·2 mm. Width of carapace, 4·6 mm. Length of abdomen, 9·0 mm. Width of abdomen, 6·0 mm.

Carapace brown (in alcohol) with a median longitudinal yellowish band. Interocular space black. Chelicerae black. Labium, maxillae, sternum and coxae dark brown. Dorsal surface of abdomen yellowish-brown with a faint dark brown median patch in front and five indistinct brown chevrons on posterior half. Ventral surface of abdomen fawn. A black spot immediately in front of the spinnerets and a transverse black band with a trilobed posterior edge close behind the epigastric furrow (pl. II, fig. 17). A narrow fawn band in front of the furrow. Lung-covers brown and the area between them dark brown. Spinnerets dark brown.

Head with slanting sides. Thoracic groove longitudinal with a pair of setae close in front of its anterior end. The front row of eyes shorter than the second in ratio 23 : 33, and curved downward. Ratio of eyes AME: ALE: PME: PLE = 5 : 4 : 13 : 10. The AME are separated from each other by 3/5 of their diameter, from ALE by 2/5 of their diameter and from PME by the same distance. The PME are separated from each other by 8/13 of their diameter and from PLE by once their diameter. The PLE are separated from each other by 21/10 of their diameter. The quadrangle formed by the posterior eyes is wider behind than in front in ratio 36 : 33 and its length is equal to its width in front. The clypeus is slightly less than the diameter of AME and is provided with a transverse row of four setae.

Chelicerae clothed in front with yellowish hairs and long brown setae. Promargin of furrow with three teeth, of which the median is the largest. Retromargin with three subequal teeth. Maxillae wider in front than at the base and provided with a thick brown scopula. Labium slightly longer than wide in ratio 16 : 15, truncate in front and with lateral excavations at the base. Sternum oval, pointed behind, longer than wide in ratio 50 : 38 and clothed with erect brown setae and short grey hairs.

Legs: 4.1.2.3 Tarsi and metatarsi scopulate to base. The first and second tibiae slightly scopulate. The scopula on the third and fourth tarsi bisected by a band of setae. On the third and fourth metatarsi the scopulation is very slight and mainly on the sides of the segment. Trichobothria in two rows on tibiae and tarsi, in one row on metatarsi. Upper tarsal claws of front legs with six teeth, those of hind legs with eight teeth. Third claw small and bare. The palpal claw has four teeth. The segments of the legs and palpi have the following measurements in millimetres:

Leg		Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	....	4·5	2·4	3·4	3·4	2·3	16·0
II	....	4·3	2·3	3·1	3·2	2·2	15·1
III	....	4·1	2·0	2·6	3·8	2·3	14·8
IV	....	5·2	2·2	4·4	6·4	2·9	21·1
Palpi	....	2·2	1·2	1·2	—	1·7	6·3

The spines on the legs and palpi are arranged as follows: *First leg*—Femur: dorsal 1 – 1 – 1, prolateral 2 near end, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, elsewhere 0. Tibia: dorsal 0, prolateral 1, retrolateral 0, ventral 2 – 2 – 2. Metatarsus: ventral 2 – 2 – 3, elsewhere 0. *Second leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 –1, retrolateral 1 – 1 – 1, ventral 0. Patella, tibia and metatarsus armed as in first leg. *Third leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia: dorsal 1 – 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2 – 2. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 3. *Fourth leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 near end, ventral 0. Patella, tibia and metatarsus armed as in third leg. *Palpus*—Femur: dorsal 1 – 1 – 2, prolateral 1 near end, retrolateral 1 near end, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1 bristle. elsewhere 0. Tibia: dorsal 1 bristle, prolateral 2 bristles, elsewhere 0. Tarsus: prolateral 1 – 1 bristles, retrolateral 1 bristle, elsewhere 0.

Abdomen oval. The form of the epigynum is shown in pl. II, fig. 18.

Locality—Finke River, 25 miles from Abminga, South Australia. Coll. 520 (1 adult ♀).

Lycosa fletcheri n. sp.

(Pl. II, fig. 19)

♀—Total length, 13·0 mm. Length of carapace, 5·0 mm. Width of carapace, 3·6 mm. Length of abdomen, 8·0 mm. Width of abdomen, 4·9 mm.

Carapace dark brown (in alcohol) with a light brown patch surrounding the thoracic groove and a small light brown marginal spot above each coxa. Ocular space black. Surface of carapace clothed with white hairs. Legs and palpi yellowish-brown. Chelicerae nearly black. Maxillae, labium and sternum dark brown. Dorsal surface of abdomen light brown with dark brown markings. Ventral surface and sides yellowish-brown without markings.

Sides of head slanting. First row of eyes shorter than second in ratio 20 : 27. Ratio of eyes AME : ALE : PME : PLE = 5 : 3 : 10 : 9. AME are separated from each other by 2/5 of their diameter, and from ALE and PME by the same distance. PME are separated from each other by 7/10 of their diameter and from PLE by once their diameter. PLE are separated from each other by 21/9 of their diameter. The quadrangle of the posterior eyes is wider than long in ratio 33 : 26. Each PME is partly surrounded by an irregular circle of bristles. There is a single bristle between AME, and also a row of five bristles just below and between PLE and PME. A median longitudinal row of about five weak bristles extends from the eyes to the thoracic groove. At the anterior end of the groove is a pair of bristles. Clypeus is equal to 4/5 of the diameter of AME and is furnished with a transverse row of four strong setae.

Chelicerae nearly black but clothed with white hairs and long black bristles in front. Lateral condyles large. Promargin of furrow with three teeth, of which the median is the largest. Retromargin with three sub-equal teeth. Scopula brown and on promargin only. Labium as wide as long. Maxillae wider in front than at the base, with a well-developed brown scopula and black serrula. Sternum oval, longer than wide in ratio 36 : 27, clothed with white hairs and, near the margin, a few brownish bristles. It ends in a sharp point between the fourth coxae.

Legs: 4.1.2.3. First and second tarsi and metatarsi densely scopulate to base. Scopula on third and fourth tarsi and metatarsi not very dense and bisected by a longitudinal band of setae. The upper claws of first legs with five teeth, those of fourth legs with six teeth. Trichobothria in two rows on tibiae and tarsi, in one row on metatarsi. Palpi yellowish-brown with end segment darker. Palpal claw with four teeth. The legs and palpi have the following measurements in millimetres:

Leg		Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	....	3·9	1·9	2·8	2·7	1·7	13·0
II	....	3·6	1·7	2·5	2·7	1·7	12·2
III	....	3·1	1·6	2·3	2·9	1·6	11·5
IV	....	4·1	1·8	3·5	4·9	2·1	16·6
Palpi	....	1·7	0·9	1·0	—	1·5	5·1

The spines on the legs and palpi are arranged as follows: *First leg*—Femur: dorsal 1 – 1 – 1, prolateral 2 near end, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, elsewhere 0. Tibia: dorsal 0, prolateral 1, retrolateral 0, ventral 2 – 2 – 2. Metatarsus: ventral 2 – 2 – 3, elsewhere 0. *Second leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella armed as in first leg. Tibia: dorsal 0, prolateral 1 – 1, retrolateral 0, ventral 2 – 2 – 2. Metatarsus armed as in first leg. *Third leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia: dorsal 1 – 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2 – 2. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 3. *Fourth leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 near end, ventral 0. Patella and tibia armed as in third leg. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 1 – 2 – 2 – 3. *Palpus*—Femur: dorsal 1 – 1 – 2, prolateral 1 near end, retrolateral 1 near end, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1 bristle, elsewhere 0. Tibia: dorsal 0, prolateral 1 – 1 bristles, retrolateral 1 bristle, ventral 0. Tarsus: dorsal 0, prolateral 2 – 1 bristles, retrolateral 1 bristle, ventral 0.

Abdomen oval, clothed with yellowish and brown hairs. The form of the epigynum is shown in pl. II, fig. 19. Spinnerets yellowish-brown.

Locality—Charlotte Waters, Northern Territory, 27 May 1939. (1 adult ♀.)

Lycosa goyderi n. sp.

(Pl. II, fig. 20)

♀ Total length, 8·2 mm. Length of carapace, 4·4 mm. Width of carapace, 3·0 mm. Length of abdomen, 4·1 mm. Width of abdomen, 2·9 mm.

Carapace dark brown (in alcohol) with a narrow median longitudinal stripe of yellowish-brown. Caput, chelicerae, labium and sternum very dark brown, almost black. Maxillae brown. Legs yellowish-brown with faint bands of dark brown on femora and tibiae. Dorsal surface of abdomen dark brown with two pairs of dark spots near the middle and three transverse rows of indistinct spots on posterior half. Ventral surface of abdomen and spinnerets yellowish-brown.

Sides of head slanting. Carapace clothed with short brown hairs. A median row of short black setae ends in a pair of bristles in front of the longitudinal thoracic groove. First row of eyes almost straight and as long as the second row of eyes. Ratio of eyes AME : ALE : PME : PLE = 11 : 9 : 21 : 18. The AME are separated from each other by 6/11 of their diameter, from ALE by 4/11 of their diameter, and from PME by 6/11 of their diameter. PME separated from each other by 15/21 of their diameter and from PLE by once their diameter. PLE separated from each other by 42/18 of their diameter. Quadrangle of posterior eyes wider behind than in front in ratio 68 : 52. The length of the quadrangle is equal to its width in front. There is a seta above each AME and also a large bristle between them. The clypeus is 9/11 of the diameter of AME and is furnished with a row of four strong bristles.

Chelicerae clothed in front with black bristles. The promargin armed with three teeth, of which the median is the largest. Retromargin with two teeth.

Scopula brown and on promargin only. Maxillae wider in front than at the base. Labium truncate in front, as wide as long and about half the length of the maxillae. Sternum shield-shaped, longer than wide in ratio 30 : 24. It is clothed with erect black setae and fine recumbent yellowish hairs. Fourth coxae contiguous.

Legs: 4.1.2.3. Light scopula on tarsi, that of the fourth tarsi being confined to the sides of the segment. The ventral surface of the fourth tarsi is occupied by a band of setae. Weak scopulation on the first and second metatarsi, none on the third and fourth metatarsi. Upper tarsal claws with about six teeth. The lower claw bare. Palpal claw with one large and two very small teeth. The segments of the legs and palpi have the following measurements in millimetres:

Leg		Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	....	2·90	1·51	2·03	1·97	1·56	9·97
II	....	2·61	1·33	1·86	1·91	1·33	9·04
III	....	2·44	1·27	1·55	2·09	1·28	8·63
IV	....	3·25	1·56	2·55	3·36	1·74	12·41
Palpi	....	1·39	0·69	0·81	—	1·04	3·93

The spines on the legs and palpi are arranged as follows: *First leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 near end, elsewhere 0. Patella: dorsal 1 – 1 fine bristles, elsewhere 0. Tibia: dorsal 0, prolateral 1 – 1, retrolateral 0, ventral 2 – 2 – 2. Metatarsus: ventral 2 – 2 – 3, elsewhere 0. *Second leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, elsewhere 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, elsewhere 0. Tibia armed as in first leg. Metatarsus: prolateral 1 near middle and 1 apical, ventral 2 – 2 – 3, elsewhere 0. *Third leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia: dorsal 1 – 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2 – 2. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 3. *Fourth leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 near end, ventral 0. Patella, tibia and metatarsus armed as in third leg. *Palpus*—Femur: dorsal 1 – 1 – 1, prolateral 1, retrolateral 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1 bristle, elsewhere 0. Tibia: dorsal 0, prolateral 1 – 1 bristles, retrolateral 1 bristle, ventral 0. Tarsus: dorsal 0, prolateral 2 – 1 bristles, elsewhere 0.

Abdomen oval. Clothed with yellowish hairs and short black setae. A fringe of white setae in front. The form of the epigynum is shown in pl. II, fig. 20. Spinnerets normal for genus. A small colulus present.

Locality—Goyder's Lagoon Bore. South Australia, Coll. 647 (1 adult ♀).

Lycosa halei n. sp.

(Pl. II, fig. 21)

♀—Total length, 20·0 mm. Length of carapace, 9·5 mm. Width of carapace, 8·0 mm. Length of abdomen, 11·0 mm. Width of abdomen, 7·5 mm.

Carapace yellowish-brown (in alcohol), clothed with recumbent white hair. Radial grooves dark brown and clothed with black hair. Legs light brown, clothed with white hair and black bristles. Tarsi appear black underneath owing to the dark scopula. Labium, sternum and chelicerae dark brown. Fang nearly black. Dorsal surface of abdomen light brown speckled with black, the small black spots forming six transverse bands. Ventral surface of abdomen light brown with a narrow transverse black band immediately behind the epigastric furrow. Behind the band are a few black spots. Lung-covers light brown. Area between lung-covers nearly black. Spinnerets light brown, clothed with black hairs.

Carapace convex. Head with slanting sides. Thoracic groove longitudinal. First row of eyes shorter than second. Ratio of eyes AME : ALE : PME :

PLE = 8 : 6 : 21 : 18. AME separated from each other by 5/8 of their diameter, from ALE by 3/8 of their diameter and from PME by 4/8 of their diameter. PME separated from each other by 14/21 of their diameter and from PLE by 20/21 of their diameter. PLE separated from each other by 46/18 of their diameter. Quadrangle of posterior eyes wider than long in ratio 62 : 46. A row of four strong bristles, together with several smaller setae and white hairs on clypeus. Clypeus equal to twice the diameter of AME. PME surrounded by a circlet of white hairs. A black bristle between AME and a pair of black bristles a little above AME. An irregular circle of black bristles round each PME. Three or four black bristles behind each PLE.

Chelicerae clothed with white hair interspersed with slender black setae. Promargin of furrow with three teeth, of which the median is the largest. Retromargin with three equal teeth. Scopula on promargin only and of a dark brown colour. Labium as wide as long. Maxillae wider in front than at base. Scopula dark brown. Serrula short. Sternum longer than wide in ratio 65 : 60, pointed behind, truncate in front and clothed with erect black setae.

Legs: 4.1.2.3. All tarsi and metatarsi scopulate to base. The tarsal scopulae bisected by a longitudinal band of setae. The band is more strongly developed on the third and fourth than on the first and second tarsi. In the first two pairs of legs the tibiae are also scopulate almost to the base. Trichobothria are in two rows on the tibiae and tarsi, and in one row on metatarsi. On the tibiae there are also a few lateral trichobothria on each side near the base. Tarsal claws three. Superior claws with six teeth, inferior claw without teeth. The segments of the legs and palpi have the following measurements in millimetres.

Leg		Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	....	7·5	3·6	5·3	5·7	3·5	25·6
II	....	8·0	3·4	5·2	6·0	3·5	26·1
III	....	7·0	3·2	5·3	6·0	3·5	25·0
IV	....	8·0	3·5	7·0	8·5	4·1	31·1
Palpi	....	3·2	1·8	2·6	—	3·2	10·8

The spines on the legs and palpi are arranged as follows: *First leg*—Femur: dorsal 1 – 1 – 1, prolateral 2 at apex, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1 near middle, elsewhere 0. Tibia: dorsal 0, prolateral 1 – 1, retrolateral 0, ventral 2 – 2 – 2. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 0, ventral 2 – 2 – 3. *Second leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella and tibia armed as in first leg. Metatarsus: dorsal 0, prolateral 1 – 1, retrolateral 0, ventral 2 – 2 – 3. *Third leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia: dorsal 1 – 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 1 – 2. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 3. *Fourth leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1 – 1 on left leg and 1 – 2 – 1 on right, retrolateral 1 at end on left leg and 1 – 1 – 1 on right, ventral 0. Patella armed as in third leg. Tibia: dorsal 1 – 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2 – 2. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 1 – 3. *Palpus*—Femur: dorsal 1 – 1 – 2, prolateral 1 at end, retrolateral 1 at end, ventral 0. Patella 1 – 1 fine bristles, prolateral 1 near base, elsewhere 0. Tibia: dorsal 1 bristle, prolateral 1 – 1 bristles, elsewhere 0. Tarsus: dorsal 0, prolateral 2 – 1 bristles, retrolateral 1 bristle, ventral 0.

Abdomen ovate, clothed with recumbent white hairs interspersed with black bristles, many of which arise from little spots composed of black hairs. The form of the epigynum is shown in pl. II, fig. 21. Spinnerets normal for the genus. Colulus distinct.

Locality—Eleven miles east of Hale River, Simpson Desert, Coll. 549 (1 adult ♀).

This species bears some resemblance to *Lycosa palabunda* L. Koch, but differs from it in the form of the epigynum, in the arrangement of the eyes and in the markings on carapace.

Lycosa madigani n. sp.

(Pl. II, fig. 22-25)

♀—Total length, 16·0 mm. Length of carapace, 9·0 mm. Width of carapace, 6·0 mm. Length of abdomen, 8·0 mm. Width of abdomen, 5·0 mm.

Carapace yellowish-brown (in alcohol) with a wide longitudinal band of black hairs on each side. Margin yellow. Legs yellow-brown. Tarsi and metatarsi dark underneath. Sternum black. Prolateral surface of first coxae black. Labium and maxillae dark brown. Chelicerae almost black. Abdomen brown above with a faint pattern of transverse bars. Sides of abdomen yellowish-brown. Ventral surface yellowish-brown with a large black shield behind the epigastric furrow (pl. II, fig. 22). The shield reaches about half-way to spinnerets. Lung-covers and region in front of epigastric furrow yellowish-brown.

Head with slanting sides. Thoracic groove longitudinal with a pair of setae immediately in front of its anterior end. First row of eyes shorter than the second. Ratio of eyes AME : ALE : PME : PLE : = 8 : 5 : 19 : 17. AME separated from each other by 4/8 of their diameter, from ALE by 2/8 of their diameter, and from PME by 2/8 of their diameter. PME separated from each other by 13/19 of their diameter and from PLE by 17/19 of their diameter. PLE separated from each other by 33/17 of their diameter. Quadrangle of posterior eyes wider than long in ratio 54 : 47. A row of four large bristles on clypeus. Behind each PLE an oblique row of six long setae. The four posterior eyes with a dorsal fringe of yellowish hairs and long brown setae. A number of setae which point forward occupy the space enclosed by the quadrangle of the posterior eyes.

Chelicerae clothed in front with white hairs and black bristles. Condyles well developed. Promargin of furrow with three teeth, of which the median is the largest. Retromargin with two equal teeth. Scopula on promargin only. Fang black and well curved. Labium longer than wide in ratio 22 : 19. Maxillae wider in front than at the base. Clothed with black setae. Scopula dark brown. Serrula short. Sternum longer than wide in ratio 53 : 47, black and clothed with black setae.

Legs: 4.1.2.3. All tarsi scopulate, but the scopulation on the third and fourth tarsi is not very dense and is divided by a broad band of black setae. A scopula is also present on the first and second metatarsi but not on the third and fourth. In the first two pairs of legs the scopula extends on to the ventral surface of the tibiae. Trichobothria in two rows on tarsi and tibiae, in one row on metatarsi. There are also a few lateral trichobothria on each side of the tibiae near the base. Tarsal claws three. The superior claws with eight teeth, inferior claw without teeth. Palpal claw with seven teeth. The segments of the legs and palpi have the following measurements in millimetres:

Leg		Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	....	5·6	2·9	3·9	3·7	2·8	18·9
II	....	5·4	2·8	3·6	3·9	2·7	18·4
III	....	5·0	2·5	3·3	4·5	2·9	18·2
IV	....	6·5	3·1	4·6	6·0	3·2	23·4
Palpi	....	2·9	1·4	1·4	—	2·0	7·7

The spines on the legs and palpi are arranged as follows: *First leg*—Femur: dorsal 1 – 1 – 1, prolateral 2 near end, retrolateral 1 – 1 – 1, ventral 0. Patella:

dorsal 1 – 1 fine bristles, prolateral 1, elsewhere 0. Tibia: prolateral 1 – 1, ventral 2 – 2 – 2, elsewhere 0. Metatarsus: ventral 2 – 2 – 3, elsewhere 0. *Second leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella and tibia armed as in first leg. Metatarsus: prolateral 1, ventral 2 – 2 – 3, elsewhere 0. *Third leg*—Femur armed as in second leg. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia: dorsal 1 – 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2 – 2. Metatarsus: dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 3. *Fourth leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 0. Patella: tibia and metatarsus armed as in third leg. *Palpus*—Femur: dorsal 1 – 1 – 2, prolateral 1 near end, retrolateral 1 near end, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1 bristle, elsewhere 0. Tibia: dorsal 1 bristle, prolateral 1 – 1 bristles, elsewhere 0. Tarsus: dorsal 0, prolateral 2 – 1, retrolateral 1, all bristles, ventral 0.

Abdomen ovate. Dorsal surface clothed with light brown hairs and fine black bristles. Five pairs of small spots composed of black hairs on anterior half. Sides and ventral surface, excepting the black shield behind the epigastric furrow, clothed with pale yellow hairs. The form of the epigynum is somewhat variable. (See pl. II, fig. 23 and 24.) Spinnerets clothed with dark hairs. Colulus present.

♂—Total length, 10·8 mm. Length of carapace, 5·7 mm. Width of carapace, 4·1 mm. Length of abdomen, 5·1. Width of abdomen, 3·5 mm.

The male resembles the female in colouration and markings of carapace, legs, chelicerae, labium, sternum, ventral surface of abdomen and spinnerets. The dorsal surface of the abdomen, however, is marked in the anterior two-thirds with a median longitudinal patch of dark brown, while the sides are speckled with small black spots.

Carapace as in female. First row of eyes shorter than second. Ratio of eyes AME : ALE : PME : PLE = 6 : 4 : 13 : 12. AME separated from each other by 4/6 of their diameter, from ALE by 1/6 of their diameter and from PME by 2/6 of their diameter. PME separated from each other by 10/13 of their diameter and from PLE by 11/13 of their diameter. PLE separated from each other by 21/12 of their diameter. The quadrangle of the posterior eyes wider than long in ratio 35 : 32.

Chelicerae clothed in front with white hairs and slender black bristles. Promargin with three teeth, retromargin with two teeth. Scopula on promargin only. Labium longer than wide in ratio 13 : 11. Maxillae as in female. Sternum black, longer than wide in ratio 45 : 36, clothed with black setae.

Legs: 4.1.2.3. The first and fourth pairs of legs are equal in length. All tarsi except the fourth scopulate. A scopula is also present on the first and second, but not on the third and fourth metatarsi. The trichobothria are arranged as in the female. Superior tarsal claws with about eleven teeth. The inferior claw small and bare. The form of the palpus is shown in pl. II, fig. 25. The segments of the legs and palpi have the following measurements in millimetres:

Leg		Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	....	4·9	2·3	3·7	4·2	2·9	18·0
II	..	4·8	2·3	3·6	4·0	2·8	17·5
III	....	4·6	2·1	3·2	4·4	2·7	17·0
IV	....	4·9	1·8	3·8	4·8	2·7	18·0
Palpi	....	2·4	1·2	1·2	—	1·7	6·5

The spines on the legs are larger and more numerous than in the female, and those of the fourth tibiae are curved. The arrangement of the spines is as follows: *First leg*—Femur: dorsal 1 – 1 – 1, prolateral 2 near end, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia: dorsal 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2 – 2. Metatarsus:

dorsal 0, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 3. *Second leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella, tibia and metatarsus armed as in first leg. *Third leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia: dorsal 1 – 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2 – 2. Metatarsus : dorsal 2 at apex, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 3. *Fourth leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 near end, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia and metatarsus armed as in third leg. *Palpus*—Femur: dorsal 1 – 1 – 1, prolateral 1 near end, retrolateral 1 near end, ventral 0. Patella: dorsal 1 – 1 bristles, prolateral 1 bristle, elsewhere 0. Tibia: dorsal 1 bristle, prolateral 1 – 1 bristles, elsewhere 0. Tarsus: ventral 4 at apex, elsewhere 0.

Abdomen oval, shorter than carapace. Ventral surface with a black shield behind epigastric furrow as in female. Spinnerets light brown clothed with dark hair.

Locality—Six miles north of junction of Todd and Hale Rivers, Coll. 540 (1 adult ♂ and 1 pullus). Centre of Simpson Desert, Coll 570 (2 adult ♀ ♀). Indinda Well, near Andado Station, Northern Territory (1 adult ♀).

Family OXYOPIDAE

Genus Oxyopes Latreille 1804

Oxyopes elegans L. Koch 1878

Locality—Andado Station, Northern Territory (1 immature ♀).

The immaturity of this specimen makes the specific identity somewhat doubtful. It is the only member of the genus *Oxyopes* in the present collection.

Three species belonging to this genus were collected by the Horn Scientific Expedition to Central Australia in 1894.

Family ZODARIIDAE

Sub-Family ZODARIINAE

Genus Storena Walckenaer 1805

Storena toddi n. sp.

(Pl. II, fig. 26-28; pl. III, fig. 29-30)

♂—Total length, 4·1 mm. Length of carapace, 2·1 mm. Width of carapace, 1·5 mm. Length of abdomen, 2·0 mm. Width of abdomen, 1·3 mm.

Carapace yellow (in alcohol) with a V-shaped patch of dark brown extending from the sides of the head region to the posterior margin. Clypeus dark brown. Legs yellow. Chelicerae and palpi slightly darker than legs. Sternum, labium and maxillae pale yellow. Dorsal surface of abdomen dark brown with a white spot above the spinnerets and four pairs of white spots arranged as shown in pl. II, fig. 26. Sides of the abdomen white, ventral surface light brown.

Carapace smooth and without bristles. A few minute hairs on clypeus and round the margin. Thoracic groove longitudinal. Eyes in two strongly procurved rows. All eyes with black rims. The interocular space is black except between the PME. Eye ratio AME : ALE : PME : PLE = 9 : 7 : 6 : 8. The eyes are arranged as shown in pl. II, fig. 27. The AME are separated from each other by 5/9 of their diameter, from ALE by 3/9 and from PME by 7/9 of their diameter. The PME are separated from each other by 9/6 of their diameter and from PLE by the same distance. The PLE are separated from ALE by 3/8 of their diameter and from AME by 4/8 of their diameter. The quadrangle formed by the median eyes is wider in front than behind in ratio 23 : 21, and its length is slightly less than its width in front. The clypeus is very high and slopes steeply to the front (pl. II, fig. 28). The distance from AME to the margin of the clypeus is equal to 38/9 of the diameter of AME. There is a small seta between the AME and in line with their lower margin. A thin dark brown line extends from the eye-space down the middle of the clypeus almost to the margin.

Chelicerae conical, clothed in front with black hairs. Lateral condyles present. Margins of furrow without teeth. Promargin with a black scopula. Fang short. Maxillae strongly converging, provided with a black scopula. Serrula absent. Labium triangular, its apex reaching almost to the front of the maxillae. Sternum shield-shaped, longer than wide in ratio 18 : 16, and lightly clothed with small hairs which point backwards. There are a few erect setae near the margin.

Legs: 4.1.3.2. Slender, tapering and clothed with short barbed hairs. Trichobothria in two rows on tibiae, in one row on metatarsi and tarsi. Three tarsal claws. The upper claws similar and armed with about eleven teeth. The lower claw small and bare. The form of the palpus is shown in pl. III, fig. 29. The segments of the legs and palpi have the following measurements in millimetres:

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	1·86	0·58	1·51	1·51	1·16	6·62
II .	1·74	0·58	1·39	1·57	1·04	6·32
III ...	1·74	0·64	1·27	1·80	0·99	6·44
IV ...	2·09	0·70	1·74	2·44	1·28	8·25
Palpi	0·81	0·35	0·17	—	1·16	2·49

The spines on the legs and palpi are arranged as follows: *First leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 near end, elsewhere 0. Patella: ventral 2 near end; elsewhere 0. Tibia: dorsal 1 near base, prolateral 1 – 1, retrolateral 0, ventral 2 – 2 – 2 and about 26 small spines distributed over the whole ventral surface (pl. III, fig. 30). Metatarsus: dorsal 2 at apex, prolateral 1 – 1, retrolateral 1 at apex, ventral 2 – 2 – 2 and about nine small spines on basal half. *Second leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 near end, elsewhere 0. Patella: prolateral 1 – 1, elsewhere 0. Tibia: dorsal 1 near base, prolateral 1 – 1, retrolateral 0, ventral 2 – 2 – 2. Metatarsus: dorsal 2 at apex, prolateral 1 – 1, retrolateral 1 at apex, ventral 2 – 2 – 2. *Third leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1, retrolateral 1 near end, ventral 0. Patella: dorsal 1, prolateral 1 – 1 – 1 – 1, elsewhere 0. Tibia: dorsal 1 – 1, prolateral 1 – 1, retrolateral 1 near end, ventral 2 – 1 – 2. Metatarsus: dorsal 2 at apex, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 2. *Fourth leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 near end; elsewhere 0. Patella: dorsal 1, prolateral 1 – 1 – 1 – 1, elsewhere 0. Tibia: dorsal 1 – 1, prolateral 1 – 1 – 1, retrolateral 1 near end, ventral 1 – 1 – 2. Metatarsus: dorsal 2 at apex, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 2. *Palpus*—Femur: dorsal 1 – 1, prolateral 0, retrolateral 1 near end, ventral 1 – 1 – 1 slender bristles. Patella: dorsal 1 near base, prolateral 1, elsewhere 0. Tibia: dorsal 0, prolateral 2 bristles, elsewhere 0. Tarsus: ventral 6 near apex.

Abdomen oval, clothed with very small fine hairs. At anterior end are six slender bristles, arranged three on each side just above petiolus. Anterior spinnerets much longer than the posterior pair, which are small and indistinct. Middle pair not visible.

Locality—Six miles north of junction of Todd and Hale Rivers. Coll. 540 (1 adult ♂).

Family THERIDIIDAE

Sub-Family LATRODECTINAE

Genus LATRODECTUS Walckenaer 1805

LATRODECTUS HASSELTII Thorell 1870

Locality—Camp No. 37, Cowarie Station, South Australia (1 adult ♀).

This poisonous spider is widely distributed throughout Australia, including Tasmania. It also occurs in New Zealand, India and Arabia.

Family ARGIOPIDAE

Sub-Family ARGIOPINAE

Genus ARGIOPE Audouin, 1825

ARGIOPE PROTENSA L. Koch 1871

Locality—Six miles north of junction of Todd and Hale Rivers, Coll. 540 (1 pullus). Sixteen miles east of Hay River, near Queensland border, Coll. 608 (1 ♀). Fourteen miles north-east of Cowarie Station, South Australia, Coll. 659 (1 pullus). Twenty miles west of Cowarie Station, South Australia, Coll. 661 (1 pullus). Camp No. 16, Hay River, near Queensland border (1 pullus). Camp No. 21, Annandale Station, Queensland (1 ♀). Camp No. 37, Cowarie Station, South Australia (1 ♀ mature and 1 pullus).

Sub-Family ARANEINAE

Genus ARANEUS Clerk 1757

ARANEUS TRANSMARINUS (Keyserling)

Locality—Finke River, 25 miles from Abminga, South Australia, Coll. 520 (1 ♀). Birdsville-Marree Track, Mount Gason, South Australia, Coll. 651 (1 ♀). Twenty miles west of Cowarie Station, South Australia, Coll 661 (1 ♀). Camp No. 21, Annandale Station, Queensland (2 ♀♀). Camp No. 23, thirty miles north-west of Birdsville, Queensland (1 ♀).

Sub-Family NEPHILINAE

Genus NEPHILA Leach 1815

NEPHILA IMPERATRIX L. Koch 1871

Locality—One mile east of Andado Station, Northern Territory, Coll. 503 (1 ♀). Finke River, 25 miles from Abminga, South Australia, Coll. 520 (1 ♀). Sixteen miles east of Hay River, near Queensland border, Coll. 608 (1 ♀). Kaliduwarry Station, Queensland, Coll. 620 (2 ♀♀). Birdsville-Marree Track, Mount Gason, South Australia, Coll. 651 (1 ♀). Twenty miles west of Cowarie Station, South Australia, Coll. 661 (1 ♀). Camp No. 2, twenty-two miles north of Andado Bore No. 1, Andado Station, Northern Territory (1 pullus). Camp No. 19, Hay Rvier, near Queensland border (1 ♀). Camp No. 21, Annandale Station, Queensland (1 ♀). Camp No. 23, thirty miles north-west of Birdsville, Queensland (1 ♀).

Family CTENIDAE

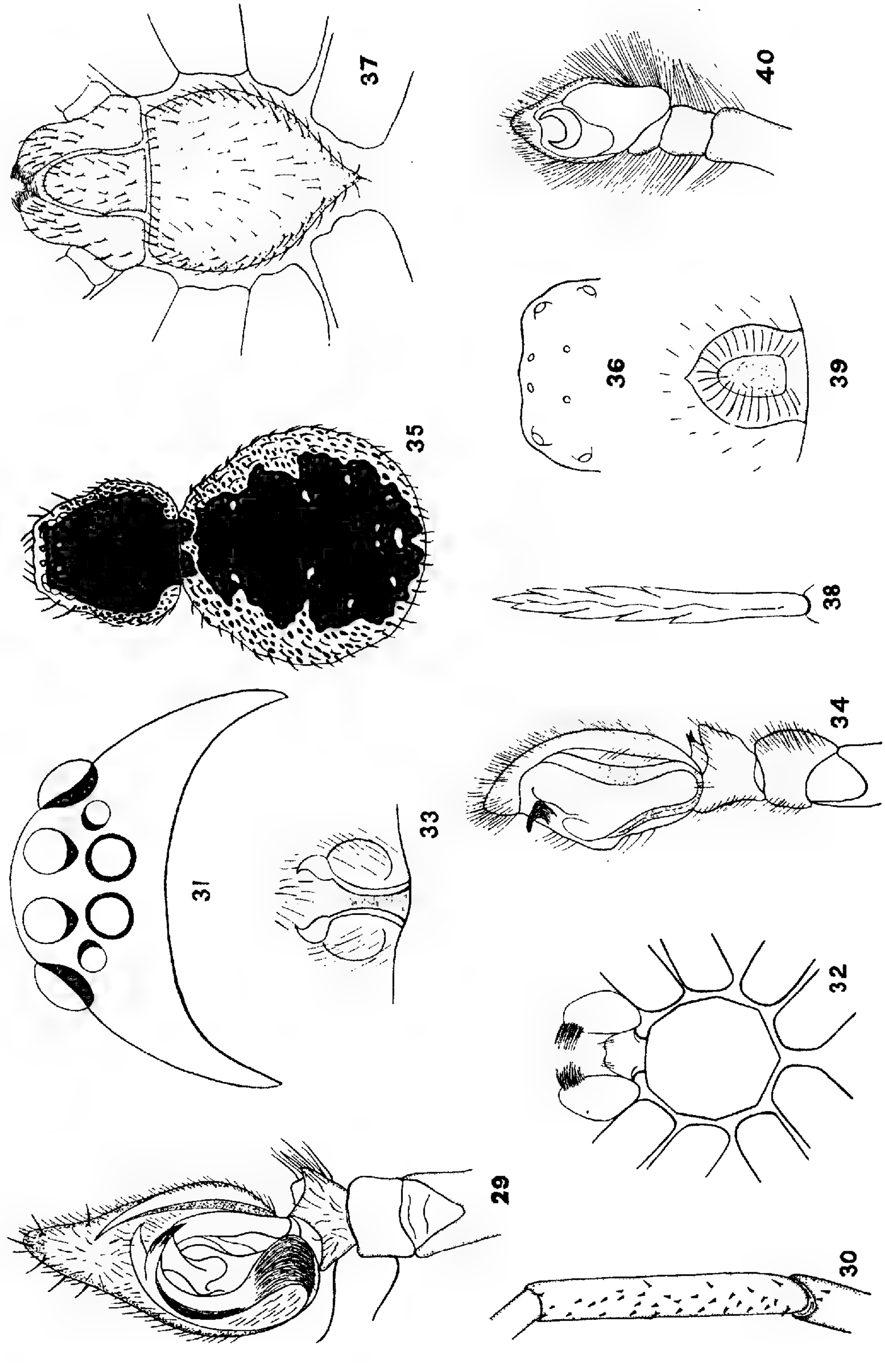
Sub-Family CALOCTENINAE

Genus ODO Keyserling 1887

Odo australiensis n. sp.

(Pl. III, fig. 31-34)

♀—Total length, 9·7 mm. Length of carapace, 4·35 mm. Width of carapace, 3·13 mm. Length of abdomen, 6·09 mm. Width of abdomen, 3·71 mm.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Carapace yellow (in alcohol) with four irregular dark brown patches on each side. Legs yellow with faint brownish rings. Chelicerae reddish-brown with a dark brown patch in front. Maxillae, palpi, labium and sternum yellow. Abdomen yellow with four pairs of small dark brown marks in the middle third of the dorsal surface. Sides of abdomen speckled with dark brown.

Carapace convex, clothed with a band of white silky hairs near the margin, and above this a band of dark brown hairs extending from PLE to posterior margin. Thoracic groove longitudinal. Front of groove ends in a thick patch of brown hairs. A median row of small setae extends from eyes to the thoracic groove. A long seta behind and a row of six setae above each PLE.

The eyes are arranged in two strongly recurved rows (pl. III, fig. 31). Ratio of eyes AME : ALE : PME : PLE = 7 : 5 : 9 : 10. AME separated from each other by 2/7 of their diameter, from ALE by the same distance and from PME by 4/7 of their diameter. The PME are separated from each other by 2/9 of their diameter, from PLE by 5/9 of their diameter and from ALE by 4/9 of their diameter. The posterior row of eyes is longer than the front row in ratio 32 : 26. The quadrangle formed by the four median eyes is wider behind than in front in ratio 20 : 17, and its width behind is equal to its length. Clypeus narrow, being equal to 6/7 of AME. A row of about eleven setae along margin of clypeus.

Chelicerae conical. Furnished in front with a number of long brownish bristles. Lateral condyles large. Promargin of furrow with three teeth, of which the middle one is the largest. Retromargin with two teeth. A scopula is present on the promargin.

Maxillae parallel. Clothed with long yellowish setae on outer side. Scopula extending slightly onto the ventral surface. Labium wider than long in ratio 20 : 15, excavated at the base, and not exceeding half the length of the maxillae (pl. III, fig. 32). Sternum slightly convex, longer than wide in ratio 50 : 47, clothed with brownish setae and white hair around the margin. The setae near the first coxae are larger than those on other parts of the sternum. The fourth coxae meet behind the sternum.

Legs: 4.3.1.2. Trochanters notched. All tarsi and metatarsi scopulate. In the first two pairs of legs the scopulation extends onto the sides of the basal half of the tibiae. The scopulae of the third and fourth metatarsi and tarsi are bisected by a longitudinal band of setae. Trichobothria in two rows on tarsi and tibiae, in one row on metatarsi. Two tarsal claws which are long and slightly curved. About five teeth on the claws of the first tarsi, and about eight on those of the fourth. Palpal claw with five teeth. The segments of the legs and palpi have the following measurements in millimetres:

Leg		Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	....	3·60	1·74	2·96	2·38	1·74	12·42
II	....	3·25	1·68	2·84	2·32	1·74	11·83
III	....	3·60	1·56	2·78	2·96	1·91	12·81
IV	....	4·81	1·74	4·06	4·23	2·20	17·04
Palpi	....	1·74	0·93	0·81	—	1·45	4·93

Spines on legs and palpi are arranged as follows: *First leg*—Femur: dorsal 1 – 1 – 1, prolateral 2 near end, retrolateral 1 near middle, ventral 0. Patella 0. Tibia: dorsal 0, prolateral 1 – 1, retrolateral 0, ventral 2 – 2 – 1. Metatarsus: ventral 2 near base, elsewhere 0. *Second leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1 – 1, retrolateral 1 near middle, ventral 0. Patella 0. Tibia: dorsal 0, prolateral 1 – 1, retrolateral 0, ventral 2 – 2 – 2. Metatarsus: ventral 2 near base, elsewhere 0. *Third leg*—Femur: dorsal 1 – 1 – 1, prolateral left 1 – 1 – 1 – 1 (right 2 – 1 – 1 – 1), retrolateral 1 – 1 – 1 – 1, ventral 0. Patella 0. Tibia: dorsal 2 – 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2 – 2. Metatarsus: dorsal 0, prolateral 1 – 2 – 1, retrolateral 2 – 1 – 1, ventral 2 – 0 – 1. *Fourth* *leg* — Femur: dorsal 1 – 1 – 1, prolateral 1 – 1 – 0 – 1, retrolateral 1 near end, ventral 0. Patella 0. Tibia: as for tibia of third leg. Metatarsus: dorsal 0, prolateral 1 – 2 – 2, retrolateral 2 – 2 – 2, ventral 2 – 2 – 1. *Palpus*—Femur: dorsal 1 – 1 – 1, prolateral 1 near end, retrolateral 1 near end, ventral 0. Patella: dorsal 1 – 1, prolateral 1, retrolateral 0, ventral 0. Tibia: dorsal 1 – 1, prolateral 2 – 2, elsewhere 4. Tarsus: dorsal 1 – 1, prolateral 2 – 2, retrolateral 2 – 2, ventral 3 near claw.

Abdomen oval, clothed with white hair and fine brown setae. In front there are dark curved bristles. The epigynum has the form shown in pl. III, fig. 33. Six spinnerets. The anterior pair cylindrical and two-segmented. The end segment is very small and sunken in the apex of the first segment. The posterior spinnerets slightly longer than the anterior. The middle spinnerets slender and hidden by the others.

♂—Total length 6·9 mm. Length of carapace, 3·48 mm. Width of carapace, 2·61 mm. Length of abdomen, 3·48 mm. Width of abdomen, 2·09 mm.

The colouration and markings as in the female. The body, however, is somewhat smaller and the legs longer and more slender.

The eyes are arranged in two strongly recurved rows. The AME are relatively larger than those of the female. Ratio of eyes AME : ALE : PME : PLE = 7 : 4 : 5 : 5. The AME are separated from each other by 2/7 of their diameter, from ALE by 1/7 of their diameter, and from PME by 3/7 of their diameter. The PME are separated from each other by 2/5 of their diameter and from PLE by 4/5 of their diameter. The PLE are separated from ALE by 4/5 of their diameter. The posterior row of eyes is longer than the front row in ratio 25 : 21. Owing to the large size of the AME the quadrangle formed by the median eyes is wider in front than behind in ratio 14 : 12. It is longer than its front width in ratio 15 : 14. The clypeus is 5/7 of the diameter of AME.

The chelicerae resemble those of the female. The promargin of the furrow is armed with three teeth, the retromargin with two. The maxillae as in the female. The labium wider than long in ratio 13 : 9 and less than half the length of the maxillae. The base of the labium is not so strongly excavated as in the female. Sternum oval, convex and slightly longer than wide in ratio 45 : 43. Fourth coxae meet behind sternum.

Legs: 4.1.3.2. Long and slender. All tarsi and metatarsi scopulate. Trichobothria as in female. Two tarsal claws, similar and armed with about 8 teeth. The palpus has the form shown in pl. III, fig. 34. The tibia is short and on its retrolateral side there is a short black bifid apophysis. The segments of the legs and palpi have the following measurements in millimetres:

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I ...	4·06	1·45	3·60	3·36	2·32	14·79
II	3·88	1·39	3·48	3·36	2·26	14·37
III	3·77	1·28	3·19	3·83	2·38	14·45
IV ...	4·93	1·45	4·29	5·22	2·78	18·67
Palpi	1·51	1·33	0·40	—	1·51	4·75

Spines on the legs and palpi are arranged as follows: *First leg*—Femur: dorsal 1 – 1 – 1, prolateral 2 near end, retrolateral 1 – 1 – 1, ventral 0. Patella 0. Tibia: dorsal 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2 – 2. Metatarsus: dorsal 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 1. *Second leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1 – 1, ventral 0. Patella 0. Tibia: dorsal 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2 – 2. Metatarsus: dorsal 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 1. *Third leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1 – 1 – 1, retrolateral 1 – 1 – 1 – 1, ventral 0. Patella 0. Tibia: dorsal 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1, ventral

2 – 2 – 2. Metatarsus: dorsal 0, prolateral 1 – 2 – 1, retrolateral 2 – 2 – 1, ventral 2 – 1 – 1. *Fourth leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 – 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 0. Patella 0. Tibia: dorsal 1 – 1, prolateral 1 – 1, retrolateral 1 – 1 – 1 ventral 3 – 2 – 2. Metatarsus: dorsal 0, prolateral 2 – 2 – 2, retrolateral 2 – 2 – 2, ventral 2 – 2 – 1. *Palpus*—Femur: dorsal 1 – 1 – 1, prolateral 1 near end, retrolateral 1 near end, ventral 0. Patella: dorsal 1 – 1 bristles, prolateral 1, elsewhere 0. Tibia: dorsal 1 bristle, prolateral 1 – 1 bristles, retrolateral 1 bristle, ventral 0.

Abdomen oval and fringed in front with dark curved bristles which are coarser and more numerous than in the female.

Locality — Eleven miles east of Hale River, Simpson Desert, Coll. 549 (1 adult ♀). Centre of Simpson Desert, No. 8 Camp, Coll. 567 (1 adult ♂).

Family EUSPARASSIDAE

Sub-Family EUSPARASSINAE

Genus Isopeda L. Koch 1875

Isopeda pessleri (Thorell)

Heteropoda pessleri Thorell 1870, Ofv. K. Vet. Akad. Forh., 387.
Isopeda pessleri L. Koch 1875, Arachn. Austral., 684.
Isopeda pessleri H. R. Hogg 1896, Horn Exped., Zool., Ar., 342.
Isopeda pessleri H. R. Hogg 1902, Proc. Zool. Soc. Lond., 444.

Locality — Camp No. 16, Hay River, near Queensland border, Coll. 606 (2 ♀ ♀ and 2 pullus). Kaliduwarry Station, Queensland, Coll. 620 (1 ♀). Goyder's Lagoon Bore, South Australia (1 pullus). Andado Station, Northern Territory (2 pullus).

Genus Pediana Simon 1880

Pediana horni (Hogg)

Isopeda horni H. R. Hogg 1896, Horn Exped., Zool., Ar., 340.
Pediana horni H. R. Hogg 1902, Proc. Zool. Soc., Lond., 462.

In his original description of this species Hogg (1896, 340) states that "on tibia III and IV there is one spine on the upper side." Some years later (1902, 462) he transferred the species to the genus *Pediana* and said that there are "no spines on tibia III or IV." In view of these contradictory statements it is difficult to identify the species. However, the specimen in the present collection agrees very closely with Hogg's original description, and possesses a dorsal spine on the third and fourth tibiae.

Locality—Finke River, 25 miles from Abminga, South Australia, Coll. 520 (1 adult ♀).

Pediana regina (L. Koch)

Heteropoda regina L. Koch 1875, Arachn. Austral., 716.
Pediana regina H. R. Hogg 1902, Proc. Zool. Soc. Lond., 460.

Locality—Goyder's Lagoon Bore, South Australia, Coll. 647 (1 pullus).

Sub-Family MICROMMATINAE

Genus Olios Walckenaer 1873

Olios inframaculatus (Hogg)

Heteropoda inframaculata H. R. Hogg 1896, Horn. Exped., Zool., Ar., 343.
Neosparassus inframaculatus H. R. Hogg 1902, Proc. Zool. Soc. Lond., 428.

Locality—Camp No. 13, 24 miles west of Hay River, Simpson Desert (1 pullus).

Family THOMISIDAE
Sub-Family MISUMENINAE
Genus Tharpyna L. Koch 1874
Tharpyna simpsoni n. sp.
(Pl. III, fig. 35-39)

♀—Total length, 5·6 mm. Length of carapace, 2·0 mm. Width of carapace, 2·0 mm. Length of abdomen, 3·8 mm. Width of abdomen, 3·4 mm.

Carapace dark chocolate-brown with cream spots (in alcohol). Radial grooves lighter brown. Face, sides and ocular tubercles cream with brownish blotches. Femora cream, spotted and blotched with dark brown on dorsal, ventral and prolateral surfaces. Retrolateral surface dark brown. Other podomeres with brown and cream markings not so distinct as on femora. Labium brown. Maxillae brown towards inner side and base, cream towards outer side and apex. Sternum cream with brown blotches. Dorsal surface of abdomen almost covered by an irregular brownish-black patch, marked with a few cream spots (pl. III, fig. 35). Sides of abdomen cream, speckled with dark brown. Ventral surface light brown, speckled with cream and dark brown. Lung-covers brown. Spinnerets cream.

The carapace is as wide as long with steep sides and flat upper surface. It is clothed with a number of coarse black setae, some of which are arranged in radial rows.

The eyes are arranged in two recurved rows (pl. III, fig. 36). The posterior row is longer than the front row in ratio 112 : 89. The median eyes are much smaller than the lateral eyes. All the eyes have conspicuous black pupils. The ratio of the diameters of the pupils AME : ALE : PME : PLE = 6 : 10 : 5 : 10. The AME are separated from each other by 14/6, from ALE by 22/6 and from the PME by 20/6 of their pupil-diameter. The PME are separated from each other by 28/5 and from PLE by 33/5 of their pupil-diameter. The PLE are separated from ALE by 25/10 of their pupil-diameter. The median ocular quadrangle is wider than long in ratio 38 : 30. The lateral eyes are mounted on slightly raised tubercles.

The chelicerae are small and cone-shaped. There are about 13 coarse setae on the front of the paturon. Margins of furrow without teeth. Fang small.

Labium longer than wide in ratio 3 : 2. Surface provided with about 15 short setae. Maxillae longer than labium in ratio 23 : 18, converging and almost meeting in front of lip (pl. III, fig. 37). Surface of each maxilla furnished with about 14 coarse setae. Sternum shield-shaped, longer than wide in ratio 41 : 36, ending in a sharp point between the fourth coxae. This point bears three conspicuous setae. The lateral margins of the sternum are furnished with two or three rows of coarse setae, the central region with a few hairs (pl. III, fig. 37).

Legs: 1.2.4.3. Laterigrade. Clothed with longitudinal rows of spine-like setae, except the retrolateral side of each femur, which is smooth. The setae on the legs and body are barbed (pl. III, fig. 38). Trichobothria are present on tibiae, metatarsi and tarsi. Two tarsal claws, each having about ten teeth, are present. Claw tufts absent. Palpi are small and without a claw. The segments of the legs and palpi have the following measurements in millimetres:

Leg		Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	....	1·74	0·87	1·51	1·45	0·87	6·44
II	....	1·85	0·93	1·56	1·27	0·81	6·42
III	....	1·23	0·70	1·16	0·99	0·64	4·72
IV	....	1·27	0·70	1·16	0·99	0·64	4·76
Palpi	....	0·52	0·35	0·41	—	0·58	1·86

The spines on the legs differ very little from the ordinary setae. They are arranged as follows:—*First leg*—Femur: dorsal 1 – 1 – 1 – 1, prolateral 1 – 1 – 1 – 1, elsewhere 0. Patella: dorsal 1 – 1 very small, elsewhere 0. Tibia: dorsal 1 near middle, elsewhere 0. Metatarsus 0. *Second leg*—Femur: dorsal 1 – 1 – 1 – 1, elsewhere 0. Patella: dorsal 1 – 1 very small, elsewhere 0. Tibia: dorsal 1 before middle, elsewhere 0. Metatarsus 0. The spines on the *third* and *fourth legs* are arranged as on the second.

Abdomen broadly ovate and somewhat dorso-ventrally compressed. It is furnished with coarse setae arranged in rows. There is a pair of large oval muscle spots near the middle of the dorsal surface. The epigynum has the form shown in pl. III, fig. 39.

Locality—Twenty miles west of Cowarie Station, South Australia. Coll. 661 (1 adult ♀).

Family CLUBIONIDAE

Sub-Family LIOCRANINAE

Genus Miturga Thorell 1870

Miturga lineata Thorell

Locality—Finke River, 25 miles from Abminga, South Australia, Coll. 520 (2 pullus). Mount Gason, Birdsville-Marree Track, South Australia, Coll. 651 (2 pullus). Fourteen miles north-east of Cowarie Station, South Australia. Coll. 659 (1 ♂ and 1 ♀).

Family SALTICIDAE

Sub-Family PLEXIPPINAE

Genus Saitis Simon 1876

Saitis lacustris n. sp.

(Pl. III, fig. 40)

♂—Total length, 4·70 mm. Length of carapace, 2·49 mm. Width of carapace, 1·85 mm. Length of abdomen, 2·44 mm. Width of abdomen, 1·97 mm.

Thorax dark brown (in alcohol). Caput nearly black. The dorsal surface of the head is clothed with recumbent white hairs interspersed with a few slender erect black bristles. Clypeus yellow and densely clothed with white hairs. Dorsal surface of the three distal segments of the palpi yellow and clothed with long white hairs. Legs dark brown with yellowish-brown markings on dorsal side of patellae, the ventral side of the femora and the coxae. Chelicerae brown with patches of yellowish-brown in front. Maxillae, labium and sternum dark brown. Legs lightly clothed with white silky hairs. Abdomen dark brown above; paler at the sides and underneath; not marked by any distinct pattern; clothed with silky hairs.

Carapace high and convex. Head region somewhat flat, but sloping gently forward from the posterior eyes. Thorax sloping steeply under the front of the abdomen.

Eye-group wider in front than behind in ratio 25 : 23. The front width greater than the length in ratio 25 : 18. First row of eyes slightly recurved, wider than the second in ratio 25 : 24. Ratio of eyes AME : ALE : PME : PLE = 7 : 5 : 1·5 : 3·5. AME separated from each other by about 1/7 of their diameter and from ALE by about twice this distance. PME separated from ALE by a distance equal to the diameter of AME, and from PLE by 4/7 of the diameter of AME, that is the eyes of the second row are nearer PLE than ALE. Clypeus 4/7 of diameter of AME and sloping backward.

Chelicerae conical, not diverging, condyles lacking. Margins oblique. Two teeth on promargin, one on retromargin. Lip triangular, about as wide as long.

Maxillae short and wide. Sternum oval, longer than wide in ratio 17 : 11. Fourth coxae almost contiguous.

Legs: 3.4.2.1. Trichobothria in two rows on tibiae, in one row on metatarsi and tarsi. Two tarsal claws, similar, with about five teeth. The three distal teeth are large and widely spaced. Palpi are clothed with long white hairs on the dorsal surface and sides of the tarsus, tibia and patella. No spines are present, but there is a small black seta on the dorsal surface of the femur and patella near the apex of the segment. On the prolateral side the tibia is produced into a sharp apophysis. The genital bulb has the form shown in pl. III, fig. 40. The segments of the legs and palpi have the following measurements in millimetres:

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	1·28	0·81	0·87	0·87	0·70	4·53
II ..	1·33	0·87	0·87	0·87	0·70	4·64
III	1·85	0·87	1·22	1·28	0·58	5·80
IV	1·51	0·70	0·99	1·28	0·70	5·18
Palpi	0·60	0·35	0·23	—	0·64	1·82

The spines on the legs are arranged as follows: *First leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 near end, elsewhere 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia: dorsal 1 near base, prolateral 1 –1, retrolateral 1, ventral 2 – 2 – 2. Metatarsus: dorsal 1 near base, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2. *Second leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 near end, retrolateral 1 near end, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia: dorsal 1, prolateral 1 – 1, retrolateral 1, ventral 2 – 2 – 2. Metatarsus: dorsal 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2. *Third leg*—Femur: dorsal 1 – 1 – 1, prolateral 1 –1 near end, retrolateral 1 near end, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1, retrolateral 1, ventral 0. Tibia: dorsal 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 1 – 2. Metatarsus: dorsal 1, prolateral 1 – 1, retrolateral 1 – 1, ventral 2 – 2. *Fourth leg*—Femur: dorsal 1 – 1 – 1, prolateral 0, retrolateral 0, ventral 0. Patella: dorsal 1 – 1 fine bristles, prolateral 1 – 1, retrolateral 1 – 1, ventral 0. Tibia: dorsal 1, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 1 –2. Metatarsus: dorsal 1, prolateral 1 – 1 – 1, retrolateral 1 – 1 – 1, ventral 2 – 2 – 2.

Abdomen oval somewhat dorso-ventrally compressed. Spinnerets six, almost cylindrical. Anterior pair much larger than the others. Colulus absent.

Locality—Surface of North Lake Eyre, two and a half miles from shore, Coll. 669 (1 adult ♂).

Sub-Family MARPISSINAE

Genus Ocrisiona Simon 1901

Ocrisiona sp.

Locality—Twenty miles west of Cowarie Station, South Australia, Coll. 661 (1 pullus).

The specimen is immature but appears to be closely related to, if not identical with, *Ocrisiona complana* (L. Koch).

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DESCRIPTION OF PLATES

PLATE I

Fig. 1 *Urodacus yaschenkoi*—Sternum, genital operculum and pectines.
Fig. 2 *Urodacus yaschenkoi*—Ventral view of left chelicera.
Fig. 3 *Urodacus yaschenkoi*—Trichobothria on ventral surface of brachium of left pedipalpus.
Fig. 4 *Urodacus yaschenkoi*—Trichobothria on inner side of under-hand of left pedipalpus.
Fig. 5 *Urodacus yaschenkoi*—End of fourth tarsus, showing minute inner claw.
Fig. 6 *Urodacus yaschenkoi*—Last two segments of first leg showing dorsal row of seven spines on metatarsus.
Fig. 7 *Aganippe simpsoni* n. sp.—♀ Dorsal view of eyes.
Fig. 8 *Aganippe simpsoni* n. sp.—Sternum, labium and maxillae.
Fig. 9 *Aganippe simpsoni* n. sp.—An upper claw of first tarsi.
Fig. 10 *Aganippe simpsoni* n. sp.—An upper claw of fourth tarsi.
Fig. 11 *Pardosa eyrei* n. sp.—♂ Dorsal view of abdomen, to show the shape of the median dark brown patch.
Fig. 12 *Pardosa eyrei* n. sp.—Front view of eyes.
Fig. 13 *Pardosa eyrei* n. sp.—Ventral view of right palpus.

PLATE II

Fig. 14 *Pardosa pexa* n. sp.—♂ Ventral view of left palpus.
Fig. 15 *Lycosa abmingani* n. sp.—♀ Epigynum.
Fig. 16 *Lycosa burti* n. sp.—♀ Epigynum.
Fig. 17 *Lycosa finkei* n. sp.—♀ Ventral view of abdomen.
Fig. 18 *Lycosa finkei* n. sp.—♀ Epigynum.
Fig. 19 *Lycosa fletcheri* n. sp.—♀ Epigynum.
Fig. 20 *Lycosa goyderi* n. sp.—♀ Epigynum.
Fig. 21 *Lycosa halei* n. sp.—♀ Epigynum.
Fig. 22 *Lycosa madigani* n. sp.—♀ Ventral view of abdomen.
Fig. 23 *Lycosa madigani* n. sp.—Epigynum of a specimen from the Simpson Desert.
Fig. 24 *Lycosa madigani* n. sp.—Epigynum of a specimen from Indinda Well.
Fig. 25 *Lycosa madigani* n. sp—♂ Ventral view of right palpus.
Fig. 26 *Storena toddi* n. sp.—♂ Dorsal view of the carapace and abdomen.
Fig. 27 *Storena toddi* n. sp.—Dorso-anterior view of eyes.
Fig. 28 *Storena toddi* n. sp.—Lateral view in outline.

PLATE III

Fig. 29 *Storena toddi* n. sp.—♂ Ventral view of left palpus.
Fig. 30 *Storena toddi* n. sp.—Spines on ventral surface of tibial segment of first pair of legs.
Fig. 31 *Odo australiensis* n. sp.—♀ Front view of eyes.
Fig. 32 *Odo australiensis* n. sp.—Maxillae, labium and sternum.
Fig. 33 *Odo australiensis* n. sp.—Epigynum.
Fig. 34 *Odo australiensis* n. sp.—♂ Left palpus from below.
Fig. 35 *Tharpyna simpsoni* n. sp.—♀ Dorsal view of carapace and abdomen.
Fig. 36 *Tharpyna simpsoni* n. sp.—Dorsal view of eyes.
Fig. 37 *Tharpyna simpsoni* n. sp.—Maxillae, labium and sternum.
Fig. 38 *Tharpyna simpsoni* n. sp.—A barbed seta from the legs.
Fig. 39 *Tharpyna simpsoni* n. sp.—Epigynum.
Fig. 40 *Saitis lacustris* n. sp.—♂ Ventral view of left palpus.

THE SIMPSON DESERT EXPEDITION, 1939
SCIENTIFIC REPORTS: NO. 2, GEOLOGY - DESERT SANDS

By DOROTHY CARROLL, University of Western Australia[(1)]

Summary

The grading, mineralogy and various other features of some sands collected in the Simpson Desert by the Simpson Desert Expedition of 1939 are described in this paper. The material was examined through the courtesy of Dr. C. T. Madigan.

THE SIMPSON DESERT EXPEDITION, 1939
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[Read 13 April 1944]

Plate IV

Introduction

The grading, mineralogy and various other features of some sands collected in the Simpson Desert by the Simpson Desert Expedition of 1939 are described in this paper. The material was examined through the courtesy of Dr. C. T. Madigan.

The Simpson Desert is situated almost in the centre of Australia, where it covers about 56,000 square miles between Lat. 23° S. and 27° S. and Long. 135° and 139° E. (Madigan 1938, 506.)

The Desert consists of straight, parallel, spinifex-covered sand-ridges running in a north-north-west, south-south-easterly direction. Individual ridges, which are about 60 feet high on an average, may run unbroken for fifty miles or more. There are three or four ridges to the mile, and each ridge is separated from the next by a narrow flat. To the north of the Simpson Desert the country gradually merges into a sandy plain; to the south is Lake Eyre. East and west it gradually changes to plain country with remnants of sediments and wide flats, on which water from the infrequently flowing rivers dries up. (Madigan 1936, 213.)

The sand is fine-grained, bright red in colour, except in the south-east of the Desert, and consists mainly of quartz. It is somewhat similar (Madigan 1938, 515) to the sand in English hour-glasses, which is obtained from the Bunter sandstones which originated as desert sands in the Triassic period. (Boswell 1933, 31.)

The samples examined can be divided into those from the crests of dunes and those from the hollows. Most of the sands are bright red in colour, except Nos. 3 and 4, which are white, and several of the inter-ridge sands from the eastern side of the Desert which are brownish. The distribution of samples is given in Table I. Further particulars of locality and depth of sample appear in the Appendix.

Table I

Geographical Distribution of the Samples within the Simpson Desert

	Nos.	Nos.	Nos.	Nos.
Sands from dune crests	—	2	—	—
	1	6223	6222	3, 4
	—	6227	—	—
	—	6228	—	—
Sands from inter-ridge areas, etc.	—	6224	6221	6236
	—	6225	6232	—
	—	6226	6233	—
	—	6229	6234	—
	—	6230	6235	—
	—	6231	—	—

(1) Written in 1940, while a Research Fellow of the University of Western Australia.

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Grading and Sorting of the Sands

1 Mechanical Analysis

Mechanical analyses of the samples were made by hand-shaking through a set of Tyler screens giving the Wentworth scale (Wentworth 1922) of grade terms for sediments. The details of these analyses are given in Table II.

Table II

Mechanical Analyses of Simpson Desert Sands

Retained on:	16	32	60	115	250	−250
Screen openings (mm.):	0·99	0·49	0·24	0·12	0·06	—
Sands from crests:	%	%	%	%	%	%
1	—	—	12·65	69·57	17·11	0·27
2	—	—	1·5	83·18	14·82	0·50
6223	—	—	6·34	61·28	31·47	—
6227	—	1·63	11·20	41·63	43·14	4·39
6228	—	—	14·02	76·42	9·32	0·24
6222	—	2·13	27·10	49·25	20·70	1·82
3	—	0·27	33·56	52·02	13·82	0·49
4	—	0·28	50·17	39·65	9·57	0·33
Sands from inter-ridge areas:						
6224	—	5·1	7·54	20·76	60·59	5·91
6226	1·93	5·94	12·80	33·28	41·06	4·99
6229	—	3·02	15·87	18·05	57·40	5·66
6231	0·25	5·27	23·51	24·84	42·19	3·94
6232	—	0·42	4·12	19·87	66·74	8·85

The samples from the dune crests are coarser than those from the inter-ridge areas. The dune crest sands are well sorted and contain no grains larger than 1 mm. diameter. In general the bulk of each sample is contained in the −60 +115 grade, *i.e.*, the grain diameters are between 0·24 and 0·12 mm. This distribution of size is shown in fig. 1, where the frequency curves have high sharp peaks at the position of the maximum grade. Fine dusty material makes up the smallest grade.

The samples from the inter-ridge areas were collected as soil profile samples, but in this investigation only the surface and lowest samples were sieved. The maximum grade in the inter-ridge sands is in the −115 +250 grade, grain diameters between 0·12 and 0·06 mm. This difference in size of the grade containing the bulk of the sand grains in the dune crest sands and the inter-ridge sands is seen in fig. 1.

Gypsum was found in all sand samples taken near Lake Eyre. In the case of No. 6236, from an inter-ridge area north of Lake Eyre, no mechanical analysis was made, as the coarse secondary gypsum crystals were in sufficient proportion to give a false impression of the coarseness of the sand as a whole. In Nos. 3 and 4, dune crest sand from the east side of the Lake, the gypsum was less and finer and the mechanical analyses were done in the usual way.

2 Sorting

The samples from the ridge crests and from the hollows are well sorted. There is very little difference in the degree of sorting between the samples collected at the edges and at the middle of the Desert, although the best sorted sample is from the middle of the Desert, and samples from the eastern and southern sides show slightly less perfect sorting, which appears in the frequency curve of fig. 1 as a spreading and a lowering of the peak. Samples from the ridge slopes are not nearly so well sorted as those from the ridge crests (see 6227, fig. 1).

3 Comparison with other Desert Sands

The grade containing the bulk of the sand in samples from the ridge crests in the Simpson Desert is slightly finer in grain size than similar sands from other deserts; for instance, the majority of sand grains in the Libyan Desert are between 0·8 and 0·08 mm. and less than 3% are smaller than 0·04 mm. (Bagnold 1935, 343). In the Simpson Desert sands the greatest number of grains are between 0·24 and 0·06 mm., and there is sometimes a greater percentage of very fine grains than in the Libyan Desert sand. Mechanical analyses of wind accumulated sands for grain size show that the peaks of such curves never occur of the small side of 0·015 cm. and rarely of 0·022 cm. Sand having a peak size nearest

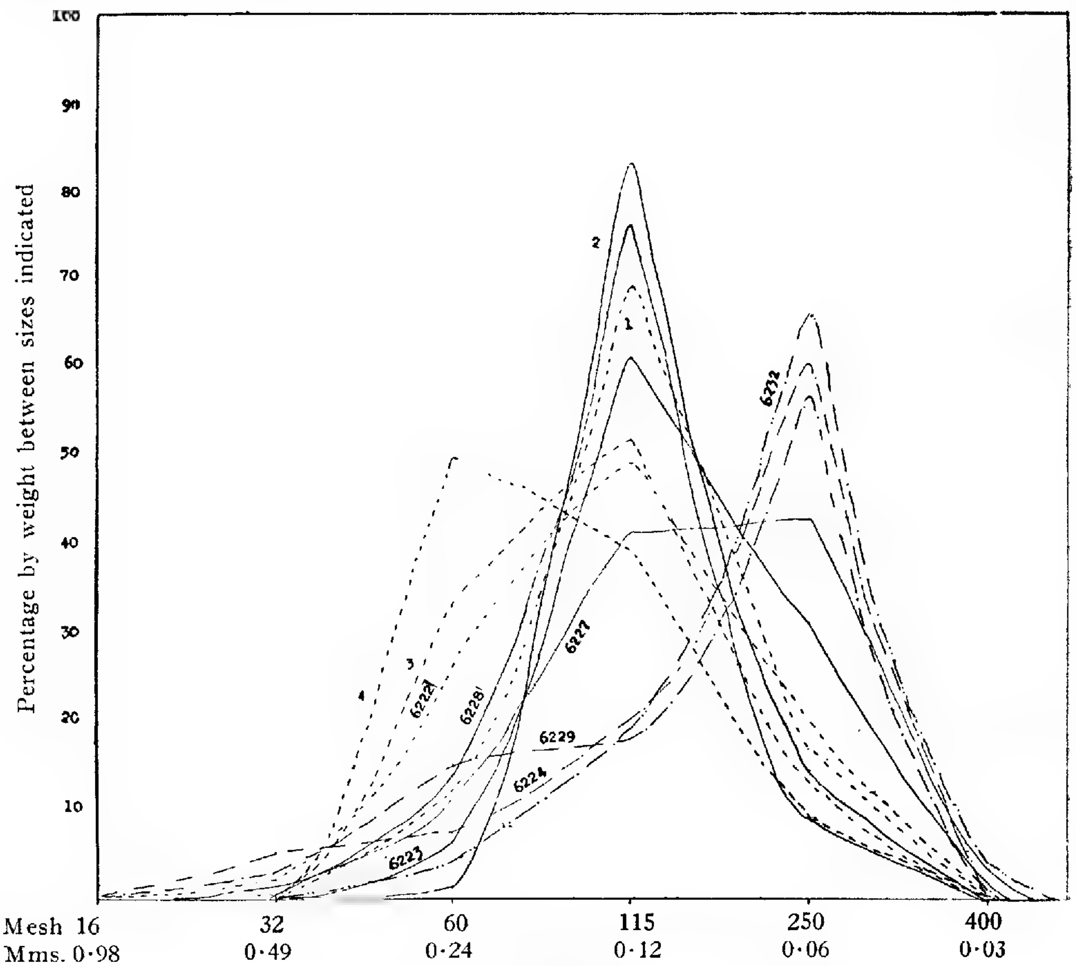


Fig. 1

Mechanical Analses of the Simpson Desert Sands

Sands from middle of Desert, Nos. 2, 6223, 6227, 6228, shown thus: ————
Sands from edges of Desert, Nos. 1, 3, 4, 6222, shown thus — — — · — -·-
Inter-ridge sands, middle of Desert, Nos. 6224, 6229, shown thus: —.—.—.—.—
Inter-ridge sands, edge of Desert, No. 6232, shown thus: —..—..—..—..—..—

to this is found at the crests of dunes (Bagnold 1937, 435). It will be seen from fig. 1 that the Simpson Desert sand fits into this limit, and the analyses can also be matched with many of Wentworth's aeolian sands (Wentworth 1932).

The difference in grain size between the sand from crests and hollows in the Simpson Desert is similar to the differences observed in the Libyan Desert.

Mineralogy of the Sands

1 Laboratory Procedure

The heavy minerals were separated from quartz in the sands with bromoform. Experience has shown that by using one of the finer grades of any sedimentary material for separation a larger crop of more easily identifiable heavy minerals is obtained than if the unsieved sand is used (Carroll 1939, 101), for most heavy minerals belong among the originally smallest grains in rocks, and are therefore to be expected in the finer grades of sediments. This statement is particularly true for zircon, rutile, tourmaline and the minerals more rarely seen in heavy residues. During transportation large grains of the heavy minerals, even if they were present in the source rock, cannot be carried as readily as can quartz and felspar grains (Rubey 1933). Therefore, although some heavy mineral grains could probably be obtained from the grade containing the bulk of the sand, it is more profitable to obtain them from the sand with grains smaller than those in the maximum grade. Often the very finest grade shows abundant heavy minerals. (See fig. 3. Dark grains are heavy minerals in an unseparated fine sand of less than 0·06 mm. grain diameter.)

Before microscopic examination, the red film of iron oxide was removed by boiling in 1 : 1 conc. HCl.

2 Details of the Mineralogy

(i) Heavy Minerals

Table III gives the details of the heavy mineral assemblages, the grade of sand separated, and the index figure, or percentage by weight of the heavy fraction. The percentage figures for the individual minerals were obtained by counting the grains in 10 to 12 microscope fields, amounting to approximately 500 grains for each residue. These figures refer only to the non-magnetic minerals as the highly magnetic grains, usually comprising one-third to one-half of the heavy fraction, were removed before mounting so that the remaining grains could be more easily seen. The order in which the minerals are arranged in Table III has no special significance. Where counts were not made, the presence of a mineral is indicated by +.

As seen in Table III the residues contained the following heavy minerals: magnetite, ilmenite (and leucoxene), tourmaline, rutile, zircon, amphiboles, epidote, zoisite, garnet, sillimanite, titanite, staurolite, anatase, apatite, kyanite, chlorite, corundum, monazite, andalusite, and spinel. The first ten of these are present in nearly every sample.

Details of the Individual Minerals are:

Ilmenite—The ilmenite percentage of the total heavy residue in Table III includes that for leucoxene, which may make up about one-third of the total. Both ilmenite and leucoxene grains are rounded.

Tourmaline often occurs as spherical grains, commonly of green, brown, pinkish-brown, and blue colours, respectively. Pale blue, parti-coloured blue and brown, and mauve grains were much less common. Some samples contain worn prismatic grains, but the tourmaline is generally well worn, which indicates a long period of attrition.

Rutile, in deep reddish-brown, well-worn prismatic grains is one of the minor constituents of these residues. Small golden-brown geniculate twins, also well worn, occur in sample 6224 from the middle of the Desert.

Zircon—Each non-magnetic residue contains between 9 and 40%, generally about 24%, of zircon grains the majority of which are well worn, clear, colourless, and contain few inclusions. There are occasional brownish grains (No. 1)

Table III

Heavy Minerals in the Simpson Desert Sands

	WEST	MIDDLE								EAST				SOUTH		
Sample No.:	1	2	6223	6227	6228	6224	6226	6229	6231	6222	6221	6232	6235	3	4	6236
Description:	C	C	C	C	C	H	H	H	H	C	H	H	H	C	C	H
Grade Separated:	+250	+250	+250	−250	+250	−250	−250	−250	−250	+250	+250	−250	−115	+250	+250	+250
Index Figure:	1·6	2·5	1·1	2·1	2·3	3·4	2·0	2·8	3·1	1·6	0·5	2·4	0·4	1·1	1·1	0·2
Magnetite	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Ilmenite	27	32	23	+	+	28	+	+	+	31	+	+	+	38	39	+
Tourmaline	9	13	12	+	+	3	+	+	+	11	+	+	+	11	11	+
Rutile	+	3	2	+	+	7	+	+	+	7	+	+	+	13	8	+
Zircon	16	9	12	+	+	40	+	+	+	24	+	A	+	28	24	+
Amphibole (gr.)	5	6	3	+	+	3	+	+	+	1	+	+	+	½	1	
Amphibole (c'less)	2	2	+	+	+	1		+		½			+	2		+
Epidote	21	10	17	+	+	5	+	+		4	+	+	+	1	4	+
Garnet	15	4	5	+	+	6	+	+	+	3	+	+	+	2	1	+
Sillimanite		22	15		+			+		3			+			
Titanite	1	1	2			1	+			2				1	1	
Staurolite	½	½		+		½		+		½				½	1	
Zoisite	1	½	1			3								+		
Anatase		+													+	
Apatite															2	
Kyanite			2		+		+	+	+	½	+		+			+
Chlorite	½							+		+						
Corundum										+					½	
Monazite		+	½		+					2					½	
Andalusite										2				½		
Spinel		+														

C = sand from crest of ridge; H = sand from inter-ridge area; A = very abundant; + = present.

Figures in table are percentages, not determined for all samples.

and one or two purple grains (No. 6236). Purple zircon is present in some of the residues of sediments derived from the Pre-Cambrian in Western Australia, and the writer had expected to see more of it in this material which must have originally come from the surrounding Pre-Cambrian terrains. American workers (Report on Accessory Minerals in Crystalline Rocks, 1935) consider that purple zircon is characteristic of Archaean gneisses. The increase to 40% zircon in sample 6224 may be due only to the fact that the very finest grade was separated, for zircon, occurring in minute grains in most rocks, nearly always tends to be concentrated in the finest grade of any sediment.

Amphiboles—Both green and colourless amphibole grains are found in these residues. Most of the grains are worn at the edges. Green amphibole is more plentiful than colourless, and is the blue-green variety characteristic of metamorphosed basic rocks. $Z \wedge c = 13°$, indicating the cummingtonite group. Some residues, notably No. 1, contain occasional brownish-green grains, slightly pleochroic, with $Z \wedge c = 18°$, belonging to the pargasite group. Colourless amphibole grains with a very small extinction angle or with parallel extinction occur in nearly all the samples, and may have accompanied the blue-green variety in the original parent rock.

Epidote and *zoisite*—In some of the samples epidote makes up a considerable proportion of the residue. In samples from the south and east of the Desert there is much less than in those from the middle and west. The epidote is a very pale yellowish-green colour and the grains are generally somewhat worn, though almost un-worn prismatic grains also occur. Some grains appear to be between epidote and zoisite in optical properties. Zoisite has the characteristic ultra blue or watery yellow polarisation colours in many instances, but could not be identified with certainty in all the residues. A suggested origin for both epidote and ziosite is in metamorphosed basic rocks, such as greenstones.

Garnet is constantly present in these residues. The grains are almost invariably angular, with surfaces sometimes lightly etched, occasionally fracture surfaces or smooth. Garnet seems seldom to become well rounded during transport, and in the writer's experience most of the garnet encountered amongst well-worn grains of other minerals is still angular; this may suggest that garnet is too brittle to be abraded without breaking, and that angular garnet in a sediment is no proof of the nearness of the parent rock. The colours of these grains range from deep pinkish-brown, light brown, to colourless; these suggest pyrope, almandine, and grossularite.

Sillimanite, in clear, colourless, slightly worn prismatic grains was identified in a number of the residues, but only in Nos. 2 and 6223, from the Middle of the Desert, is it in conspicuous amounts.

Small quantities of *staurolite, kyanite,* and *andalusite* occurred in some of the residues. The staurolite is a pale yellowish-brown variety; the grains are chunky, angular prisms. In contrast, kyanite and andalusite are well worn; the latter is sometimes strongly pleochroic and may be rather more plentiful than indicated in Table III, as there were some colourless grains which could not be satisfactorily identified.

The remaining minerals, *titanite, anatase, apatite, chlorite, corundum, monazite,* and *spinel* call for little comment. *Titanite* was found as rather angular, colourless grains. *Anatase,* because of its well-developed crystal faces, appears to be authigenic, but not necessarily formed in the Desert sand as it now is, but perhaps in a sandstone or limestone from which the Desert sand was derived.

Apatite was only found in samples which were not boiled in acid. It occurs in well-worn prismatic grains exhibiting no unusual features. White (1939, 746)

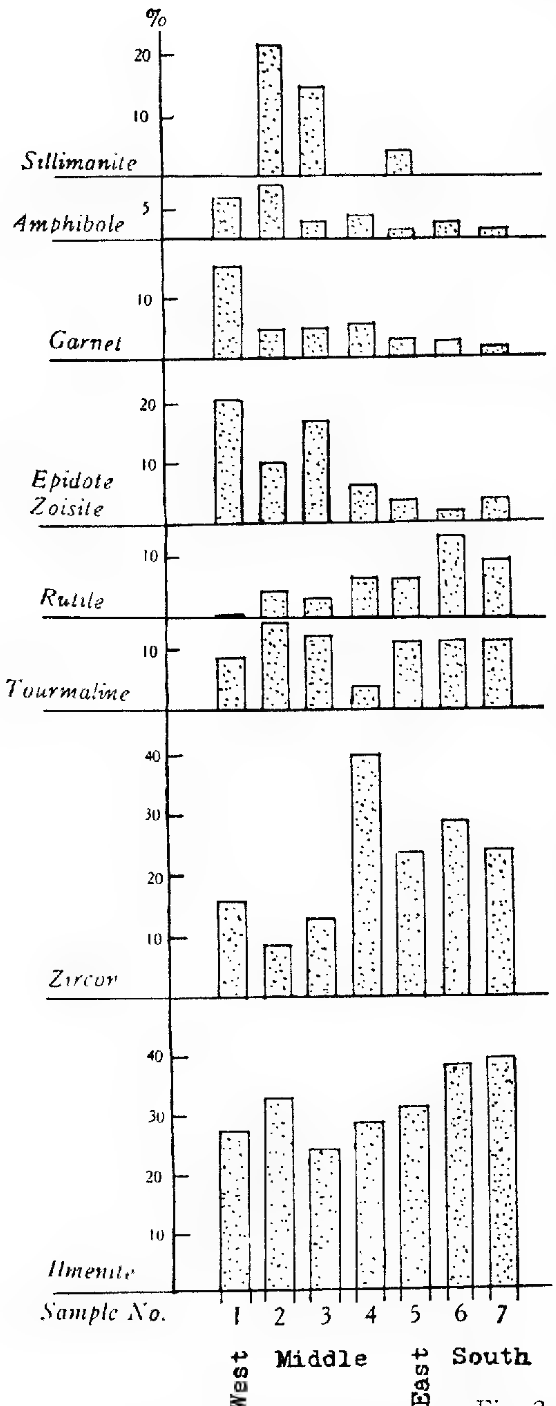


Fig. 2

HISTOGRAMS OF NON-MAGNETIC HEAVY RESIDUES, SIMPSON DESERT SANDS.

Percentage figures from counts as in Table III.

1, represents sample 1, west side of desert.
2, represents sample 2, middle of desert.
3, represents sample 6223, middle of desert.
4, represents sample 6224, middle of desert.
5, represents sample 6222, east side of desert.
6, represents sample 3, south side of desert.
7, represents sample 4, south side of desert.

has recorded apatite from most desert sands. He suggests that its presence is due to the greater stability in an arid environment than elsewhere. Apatite is certainly not stable in all environments, but does occur in beach sands. (Carroll 1939, 102.)

Corundum—The presence of a few grains of blue corundum is interesting, for it is one of the minerals less frequently encountered in heavy residues.

Monazite occurs in the usual pale yellowish-green, rounded grains. It is present in five of the residues. White (1939, 746) states that it is an unusual mineral in desert sands, but this probably depends on the ability of the desert-forming rocks to supply it.

Spinel is a rare mineral in these residues. The grains are pale green which may indicate gahnite, the zinc spinel, but this identification requires a chemical analysis.

Few generalisations concerning the heavy residues of these sands can be made on a small number of samples, but there are several noteworthy features:

1 The dominantly metamorphic and granitic nature of these mineral assemblages.
2 The uniformity of the index figure or percentage by weight of the residue in the grade of sand separated.
3 Variation in percentage of individual minerals. The distribution of the principal non-magnetic minerals, arranged according to position of each sample in the Desert, is given in fig. 2. The amount of ilmenite, tourmaline, rutile, and zircon does not

vary much with respect to locality; garnet, epidote, and sillimanite do vary considerably. This variation may indicate that the sands have been derived from rocks which have disintegrated more or less *in situ*.

4 Attrition, resulting in rounding and blunting of corners, is noticeable with most minerals except garnet and staurolite.

(ii) *The "Light" Minerals*

Quartz makes up the bulk of these sands which had to be boiled in acid to remove the red colouring matter, probably hematite, which occurred as a thin film around each grain. The grains are sub-angular to well-rounded, and many contain inclusions of rutile needles (sagenite webbing), chloritic or sillimanitic needles, and pepper-dust ores. Such inclusions fall into Mackie's acicular group (1889) and indicate a metamorphic parentage.

The appearance of quartz grains in three grades of sand from the middle of the Desert (Sample No. 2) is illustrated in pl. IV. There are no grains with angular corners, so that the sand as a whole has suffered considerable movement. Many of the grains have matt surfaces and are not shiny as is usual with grains of water-borne sediments.

Plate IV shows that in the coarsest grade a few of the grains are very well rounded, but the majority merely have had the corners blunted. In the finer grades most of the grains are sub-angular, the attrition having only been sufficient to remove the angular edges which must originally have been present.

In this investigation it was not possible to work out any numerical value for the degree of roundness of the quartz grains by the methods now used (Krumbein and Pettijohn, chap. 8), but an estimation of roundness is given in Table IV.

TABLE IV

Roundness of Quartz Grains

Sample No.	Desc.	Loc.	Grade +16	+32	+60	+115	+250	—250
1	Sand	W			SA-WR	SA-WR	SA	SA-WR
2	Sand	M			SA-WR	SA-WR	SA-WR	SA-WR
6223	Sand	M			SA-WR	SA-WR	SA+	SA+
6227	Sand	M		**SA+WR**	SA+WR	SA-R	SA-WR	SA-WR
6228	Sand	M			SA	SA+	SA+	SA-R
6224	Soil	M		SA-WR	SA-WR	SA-R	A, SA-R	SA-R
6226	Soil	M	SA	SA-WR	SA-R	SA-R	SA-R	SA-R
6222	Sand	E		SA-WR	SA+R	SA	SA+	SA+
3	Sand	S		R	SA-WR	WR-SA	SA	SA
4	Sand	S		R	SA-R	SA+	SA	SA+R

SA = sub-angular, corners blunted; SA+ = grains somewhat more worn than SA; R = corners of grains rounded; WR = corners well rounded; SA-WR = some of the grains are SA, others WR; SA+WR = majority of grains are SA, but there are a few WR; SA+R = majority of grains are SA, but some are R.
W = west side of desert; M = middle of desert; E = east side of desert; S = southern side of desert.

The quartz grains of the Simpson Desert sand are not more worn than those in many beach sands or beach dune sands, but there appear to be a greater number of slightly rounded or sub-angular grains in the finer grades than is usual with sands from other environments in which the finer grades are generally angular.

The wear which is shown in the rounding of these Simpson Desert sand grains may have been due to movement during several cycles of sedimentation. This does not mean that desert conditions have alone been responsible for the rounding, for the source of the sand may be a sandstone as in the Egyptian and Libyan Deserts.

Felspar is a fairly prominent constituent and occurs in fresh angular grains. Orthoclase and microcline are both present.

Gypsum is plentiful in some of the inter-ridge sands, particularly in samples from below the surface, where it has arisen authigenically. Only odd grains of gypsum were seen in the dune sands. (Sands from crests of ridges.)

(iii) Comparison with other Desert Sands

Comparatively little has been written about the mineralogy of desert sands, the most comprehensive account being by White (1939). He has recorded the heavy minerals found in a great many desert sands, including sands from Oodnadatta, Cooberpedy Tablelands, Tarcoola, and Glenloth. The sample from Oodnadatta is the only one which is near enough geographically to be compared with the Simpson Desert sands. The Oodnadatta sample contained hematite, limonite, tourmaline, calcite, epidote, zircon, hornblende, and zoisite. The absence of ilmenite and magnetite is surprising as these minerals are so conspicuous in the Simpson Desert sands.

In Arabia and Egypt many of the heavy minerals recorded from the sands are also found in the sandstones surrounding the deserts, which implies that there has been little addition of material from outside the desert basin; a conclusion which might also be reached if sedimentary rocks from around the Simpson Desert were examined.

The suites of heavy minerals recorded for a number of sands collected in deserts in other parts of the world are restricted in number of constituents. White (1939) has suggested that this restriction is caused by abrasion during movement of the sand itself. Certainly only the most resistant minerals remain, but it seems likely, however, that the poverty or richness in heavy minerals of the rocks, in most instances sandstones, from which the sands are derived is probably as important a cause as the loss by abrasion. If large numbers of sands from each desert could be examined, it is possible that the number of heavy minerals recorded would be increased. As an example, White's sample from Oodnadatta contained 8 heavy minerals; the total from the Simpson Desert sands is 20 heavy minerals.

General Conclusions

As only a few sands from the Simpson Desert have been examined the following conclusions must be regarded as tentative:

1 Immediate Source of the Sands

(i) The mechanical analyses show that the sands have been sorted into two well-defined groups (see fig. 1), the finer sands being from the inter-ridge areas, the majority of whose grains are between 0·12 and 0·06 mm. in diameter, a size, as noted by Bagnold (1937, 436) difficult to remove by wind. Material of this size will not form dunes, so that it is reasonable to suppose that in the Simpson Desert this fine sand has been left when the coarser was formed into dunes. [Sand from slopes is apparently a mixture of crest-sand and inter-ridge sand.] It is possible, too, that the inter-ridge sands are soils developed from very fine parent rocks such as shale or fine-grained argillaceous sandstone underlying the desert.

(ii) Roundness of grains—There is nothing remarkable or characteristic about the grain roundness in these sands, except the amount of rounding of the heavy minerals; the sands might, so far as this feature goes, have come from a beach dune. The grains have undergone considerable attrition but there is no way of telling whether this was by wind or water or both. Nor, of course, is it

possible to say through how many cycles of sedimentation separated by periods of rest as consolidated sediments the grains have passed.

At the present time there is no agreement as to the method and time taken to round sand grains, nor whether wind is more efficient at rounding small particles than water. Aeolian sands generally show better sorting and rounding than sands transported by other agents (Russell 1939, 41). The greater roundness of grains in dunes is often due (McCarthy 1935) to the selective transportation of the rounder grains in beach sand by wind, and even many desert dunes are derived from beach sands of former lakes and inland seas (Russell 1939, 37).

The degree of roundness of the quartz grains and of most of the heavy minerals in the Simpson Desert sand indicates that they have all had a fairly long past history, involving considerable attrition. This attrition may have taken place within the basin now containing the Desert and its surroundings and may be the result of much movement in a fairly restricted area.

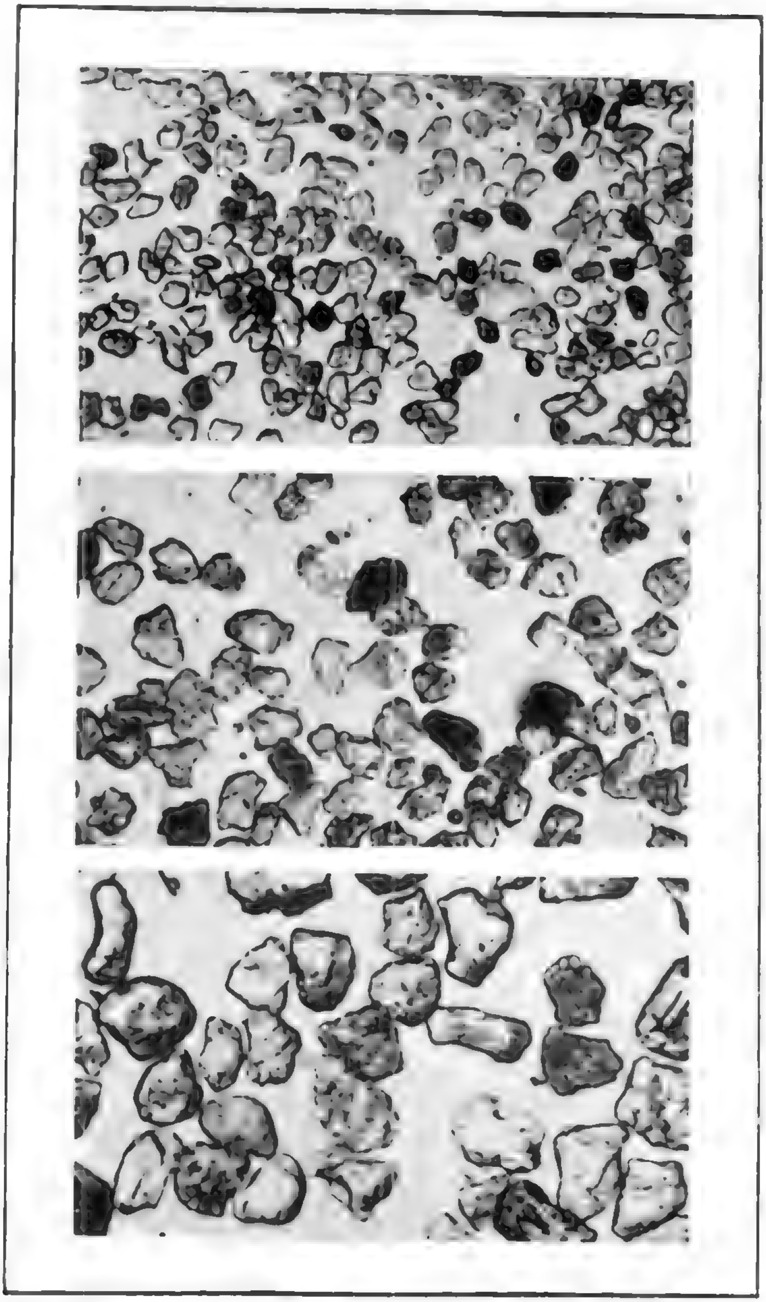
(ii) Heavy mineral evidence—Apart from the roundness of the heavy mineral grains these minerals present little evidence of source. The variation in composition of the heavy mineral residues from different parts of the Desert and the rather uniform Index Figure, together with a similarity of grain size throughout the samples examined, suggest that the sands were derived from the parent material without much transport. The wear exhibited by the grains themselves shows that at some stage considerable transportation must have occurred. The sand may have come from the slightly higher surrounding country and come to rest in the desert basin from which it never appreciably moved; alternatively, as Madigan suggests (1938, 524), the sand may be due to the disintegration of sediments, *in situ*, which by the mineralogy of the resulting sands must have come fairly directly from crystalline rocks. The variation in percentage composition of the heavy non-magnetic residues, as shown in fig. 2, indicates that this is a likely possibility. If the sands had been re-worked from underlying sandstones or other rocks, then it is likely that there would be an impoverishment in mineral species, which is not shown in Table III. The Simpson Desert sands contain the same variety of minerals as would be expected in post-Tertiary sands to which newly disintegrated igneous and metamorphic rocks had contributed.

The variation in heavy mineral percentages suggests that transportation was not very active during dune formation. It has been thought possible that the river flood-plains to the south-east have contributed to the desert sands (Madigan 1938). Transport of large quantities of sand would have been reflected in the heavy minerals, first by a marked decrease in the index figure in the direction of movement, *i.e.*, in the north-west; and secondly, by the disappearance of prismatic grains such as amphibole and sillimanite which do not "carry" so well as the more equidimensional grains, but amphibole and sillimanite are at their maximum percentages in the samples from the middle and west.

Active transportation would also result in marked differences in the grain size and the sorting of sands from different parts of the Desert. Table II and fig. 1 show that there are very few of these differences.

2 Primary Source of Sand Grains

Reasons have been given in 1 for considering that the last parent rock of the Desert sands may have been a sediment. Whether this is correct or not, it is evident that the heavy minerals must have originated in crystalline rocks which are similar to those strongly developed north, west, and south of the Desert area. Possible source-rocks for a number of the heavy minerals occur in these peripheral regions; *e.g.*, amphiboles, epidote, zoisite and garnet in the MacDonnell Ranges, and corundum in the schists of the Mount Painter area. Gneisses and granites are indicated by the abundant zircon. Tourmaline indicates that the source rocks included pegmatites and granite.



Photos: H. J. Smith Magnification: 37

PHOTOMICROGRAPHS OF QUARTZ GRAINS FROM SAMPLE 2, MIDDLE OF SIMPSON DESERT

Above, grains from the –250 grade, less than 1/16 mm. in diameter. Note the concentration of heavy minerals (dark) in this grade which represents only ½% of the sand.

Centre, grains from the –115 +250 grade, between 1/8 and 1/16 mm. in diameter. This grade was separated for heavy minerals.

Below, grains from the maximum grade, between 1/4 and 1/8 mm. in diameter. 83% of the sand is made up of this grade.

All grains were boiled in acid to remove the red coating, and were mounted in kerosene, R.I. about 1·46, to show the outlines.

ACKNOWLEDGMENTS

My thanks are due to Dr. C. T. Madigan who very willingly gave the samples of sand described in this paper; to Professor E. de C. Clarke for advice and help during the preparation of this manuscript; and to the University of Western Australia in whose programme of research in Geology initiated by the Commonwealth grant to the Universities this investigation is a part.

APPENDIX

List of Sand and Soil Samples from the Simpson Desert

1 Live sand, Andado Station, west side of desert; dune crest.
2 Live sand, Camp 14, middle of desert; dune crest.
3 Live sand, Camp 44, east side Lake Eyre; dune crest.
4 Live sand, Camp 48, east side Lake Eyre; dune crest.
6221 Soil, 0–12", Goyder's Lagoon Plain.
6222 Live sand, Camp 20, Kaliduwarry Station, Mulligan River; crest.
6223 Live sand, Camp 8, middle of desert; dune crest, 0–46".
6224 Sand, Camp 8, inter-ridge area, 0–5".
6225 Sand, Camp 8, inter-ridge area, 5–37".
6226 Sand, Camp 8, inter-ridge area, 37–46".
6227 Sand, Camp 8, sand-ridge slope, 0–45".
6228 Sand, Camp 8, crest of ridge, 0–18".
6229 Sand, Camp 8, inter-ridge area, 0–5".
6230 Sand, Camp 8, inter-ridge area, 5–26".
6231 Sand, Camp 8, inter-ridge area, 26–45".
6232 Sand, Camp 19, west of Mulligan River, inter-ridge area, 0–12".
6233 Sand, Camp 19, west of Mulligan River, inter-ridge area, 16–27".
6234 Sand, Camp 19, west of Mulligan River, inter-ridge area, 27–32".
6235 Sand, Camp 19, west of Mulligan River, inter-ridge area, 32–45".
6236 Sand, Camp 42, north of Lake Eyre, inter-ridge area, 0–6".

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REMARKS ON SOME PARASITIC NEMATODES FROM AUSTRALIA AND NEW ZEALAND

By T. HARVEY JOHNSTON and PATRICIA M. MAWSON, University of Adelaide

Summary

During the past year several collections of nematodes have been submitted to us for examination. Amongst them were many from birds from Dunedin and Invercargill in southern New Zealand, the material having been forwarded to us by Miss Marion Fyfe, Zoology Department, University of Otago. H. McL. Gordon, of the MacMaster Veterinary Research Institute, Sydney, sent us oxyurids from a Fijian lizard, Brachylophus faciatus. Messrs. K. Sheard, of the C.S.I.R. Fisheries Laboratory, Cronulla, and A. Rau, of the South Australian Museum, forwarded viscera from some fish. Mr. J. M. Holtham, of Narrung, sent us specimens and information relating especially to worm infestation of fish in the lakes near the mouth of the Murray. Mr. G. G. Jaensch assisted us in regard to material from the Murray swamps at Tailem Bend. To all of these collaborators we express our thanks. The study was carried out in connection with the Commonwealth Research Grant to the University of Adelaide. Types of new species have been deposited in the South Australian Museum, Adelaide.

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[Read 11 May 1944]

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List of Hosts and Parasites mentioned in this Paper.

BIRDS

PHALACROCORAX BREVIROSTRIS Gould — *Contracaecum spiculigerum* (Rud.) *Cosmocephalus jaenschi* Johnston and Mawson, New Zealand.

PHALACROCORAX CARBO L. — *Procamallanus murrayensis* Johnston and Mawson. Tailem Bend, S.A. (probably ingested with its fish host).

SULA SERRATOR Gray—*Contracaecum magnicollare* Johnston and Mawson; *Contracaecum* sp. immature, New Zealand.

NINOX NOVAESEELANDIAE Gmelin—*Heterakis gallinae* (Gmelin), probably ingested with its avian host; **Capillaria strigis** n. sp., New Zealand.

EUDYPTULA MINOR Forst.—*Contracaecum* sp. immat., New Zealand.

EMBERIZA CITRINELLA Linn. — *Capillaria emberizae* Yamaguti, New Zealand (introduced species).

GYMNORHINA TIBICEN Latham—*Diplotriaena clelandi* (Johnston), Burnett River, Queensland.

PELAGODROMA MARINA Lath.—*Seuratia marina* Johnston and Mawson, Bass Strait.

REPTILES

BRACHYLOPHUS FASCIATUS—**Alaeuris brachylophi** n. sp., Fiji (via Sydney).

AMPHIBIA

HYLA AUREA Lesson—*Spironoura simpsoni* nom. nov., for *S. hylae* Johnston and Simpson, N.S.W.

FISH

GALAXIAS ATTENUATUS Jenyns—*Eustrongylides gadopsis* (larva), *Contracaecum* sp. (larva), Lake Alexandrina, S.A.

SALMO FARIO L.—*Eustrongylides gadopsis*, Murray Bridge, S.A.

RETROPINNA SEMONI Weber—*Eustrongylides gadopsis*, Tailem Bend, S.A.

AGONOSTOMUS FORSTERI Cuv. and Val.—*Eustrongylides gadopsis*, Lake Alexandrina and Tailem Bend.

PLECTROPLITES AMBIGUUS Rich.—*Eustrongylides gadopsis*, Lake Alexandrina.

THERAPON (BIDYANA) BIDYANA Mitchell—*Eustrongylides gadopsis*, Lake Alexandrina.

SERIOLA GRANDIS Casteln.—*Capsularia marina* L., Rapid Bay, S.A.

THREPTERIUS MACULOSUS Rich.—*Contracaecum legendrei* (larva), **Cucullanellus sheardi** n. sp., **Ascarophis australis** n. sp., Cape Borda, S.A.
UPENEICHTHYS POROSUS Cur. and Val.—*Contracaecum legendrei* (larva), Port Lincoln, S.A.
LEPIDOPUS CAUDATUS Euphr.—*Capsularia marina* L.; **Capillaria lepidopodis** n. sp., St. Vincent Gulf, S.A.

Alaeuris brachylophi n. sp.

Fig. 1-3

The following description is based on specimens forwarded to us for identification by Mr. H. Gordon of the McMaster Veterinary Research Laboratory, Sydney. They were taken from a lizard, *Brachylophus fasciatus,* from Fiji.

The males are 1·5 mm. – 3 mm. in length, the females 3·5 – 4·5 mm. The oesophagus is very long and thin, ending in a somewhat pyriform bulb, the entire organ being about half the body length in the male, and two-fifths in the female. The nerve ring is very near the anterior end, ·2 mm. in the female; the excretory pore is just prebulbar in both sexes.

The spicule of the male is about ·6 mm. long, very stout for the greater part of its length but tapering in the distal quarter to a fine point. The V-shaped gubernaculum is strongly chitinised. The caudal alae are wide and extend to the extremity of the tail. There are three pairs of perianal papillae, and one pair at the extreme tip of the tail.

The vulva in the female lies at about the middle of the body; the eggs are about 130 – 150 μ by 60 – 70 μ. The tail is ·3 mm. long.

The species is placed in the genus *Alaeuris* because of the single spicule and the presence of gubernaculum and caudal alae. It differs from the four previously described species of this genus chiefly in the extent of the caudal alae and the size of the spicule.

HETERAKIS GALLINAE (Gmelin)

From *Ninox novaeseelandiae,* from Invercargill and Dunedin, New Zealand. The parasite has not previously been recorded from a bird of prey; it is more than probable that these specimens were accidentally ingested with the food of the host.

CONTRACAECUM MAGNICOLLARE Johnston and Mawson 1941

This species is now recorded from a gannet, *Sula serrator,* from Dunedin, New Zealand. It was originally taken from *Anous stolodus* from Queensland. In the original description the length of the spicules was inadvertently omitted; they are 1 : 3 – 3·6 of the body length.

CONTRACAECUM SPICULIGERUM (Rud.)

From *Phalacrocorax brevirostris* from Dunedin. As far as we are aware this species has not previously been recorded from this host, although it appears to be the common ascarid parasite of cormorants in many parts of the world.

In a previous communication we recorded it from cormorants on the sub-antarctic islands of New Zealand (Johnston and Mawson 1943).

CAPSULARIA MARINA L.

A larval worm apparently belonging to this species was taken from a king-fish, *Seriola grandis,* caught at Rapid Bay, and from *Lepidopus caudatus,* washed ashore at Glenelg, South Australia.

CONTRACAECUM (THYNNASCARIS) LEGENDREI Dollfus

Young stages of this worm were taken from the "silver spot", *Threpterius maculosus,* caught at Cape Borda; and from *Upeneichthys porosus* from Port Lincoln, South Australia.

CONTRACAECUM spp. (larvae)

1 Immature specimens of *Contracaecum*, probably ingested along with fish, were obtained from *Sula serrator* and *Eudyptula minor* from Dunedin. The arrangement of the lips resembled that of *Phocascaris* sp. and no doubt represented an immature stage before the typical condition present in *Contracaecum* had become established.

2 From *Galaxias attenuatus*, Lake Alexandrina. About twenty small worms obtained, all with three larval lips, but without larval tooth. Length, 8·4–10·5 mm.; breadth, 3·3–3·6 mm.; oesophagus one-tenth body length; oesophageal appendix: length of oesophagus = 1 : 1·3; length of intestinal caecum: oesophageal appendix = 1 : 1·6 – 1·8.

SEURATIA MARINA Johnston and Mawson

In the original description (1941) of this species from the small petrel, *Pelagodroma marina*, from Flinders Island, Bass Strait, the lengths given for the spicules are incorrect, due to an error in the position of the decimal points. They should read ·14 and ·24 mm. respectively.

COSMOCEPHALUS JAENSCHI Johnston and Mawson

A female was identified from *Phalacrocorax brevirostris* from Dunedin. The species was originally described (1941) from males from *P. carbo* from South Australia. Subsequently a female worm from *Pelecanus conspicillatus*, also from South Australia, was identified with the species, although its cervical papillae were bicuspid, while those of the male were tricuspid. In the present material, one female, the cervical papillae are bicuspid.

Ascarophis australis n. sp.

Fig. 4-5

A number of specimens of an apparently new species of *Ascarophis* were obtained from a "silver spot," *Threpterius maculosus*, caught by Mr. K. Sheard off Cape Borda, South Australia. The body of the female is swollen in the posterior third which contains the uteri; and this is especially marked in older females, which at first glance suggest members of the genus *Capillaria*. The males are 6 – 6·5 mm. long, the females up to 25·5 mm. long, 120 μ wide anteriorly, 200 μ wide posteriorly.

The head bears two large lip-like processes. The mouth leads into a long narrow cylindrical vestibule ·15 mm. long, 50 μ wide (measured in the largest female.) The nerve ring surrounds the anterior end of the oesophagus and the excretory pore is shortly behind this. The narrower part of the oesophagus is ·24 mm. in length in the female, and ·17 mm. in the male; the wider posterior part 2·1 mm. in the female, 1·1 mm. in the male.

The ventral surface of the male for a short distance anterior to the cloaca is raised into several longitudinal rows of bosses. The caudal alae appear to be more or less symmetrical, but it was not possible to get a direct ventral view of the entire tail. There are three pairs of preanal papillae, the most anterior of them double-headed, the second and third close together, and six pairs of post-anal papillae arranged as in fig. 5. The spicules are ·08 mm. and ·28 mm. long; a gubernaculum is not present.

In the female the vulva is ·64 mm. in front of the anus; the tail is ·18 mm. long and ends in a knob. The eggs are more or less spherical, 36 μ in diameter and contain a coiled embryo.

The species appears closest to *A. morrhua* Beneden with which it agrees in the appearance of the head and vestibule, but it differs from that species in the position of the vulva.

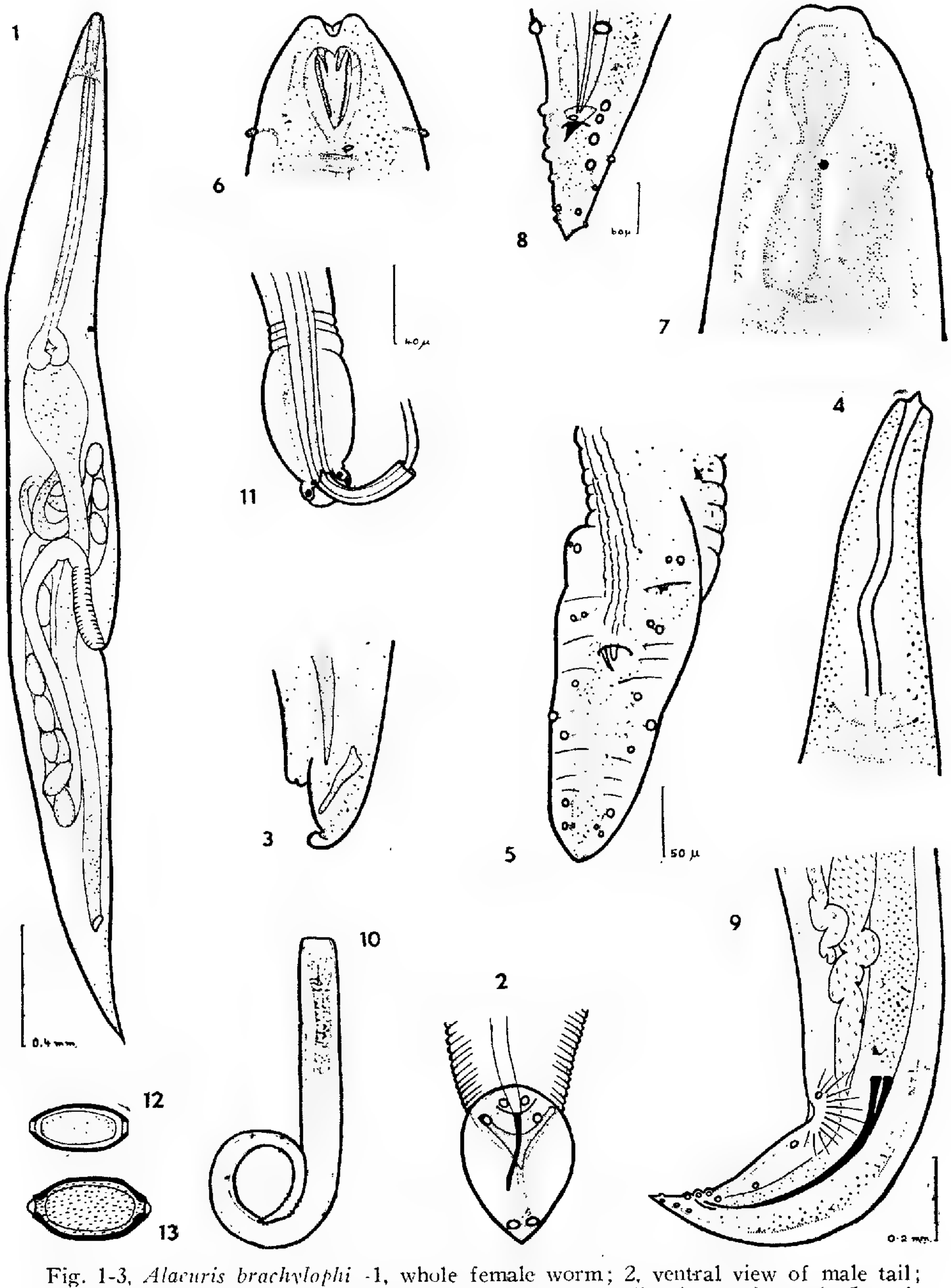

Fig. 1-3, *Alaeuris brachylophi* -1, whole female worm; 2, ventral view of male tail; 3, lateral view of male tail. Fig. 4-5, *Ascarophis australis*—4, anterior end; 5, male tail. Fig. 6-10, *Cucullanellus sheardi*—6 and 7, lateral and ventral views of head; black spot on fig 7 marks position of cervical papilla; 8, tip of male tail in ventral view (young specimen); 9, male tail; 10, very young male. Fig. 11, *Capillaria emberizae*, ventral view of male tail. Fig. 12, *Capillaria strigis*, egg. Fig. 13, *Capillaria lepidopodis*, egg. Fig. 2, 3, and 5 to same scale; fig. 4, 11, 12, and 13 to same scale; fig. 6, 7, 9, and 10 to same scale.

PROCAMALLANUS MURRAYENSIS Johnston and Mawson

A male was collected from the cormorant, *Phalacrocorax carbo,* from Tailem Bend. It must have been ingested with its normal fish host. It was 9·2 mm. long, the male being recorded in the original account (1940) as 4 to 5 mm. in length.

Cucullanellus sheardi n. sp.

Fig. 6-10

From *Threpterius maculosus* from Cape Borda (coll. K. Sheard) and the Althorpe Islands (Adelaide fish market). Stout worms, tapering from the level of the base of the oesophagus backwards; the young forms, of which several are present, markedly nail-shaped, tapering from the truncated head end to a pointed tail (fig. 10). Males to 2·4 mm., females to 4 mm. Cuticle very thick. Oesophagus ·64 mm. long in female, ·52 mm. in male, greatly widened anteriorly and with a marked constriction at level of nerve ring. Intestinal caecum reaches to nerve ring. Excretory pore and cervical papillae at about level of nerve ring, ·36 mm. from head in female and ·22 mm. in the male. In the male, spicules ·55 mm. long; 11 pairs of caudal papillae and sometimes one or two additional pairs anterior to the sucker; in young worms a single more or less dorsally-situated papilla observed more anteriorly still—shown in very young male in fig. 10. On the female tail are two large papillae situated at the beginning of the second half. Vulva 1 mm. from the tail. Eggs 63 μ x 39 μ.

The species is apparently very close to *C. fraseri* Baylis, from which it may be distinguished by the arrangement of caudal papillae in the male (the three adanal with one laterally from the first and another laterally from the third), by the more posterior position of the vulva, and by the relatively greater length of the spicules.

Spironoura simpsoni nom. nov.

Dr. H. A. Baylis, in a private communication, has kindly drawn our attention to the fact that *Spironoura hylae* Johnston and Simpson 1943 is a nom. praeocc., having been used by Reiber, Byrd and Parker, 1940, for a parasite from *Hyla* spp. We therefore suggest *S. simpsoni* as a new name for the species parasitic in *Hyla aurea* from Sydney.

DIPLOTRIAENA CLELANDI (Johnston 1912)

In 1912 *Filaria clelandi* was described by the senior author from a single male specimen. The type is not at present available, but from the drawings and description the species obviously belongs to the genus *Diplotriaena.* From the brief account given, it is impossible to say whether any of the *Diplotriaena* spp. since described are referable to *D. clelandi;* this point may be cleared up by the examination of further material from the type host, *Gymnorhina tibicen.* The specimen was collected at Eidsvold, Burnett River, Queensland.

EUSTRONGYLIDES GADOPSIS Johnston and Mawson

This long larval worm was first described (1940) from *Gadopsis marmoratus* from New South Wales and was recorded from a perch, probably *Plectroplites ambiguus,* from Northern Queensland. Baird's *Filaria sanguinea* from *Galaxias scriba* from the Murray, and Linstow's *Spiroptera bicolor* (1889) from *G. attenuatus* from the Adelaide district were also placed under it. *E. galaxias,* a larval form from *Galaxias olidus* from the vicinity of Adelaide was regarded as a distinct, but closely allied, form. We think it probable that *E. gadopsis* and *E. galaxias* are synonyms and represent the larval stage of *E. phalacrocoracis* Johnston and Mawson 1941, which was recorded from two species of cormorants, *Phalacrocorax melanoleucus,* and *P. carbo* in 1941, and later (1942) from *P. fuscescens,* all from South Australia. Our attempts to infect freshwater fish with eggs of *E. phalacrocoracis* have been unsuccessful.

Mr. J. M. Holtham, of Narrung, sent us larval material from the congolli, *Pseudaphritis urvillei;* callop, *Plectroplites ambiguus; Galaxias attenuatus;* and Murray bream, *Therapon bidyana;* all from Lake Alexandrina. He also forwarded an adult from *Phalacrocorax melanoleucus* from the same locality. He informed us that the same species of larva occurred in the mullet, *Agonostomus forsteri.* Mr. E. Deed told us that he had observed the larva in the introduced trout, *Salmo fario,* in the vicinity of Murray Bridge. We have taken it from *Philypnodon grandiceps, Retropinna semoni,* and *Pseudaphritis urvillei* from the swamps at Tailem Bend.

In a larva forwarded by Mr. Holtham the six inner lips are well developed, each bearing a large conical papilla. Behind these is a ring of six rounded papillae. None was seen on the lateral lines. The buccal cavity measures ·13 mm. long, and the oesophagus 12 mm. in length in a worm 102 mm. long. The specimens differed from those previously described by us in the shorter length of the buccal cavity and in the greater development of the lips whose condition was much more suggestive of that which we figured for the adult *Eustr. phalacrocoracis.*

In 1819 Rudolphi described *Filaria cystica* from a Brazilian freshwater fish, *Symbranchus laticaudus.* Leuckart (1876, 381) referred to Rudolphi's parasite and associated with the same species two worms collected from *Galaxias* by Schomburgk and identified previously as *F. cystica* by Schneider (1866), who considered the species to be the larval stage of *Eustrongylus gigas.* Leuckart figured a specimen from *Galaxias,* the worm being 75 mm. long and 0·6 mm. in maximum diameter, and considered the parasites to belong to the same species as Rudolphi's *F. cystica,* and to be larval stages of *Eustrongylus.* His remarks imply that Schomburgk's material came from Guiana. Cobbold (1879, 209) referred to *F. cystica* as being the young stage of *Eustrongylus gigas.* Shipley in the Cambridge Natural History (2, 1896, 142) mentioned *Galaxias scriba* and *Symbranchus laticaudatus* as hosts for *F. cystica.*

Baird's identification (1861) of the red worms from *Galaxias scriba* from the Murray as *Fil. sanguinea* Rud. has been mentioned by us in our account of *Eustrongylides gadopsis* (Johnston and Mawson 1940, 350), as also has Linstow's identification of material from *Galaxias attenuatus* (collected by Schomburgk in Adelaide, and housed in the Berlin Museum) as *Spiroptera bicolor.*

Leuckart's association of *Galaxias* with the name of Schomburgk and with Guiana as a locality may be explained by the fact that the latter botanist in 1840-42 accompanied his brother during the delimitation of the boundary of British Guiana, but R. Schomburgk came to South Australia in 1848 and was Director of the Adelaide Botanic Garden from 1866 to 1890—hence the locality mentioned by Linstow (1899, 17) for the material. *G. scriba* is a synonym of *G. attenuatus.* Gunther (Introduction to the Study of Fishes, 1880, 625) reported that the genus *Galaxias* occurred in New Zealand, Southern Australia, Tasmania and the extreme south of South America, hence Guiana can be excluded as a habitat for fishes of the genus. Miss Cram (1927, 368) was in error in quoting Rudolphi as recording *G. scriba* as a host for *Fil. cystica.* Jägerskiöld (1909) noted that the larvae from *G. scriba* resembled *Eustr. ignotus,* but we have not been able to consult his paper. Yamaguti (1941, 345) described larvae from a Japanese fish, *Rhinogobius similis.*

Available evidence has led us to believe that, for the present, the species occurring as larvae in Southern Australian freshwater and estuarine fish should be listed under *E. gadopsis.*

Capillaria strigis n. sp.

Fig. 12

From *Ninox novaeseelandiae,* Invercargill. One male specimen, 12 mm. long, with oesophagus 4·7 mm. long, width of body at head 11 μ, at base of oesophagus 54 μ, and at the widest part of the body 63 μ. The spicules are exceedingly long, the distal ends, which are poorly chitinised, lying just posterior to the oesophagus. There is apparently no bursa-like structure, the posterior end being simply rounded.

Capillaria emberizae Yamaguti

Fig. 11

Both males and females of a species of *Capillaria* were taken from *Emberiza citrinella* from Dunedin. Males about 13 – 13·5 mm. long, females to 14 mm. Ratio of oesophageal to post-oesophageal region = 1 : 2·4 in both sexes. Breadth across head 9 μ in the female, 8 μ in the male; at base of oesophagus 54 μ in female, 45 μ in male; at widest part of body 72 μ in female, 54 μ in male; across anal region 30 μ in female, 36 μ in male. Anus 16 μ from posterior end in female. Egg, 22 μ by 54 μ. Cuticle at posterior end of male swollen to form two lateral "alae" 6 μ long, which at the extremity of the worm are constricted and give place to a small "bursa" containing two pairs of papillae. Spicule 1·26 mm. long; sheath not spinous.

The specimens differ from *Capillaria emberizae* Yamaguti 1941 from *Emberiza* spp. from Japan in the form of the bursa and the ratio of body parts in the female, but otherwise agree with it.

Capillaria lepidopodis n. sp.

Fig. 13

A single female worm, of which the posterior extremity is missing, was taken from *Lepidopus caudatus* from St. Vincent's Gulf. The worm is 25·2 mm. long, the oesophagus 7·1 mm. long, the rest of the body 18·1 mm. at least (worm much coiled and tip of tail missing), so that the ratio of anterior to posterior parts of body is about 1 : 3. The width at the head is 11 μ, at base of oesophagus 54 μ, at widest part 72 μ. The vulva is a simple opening situated just behind oesophagus; the eggs are 30 μ x 60 μ, their shells marked with fine irregular grooves.

According to the method of identification of *Capillaria* spp. from fish, devised by Heinze 1933, this species falls into the group in which females are longer than 10 mm.; this group comprises *C. gracilis* (Bellingh.), *C. fritschi* (Trav. 1914), and *C. pterophylli* Heinze 1933. Of these it is distinguished from *C. pterophylli* and *C. gracilis* by the shape of the egg, and from *C. fritschi* by the absence of papillae on the cuticle.

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A CONTRIBUTION TO THE KNOWLEDGE OF THE MICROCOTYLIDAE THE OF WESTERN AUSTRALIA

By DOROTHEA F. SANDARS, M.Sc., Hackett Student, University of Western Australia

Summary

The measurements (taken from specimens mounted in balsam) are the average for several parasites where possible, and those of the type specimen are given in brackets. The parasites were fixed in Kleinenberg's picric acid; acetic acid alum carmine was the commonly used stain, but cochineal alum carmine was also utilised. 70% alcohol saturated with chlorine gas was used as a destaining agent with both stains. Borax carmine was also used, followed by weak acid alcohol as the destaining agent.

A CONTRIBUTION TO THE KNOWLEDGE OF THE MICROCOTYLIDAE OF WESTERN AUSTRALIA

By Dorothea F. Sandars, M.Sc.,
Hackett Student, University of Western Australia

[Read 11 May 1944]

Introduction

The following is a list of the hosts and the respective parasites obtained from them:

Gerres ovatus Waite—*Microcotyle gerres* n. sp.
Pentapodus milii Bory St. Vinc.—*Microcotyle pentapodi* n. sp.
Scorpis aequipinnis Richdon.—*Microcotyle scorpis* n. sp.
Helotes sexlineatus Q. & G.—*Microcotyle helotes* n. sp.
Caranx georgianus Cuv. Val.—*Gonoplasius carangis* n. g., n. sp.
Agonostomus forsteri Cuv. Val.—*Diplasiocotyle johnstoni* n. g., n. sp.

The measurements (taken from specimens mounted in balsam) are the average for several parasites where possible, and those of the type specimen are given in brackets. The parasites were fixed in Kleinenberg's picric acid; acetic acid alum carmine was the commonly used stain, but cochineal alum carmine was also utilised. 70% alcohol saturated with chlorine gas was used as a destaining agent with both stains. Borax carmine was also used, followed by weak acid alcohol as the destaining agent.

Appreciation is expressed for the co-operation of the Government Fisheries Department, which has been very useful in this work, especially under the present conditions due to war-time restrictions. The writer would also like to express thanks to Professor G. E. Nicholls for his help and encouragement; to Miss O. Goss for guidance, and to Professor T. Harvey Johnston for assistance in preparing this paper for publication.

Microcotyle gerres n. sp.

(Fig. 1-3)

From the gills of the silverfish, silverbelly or roach, *Gerres ovatus,* from Mandurah. The gills of the host species were examined frequently during a period from the middle of February to the middle of June, 1943. The parasites were not numerous at any time, nor does there appear to be any period when their occurrence is more prevalent. The maximum taken from one fish was three. Of 52 fish examined only 15 had parasites, only one Microcotylid being present in most cases.

M. gerres is a small, elongated form, having a total length 2·43 mm. (2·35) and a maximum breadth of 0·36 mm. (0·37) across about the middle of the genital complex. Body tapering slightly towards both ends. Body width across region of oral sucker 0·14 mm.; across region of penis 0·20 mm. Cotylophore distinctly demarcated from rest of body; 1·07 mm. (0·98) long, hence about two-fifths of total body length. Fifty pairs of posterior suckers on cotylophore, varying in size from anterior to posterior; anterior having width of 0·038 mm. (0·037), those at about the middle length 0·058 mm. (0·062), and those posteriorly 0·042 mm. (0·050); the length in each case being 0·025 mm. (fig. 3).

Oral suckers approximately circular, 0·063 mm. diameter, without transverse septa. Three groups of "sticky" glands near mouth and anterior to oral suckers (fig. 1). Buccal cavity large; pharynx circular 0·037 mm. diameter; oesophagus 0·125 mm. long with lateral diverticula and dividing just in front of penis, at 0·20 mm. from anterior end of body; intestinal canals with numerous lateral diverticula and extending 0·63 mm. into cotylophore (fig. 1).

Brain rectangular, at 0·13 mm. from head end; a pair of small nerves passing forwards from its anterior corners; a pair of longitudinal nerves and a pair of smaller nerves given off posteriorly (fig. 1).

Sixteen testes, subcircular, average diameter 0·375 mm., occupying intervitelline field 0·63 mm. long, approximately the posterior half of body anterior to cotylophore; several of most anterior lying beside part of main genital complex. Vas deferens, wide, running from anterior end of testicular field in an almost straight course to penis; anterior end of latter 0·187 mm. from anterior end of body (fig. 1). This Microcotylid is peculiar in that it possesses no genital armature, there being merely a chitinous penis, which, when extended, has a length of 0·046 mm. (0·037) (fig. 2).

Ovary median, differing from the typical ovary in that it begins on the left side of the intervitelline field about half-way up the genital complex, and curves over to the right, the oviduct then passing posteriorly to be joined by the common vitelline duct. Vitellarium arising 0·24 mm. from anterior end of body, occupying two lateral fields which join behind testicular field and extend 0·65 mm. (0·63) into cotylophore. Vitelline ducts arising laterally at unequal distances from anterior end; left and right ducts leaving vitellarium at 0·96 mm. and 0·88 mm. respectively from anterior end of worm; common vitelline duct passing posteriorly for 0·04 mm. to unite with oviduct; genito-intestinal canal passing to the left. Uterus thin-walled, straight, dorsal, passing forwards to open by pore at anterior end of penis (fig. 1).

M. gerres appears to be a rather distinct form, bearing perhaps the closest resemblance to *M. sillaginae* Woolcock (1936) and *M. parasillaginae* Sandars (1944). There are, however, many outstanding differences between these forms, as shown in the table (measurements in mm.).

TABLE I

	Total Body Length	Length of Cotylophore	Pairs and Size of Posterior Suckers	Size of Oral Suckers	Oral Suckers with or without Septa	No. of Testes	Length of Penis	Genital Atrium Armature	Relation of Intestinal Bifurcation to Atrium
M. gerres ..	2·43	1·07 Ca. $\frac{2}{5}$ Body length	50; Vary.: Ant. 0·038, Mid. 0·058, Post. 0·042	0·063 Diam.	Without	16	·046	Absent	Anterior
M. sillaginae ..	4·0	Half-length or more	32; ·05–·07 wide	·08 x ·04	With	11	·027, plus Papilla	Absent	Anterior
M. parasillaginae	2·15	Ca. $\frac{1}{3}$ length	25–27; Constant ·064	·08 x ·048	With	14	·048, No Papilla	Present	Posterior

Microcotyle pentapodi n. sp.

(Fig. 4-7)

From the gills of the butterfish, *Pentapodus milii,* from Rockingham. The gills of several hosts were examined during January 1943, and all were heavily infected with Microcotylids. Examination from 23 to 26 April 1943 showed the fish to be infected, 0–5 parasites being obtained from each fish. No systematic investigation could be carried out, but examinations indicated the Microcotylids as being more numerous during summer months and decreasing in April.

M. pentapodi is a small, elongated, slender form, 2·06 mm. (2·14) long; maximum width 0·25 mm. at approximately half-way along the body proper; body tapering towards both ends; body width 0·2 mm. at level of genital armature;

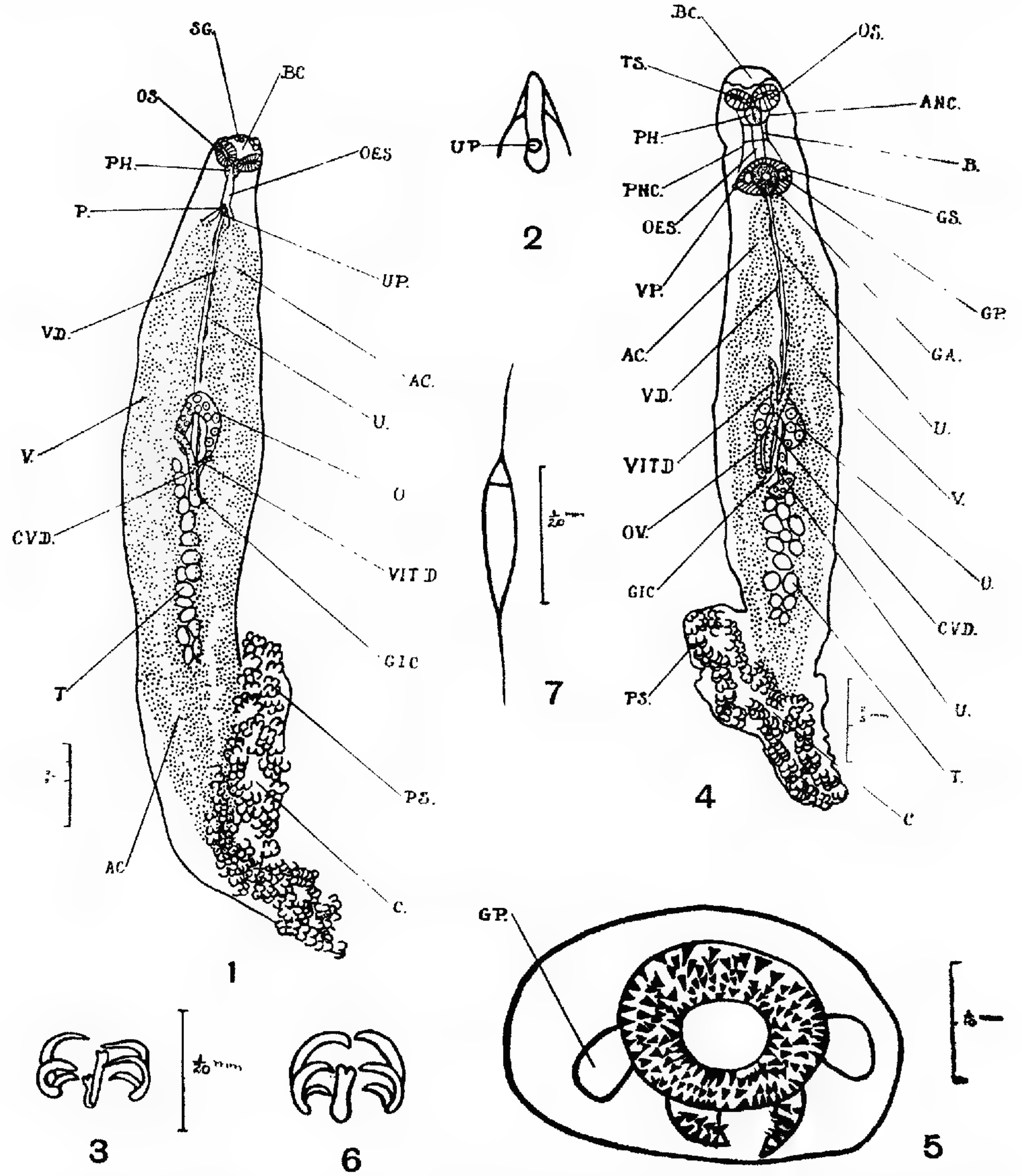

Fig. 1-7—1-3, *Microcotyle gerres:* 1, whole specimen; 2, penis; 3, skeleton of posterior sucker. 4-7, *Microcotyle pentapodi:* 4, whole specimen; 5, genital armature; 6, skeleton of posterior sucker; 7, egg.

0·16 mm. across oral suckers. Cotylophore sharply demarcated from rest of body, 0·623 mm. (0·617) long, anterior border 0·04 mm. (0·05) wide, 0·023 mm. (0·016) long (fig. 6).

Oral suckers with transverse septa; width 0·063 mm. (0·066); length 0·052 mm. (0·05). Buccal cavity large, opening anteriorly; pharynx 0·033 mm. wide, 0·05 mm. long; oesophagus passing anteriorly for 0·22 mm., then bifurcating immediately behind genital sucker, uniting again in cotylophore and extending into it for 0·25 mm.; lateral diverticula present (fig. 4).

Fifteen circular testes in intervitelline field; latter approximately one-fifth of body length, 0·059 mm. (0·066) diameter in middle of testicular field, 0·046 mm. (0·05) diameter at both ends. Vas deferens thick-walled, wide, passing anteriorly and medially in a sinuous course to genital atrium 0·24 mm. from head end of worm. Atrium unusual in being completely surrounded by a large sucker (genital sucker), 0·125 mm. (0·15) maximum width, 0·1 mm. maximum length. Atrial hooks approximately central in atrium and forming complete circlet, 0·06 mm. wide, 0·05 mm. long, 0·24 mm. (0·25) from anterior end of body. Two curved rows of hooks arranged lengthwise occur posteriorly to this. All hooks extremely small. Atrial cavity with two lateral pockets, diameter approximately 0·025 mm., outside the armature of spines (fig. 5).

Median ovary arising near anterior testes and passing forwards to form enlarged broad curved portion, thence transversely and backwards. Vitellarium commences 0·35 mm. (0·38) from anterior end of body, uniting behind testicular field and extending 0·32 mm. (0·28) into cotylophore. Paired vitelline ducts 0·16 mm. long, originating 0·83 mm. from head end, uniting as common vitelline duct 0·15 mm. long, joined by oviduct; genito-intestinal canal, passing to left. Uterus thin-walled, straight, opening into genital atrium between two curved rows of hooks, posterior to vas deferens. Posteriorly to left of genital pore, 0·3 mm. from anterior end of worm, a single pore (probably vaginal) opens (fig. 4).

Egg single, oval, with appendage 0·15 mm. at each end, observed in uterus; egg length (excluding appendages) 0·2 mm., width 0·05 mm. (fig. 7).

M. pentapodi appears to be related to *M. ditrematis*, which Yamaguti (1939) related to *M. incisor* Linton (1910). It differs from *M. ditrematis* in the genital atrium, which, although apparently of a related type in both, shows obvious differences. Both bear saccular outgrowths; in *M. ditrematis* single and armed; in *M. pentapodi*, paired and unarmed. It also shows some resemblances in general structure to the group *M. elegans* and *M. sebastis* Goto (1895), *M. hiatulae* Goto (1899), *M. australiensis* MacCallum (1921), *M. bassensis* Murray (1931),

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ABBREVIATIONS

AC, alimentary canal; AGS, anterior glandular structure; ALH, anterior large hooks; ANC, anterior nerve cord; ANT, anterior; B, brain; BC, buccal cavity; C, cotylophore; CI′, cilia of 1st region of body of larva; CI″, cilia of 2nd region of body of larva; CI‴, cilia of 3rd region of body of larva; CVD, common vitelline duct; DGS, duct connecting glandular structures; DS, dorsal sucker; E, egg; E′, eyespot; EC, excretory canal; EP, excretory pore; EV, excretory vesicle; GA, genital atrium; GC, genital complex; GD, genital duct, GH, genital hooks; GIC, genito-intestinal canal; GP, genital pockets of atrium; GS, genital sucker; H, hooks; I, intestine; M, mouth (fig. 25-30 miracidium): MB, muscular base; O, ovary; O′, developing ovary; OES, oesophagus; OS, oral sucker; OSH, hooks of oral sucker; OV, oviduct; P, penis; PGS, posterior glandular structure; PH, pharynx; PNC, posterior nerve cord; PS, posterior sucker; RS, receptaculum seminis; SH, small hooks; SO, shell gland and ootype; SPS, small posterior sucker; T, testes; T′, tail; TS, transverse septum; U, uterus; UP, uterine pore; V, vitellarium; VC, vaginal canal; VD, vas deferens; VITD, vitelline duct; VP, vaginal pore.

M. temnodontis Sandars (1944). These vary in structure of the genital atrium. Other differences shown in the table (measurements in mm.).

TABLE II

	Total Length	Length of Cotylo-phore	Pairs and Size of Posterior Suckers	Oral Suckers, With or Without Septa	Genital Atrium With or Without Sucker	No. of Testes	Vitellarium extends into Cotylo-phore
M. pentapodi ..	2.06	0.62	24–25; .04 x .023	With	With	15	0.32
M. ditrematis ..	3.4–4.5	1.2–2.1	39–44; .06–.08	With	Without	22–25	Almost to Post. End
M. temnodontis ..	2.72	0.72	55; .016 x .32	Without	Without	21	0.08
M. australiensis ..	4.0	1.4	Numerous; ?	?	Without	25	?
M. sebastis	5.50	1.83	29; .068–.128	With	Without	40	Nil
M. elegans	4.0	1.3	50: .04–.063	With	Without	27	?
M. victoriae ..	4.82	Ca. 1.2	21; ?	With	Without	18–22	?
M. hiatulae	3.5		23; ?	?	Without	15	Nil

Microcotyle scorpis n. sp.

(Fig. 8-10)

From the gills of the sweep, *Scorpis aequipinnis,* from Safety Bay. In January 1943, from the gills of the only sweep examined, six Microcotylids were collected. No further specimens could be obtained, hence no systematic examination could be made.

M. scorpis is a broad, compact form of total length 2·67 mm. (2·68), maximum breadth (at level of ovarian curve) 0·66 mm. Body tapering anteriorly to 0·38 mm. from front of body, then narrowing conspicuously. Body width across genital armature 0·22 mm.; across oral suckers 0·20 mm. Body not tapering posteriorly; cotylophore not distinctly separated (fig. 8). Cotylophore of total length 0·83 mm. (0·81); width across anterior border 0·63 mm., across posterior border 0·09 mm. Twenty suckers along left border of cotylophore which is 0·63 mm. long, 34 along right border which is 0·94 mm. Each sucker 0·037 mm. long, 0·062 mm. (0·05) wide (fig. 10).

Oral suckers, without transverse septa, maximum width 0·07 mm. (0·075), length 0·062 mm. Mouth aperture at anterior end. Circular muscular pharynx, diameter 0·037 mm., leading into oesophagus 0·125 mm. long; latter bifurcating immediately anterior to region of genital atrium; latter 0·24 mm. from anterior end of body. Intestinal canals with numerous lateral diverticula and extending 0·5 mm. into cotylophore, but left arm 0·13 mm. longer than right arm (fig. 8). Anterior portion of both longitudinal excretory ducts run along either side of body (fig. 8).

Brain complex rectangular, dorsal to oesophagus, at 0·13 mm. from anterior of body; one pair of nerves passing forwards, another pair backwards (fig. 8).

Testes 32, irregularly shaped, varying in size from 0.112 mm. wide by 0·025 mm. long, to 0·212 mm. wide by 0·05 mm. long, close together, occupying approximately one-third of total body length posteriorly. Vas deferens thick-walled, fairly wide, winding anteriorly, opening into ventral genital atrium; latter 0·275 mm. from anterior end of body and with an armature of conical hooks curving inwards, length 0·012 mm. Genital armature arranged ovally, maximum width 0·037 mm., maximum length 0·025 mm.

Ovary, maximum length 0·35 mm. median, arising in front of anterior testes, passing forwards to left, bending to right, curving to pass backwards and then joined by common vitelline duct. Vitellarium commencing 0·40 mm. from anterior end of body, occupying both lateral fields, extending 0·44 mm. (0·41) into cotylophore where the two arms join behind the testes. Left vitelline duct arising 0·69 mm. from anterior of body, right 0·56 mm.; left passing 0·38 mm. posteriorly, right 0·50 mm., before joining to form common vitelline duct with length 0·23 mm.; genito-intestinal canal passing to right. Uterus thin-walled, passing posteriorly, then curving forwards to genital atrium (fig. 8).

M. scorpis appears to be most closely related to *M. seriolae* Yamaguti (1939) and *M. reticulata* Goto (1895), the most obvious feature in common being the asymmetry of the cotylophore, whose suckers are in each case more numerous on the right side. The general anatomy of these forms seems to be similar; that of *M. scorpis* most resembling *M. seriolae*. Many differences are shown in the table.

TABLE III

	Total Body Length	Length of Cotylophore	No. of Posterior Suckers	Av. Size of Suckers of Cotylophore	Oral Suckers with or without Septa	Size of Oral Suckers	No. and Form of Testes	Genital Atrium Armature
M. scorpis	2·68	0·83	34 right, 20 left	0·037 long, ·062 wide	Without	0·062 long, x 0·07 wide	32, irregular	Present
M. seriolae	4·1–8·5	1·75–3·5	Right 45–47, left 39–42	0·036–·12 wide	?	0·060–·075 x ·080–·093	80–100, irregular	Absent
M. reticulata ..	6–10	Little more than ⅛ Body length	Right 42, left 23	0·075–·227 wide	Without	?	Numerous, rounded ?	Present

Microcotyle helotes n. sp.

(Fig. 11-14)

From gills of the trumpeter, *Helotes sexlineatus,* from Swan River, at Nedlands, Rockingham, Safety Bay. During January 1943 the gills of several hosts were examined and Microcotylids found. From two from Swan River, in mid-

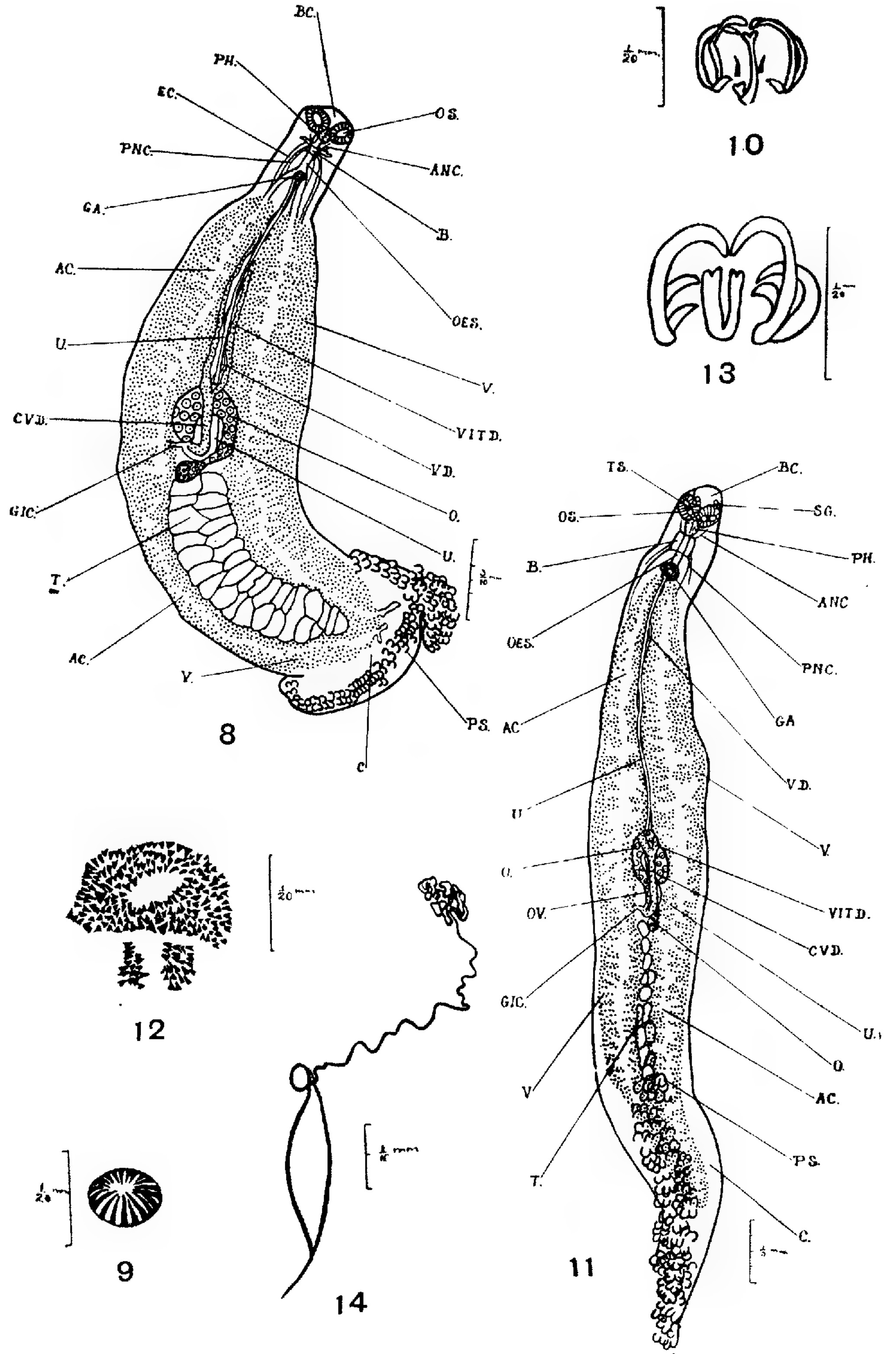

Fig. 8-14—8-10, *Microcotyle scorpis:* 8, whole specimen; 9, genital armature; 10, skeleton of posterior sucker. 11-14, *Microcotyle helotes:* 11, whole specimen; 12, genital armature; 13, skeleton of posterior sucker; 14, egg.

March, 1 and 11 parasites respectively were collected. Of 23 fish from Safety Bay, in early May, two had each one parasite, three had each two.

M. helotes is a medium-sized, elongated form of total length 2·87 mm. (2·69); maximum width (just anterior to commencement of paired vitelline ducts) 0·38 mm. Body tapering anteriorly and posteriorly. Width across oral suckers 0·14 mm.; across genital atrium 0·2 mm. Cotylophore not distinctly demarcated from rest of body; 1·02 mm. (0·81) long; with 32 pairs of suckers, each 0·058 mm. (0·037) wide; 0·033 mm. (0·037) long (fig. 13).

Oral suckers, 0·059 mm. (0·052) wide, 0·071 mm. (0·075) long, with transverse septa. Three groups of "sticky" glands anterior to oral suckers (fig. 11). Buccal cavity opening anteriorly; pharynx circular, diameter 0·038 mm. Straight oesophagus passes 1·187 mm. backwards, dividing shortly behind genital armature, 0·31 mm. from the anterior of body. The two longitudinal arms with numerous diverticula, extending 0·46 mm. into the cotylophore. Brain rectangular, 0·15 mm. from head end; dorsal to oesophagus; one pair of nerves passing anteriorly, two pairs posteriorly (fig. 11).

Fourteen irregular testes approximately 0·05 mm. by 0·054 mm. (0·037), in an intervitelline field 0·625 mm. long, hence one-quarter of body length; most anterior testes extending forwards, laterally to main genital complex. Genital armature of numerous minute hooks; of maximum width 0·087 mm. (0·087), maximum length 0·07 mm. (0·063) situated 0·24 mm. (0·25) from anterior end of body (fig. 12).

Ovary, maximum length 0·3 mm., passing forwards to left, then swinging to right by an enlarged region, then passing backwards to become joined by common vitelline duct. Vitellarium begins 0·34 mm. from anterior of body, occupying both lateral fields, extending into the cotylophore 0·51 mm. (0·46), uniting behind testicular field. Paired vitelline ducts arising laterally 1·06 mm. from anterior end of body, passing posteriorly for 0·06 mm., then joining to form common vitelline duct, 0·175 mm. long; genito-intestinal canal passing to left. Uterus thin-walled, median (fig. 11). Egg seen in uterus only; anterior appendage over 1 mm., posterior 0·06 mm.; body of egg 0·225 mm. long, 0·062 mm. wide (fig. 14).

M. helotes appears to have closest affinities with *M. acanthogobii* Yamaguti (1939). In both the body is fusiform, and the cotylophore is not sharply demarcated from the rest of the body. In *M. acanthogobii* it commences at the level of the posterior testes; in *M. helotes* it begins just anterior to the latter. Testes of both species are of like shape, and are similarly arranged. Major differences are tabulated (measurements in mm.).

TABLE IV

	Total Body Length	Length of Cotylophore	Pairs of Posterior Suckers	Size of Suckers of Cotylophore	Oral Suckers with or without Septa	Size of Pharynx	No. of Testes	Size of Body of Egg
M. helotes	2.87	1.02	32	0.033 x 0.058	With	0.038 diam.	14	0.255 x 0.062
M. acanthogobii .	1.55–3.05	0.62–1.2	20–25	0.08 diam.	With	0.030–.048 x .036–.054	7–12	0.18–.20 x 0.066–.075

Gonoplasius carangis n. g., n. sp.

(Fig. 15-19)

From gills of the skipjack, *Caranx georgianus,* from North Beach, Rockingham. From 24 fish examined between mid-February and mid-July 1943, five parasites were obtained, two from one host, one from each of three others. No parasites were obtained from *Caranx* caught at Mandurah, Bunbury, Augusta and Albany.

G. carangis is a very elongated, narrow form of total body length 4·75 mm.; maximum width of body (anterior to cotylophore) 0·4 mm. in region of genital complex where ovary curves from one side to other; this width continuing forwards for 0·625 mm., then tapering very gradually both anteriorly and posteriorly; width at level of genital armature 0·337 mm.; across oral suckers 0·275 mm. Cotylophore 0·75 mm. long, approximately one-sixth total body length, sharply demarcated from rest of body by increase in width. Anterior border of cotylophore 0·525 mm. wide, posterior border 0·037 mm. Cotylophore with unequal lateral borders; right 0·112 mm. long, bearing 34 small suckers; left 0·56 mm., bearing 17 small suckers, each with characteristic framework (fig. 18); constant length 0·037 mm.; width of anterior suckers 0·062 mm.; middle suckers 0·075 mm.; posterior 0·05 mm. At anterior end of body five conspicuous glandular structures, four large, one small; of three around buccal cavity two are large with maximum width 0·125 mm., length 0·037 mm.; most anterior central glandular structure 0·05 mm. wide, 0·037 mm. long. Close to oesophagus, at 0·162 mm. from anterior of body, two more glandular structures, left with maximum width 0·075 mm., length 0·1 mm.; right with maximum width 0·087 mm., length 0·1 mm. From each, running anteriorly, are two ducts; the inner branches 0·062 mm. from anterior of body, the outside branch in each case going to one of the large anterior structures and the inner to smaller central structure. Each anterior structure has two branches from two posterior groups (fig. 16).

Laterally and dorsally, 1·01 mm. from anterior of body are two pairs of structures of unknown function, appearing as apertures with edges set with minute hooks in a slightly muscular structure (fig. 19). These may be remnants of dorsal suckers in process of disintegration, since *Microcotyle agonostomi, M. canthari, M. alcedinis,* and *M. centrodontis* have small similarly situated suckers.

Buccal cavity at extreme anterior end of body, containing oral suckers with maximum width 0·15 mm., length 0·062 mm., and with transverse septa. Pharynx close to oral suckers, length 0·05 mm., width 0·037 mm. Oesophagus unbranched, total length 0·31 mm. Intestinal bifurcation about middle of genital atrium. Two longitudinal ducts in lateral fields of body have numerous lateral branches, and extend into cotylophore, 0·31 mm. on right and 0·15 mm. on left, beyond vitellarium. At 0·875 mm. from anterior end of body in mid-ventral line, 0·25 mm. posterior to genital atrium, is excretory vesicle, a nearly globular structure with maximum width 0·05 mm., length 0·037 mm. Paired lateral longitudinal ducts connect with vesicle (fig. 15).

Testes 48, rounded, 0·025-0·05 mm. diameter, occupying about one-fifth of total body length in an intervitelline field; vasa efferentia clearly seen between many of the testes; winding vas deferens passing anteriorly centrally; very coiled between excretory vesicle and genital atrium (fig. 15). Genital atrium with complex armature on ventral body surface, 0·387 mm. from anterior end of body; armature of small and large hooks, some set in a muscular base at anterior and posterior ends of atrium and of varying shapes; small hooks distributed between these; large anterior hooks 0·037 mm. long; largest posterior hooks 0·025 mm. long; small hooks in central groups 0·012 mm. Width of anterior part of atrium (with armature) 0·137 mm.; of middle part 0·075 mm.; of posterior 0·125 mm.; maximum length of genital atrium with armature 0·237 mm. (fig. 17).

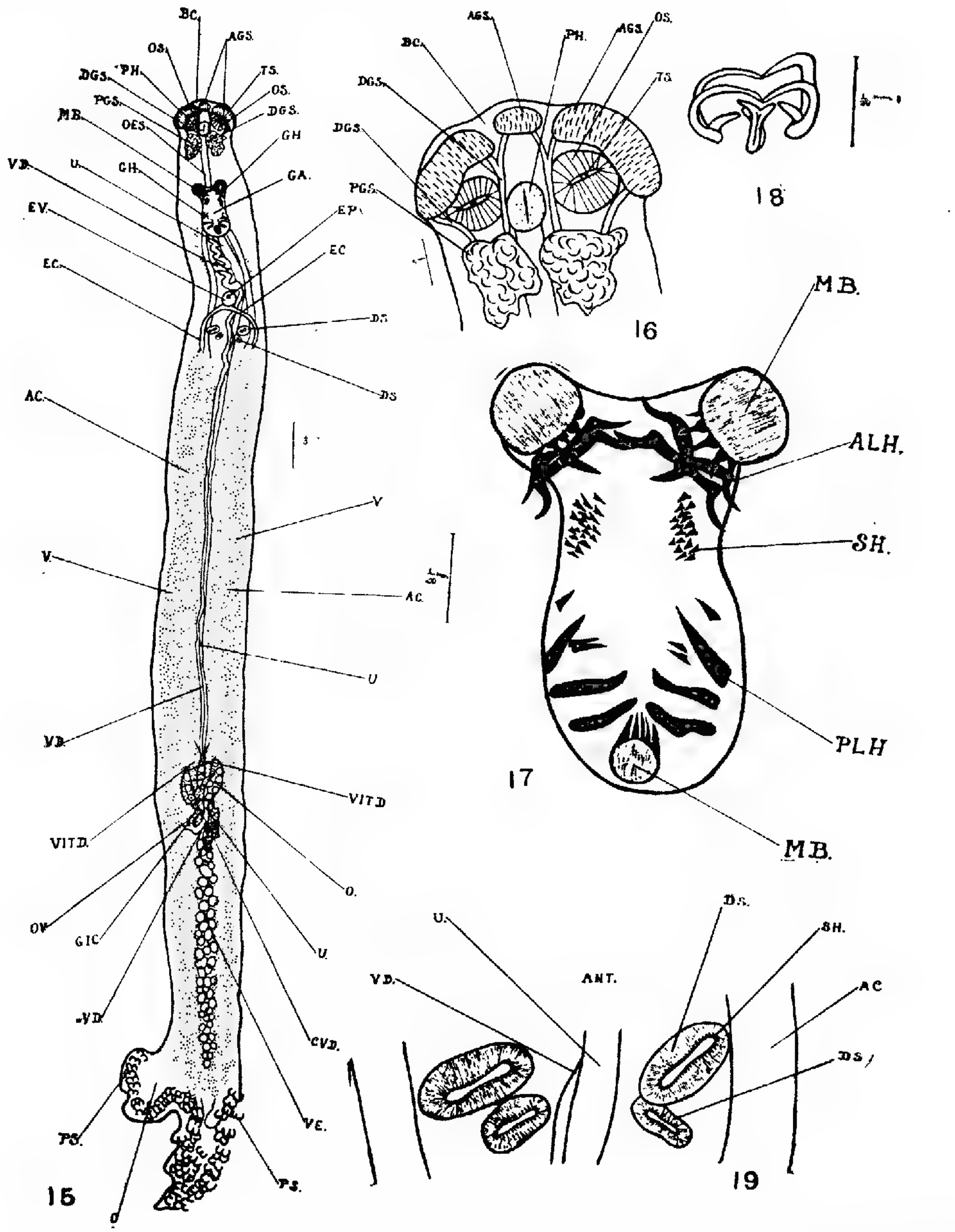

Fig. 15-19—*Gonoplasius carangis:* 15, whole specimen; 16, anterior of body showing glandular structures; 17, genital armature; 18, skeleton of one posterior sucker; 19, structure, probably dorsal suckers.

Conspicuous ovary at anterior end of posterior half of body, beginning immediately anterior to the testicular field, from which it winds to the right and at 2·62 mm. from anterior end of body, then curves to left and passes posteriorly on right. Ovary, maximum length 0·412 mm., maximum width 0·062 mm. Two lateral fields of vitellarium commencing 0·587 mm. from anterior end of body, quite distinct anteriorly and posteriorly; posteriorly left arm extending 0·235 mm. into cotylophore; right 0·037 mm. Paired vitelline ducts arising from lateral fields 2·625 mm. from anterior end of body; base of each with enlargement, probably vitelline reservoirs; ducts then passing 0·012 mm. posteriorly to unite as common vitelline duct, 0·187 mm. long and joining oviduct. Genito-intestinal canal entering right intestinal arm. Uterus straight, thin-walled, opening apparently posterior to male pore.

GENERIC DIAGNOSIS: **Gonoplasius** n. g. Microcotylidae—Body very elongated, narrow; symmetrical except for the cotylophore. Latter comparatively short, sides unequal in length, longer side with a greater number of small suckers. Genital atrium large, armed with small and large hooks, some of the latter being embedded in a muscular base. Several groups of large glands associated with buccal cavity. Excretory system with terminal vesicle, median, dorsal, posterior to genital atrium.

Gonoplasius bears a very strong resemblance to *Microcotyle* Beneden and Hesse, but differs in several features. One of the most conspicuous differences is the presence in the former of the groups of anterior glandular structures, some around the buccal cavity and the rest near the oesophagus. *Gonoplasius* has a completely different and much more elaborate genital armature than that of *Microcotyle*. Goto (1897) stated regarding the excretory system, "in *Microcotyle* there is no distinct terminal sac, the vessel presenting just a perceptible enlargement before it opens to the exterior." Also in *Microcotyle* the excretory opening appears to be always on the same level as the genital armature or anterior to it. In *Gonoplasius* there is a very conspicuous excretory vesicle posterior to the genital atrium, opening medially and dorsally.

Diplasiocotyle johnstoni n. g., n. sp.

(Fig. 20)

From gills of the yellow-eyed mullet or pilchard, *Agonostomus forsteri*, from Mandurah and Bunbury. From the middle of February to the middle of August 1943, gills of 146 of these fish were examined, 185 parasites being obtained, there being usually only one parasite per fish until the middle of May. After that date they were very numerous, especially in June, when on one occasion 21 parasites were taken from one fish; the average at that period being three parasites per fish.

D. johnstoni is a large form, of total length 5·96 mm. (6·47); maximum body with 0·83 mm. (0·937) across region anterior to testicular field; body tapering anteriorly and posteriorly; body width across oral suckers 0·25 mm.; across genital atrium 0·287 mm. Cotylophore 1·77 mm. (1·94) long, hence occupying approximately one-third total body length; anterior margin 1·25 mm. long, posterior margin 0·562 mm. Seven large long-stalked suckers along each margin of cotylophore; one pair of minute suckers at extreme posterior end of cotylophore. Former of varying sizes; most anterior pair 0·425 mm. wide, 0·312 mm. long; middle pair 0·437 mm. wide, 0·312 mm. long; penultimate pair 0·375 mm. wide, 0·25 mm. long; last pair 0·25 mm. wide, 0·187 mm. long. All suckers with characteristic skeleton of a median hollow piece, with solid piece attached at one end to form U-shape; on either side two more pieces, one arm of which moves in the other which is slightly hollow (fig. 22). The pair of minute suckers 0·062 mm. wide, 0·044 mm. (0·05) long, have skeletons much as above, except that the lateral pieces are comparatively longer (fig. 23). A pair of small, simple, dorsal, lateral suckers of 0·075 mm. diameter at 1·125 mm. from anterior side of body.

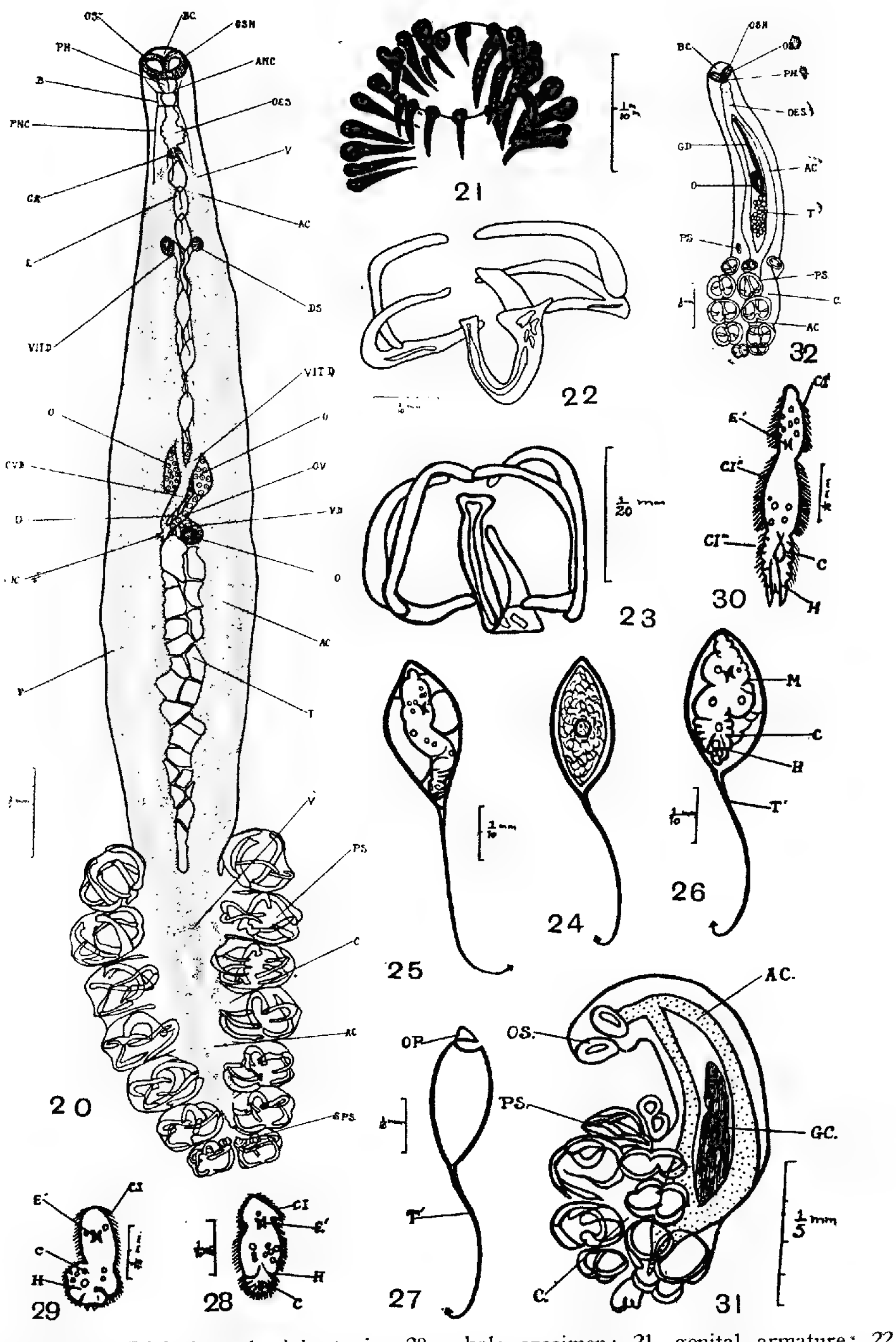

Fig. 20-32—*Diplasiocotyle johnstoni:* 20, whole specimen; 21, genital armature; 22, skeleton of large posterior sucker; 23, skeleton of small posterior sucker; 24, egg; 25 and 26, egg showing developing miracidium; 27, egg after miracidium has escaped; 28 and 29, miracidium; 30, miracidium elongated (28, 29, 30 to same scale = ·1 mm.); 31, very immature specimen; 32, immature specimen (scale = ·2 mm.).

Buccal cavity with subterminal aperture, with pair of conspicuous oral suckers, without septa, 0·137 mm. wide, 0·109 mm. (0·125) long, with inner margins set with small hooks. Pharynx, close to oral suckers, diameter 0·10 mm. Oesophagus 0·375 mm. long with numerous lateral diverticula. Intestinal bifurcation dorsal to genital atrium; two main longitudinal ducts along each side of body with numerous lateral diverticula, uniting behind testicular field; in cotylophore forming common canal 0·875 mm. long. Alimentary canal extending total distance of 1·624 mm. into cotylophore.

Twenty-two sub-quadrangular testes, all closely applied together in an intervitelline field, occupying approximately one-quarter total body length. Testes varying from 0·10 to 0·212 mm. in width, 0·075 to 0·25 mm. in length. Vas deferens passes anteriorly to genital atrium (fig. 20). Genital atrium 0·525 mm. from anterior end of body, armed with hooks constantly 0·013 mm. long; one central circlet of 15 hooks and on either side of this a semi-circle each with nine and seven hooks respectively (fig. 21).

Conspicuous ovary, shaped like mark of interrogation (viewed dorsally), arising anterior to testicular field towards left of body; maximum width 0·137 mm.; maximum length 0·562 mm.; oviduct passing diagonally to right. Vitellarium occupying both lateral fields, beginning 1·022 mm. (0·687) from anterior end of body. Vitelline fields distinct anteriorly, joining posteriorly to testicular field and passing 1·503 mm. (1·562) into cotylophore. Paired vitelline ducts commencing 1·125 mm. from anterior end of body in same region as dorsal suckers and passing 1·06 mm. posteriorly to unite as common vitelline duct, 0·312 mm. long, which joins oviduct. Genito-intestinal canal joining right arm of alimentary canal. Uterus passing posteriorly and then curving forwards as a thin-walled duct to open into atrium. Often as many as six eggs at one time seen in uterus. Eggs oval, with long hooked tail at end opposite to operculum. Egg ·2 mm. wide, 0·575 mm. long, including tail 0·038 mm. long; hook 0·013 mm. long, 0·10 mm. wide (fig. 24).

Generic Diagnosis: **Diplasiocotyle** n. g. Microcotylidae — Body large, symmetrical; mouth aperture subterminal; buccal cavity with two oral suckers. Mid-ventral genital atrium armed with equal-sized small hooks. Conspicuous cotylophore without hooks but bearing several pairs of large suckers with typical skeletal support; also one pair of small suckers at posterior extremity.

Diplasiocotyle is assigned to the Microcotylidae, since it agrees with known members in its general anatomical structure. It probably approaches *Microcotyle* most closely, but differs in the cotylophore, which in the latter genus has numerous small suckers, all of approximately the same size, whereas *Diplasiocotyle* bears suckers of two widely different sizes but the majority are extremely large. Skeletal structures of these suckers differ from the type found in *Microcotyle*. The name of Professor T. Harvey Johnston is associated with the species.

Several Stages in the Life History of Diplasiocotyle johnstoni

A number of specimens of *D. johnstoni* were taken from their host and placed in some small glass dishes containing water from the Swan River at Crawley, which was approximately of the same salinity as sea water. After periods varying from one to several hours, these forms which had been quite inert, recovered and became active. A few of these specimens produced some eggs, laying an average of 25 each, although some produced as many as 60, which, when laid, sank to the bottom of the dish. The parasites lived usually for a period of three days, but some remained alive for four days, during which they were quite active.

In order to hatch the eggs it was found necessary to keep them in sterilized river water at a constant temperature and in an enclosed vessel to prevent evaporation and to ensure a constant salinity. A larval form, almost ready to be hatched, moved quite actively and rotated within the egg by means of cilia (fig. 26 and 27). The operculum was eventually forced open by the movement of the miracidium which, after it had liberated itself, immediately began to swim about quite rapidly (fig. 27). The opening of the operculum required from one to two hours. The eggs hatched within 19 days after having been laid, producing larvae with bodies constricted into three definite regions, each covered with cilia. A cotylophore region is distinctly constricted and bears three pairs of minute hooks set in small projections, as well as two pairs of large median hooks 0·037 mm. long, one pair of which can be protruded from the posterior end of the body. This miracidium has a maximum length of 0·186 mm. including 0·062 mm. occupied by the cotylophore and a maximum width of 0·062 mm. when at its normal length. The eye-spots then are situated 0·062 mm. from the anterior extremity of the body (fig. 28 and 29). The body can be extended considerably, reaching two or three times its normal length (fig. 30). The miracidia move very rapidly by a rotating movement and are usually most numerous round the edges of the container. These larvae continue their movements for two days, at the end of which time their activities are considerably lessened and death soon follows, if the required host has not been reached.

The youngest parasite form (fig. 31) recovered from the gills of the host has a maximum length of only 0·687 mm.; maximum with 0·137 mm. at approximately the anterior end of the genital complex.

The developing cotylophore occupies 0·312 mm. of the total body length and bears altogether four pairs of suckers and two developing suckers. Three pairs of these suckers, those centrally situated are large, those of the middle pair being 0·125 mm. wide, 0·05 mm. long. Posterior to these three pairs is another pair of much smaller suckers, 0·062 mm. wide, 0·05 mm. long. The right side of the cotylophore bears both at its anterior and its posterior ends a small developing sucker. The anterior one of these is 0·062 mm. wide, 0·037 mm. long; while the most posterior one is 0·025 mm. wide, 0·037 mm. long.

The small paired oral suckers have a diameter of 0·037 mm.; no hooks are apparent along the edges. At this stage the genital organs have not become differentiated, though a genital mass is present, occupying the region of the future ovary and testes. This mass has a maximum width of 0·075 mm. and a maximum length of 0·25 mm.

Another immature, but later and more developed stage (fig. 32) in the life history was also obtained from the gills of *Agonostomus forsteri*. Total body length of parasite 1·375 mm. and the maximum width of the body anterior to the cotylophore 0·175 mm., occurring across the middle of the testicular field. The cotylophore, 0·525 mm. long, occupies approximately two-fifths of total body length and measures 0·237 mm. across its anterior border, while the width across its posterior border is 0·162 mm. It bears three pairs of large suckers; the largest is the central pair with a maximum width of 0·137 mm. and a maximum length of 0·112 mm. The most posterior pair have each a maximum width of 0·075 mm. and maximum length of 0·05 mm. Anteriorly to these four pairs of suckers is another pair, 0·087 mm. wide and 0·075 mm. long. The most anterior pair of suckers are in the process of developing, and the larger of these has a maximum width of 0·075 mm. and a length of 0·037 mm.

The oral suckers in the buccal cavity have acquired very small hooks along their edges; each sucker has a maximum width of 0·075 mm. and a maximum length of 0·05 mm. The buccal cavity leads into the pharynx, which is very close to the oral suckers and has a diameter of 0·05 mm. The oesophagus has lateral branches and bifurcates at 0·25 mm. from the anterior end of the body.

The pair of longitudinal arms of the alimentary canal pass backwards and unite immediately behind the testicular field.

By this stage the genital complex has advanced sufficiently for the testes to have become differentiated and individual follicles can be recognised. Each follicle has an average diameter of 0·012 mm. The whole testicular field is 0·25 mm. long. The ovary has not yet become specialised. Leading from the field occupied by the genital organs is a duct, probably the developing vas deferens, which terminates at 0·312 mm. from the anterior end of the body. There are no signs of any genital armature.

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NOTES ON AND ADDITIONS TO THE TROMBICULINAE AND LEEUWENHOEKIINAE (ACARINA) OF AUSTRALIA AND NEW GUINEA

By H. WOMERSLEY, A.L.S., F.R.E.S., Entomologist, South Australian Museum

Summary

Since the publication of the preliminary monograph on the "Trombiculinae of the Austro-Malayan and Oriental Regions" by Womersley and Heaslip (Trans. Ray. SOC. S. Aust., 67, (1). 68-142, 1943) a large number of larvae and a few adults have been received from various localities in Australia and New Guinea. Some of these specimens represent new species, which are described and figured in this contribution.

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[Read 11 May 1944]

Since the publication of the preliminary monograph on the "Trombiculinae of the Austro-Malayan and Oriental Regions" by Womersley and Heaslip (Trans. Roy. Soc. S. Aust., **67**, (1), 68-142, 1943) a large number of larvae and a few adults have been received from various localities in Australia and New Guinea. Some of these specimens represent new species, which are described and figured in this contribution.

In the above cited paper, on p. 71, it was also suggested that, when sufficient material was available for study, it would be useful taxonomically, to study the "Standard Data" statistically. The additional material now in hand has enabled me to do this for certain species, and in most cases it is possible to get some idea of the theoretical possible range of variation in the different characters used. In 1943, stress was laid firstly on the number and arrangement of the dorsal setae, and secondly on the Standard Data. The statistical studies show that where the arrangement and number of dorsal setae are close in two species, there are usually significant differences in the statistics of the Standard Data. Further, in certain species it is revealed that there are slight but statistically significant differences in a few or many characters of the same species from different localities. This is of much importance and, as indicating geographical races or variations, may throw some light on the occurrence or not of "scrub-typhus" in different areas.

The statistical calculations have been based on Simpson and Roe's "Quantitative Zoology" and the statistics employed are: (1) Mean, (2) Standard Deviation, (3) Theoretical Range as expressed by $M \pm 3\sigma$, and (4) the Coefficient of Variation.

Closely allied species and different populations of the same species have been compared by calculating the Standard Deviation (Error) of the Difference of Means, using the formula

$$\sigma_d = \sqrt{\frac{N_1}{N_2}\sigma^2_{M_1} + \frac{N_2}{N_1}\sigma^2_{M_2}}$$

and regarding a value of $d/\sigma_d > 2$ as a positive and significant difference.[1]

In the above cited 1943 paper, all the specimens of *Leeuwenhoekia* then available were referred to the one species, *L. australiensis* Hirst. With fresh and additional material now before me, I have found that three species are represented, while three other species are also described. The genus is thus represented in Australia and New Guinea by six species, five of which are new. While studying this material, especially fresh mounts, it was found that the genus differs from all other genera of the Trombiculinae in possessing a pair of true stigmata from which tracheal tubes traverse the body. These stigmata are situated one on each side, between the base of the gnathosoma and the first coxae. The atrium itself is not so well chitinised as the so-called "ventral stigma" or "urstigma" which is present in all larval Trombidiidae between the first and second coxae, and from which no tracheal tubes run. No trace of a true stigma has been seen in any other genus.

[1] d = Difference of Means.

The presence of such an important feature in the genus *Leeuwenhoekia* necessitates the separation of the genus from the rest of the Trombiculinae (except possibly *Hannemannia*) as a new subfamily, the Leeuwenhoekiinae. The genus *Hannemannia* in the structure of the dorsal scutum, with its paired AM, but lacking the median anterior process, is possibly closely related and, if shown to possess true stigmata, should be placed in the new subfamily. No such stigmata have, however, been figured for any species, and the genus is so far unknown from Australia or New Guinea.

In addition two insufficiently described species, *Schöngastia salmi* Oudms. 1922 from Java and *Schöngastiella disparunguis* Oudms. 1929 also from Java, are discussed.

Subfam. TROMBICULINAE s. str.

Genus TROMBICULA Berl. 1905

Acari nuovi; Manipl. IV, 155, in Redia II, fasc. 2, 1905.

Trombicula translucens n. sp.

Fig. 1, A–E

Description—Adult ♀. Colour in life a translucent white with the body contents showing through as a dark mass. Length 850 μ, width across propodosoma 425 μ, across hysterosoma 510 μ. Eyes absent. Crista 104 μ long, with triangular posterior sensillary area, with paired fine ciliated sensillae 50 μ apart at bases and

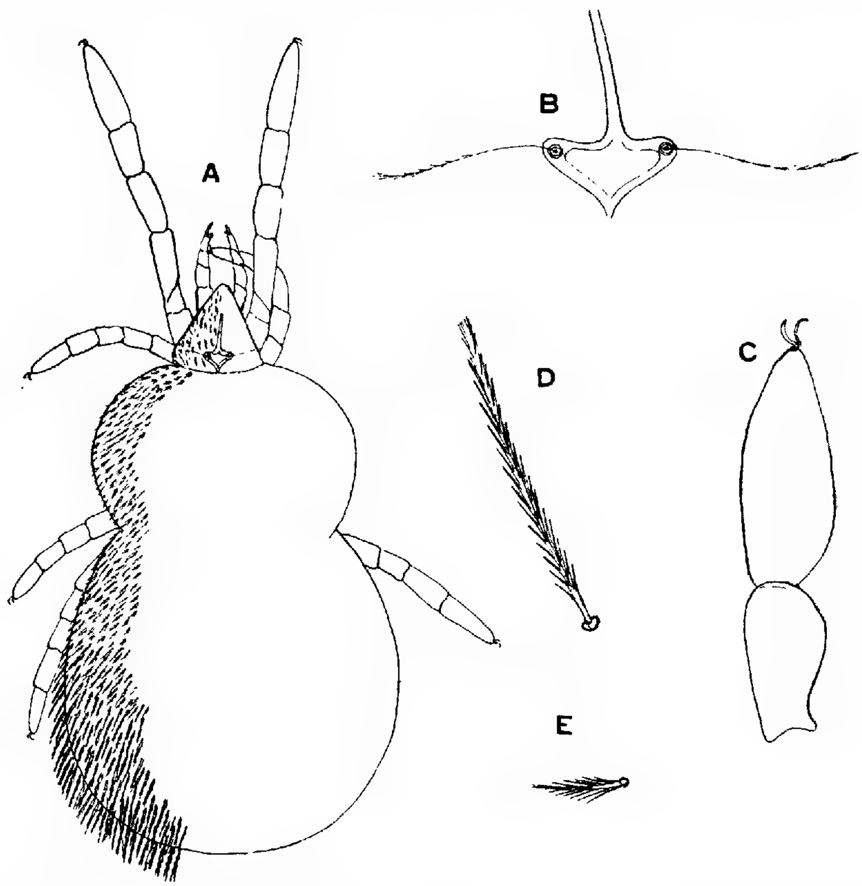


Fig. 1 *Trombicula translucens* n. sp. Adult: A, dorsal; B, crista, C, front tarsus and metatarsus; D, posterior dorsal seta, E, anterior dorsal seta.

75 μ long. Body clothed with strongly ciliated setae, those on the propodosoma short, 13 μ; on hysterosoma anteriorly 13 μ, posteriorly to 65 μ long, and appearing as a characteristic fringe. Legs rather short, anterior the longest; front tarsi 110 μ long by 45 μ wide, metatarsi 65 μ long.

Locality—Two adult females from moss from Mount Arden, South Australia, October 1943 (H. M. Cooper).

Remarks—This species, by the key (*loc. cit.* 1943, 48) to the adults and nymphs, will fall into the *akamushi* group. All of this group, however, are from Japan and are all said to be reddish in colour. The posterior fringe of long setae seems to be rather characteristic.

Trombicula scincoides n. sp.

Fig. 2, A–C

Description—Larvae. Colour in life a light reddish-yellow. Shape oval. Length to 550 μ, width to 340 μ (moderately engorged). Dorsal scutum with

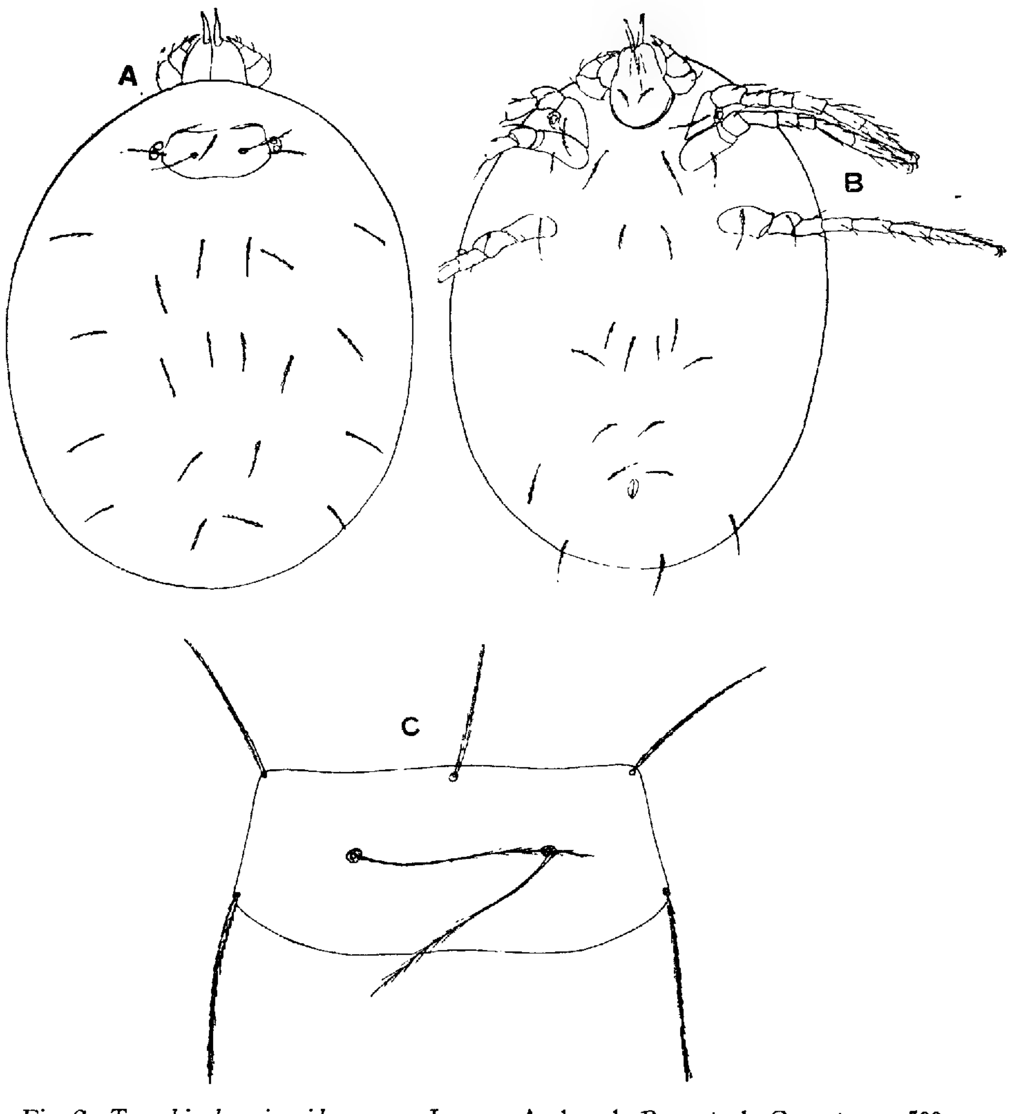
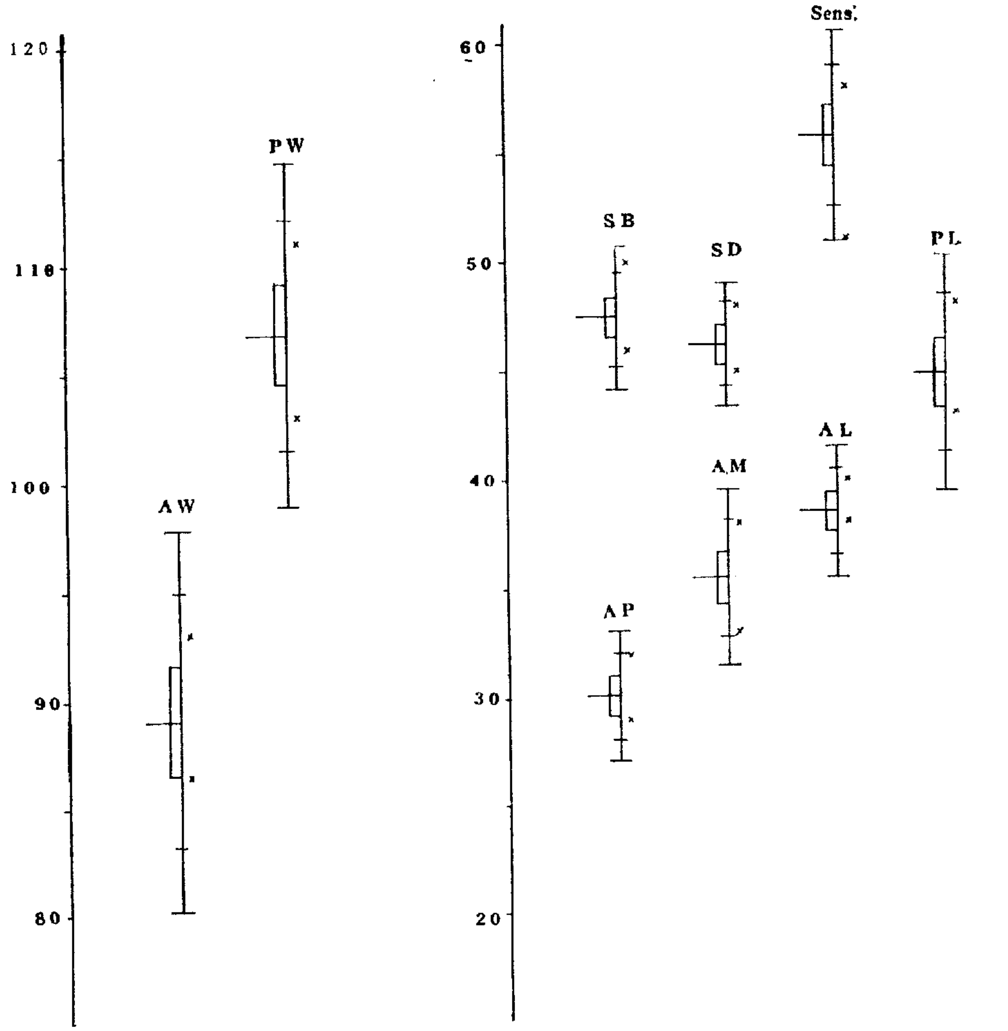


Fig. 2 *Trombicula scincoides* n. sp. Larva: A, dorsal; B, ventral; C, scutum x 500.

transverse rows of punctuations, shaped as in figure and with the following Standard Data in microns, derived from 12 specimens.

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	89·1 ± 0·85	2·95 ± 0·60	80·3–97·9	86·5–93·0	3·3
PW - -	106·8 – 0·76	2·65 ± 0·54	98·9–114·7	103·0–111·0	2·5
SB - -	47·5 ± 0·30	1·10 ± 0·22	44·2–50·8	46·0–50·0	2·3
SD - -	46·2 ± 0·30	0·94 ± 0·20	43·4–49·0	45·0–48·0	2·0
A–P - -	30·1 ± 0·30	0·99 ± 0·21	27·1–33·1	29·0–32·0	3·3
AM - -	35·5 ± 0·42	1·35 ± 0·32	31·5–39·5	33·0–38·0	3·8
AL - -	38·5 ± 0·30	0·99 ± 0·21	35·5–41·5	37·0–40·0	2·5
PL -	44·8 ± 0·52	1·80 ± 0·37	39·4–50·2	43·0–48·0	4·0
Sens. - -	55·7 ± 0·48	1·60 ± 0·34	50·9–60·5	51·0–58·0	2·9



Graphs showing the Statistics of the Standard Data of larval *Trombicula scincoides* n. sp. (Measurements in microns.)

PSB is slightly longer than ASB. Eyes 2 + 2, about one diameter from edge of scutum. Mandibles and palpi normal. Dorsal setae arranged 2.6.6.4.2, fairly stout and straight with serrations rather than ciliations. Legs: I 240 μ, II 260 μ, III 200 μ; all tarsi with paired claws and longer median claw-like empodium, I and II with the usual dorsal rod-like seta. All coxae unisetose with a long slender finely ciliated seta; a pair of such setae between coxae I and between coxae III; thereafter ventral setae arranged 6.2.4.2., the posterior two rows stronger and more like the dorsal setae.

Locality and *Host*—A number of specimens from the axillae of a scink, *Lygosoma* (*Liolepisma*) *bicarinatus* (MacL. 1877) from New Guinea, October 1 1943 (R. N. McCulloch), host *id.* by Mr. J. R. Kinghorn, Australian Museum, Sydney. A single specimen, collected on boots, Buna, N.G., 27 August 1943 (R. N. McC.).

Remarks—In the arrangement of the DS this species belongs to the *minor* group, but comes nearest to *wichmanni* Oudms. in the shape of the dorsal scutum, which is shorter and wider in the new species. The ratio of PW/SD = 2·31 in *scincoides* and 1·85 in *wichmanni*. The DS are not so tapering, nor so finely ciliated as in *minor* and its allies.

Trombicula obscura n. sp.

Fig. 3, A–C

Description—Larvae. Shape oval. Length to 300 μ, width to 150 μ. Dorsal scutum as figured and with the following Standard Data for the two specimens

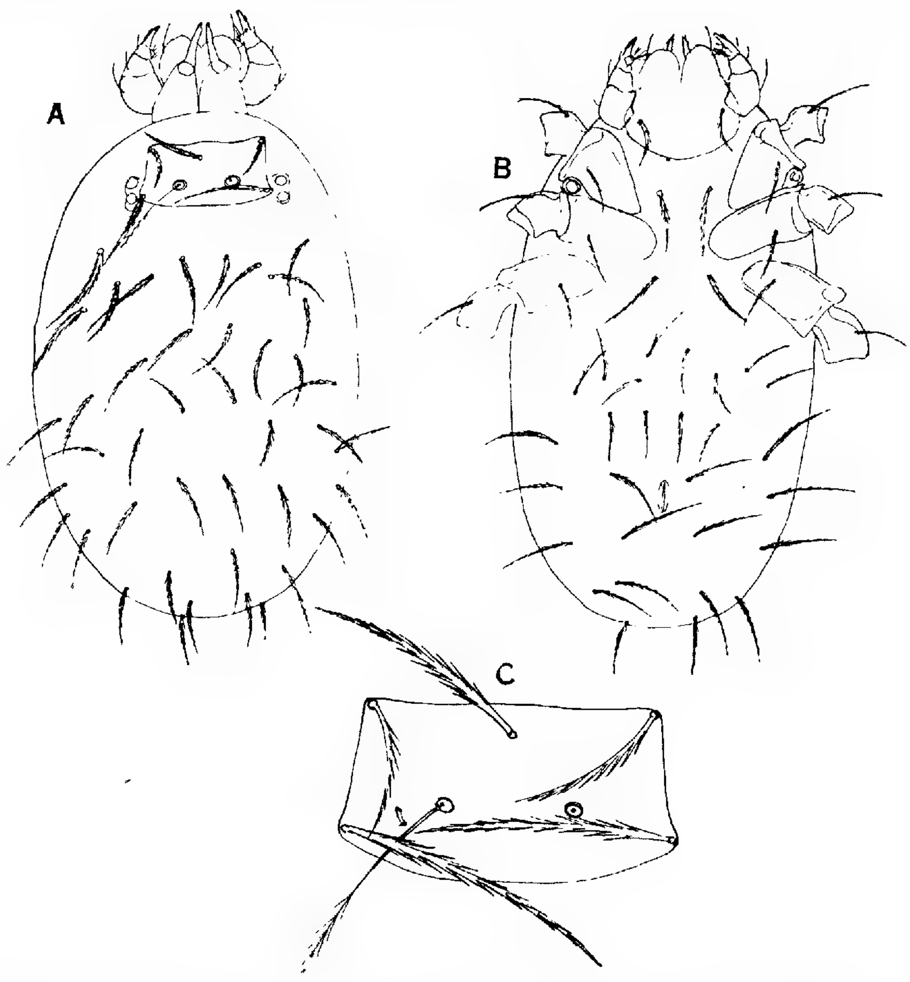


Fig. 3 *Trombicula obscura* n. sp. Larva: A, dorsal, B, ventral; C, sctum x 500.

measured: AW 65, 68, PW 79, 79, SB 32, 32, ASB 29, 26, PSB 14, 18, A-P 32, 32, AM 57, 58, AL 43, 45, PL 70, 72, Sens. 60, 60. Dorsal setae robust and strongly ciliated, arranged 2.8.8.8.6.4.2. Eyes 2 + 2. Mandibles and palpi normal. Legs: I 255 μ, II 205 μ, III 250 μ; tarsi I and II with the usual rod-like seta. All coxae unisetose; a pair of setae between coxae I and between coxae III, thereafter the ventral setae are arranged approximately 4.4.6.4.4.4.2, those posterior of the anal opening being stronger and similar to dorsal setae.

Locality and *Hosts*—Type and three paratypes (only two measured) from the ear of a rat at Milne Bay, New Guinea, August 1943 (A. L. A.), along with numerous *T. deliensis* Walch, and rather fewer *Schöngastia blestowei* Gunther and *Neoschöngastia impar* Gunther.

Remarks—Somewhat near to *T. deliensis* Walch but differing in the number and arrangement of the dorsal setae.

Since drawing up the above description a number of other specimens from Buna, New Guinea, collected from rats, January 1944 (Maj. Hicks) have come to hand. Of these, 10 specimens have been measured, giving the following Standard Data:

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	68·3±0·88	2·10±0·47	62·0–74·6	65·0–72·0	3·0
PW - -	78·8±0·83	1·99±0·44	72·8–84·8	76·0–82·0	2·5
SB - -	32·6±0·49	1·56±0·35	27·9–37·3	30·0–36·0	4·8
SD - -	41·1±0·85	2·70±0·60	33·0–49·2	38·0–46·0	6·6
A–P - -	27·4±0·61	1·96±0·61	21·5–33·3	25·0–29·0	7·1
AM -	52·2±0·82	2·33±0·58	45·2 59·2	50·0–56·0	4·5
AL - -	36·9±0·55	1·66±0·39	31·9–41·9	36·0–44·0	4·5
PL - -	56·9±1·04	3·30±0·74	47·0–66·8	54·0–65·0	4·8
Sens. - -	62·6±0·89	2·82±0·63	54·1–71·1	57·0–68·0	4·5

From the above it is seen that the specimens from the two localities agree except in the AL and PL values which are significantly different, but this is not sufficient to regard them as more than different populations of the one species.

Trombicula kohlsi n. sp.

Fig. 4, A–F

Description—Larvae. Shape subrotund. Length (excluding gnathosoma) 216 μ, width in line of coxae III, 180 μ. Dorsal scutum very large and wide, occupying almost all of the anterior width of dorsum, as figured. The Standard Data from four specimens are as follows:

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW -	110·25 – 1·98	3·96±1·4	98·35–122·15	104·0–115·0	3·6
PW - -	125·5±1·09	2·18±0·77	119·0–132·0	122·0–128·0	1·72
SB - -	62·0±0·61	1·73±0·43	56·8–67·2	61·0–65·0	2·4
SD - -	66·0	No variation recorded			
A–P - -	36·75±0·65	1·30±0·45	32·85–40·65	36·0–39·0	3·5
AM - -	46·25±0·65	1·30±0·45	42·35–50·15	44·0–47·0	2·8
AL - -	47·0	No variation recorded			
PL - -	58·0	No variation recorded			
Sens. - -	61·0	No variation recorded			

Dorsal scutum pitted in transverse rows, setae thick, blunt-ended and strongly ciliated. Eyes 2 + 2. Mandibles and palpi normal. Chelicerae as figured. Dorsal setae thick, apically blunt and strongly ciliated, arranged 2.6.6.4.2.2. Legs relatively long, I 324 μ, II 288 μ, III 324 μ; tarsi I and II with long stout sensory rod as figured; tibiae I and II dorsally with a similar but shorter rod and another rod which is pointed; tarsi with stout paired claws and a longer, more slender empodium. Venter: gnathosoma with transverse lines of pits and a pair of long

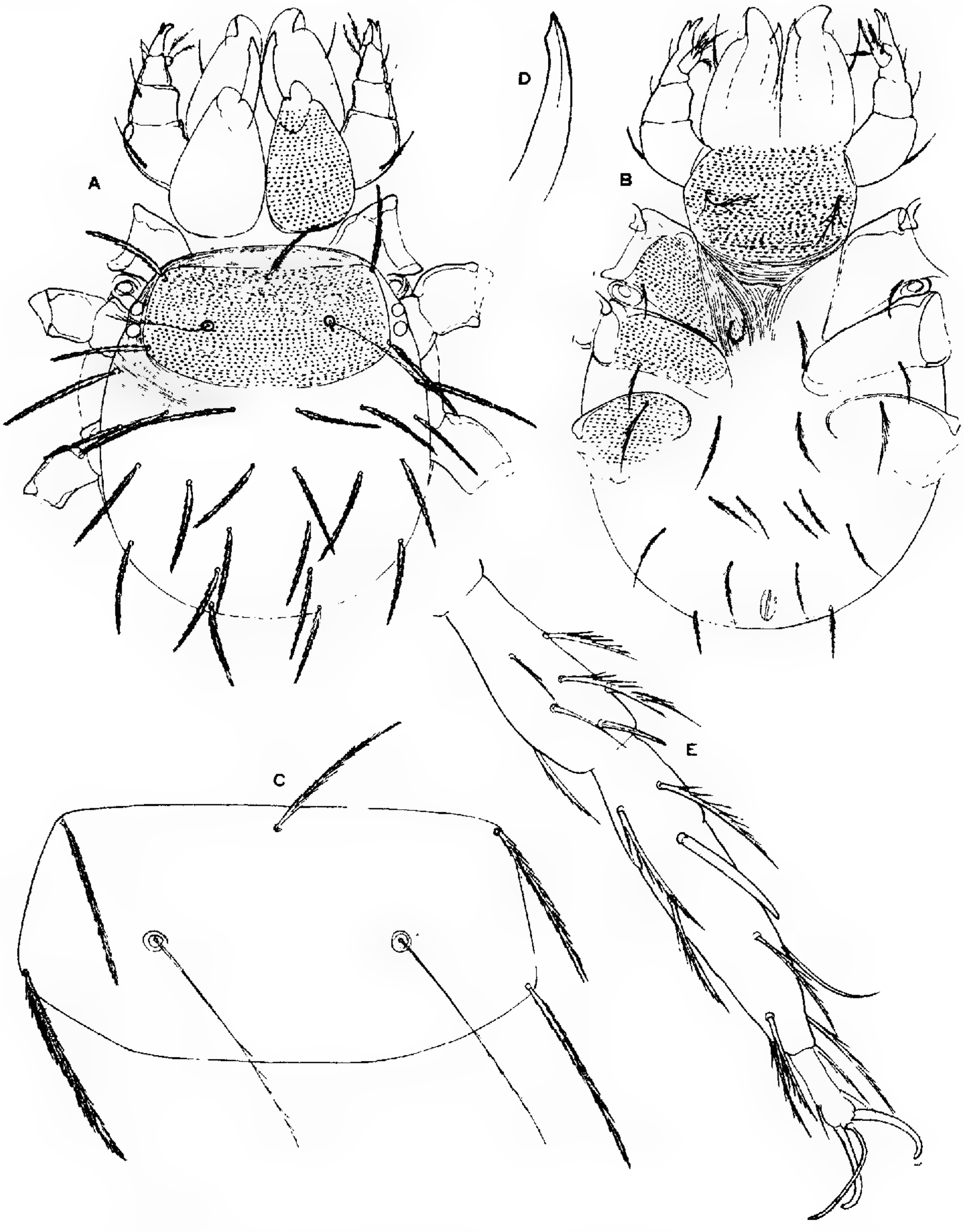


Fig. 4 *Trombicula kohlsi* n. sp. Larva: A, dorsal; B, ventral; C, scutum x 500; D, chelicera; E, tarsus and metatarsus I.

ciliated setae; all coxae unisetose; a pair of long ciliated setae between coxae I and between coxae III, and thereafter the setae are arranged 4.4.2, these are tapering and not so thickly ciliated as the dorsal setae; all coxae with lines of pits but the cuticle otherwise striated. Anus at extreme end of venter.

Locality—A small number of specimens collected on shoes from amongst Kunai grass, Buna area, New Guinea, November 1943 (G. M. Kohls).

Remarks—In the DS this species belongs to the *minor* group, but differs conspicuously in the large and wide dorsal scutum, which would place it at the end of the key (*loc. cit.,* 75) to the larvae of this genus, and in caption 28, together with *samboni* Wom. and *macropus* Wom.

TROMBICULA WALCHI Wom. and Heasp. 1943

Trans. Roy. Soc. S. Aust., **67**, (1), 83, 1943.

This species occurs commonly in parts of New Guinea along with the following species, *T. fletcheri* W. and H. The DS are arranged 2.8.6.6.4.2 and the ventral setae 4.6.4.4.2.

Beside the type and paratype, 16 specimens from the Buna and Abidari areas of New Guinea have been examined and the following statistics of the Standard Data calculated.

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	60·5±0·36	1·54±0·26	55·9–65·1	58·0–65·0	2·5
PW - -	68·2±0·55	2·32±0·39	61·2–75·2	65·0–75·0	3·4
SB - -	28·65±0·23	1·00±0·16	25·6–31·6	26·0–30·0	3·5
SD - -	38·5±0·68	2·89±0·48	29·8–47·2	33·0–43·0	7·5
A–B - -	26·7±0·62	2·65±0·46	18·8–34·6	25·0–32·0	9·9
AM - -	43·1±0·86	3·54±0·60	32·5–53·7	40·0–52·0	8·2
AL - -	35·0±0·36	1·53±0·25	31·0–40·2	32·0–39·0	4·3
PL - -	42·4±0·96	4·07±0·68	30·2–54·6	40·0–54·0	9·6
Sens. - -	60·3±0·65	2·05±0·46	54·1–66·4	56·0–65·0	3·4

TROMBICULA FLETCHERI Wom. and Heasp. 1943

Trans. Roy. Soc. S. Aust., **67**, (1), 86, 1943.

The DS in this species are arranged 2.10.8.6.4.2 to 2.10.8.8.6.4.2, *i.e.,* 32-38 as compared with only 28 in *T. walchi.* The ventral setae are arranged ca. 8.8.8.6.4.4.2.

Of this species, which occurs along with the preceding, 13 specimens have been carefully measured, and the statistics for the Standard Data estimated as follows:

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	67·8±0·79	2·87±0·56	59·2–76·4	62·0–72·0	4·2
PW - -	77·2±0·65	2·29±0·45	70·4–83·0	73·0–79·0	2·9
SB - -	32·1±0·41	1·49±0·28	27·6–36·6	30·0–36·0	4·6
SD - -	40·2±0·76	2·76±0·54	31·9–48·5	34·0–44·0	6·8
A–P - -	28·3±0·58	2·09±0·41	22·0–34·6	25·0–32·0	7·4
AM - -	52·0±0·89	3·08±0·63	42·8–61·2	45·0–56·0	5·9
AL - -	37·5±0·57	1·98±0·40	31·6–43·0	35·0–40·0	5·3
PL - -	51·1±1·24	4·48±0·88	37·7–64·5	43·0–57·0	8·8
Sens. - -	64·4±0·57	1·80±0·40	59·0–69·8	62·0–68·0	2·8

Remarks—A calculation of the Standard Error of the Difference of Means of the populations of this and the preceding species shows clearly that the two species are distinct and that the two groups cannot belong to the same population. The values of d/σ_d for all the items AW, PW, SB, AM, AL, PL, and Sens. are >2, but SD and A-P both show an insignificant value of $<2·0$.

The statistical evidence from the Standard Data therefore confirms the separation of the two species based on the DS.

TROMBICULA DELIENSIS Walch 1923

Kitasato Arch Exper. Med., **5**, (3,) 63, 1923; Tr. 5th Bien. Congr. Far East. Assoc. Trop. Med., Singapore, 1923 (publ. 1924).
Trombicula vanderghinstei Gunther 1940, Proc. Linn. Soc. N.S.W., **65**, (3-4), 252.
Trombicula deliensis Wom. and Heasp. 1943, Trans. Roy. Soc. S. Aust., **67**, (1), 87.

This is one of the most abundant species both in New Guinea and in Queensland. It was originally described from Sumatra, and Mehta's record (1937) of "*T. deliensis*" as associated with scrub typhus in the Simla Hills may be correct.

From information available from both Queensland and New Guinea this species is probably one of the few which seem, so far, to be somewhat more definitely associated with scrub typhus in those areas.

Morphologically the species is well separated by the DS being 2.8.6.6.4.2, and by the "Standard Data." Since the original "Standard Data" was published, collections have been received from the Buna and Milne Bay area of New Guinea. These collections, together with the original lot from Cairns, Queensland, and the small lot from Bulolo, New Guinea, described by Gunther as *vanderghinstei*, have been studied statistically and separately. The difference between the various pairs of populations have been tested for significance by taking the value of d/σ_d

The Standard Data for the individual populations are as follows:

Cairns—Number of specimens = 20.

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	63·15±0·50	2·24±0·35	56·4–69·8	60·0–67·0	3·5
PW - -	76·95±0·75	3·38±0·53	66·8–87·0	70·0–82·0	4·4
SB - -	29·9±0·34	1·53±0·24	25·3–34·5	26·0–32·0	5·1
SD - -	37·2±0·43	1·94±0·30	31·4–43·0	35·0–41·0	5·2
A–P - -	28·4±0·28	1·28±0·20	24·6–32·2	27·0–30·0	4·5
AM - -	55·9±0·49	2·15±0·34	49·4–62·3	52·0–60·0	3·8
AL - -	43·6±0·49	2·20±0·35	37·0–50·2	40·0–48·0	5·0
PL - -	62·6±0·56	2·52±0·40	55·1–70·1	57·0–67·0	4·0
Sens. - -	62·8±0·52	2·09±0·37	56·5–69·1	60·0–65·0	3·3

Bulolo—Number of specimens = 4.

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	65·0±0·47	0·82±0·33	62·6–67·4	64·0–66·0	1·25
PW - -	74·0±1·24	2·16±0·81	67·5–80·5	71·0–76·0	2·9
SB - -	29·3±0·98	1·70±0·69	24·2–34·4	27·0–31·0	5·8
SD - -	39·7–1·26	2·18±0·89	33·2–46·2	36·0–40·0	5·5
A–P - -	27·5±0·75	1·50±0·53	23·0–32·0	26·0–30·0	5·4
AM - -	54·2±1·82	3·63±1·28	43·3–65·2	50·0–60·0	6·7
AL - -	42·7–0·25	0·51±0·18	41·25–44·25	42·0–43·0	1·2
PL - -	61·7–0·74	1·48±0·52	57·25–66·25	60·0–64·0	2·4
Sens. - -	65·0	No variation recorded			

Milne Bay—Number of specimens = 22.

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	67·2±0·57	2·69±0·40	59·2–75·2	61·0–72·0	4·0
PW - -	84·2±1·32	6·20±0·93	65·6–102·8	72·0–93·0	7·3
SB - -	32·2±0·43	2·02±0·30	26·2–38·2	29·0–36·0	6·2
SD - -	40·0±0·41	1·94±0·29	34·2–45·8	39·0–44·0	4·8
A–P - -	30·4±0·25	1·13±0·18	27·0–33·8	29·0–32·0	3·7
AM - -	52·8±0·48	2·25±0·34	46·0–59·6	47·0–57·0	4·2
AL - -	42·3±0·31	1·45±0·22	38·0–46·6	40·0–45·0	3·4
PL - -	58·0±0·63	2·95±0·44	49·0–67·0	50·0–65·0	5·0
Sens. - -	63·0±0·61	2·54±0·44	55·4–70·6	61·0–68·0	4·0

Buna—Number of specimens = 7.

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	70·4±0·69	1·84±0·49	64·9–75·9	68·0–72·0	2·6
PW - -	83·7±1·07	2·86±0·76	75·1–92·3	79·0–86·0	3·4
SB - -	32·8±0·91	2·41±0·64	25·6–40·0	29·0–36·0	7·3
SD - -	41·85±1·30	3·35±0·89	31·8–51·8	39·0–47·0	8·0
A–P - -	30·3±1·04	2·76±0·74	22·0–38·6	25·0–32·0	9·1
AM - -	67·6±0·96	2·55±0·68	60·0–75·2	65·0–72·0	3·8
AL - -	55·3±0·56	1·48±0·40	50·8–59·8	54·0–57·0	2·7
PL - -	86·4±1·47	3·90±1·04	74·7 98·1	83·0–94·0	4·5
Sens. - -	69·7±1·30	3·45±0·92	59·35–80·0	62·0–72·0	5·0

The significance of the differences between these populations, taking a value of $d > 2\sigma_d$ as being positively significant, is shown in the following table.

Table of Significance of Four Populations of *T. deliensis*

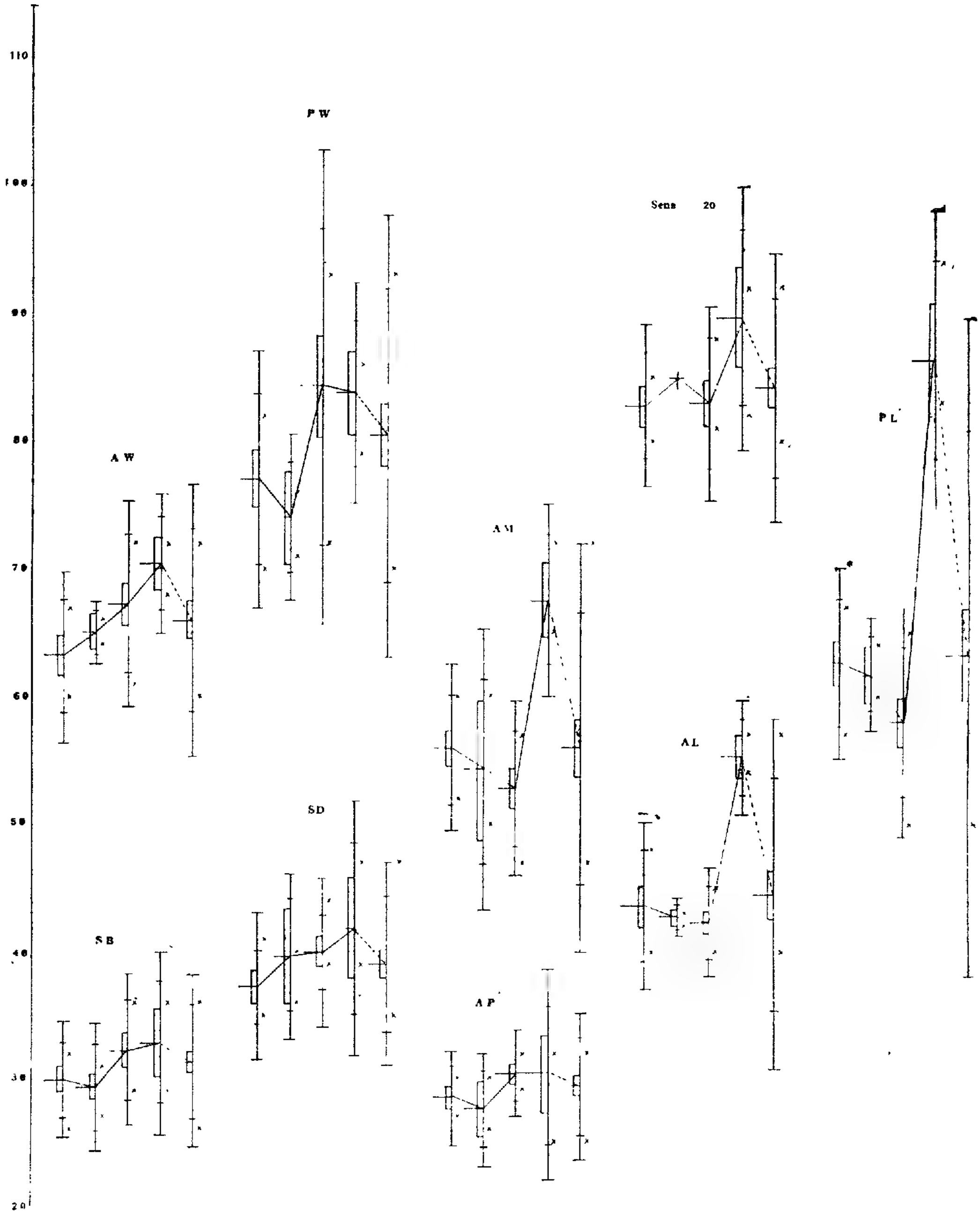
	AW	PW	SB	SD	A-P	AM	AL	PL	Sens.
Cairns-Buna - -	−	−	+	+	+	+	+	+	+
Cairns-Milne Bay -	+	+	+	+	+	+	+	+	−
Cairns-Bulolo - -	−	−	−	+	+	−	−	−	−
Buna-Milne Bay -	+	−	−	−	−	+	+	+	−
Buna-Bulolo - -	−	+	+	−	−	+	+	+	+
Milne Bay-Bulolo -	−	+	±	−	+	−	−	+	−

It is seen that while the Cairns population shows a significant difference from, and might conceivably be separated from those of Buna and Milne Bay, yet they are linked together by the Bulolo population. *T. deliensis* is, then, rather a widely variable species, and for specific identification the range of variation of the Standard Data as given by the four above populations *combined* must be taken into account. It is also to be noticed that the statistics for AM, AL and PL of the Buna populations are markedly higher than for the other populations, and this may indicate a tendency for a genetical separation in this locality. The statistics of the "Standard Data for the combined populations are as follows:

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	65·9±0·50	3·58±0·35	55·2–76·6	60·0–72·0	5·4
PW - -	80·3±0·80	5·77±0·57	63·0–97·6	70·0 93·0	7·2
SB -	31·3±0·31	2·28±0·22	24·5–38·1	26·0–36·0	7·3
SD - -	39·0±0·37	2·67±0·26	31·1–47·1	35·0–47·0	6·8
A–P - -	29·4±0·26	1·93±0·19	23·6–35·2	25·0–32·0	6·5
AM - ·	56·0±0·74	5·30±0·52	40·0–72·0	47·0–72·0	9·5
AL -	44·0±0·63	4·57±0·44	30·7–58·3	40·0–57·0	10·0
PL - -	63·3±1·20	8·78±0·85	37·0–89·6	50·0–94·0	5·4
Sens. - -	64·2±0·52	3·48±0·37	53·7–74·7	60·0–72·0	5·4

The accompanying graphs of the parameters for each particular character of the different populations give a more visual picture of the variations within the species.

Each measurement, *e.g.*, AW, PW, etc., in microns is shown separately for the four populations in the order from left to right of Cairns, Bulolo, Milne Bay and Buna. The Means for each are linked together, and to the right again is a graph showing the statistics considering the four populations as one. The statistics shown are: Mean $\pm 3\sigma_M$, theoretical range as expressed by Mean $\pm 3\sigma$, the value of Mean $\pm 2\sigma$, and the observed range (indicated by x, x). To save space the graph of Sens. has been increased $20\,\mu$, so that this must be allowed for in reading.



Graphs showing Variation in Statistics of Standard Data of four populations of larval *Trombicula deliensis* Walch.

(Measurements in microns, except Sens., to which 20 μ has been added to save space. Populations from left to right in each set are from Cairns, Bulolo, Milne Bay and Buna, followed by the combined graph.)

Trombicula minor Berl. 1904

Trombicula minor Berl. 1905, Acari Nuovi, Manip. IV, 135; Womersley 1939 (July), Trans. Roy. Soc. S .Aust., **63**, (2), 152; Gunther 1939 (December), Proc. Linn. Soc. N.S.W., **64**, (51-6), 466; *ibid.*, **65**, (5-6), 477; Womersley and Heaslip 1943, Trans. Roy. Soc. S. Aust., **67**, (1), 92.

Trombicula pseudoakamushi v. *deliensis* Walch 1924, Tr. 5th Bien. Congr. Far East. Assoc. Trop. Med., 601.

Trombicula hirsti Sambon 1927, Ann. Mag. Nat. Hist., (9), **20**, 157; *nec* Hirst 1929, *ibid.*, (10), 3, 564; *nec* Womersley 1934, Rec. S. Aust., **5**, (2), 212; Gate 1932, Parasitology, **24**, 143.

Trombicula hirsti v. *morobensis* Gunther 1938 (*nom. nud.*), Med. J. Aust., **2**, (6), 202.

Trombicula hirsti v. *buloloensis* Gunther 1939, Proc. Linn. Soc. N.S.W., **64**, (1-2), 78.

Trombicula minor v. *deliensis* Wom. and Heasp. 1943, Trans. Roy. Soc. S. Aust., **67**, (1), 93.

Of this species, which is common in parts of New Guinea and Queensland, separate populations for each area (New Guinea 23 specimens, Queensland 50 specimens) have been examined with the following results:

Queensland.

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	83·4±0·38	2·69±0·27	75·3–91·4	75·0–90·0	3·2
PW - -	96·6±0·37	2·63±0·26	88·7–104·5	90·0–104·0	2·7
SB - -	42·8±0·21	1·52±0·15	38·3–47·3	40·0–47·0	3·5
SD - -	67·7±0·33	2·35±0·23	60·7–74·7	61·0–72·0	3·4
A–P - -	35·9±0·17	1·21±0·12	32·3–39·5	32·0–39·0	3·4
AM - -	40·6±0·33	2·33±0·24	33·6–47·6	34·0–47·0	5·7
AL - -	45·9±0·33	2·35±0·23	38·9–53·0	40·0–50·0	4·1
PL - -	54·1±0·28	2·00±0·20	48·1–60·1	47·0–60·0	3·7
Sens. - -	64·4±0·57	3·08±0·40	55·2–73·7	51·0–68·0	4·8

New Guinea.

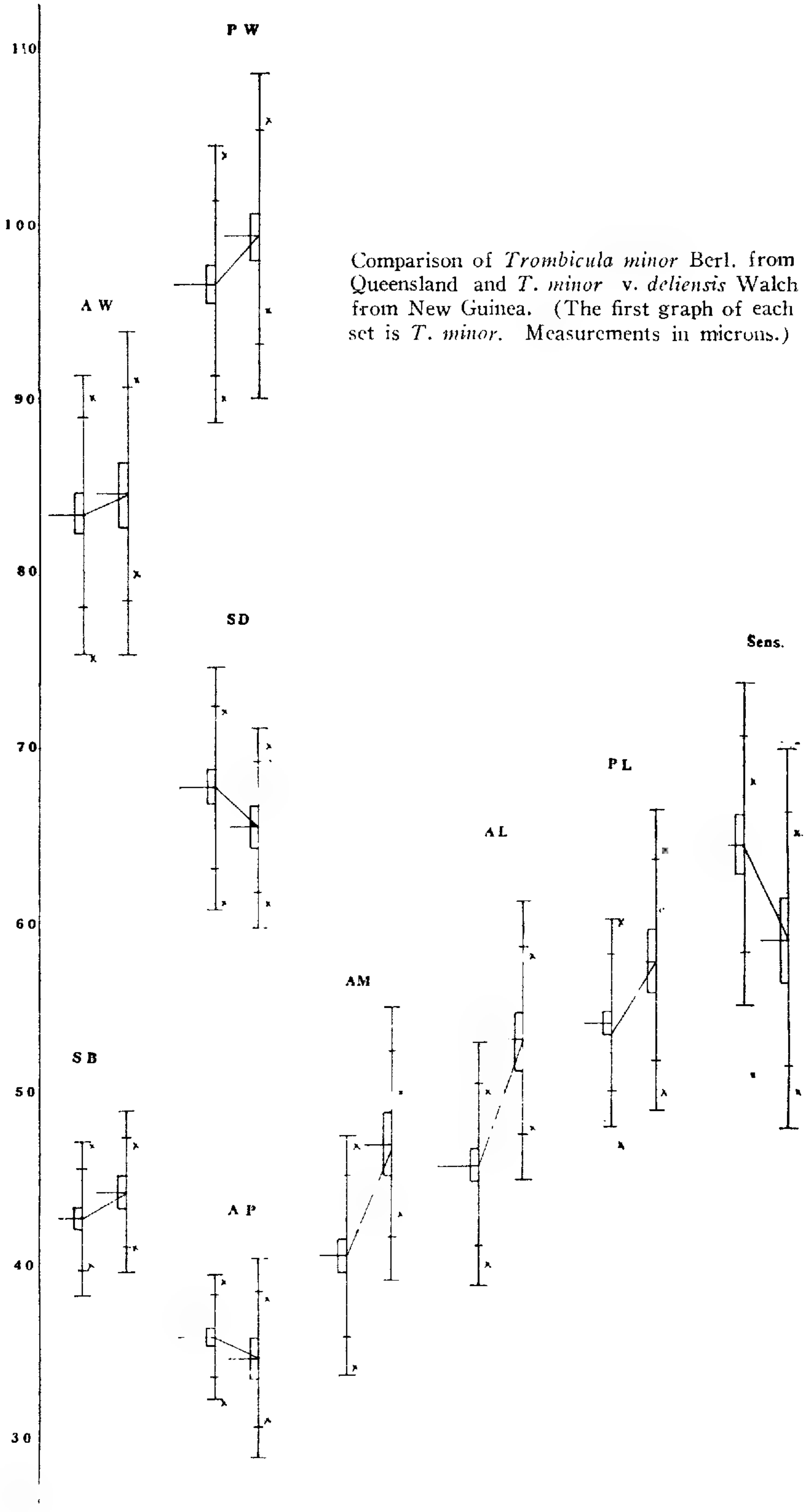
	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	84·5±0·64	3·06±0·45	75·3–93·7	80·0–91·0	3·6
PW - -	99·3±0·46	3·10±0·33	90·0–108·6	95·0–106·0	2·2
SB - -	44·3±0·33	1·58±0·23	39·6–49·0	41·0–47·0	3·5
SD - -	65·4±0·41	1·89±0·29	59·7–71·7	61·0–70·0	2·9
A–P - -	34·6±0·40	1·93±0·28	28·8–40·4	31·0–38·0	5·7
AM - -	47·1±0·60	2·68±0·42	39·1–55·1	43·0–50·0	5·7
AL - -	53·1±0·56	2·72±0·40	45·0–61·2	48·0–58·0	5·1
PL - -	57·7±0·60	2·89±0·43	49·0–66·4	50·0–64·0	5·0
Sens - -	58·9±0·81	3·65±0·57	48·0–69·9	50·0–65·0	6·2

Comparing these two populations in which the ranges of variation but not the ranges of Means, except for AW and SB, overlap considerably, it is found that, taking the standard error of the difference of means, they are significantly different for all characters except AW, the values for d/σ_d being AW 1·48, PW 4·37, SB 4·05, SD 4·0, A-P 3·5, AM 10·0, AL 11·6, PL 6·8, Sens. 5·7.

Further, the ratio of PW/SD differs considerably, as follows: Queensland 1·427, New Guinea 1·519.

It seems reasonable therefore that, while both populations may belong to the same species, and there is not sufficient difference to regard the New Guinea (and Sumatran) material (previously recorded as *T. minor* v. *deliensis* Walch) as a distinct variety, yet there is a geographical genetical difference between the two populations.

The two closely allied species, *T. wichmanni* Oudms. and *T. hatorii* Wom. and Heasp. are not known from sufficient material but appear to be significantly different, in the Stan rd Data, and in the ratio of PW/SD which for *wichmanni* is 1·85 and for *hatorii* 1·57.



Comparison of *Trombicula minor* Berl. from Queensland and *T. minor* v. *deliensis* Walch from New Guinea. (The first graph of each set is *T. minor*. Measurements in microns.)

Trombicula sarcina n. sp.

Fig. 5, A–C

Description—Larva. Shape shortly oval. Length 25 μ, width 160 μ. Dorsal scutum as figured with the following Standard Data in microns: AW 79, PW 90, SB 36, ASB 25, PSB 32, SD 57, A-P 32, AM 26, AL 34, PL 40, Sens. ? Dorsal setae 26 in number, arranged 2.6.6, then two well separated clusters of 6 on each

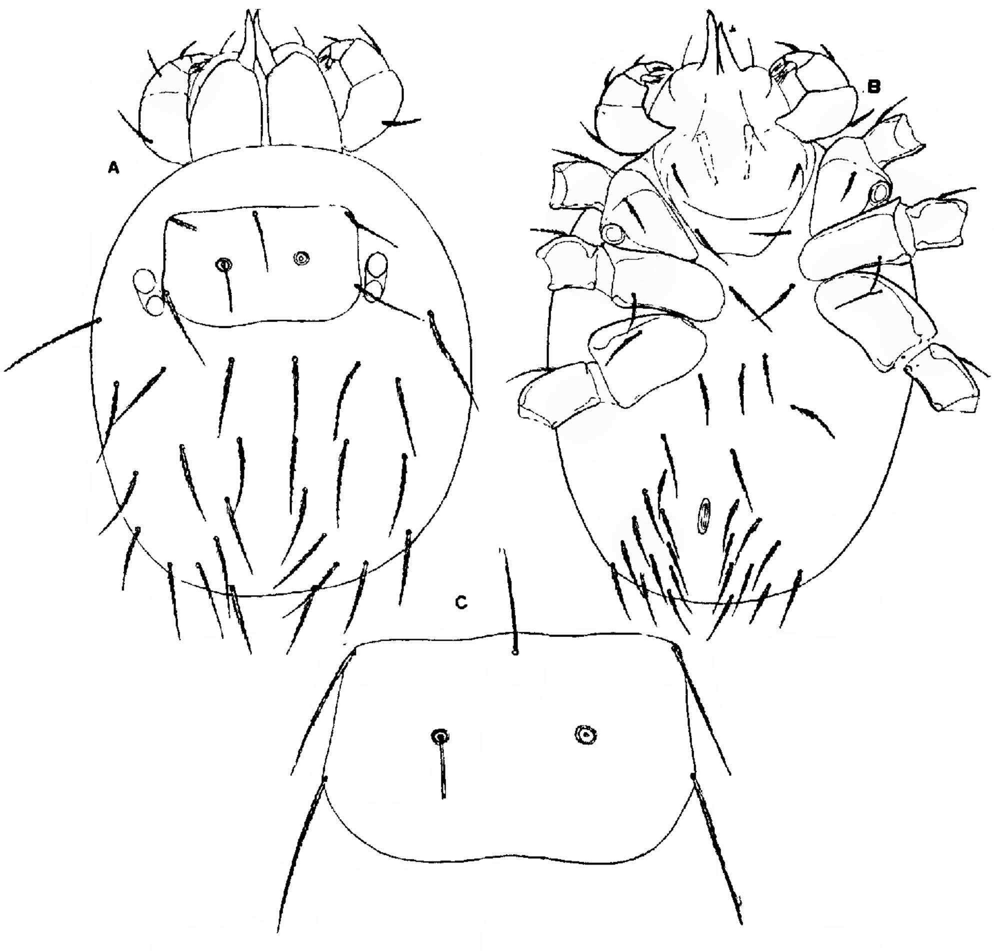


Fig. 5 *Trombicula sarcina* n. sp. Larva: A, dorsal; B, ventral; C, scutum x 500.

side (see fig. 5 A), 40-47 μ long, fairly robust and well ciliated. Eye 2 + 2. Palpi and mandibles typical of the genus. Venter: gnathosoma with a pair of ciliated setae, a pair between coxae I and between coxae III, thereafter 4.2, and then a pair of clusters of 9 to 10 each as on the dorsum (fig. 5 B). All coxae unisetose. Legs: I 270 μ, II 250 μ, III 290 μ; tarsi I and II with dorsal rod-like seta; all tarsi with paired claws and claw-like empodium.

Locality and *Host*—A single specimen (one of two) found in lesions on the skin about the shanks and coronets of sheep, Clermont, Queensland, March 1944 (sent by Mr. D. A. Gill, McMaster Laboratory, Sydney). Eight specimens collected on boots in ti-tree sheep camp, Clermont, Queensland, April 1944.

Remarks—This species is rather closely related to *T. minor* in the general conformation of the scutum but differs in the length of AM, AL, and PL, and more particularly in the greater number of DS, and their arrangement posteriorly into two well separated lateral clusters. The sensillae are missing except for a short piece of one, but long enough to place the species in *Trombicula*. With the eight specimens from Clermont, Queensland, received after the above description was drawn up the Standard Data are as follows:

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	77·0±0·63	1·9±0·44	71·35–82·65	75·0–79·0	2·45
PW - -	88·65±0·57	1·7±0·40	83·55–93·75	85·0–90·0	1·91
SB - -	40·1±0·85	2·55±0·60	32·5–47·7	36·0–43·0	6·3
SD - -	57·0	No variation recorded			
A-P - -	57·0	No variation recorded			
AM - -	29·0±0·47	1·41±0·33	24·8–33·2	26·0–32·0	4·85
AL - -	35·8±0·21	0·63±0·15	33·9–37·7	34·0–36·0	1·8
PL - -	42·7±0·31	0·94±0·22	39·9–45·5	40·0–43·0	2·2
Sens. - -	57·0	No variation recorded			

Genus SCHÖNGASTIA Oudemans 1910

Entom., Ber., 1910, 3, (54), 86.

Schongastia pusilla n. sp.

Fig. 6, A–C

Description—Larvae. Colour in life probably light yellowish-red. Shape ovoid. Length to 210 μ, width to 155 μ. Dorsal scutum typical of the genus, as figured, and with the following Standard Data as derived from 28 specimens.

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	54·85±0·48	2·57±0·34	47·1–62·5	50·0–61·0	4·7
PW - -	72·7±0·51	2·72±0·36	64·5–80·8	68·0–79·0	3·7
SB - -	21·25±0·21	1·13±0·15	17·85–24·65	19·0–23·0	5·3
SD - -	50·6±0·47	2·34±0·33	43·6–57·6	44·0–57·0	4·6
A–P - -	25·45±0·31	1·68±0·22	20·4–30·5	23·0–32·0	6·6
AM - -	30·4±0·30	1·50±0·21	25·9–34·9	28·0–32·0	5·0
AL - -	57·5±0·54	2·87±0·39	48·9–66·1	54·0–61·0	5·0
PL - -	44·2±0·70	3·63±0·49	33·3–55·1	39·0–50·0	8·2
Sens. - -	Nude, ca. 33 μ long, with head 24 μ x 24 μ				

Dorsal setae slender, tapering and ciliated, and arranged 2.8.2 (outer). 8.8.6.2.2. Eyes 2 + 2. Mandibles and palpi normal for genus. Legs: I 250 μ long, II 210 μ, III 235 μ; tarsi with paired claws and median claw-like empodium; tarsi I and II with the usual sensory dorsal rod. Venter: all coxae unisetose; between coxae I and between coxae III with the usual pairs of similar setae; thereafter the setae are arranged approximately 2.6.6.6(4).4(2). (2).

Locality—In numbers, collected on boots in Kunai grass, Buna area of New Guinea, 1943, together with *S. blestowei* Gunther and *T. walchi* Wom. and Heasp.

Remarks—This is rather a small species and in the key (Trans. Roy. Soc. S. Aust., **67**, (1), 102) comes near to *S. katonis* Wom. and Heasp. but can be distinguished by the Standard Data and arrangement of DS, and the nude head of the sensillae. As it might also be confused with *S. blestowei*, with which it occurs, the Standard Error of the Difference of the Means for both species have been compared and found to be significant (see under *S. blestowei*).

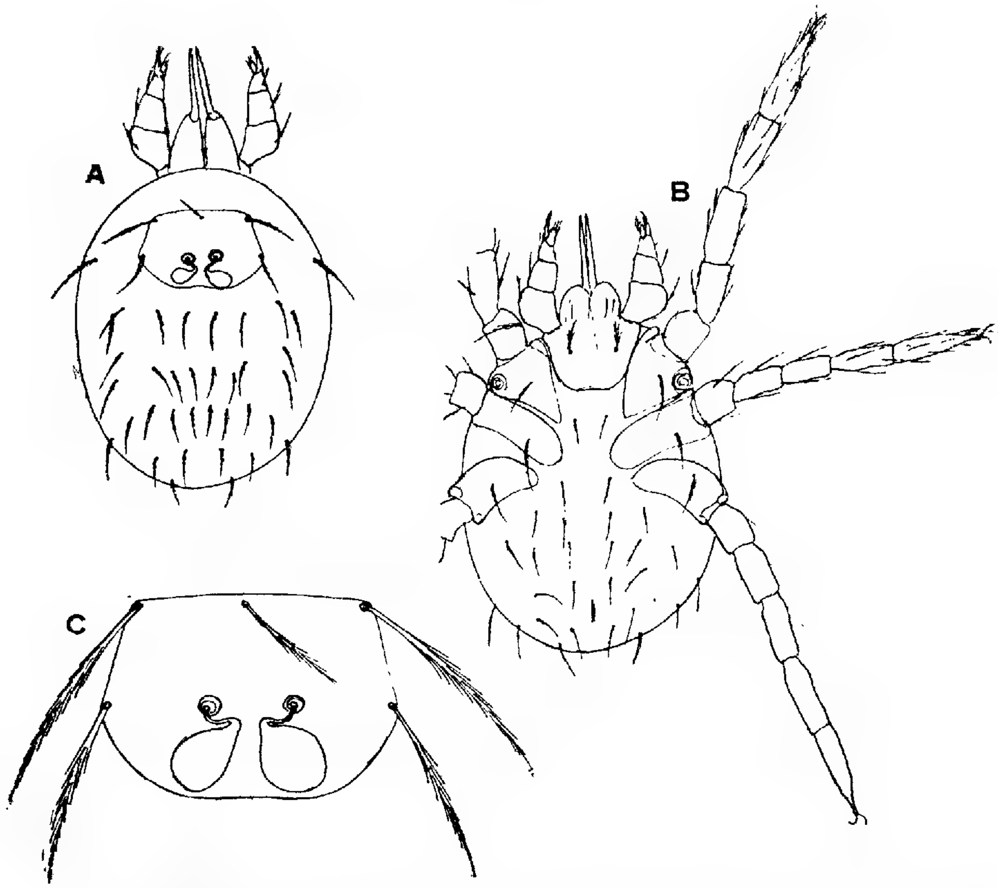


Fig. 6 *Schöngastia pusilla* n. sp. Larva: A, dorsal; B, ventral; C, scutum x 500.

SCHÖNGASTIA BLESTOWEI Gunther 1939

Schöngastia yeomansi Gunther 1938, Med. J. Aust., 2, (6), 202, (nom. nud.); *blestowei* Gunther 1939, Proc. Linn. Soc. N.S.W., **64**, (1, 2), 92; Womersley and Heaslip 1943, Trans. Roy. Soc. S. Aust., **67**, (1), 103.

Of this species, which so far is only known from New Guinea, I am now able to report on three populations from different areas, *viz.*, Suein River, Sepik District (7 specimens from man); 3 specimens from Bulolo from *Megapodius duperreyi;* and 32 specimens collected on boots, Buna area. The Standard Data for the first two populations were reported in 1943, but are now examined statistically with those of the Buna collection.

Buna—Number of specimens = 32.

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	67·6±0·80	5·0±0·62	52·6–82·6	61·0–79·0	7·4
PW - -	88·8±0·70	3·95±0·49	77·0–100·5	82·0–97·0	4·4
SB - -	27·25±0·35	1·97±0·25	21·2–33·3	25·0–29·0	6·5
SD - -	67·1±0·77	4·27±0·54	54·3–79·9	56·0–75·0	6·4
A–P - -	32·7±0·35	1·97±0·25	26·8–38·6	29·0–36·0	6·0
AM - -	39·5±0·40	2·16±0·76	33·0–46·0	35·0–43·0	5·5
AL - -	77·8±0·99	5·6±0·70	61·0–94·6	70·0–90·0	7·2
PL - -	59·6±0·85	4·8±0·60	45·5–74·1	50·0–72·0	8·0
Sens. - -	35·0	Not individually measured			

Suein River, Sepik District, on man. Number of specimens = 7.

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	65·0	No variation recorded			
PW - -	89·3±0·66	1·75±0·47	84·0–94·5	87·0–91·0	1·95
SB - -	25·7±0·26	0·70±0·19	23·6–27·8	24·0–26·0	2·7
SD - -	60·4±0·75	1·99±0·53	54·4–66·4	58·0–65·0	3·3
A–P - -	30·0±0·28	0·75±0·20	27·75–32·25	29·0–31·0	2·8
AM - -	36·2±0·70	1·87±0·50	30·6–41·8	35·0–40·0	5·1
AL - -	65·0	No variation recorded			
PL - -	50·85±0·37	0·99±0·26	47·8–53·9	50·0–52·0	1·95
Sens. - -	35·0	No variation recorded			

Bulolo (ex *Megapodius*)—Number of specimens = 3

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	90·0±0·47	0·81±0·33	56·6–61·4	58·0–60·0	1·4
PW - -	90·0±0·47	0·91±0·33	77·0–83·0	78·0–82·0	1·4
SB - -	33·0±0·81	1·41±0·57	28·8–37·2	32·0–35·0	4·2
SD - -	62·0	No variation recorded			
A–P - -	20·0	No variation recorded			
AM - -	37·0	Only 1 specimen measured			
AL - -	63·0	Only 1 specimen measured			
PL - -	60·0±1·42	2·00±1·0	54·0–66·0	58·0–62·0	3·3
Sens. - -	30·0	No variation recorded			

The above three populations have been tested for significant differences and the results summarised in the following table, a value of $d/\sigma_d > 2$ being regarded as positive, those in the neighbourhood of 2·0 being indicated by ±.

Significance of Differences of three Populations of *Schöngastia blestowei* Gunther.

	AW	PW	SB	SD	A-P	AM	AL	PL
Buna-Suein Rv. -	–	–	+	+	+	+	+	+
Buna-Bulolo - -	+	+	+	+	+	+	+	–
Suein Rv.-Bulolo -	+	+	+	+	+	–	+	–

From this it is seen that the Bulolo specimens regarded in the 1943 paper as a variety *megapodius* of *blestowei* differ significantly from those of Suein River and Buna, but that the Suein River population only differs from the Buna population in the factors SD, A-P, AM, AL and PL.

That *megapodius* should be regarded as a distinct variety is also borne out by: (1) that its host is a bird *Megapodius duperreyi* and (2) that on the venter behind coxae III the setae number 26 arranged ca. 6.6.4.4.4.2, whereas in *blestowei* f. typ. they number 40, arranged approximately 8.8.8.6.4.4.2.

The ratios of the PW/SD of the three populations are Buna 1·32, Bulolo 1·29, Suein River 1·48. A comparison of the Standard Data of these populations with those of *S. pusilla* shows a positive difference in all characters, the values of d/σ_d in all cases greatly exceeding one of 2.

Schöngastia salmi Oudms. 1922

Ent. Bericht, 1922, **6,** (126), 81; *idem,* **6,** (128), 114.

This species, overlooked in the 1943 paper, was described from Java without any figure and with only the briefest description, a translation of which is as follows:

"Differs from hitherto described species in the form of the scutum, which is trapezoidal, wider behind than in front, anteriorly concave, posteriorly strongly convex with a deep medial incision. The posterior half of the scutum is finely wrinkled as is the dorsal cuticle. On the dorsum with 12 transverse rows of 10 ciliated setae.

"Living in grass; parasitic on ————? Kediri, (Java), Dr. A. J. Salm."

In a short additional note (above) Oudemans says, "Tenkoe des abres; in gras, Magelang, Sept. 1916."

There is, unfortunately, nothing in the above by which one can place the species in *Schöngastia, Neoschöngastia* or *Paraschöngastia*, except possibly the wrinkling (striations) of the posterior half of the scutum which perhaps suggests a member of the last genus. It seems, therefore, that until the type can be located and examined, the species must be regarded as "incertae sedis".

Genus Neoschöngastia Ewing 1929

Manual of External Parasites, 1929, 187.

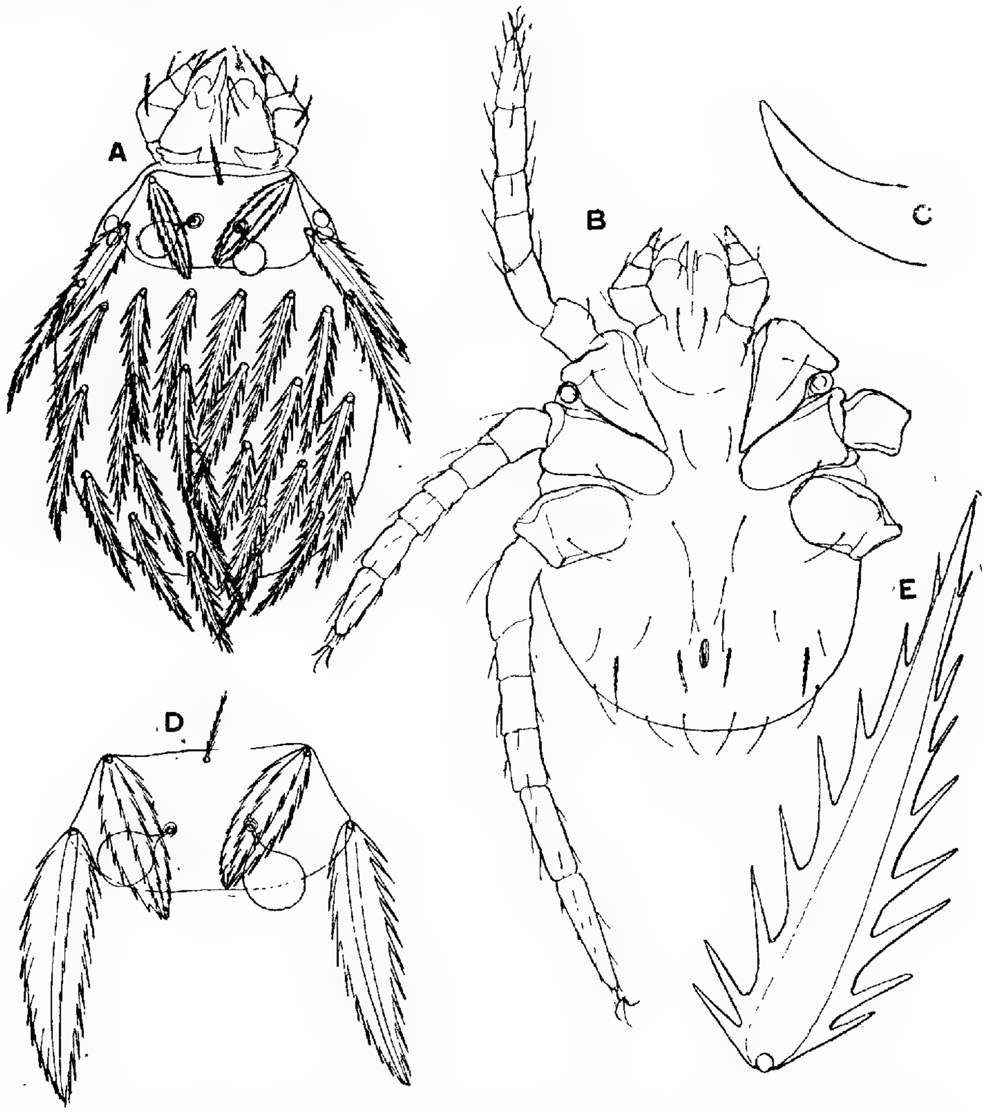


Fig. 7 *Neoschöngastia mccullochi* n. sp. Larva: A, dorsal; B, ventral; C, chelicera; D, scutum x 500; E, dorsal seta.

Neoschongastia mccullochi n. sp.

Fig. 7, A–E

Description—Larvae. Shape ovate. Length 170 μ, width 130 μ. Dorsal scutum as figured, with the following Standard Data in microns: AW 48, PW 67, SB 19, ASB 19, PSB 16, A-P 20, AM 16, AL 42, PL 64, Sens. 22 (head nude, 17 x 17). Dorsal setae 48 μ long, foliate with very large lateral teeth (cf. fig. 7 A) and arranged 2.6.6.6.4.2. The scutal AL and PL are similar to the DS in form; but AM is of normal form. Eyes 2 + 2, close to the margins of the scutum. Mandibles and palpi normal. Legs: I 248 μ long, II 208 μ, III 248 μ; tarsi with paired claws and median claw-like empodium. Venter: all coxae with 1 normal ciliated setae; a similar pair between coxae I and between coxae III, and thereafter arranged 2.6.4.4.2, the first row of 4 stronger and more ciliated than the rest.

Locality—A single specimen collected on boots, Abidari, New Guinea, 28 July 1943 (R. N. McCulloch).

Remarks—This species is close to *N. foliata* Gunther, but differs in the broader and stronger toothed DS, which are only 26 in number as compared with 32. Other differences lie in the smaller scutum and the Standard Data.

Genus GUNTHERANA Womersley 1943

Trans. Roy. Soc. S. Aust., 1943, 67, (1), 132.

Guntherana parana n. sp.

Fig. 8, A–B

Description—Larvae. Shape broadly oval, without a distinctive waist. Length to 195 μ, width to 143 μ. Anterior dorsal scutum rectangular as figured, with the following Standard Data based on seven specimens.

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	46·7±0·78	2·05±0·55	40·6–52·8	43·0–50·0	4·4
PW - -	64·7±1·00	2·65±0·71	56·7–72·6	61·0–68·0	4·1
SB - -	17·4±0·34	0·90±0·24	14·7–20·1	16·0–18·0	5·2
SD - -	46·6±0·4	1·05±0·28	43·5–49·7	44·0–47·0	2·25
A–P - -	29·1±0·51	1·35±0·36	25·1–33·1	27·0–32·0	4·7
AM - -	30·0±0·4	1·07±0·28	26·8–33·2	29·0–32·0	3·5
AL - -	30·0±0·4	1·07±0·28	26·8–33·2	29·0–32·0	3·5
AL - -	74·0±1·6	4·37±1·17	60·9–87·1	68·0–81·0	5·9
PL - -	98·4±1·6	4·34±1·13	85·4–111·4	93·0–108·0	4·4
Sens. - -			No variation recorded		

The ratio of PW/SD = 1·39 and the ASB is slightly greater than PSB (19:16). Sensillae globose, the head nude and 16 x 16. Dorsal setae arranged 2.6.4.6.2, the last 2 being 90-120 μ long. Posterior dorsal scutum somewhat reniform, 104 μ wide, by 65 μ long, not subdivided, with very fine pitting (or pubesence) and with three pairs of very fine setae uniformly 31 μ long. Eyes 2 + 2. Mandibles and palpi normal as in *G. bipygalis* (Gunther). All coxae unisetose, a pair of setae between coxae I and between coxae III, and thereafter ventral setae 8.6.4.4.2. Legs: I 260 μ, II 235 μ, III 286 μ; tarsi with paired claws and a claw-like empodium; tarsi I and II with a short smooth sensorial rod dorsally.

Locality—A number of specimens collected on boots at Abidari, New Guinea, 28 July 1943 (R. N. McCulloch).

Remarks—Differs from the genotype in the smaller anterior dorsal scutum with different Standard Data, especially SB, and the fewer and different arrangement of the DS (20 as compared with 28 in *bipygalis*). The posterior dorsal scutum also differs, the setae being uniform in length, whereas in *bipygalis* they are shorter and not uniform.

The remarkable habit of *G. bipygalis* of attaching its eggs to the fur of its host has not been observed for *G. parana*, neither has it yet been found upon any host.

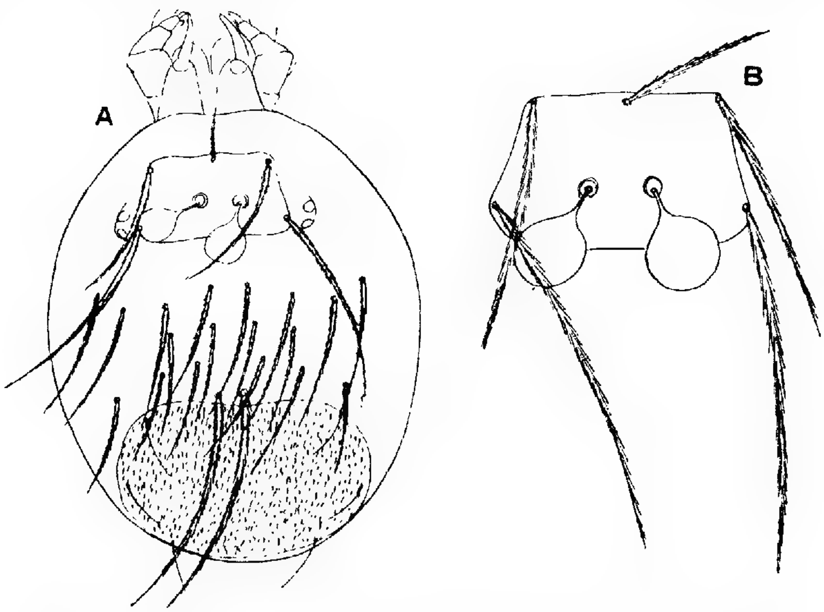


Fig. 8 *Guntherana parana* n. sp. Larva: A, dorsal; B, scutum x 500.

Genus WALCHIA Ewing 1931

Proc. U.S. Nat. Mus., **80**, (8), 10. Genotype *Walchium glabrum* Walch.

WALCHIA DISPARUNGUIS (Oudms. 1929)

= *Schöngastiella disparunguis* Ouds. 1929, Ent. Ber., **7**, (165), 398.

This species was described from specimens from the ears of *Mus rattus* var. from Garoet (W. Java), Aug., W. C. van Heuren.

Oudemans' original description, translated, reads as follows:

"Length of a moderately engorged specimen 225 μ, greatest breadth 145 μ. Scutum roughly pentagonal with one angle directed posteriorly; in each of the other four angles a seta. On each shoulder is a seta and behind the scutum five rows of six setae in each. Pseudostigmal organ clavate, the stem about one-third of its length. Dorsal setae about 30 μ long, brush-like and shortly ciliated. Eyes small, cornea half-spherical. Venter: all coxae (also maxillae) with a feathered seta; coxae III with two such. Between coxae I and between coxae III a pair of similar setae. Then 17 pairs of setae similar to the dorsal setae. Gnathosoma dorsally with six pairs of smooth setae, ventrally with one more; externally on the tibiae with a short smooth seta, and on the very short and difficult to see palpus are four setae of which one is a short thick rod-like olfactory seta, the three others are short thick setae distally divided into four or five branches. Palpi claw bifid."

Oudemans was rather uncertain about placing this species in *Schöngastiella* Hirst as it differed from Hirst's diagnosis in having only four setae besides the sensillae on the scutum instead of three pairs. He also noted that the scutum resembles that of *Typhyothrombium* Ouds. 1910 (= *Gahrliepia* Ouds. 1912), but in his description it is suggested that the posterior angle is sharply defined (not tongue-like as in *Gahrliepia* as now understood) and similar to that of *Walchia* Ewing.

Oudemans also refers to the disparity in form and size of the three tarsal claws, and named his species on this character. This feature, in which the median claw (empodium) is much stronger than the others and of median length, the outer longer and only slightly more slender, and the inner only slightly shorter than the median but much thinner, is, however, present in all the species of *Walchia* known to me and is, I believe, a good generic character.

The multisetose coxae III also places Oudemans' species in *Walchia,* but all other species have either one, three, four or six setae present and *disparunguis* is intermediate between *W. glabrum* Walch (= *pingue* Gater) with three coxal setae and the group, *morobensis* Gunther, *rustica* (Gater) and *turmalis* (Gater) with only a single seta on coxae III. In the DS it will be closely related to *glabrum.*

Walchia glabrum (Walch 1927)

Trombicula glabrum Walch 1927 Genesk., Tijdsch. v. Ned., Indie, **67,** (6), 926.
Walchia glabrum Ewing 1931, Proc. U.S. Nat. Mus., **80,** (8), 10; Womersley and Heaslip 1943, Trans. Roy. Soc. S. Aust., **67,** (1), 134.
Walchia pingue Gater 1932, Parasitology, **24,**

Of this species I have now been able to examine seven specimens from the Buna area of New Guinea, 1943 (G. M. Kohls). The statistical values of the Standard Data for these specimens are as follows:

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	29·3±0·26	0·70±0·19	27·2–31·4	28·0–30·0	2·4
PW - -	51·4±0·90	2·55±0·68	43·7–59·1	48·0–54·0	5·0
SB - -	26·85±0·55	1·46±0·39	22·5–31·2	25·0–29·0	5·4
SD - -	54·85±0·47	1·25±0·33	51·0–58·6	53·0–57·0	2·3
A–P - -	36·85±0·37	·98±0·37	33·9–39·8	36·0–38·0	2·7
AL - -	29·0	No variation recorded			
PL - -	33·4±0·52	1·4±0·37	29·2–37·6	32·0–35·0	4·2

In the 1943 paper, on page 135, it was stated that one of the lateral claws was wanting. I now find that this is not so, the inner claw is definitely present but fine and difficult to see, in comparison with the outer claw and empodium.

Subfam. **LEEUWENHOEKIINAE** nov.

Trombiculinae with a respiratory spiracle situated in front of the first coxae and on each side of the gnathosoma, from which radiate tracheal tubes.

A study of many specimens of *Leeuwenhoekia* has recently revealed the presence of the above pair of true spiracles, each of which is supplied with a tracheal system. The larvae of the Trombidiidae are separated from those of the Erythraeidae by the presence ventrally between the first and second coxae of a pronounced and conspicuous spiracle-like opening or "urstigma". No tracheal tubes, however, have ever been observed arising therefrom and its precise function is unknown. The above true stigma, however, is of a different type, smaller and less strongly chitinised, and long tracheae can be traced running down the body for a considerable distance.

On the presence of an organ of such fundamental importance it becomes necessary to erect a new family, ranking with the *Trombiculinae* in the restricted sense.

Unfortunately, the allied genus *Hannemannia* has not been found in this region and the presence of such an organ in the species of that genus requires determination by other workers. At present only the genus *Leeuwenhoekia* can be placed in the subfamily.

Genus Leeuwenhoekia Ouds. 1911

Entom., Ber., **3**, (5-8), 137. Genotype *Heterothrombium verduni* Ouds. 1910.

The first species of this larval genus to be recorded from Australia was *L. australiensis* Hirst 1925 (Trans. Roy. Soc. Trop. Med. and Hyg., 19), which was described from specimens collected in the suburbs of Sydney, where they were a source of much annoyance to people working in the gardens.

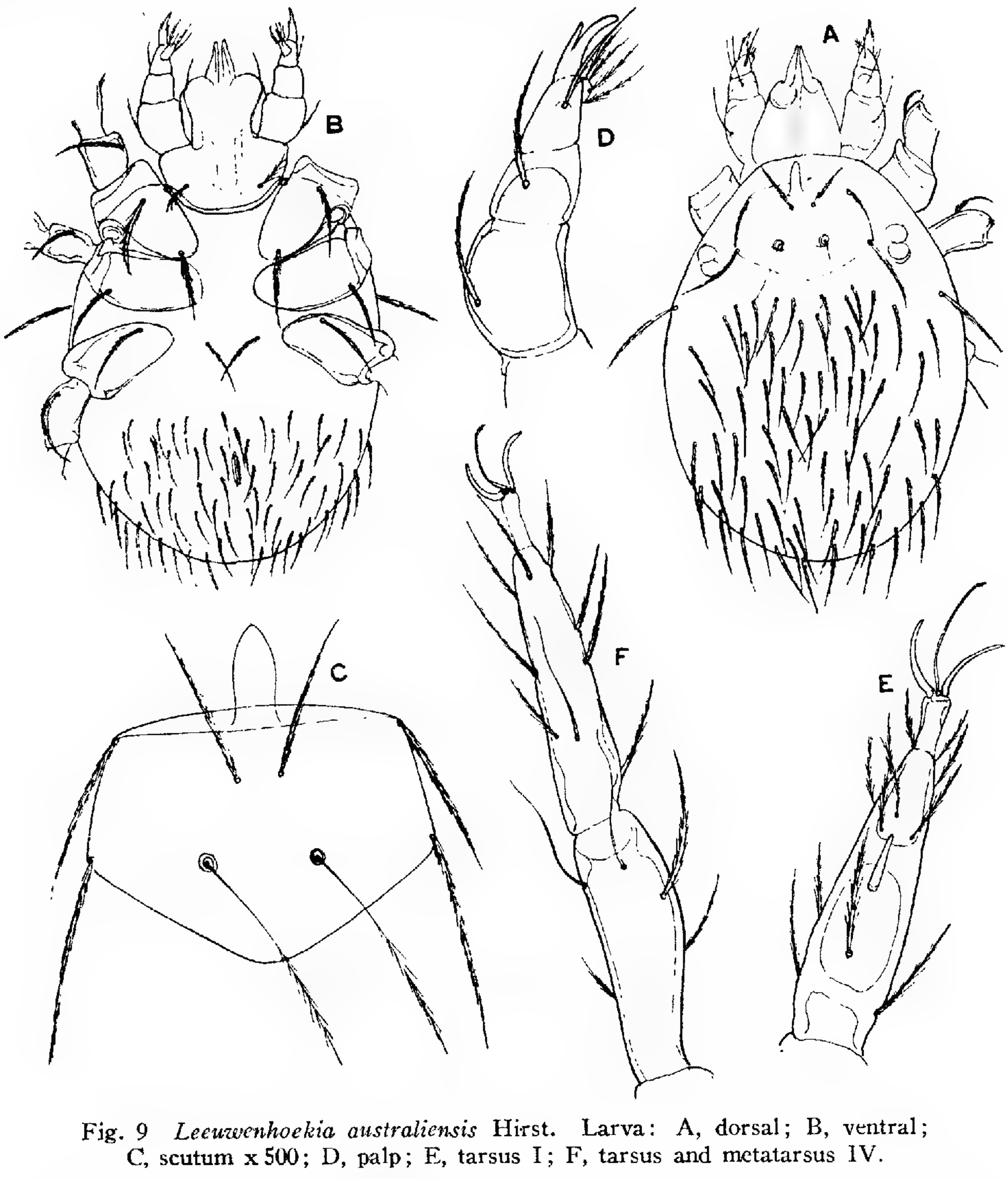


Fig. 9 *Leeuwenhoekia australiensis* Hirst. Larva: A, dorsal; B, ventral; C, scutum x 500; D, palp; E, tarsus I; F, tarsus and metatarsus IV.

In 1934 (Records S. Aust. Mus., **5**, (2), 217) I recorded, under the same name, specimens taken from the ears of a cat from Glen Osmond, Adelaide (D. C. S., 1931), and in 1939 (Proc. Linn. Soc. N.S.W., **64**, (1, 2), 95) Gunther recorded it for New Guinea from a single specimen from a Cassowary at Bulolo, upon my determination.

In my joint paper with W. G. Heaslip (Trans. Roy. Soc. S. Aust., **67**, (1), 1943, 141) the Standard Data for a number of specimens from Queensland were also recorded.

It is now found that the Adelaide specimens are different and they are redescribed as a new species. Several other new species are also described and a key to the species of the genus presented.

Leeuwenhoekia australiensis Hirst

Fig. 9, A–F

Trans. Roy. Soc. Trop. Med. and Hyg. 1925, *nec* Womersley 1934. Rec. S. Aust. Mus. 1934, 5, (2), 217; Gunther 1939, Proc. Linn. Soc. N.S.W., **64**, (1, 2), 95; Womersley and Heaslip 1943, Trans. Roy Soc. S. Aust., **67**, (1), 141 (in part).

A population of 13 specimens from Chatswood, Sydney, practically the type locality, collected in April 1943 (R. N. McCulloch), have been examined together with four from Cairns, Queensland, 1939, on bandicoots (W. G. Heaslip); four from bandicoots, Brisbane, Queensland, 1938, (W. G. H.), one from the same host, Little Mulgrave, Queensland, and one from man, Brisbane, Queensland, 1935 (F. H. S.). Both the Queensland and Sydney populations showed no significant differences in any of the characters used for the Standard Data.

Another specimen from Bulolo, New Guinea, collected by Gunther does, however, show a slight and significant difference from the Australian specimens in that the AL and PL are longer. It cannot, however, be regarded as more than a minor geographical difference.

In his original description Hirst gives the following data: scutal length 60 μ, width 96 μ; length of anterior scutal process 21 μ; AM 40-45 μ AL 46 μ, PL 63 μ DS 42-43 μ. The DS, according to his figures, are arranged ca. 2.10.7.10.12.11.8.6.4 = 70.

A fresh description is now drawn up from the Chatswood, Sydney, material, except that the Standard Data is from the Sydney and Queensland material combined.

Description—Length (excluding gnathosoma) to 340 μ, width to 230 μ. Shape an elongate oval. Dorsal scutum as figured, with following Standard Data:

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	77·35±0·98	4·73±0·70	63·25–91·45	72·0–90·0	6·1
PW - -	93·4±1·0	4·78±0·70	79·1–107·7	86·0–102·0	5·1
SB - -	30·2±0·43	2·06±0·30	24·1–36·3	25·0–36·0	6·8
SD - -	70·8±0·73	3·51±0·52	60·3–81·3	63·0–77·0	5·0
A-P - -	31·9±0·64	1·76±0·45	26·6–37·2	29·0–36·0	9·7
AM - -	44·9±0·68	3·27±0·48	35·1–54·7	40·0–50·0	7·3
AL - -	49·0±0·67	3·21±0·47	39·4–58·6	45·0–58·0	6·5
PL - -	63·6±0·57	2·75±0·40	55·4–71·8	58·0–70·0	4·3
Sens. - -	64·0±0·71	2·77±0·50	55·7–72·3	61·0–68·0	4·3

Ratio of ASB/PSB = 41/30 and PW/SD = 1·32.

Dorsal setae about 76 in number, 45-60 μ long and arranged approximately 2.12.8.8.12.12.10.6.4.2. Anterior median projection of scutum 25 μ long by 14 μ wide at base. The AM setae are 12 μ apart at bases and placed about 21 μ behind the anterior margin of scutum. Eyes 2 + 2. Legs: longer than body, I 395 μ, II 310 μ, III 410 μ, including coxae; coxae I with two setae, II and III with one seta, these setae 40 μ long; tarsi I and II with a stout dorsal sensory rod; all tarsi with paired claws and a longer median claw-like empodium; tibiae III with a pair of long slender whip-like setae and tarsi III with one such. Palpi and mandibles normal, chelae serrated. Gnathosoma with a pair of ciliated setae. Between gnathosoma and coxae I on each side is a distinct, lightly chitinised stigma from which tracheal tubes run; between coxae I and coxae II on each side is the larger, more chitinised pseudo-stigmata (urstigma) from which no tracheal tubes arise, and which is characteristic of all larval Trombidiidae. Ventrally, between coxae I, there are no setae, a pair between coxae III, and thereafter about 60 setae, to 60 μ long.

Locality and Hosts—As given in the introduction of this species.

Remarks—The Standard Data for the single specimen from Bulolo, New Guinea, are as follows:

AW	PW	SB	ASB	PSB	SD	A-P	AM	AL	PL	Sens.
83	97	32	43	32	32	30	54	61	72	60

As stated above, it is only significantly different in the values for AL and PL, and agrees in all morphological characters. Pending more material from Bulolo, it can only be regarded as a geographical variation.

Leeuwenhoekia adelaideae n. sp.

Fig. 10, A–C

Description—Larvae. Shape elongate oval. Length to 360 μ, width to 210 μ. Dorsal scutum as figured, and the Standard Data based on the South Australian material as follows:

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	76·4±0·88	1·96±0·62	70·5–82·3	74·0–80·0	2·5
PW - -	92·4±0·53	1·20±0·38	88·8–96·0	90·0–93·0	1·3
SB - -	28·8±0·65	1·47±0·46	24·4–33·2	26·0–30·0	5·1
SD - -	69·2±0·18	·40±0·12	68·0–70·4	69·0–70·0	·5
A–P - -	32·8±0·18	·40±0·12	31·6–34·0	32·0–33·0	1·2
AM - -	41·2±0·65	1·47±0·46	36·8–45·6	40·0–43·0	3·6
AL - -	37·8±0·43	·98±0·31	34·9–40·7	37·0–39·0	2·6
PL - -	59·8±1·14	2·56±0·81	52·1–67·5	56·0–64·0	4·2
Sens. - -	63·0±0·86	1·73±0·61	57·8–68·2	60·0–64·0	2·7

Ratio of ASB/PSB = 40/29 and PW/SD = 1·335.

Dorsal setae ca. 52 in number and arranged ca. 2.12.8.10.8.6.4.2. Anterior median projection of scutum 18 μ long by 7 μ wide at base. The AM setae 11 μ apart at base and about 7 μ behind anterior scutal margin. Eyes 2 + 2. Legs rather longer than body, I 450 μ, II 370 μ, III 430 μ, including coxae; coxae I with two setae, II and III with one seta each, these setae tapering, finely ciliated and about 50 μ long; tarsi I and II with a stout dorsal sensory rod; all tarsi with paired claws and a rather longer slender, claw-like empodium; tibiae III with a pair of long slender whip-like setae, tarsi III with one such. Palpi and mandibles normal, chelae serrate. Gnathosoma with a pair of long ciliated setae. Between gnathosoma and coxae I on each side with a true stigmal opening as in *australiensis*. Ventrally, no setae between coxae I, a pair between coxae III and thereafter about 26 setae to 40 μ long.

Remarks—Three specimens from rats from Cairns, Queensland, 1939 (W. G. H.), agree with the above data except that PW, A-P and especially AL and Sens., are significantly greater. It hardly seems possible, however, to regard these specimens as more than a geographical variation.

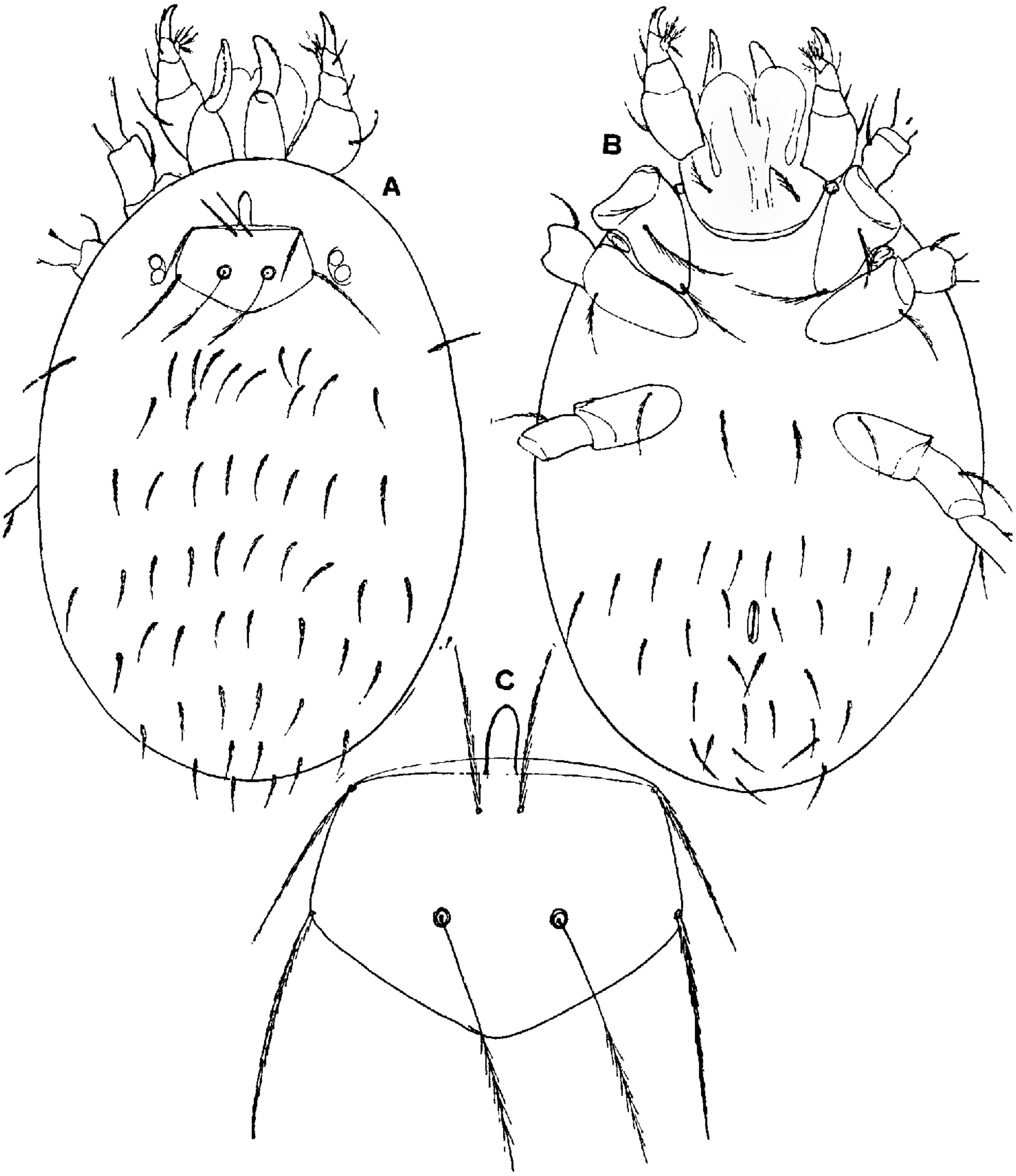


Fig. 10 *Leeuwenhoekia adelaideae* n. sp. Larva: A, dorsal; B, ventral; C, scutum x 500.

The Standard Data for these specimens are as follows:

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	74·0±1·05	1·82±0·74	68·5–79·5	72·0–75·0	2·5
PW - -	88·3±1·96	3·40±1·39	78·1–98·5	85·0–93·0	3·8
SB - -	29·0	No variation recorded			
SD - -	67·3±1·90	3·30±1·35	57·4–77·2	65·0–72·0	4·9
A–P - -	31·0±0·81	1·41±0·58	26·8–35·2	29·0–32·0	4·5
AM - -	43·3±1·65	2·87±1·17	34·7–51·9	40·0–47·0	6·6
AL - -	45·7±1·09	1·89±0·77	40·1–51·3	43·0–47·0	4·1
PL - -	58·0±1·49	2·58±1·05	50·3–65·7	54·0–60·0	4·45
Sens. - -	70·7±0·54	·94±0·38	67·9–73·5	70·0–72·0	1·33

Locality and *Hosts*—Five specimens from ears of domestic cats, three from Glen Osmond, South Australia, November 1931 (D. C. S.), and two from Unley, South Australia, February 1941 (R. V. S.). Also three specimens from rats, Cairns, Queensland, 1939 (W. G. H.).

Leeuwenhoekia hirsti n. sp.

Fig. 11, A–C

Description—Larva. Length (excluding gnathosoma) 330 μ, width 275 μ. Shape an elongate oval. Dorsal scutum as figured with the following Standard

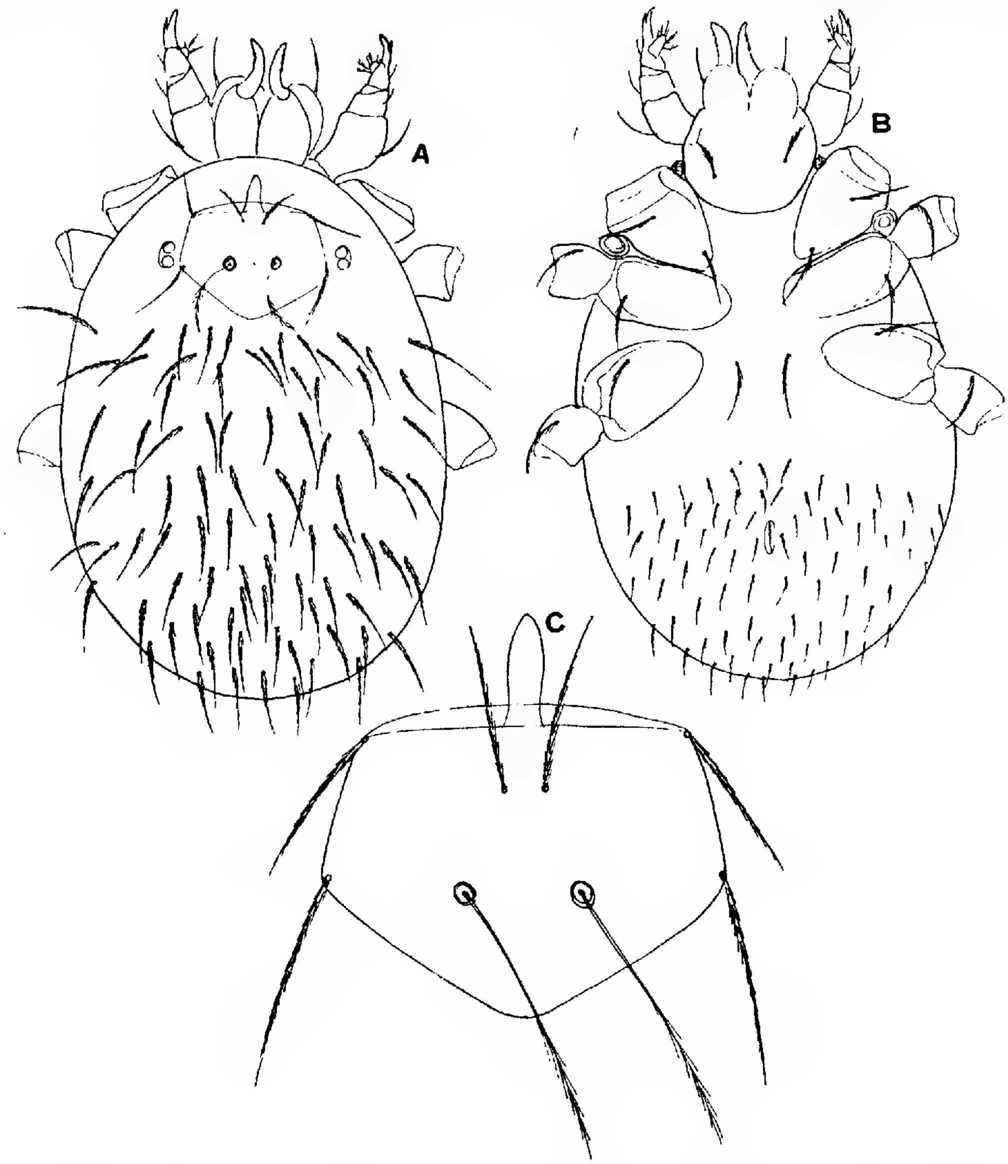


Fig. 11 *Leeuwenhoekia hirsti* n. sp. Larva: A, dorsal; B, ventral; C, scutum x 500.

Data in microns: AW 79, PW 97, SB 29, ASB 46, PSB 31·5, SD 77·5, A-P 36, AM 43, AL 43, PL 54, Sens. 72, DS 45-60, Ratio PW/SB = 1·252. Dorsal setae rather more robust than in *australiensis*, 82 in number and arranged ca. 2.8.12.10.10.12.8.8.6.4.2, the anterior rows rather confused. The AM setae 11 μ apart at base and about 21 μ behind anterior scutal margin. Anterior process of scutum 29 μ long, and 11 μ wide at base. Eyes 2 + 2. Legs: I 360 μ, II 330 μ, III 375 μ, including coxae; coxae I with two setae, II and III with one seta, these setae to 40 μ long; tarsi I and II with dorsal rod-like seta; tibiae III with two long whip-like setae, tarsi III with one such; all tarsi with paired claws and rather longer, median claw-like empodium. A true stigma present on each side of gnathosoma. Palpi normal, with bifurcate tibial claw. Mandibles normal, chelae serrate. No setae between coxae I, a pair between coxae III, and thereafter 12.12.12.10.10. 8.6.4.2 setae, to 36 μ long.

Locality—Described from a single specimen collected on boots at Skull Pocket, Kairi, Queensland, February 1943 (R. N. McC.).

Remarks—In the Standard Data this species agrees with *australiensis*, but differs in the greater number of DS (82) and in the somewhat deeper scutum, giving a PW/SD of 1·252. The DS are also more robust, and the ventral setae more numerous.

Leeuwenhoekia mccullochi n. sp.
Fig. 12, A–C

Description—Larvae. Length (excluding gnathosoma) to 315 μ, width to 210 μ. Shape an elongate oval. Dorsal scutum smaller and not as long as in other

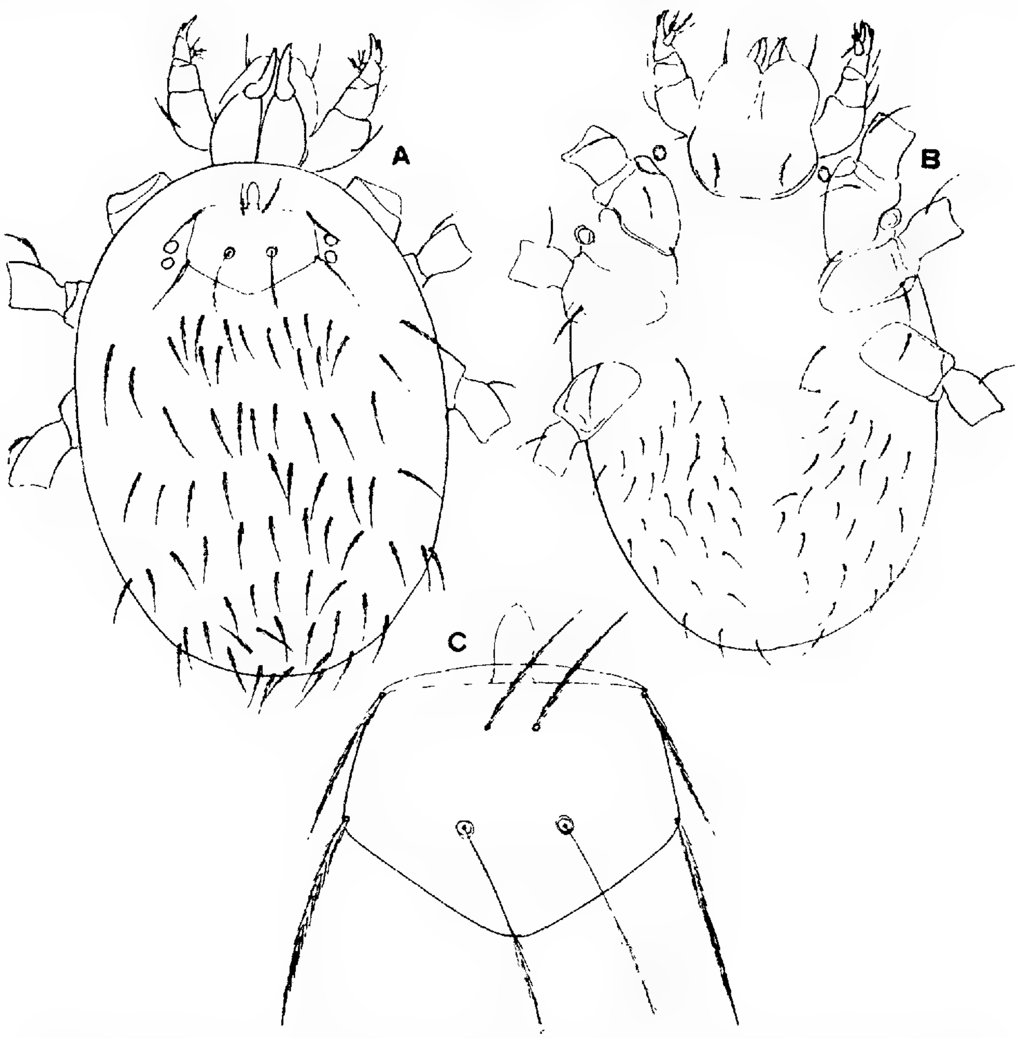


Fig. 12 *Leeuwenhoekia mccullochi* n. sp. Larva: A, dorsal; B, ventral; C, scutum 500.

species, as figured with the following Standard Data in microns, based on four specimens.

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	64·0±0·87	1·73±0·61	58·8–69·2	61·0–65·0	2·7
PW - -	81·0±1·00	2·00±0·71	75·0–87·0	79·0–83·0	2·5
SB - -	25·0	No variation recorded			
SD - -	71·0±1·41	2·83±1·00	62·5–75·5	67·0–75·0	4·0
A–P - -	32·5±0·43	0·87±0·31	29·9–35·1	32·0–34·0	2·7
AM - -	36·5±0·43	0·87±0·31	33·9–39·1	36·0–38·0	2·4
AL - -	38·0±1·0	2·0±0·71	32·0–44·0	36·0–40·0	5·2
PL - -	54·0	No variation recorded			
Sens. - -	44·3±1·09	1·89±0·75	38·6–49·9	43·0–47·0	4·3

Ratio of ASB/PSB = 39/29 and of PW/SD = 1·194.

Dorsal setae ca. 70 in number 45-55 μ long, and arranged ca. 2.8.10.8.10.10.10. 6.4.2. Anterior median projection of scutum about 22 μ long and 10 μ wide at base. The AM setae 11 μ apart at base and about 15 μ behind anterior margin of scutum. Eyes 2 + 2. Legs: I 345 μ II 290 μ, III 360 μ; coxae I with two setae, II and III with one seta, these setae to 47 μ long, tarsi I and II with dorsal rod-like seta, all tarsi with paired claws and median claw-like empodium; tibiae III with a pair of long slender whip-like setae, tarsi III with one such. Gnathosoma with a pair of ciliated setae. A true stigma present on each side of gnathosoma. No setae between coxae I, a pair between coxae III, and thereafter 12.10.10.10. 6.4.2. setae, to 36 μ long and finer than the dorsal and other ventral setae. Palpi normal with bifurcate tibial claw. Mandibles with serrate chelicerae.

Locality—Four specimens collected on boots, on edge of scrub. Trinity Beach area, Queensland, July 1943 (R. N. McC.).

Remarks—Very distinct from all other species with approximately similar number of DS and whip-like setae on tibiae and tarsi III, in the Standard Data of the scutum.

Leeuwenhoekia southcotti n. sp.

Fig. 13, A–C

Description—Larvae. Length (excluding gnathosoma) to 310 μ, width to 260 μ. Shape elongate oval. Dorsal scutum small and relatively short, as figured, with the following Standard Data in microns based on seven specimens.

	Mean	Standard Deviation	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	62·15±0·56	1·48±0·39	57·7–66·6	61·0–65·0	2·4
PW - -	82·4±0·66	1·76±0·46	77·1–87·7	79·0–85·0	2·1
SB - -	28·6±0·37	1·0±0·26	25·6–31·6	26·0–29·0	3·4
SD - -	49·1±0·51	1·35±0·36	45·1–53·1	47·0–50·0	2·7
A–P - -	27·6±0·49	1·29±0·34	23·7–31·5	26·0–29·0	4·6
AL - -	29·95±0·41	1·20±0·30	26·6–33·3	29·0–32·0	3·7
PL - -	40·85±0·51	1·35±0·36	36·8–44·9	40·0–43·0	3·3
Sens. - -	64·3±0·58	1·48±0·43	59·9–68·7	61·0–65·0	2·3

Ratio of ASB/PSB = 24/19 and of PW/SD = 1·744.

Dorsal setae ca. 42, arranged ca. 2.6.6.8.8.6.4.2, strong, ciliated and apically blunt. Anterior median projection of scutum 14 μ long by 5 μ wide at base. The AM setae with bases 5 μ apart and about 4 μ behind anterior margin of scutum. Eyes 2 + 2. Legs: I 340 μ, II 305 μ, III 390 μ, including coxae; coxae I with two setae, II and III with one seta, 32 μ long; tarsi I and II with usual dorsal rod-like seta, III without any whip-like setae on tibiae or tarsi; all tarsi with paired claws and longer claw-like empodium. Gnathosoma with a pair of ciliated setae.

On each side of gnathosoma and between coxae I is a true stigma as in *australiensis*. No setae between coxae I, a pair between coxae III, and thereafter 8.4.4.4.4.4.4 setae.. Palpi normal with bifurcate tibial claw. Mandibles with chelae serrated.

Locality and *Hosts*—Two specimens from a skink (*Lygosoma* sp.) from Adelaide River, Northern Territory, Australia, June 1943 (R. V. S. Slide ACB 169B) and eight specimens from a similar host and the same locality July 1943 (R.V.S. Slide ASB 169A).

Remarks—Differs markedly from all other species in the Standard Data and the lack of the long whip-like setae on tibiae and tarsi III.

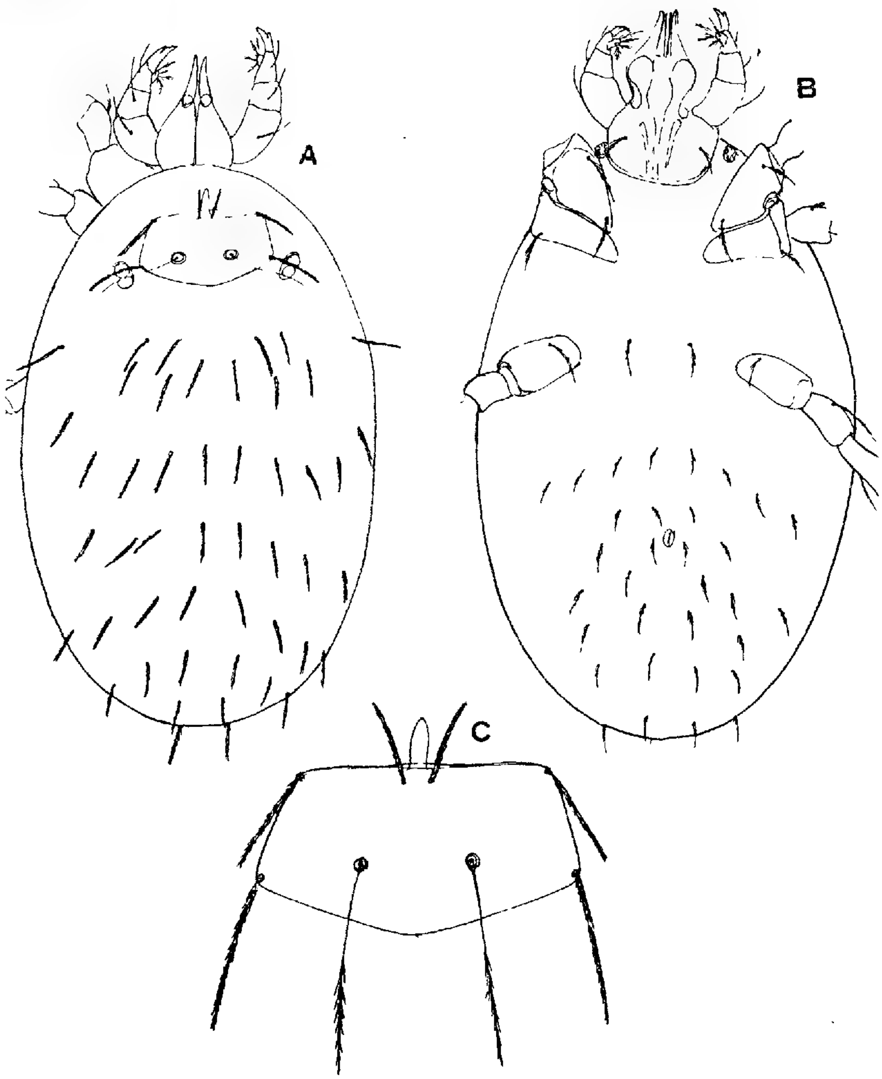


Fig. 13 *Leeuwenhoekia southcotti* n. sp. Larva: A, dorsal; B, ventral, C, scutum x 500.

Leeuwenhoekia nova-guinea n. sp.

Fig. 14, A–C

Description—Larvae. Length, fully fed to 800 μ, unfed 400 μ, width fully fed to 600 μ, unfed 320 μ. Shape an elongate oval, in life and before mounting with a distinct contraction behind coxae III. Dorsal scutum as figured, with the sides of the posterior angle slightly concave, and with the following Standard Data in microns based on 12 specimens.

	Mean	Deviation	Range	Range	Variation
		Standard	Theoretical	Observed	Coeff. of
AW - -	85·75 ± 1·35	4·69 ± 0·96	71·7–99·8	79·0–93·0	5·4
PW - -	98·4 ± 1·18	4·09 ± 0·83	86·1–110·7	94·0–108·0	4·1
SB - -	27·9 ± 0·65	2·27 ± 0·46	21·1–34·7	25·0–32·0	8·1
SD - -	73·0 ± 1·84	5·21 ± 1·30	57·4–88·6	65·0–79·0	7·1
A–P - -	34·25 ± 1·23	3·48 ± 0·87	23·85–44·65	29·0–38·0	10·1
AM - -	41·5 ± 0·94	2·97 ± 0·66	32·6–50·4	36·0–45·0	7·1
AL - -	62·1 ± 1·68	5·84 ± 1·19	44·6–77·6	54·0–72·0	9·4
PL - -	72·8 ± 0·74	2·58 ± 0·52	65·1–80·5	70·0–79·0	3·5
Sens. - -	58·7 ± 1·33	4·22 ± 0·94	46·1–71·3	54·0–65·0	7·2

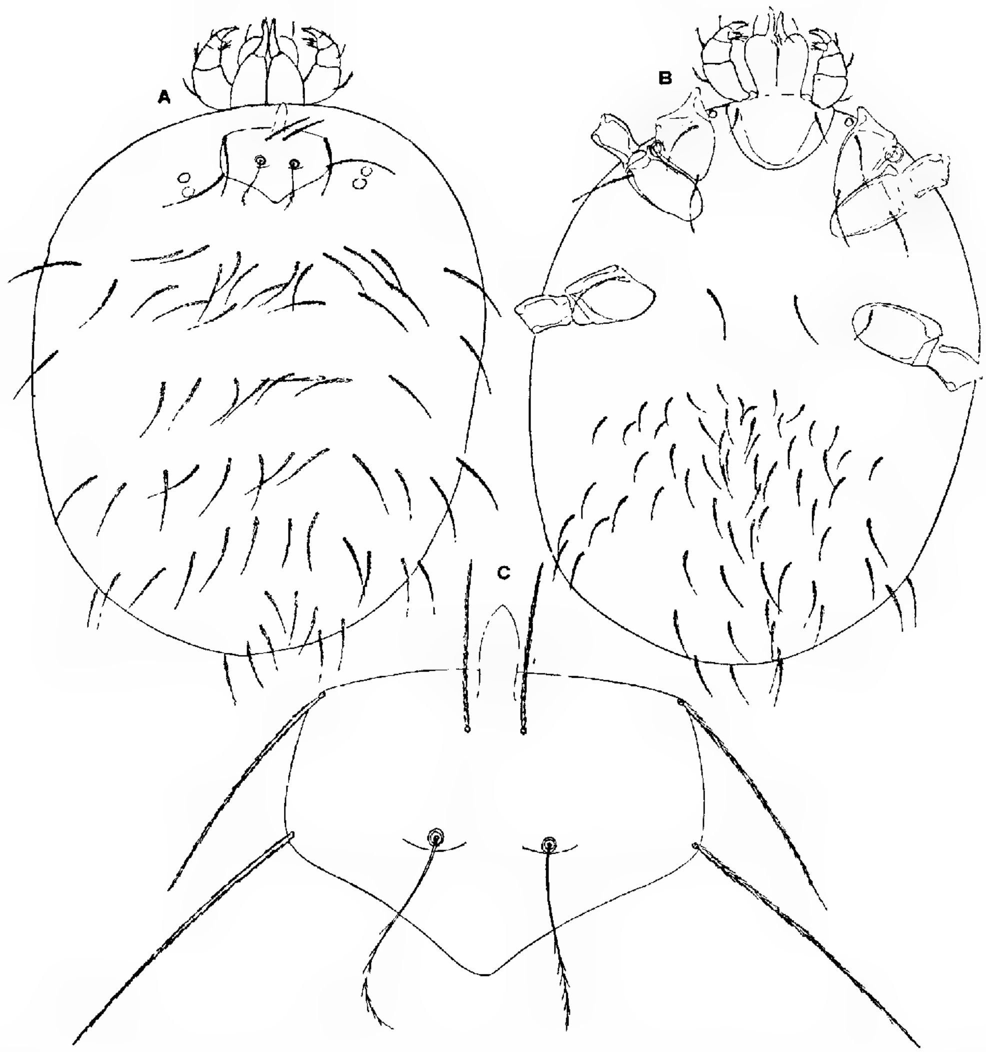


Fig. 14 *Leeuwenhoekia nova-guinea* n. sp. Larva: A, dorsal; B, ventral; C scutum x 500.

Ratio setae ca. 62 and arranged ca. 2.12.8.10.12.10.6.2, but the transverse rows are difficult to interpret, fairly strong and strongly ciliated. Anterior process of scutum 25 μ long by 11 μ wide at the base. The AM setae with their bases 14 μ apart and placed 14 μ behind the anterior margin of scutum. Eyes 2 + 2. Legs: I 480 μ long including coxae, II 430 μ, III 490 μ; coxae I with two slender, 60 μ, fine setae, II and III with one seta; no pair of setae between coxae I, a pair between coxae III and thereafter about 70 setae 30-45 μ long; tarsi with paired claws and slender claw-like empodium; tarsi I and II with short dorsal rod-like seta; tibiae III with a pair of long simple whip-like setae and tarsi III with one such. Palpi normal with bifurcate tibial claw. Mandibles with serrate chelae. Gnathosoma with a pair of ciliated setae. Between base of gnathosoma and coxae I, on each side is the characteristic true stigma of the subfamily.

Locality and *Hosts*—A number of specimens from a magpie, *Gymnorhina* sp. Buna area, New Guinea, 21 November 1943 (G. M. Kohls), and from a kingfisher, same locality, 27 November 1943 (G. M. K.).

Remarks—Differs from other species in the number of DS, the Standard Data and the form of the dorsal scutum, as well as the construction behind the third pair of coxae.

KEY TO THE AUSTRALIAN AND NEW GUINEA SPECIES OF LEEUWENHOEKIA

1 Tibia and tarsi of leg III with some long simple whip-like setae. 2

No long whip-like setae on tibiae or tarsi of leg III. Scutum small and relatively shallow, PW/SD = 1·74. AW 62·15 ± 4·45, PW 82·4 ± 5·3, SB 28·6 ± 3·0, SD 49·1 ± 4·0, A-P 27·6 ± 3·9, AM 20·9 ± 1·1, AL 29·9 ± 3·3, PL 40·8 ± 4·0, Sens. 64·3 ± 4·4. DS relatively short, straight and blunt at apex, 42 in number. *L. southcotti* n. sp.

2 PW/SD less than 1·3. 3

PW/SD greater than 1·3. 4

3 PW/SD = 1·194, DS ca. 70 in number. AW 64·0 ± 5·2, PW 81·0 ± 6·0, SB 25·0, SD 71·0 ± 8·5, A-P 32·5 ± 2·6, AM 36·5 ± 2·6, PL 54·0, Sens. 44·3 ± 5·7. DS tapering 45-55 μ long. *L. mccullochi* n. sp.

PW/SD = 1·252. DS ca. 82 in number AW 79·0, PW 97·0, SB 29·0, SD 77·5, A-P 36·0, AM 43·0, AL 43·0, PL 54·0, Sens. 72·0. DS tapering. *L. hirsti* n. sp.

4 DS 52-54 in number. PW/SD = 1·336. AW 76·4 ± 5·9, PW 92·4 ± 3·6, SB 28·8 ± 4·4, SD 69·2 ± 1·2, A-P 32·8 ± 1·2, AM 41·2 ± 4·4, AL 37·8 ± 2·9, PL 59·8 ± 7·7, Sens. 63·0 ± 5·2. *L. adelaideae* n. sp.

DS 62 in number. PW/SD = 1·32. AW 85·7 ± 14·0, PW 98·4 ± 12·3, SB 27·9 ± 6·8, SD 73·0 ± 15·6, A-P 34·2 ± 10·4, AM 41·5 ± 8·9, AL 62·1 ± 17·5, PL 72·8 ± 7·7, Sens. 58·7 ± 12·6. *L. nova-guinea* n. sp.

DS 76 in number. PW/SD = 1·32. AW 77·3 ± 14·2, PW 93·4 ± 14·3, SB 30·2 ± 6·1, SD 70·8 ± 10·5, A-P 31·9 ± 5·3, AM 44·9 ± 9·8, AL 49·0 ± 9·6, PL 63·6 ± 8·2, Sens. 64·0 ± 8·3. *L. australiensis* Hirst

N.B.—The values of the Standard Data given in this key are the Means plus or minus three times the Standard Deviation, *i.e.*, they indicate the theoretical range of variation.

LIFE HISTORY OF THE TREMATODE, ECHINOCHASMUS PELECANI N. SP-

By T. HARVEY JOHNSTON and E. R. SIMPSON, University of Adelaide

Summary

Echinochasmus pelecani n. sp.

This small echinostome has been found in the small intestine of the pelican, *Pelecanus conspicillatus* Temm., at Tailem Bend, Murray River, on several occasions during the past six years, the number present being always small. The following measurements (in millimetres) have been taken from specimens which were egg-bearing, the average being based on ten worms in glycerine or methyl salicylate. Length 1·4-2·57 mm., average 1·92; maximum breadth ·29-·4 mm., average ·36, occurring in the vicinity of the acetabulum, though the width at the oral crown (excluding the oral spines) is in most cases almost equal to it. Oral sucker terminal, approximately circular, though sometimes the length is slightly greater, ·062-·075 mm. diameter. Acetabulum circular. ·24- ·28 mm. diameter; distance of its anterior edge from head end of worm ·72-1·1 mm., the ratio of this distance to length of worm 1: 2·2-2·9; acetabulum entirely in anterior half in. larger specimens, more or less completely so in smaller worms, the post-acetabular length being relatively greatest in largest worms. The ratio of the breadths of the oral and ventral suckers is nearly 1:4 (1: 3·7-4·0) in most specimens, but in the best-preserved material the oral sucker is ·087 mm. wide by ·070 long, and the acetabulum ·225 mm. in diameter, the ratio of breadths thus being approximately 1: 2·6. The maximum breadth of such a worm was ·35 mm, in the vicinity of the acetabulum, while the oral crown measured ·31 mm. in width.

LIFE HISTORY OF THE TREMATODE, ECHINOCHASMUS PELECANI n. sp.

By T. Harvey Johnston and E. R. Simpson, University of Adelaide

[Read 11 May 1944]

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This small echinostome has been found in the small intestine of the pelican, *Pelecanus conspicillatus* Temm., at Tailem Bend, Murray River, on several occasions during the past six years, the number present being always small. The following measurements (in millimetres) have been taken from specimens which were egg-bearing, the average being based on ten worms in glycerine or methyl salicylate. Length 1·4-2·57 mm., average 1·92; maximum breadth ·29-·4 mm., average ·36, occurring in the vicinity of the acetabulum, though the width at the oral crown (excluding the oral spines) is in most cases almost equal to it. Oral sucker terminal, approximately circular, though sometimes the length is slightly greater, ·062-·075 mm. diameter. Acetabulum circular, ·24-·28 mm. diameter; distance of its anterior edge from head end of worm ·72-1·1 mm., the ratio of this distance to length of worm 1:2·2-2·9; acetabulum entirely in anterior half in larger specimens, more or less completely so in smaller worms, the post-acetabular length being relatively greatest in largest worms. The ratio of the breadths of the oral and ventral suckers is nearly 1:4 (1:3·7-4·0) in most specimens, but in the best-preserved material the oral sucker is ·087 mm. wide by ·070 long, and the acetabulum ·225 mm. in diameter, the ratio of breadths thus being approximately 1:2·6. The maximum breadth of such a worm was ·35 mm, in the vicinity of the acetabulum, while the oral crown measured ·31 mm. in width.

In most specimens the covering of body spines had disappeared, since the worms disintegrate rather rapidly. These triangular, scale-like spines are closely arranged, similarly to those figured for *E. donaldsoni* by Beaver (1941), and the series extends on the dorsal and ventral surfaces from the oral region at least as far as the level of the testicular region.

The collar spines are lost more or less completely soon after the death of the worms. The series is interrupted mid-dorsally where the interval between two spines is rather less than the diameter of the oral sucker. The majority of the spines are about ·075 mm. long by 16-17 μ, but the three situated on each ventral lobe are smaller and exhibit an alternate arrangement (fig. 10). The inmost is the smallest, ·045 mm. long by 12·5 μ; the next ·065-·07 mm. by 17 μ; and the next ·0575 by 15-16 μ. There are about 10 minute spinules on the anterior border of the oral sucker.

Prepharynx about as long as oral sucker; pharynx ·075-·103 mm. long, as long as or slightly longer than diameter of oral sucker, ·038-·07 mm. wide, usually ·055. Oesophagus long, widening posteriorly, bifurcating immediately in front of genital aperature. Crura extending to sides of excretory bladder. Lateral excretory siphons passing forwards laterally from caeca, oesophagus and pharynx, terminating each as a narrow canal close to prepharynx a short distance behind oral sucker.

Testes almost entirely in third quarter of worm; anterior ·11-·20 mm. long, ·15-·21 mm. broad, in contact with posterior testis; latter more elongate, usually rounded-triangular but occasionally almost elliptical, ·15-·275 mm. long, ·138-·20 mm. broad. Cirrus sac relatively large, lying largely in area bounded by crura and anterior border of acetabulum, but extending dorsally above latter to about its middle; ·175-·25 mm. long, ·112-·162 mm. broad; seminal vesicle consisting of rounded anterior and posterior chambers; numerous prostate glands associated with most anterior part of cirrus sac; cirrus very short, simple.

Ovary more or less spherical, ·07-·08 mm. diameter, lying on right side of midline just in front of anterior testis; oviduct arising dorso-medianly, and curving downwards to enter Mehlis gland lying on left side of midline and continuing ventrally as the uterus; inner portion of latter sometimes considerably swollen with semen (receptaculum seminis uterinum of Yamaguti). Uterus thrown into a few convolutions closely crowded into region between anterior testis and acetabulum, then passing above latter to one side of, and somewhat ventral to, cirrus sac as the metraterm to terminate in the shallow genital atrium. Eggs 1-24 in uterus; ·075-·087 by ·050-·062 mm.; average of 20 eggs, ·081 x ·059. Vitellaria lateral, extending from anterior border of excretory vesicle to level of posterior border of acetabulum, fields more or less coalescing in post-testicular region; rarely with narrow irregular isthmuses crossing testicular zone. Transverse vitelline ducts lying immediately in front of anterior testis, one on more ventral level than the other; passing below corresponding crus to travel inwards and dorsally to enter the prominent yolk reservoir; latter approximately median, dorsal. Laurer's canal transverse, just in front of anterior testis.

A specimen which had not yet produced an egg but whose seminal vesicle was distended with sperms, possessed the following measurement in millimetres:—length 1·47 mm.; breadth of oral crown ·30, breadth at acetabulum ·286; oral sucker ·057 diameter; acetabulum ·20 by ·185; sucker ratio 1:2·6; front of acetabulum at ·72 mm. from head end, *i.e.*, at almost half body length. In three specimens which were each producing the first egg, their dimensions were 1·4 long, ·29 broad; 1·6, ·36; and 1·65, ·37 respectively, with the front of the acetabulum at 1:2·3-2·4 of body length distant from the anterior end.

Very young worms were taken on various occasions. The smallest worm (a well-preserved specimen, fig. 12) found in a pelican measured ·42 mm. long; ·162 mm. across the oral crown; ·125 mm. across the acetabular level; breadth of oral sucker ·045 mm., of acetabulum ·07, the ratio of widths thus being 1:1·6; the two testes and ovary were recognisable; and the oral crown showed the same relative sizes and positions of the oral spines as in the adult. In specimens ·7 (fig. 13) and ·8 mm. (fig. 14) long the corresponding measurements were:—·187, ·20; ·125, ·187; ·375, ·40 (ratio 1:1·86, 1:2); ·05, ·06; and ·087, ·137 (ratio of widths of suckers 1:1·7, 1:2·3) respectively. Vitelline glands in an immature condition were abundant, but rather restricted in their distribution, in a specimen 0·99 mm. long; they were not seen in smaller worms.

We believe that our species is *E. mordax* (Looss) described (1899, 688) from an Egyptian pelican, *P. onocrotalus*, but the account of the parasite is brief and Looss' figure indicates a different arrangement of the ventral collar spines. We are not aware of any subsequent description of that species and consequently consider it wiser to describe our own as new, than to include it under *E. mordax*. We expect that re-examination of the latter will reveal an arrangement of the collar spines similar to that seen in the Australian parasite and will lead to the suppression of our specific name. The dimensions mentioned by Looss generally fall within the range stated by us; the general form is similar; the presence of 22 collar spines in both; the inmost ventral collar spine has a similar length; his figure shows that the ratio of the breadths of the oral sucker and acetabulum is about 1:2·6; the front end of the acetabulum is at about two-fifths of the body length; and the eggs have similar dimensions. The host in each case is a species of *Pelecanus*.

Echinostomum mordax was selected by Odhner (1910, 163) as the type of a new genus, *Heterechinostomum* (Echinochasminae), but Price (1931, 6)

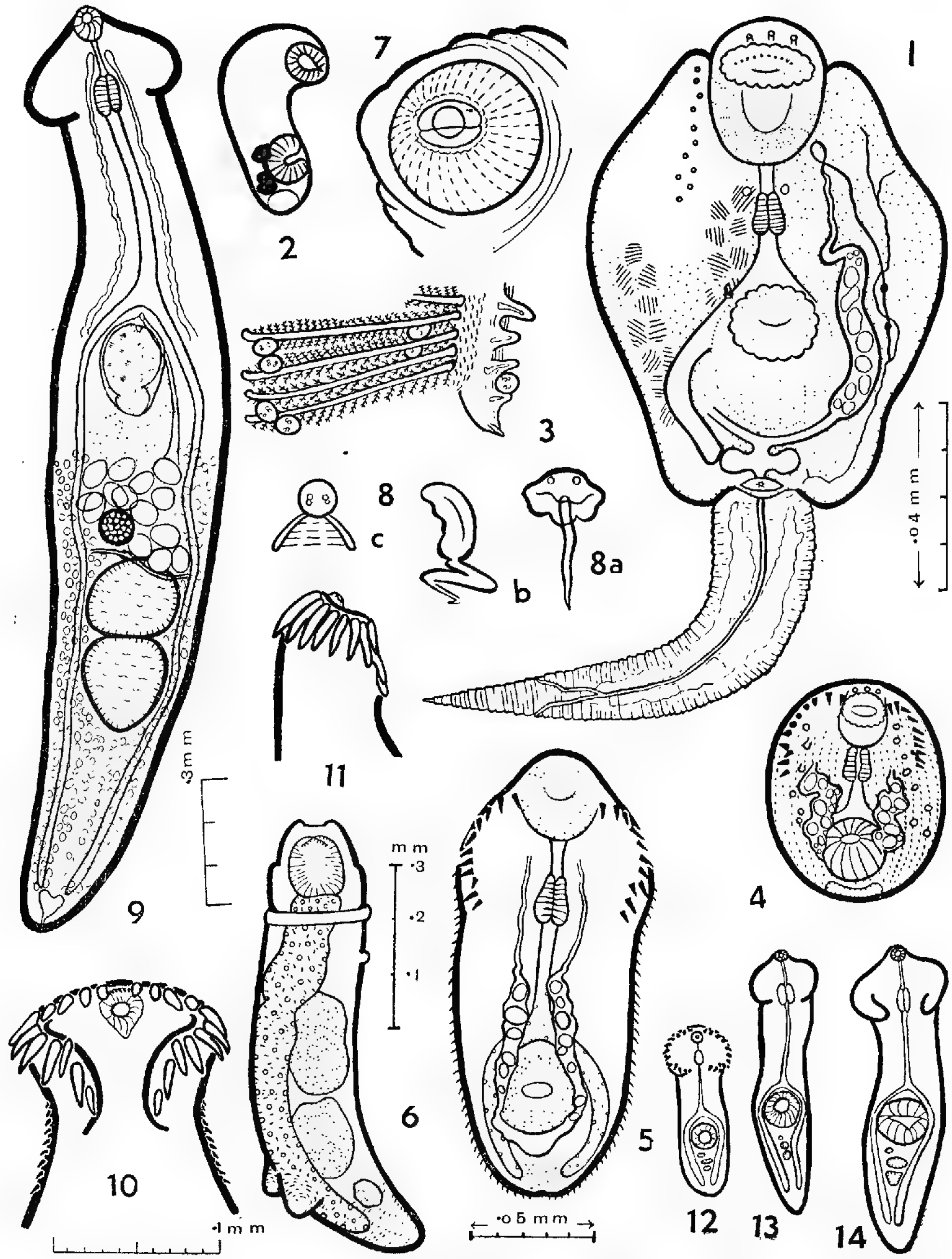

Fig. 1-10, *Echinochasmus pelecani*—1, cercaria; 2, lateral view of cercaria showing genital system; 3, cysts on gills of fish; 4, metacercaria in cyst; 5, metacercaria; 6, redia; 7, mouth of redia, end view, showing pharyngeal lips; 8, freehand sketches of cercaria: (a) in resting position, (b and c) when swimming; 9, adult, ventral view, collar crown and body spines omitted; 10, head region, ventral view; 11, head end, lateral view; 12-14, very young stages from pelican, spines omitted from 13, 14. Fig. 1, 4-6, 9-14, drawn with the aid of a camera lucida; fig. 4 and 5 to scale below fig. 5; 10 and 11 to scale below 10; 9, 12 to 14 to same scale.

suppressed the latter as a synonym of *Echinochasmus*, to which genus he transferred *H. mordax*.

Two Australian species of *Echinochasmus* have been described: *E. tenuicollis* S. J. Johnston 1919, from a cormorant in New South Wales; and *E. prosthovitellatus* Nicoll 1914 from a hawk in Queensland. The former species was transferred to *Paryphostomum* by Price (1931) and by Johnston and Angel (1942), and was subsequently shown by Johnston (1942) to be a synonym of *P. radiatum* (Rud.). *E. prosthovitellatus*, because of the forward distribution of its vitellaria, was transferred by Price (1931, 6) to *Episthmium*.

The presence of 22 spines on the oral collar links *E. mordax* and *E. pelecani* with a small number of other species of the genus. *E. schwartzi* Price (1931), from the muskrat and dog in U.S.A., seems to be the nearest species, but it differs in the sizes of the suckers, length of oesophagus, size of eggs, and arrangement of the oral spines on the ventral lobes. *E. milvi* Yamaguti 1939, from *Milvus migrans* in Japan, is a smaller species with a less extensive uterus containing very few eggs, with a shorter oesophagus, and with a different form of the testes; but it has a similar arrangement of the oral spines on the ventral lobes, and the eggs are of similar size. *E. dietzevi* Issaitchikov (1927), a 20-spined form, possesses three alternating angle spines on each side, as also do the 24-spined species. *E. bursicola* (according to Odhner 1910, pl. v, fig. 1) and *E. corvi* Bhalerao (1926). *E. bursicola* was placed under *Episthmium* by Lühe (1919), under *Echinochasmus* by Odhner (1910, 162), and restored to *Episthmium* by Price (1931).

We have not succeeded in our attempts to infect with eggs of *E. pelecani*, *Ameria* spp., *Limnaea lessoni*, *Plotiopsis* and *Corbiculina angasi*, the chief molluscan species occurring in the Murray and its swamps at Tailem Bend. However, we have encountered very commonly in *Plotiopsis tatei* (Melaniidae) as a natural infection, a cercaria which, though gymnocephalous, enters fish and gives rise to an echinostome metacercaria belonging to *Echinochasmus*. This larva possesses the same number of collar spines, and these have a similar arrangement to that present in *E. pelecani*. Such similarity has not been observed in any other adult and larva known to us. *Plotiopsis* is restricted in the region to the banks of the Murray, occupying a zone about three to six feet in depth, pelicans utilising the adjacent bank as a resting place. We had not used the mollusc for our subsequent attemps at infection because we had not yet succeeded in rearing the species in our aquaria. For the reasons given above we consider that the redia, cercaria and metacercaria to be described are the larval stages of *E. pelecani*.

Cercaria Stage

This cercaria is the commonest of those observed by us to be emitted from *Plotiopsis tatei* (Melaniidae) at Tailem Bend and Swan Reach, and was found in 514 out of 7,123 examined, the percentage of infected individuals being 7·2. The highest infection rate was observed on 12 December 1937, when 227 out of 519 individuals collected harboured the parasite, the percentage of infection being nearly 44. The cercaria has been met with fairly regularly since then during the period November to May of each year. It has not been looked for during the remaining months.

The swimming movements of this small active cercaria resemble those of an echinostome. The resting position is typical (fig. 2), the organisms hanging as a fine cloud in the water in that part of the tube which is of optimum light intensity. The cercariae are given off in great numbers usually before 8 o'clock in the morning for the first few days in the laboratory, but on succeeding days few cercariae emerge. Snails kept in captivity over the winter have not been observed to give off cercariae in the following December, although small rediae were found in the liver.

In ten specimens killed in boiling 10% formalin the body length varied from 114 to 179 μ (average 129 μ), and the breadth from 68 to 87 μ (average 79 μ). The anterior sucker varied in length from 30 to 38 μ, and in breadth from 27 to 30 μ; and the posterior sucker measured 27 to 30 μ long by 27 to 30 μ broad. The sucker ratio is 17:16. The distance of the posterior sucker from the anterior end varied from 61 to 152 μ (average 84 μ). The short annulate tail measured 91 to 178 μ long (average 122 μ). Both suckers have a frilled edge. The anterior sucker is retractile and can be withdrawn for some distance into the body of the cercaria, which then acts as a hood. Three refractive structures having the appearance of ducts are present on the dorsal part of the sucker, and ventral to them are 10 minute spinules. The body cells stain heavily with neutral red. Cystogenous cells are arranged in four longitudinal groups and fill the central parts of the body. They are pale yellow and are filled with rod-shaped granules. In nearly every specimen two refractive spots were seen on either side of the pharynx. These were the nuclei of the most anterior cystogenous cells of the two median rows. The body has a fine granular appearance, due to minute spines on the surface. Collar spines are not apparent, but in a few specimens refractive dots (apparently the immature collar spines) are seen arranged vertically as in fig. 1.

Following the mouth is a prepharynx. The pharynx is pear-shaped and is consistently on its side when the cercaria contracts. The oesophagus is long and the intestine is large and refractive and reaches to the bladder. The first part of the intestine is particularly hard to see.

The excretory system resembles that of an echinostome. The bladder is bilobed and a small duct leads posteriorly to a wide prominent opening at the junction of tail and body. The two main excretory tubes meet before entering the bladder by a median duct. About nine excretory granules, some of them compound, are present. Before these excretory tubes reach the anterior sucker, they form a loop and descend to the level of the middle of the ventral sucker. Two ciliated patches are present in these parts (fig. 1). The tube then divides into two; the ascending ramus, travelling anteriorly, gives off a secondary branch near the level of the pharynx; and the posterior ramus divides into two in the region of the bladder. Flame cells were not seen, though consistently looked for, and immature cercariae were examined. The excretory system in the tail is seldom seen. It consists of a median tube dividing into two in the distal part of the tail. This was confirmed by the study of immature cercariae.

The reproductive apparatus is represented by two masses of cells medially placed, dorsal to the posterior sucker. They are connected by a strand of cells (fig. 2) . Their position indicates that the anterior is the anlagen of the cirrus sac and associated structures, and that the posterior mass will differentiate into the gonads.

Redia Stage

Rediae (fig. 6) are present in all stages of development in the tissues of the snail. The liver is not usually discoloured but contains rediae and cercariae, which are often present in far greater numbers elsewhere in the body. These parts are coloured orange, and in heavily infected snails are compact masses of cercariae and rediae. The former are present in such numbers that they must, after birth, remain in the tissues of the snail several days before being emitted.

One well developed redia measured about 1·68 mm. and contained numerous developing cercariae and germ balls. The mouth leads into a small vestibule just in front of a well-developed pharynx. The mouth of the pharynx (fig. 7) has two semi-circular lips with thickened (probably chitinised) edges which form strong biting jaws. The intestine is large and extends beyond the two foot processes. The collar and birth pore are usually readily seen. The walls contain orange pigment. Some snails giving off this cercaria during the summer were kept through the winter and retested in the following December; although no cercariae had been given off in the aquarium during the latter period, a number of small rediae were found in the liver.

Metacercaria Stage

The cercaria has been found experimentally to encyst in the laboratory in the fish, *Oryzias latipes* and *Gambusia affinis*. Tadpoles (*Crinia* sp.) and the snails, *Limnaea lessoni* and *Ameria* spp. were tried, but with negative result. The metacercariae (fig. 3) are found only on the gills of the fish, where they may be present in great numbers. They are oval and fairly uniform in size. Of ten specimens the average measurements were 88 μ by 68 μ. In the laboratory all the cysts were dead on the third day after the death of the fish. The cyst is thin-walled and easily broken and the expressed metacercariae die almost immediately, thus making examination difficult. The addition of horse serum to the water did not increase their longevity.

Free metacercariae measure about 0·18 mm. long, with a maximum width (across the oral crown) of ·075 mm. Small spines in transverse and longitudinal rows completely cover the body, giving a fine, but distinctly hairy, appearance to the metacercaria. Ventrally the collar spines become smaller and the first and third spines from the ventral end are markedly smaller than any of the others. The third spine, set at an angle to the others, is the most anterior in position. No separate group of corner spines was seen. Body spines, slightly smaller than the rest, are present between the mid-dorsal gap of the collar spines and continue up to the anterior sucker. The ten oral spinules noticed in the cercaria are still present, though not readily seen. The globules (usually eight or nine on each side) present in the metacercaria are probably the ducts of small gland (cystogenous) cells. They stain the same shade as the three oral ducts.

We fed to a pigeon and to a rat numerous small fish which had been infected in the laboratory, an estimated total of about 200 cysts being fed in each case, but no adult stages were recovered. Yamaguti (1933) described various stages in the life cycle of some Japanese species (*E. elongatus*, *E. rugosus* and *E. redioduplicatus*), having obtained his adults by feeding to rats, mice or dogs, infected molluscs or tadpoles in which the metacercaria stage occurred. He also figured the miracidium of *E. rugosus* (1933, 113). Cuirea (1931, 292) reported that cysts of *E. liliputanus* occurred on the gills of Roumanian marine fish and obtained adults by feeding the latter to dogs. Kurisu (1931) found that, from a cercaria from *Melania*, adult stages of *E. grandis* could be obtained from experimental rats and dogs. Beaver (1941) published an excellent account of the life history of *E. donaldsoni* from a grebe.

Our cercaria may be compared with that of *Echinochasmus donaldsoni*, as described by Beaver (1941). The behaviour and general characteristics are similar. The latter cercaria is distinctly smaller and the spination present on the ventral sucker and ventral lip of the anterior sucker were not noticed in our specimens. The body spines and collar spines have been seen, though with difficulty, in our form. Slight differences in the excretory system are apparent. The number of excretory granules is less and their position more restricted in our cercaria, and the bladder seen in the proximal part of the tail is not present in our form, unless the excretory sac, consistently present below the dorsal excretory pore, be it. The difference between the two is more marked in the metacercaria, where the collar spines number 22 in our form but only 20 in *E. donaldsoni*.

Rediae are similar in both forms, though in our species they are considerably larger, and the lips of the pharynx are reinforced.

Cercaria indica XLI (Sewell 1922) is probably the cercaria of an *Echinochasmus.* Its habits and general appearance, including the three oral ducts, are similar to those of our cercaria. Obvious differences are the much greater size of the Indian form, the presence of diverticula at the base of the caudal excretory canal, and the presence in the redia of an intestine which does not reach the level of the foot processes.

Type specimens of the various stages have been deposited in the South Australian Museum. We desire to acknowledge generous assistance rendered by Messrs. G. G., F., and Bryce Jaensch and L. Ellis, of Tailem Bend, in regard to collecting host material. The work was carried out with the aid of the Commonwealth Research Grant to the University of Adelaide.

Summary

1. The anatomy of *Echinochasmus pelecani* n. sp. from *Pelecanus conspicillatus* is described.

2. Cercariae and rediae from *Plotiopsis tatei* are regarded as its larval stages, the metacercaria developing experimentally in freshwater fish (*Oryzias latipes, Gambusia affinis*).

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THE OCCURRENCE OF CYCLOCLYPEUS IN THE TERTIARY DEPOSITS OF SOUTH AUSTRALIA

By IRENE CRESPIN, B.A., Commonwealth Palaeontologist,
Mineral Resources Survey Branch, Canberra, A.C.T.
Communicated by Sir Douglas Mawson

Summary

In a recent microscopic examination by the writer of a sample of bryozoal limestone from a locality labelled "4 miles below Morgan, River Murray, South Australia," and collected by Mr. F. A. Cudmore some years ago, the discovery was made of the zonal foraminifera *Cycloclypeus victoriensis* Crespin. As far as can be ascertained, this is the first record of the occurrence of the genus *Cycloclypeus* in the South Australian Tertiary deposits. In the Victorian Tertiaries *Cydoclypeus* is restricted to a definite horizon in the Middle Miocene, namely the Batesford Substage (Crespin 1943), which is considered as a subdivision of the Balcombian Stage

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[Read 11 May 1944]

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Cycloclypeus victoriensis is very common in certain beds in the limestone quarries at Batesford near Geelong, Victoria. It is also recorded from the Hamilton Bore in Western Victoria, which is the nearest known occurrence to the present South Australian one at Morgan. The genus is restricted to a very limited zone in the Gippsland Bores. In all these instances it is found in association with the important zonal foraminiferal genus *Lepidocyclina,* together with a typical foraminiferal assemblage. Further systematic collecting from the limestones near Morgan may yield *Lepidocyclina.*

The genus *Cycloclypeus* is practically restricted to the Indo-Pacific region. It is found living in shallow, warm, tropical waters in the vicinity of coral reefs. It is well distributed in the Miocene rocks in North-west Australia, Papua, New Guinea, the Netherlands East Indies and Japan, the various species being of distinct zonal value.

Description of the Limestone and Notes of the Foraminiferal Assemblage

The rock from Morgan is a cream-coloured bryozoal limestone containing foraminifera, bryozoa, fragments of echinoids, molluscan shells and ostracoda. The bryozoa are well preserved and all species are typical of those present in the bryozoal limestones referable to the Balcombian Stage in Victoria. The species of ostracoda are similar to those found in all Balcombian deposits.

As previously stated, the foraminiferal assemblage in the limestone from Morgan is typical of the Batesford Substage. *Operculina victoriensis* Chapman and Parr is very well developed and the eccentric shapes of many of the tests indicate the warm to hot climatic conditions under which the organisms existed. *Gypsina howchini* Chapman and *Amphistegina lessonii* d'Orb. are also common, and the irregular shapes of the tests of these forms are also results of the climatic conditions. Numerous tests of a species of *Elphidium* are present. The form is apparently new and seems referable to "*Elphidium* sp." recorded by Howchin and Parr (1938) from the Miocene beds in the Abattoirs Bore near Adelaide.

Foraminifera determined from the limestone near Morgan are as follows:

Textularia fistulosa Brady
Dorothia parri Cushman
Clavulinoides szaboi (Hantk.) var. *victoriensis* Cush.
Trifarina bradyi Cushman
Dentalina soluta Reuss
Gypsina globulus Reuss
Notorotalia howchini (Chapman, Parr and Collins)
Cibicides victoriensis Chapman, Parr and Collins
Siphonina australis Cushman
Elphidium sp.
Amphistegina lessonii d'Orb.
Operculina victoriensis Chapman and Parr
Cycloclypeus victoriensis Crespin

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ON THE ANALYSIS OF BERYL FROM BOOLCOOMATTA, SOUTH AUSTRALIA

By A. W. KLEENMAN, M.Sc.

Summary

Beryl, associated with quartz, feldspar and muscovite, is a not uncommon constituent of the pegmatites associated with the Boolcoomatta granitic Bathylith. The first specimens from this area were collected by Professor D. Mawson in the year 1906. In more recent years some few tons have been mined to meet the demand for beryllium ore.

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By A. W. Kleeman, M.Sc.

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The beryl is met with as prismatic crystals from less than an inch to several feet in diameter. Its colour varies from waxy yellow-green to a bluish-green. though the Refractive Index ($\omega = 1{\cdot}581$) remains sensibly constant for specimens that have been examined from several localities in the area. Of the specimens collected from many occurrences on Old Boolcoomatta and Outalpa stations, two have been subjected to critical chemical analysis with the following results.

The analyses are as set out below:

	A	B	Molecular Proportions in B
SiO_2	64·70	64·51	1·075
Al_2O_3	19·00	18·90	·185
FeO (total Iron)	1·50	1·57	·011
BeO	12·50	12·74	·510
MgO	·13	·14	·0035
CaO	·36	·25	·0045
Na_2O	34	·34	·0055
K_2O, Li_2O, Rb_2O, Cs_2O	nil	nil	
H_2O-	·10	·07	
H_2O+ (loss on ignition)	1·74	1·72	·095
TiO_2	nil	nil	
	100·37	100·24	

A. is a light bluish-green beryl from a small open cut one mile south of Binberrie Hill.

B. is a light yellow-green specimen, collected from an open cut on mineral claim 2785, four and a half miles south of Bimbowrie.

The specific gravity (compared with water at 4° C.) of specimen A was determined as 2·654 but it contains many microscopic bubbles, hence the true value exceeds that obtained.

The determination of Refractive Index was made by the immersion method using sodium light, the Refractive Index of the liquid being checked on an Abbe Refractometer beside the microscope.

Through the good offices of Mr. M. Mawby, who recently visited America to investigate the supply of the lighter metals, I was able to obtain a copy of a graph which Dr. W. T. Schaller, of the United States Geological Survey, has compiled from a study of the better class analyses of beryl. In this graph, which Dr. Schaller is preparing for publication and which he has emphasised, is only tentative, the percentage of the various oxides has been plotted against the Refractive Index ω. According to the graph our specimen should have 12·6% BeO, 64·9% SiO_2, 2·0% H_2O, and 1·7% total alkalies.

The only oxides that differ widely from our analysis are the alkalies. The explanation seems to be that the calcium, and perhaps iron and magnesium, are proxying the alkalies in this beryl.

The analysis, when calculated on a basis of 18 oxygen atoms and excluding water, gives the result:

$(Be_{2\cdot80}, Ca_{\cdot02}, Mg_{\cdot02}, Fe_{\cdot12}, Na_{\cdot06})\ Al_{2\cdot00}\ (Si_{5\cdot91}, Al_{\cdot05})\ O_{18}$.

This agrees with the accepted formula, Be_3, Al_2, Si_6, O_{18}.

However, if the water is considered and the whole calculated to 18 atoms of oxygen the result is:

$(Be_{2\cdot73}, Ca_{\cdot02}, Mg_{\cdot02}, Fe_{\cdot12}, Na_{\cdot06})\ Al_{1\cdot98}, Si_{5\cdot76}\ (O_{16\cdot98}, OH_{1\cdot02})$.

This is similar to the grossularoid formula suggested recently (Hutton 1943, Belyankin and Petrov 1941, Pabst 1942), where four hydroxyl groups replace one silicon-oxygen group.

Rough tests suggest that the majority of the water is lost at about 700°-800° C.

Some Notes on the Quantitative Estimation of Beryllium in Beryl

In the analysis of Beryl the chemist is faced with several difficulties, consequently a summary of the following methods based upon the author's experience in this field is worthy of record. Schoeller and Powell (1941) review the methods for separating Beryllium from all the elements which are precipitated with it by ammonia. However, the analysis can go astray long before the ammonia oxides are assembled free from other metals.

Fusion with sodium carbonate and subsequent double evaporation with hydrochloric acid to remove silica does not get beryllium into solution. In fact, fusion at 1,100° C., as suggested by some authorities, results in forming ignited beryllium oxide which is insoluble in concentrated hydrochloric. Sulphuric acid will dissolve the beryllia but is not suitable where silica is to be separated and, in any case, it is not expedient to have any amount of sulphate present at this stage. However, the presence of even small amounts of potassium keeps beryllium in an acid-soluble form, and it is suggested that fusion mixture be used to attack the mineral. This attack is effective with ordinary finely ground powders. Some beryllia remains with the silica, and is recovered after the evaporation of silica with hydrofluoric acid, by fusion with potassium pyrosulphate.

Assembly of the Oxides of the Ammonia Group

In ordinary mineral analysis, alumina, iron, titania, etc., are precipitated by a slight excess of ammonia, using methyl red as an indicator. Mellor quotes the iso-electric point of beryllium hydroxide at pH 7·5, and it is therefore suggested that brom-thymol blue be used as an indicator in preference to methyl red, as it appears that the precipitation of beryllium hydroxide is not complete at the end point of methyl red. In the presence of the sulphate ion beryllium hydroxide is not quantitatively precipitated at any pH.

The filtrate from this precipitation should be evaporated down to small bulk as recommended by Washington (1930) and, to assist the recovery of traces of hydroxide, about 1 cc of a 10% aqueous solution of tannin should be added.

The small amount of oxide which has been recovered from the silica and which has been brought into solution by fusion with potassium pyrosulphate should be precipitated separately in order to keep the main bulk of the analysis free from sulphate. About 1 cc of tannin solution can be added to ensure complete precipitation.

The Separation of Aluminium and Beryllium

Schoeller and Powell (*op. cit.*, 49) recommend the fusion of the ignited oxides from the ammonium precipitate with 6 grams of sodium carbonate for two hours. (This sodium carbonate should be free from potassium.) Leaching the melt leaves beryllium and iron as an insoluble residue and alumina passes into the filtrate. This alumina can be precipitated as hydroxide after acidifying the filtrate with nitric acid. The leached residue from the fusion is washed with hot water, ignited and weighed as "crude BeO". This precipitate is then dissolved in potassium pyrosulphate; iron and traces of alumina are precipitated by tannin in the acetic acid solution. Schoeller and Powell (*op. cit.*, 48) add ammonia till it produces turbidity and then just clear the solution with acid. They then precipitate by adding 10 grams each of ammonium chloride and ammonium acetate, and one gram of tannin in water. This, however, tends to co-precipitate some beryllium, and it is recommended that the ammonia be added to slight turbidity (or the end point of bromphenol blue) and then 3 cc of glacial acetic be added and the aluminium and iron precipitated as before. This procedure precipitates aluminium, iron and titanium free from beryllium. If doubt exists as to the completeness of precipitation of aluminium, enough ammonia should be added to neutralise most of the acetic. If no precipitate is formed aluminium was completely precipitated. If any precipitate is formed it should be carefully examined to determine whether it is aluminium or beryllium hydroxide or a mixture of both.

The Separation of Iron and Beryllium

Iron cannot be separated from beryllium by boiling with a slight excess of caustic soda, as is advocated by some workers (Groves 1937, Van Tongeren 1937). Gilchrist (1943) has shown that beryllium hydroxide is precipitated hydrolytically by sodium hydroxide in solutions ranging from pH 4·7 to pH 10. Experiment has shown that in the separation of iron from beryllium, with slight excess of sodium hydroxide, considerable amounts of beryllium are precipitated even in a short period of boiling. Probably the separation can be made by using warm solutions but this possibility was not tested, as with small amounts of iron the precipitation with tannin is much more convenient. The precipitate with tannin does not adsorb sulphate as the charge on the colloidal hydroxide is neutralised by the colloidal tannin.

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LARVAL TREMATODES FROM AUSTRALIAN FRESHWATER MOLLUSCS PART IX

By T. HARVEY JOHNSTON and E. R. SIMPSON, University of Adelaide

Summary

Cercaria ellisi n. sp.

A new echinostome cercaria with 45 collar spines has been studied in the laboratory for several years. It is frequently obtained from *Limnaea lessoni*, from the Murray at Tailem Bend, and is the only echinostome cercaria, with the exception of *C. Paryphostomi-radiati*, so far noticed by us from this snail host. During the months mentioned the following numbers of snails were found infected with it: May 1937, 10 out of 119 collected; December 1937, 100 of 639; April 1938, 1 of 12; October 1939. 1 of 4; February 1940, 2 of 63; November 1940, 1 of 15; February 1941, 1 of 106; January 1942, 6 of 116; February 1942, 2 of 96; March 1941, 30 of 883; May 1942, 1 of 8; Marc11 1943. 1 of 3 - a total of 156 out of 2,064 examined during the period October to May, i.e., 7·5%. It was not recognised in collections made on other occasions during the spring, summer and autumn 1937-1944.

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By T. Harvey Johnston and E. R. Simpson, University of Adelaide

[Read 8 June 1944]

Cercaria ellisi n. sp.

(Fig. 1-6)

A new echinostome cercaria with 45 collar spines has been studied in the laboratory for several years. It is frequently obtained from *Limnaea lessoni*, from the Murray at Tailem Bend, and is the only echinostome cercaria, with the exception of *C. Paryphostomi-radiati*, so far noticed by us from this snail host. During the months mentioned the following numbers of snails were found infected with it: May 1937, 10 out of 119 collected; December 1937, 100 of 639; April 1938, 1 of 12; October 1939, 1 of 4; February 1940, 2 of 63; November 1940, 1 of 15; February 1941, 1 of 106; January 1942, 6 of 116; February 1942, 2 of 96; March 1941, 30 of 883; May 1942, 1 of 8; March 1943, 1 of 3—a total of 156 out of 2,064 examined during the period October to May, *i.e.*, 7·5%. It was not recognised in collections made on other occasions during the spring, summer and autumn 1937-1944.

The cercariae are almost incessantly active and exhibit in swimming the typical echinostome figure of 8. When the movement slackens, the tail moves slowly from side to side and the body straightens and is thrust forwards. They are negatively phototropic. The greatest numbers of cercariae are emitted between 11 and 12 in the morning.

The body measurements (in micra) given below are taken from 10 specimens killed by adding to the liquid containing them an equal volume of boiling 10% formalin: length of body from 190-239 μ (average 224); across region of ventral sucker 129-141 μ (average 136); anterior sucker 34-42 μ long (average 38) by 38-46 μ wide (average 42). The posterior sucker was difficult to measure, since in most specimens it was flattened, as in fig. 1. The length in such cases was from 23 to 34 μ, but in well-extended specimens ranged from 46 to 53 μ. The breadth was more constant, varying from 57 to 65 μ (average 61). No satisfactory sucker ratio could be ascertained, though their relative breadths in compressed specimens are about 1 : 1·5. The distance of the posterior sucker from the anterior end of the cercaria varied from 103 to 148 μ (average 129), and the length of the tail from 342 to 440 μ (average 391). There is no finfold on the tail.

The collar, which is not very evident, bears 45 inconspicuous spines (including four corner spines at each end) arranged in two rows. The spines of the aboral row are slightly longer than those of the oral series. One spine from the aboral row and one from a corner group both measured 11·9 μ. On the ventral and dorsal surfaces minute spinules are arranged regularly as far as the level of the ventral sucker.

The alimentary system is typical of echinostomes. The pharynx is succeeded by a relatively long oesophagus, from which the intestinal caeca arise at the level of the anterior border of the acetabulum and extend to the urinary bladder. Cystogenous cells are numerous and finely granular. The glands were not seen. The genital anlage consisted of two cell masses connected by a string of cells, one mass slightly posterior to the ventral sucker, the other on a level with the anterior border of the ventral sucker.

The excretory system is typical of echinostomes. The cercariae were studied in equal parts of horse serum and water. In most specimens 22 flame cells were seen on each side, arranged as in fig. 1, and appeared to be grouped in threes, but their connections were extremely difficult to work out. These cells opened into a descending ramus which, near the base of the bladder, connected with an ascending ramus. The latter had 15 ciliated patches arranged as in fig. 1, and its convolutions were fairly constant in the cercariae studied. On a level with the top of the pharynx it loops around to enter the main excretory tube. This, as far as the level of the acetabulum, is filled with many small granules, two or three being present in cross section. At the level of the acetabulum the concretions cease, and the main tube forms a characteristic bend in towards the centre and continues to the bladder. The latter is in two parts, a smaller anterior and larger posterior. From the latter a median tube extends for a short distance into the tail and opens by two

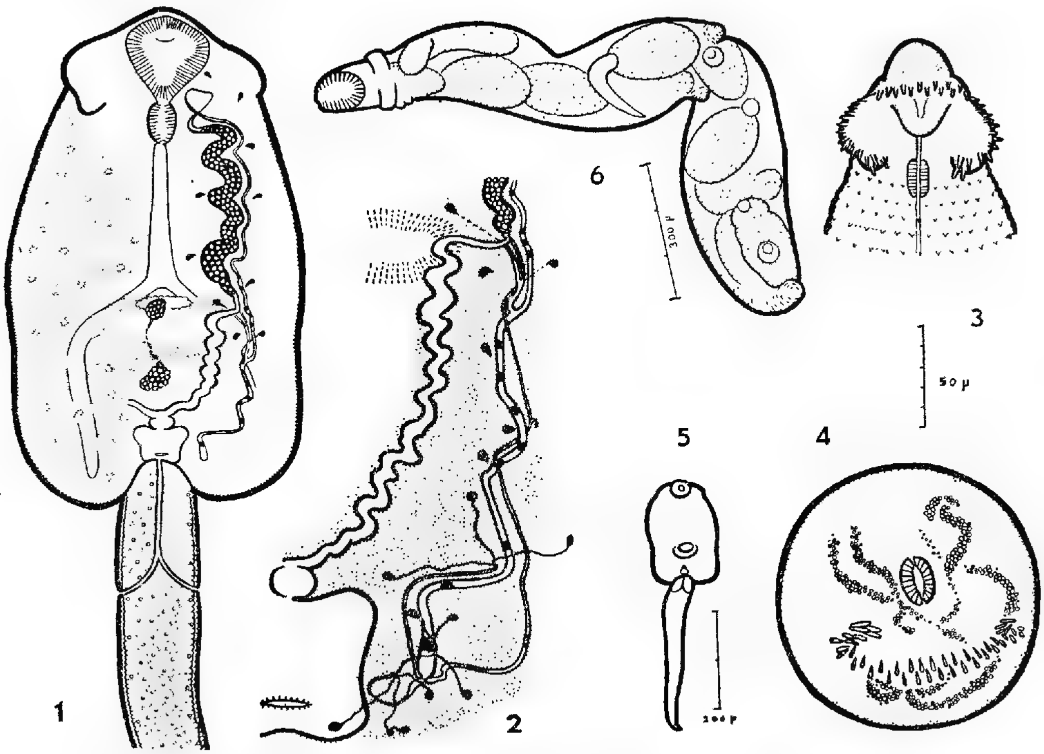

Fig. 1-6—*Cercaria ellisi:* 1, cercaria, collar spines omitted; 2, enlarged freehand diagram of posterior part of excretory system of one side to show position of ciliary flames and flame cells; 3, head end, showing spination; 4, cyst; 5, cercaria, general appearance; 6, redia. Fig. 1, 3 and 4 drawn to scale below fig. 3.

short branches laterally. A small external opening is present on the dorsal surface of the bladder.

Cysts have been obtained experimentally from the following hosts: *Amerianna pyramidata; A. tenuistriata* (abundant in mantle cavity); *Planorbis isingi; Limnaea lessoni; Plotiopsis tatei* (abundant in mantle cavity); *Corbiculina angasi* (a few); and a tadpole, *Crinia signifera* (numerous in kidneys). The almost circular cysts varied in measurement between 118 and 133 µ; 10 from tadpoles averaged 126 by 125 µ, while those from snails were slightly smaller, 122 by 125 µ.

Two young tadpoles were placed in water infested with *C. ellisi,* and within a few minutes cercariae were seen creeping over the surface of the tadpoles and entering and emerging through the various apertures. After four hours the tadpoles were killed. Twenty-nine cysts and five tailless cercariae were found in the tissues of the mesonephros of one; they were present in least numbers amongst the tubules of the kidney, and in greatest numbers massed near the glomeruli along the nephric ducts. They were also present in the mesenteries.

Another tadpole, killed two hours after having been placed in infected water showed, in addition to the positions mentioned above, two cercariae encysted in the auricle, and several around the heart and aorta, in addition to one in the lung.

Cysts were fed to a canary in February and March 1942, and to a fowl in November and December 1939, but the adult stage was not obtained.

The specific name is given in recognition of assistance received for many years from Mr. L. Ellis, of Tailem Bend and Murray Bridge.

Cercaria ellisi most closely resembles *C. clelandae* Johnston and Angel 1939. When killed under the same conditions our cercaria is slightly shorter and wider than *C. clelandae* (230-290 μ by 89-130 μ). This difference is more marked in the metacercaria, the cysts of *C. clelandae* being consistently 30 μ larger in diameter than those of the present species. *C. clelandae* could not be made to encyst in tadpoles which are a normal secondary host of *C. ellisi*. The rediae in our species are similar but grow to a larger size and contain more developing cercariae. The gut is dark-coloured in *C. clelandae* and inconspicuous in our form. Slight differences occur in the excretory system, which was extremely difficult to work out. Seventeen flames and 24 flame cells have been counted on each side in *C. clelandae*, but only 15 flames and 22 flame cells were seen on each side in our form. As the flame cells are inconspicuous, one or more may have been overlooked.

During January 1943 faecal material deposited by a pelican at Tailem Bend was placed in an aquarium along with several *Limnaea lessoni*, *Amerianna* spp., *Hydrobia* and *Segmentina australis*, and some carp. The snails were tested at the end of February, and weekly after that. Ninety days later two of the *Limnaea* were observed to be giving off a 45-spined echinostome cercaria closely resembling *Cercaria ellisi*, and continued to do so until they died on 5 May 1943 and 5 June 1943 respectively. The remaining snails which had not already died before the latter date, showed no infection.

The body length of these cercariae measured 201 to 243 μ (average 216); the maximum breadth 106-125 μ (average 118); and the tail 293-343 μ long (average 326). The anterior sucker was 42 to 57 μ long (average 46); the posterior sucker 42-57 μ (average 46) long by 46-49 μ (average 48) across, and its distance from the anterior end of the cercaria varied from 106 to 140 μ (average 114). These measurements are similar to those given above for *C. ellisi*, the main differences being in the breadth of the ventral sucker and the length of the tail, which are somewhat less in this form. The material examined consisted of preserved free cercariae as well as of others taken from preserved *Limnaea* snails, and the former may not have been mature when measured. The collar spines are similar to those of *C. ellisi*, and body spines are present on the dorsal and ventral surfaces down to the ventral sucker.

Numerous cysts were found in the liver (particularly at the apex) and mantle cavity and scattered throughout the tissues of the longer-lived host snail. The average measurement of ten cysts was 120 by 121 μ. 114 μ was the lowest and 125 μ the greatest length measurement observed by us. The *Limnaea* snails used in the experiment were laboratory bred and free from infection. In experimental infections of snails, to obtain cysts of *C. ellisi*, it is unusual to find these elsewhere in the body than in the mantle cavity. It is possible that the cysts present in the liver belonged to cercariae which had encysted there instead of emerging and then encysting in a suitable host. It was very difficult to count the oral spines of these metacercariae, but there seemed to be about 43. We regard this form as belonging to *C. ellisi.*

The characters of the collar spines of *C. ellisi* (and *C. clelandae*) indicate that the adult is probably a species of *Echinostoma* or allied genus. The vertebrate host is probably a bird whose diet includes freshwater molluscs. Nicoll (1914, 112) described *Echinostoma hilliferum*, a 47-spined species from a coot, *Porphyrio melanotus,* North Queensland. *Echinostoma bancrofti* Johnston (1928, 140), described from a waterhen, *Gallinula tenebrosa,* from the Burnett River, Queensland, is recorded to have about 44 collar spines arranged in two alternating rows, with the four corner spines larger and more prominent, but the actual number of oral spines is more likely to be 43 or 45. *Gallinula tenebrosa* and other species of waterhens and coots occur abundantly in the swamps at Tailem Bend. We have not yet found in the pelican an echinostome with 45 collar spines. Waterhens and pelicans frequent the same narrow bank between the swamp and Murray River on which the faecal sample was collected. Contamination of the material from a pelican with that from a waterhen was thus possible.

Cercaria gigantura var. **grandior** nov.

(Fig. 7, 9-11)

On 27 January 1943 one, and on 24 February 1943 two, snails of *Amerianna pyramidata,* from Tailem Bend, were found giving off a cercaria closely resembling *C. gigantura* Johnston and Angel 1941, which these authors regarded as the larva of *Petasiger australis.* On the latter date two snails also (*Amerianna pyramidata*) gave off *C. gigantura,* and it was possible to study the two cercariae side by side in the laboratory (fig. 8, 9). Macroscopically they appeared to be quite distinct. *C. gigantura* var. *grandior* was much the larger and was relatively a sluggish cercaria. The resting period was usually 4-5 seconds (2-3 seconds in *C. gigantura*); and the tail, because of its greater size, did not move as freely from side to side as that of *C. gigantura.*

Microscopically *C. gigantura* var. *grandior* differed in the following characters: The tail was considerably larger, varying in length from 571 to 1,175 μ, with an average of 717 μ in ten specimens (*C. gigantura* 434 to 584 μ), its breadth ranging from 144 to 245 μ, with an average of 184 μ (*C. gigantura* 134 to 200 μ). The longitudinal muscles were more distinct in our variety, and the circular muscles less so. There was no clear area between the central longitudinal muscle strand and the outer edge (a consistent feature in *C. gigantura*), and the tail was much less transparent. The myomere cells in the tail were also smaller. The tail whip was neither as distinctly marked off, nor as long, as in the typical form, its approximate length being 53 to 114 μ with an average of 79 μ (*C. gigantura* 83-192 μ).

The body of the cercaria seemed in no essential particular other than size to differ from that of *C. gigantura.* The measurements of the variety, with those of *C. gigantura* added in brackets for comparison, were as follows. Length of body 137-300 μ, average 258 μ (105-267); breadth of body across ventral sucker 57-103 μ, average 70 μ (50-100 μ); length of anterior sucker 30-38 μ, average 34 (21-30 μ); breadth of anterior sucker 30-38 μ, average 34 μ; length of posterior sucker 34-42 μ, average 36 (21-30 μ); breadth of posterior sucker 34-42 μ, average 36 μ (28-38 μ). On remeasurement we found that the size of the ventral sucker of *C. gigantura* fell within the range of that of the variety. The spinules present on the ventral surface of the body were slightly larger in the new variety. The position and character of the collar spines were identical. The length of the latter was 5 μ. Their length in *C. gigantura* was given in error as 13 μ, but on remeasurement they were found to have the same length (5 μ) as in the variety; thus bringing the species closer to *C. Petasigeri-nitidi* Beaver 1939.

Our snail hosts died before work on the excretory system of the cercaria was completed. The details found agreed with those of *C. gigantura.* In addition, there was seen in the proximal part of the tail of one specimen a short tube apparently connecting with the excretory bladder in the tail stem. This tube had two short arms, hence it was possible that the excretory tube extended into the

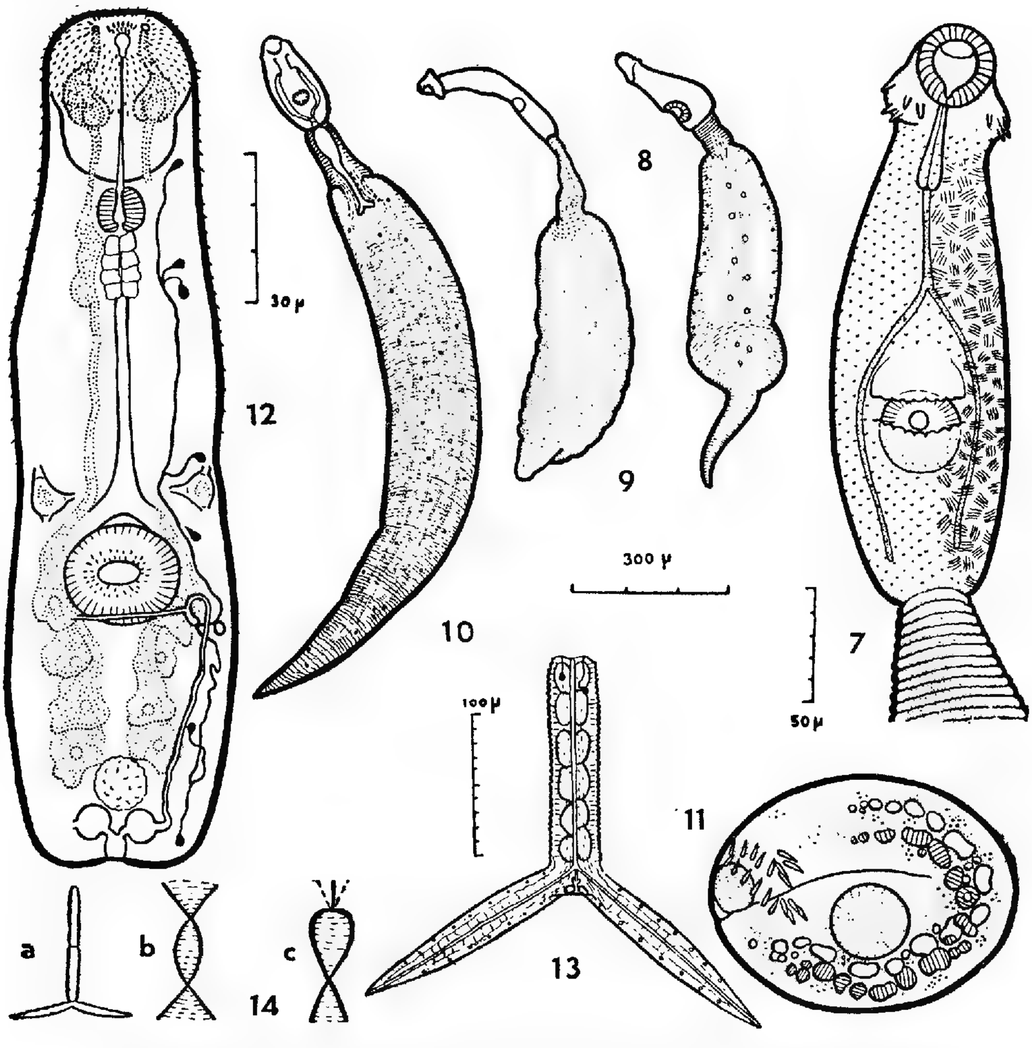

Fig. 7-14. fig. 7, 9-11—*Cercaria gigantura* var. *grandior:* 9, with tail contracted; 10, with tail elongated—its more usual condition while alive; 11, cyst. Fig. 8—*Cercaria gigantura* (typical), for comparison with its variety, fig. 9. Fig. 8-10 to same scale (below 9); 7 and 11 to same scale (beside 7). Fig. 12-14—*Cercaria angelae:* 12, body; 13, tail; 14, a, b, c, freehand sketches of attitudes of living cercariae.

tail for a short distance and opened by two branches laterally. The redia was similar to that of *C. gigantura.*

Cercariae were found experimentally to encyst around the oesophagus and pharynx of the aquarium fish, *Gambusia affinis,* and leopard fish, *Phalloceros caudimaculatus.* Cysts were not recovered from a *Barbus* exposed to infection at the same time. The cysts were similar to those of *C. gigantura* but the dimensions were slightly larger, ranging from 129 to 133 μ in length, and 91 to 99 μ in breadth (*C. gigantura* 125 by 75 μ).

Cercaria angelae n. sp.

(Fig. 12-14)

Cercaria angelae is a small furcocercaria which has been found consistently, though not frequently, emerging from its snail hosts, *Amerianna pyramidata* and *A. tenuistriata*, from the Tailem Bend swamps. The examination of snails for its presence took place from 15 January 1941 to 3 February 1944, and the percentage infection for the period was 0·9%. The largest number of infected snails was observed on 15 January 1941, when 27 out of 861 snails were found giving off the parasite. We have associated with this new form the name of our colleague, Miss L. M. Angel.

C. angelae remains fairly evenly distributed in water, and is an active and vigorous swimmer, appearing to have no resting period. The maximum emission from infected snails occurred between 12 noon and 1.30 p.m., during the summer months. Cercariae collected during these hours were all dead by 9 a.m. the next morning.

The following measurements of 10 cercariae were obtained after adding to the water containing them an equal volume of boiling 10% formalin: Body length 111-216 μ (average 158 μ); body breadth 27-53 μ (average 41); length of tail stem 163-190 μ (average 175); breadth of tail stem 30-46 μ (average 36); length of furcae 163-190 μ (average 176); length of anterior organ 30-46 μ (average 37); length of posterior sucker 19-23 μ (average 19); breadth of posterior sucker 19-23 μ (average 22); distance of posterior sucker from anterior end of cercaria 53-110 μ (average 77).

About eight rows of irregularly-placed spines are present, forming a collar immediately behind the mouth. Two rows of irregularly situated spines (about 12 in number) lie immediately dorsal and anterior to the mouth. Scattered spines, difficult to see, occur on the anterior part of the body, and two irregular rows of spines are present on the ventral sucker. The body has about the same width as the tail stem, and the furcae and tail stem are of almost equal length.

The mouth is subterminal and the pharynx is immediately behind the anterior organ. The latter is more muscular in its posterior portion, though not markedly so. Immediately behind the pharynx are eight large nucleated cells staining deeply with neutral red. The oesophagus is difficult to see and divides into two immediately in front of the ventral sucker. The length of the intestine was not determined owing to the presence of gland cells obscuring it.

Four pairs of large, granular, irregularly-shaped penetration glands, staining with neutral red, are present posterior to the ventral sucker. Their ducts lead anteriorly (fig. 12) with irregular swellings opposite the nucleated post-pharyngeal cells, and with an enlarged section in the anterior part of the anterior organ. A pair of clear cells, with a central granular portion, are present just anterolateral from the ventral sucker. They do not stain with neutral red; perhaps these preacetabular bodies (of Cort and Brackett 1937) are non-pigmented eyes. The reproductive anlage is represented by a group of cells, staining with haematoxylin, in the posterior part of the body. Six well-defined caudal bodies are present in the tail stem. The first caudal body is often considerably smaller than the remainder. A small pair of caudal bodies is present at the base of the furcae. They vary considerably in shape and size, the size probably depending on the age of the cercaria. In this region two globules of similar material are usually present, attached to the central core which supports the caudal bodies.

The bladder consists of two rounded parts each connecting with a short median section which reaches the tail. From the bladder a slightly coiled collecting tube extends to the level of the posterior part of the ventral sucker. Here it forms a loop, from which arises a postacetabular transverse commissure which joins the loop of the excretory tube on the other side. The main duct then divides into two, an anterior and a posterior collecting tubule. Two flame cells open into the posterior collecting tubule, and five flame cells into the anterior collecting tube. Their arrangement is given in fig. 12. Two flame cells are present in the proximal part of the tail. A median excretory tube runs down the tail stem, divides into two branches which open at the tip of the furcae.

The long, much twisted sporocysts, present in the liver of the snail host, are colourless or faintly tinged with yellow, and are hard to disentangle without breaking. One end is pointed and very retractile, the other end rounded, the rest of the body being of uniform thickness except where the cercariae are mature. One sporocyst measured was 2·1 mm. long.

Attempts to obtain the metacercaria by exposing to infection freshwater molluscs, prawns, crayfish and aquatic insect larvae, and fish (*Gambusia, Barbus*) and a leech (*Limnobdella australis*) were unsuccessful. Many laboratory-bred tadpoles of *Limnodynastes tasmaniensis* were also utilised, most of them unsuccessfully, but in one of them a number of *Tetracotyle* were recovered many months later in the walls of the thorax and rectum, in the pericardium, and in tissues of the tail and those near the base of the forelimbs. The oval cyst, about 325 by 400 μ, had a thick clear outer wall, and a thin pigmented inner wall surrounding the *Tetracotyle* which varied in size in different cysts. The *Tetracotyle* will be described later. The presence of a pharynx was not demonstrated with certainty.

C. angelae is a Strigeid larva belonging to the pharyngeal longifurcate group. The posterior position of the eight gland cells and of the transverse excretory canal, as well as the presence of a well-developed acetabulum suggest that the adult may belong to *Apatemon, Strigea,* or perhaps *Apharyngostrigea*.

In swimming constantly during its free life our cercaria is similar to *C. longifurca, C. dohema* and the cercaria of *Cotylurus flabelliformis*. Of these three, *C. angelae* in its anatomy somewhat resembles *C. dohema* Cort and Brackett 1937. The measurements of our specimens (which were killed in similar manner to theirs) agree within a few micra with those given for *C. dohema,* except that the furcae appear to be 20 μ shorter in our species. Caudal bodies agree in number and size except that in our specimens the caudal bodies at the base of the furcae are not so large. The caudal excretory tube in *C. angelae* (though not readily seen) opens at the tip of each furca. The excretory bladders are similar; that illustrated in fig. 12 for our species is somewhat contracted, but when it is fully expanded it assumes the form given for *C. dohema*. The number of flame cells is four on each side of the body in *C. dohema,* but there are seven in our species and their arrangement is somewhat different. The nucleated postpharyngeal cells are absent in *C. dohema* which has three instead of four pairs of penetration glands in the postacetabular region.

C. riponi Brackett (1939) from *Stagnicola* from Michigan is another Strigeid cercaria somewhat resembling our form. The most striking differences are in its swimming habits; the different number and arrangement of the flame cells and caudal bodies; the presence of only three pairs of postacetabular gland cells; the smaller preacetabular bodies; and the absence of the postpharyngeal group of nucleated cells.

The presence of four pairs of longitudinally arranged postacetabular glands has been rarely recorded. Lutz (1933, 35, 40, 53, pl. ii, fig. 8) mentioned and figured a "Pseudodistomulum" with such an arrangement. This organism, which is really a cercaria that has shed its tail, was found encysted in a Brazilian frog, *Hyla crepitans,* and a *Tetracotyle* resembling it was reported by him as occurring in young birds, snakes and some carnivores. The adult stage was stated to be

Strigea vaginata (Brandes) from Brazilian Accipitrine birds. Dubois (1938, 94, fig. 37) republished Lutz's figure as *Mesocercaria Strigeae-vaginatae*. From the foregoing it is most probable that the adult of *C. angelae* is a *Strigea* from an Australian bird of prey, several species having already been recorded from hawks and owls from North Queensland.

C. pseudoburti Rankin 1939 has four pairs of postacetabular gland cells, but their arrangement is different from that in *C. angelae*. In *C. burti* Miller the eight postacetabular glands are arranged in two transverse series (Cort and Brooks 1928, pl. xxviii). This cercaria is the larva of an *Apatemon* and closely resembles that of *A. gracilis* as described by Szidat (1929). *Cercaria helvetica* Dubois (1929, 94, pl. iv, fig. 14) from *Limnaea* and *Planorbis* in Switzerland has the eight glands postacetabular and arranged in two close longitudinal rows, and has pre- and postacetabular excretory commissures, but the relative lengths of the prepharynx and oesophagus are different from those of *C. angelae*. Dubois' cercaria also belongs to *Apatemon* (Dubois 1938, 96).

The cercaria of *Apharyngostrigea pipientis*, described by Olivier (1940), has its eight glands almost surrounding the acetabulum, and also differs from *C. angelae* in the relative lengths of the prepharynx and oesophagus and in the form of the tail stem, especially when contracted.

Summary

(1) **Cercaria ellisi** n. sp., a 45-spined echinostome, is described from *Limnaea lessoni*. The cyst stage occurs in the molluscs, *Amerianna* spp., *Planorbis isingi*, *Limnaea lessoni*, *Corbiculina angasi* and *Plotiopsis tatei*; as well as in the tadpole of *Crinia signifera*. The adult probably occurs in a Ralline bird, e.g., a waterhen.

(2) *Cercaria gigantura* var. **grandior** nov. from *Amerianna pyramidata* differs from the type form in the characters of the tail and in having slightly larger cysts. The latter occurs in freshwater fish.

(3) **Cercaria angelae** n. sp. from *Amerianna* spp. is a Strigeid larva with eight longitudinally arranged postacetabular penetration glands. The metacercaria is a *Tetracotyle* occurring in tadpoles. Its adult stage is perhaps a species of *Strigea* parasitic in Australian birds of prey or an *Apharyngostrigea* from herons.

We desire to acknowledge assistance generously given by Messrs. G. G. Jaensch, Bryce Jaensch and L. Ellis, of Tailem Bend, Murray River, in regard to material. The work was carried out under the terms of the Commonwealth Research Grant to the University of Adelaide. Type material is being deposited in the South Australian Museum.

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AUSTRALIAN ACARINA, FAMILIES ALYCIDAE AND NANORCHESTIDAE

By H. WOMERSLEY, A.L.S., F.R.E.S., Entomologist, South Australian Museum

Summary

Subfam. BIMICHAELINAE nov.

The family Alycidae Canest. 1891 (previously unknown from Australia), as hitherto understood by acarologists, includes the following twelve genera:

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By H. Womersley, A.L.S., F.R.E.S., Entomologist, South Australian Museum

[Read 8 June 1944]

Subfam. BIMICHAELINAE nov.

The family Alycidae Canest. 1891 (previously unknown from Australia), as hitherto understood by acarologists, includes the following twelve genera:

Alycus C. L. Koch 1842 (= *Pachygnathus* Dugés 1834).
Bimichaelia Sig Thor 1902 (= *Michaelia* Berl. 1884, preoc.).
Nanorchestes Tops. and Trt. 1890 (= *Monalichus* Berl. 1904, in part).
Caenonychus Ouds. 1903.
Sebaia Ouds. 1903 (= *Monalichus* Berl. 1904, in part).
Sphaerolichus Berl. 1904.
Speleorchestes Trägh. 1909.
Leptalicus Berl. 1910.
? *Alicorhagia* Berl. 1910.
Hybalicus Berl. 1913.
Epistomalycus Sig Thor 1931.
Willania Ouds. 1931.

The family name Pachygnathidae has been used by Oudemans, Vitzthum and other workers, on the opinion of the first author that Dugés' genus *Pachygnathus* (type *P. villosus* Dugés 1834) is synonymous with Koch's *Alycus* (type *A. roseus* Koch 1842). A comparison, however, of the original figures and description of Dugés and Koch, reproduced by Oudemans in his "Krit. Hist. Acarol., IIIc, 868-869," does not support this view, and it seems preferable at present to keep to Sig Thor's use of Canestrini's family name Alycidae based on Koch's genus. In the Zool. Anz., **95**, 109, 1931, Sig Thor erected a third suborder, the Monoprostigmata, of the Prostigmata (in which he also placed the Stomatostigmata as a suborder) for the genera *Nanorchestes* and *Speleorchestes*. In the Prostigmata s. str. the peritremal tubes are paired and open in front of the mandibles, and in the Stomatostigmata the opening is medial and behind the mandibles, whereas in the Monoprostigmata the stigmal tube is unpaired, somewhat hook-like, with a small median sac, and opens amidst the mouth parts and in close association with the mandibles.

Sig Thor, however, did not follow this up by making the necessary new family for these genera, and the name Nanorchestidae is herewith proposed.

A close study of the other genera hitherto placed in the Alycidae reveals further important differences in the various genera which suggest that it is in reality a rather heterogeneous assemblage.

The genus *Bimichaelia*, with very long slender mandibles with short simple, almost styliform chelicerae, and without dorsal setae, must be separated from the rest, which all have short robust mandibles with stout, sometimes dentate chelicerae, and with two dorsal setae. For this genus, a new subfamily, Bimichaelinae is proposed.

The genera *Nanorchestes, Speleorchestes, Epistomalycus, Sebaia, Caenonychus* and *Willania* all have the tarsal claws wanting, a claw-like empodium, a more or less triangular well developed epistome overlapping the base of the mandibles, besides a more or less quadrate propodosomal shield. As yet, however, only in the first two named genera has the structure of the stigmal organ been defined. Nevertheless, on the other above mentioned characters the other four genera are more nearly related to *Nanorchestes* and *Speleorchestes* than to *Bimichaelia* or the *Alycus* group of genera. In *Nanorchestes* and *Speleorchestes* the epistome is longitudinally bilobed, freely jointed to the anterior margin of the propodosoma, and without any setae. In the latter genus Trägårdh shows the two lobes of the epistome united to their respective mandibles. Whether this is due to pressure in mounting, or is a further development from the form seen in *Nanorchestes* cannot be decided, but if these two lobes adjoined they would certainly resemble closely that found in the latter genus.

The genus *Caenonychus* Ouds. has been rather inadequately described and has been variously placed in the Eupodidae by Oudemans, the Tydeidae by Vitzthum and the Alycidae by Sig Thor. From the details available it would seem to be better placed in the new family Nanorchestidae and might possibly be synonymous with Trägårdh's *Speleorchestes,* in which case *Caenonychus* would have priority.

While in *Nanorchestes* and *Speleorchestes* the epistome is distinctly marked off from the anterior margin of the propodosoma, in *Epistomalycus* and *Willania,* it is not only fused with the propodosoma but arises some distance behind the anterior margin, and in both genera near the apex is furnished with a pair of ciliated setae (or "vertical hairs" of Oudemans). *Willania* was described without any figure, but there does not appear to be any reason why it should be separated from Sig Thor's genus *Epistomalycus* which was described in March 1931, two months before Oudemans' description was published.

The genus *Sebaia* was erected by Oudemans for Berlese's *Alicus* (*Monalichus*) *siculus* on the basis of its clavate posterior sensillae and has been quoted as a synonym of *Monalichus.* Berlese, however, although placing *siculus* in *Monalichus,* definitely stated that *M. arboriger,* now *Nanorchestes arboriger,* was the type. *Sebaia,* then, is a synonym only in part of *Monalichus.*

In the present paper the old family Alycidae is divided into the Alycidae s. str. and Nanorchestidae fam., nov., as follows:

Large to small mites, of subquadrate, globose, spherical or elongate form, with an evenly rounded epistome, and tarsi furnished with paired claws and a ciliated more or less pad-like or claw-like empodium. Propodosoma often with a crista and rounded lens-like pseudo-capitulum, and with usually two pairs of sensillae.
Fam. Alycidae Canest. s. str.

Very small mites, usually saltatorial. Propodosoma with a more or less quadrate shield and with a prominent triangular epistome. With (? always) an unpaired somewhat sickle-shaped peritremal tube opening orally and in close association with the mandibles. Claws absent, empodium present and claw-like.
Fam. Nanorchestidae nov.

Fam. ALYCIDAE Canest. 1891 s. str.

In this family should be included the genera *Bimichaelia, Alycus, Sphaerolichus, Hybalicus, Leptalicus* and *Paralycus* g. nov. Of these *Bimichaelia* can be separated from all the rest on the very different form of the mandibles, etc., and is here placed in a new subfamily, Bimichaelinae, the remaining genera forming the Alycinae.

The following key will separate the genera:

1 Mandibles very long and slender with short non-dentate, almost styliform chelicerae; without dorsal setae. Propodosoma with a broad, more or less distinct crista ending anteriorly in a lens-like pseudocapitulum; with two pairs of sensillae of which the posterior are globose, the anterior filamentous. Eyes absent. Body form subquadrate. Claws 2; empodium ciliated, not claw-like. Subfam. Bimichaelinae nov.
Gen. *Bimichaelia* Sig Thor 1902
(= *Michaelia* Berl. 1884 preoc.)

Type—*M. angustana* Berl. 1884, A. M. S., fasc. 6, Italy; also *M. setigera* Berl. 1904. Redia II. Acari nuovi, Manip. III, Italy; *M. subnuda* Berl. 1905. Redia II. Mat. pel. Manip. V, Italy; *M. grandis* Berl. 1913. Redia IX. Acari nuovi. Manip. VII-VIII, Java; and the following new species, *B. australica* n. sp., *B. stellaris* n. sp., and *B. pusilla* n. sp., from Australia, *B. nova-zealandica* n. sp., from New Zealand.

Mandibles short and robust with short slender chelicerae. Propodosoma without crista, with or without pseudocapitulum, with one or two pairs of sensillae of which the posterior may be globose, clavate or filamentous. Shape subquadrate, elongate-oval or globose. Subfam. Alycinae nov. 2

2 Body shape subquadrate. Propodosoma with both pairs of sensillae filamentous, without crista or pseudocapitulum. Hysterosoma with impressed transverse lines. Eyes present. Two claws with claw-like ciliated empodium. Gen. *Alycus* Koch 1842

Type—*Alycus roseus* Koch 1842. C. M. A. (= ? *Pachygnathus villosus* Dugés 1834), Europe; also *Alycus occidentalis* n. sp., Australia.

Body globose or spherical, with or without pseudocapitulum and without crista. One or two pairs of filamentous sensillae. 3

Body elongate-oval. Posterior sensillae clavate or filamentous. Without pseudocapitulum. 4

3 Body spherical. Eyes 1 + 1 (? 2 + 2). Propodosoma triangular, indistinctly separated from hysterosoma, anteriorly with a large lens-like pseudocapitulum. Both pairs of sensillae filamentous. Anterior tibiae and tarsi dilated and spinous. Coxae in two closely adjacent groups. Gen. *Sphaerolichus* Berl. 1904

Type—*S. armipes* Berl. 1904. Redia II. Acari nuovi, Manip. III, Italy. (Berlese says only one eye on each side but his figure suggests two on each side.)

Body globose but not spherical. Propodosoma without pseudocapitulum, with only one (?) pair of sensillae, these basal. Eyes present or absent. Gen. *Hybalicus* Berl. 1913

Type—*Alicus ornatus* Berl. 1904. Redia II. Acari nuovi. Manip. III, Java; also *H. flabelliger* Berl. 1913. Redia IX. Manip. VII-VIII, Java; and *H. gibbosus* n. sp. from Australia.

4 Both pairs of sensillae filamentous. Eyes absent. Gen. *Leptalicus* Berl. 1910
Type—*A. (L.) paoli* Berl. 1910. Redia VI. Acari nuovi. Manip. V, Italy; also *A. elongatus* Berl. 1904. Redia II. Acari nuovi. Manip. III, Italy.

Posterior sensillae clavate. Eyes absent. Gen. **Paralycus** nov.
For *Alicus pyrigerus* Berl. 1905. Redia II. Mat. pel. Manip. V, Italy.

Subfam. **BIMICHAELINAE** nov.

Gen. Bimichaelia Sig Thor 1902

Bimichaelia australica n. sp.

Fig. 1, A-H

Description—Shape quadrate. Colour in life white. Length to 900 μ, width to 560 μ. Suture between propodosoma and hysterosoma, and several impressed transverse lines on hysterosoma which disappear when mounted. Propodosoma roughly triangular with a broad median crista ending anteriorly in a lens-like pseudocapitulum (cf. fig. 1, A, H); with two pairs of sensillae, posterior globose and 21 μ long, 104 μ apart, anterior filamentous, 50 μ long and apparently simple, 65 μ apart. Eyes absent. Mandibles long and slender, 230 μ, with styliform chelicerae and no dorsal setae. Palpi 5-segmented, apical segment with a stout terminal rod flanked on each side by a pointed seta. Legs relatively short, I 540 μ, II 475 μ, III 375 μ, IV 425 μ; tarsi I three times as long as wide; segments IV-VI of legs I and II with sensory rod-like setae as in fig. 1, E; tarsi with paired claws and a short median ciliated empodium. Dorsal cuticle with a reticulate pattern as in fig. 1, A, H, and with short ciliated setae 15 μ long. Coxae in two groups, somewhat widely separated. Ventral setae as on the dorsum.

Locality—Type and paratypes from moss from Waterfall Gully, South Australia, 15 April 1933 (R. V. S.); from moss from Long Gully, National Park, South Australia, August 1938, three specimens (H. W.); English Jungle, Malanda, Queensland, May 1935 (Parkhouse), one specimen; Mount Wellington, Tasmania, May 1935, December 1937 (J. W. E.), July 1943 (V. V. H.).

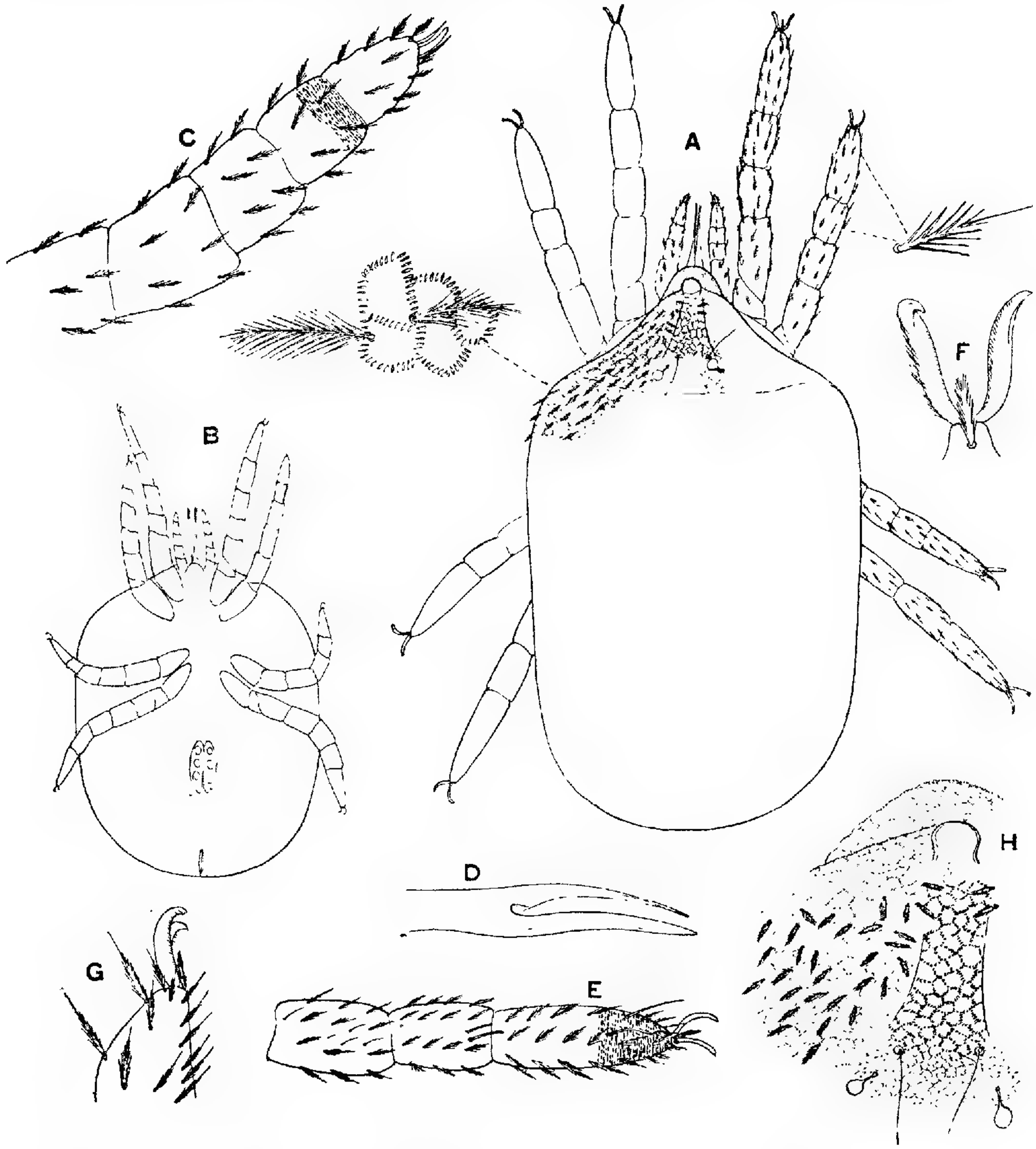

Fig. 1, A–H—*Bimichaelia australica* n. sp.: A, dorsal view showing crista, sensillae, pseudocapitulum and reticulation of cuticle, also dorsal and leg setae more enlarged; B, venter showing position of coxae; C, palp; D, chelicerae of mandibles; E, last three segments of leg I; F, claws and empodium from below; G, same from side; H, left half of propodosoma more enlarged.

Bimichaelia nova-zealandica n. sp.

Fig. 2, A-C

Description—Shape subquadrate. Colour (in spirit), white. Length 2,000 μ, width 1,360 μ. Suture between propodosoma and hysterosoma; no suture lines on hysterosoma when mounted. Propodosoma roughly triangular with broad median crista and an anterior lens-like pseudocapitulum; with two pairs of sensillae, posterior globose, 21 μ long, 140 μ apart, anterior filamentous 78 μ long, apparently simple, 85 μ apart. Eyes absent. Mandibles long and slender, 610 μ, with almost styliform chelicerae and no dorsal setae. Palpi 5-segmented, apical segment with stout terminal rod flanked on each side by a pointed seta. Legs 6-segmented, relatively short, I 1,275 μ, II 1,190 μ, III 1,100 μ, IV 1,360 μ; tarsus I three times as long as wide; no sensory rod-like setae observed on segments IV-VI of legs I and II; ciliated setae on tarsi with a longer apical point than in preceding species;

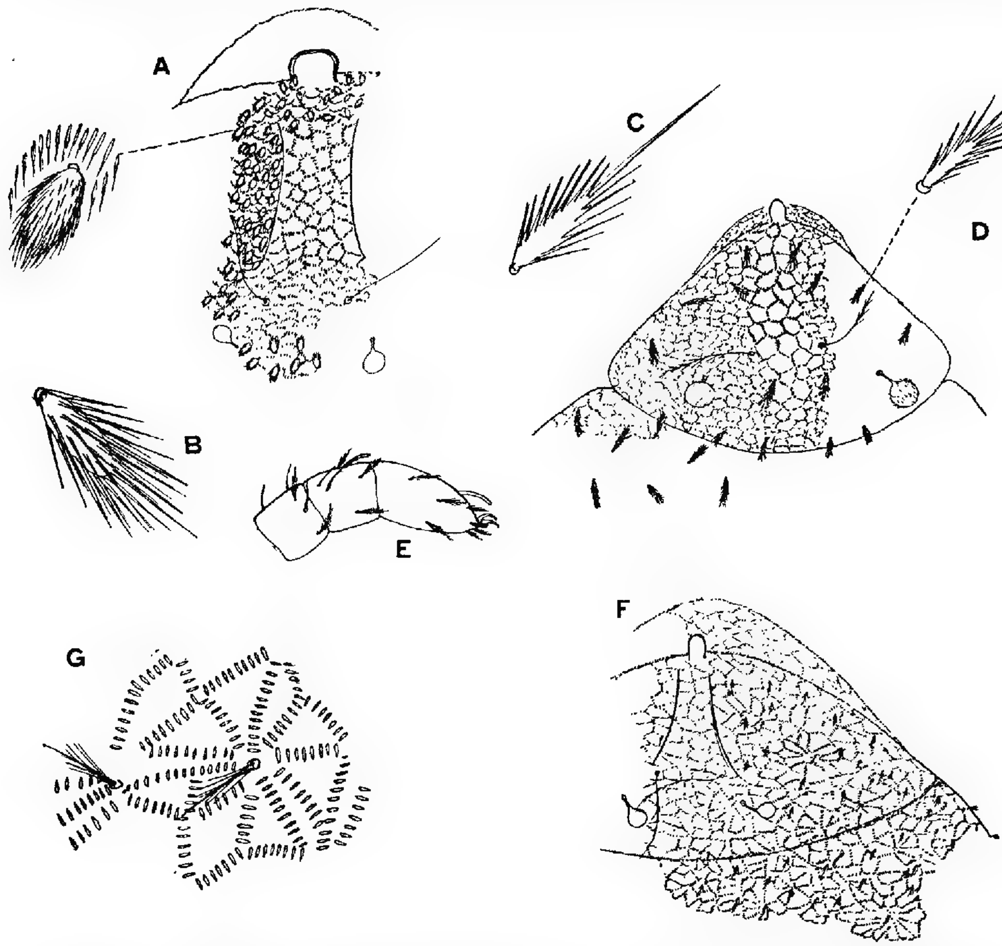

Fig. 2, A–C—*Bimichaelia nova-sealandica* n. sp.: A, crista, sensillae, pseudocapitulum and epistome with dorsal seta enlarged; B, ventral seta; C, leg seta. D–E—*Bimichaelia pusilla* n. sp.: D, propodosoma; E, last three segments of leg I. F–G—*Bimichaelia stellaris* n. sp.: F, right half of propodosoma; G, dorsal reticulations highly enlarged.

tarsi with paired claws and a short inconspicuous ciliated empodium. Dorsal cuticle reticulately patterned as in fig. 2 A, with short, 10 μ, oval setae with long ciliations. Coxae in two groups, somewhat widely separated. Ventral setae similar to dorsal but with longer ciliations.

Locality—One specimen from Davies Bush, Manurewa, New Zealand, 14 July 1933 (E. D. P.).

Bimichaelia pusilla n. sp.

Fig. 2, D-E

Description—Shape quadrate. Colour in life white. Length to 255 μ, width to 185 μ. Suture between propodosoma and hysterosoma; impressed transverse lines on hysterosoma distinct even when mounted. Propodosoma roughly triangular; crista present but not well defined, only shown by the somewhat longer and stronger reticulations, and ending in a pseudocapitulum smaller than in preceding species and longer than wide; with two pairs of sensillae, posterior globose and ciliated, 16 μ long, anterior filamentous, 27 μ long with several lateral branchlets; bases of posterior sensillae 56 μ apart, anterior sensillae 24 μ apart. Eyes absent. Mandibles long and slender, 88 μ with almost styliform chelicerae and no dorsal setae. Palpi 5-segmented, last segment with apical rod flanked by two pointed setae as in preceding species. Legs 6-segmented, short, I 152 μ, II 145 μ, III 112 μ, IV 135 μ; tarsus I short, only twice as long as wide; tarsi I and II with rod-like sensory setae as in *B. australica;* claws two, with a median ciliated empodium. Dorsal cuticle reticulately patterned as in fig. 2 D, with short ciliated setae, 8 μ long. Coxae in two groups, but not as widely separated as in other species. Ventral setae as on the dorsum.

Locality—Type and two paratypes from moss from Normanville, South Australia, September 1943 (H. M. Cooper); two specimens from moss from Sassafras, Victoria, December 1931 (H. G. A.).

Bimichaelia stellaris n. sp.

Fig. 1, F-G

Description—Shape subquadrate. Colour in life white. Length 550 μ, width 190 μ. Suture between propodosoma and impressed transverse lines on hysterosoma weak. Propodosoma rather triangular with a crista, a small hardly lens-like pseudocapitulum longer than wide, and with the usual two pairs of sensillae, the posterior globose, smooth, 15 μ long with bases 65 μ apart, anterior filamentous and ciliated, 47 μ long and bases 36 μ apart. Mandibles long and slender, 170 μ with almost styliform chelicerae, and without setae. Palpi 5-segmented, last segment with a terminal rod clavate at tip and not parallel-sided, flanked on each side with a pointed seta. Legs short, I 270 μ, II 240 μ, III 204 μ, IV 235 μ; tarsi I three times as long as wide; segments IV-VI of legs I and II with usual sensory rods; tarsi with paired claws and ciliated more or less pad-like empodium. Dorsal cuticle with reticulate pattern as figured, differing from other species in the pattern becoming stellate on hysterosoma, with short, 5 μ, ciliated setae. Coxae in two groups. Ventral setae as on dorsum.

Locality—One specimen in moss from Mount Arden, 12 miles north of Quorn, South Australia, November 1943 (H. M. C.).

Subfam. **ALYCINAE** nov.

Gen. ALYCUS Koch 1842

Alycus occidentalis n. sp.

Fig. 3, A-E

Description—Shape subquadrate with the hysterosoma rather higher than the propodosoma. Colour in life white. Length to 350 μ, width to 208 μ. Before mounting with impressed transverse lines on hysterosoma. A suture between propodosoma and hysterosoma. Propodosoma roughly triangular, without crista or pseudocapitulum; with two pairs of strongly ciliated filamentous sensillae, each 48 μ long, bases of posterior 52 μ apart, of anterior 29 μ apart. Eyes, one on each side. Mandibles short and robust, 56 μ long, with two setae, one sub-basal and about 22 μ long, the other only 8 μ long and near base of fixed finger of chelicerae, chelicerae somewhat slender but not styliform and without teeth, movable finger 15 μ long. Palpi 5-segmented, rather short and stout, last segment without apical rod or claw but with a sub-basal stout curved rod-like seta (cf. fig. 3, C). Legs short, I 136 μ, II 100 μ, III 120 μ, IV 150 μ; segments IV-VI of legs I and II with sensory rod-like setae as in fig. 3, D; tarsi with paired claws and ciliated claw-like empodium; tarsi I twice as long as wide. Dorsum with numerous short, 16 μ, ciliated setae arising from circularly striated areas (cf. fig. 3, A). Coxae in two groups, narrowly separated; coxae IV widely separated from each other. Ventral setae similar to dorsal.

Locality—Many specimens in moss from Glen Osmond, South Australia, July 1934 (R. V. S.).

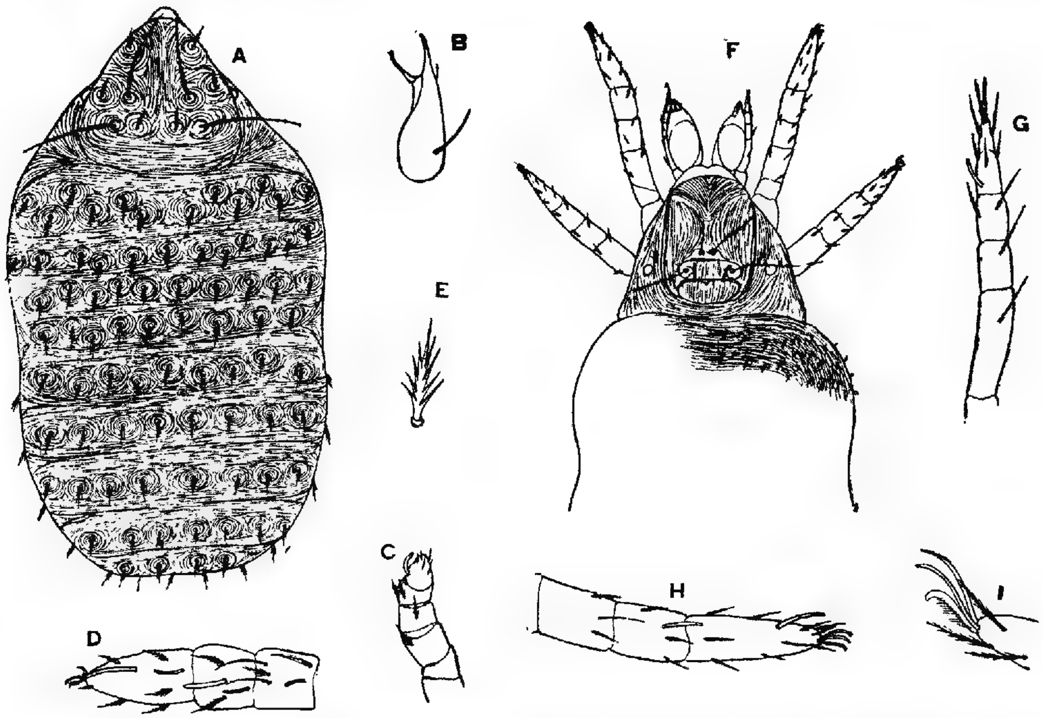

Fig. 3, A–E—*Alycus occidentalis* n. sp.—A, dorsal view; B, mandible; C, palp; D, last three segments of leg I; E, dorsal seta. F–I—*Alycus* ? *roseus* Koch: F, propodosoma; G, palp; H, leg I, last three segments; I, claws and empodium.

Alycus ? roseus Koch 1842
Fig. 3, F-I

Description—Shape subquadrate, propodosoma roughly triangular but with a rectangular shield, hysterosoma subquadrate, rather longer than wide with a slight constriction at one-third. Colour in life a light rosy pink. Length 400 μ, width 183 μ. Propodosoma with two pairs of long ciliated sensillae, posterior 52 μ long and bases 28 μ apart, anterior 40 μ long and close together, the bases not more than 5 μ apart. Eyes, one on each side, black pigmented, on outside of shield, and with the usual ocular shield. Mandibles robust, 45 μ long, probably with two setae but only a very short one near base of chelicerae visible; chelicerae small. Palpi 5-segmented, relatively longer and more slender than in *occidentalis*, last segment without apical rod but with a curved sub-basal rod. Legs short, I 182 μ, II 130 μ, III 122 μ, IV 138 μ, tarsi I with sensory rods as figured on segments IV-VI; tarsi I about three times as long as wide, tarsi with two claws and a ciliated claw-like empodium. Dorsal cuticle striated, with small ciliated setae arising from indistinct circularly striated areas, but these areas very much smaller than in *occidentalis*; dorsal setae mostly only 3 μ long but lengthening posteriorly and last three rows reaching to 10 μ in length.

Locality—Two specimens in moss from Mount Arden, twelve miles north of Quorn, November 1943 (H. M. C.).

Remarks—This is somewhat doubtfully referred to Koch's European species, but good figures and descriptions have not been published and comparison with authentic material must be awaited.

Genus Hybalicus Berlese 1913

Acari nuovi, Maniplus VII-VIII, Redia, **9**, 78, 1913. Genotype *Alicus ornatus* Berl. 1904, *ibid.*, Maniplus III, Redia, **2**, 13; also *H. flabelliger* Berl. 1913, *ibid.*

Berlese says, "With the characters of the genus *Alicus* Koch (Berlese) but with globose abdomen. Size small."

As far as one can judge from Berlese's description and figures and from a study of the following new species, the genus may provisionally be more fully diagnosed as follows:

Small mites of globose form. Propodosoma subtriangular and narrower than hysterosoma with only one posterior pair of ciliated filamentous sensillae present (Berlese shows a second anterior pair in *ornatus* but not in *flabelliger*). Mandibles short and robust with two dorsal setae, the posterior and longer being near base of chelicerae; chelicerae short, stout and dentate. Palpi 5-segmented, last segment with a terminal long apically knobbed rod. Claws two, long and slender, with long ciliated empodium. Coxae in two groups, widely separated, coxae IV very large and elongated and touching medially.

Hybalicus gibbosus n. sp.

Fig. 4, A-G

Description—Shape globose with hysterosoma much higher than propodosoma. Colour in life white. Length to 310 μ, width to 200 μ. Suture between propodosoma and hysterosoma. Anterior portion of propodosoma forming a shield, posterior margin of which runs just behind sensillae bases; with two pairs of stout curved ciliated setae and a pair of long, 104 μ, ciliated sensillae; in front of the propodosoma is a semicircular lens-like epistome carrying two short bent ciliated setae; behind the shield the propodosoma carries a pair of submedian strong curved ciliated setae, and outside of these a pair of shorter similar setae. Eyes, one on each side, difficult to see, for they are quite lateral and in front of a thickened portion of the lateral margin of the propodosoma, which apparently represents the oval organ behind the eyes of *Nanorchestes*. Mandibles bulbous, longitudinally finely striated, chelate, with two dorsal setae, a short fine one at base of chelicerae and a longer stronger and ciliated one more posterior. Maxillae as in fig. 4, E. Palpi 5-segmented, apical segment with a terminal, apically knobbed rod and a strong pointed subapical seta, all other setae ciliated. Dorsal cuticle verrucose and finely striated. Dorsal setae strongly curved, ciliated, 30 μ long and arranged 4.4.4.4.8.8.8. Legs long and slender, I 182 μ (including coxae), II 135 μ, III 150 μ, IV 235 μ; tarsi with paired slender claws and median ciliated empodium. Coxae in two groups, I, II and III small and separated, IV large elongate and meeting in mid-line, the posterior margin being very much thickened and strengthened. Venter: three pairs of small setae on gnathosoma; behind gnathosoma a pair of longer setae and a similar pair between coxae I, coxae I and III with two setae, II with one, and IV with six setae; at junction of coxae IV is a pair of very small setae; on each side of genital opening a pair of setae and posterior thereto 18 setae arranged 2.4.4.4.4, 16 μ long. Genitalia with three pairs of acetabula, and fringed with setae.

Locality—Many specimens from moss from Black Swamp, near Currency Creek, South Australia, October 1943 (H. M. C.).

Remarks—In its globose form this species fits into the genus *Hybalicus*, as briefly defined by Berlese (*loc. cit.*). It differs from both the genotype (*ornatus*) and *flabelliger* in the nature of the dorsal setae. In *ornatus* from Java the dorsal setae are more numerous, shorter and almost straight with fewer ciliations, and the cuticle is more densely furnished with oval verrucae. In *flabelliger* from Italy the dorsal setae are short and flabellate. In neither of his species has Berlese observed the presence of eyes.

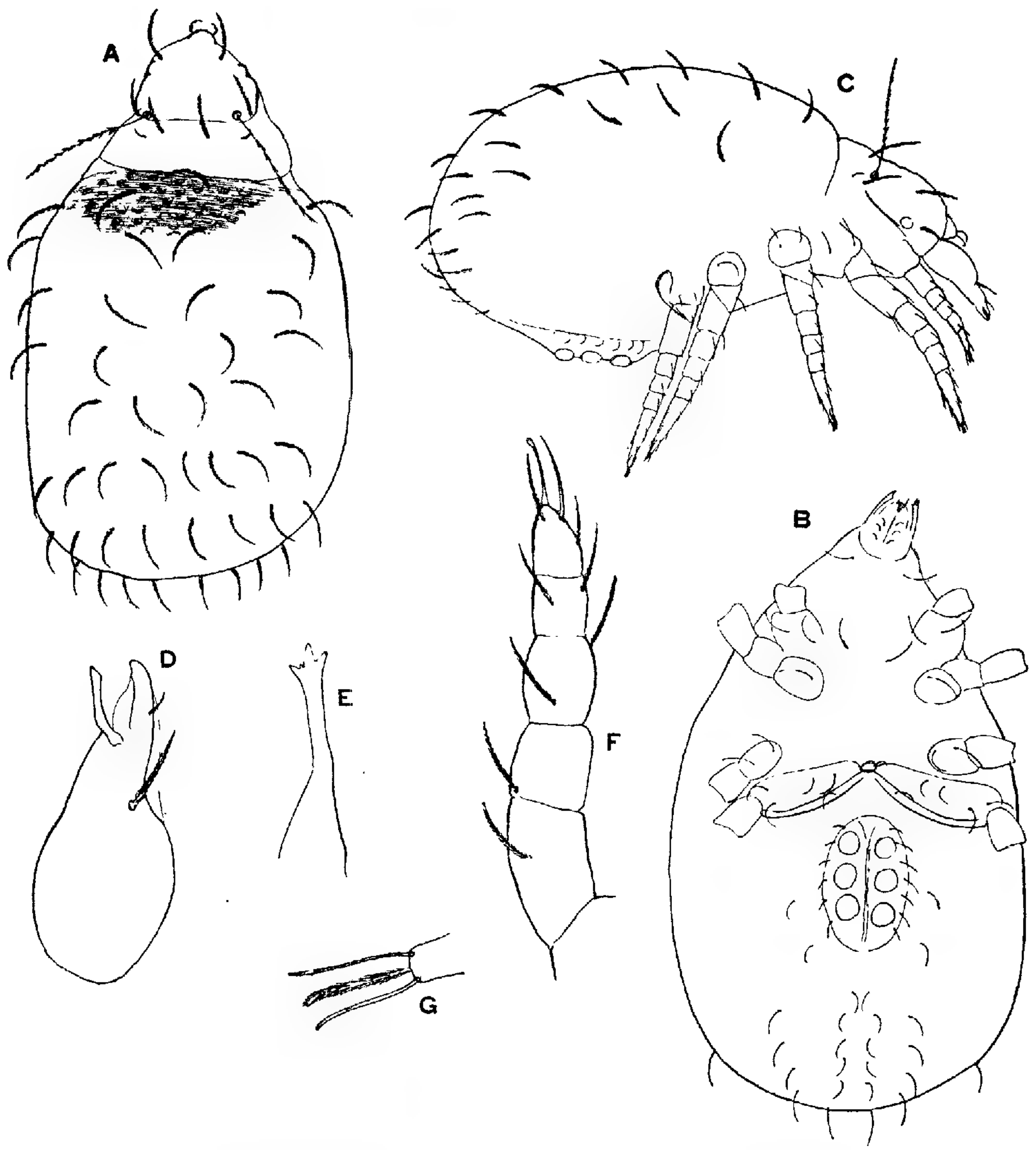

Fig. 4, A–G—*Hybalicus gibbosus* n. sp.: A, dorsal view; B, ventral view; C, lateral view; D, mandible; E, maxilla; F, palp; G, claws and empodium.

Fam. **NANORCHESTIDAE** nov.

As defined earlier in this paper in its separation from Alycidae s. str. The genera included are *Epistomalycus, Willania, Sebaia, Nanorchestes, Speleorchestes* and *Caenonychus*. Of these it seems probable that *Willania* Oudemans, May 1931, is the same as *Epistomalycus* Sig Thor, March 1931, and that *Caenonychus*

Ouds. may be synonymous with *Speleorchestes* Trägårdh. The genera may be keyed as follows:

1 Epistome fused with propodosoma and arising behind the anterior margin, not bilobed, and furnished anteriorly with paired ciliated setae. Coxae all touching, not in two groups. Only one pair of sensillae, filamentous. Eyes absent.
Gen. *Epistomalycus* Sig Thor 1931 (March)
(= ? *Willania* Ouds. 1931, May)

Type—*E. clavipilis* Sig Thor 1931, Norway; *E. plumipilis* Sig Thor 1931, Norway; and *W. miro* Ouds. 1931, Holland.

Epistome bilobed, striated, without setae and separated from anterior margin of propodosoma by a suture. 2

2 Sensillae in two pairs, both filamentous and ciliated. 3

Sensillae in two pairs, posterior clavate, anterior filamentous. Eyes absent.
Gen. *Sebaia* Ouds. 1903

Type—*Monalicus siculus* Berl. 1910

3 Body short and wide, propodosoma somewhat sunk within hysterosoma. Both sensillae placed behind midline of propodosomal shield and close together. Eyes present.
Gen. *Nanorchestes* Tops. and Trt. 1890

Type—*N. amphibius* Tops. and Trt. 1890, France; *N. arboriger* Berl. 1904, Europe and Australia; *N. collinus* Hirst 1918, England and Australia.

Body more elongate, propodosoma not sunk within hysterosoma. Anterior sensillae near anterior margin of propodosomal shield and well separated from posterior sensillae. Eyes present.
Gen. *Speleorchestes* Trägårdh
(= ? *Caenonychus* Ouds. 1903)

Type—*S. formicorum* Trägh. 1910, Sweden.

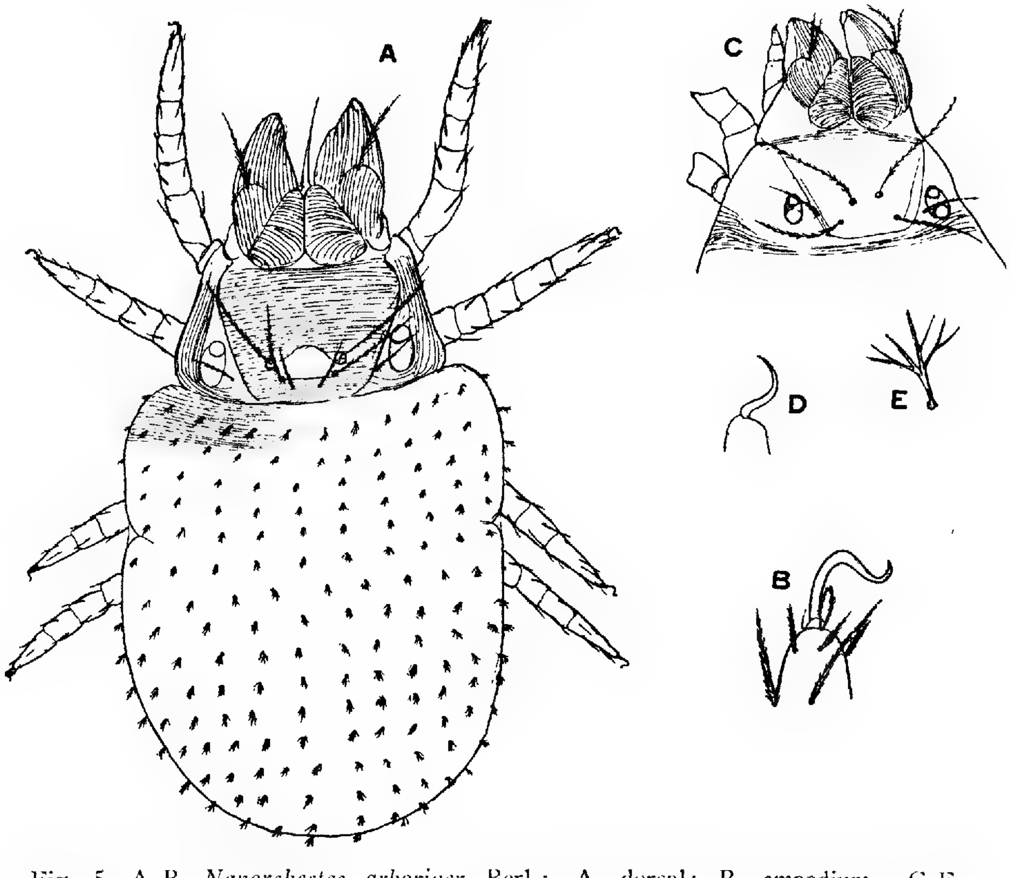

Fig. 5, A–B—*Nanorchestes arboriger* Berl.: A, dorsal; B, empodium. C–E—*N. collinus* Hirst: C, dorsal view of propodosoma; D, empodium; E, dorsal seta.

Genus NANORCHESTES Tops. and Trt. 1890

NANORCHESTES ARBORIGER (Berlese 1904)

Alichus arboriger Berl. 1904. Redia II, Acari nuovi, Manip. II, Italy, Norway.

Fig. 5, A-B

Very small saltatorial mites of a dirty white to dark greenish colour with traces of red about gnathosoma and legs. Length (excluding mandibles) 160-170 μ, width 120-130 μ. Eyes, one on each side, with the usual larger ocular lobe (?eye) behind. Anterior sensillae 37 μ long and 20 μ apart, posterior 28 μ long. Mandibles stout and robust, 40 μ long, with indefinable chelicerae, and only a single dorsal ciliated seta 28 μ long. Dorsal setae numerous, tri- to quinquetrous. Empodium claw-like and doubly bent (cf. fig. 5, B).

Locality—In moss from Normanville, South Australia, September 1943 (H. M. Cooper), and Black Swamp, near Currency Creek, South Australia, October 1943 (H. M. C.).

NANORCHESTES COLLINUS Hirst 1918

Annals and Mag. Nat. Hist., 1918, (9), **2**, 213.

Fig. 5, C-E

Very small mites similar in colour to preceding. Length (without mandibles) 273 μ, width 170 μ. Eyes, one on each side, with the usual posterior oval lobe. Anterior sensillary setae 70 μ long and 13 μ apart, posterior 52 μ long. Mandibles robust, 65 μ long with a dorsal seta divided into two unequal, 26 μ and 21 μ, branches from its base. Dorsal setae as figured, 8 μ long. Empodium claw-like but not doubly bent.

Locality—This species was hitherto known only from a single specimen from the Mendip Hills, Somerset, England. It was not unplentiful in moss from Black Swamp, near Currency Creek, South Australia, October 1943 (H. M. C.).

SOIL AND VEGITATION RELATIONSHIPS IN THE LOWER SOUTH-EAST OF SOUTH AUSTRALIA A STUDY IN ECOLOGY

By R. L. CROCKER,
Division of Soils, C.S.I.R., Waite Agricultural Research Institute, Adelaide

Summary

The vegetation of the Lower South-East of South Australia has been rather neglected in botanical literature. This is due partly to the complexity of the area, but more particularly on account of its distance from Adelaide and, until recently, its relative inaccessibility. Land development is now proceeding at such a rate that before long it will be impossible to piece together a picture of the flora of the region as a whole. Indeed even now, in a large area about Mount Gambler it is impossible to do so, and consequently this area has been omitted from the vegetation map. In other places, too, the picture is far from complete, and there is necessarily much surmise. The area has been embodied in several earlier maps, the principal of which were Prescott's "The Vegetation Map of South Australia" (16) and "Soils of Australia in Relation to Vegetation and Climate" (17), and Wood's "The Vegetation of South Australia" (25). The first of these was the original vegetation map of this State, and is of such a general nature that it is now of little interest to botanists and ecologists. The second is of more interest, although concerning Australia as a whole it is necessarily broad. By far the best general account of the vegetation of South Australia has been given by Wood in the publication cited above, but even here the Lower South-East has been inadequately dealt with. The area concerned, then, has for a long time remained unknown to students of botany.

SOIL AND VEGETATION RELATIONSHIPS IN THE LOWER SOUTH-EAST OF SOUTH AUSTRALIA

A STUDY IN ECOLOGY

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Plates V to IX with Maps

[Read 8 June 1944]

INTRODUCTION

The vegetation of the Lower South-East of South Australia has been rather neglected in botanical literature. This is due partly to the complexity of the area, but more particularly on account of its distance from Adelaide and, until recently, its relative inaccessibility. Land development is now proceeding at such a rate that before long it will be impossible to piece together a picture of the flora of the region as a whole. Indeed even now, in a large area about Mount Gambier it is impossible to do so, and consequently this area has been omitted from the vegetation map. In other places, too, the picture is far from complete, and there is necessarily much surmise. The area has been embodied in several earlier maps, the principal of which were Prescott's "The Vegetation Map of South Australia" (16) and "Soils of Australia in Relation to Vegetation and Climate" (17), and Wood's "The Vegetation of South Australia" (25). The first of these was the original vegetation map of this State, and is of such a general nature that it is now of little interest to botanists and ecologists. The second is of more interest, although concerning Australia as a whole it is necessarily broad. By far the best general account of the vegetation of South Australia has been given by Wood in the publication cited above, but even here the Lower South-East has been inadequately dealt with. The area concerned, then, has for a long time remained unknown to students of botany.

The present work is an attempt to define and delimit the principal vegetation associations, in the Lower South-East, and to establish the edaphic and other environmental factors influencing their development and maintenance. The area concerned is approximately 3,200 square miles in the Counties of Grey and Robe. The work was carried out over the period from 1937-1940, and much of it was done while on soil survey. Where the country was inaccessible use was made of the original hundred survey diagrams of the Lands Department, Adelaide. Because of the area involved the work is necessarily of a broad and general nature, but before detailed work is done in specific localities it is important to have perspective in an understanding of the area as a whole.

PHYSIOGRAPHY AND GEOLOGY

The chief physiographic feature of the South-East generally is the unique arrangement of sand-dune ranges parallel to the existing coastline. These ranges are frequently indurated. They are rarely more than 100 feet above the general level and between them are series of flats or plains. The ranges are generally recognised (28), (20), (13), (4) as representing old coastal dunes, or dune remnants, connected with successive stages in the retreat of the sea in late Pleistocene or Recent geological times. These superimposed ranges have impeded the natural drainage to the sea and have preserved a topography of extreme immaturity.

As we proceed across sand range and inter-range flat, from the coast to the most inward range, the Naracoorte Range, we retrace the successive steps in the recession of the sea. The height of the flats above sea level gradually increases from the coast to the Victorian border.

Fenner (10) considers that the Naracoorte Range represents an old fault scarp and not a sand-dune ridge. It probably does represent a fault line, but there are sand dunes and indurated dunes superimposed upon it. The important thing is that the country to the east of this range is much higher. Its physiography is now modified but it was the old land surface prior to the positive earth movements, of late Pleistocene and Recent times, which resulted in the retreat of the sea. The chief physiographic features of the Lower South-East are illustrated in an earlier paper (Crocker (4)), and in fig. 1 b on page 146.

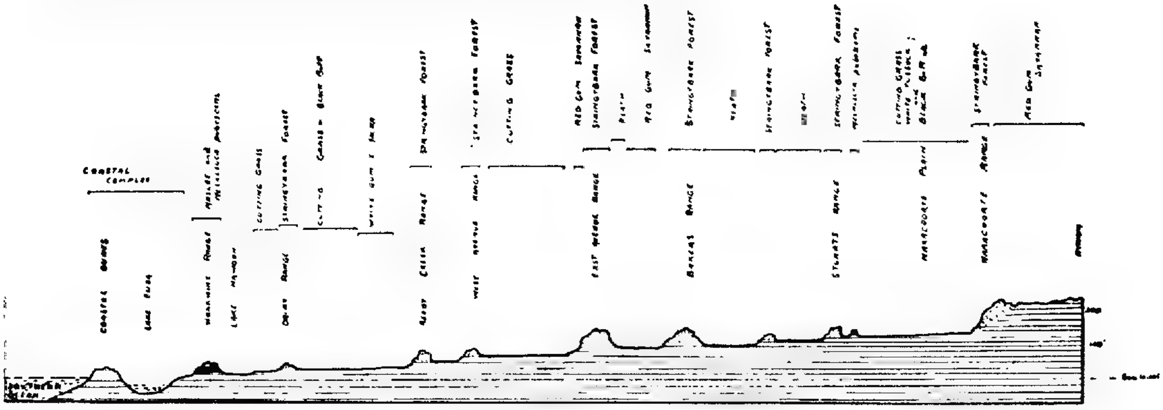


Fig 1 a

East-West Section—From coast opposite Lake Eliza to Hynam (East of Naracoorte) Illustrating successive stages in recession of the sea and the succession of dune range remnants.

The plains are underlain by flat-bedded Miocene marine limestones, but these are normally overlain by more recent calcareous material and recent deposits of sand. This latter is especially so in the flat heath areas so characteristic of the Wattle Range region and northwards.

The sand-dune ranges reach their maximum development in the Mount Burr Range, but the geological features are here further complicated by the existence of numerous small and isolated basaltic, ash and tuff hills. The volcanic activity in the Mount Burr region is considered to have been earlier (4) than that at Mount Gambier and Mount Schank. The yellow and grey podsolised sands of the Mount Burr region are superimposed on the general volcanic framework, whereas about Mount Gambier gently undulating yellow sandrises (with Mount Burr sand similarities) have a capping of volcanic ash varying in thickness up to approximately one-and-a-half feet and weathering to a fertile volcanic loam.

Despite the large number of volcanic outcrops, they are exceedingly small in area, and the bulk of the Mount Burr Range is covered with Recent sands and in places indurated sand dunes and shell-beds. Occasionally outcrops of basal Miocene limestone occur. These limestones are either polyzoal or more massive and fossiliferous. Some of the sand overlies volcanic material at depth. Fenner (10) has suggested that the western side of the Mount Burr Range, between the Bluff and Mount Muirhead, represents an old fault line.

The lava flow at Mount Gambier was of very limited extent and Stanley (22) considers Mount Gambier lavas related to the Victorian ones. Apart from this limited flow the volcanism was entirely of an explosive type.

Parallel to the coast, from Mount Benson to opposite Kongorong, there is a limestone range with very shallow soils and practically no sand—the Woakwine Range (see maps). Apart from the calcareous coastal dunes it is the first range in the series from the coast to the Naracoorte Range. The limestone varies in thickness between one foot and several feet and is underlain by a highly calcareous sand with abundant fine shell fragments. This material is practically identical with the material in many of the calcareous dunes of the coast, known so well on

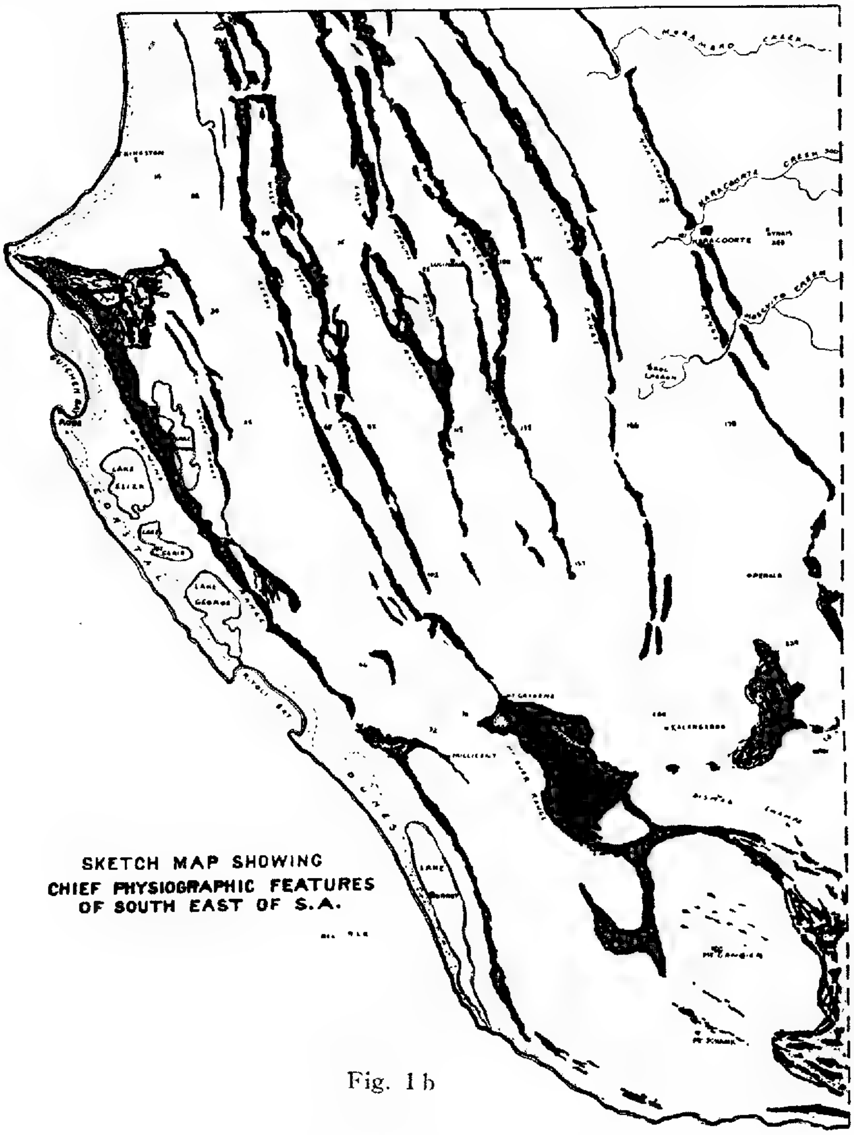


Fig. 1 b

account of "coastiness" of sheep associated with them. The limestone mantle undoubtedly represents an old fossil B horizon. Similar calcareous sand can be seen underlying limestone further inland (*e.g.*, a road cutting in West Avenue Range, near Bull Island). These indurated sandhills occur in all the sand ridges, and no doubt the method of formation has been similar. The re-sorted and re-deposited upper horizons are represented in the siliceous sand of the area. The degree of calcareousness of the original dunes probably varied considerably.

CLIMATE

The whole of the area receives more than 20 inches of rain per annum. Most of it receives more than 25 inches, and the Millicent-Kalangadoo-Mount Gambier area more than 30 inches. The rainfall distribution is shown in fig. 2.

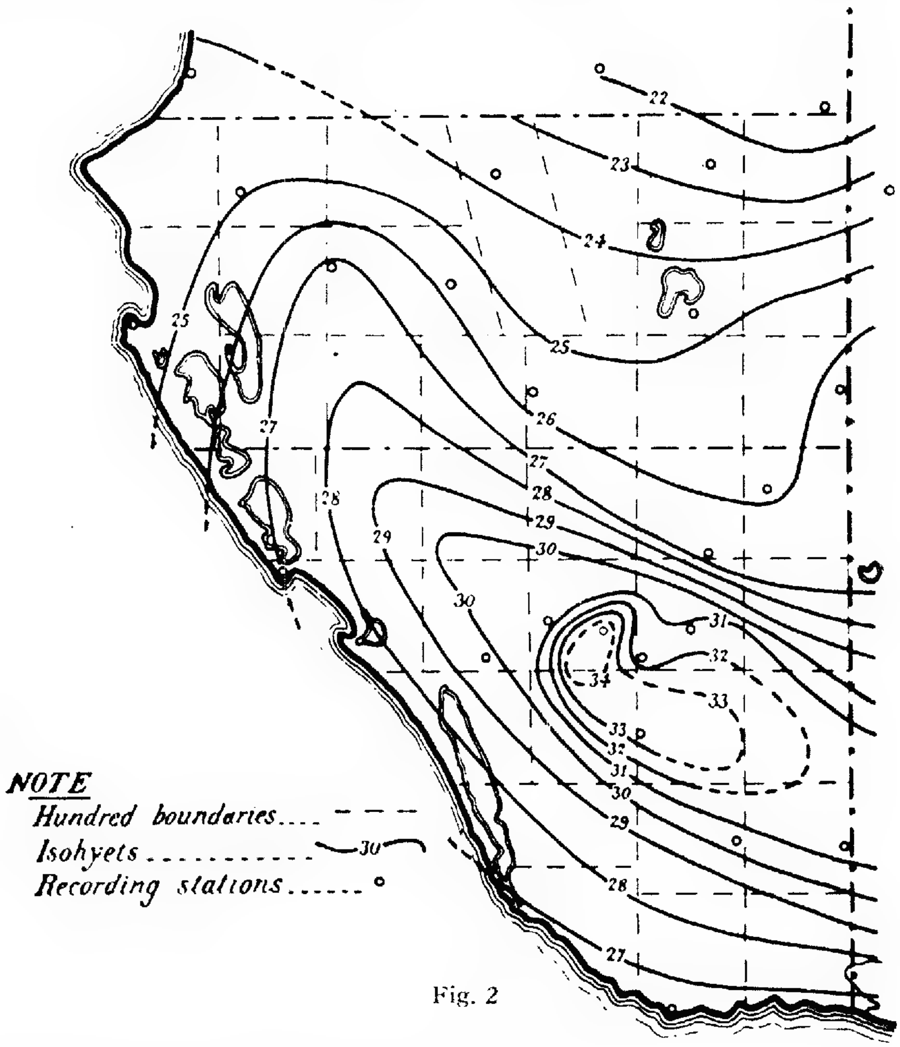


Fig. 2

Rainfall map of Lower South-East of South Australia. (After Stephens *et alia*)

The area falls within Davidson's Semi-humid Warm Temperate Zone, with the number of months in which P/E is greater than 0·5 varying from seven in County Robe to nine in the southern portion of County Grey, and mean annual temperatures of 56-58° F. (9). The amplitude of the mean annual temperature is 7-9° F., and phase, 33-36 days lag behind solar radiation (7). Most of the influential rainfall falls in the winter and spring (April-October) seasons, and the region is within Trumble's (24) Temperate and Sub-Temperate-Podsolised sands Edapho-climatic zones. The higher rainfall of the Millicent-Kalangadoo-Mount Gambier area is undoubtedly due to the higher altitude of most of it—particularly to the presence of the Mount Burr Range.

The unique parallel arrangement of sand dune ranges mentioned previously, with intervening flats and impeded drainage, has produced an extremely variable micro-climate. The micro-climatic zones are orientated at almost right angles to the major climatic zones.

Some idea of the nature and variation of the yearly rainfall is given in fig. 3.

Drainage

Because of the impeded drainage the plains are very wet in winter and early spring. Until artificial drains were cut much of the country was not suitable for agriculture and continuous pasture. In addition to local rainfall there is a considerable contribution in late winter from the adjoining Counties of Lowan and Follet in Victoria. Together with excess water from the higher land east of the Naracoorte Range, most of this flows by way of the Mosquito, the Naracoorte and the Morambro Creeks across the Naracoorte Plain. Further westerly drainage is prevented by Stuart's Range (see soil map) and the creeks lose themselves in a

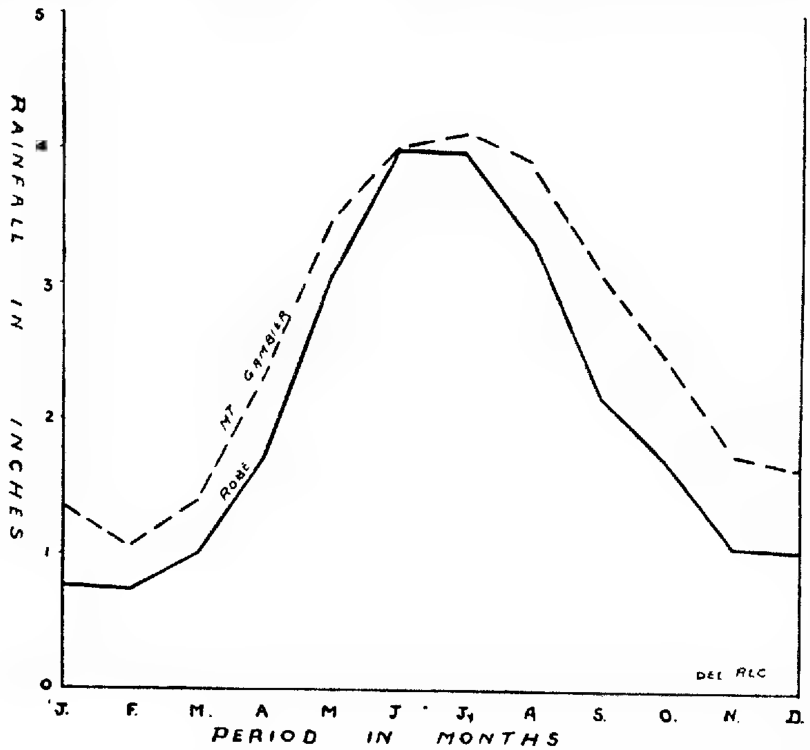


Fig. 3
The Mean Monthly Rainfall (70 years) for two selected centres

series of swamps and lagoons (Bool Lagoon, Moyhall Swamp, Lake Omerod, Salt Lake, etc.). Excess water continues to drain very slowly in a north-north-westerly direction.

While drainage directions are usually westerly on the western side of the sand ranges, towards the eastern side of the ranges they tend more northerly and finally run north-north-westerly parallel to and up against the sand ranges. Before artificial drainage most of the water finally found its way into the Coorong.

The Dismal Swamps, approximately 200 feet above sea level, drain in an easterly and south-easterly direction towards the Glenelg River in Victoria. In a wet season there is a noticeable current in the Dismal Swamps (29).

The general drainage directions can be seen by reference to earlier publications (4) (23). The approximate position of most of the main drains at present in operation is shown in fig. 4. There are many subsidiary drains not shown, particularly about Millicent and Tantanoola.

THE SOILS

The soils of the area can be classified into four main groups:

1 Podsols
2 Rendzinas
3 Terra Rossas
4 Volcanic Soils—weathered from basalt, ash or tuff

Soil surveys have recently been carried out by the Soils Division of the Council for Scientific and Industrial Research over some five hundred square miles in the Lower South-East, comprising the Hundreds of Hindmarsh, Riddoch, Grey, Nangwarry and Young (23), but the remainder of the South-Eastern soils have, by comparison, only been studied superficially by the author.

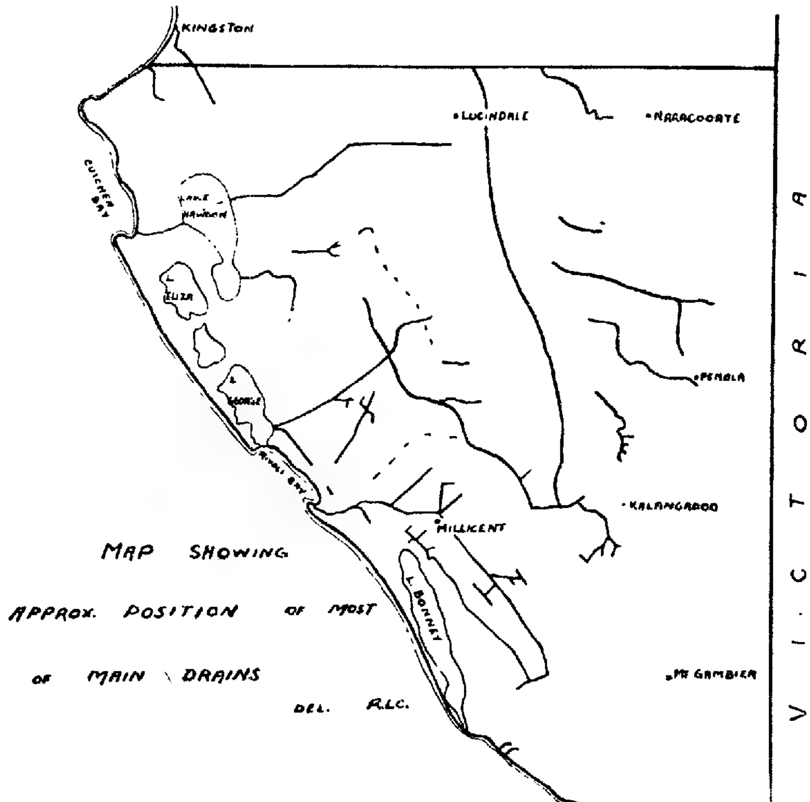


Fig. 4

As would be expected, the soils are closely related to the geological history of the area and the major soil groups closely parallel the physiographic features.

1 The Podsols

The podsols can be further subdivided into two large groups:

(1) the podsolised sands;
(2) the gley podsols.

(1) *The podsolised sands*

Podsols are essentially soils which are best developed in cold temperate climates under conditions of excess rainfall, when intense soil leaching occurs.

The distribution of podsols throughout the world is markedly influenced by geology (21). Because they are most strongly developed in soils poor in base reserves, it is not surprising that they occur so widely in the sand ranges and the sandy heath areas in the South-East.

These podsolised sands are associated with dry sclerophyll forest, or with sclerophyllous heath vegetation, and are re-deposited (aeolian) sands which have

PROFILE CHARACTERISTICS OF THE PRINCIPAL PODSOLISED SAND TYPES (after Stephens *et alia*)

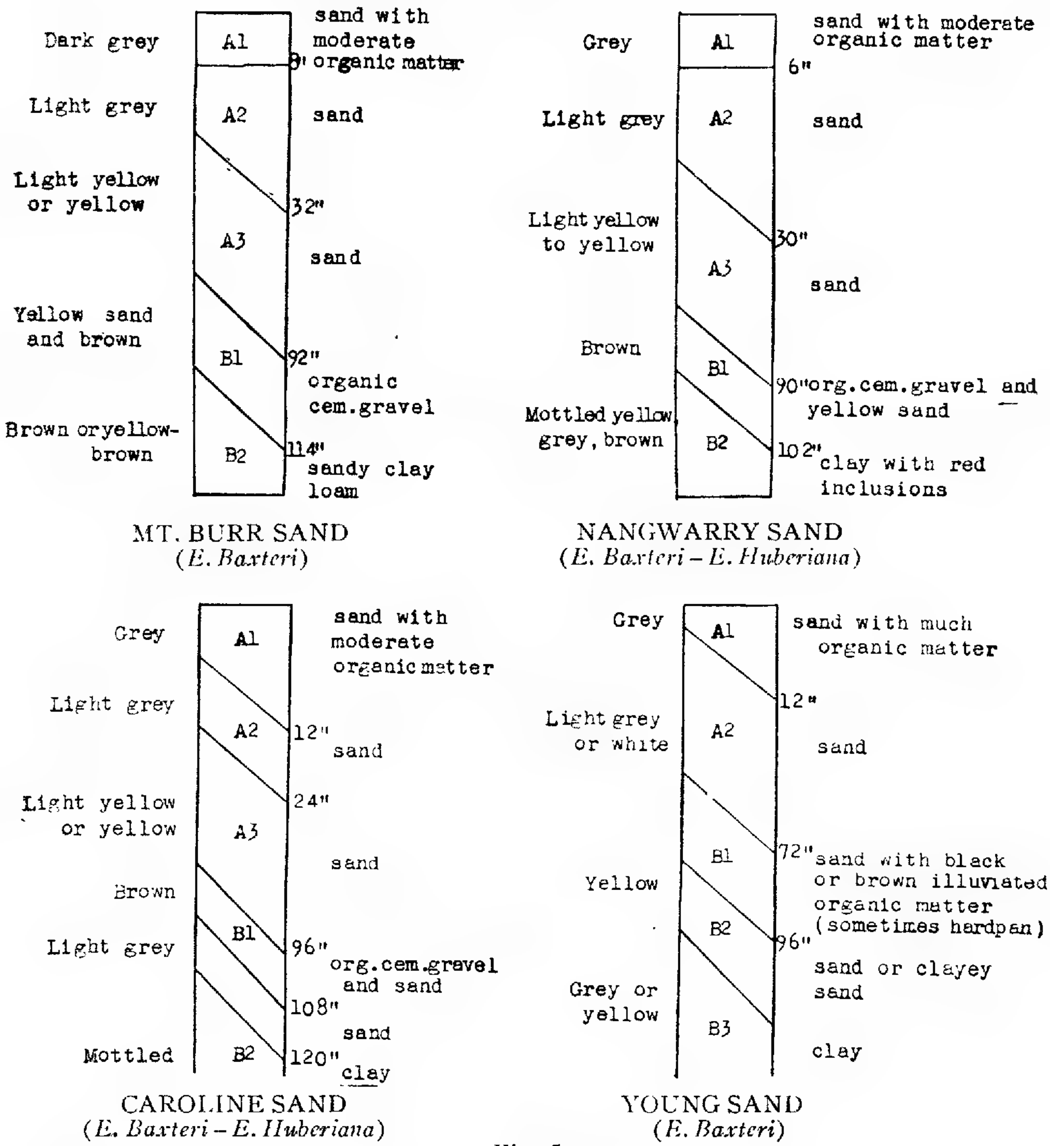


Fig. 5

undergone considerable previous leaching. They are quite variable in their degree of podsolisation, and range from podsolised grey and yellow sands to the more extremely podsolised types—the humus podsols. In the latter the B horizon is enriched by the addition of humus. This variation in podsolisation is due principally to climate and local drainage. The well-developed humus podsols, with a definite organic "hard pan" layer in the B horizon, mostly occur in areas of poor drainage or of local impeded drainage, and are particularly prevalent in hollows and about acid swamps. As we proceed northwards from the Mount Burr region humus podsols become much less prominent.

These sands are for the most part overlying limestone (chiefly Pleistocene to Recent calcareous material), although in the Mount Burr region they may overlie volcanic ash, tuff and basalt. A few inches of sandy clay loam or sandy clay is frequently present immediately above the limestone.

In the sandy areas south of Penola the topography is undulating and the sandhills much lower than in the ranges, and many of the sands are underlain by a considerable depth of grey and yellow clay, frequently with red inclusions or mottlings. These soils have affinities with the gley podsols. Some of the low-lying humus podsols also have gley affinities.

The podsols typified by heath vegetation also occur in a much flatter situation than the range sands. This area has more the characteristics of being a sand sheet, but the soils are extremely variable in profile. Some are leached grey, white, or yellow-grey sands of variable depth overlying yellow and grey clays (mottling is not uncommon), while others are podsolised sands, which may even show considerable accumulation of humus in the B horizon. They are all underlain by Pleistocene to Recent calcareous material but at variable depth.

There are modifications of the heath soils in the more northerly portion of the area, which result in modified vegetation assemblages. The heath soils are all very wet in late winter and spring.

The podsolised sands are very acid and for the most part range between pH 4·7 and pH 6·6. There is usually a considerable amount of organic matter in the A_0 and A_1 horizons. Their nitrogen status is low, normally less than 0·1% total nitrogen, and phosphate status (P_2O_5) less than ·02% and usually less than ·01%. The P_2O_5 status of the Short Sand (associated with heath vegetation) is particularly low, ·003-·005%.

The Mount Burr Sand, Nangwarry Sand and Caroline Sand are the principal normal podsolised sands already defined by soil survey. Of these, the Mount Burr Sand is the most important. The profile characteristics of the three types are summarised in fig. 5.

The humus podsols, representing extreme leaching with the development of a more or less organic stained and/or cemented pan in the B horizon, are typified by the Young Sand and the Kilbride and Wandilo Sands (fig. 5 and 6).

(2) *The gley podsols*

The gley podsols or meadow podsols are a group of soils intermediate between true podsols and meadow (or gley) soils. Alternate or seasonal waterlogging and drying (due to impeded drainage) superimposed on normal podsol development results in a meadow podsol. The presence of rusty mottlings and streaks in the clay, indicative of alternating oxidising and reducing conditions, the slight humus staining, and the ferruginous gravel layer frequently present immediately above or in the clay, are characteristic of this group.

In the lower South-East the meadow podsols are an important group of soils extending for the most part marginal to the black soil plains (rendzina) and flanking the western side of some of the sand ranges. The areas are all more or less low-lying and subject to waterlogging in winter.

The most widespread and important soils amongst the meadow podsols are the Kalangadoo and Riddoch Sands. The former is the more widespread of the two. Marginal to much of the Kalangadoo Sand country, and very frequent about the Dismal Swamps area, there occurs a soil which has meadow podsol affinities in which there is much more humus staining, and a heavy sesquioxide pan above the clay. This is the Wandilo Sand. It is relatively restricted in its distribution.

The profile characteristics of the meadow podsol types are summarised in fig. 6.

Other soil types belonging to the podsolic group occur but are of limited occurrence and relatively unimportant. They are chiefly transitional types which are intermediates between the major types described.

Stephens *et alia* (23) consider some of the sands associated with heath vegetation as meadow humus podsols.

PROFILE CHARACTERISTICS OF CERTAIN PODSOL AND MEADOW PODSOL SOILS (after Stephens *et alia*)

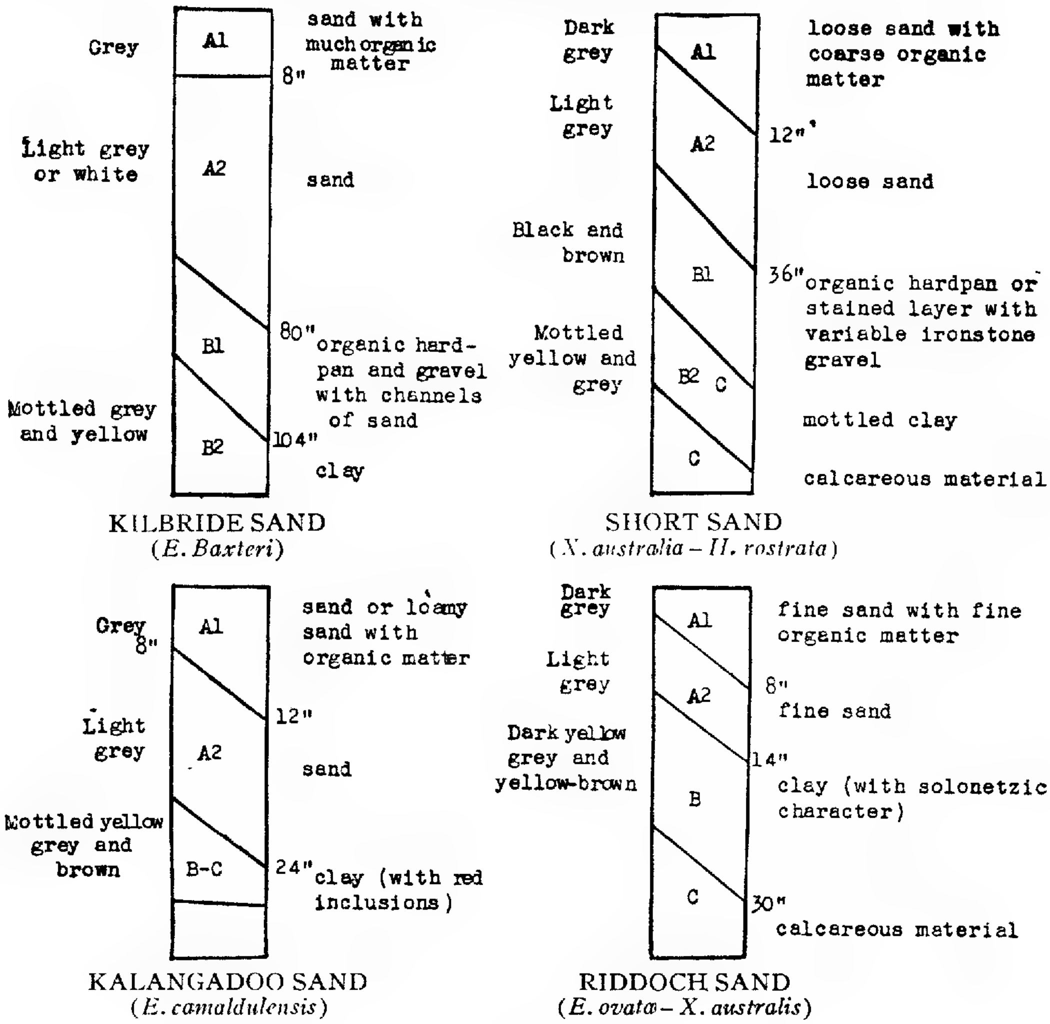


Fig. 6

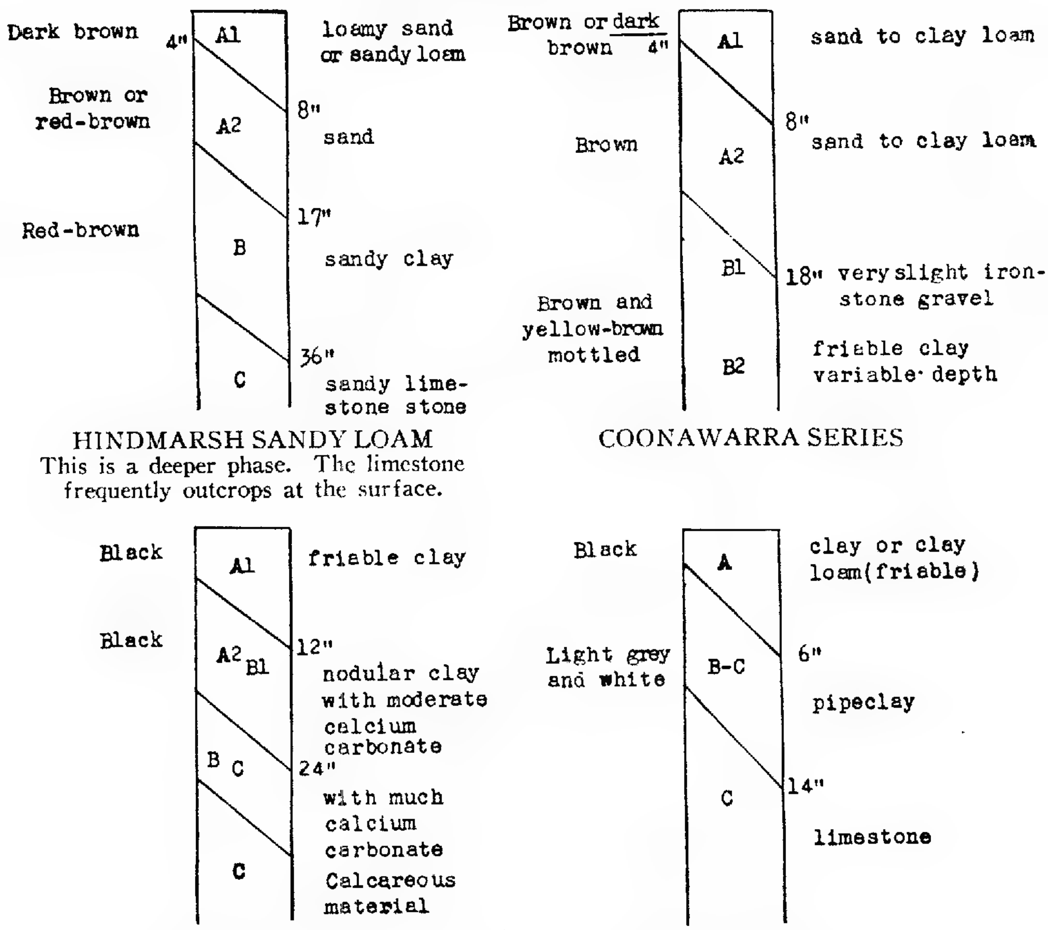
2 The Rendzinas

Soils derived from or closely associated with calcareous parent materials are broadly of two classes, the rendzinas and terra rossa soils. The former are grey or grey-black, and the latter red or reddish-brown. The terra rossa soils have a less siliceous clay complex and show a distinctly lower base status than the rendzinas. They may be even acid in reaction.

The rendzinas are grey or grey-black soils which are associated with calcareous parent material. As a world group they occur in both temperate and tropical climates and are frequently called "lime humus soils" because they contain varying amounts of humus and free calcium carbonate. In the Lower South-East they occur chiefly on the plains over limestone where drainage is imperfect. The well-known Millicent clay and black and grey soils of the Naracoorte Plain and the Reedy Creek-Conmurra Plain belong to this group. Before artificial drainage

PROFILES OF THE PRINCIPAL RENDZINA AND TERRA ROSSA SOILS

(after Stephens *et alia*)



MILLICENT CLAY Fig. 7 CONMURRA CLAY

they were exceedingly wet in winter and spring. Agriculturally they have been used principally for barley growing, but are now frequently developed with pastures. Owing to the excess of calcium carbonate they are unsuitable for subterranean clover, and other legumes like barrel medic, burr medic, and strawberry clover are substituted. Because of the poor local drainage conditions, excess salt (sodium chloride) accumulations are not uncommon, and may frequently reach critical proportions. This is particularly so on the Naracoorte Plain (where several small salt lakes occur) and in parts of the Reedy Creek-Conmurra Plain, as evidenced by salt analysis of two surface soils collected by the author.

Locality	Depth	pH	NaCl %	Total Sol. Salts %
Between Naracoorte and Stewart -	0–2"	8·9	·09	·22
Near Konetta Station - -	0–3"	8·6	·12	·45

The rendzinas vary considerably, particularly in depth of profile.

In some areas well-drained limestone hummocks have weathered to a dark-brown or almost black rendzina. These occur chiefly in the Hundred of Riddoch, but are relatively unimportant.

On the Conmurra-Reedy Creek Plain many of the rendzinas are very shallow over a grey-white and calcareous C horizon, locally called "pipeclay." Sometimes this is exposed at the surface. This type has been called the Conmurra Clay by the author. The profile characteristics of the Millicent Clay and Conmurra Clay are summarised in fig. 7.

Many of the rendzinas in the wettest situations have included shell fragments and shells of the common freshwater snail, *Amerianna pectorosa.* These grade into swamps proper.

The total nitrogen level of the rendzina surface horizon is $> \cdot 25\%$. Their P_2O_5 status ($\cdot 04\%$), and K_2O status ($\cdot 48\%$) are higher than any of the lower South-East soils, except the volcanic suite.

3 The Terra Rossa Soils

The second group of soils closely associated with calcareous parent materials are the terra rossa soils. These are red or red-brown soils. The terra rossas in the Lower South-East fall into two large groups: (1) those developed over Miocene to Recent marine limestone, (2) those associated with the old dune remnants, the so-called "consolidated dunes."

(1) *Over Miocene-Recent marine limestones*

(a) Developed over marine limestone in some moderate rises in the meadow podsol area, terra rossas which range between red-brown sands, loams and even clay loams occur. They are relatively unimportant, but a notable occurrence is about Coonawarra, a few miles north of Penola.

(b) Associated with Miocene limestone in the Mount Gambier-Kongorong district are brown and red-brown soils belonging to this group. They have been used for agricultural and pastoral purposes for many years and have never been thoroughly examined.

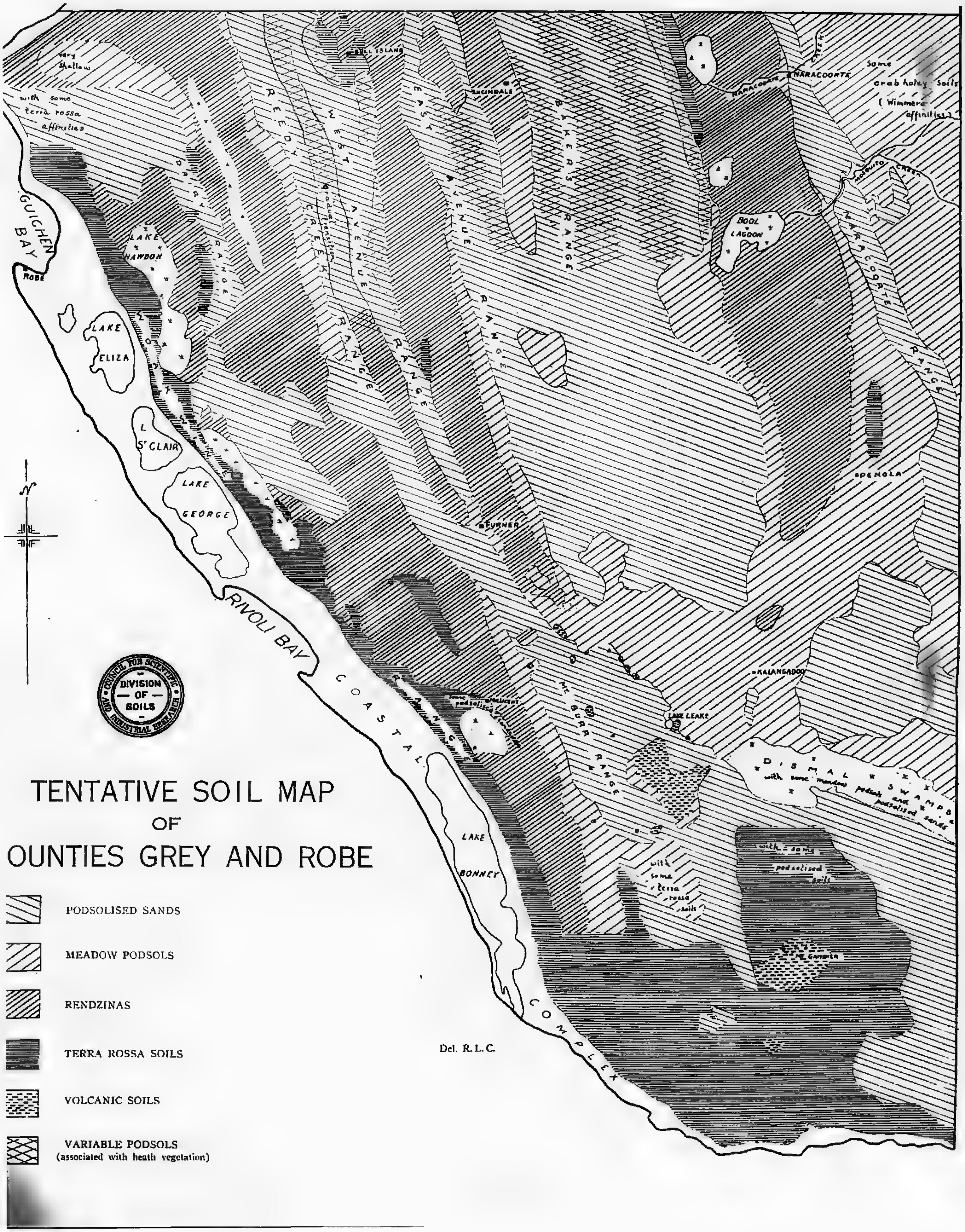
(2) *Developed on the consolidated dunes:*

Associated with the consolidated dunes are brown and red-brown shallow rather sandy soils allied to the terra rossas.

It has been suggested (4) that these consolidated sand dunes are the remnants of an old soil and represent a fossil B horizon. Downward leaching and redisposition of lime in former calcareous dunes, followed by the removal of the upper leached horizons, has exposed this old B horizon. This varies for the most part between 1 and 7 feet thick, and is underlain by white calcareous sands with abundant shell fragments. The former A horizons have been re-sorted and redeposited to form the present siliceous sands of the ranges—the Mount Burr Sand, Young Sand, etc.

These "secondary" soils are best exposed and illustrated, and most developed in the South-East, on the Woakwine Range. This is the first of the inland succession of Ranges. They also occur associated with the limestone hills throughout all the ranges from the Woakwine to the Naracoorte Range, all of which represent old consolidated dunes.

Most of the terra rossa soils of this group are brown and red-brown sands and sandy loams. In the Mount Burr Range the most important soil occurring on the consolidated dunes has been called the Hindmarsh Sandy Loam (23).


TENTATIVE SOIL MAP
OF
OUNTIES GREY AND ROBE
PODSOLISED SANDS
MEADOW PODSOLS
RENDZINAS
TERRA ROSSA SOILS
VOLCANIC SOILS
VARIABLE PODSOLS
(associated with heath vegetation)
Del. R. L. C.
DIVISION OF SOILS
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
N
GUICHEN BAY
ROBE
LAKE HAWDON
LAKE ELIZA
L. St CLAIR
LAKE GEORGE
RIVOLI BAY
COASTAL COMPLEX
LAKE BONNEY
very shallow
with some terra rossa affinities
BULL ISLAND
LUCINDALE
NARACOORTE
Some crab holey soils (Wimmera affinities)
BOOL LAGOON
NARACOORTE RANGE
PENOLA
FURNER
KALANGADOO
LAKE LEAKE
MT. BURR RANGE
DISMAL SWAMPS
with some meadow podsols and podsolised sands
with some terra rossa soils
with some podsolised soils
MT. GAMBIER
REEDY CREEK
WEST AVENUE RANGE
EAST AVENUE RANGE
BAKERS RANGE

The total nitrogen in the surface soils of the terra rossas is usually between ·20 and ·25%. Their phosphate status varies from ·01 to ·07% and, like their K_2O status, is higher in the loamy types.

4 The Volcanic Soils

The volcanic soils of the Lower South-East are of very limited extent, but especially in the Mount Gambier and Glencoe districts are of great agricultural value. They are mainly associated with the weathering of volcanic ash and tuff and, to a less extent, basalt.

The volcanic soils of Mount Gambier have been studied in detail by Prescott and Piper (19). The soils are immature and very variable, probably depending on the variable calcium carbonate content of the original parent material. The surface soils are mostly brown, dark brown or grey-brown sandy loams, loams and clay loams, ranging in reaction from pH 6·4 to pH 8·2. In the Mount Burr region the basaltic soils are more acid and range as low as pH 5·2. This is further evidence for the volcanism of this region having preceded that at Mount Gambier The most notable feature of the soils from a plant nutrition viewpoint is the high P_2O_5 content, which was as high as 0·51% in one sample analysed by Prescott and Piper.

The distribution of the major soil types in the area is shown on the accompanying soil map. Towards the northern limits of the map the soils are much less familiar to the author. This area is very complex and relatively inaccessible and should be accepted with reserve.

The relationship between soil type and physiography can be seen from reference to fig. 1 b, and reference to the vegetation map illustrates the soil and plant relationships.

Soils having some affinities with the red-brown earths occur but are not important. Some of the soils east of the Naracoorte Range, so-called "gilgai" soils, have affinities with the soils of the Victorian Wimmera, sometimes allied with the red-brown earths. Near Lucindale extremely limited soils with *Eucalyptus leucoxylon* savannah can be considered weakly podsolised red-brown earths.

With impeded natural drainage, and alternating low-lying and range areas, local swamps are very numerous and very variable. They require a special study and, with the exception of several large swamp areas, have been omitted from the soil map. The coastal dune, coastal swamp and coastal heath plain area has all been mapped as a "coastal complex." This also requires very detailed study, but the very highly calcareous nature of the sands near the coast deserves mention.

The soils will be further discussed in connection with the vegetation associations.

THE VEGETATION

The principal factors influencing the distribution of the main vegetation communities are undoubtedly edaphic and climatic. The very close general relationship existing between soils and vegetation in the Lower South-East of South Australia is readily illustrated by reference to the soil and vegetation map.

Nomenclature

Much confusion of terminology, and indeed of concept, has for a long time hampered ecology. This has, in Australia, led to a lack of understanding and practically no co-ordination by different workers in different States. Recently Wood (26), realising the inadequacy of existing systems of study and classification of plant communities, reviewed the fundamental concepts in the light of Australian experience. This general confusion of terminology has been further increased by a great difference of opinion in the ecological schools regarding the concept of succession. This has mostly been due to a dual use of the word, when applied, not only to developmental and biotic succession, but to successions which were deemed "theoretically possible" under "theoretical" conditions of edaphic uniformity. There seems little of value in retaining succession for this latter case. The duplication of nomenclature, which is at least confusing, can be overcome by using for these closely related associations the *"edaphic complex"* as defined by Wood (26).

An adequate scheme of classification for plant communities must in addition to the higher groups include a place for edaphic sub-associations and must be capable of expansion in the lower categories to include, for local or detailed work, the finer distinctions which the study of smaller areas will necessitate. Above all, it must provide for the welding of local associations and edaphic complexes into groups, which not only show the relationships of local associations to each other but also their significance in and to the broader categories.

The Floristics

In the present paper the floristics are far from complete. Apart from the great area involved and the relative inaccessibility of much of it, it was impossible for the author to visit it and collect specimens in late spring—the most favourable period. They are, however, sufficiently complete for the purposes of the paper, and in the case of the principal association—*E. Baxteri* association (Dry Sclerophyll Forest)—very detailed.

Principal Vegetation Units

The classification, nomenclature and chief structural differences between the communities are summarised below in Table I.

Table I

Association	Edaphic Complex	Formation	Climatic Climax
E. Baxteri (edaphic climax)* *E. obliqua* *E. Baxteri–E. Huberiana*	*E. Baxteri*	Eucalyptus Sclerophyll Forest	Mixed Eucalypt Forest
Xanthorrhoea australis–Hakea rostrata *Melaleuca gibbosa–Hakea rugosa*, etc.	*X. australis–H. rostrata*	Heath	
E. diversifolia	*E. diversifolia*	Mallee scrub	
Melaleuca pubescens	*M. pubescens*	Savannah woodland	
E. rostrata (*E. camaldulensis*) *E. ovata–X. australis*	*E. rostrata* *E. ovata–X. australis*	Eucalypt Savannah Woodland	
Gahnia trifida–Cladium filum	*C. trifida–C. filum*	Savannah	

* By edaphic climax is meant the association occurring on the most widespread soil type in the area.

All the communities have been seriously modified by biotic influences such as fire, agricultural development, and the imposition over the area of an artificial system of drainage.

The Dry Sclerophyll Forests

The dry sclerophyll forests are somewhat open with a sparse and discontinuous grass cover, but characterised by an abundance of sclerophyllous shrubs and undershrubs (pl. V, fig. 9-13). In the Lower South-East they reach their maximum development on the Mount Burr Range.

1 *E. Baxteri* association

Rather than regard the *E. Baxteri* and *E. obliqua* associations as co-associations, they have been given association rank. The distribution of the dominants is dependent on soil factors, and so accepting Wood's "edaphic complex" in the wider sense, *E. Baxteri* and *E. obliqua* associations are recognised. This forest reaches its greatest development on the Mount Burr Range, but it is the association par excellence of all the sandy ranges. Many of the dominants have been removed by man, and everywhere the association shows evidence of bushfires.

On the Mount Burr Range *E. Baxteri* forms an open canopy at about 40-50 feet. *E. obliqua* or *E. Huberiana* may occur, but very rarely, as associated dominants.

Below the eucalypt canopy a few tall shrubs or small trees occur sporadically. Chief of these are *Banksia marginata* (honeysuckle), *Acacia melanoxylon* (blackwood), *Exocarpus cupressiformis* (wild cherry) and *Bursaria spinosa* (native box). *Acacia pycnantha* and *A. mollisima* occur rarely in this association; they more usually form almost pure societies on some of the shallow terra rossas of the consolidated dunes. Apart from *B. marginata* these shrubs and small trees do not contribute much to the physiognomy of the forest as a whole. This is governed principally by the abundance of sclerophyllous undershrubs and small shrubs.

The most characteristic plants of this continuous sclerophyllous undergrowth stratum are *Leptospermum myrsinoides* (tea-tree), *L. scoparium* (tea-tree), *Xanthorrhoea australis* (yacka), *X. quadrangulata* (grass tree), *Acacia oxycedrus, A. myrtifolia, Brachylomum ciliatum, Pteridium aquilinum, Epacris impressa, Astroloma humifusum, Hibbertia stricta* and *Leucopogon virgatus.* Other plants occurring freely but less important include *Hibbertia sericea, H. fasciculata, Leucopogon concurvus, Correa rubra, Lepidosperma carphoides, L. canescens, Scirpus nodosus, Pultenaea acerosa, Astroloma conostephioides* and *Isopogon ceratophyllus.*

Wahlenbergia gracilis and *Goodenia geniculata* are the most important annuals. The perennial composites, *Helichrysum obtusifolium* and *H. scorpioides* are of seasonal import.

Grasses occur very sparingly. The chief are *Danthonia geniculata* and *Stipa semibarbata.*

Considerable fluctuations in the density and floristic composition of the lower strata occur. Some of these at least can be correlated with soil variation, *e.g.*, the greater abundance of *Acacia oxycedrus, Epacris impressa, Pteridium aquilinum* and *Isopogon ceratophyllus* on the more extremely podsolised sands—the humus podsols. *Pteridium aquilinum* is very important where the forest has been made more open by tree removal. Sending up fronds from its subterranean stem it is one of the first plants to recover from fire. In the absence of competition and with greater light intensity it rapidly becomes more abundant.

Towards the northern limits of the area under consideration, with conditions of much lower rainfall (22-24″), this association becomes greatly modified. *E. Baxteri* is still the dominant tree, but it is depauperate and stunted and rather scrubby in habit and only 14-25′ high. The association is much more open, and the floristic composition is modified. The small trees and tall shrubs of the Mount Burr Range area are, with the exception of *Banksia marginata* (here much reduced), entirely lacking. Many of the undershrubs remain the same, but their frequency and their sociability are different. Some new species characteristic of the drier "mallee" areas further north like *Hypolaena fastigiata, Phyllota pleurandroides* and *Adenanthos terminalis* are appearing. The most prominent of the sclerophyllous shrubs and undershrubs in this area are *Xanthorrhoea australis, Banksia marginata, Banksia ornata, Leptospermum scoparium, L. myrsinoides, Leucopogon concurvus, Lepidosperma carphoides, Astroloma humifusum, A. conostephioides, Comesperma calymega, Phyllota pleurandroides, Isopogon ceratophyllus, Epacris impressa* and *Pteridium aquilinum. Danthonia geniculata* is the most frequent of the grasses.

2 *Eucalyptus obliqua* association

This association is extremely limited. It occurs on better soils than the impoverished sands associated with the *E. Baxteri* association.

On the Mount Burr Range its occurrence is practically limited to: (1) the deeper terra rossa soils, (2) transition soils at the edge of certain basaltic hills, (3) shallow sandy soils over limestone, less acid than the normal podsolised sands. The association is usually more open and the floristic composition of the associated sclerophyllous shrubs is modified. Plants like *Acacia oxycedrus*, *Epacris impressa*, *Leucopogon virgatus*, *Isopogon ceratophyllus*, *Leptospermum* spp. are absent or much less important in the shrub stratum. *Acaena Sanguisorbae* is especially prominent.

There is a belt of *E. obliqua* and *E. vitrea* parallel to the coast from west of Kongorong to Port MacDonnell and beyond. It is very broken and not continuous, and it occurs principally on a shallow red-brown loam (4-6″) over Miocene (?) limestone. The trees are very poor and scraggly and rarely more than 20 feet high. The association here is obviously towards the limit of its edaphic range and enjoys a precarious stability. It is particularly open with very few undershrubs. The principal associated plants are depauperate *Eucalyptus ovata* (white or swamp gum), *Exocarpus cupressiformis*, *Acacia melanoxylon*, *Pteridium aquilinum*, *Danthonia* sp., *Acaena Sanguisorbe* and *Hibbertia* spp. *Xanthorrhoea australis* and *Lomandra longifolia* occur occasionally. *Acacia mollisima* (black wattle) and *A. pycnantha* tend to occur in almost pure societies.

E. obliqua has a much more restricted edaphic and climatic range than *E. Baxteri*, which explains its limited occurrence. Its approximate limits in the north are defined by the 24″ rainfall isohyet. The occurrences in the Mount Burr Range and the other sand ranges of this association are so small that no attempt has been made on the vegetation map to differentiate these "stands" from the *E. Baxteri* association.

The pH of a series of ten (10) surface soils collected at random by the author and others within the climatic zone in which both *E. obliqua* and *E. Baxteri* occur, are indicative of the relationship between soil reaction and tree dominance in the dry sclerophyll forest. pH is probably the most important single soil index. The correlation is shown below in Table II.

Table II

Relationship between pH, as a Single Soil Index, and Eucalypt Dominance in the Stringybark Forests

Dominant Eucalypt	Locality	pH
E. Baxteri	Mount Burr Range	5·94
E. Baxteri	Mount Burr Range	6·40
E. Baxteri	East of Penola	5·46
E. Baxteri	Reedy Creek Range (East of Konetta Stn.)	5·24
E. Baxteri	East Avenue Range	4·98
E. obliqua	Section 93, Hundred Smith	6·79
E. obliqua	Mount Burr Range	6·28
E. obliqua	Near Burnda Railway Station	6·30
E. obliqua	Between Kongorong and Port MacDonnell	6·84
E. obliqua	Mount Burr Range (Glencoe Hill)	8·09

Eucalyptus Huberiana (manna gum) is sometimes a co-dominant and in places may become locally dominant in the *E. Baxteri* forests of the Mount Burr area. Its occurrence is frequently difficult to explain on grounds of soil variation. It is most likely that deep-seated soil changes are involved in some instances. Some of the sands of the region overlie volcanic material at depth, and it is possible that increased fertility at depth has an influence on tree distribution.

E. Huberiana often occurs in the transition zone marginal to swamps. Here better water relationships prevail. Although having a slightly more limited climatic range than *E. obliqua* it has wider edaphic limits. Water relationships are more important.

3 *E. Huberiana-E. Baxteri* association

On the very shallow phases of the Nangwarry Sand *Eucalyptus Huberiana* often becomes sole dominant. The habitat is a wetter one. The association is more open and the sclerophyllous undershrubs less abundant. *Exocarpus cupressiformis*, *Acacia mollisima*, *A. melanoxylon* and *Pteridium aquilinum* are prominent. Grasses, especially *Themeda triandra*, may be conspicuous. The formation approaches savannah. This is not unusual when one considers that the Nangwarry Sand (shallower phases) has affinities with the gley podsols—soils which in the South-East are normally associated with savannah woodland.

Over most of the Nangwarry area there is an association dominated by *E. Huberiana* and *E. Baxteri*. Associated plants are similar to the sclerophyllous undershrubs elsewhere—*Acacia melanoxylon*, *A. mollisima*, *Xanthorrhoea australis*, *Leptospermum myrsinoides*, *L. scoparium*, *Banksia marginata*, *B. ornata*, *Astroloma conostephioides*, *A. humifusum*, *Epacris impressa*, *Pteridium aquilinum*, *Hibbertia* spp., *Leucopogon* spp., etc. *E. obliqua* is very rare in this region.

On the deeper phases of the Nangwarry Sand *E. Baxteri* is sole dominant. *E. vitrea*, a low, somewhat dwarfed tree usually about 16 feet high with fibrous bark on the stem and lower branches and long, almost pendulous, narrow leaves, is common about some of the swamps in this area. *E. pauciflora* [1] has been recorded from our South-East but has not been reported in recent years.

South of Wongalina Station and almost to Mount Benson there is a modified variable association allied to the dry sclerophyll forests. On yellow-brown and red-brown sandy soils over limestone (sometimes shallow) *Eucalyptus obliqua* occurs very sparingly. Shrubs and small trees are abundant and include *Banksia marginata*, *Bursaria spinosa*, *Acacia pycnantha* and *Xanthorrhoea australis*. Less important are *Pteridium aquilinum*, *Dodonaea* sp., *Scirpus nodosus*, *Casuarina stricta*, *Olearia* sp., etc.

The Heath

The South-Eastern heath lands are best considered in relation to the sclerophyll forests. They occur on low-lying podsolised sands. These sands are very variable in profile and some of them have affinities with the gley podsols. They are very acid and low in fertility. During the winter and early spring they are very wet. Towards the northern part of the area the heath soils are modified and for the most part much shallower. There is a parallel modification in floristic composition.

On the better drained, slightly higher sands the heath invariably gives way to *E. Baxteri* dry sclerophyll. It can be considered an edaphic subclimax association of the dry sclerophyll forests. (*E. Huberiana* is occasionally present in the more southerly portions, and *E. vitrea* has been recorded.)

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[1] Mr. C. D. Boomsma (private communication) reports that Blakely identified a Eucalypt collected by him near the Victorian Border, Caroline, South Australia, as *E. pauciflora*.

1 *Xanthorrhoea australis-Hakea rostrata* association (pl. VI, fig. 14)

The heath consists essentially of low sclerophyllous shrubs and undershrubs, for the most part 2 feet to 3 feet high. It is a difficult association to name because so many species are consistent, and being much of the same height there are many dominants. Many of the shrubs and undershrubs of the sclerophyll forest are prominent.

The principal members of the heath are *Xanthorrhoea australis* (yacka), *Banksia marginata, B. ornata* (honeysuckle), *Hakea rostrata* (kidney bush), *H. rugosa, H. nodosa, Darwinia micropetala, Leptospermum scoparium, L. myrsinoides, Casuarina pusilla, C. paludosa* var. *robusta, C. distyla, Melaleuca gibbosa, Isopogon ceratophyllus, Epacris impressa, Leucopogon virgatus, Pultenaea laxiflora, Stylidium graminifolium* (trigger plant), *Hibbertia stricta* and *H. fasciculata.* Others frequently present include *Calythrix tetragona, Acacia verticillata, Dillwynia hispida, Rutidosis multiflora, Daviesia brevifolia, Pimelia flava, P. octophylla, Pultenaea tenuifolia* and *Sphaerolobium vimineum.*

Cyperaceous and Restionaceous plants present are *Schoenus apogon, S. brachyphyllus, Chorizandra enodis, Leptocarpus Brownii, Lepidosperma carphoides, L. concavum* and *L. laterale. Gahnia trifida, Caustis pentandra* and *Scirpus antarcticus* have been recorded. The Juncaceae are represented by *Juncus capitatus.*

Plants of an ephemeral or seasonal nature, abundant in late spring, are *Drosera Planchonii, Stackhousia monogyna,* the perennial composites, *Helichrysum obtusifolium* and *H. scorpioides,* together with a few orchids, chief of which is *Caladenia Patersonii.*

Grasses are sparse although several genera are represented. Those recorded include *Stipa Muelleri, Agrostis Billardieri* and *Aira caryphyllea.* Several grasses are prominent in the transition area between the heath and the *E. ovata-X. australis* savannah. Chief of these are *Themeda triandra, Stipa pubescens* and *Danthonia setacea.*

As pointed out under the section on soils, the heath profiles are rather variable. Sufficient work has not been done in relation to the floristic composition of the associated vegetation to decide whether variations in profile can be consistently correlated with floristic variations. *X. australis* definitely prefers a slightly better drained habitat and is always more abundant on the small sandy "banks" (rarely more than 2 ft. or 3 ft. higher) that are common throughout the heath. *Banksia ornata* is indicative of a moderate clay subsoil.

Although most of the heath conforms to the above description of the *X. australis-H. rostrata* association, towards the northern part of the area modifications in the soils result in modified species composition.

2 *Melaleuca gibbosa—Hakea rugosa* association

(a) About the southern edge of the Hundred of Spence, in the low-lying area between the sand ranges, there are very shallow grey soils (over limestone), which are very wet in winter and spring, with numerous very small limestone rises. On the low-lying wetter parts the principal plants are *Melaleuca gibbosa, Darwinia micropetala, Hakea rugosa, Leptocarpus Brownii, Lepidosperma concavum* and *Pimelea glauca.* On higher ground, or very small stony rises depauperate *Eucalyptus fasciculosa* (pink gum), *Xanthorrhoea australis, Hakea rostrata, Casuarina pusilla, Banksia marginata* and *Darwinia micropetala* are associated. On slightly higher rises, in addition to *E. fasciculosa, D. micropetala* and *X. australis, Melaleuca* sp. (aff. *M. uncinata*), *Leptospermum scoparium* and *Isopogon ceratophyllus* are common.

(b) North of (a) (*e.g.*, sections 60 and 67, Hd. Spence) there are some further variations in floristic composition. The soils again are very shallow, and on them occur scattered depauperate *E. fasciculosa* with very occasional stunted *Eucalyptus leucoxylon* (blue gum). The remainder of the vegetation has heath affinities. *Olearia floribunda, Melaleuca gibbosa, M. uncinata* (?), *Hakea nodosa, H. rugosa, Banksia marginata, Gahnia* sp. (?), *Isopogon ceratophyllus, Leptospermum scoparium, Darwinia micropetala, Calythrix tetragona, Astroloma conostephioides* and *Leptocarpus Brownii* are the principal species.

3 *E. fasciculosa-Banksia marginata* association (pl. VI, fig. 16)

South-east of Lucindale, east of Baker's Range, there is a variation worth mentioning. The soil is rather variable, but principally grey sand over yellow and grey sandy clay over limestone at 10-12 inches. Scattered trees of *E. fasciculosa* are common, with numerous sclerophyllous undershrubs—the principal species are *Banksia marginata* (honeysuckle), *B. ornata, Leptospermum scoparium, L. myrsinoides, Cladium filum, Melaleuca gibbosa, Isopogon ceratophyllus, Darwinia micropetala, Calythrix tetragona, Hakea rugosa, X. australis, Acacia verticillata, Astroloma conostephenioides, A. humifusum, Hibbertia fasciculata, Hibbertia* sp. and *Epacris impressa*. This association approaches maquis, but is grouped with the heath variants for convenience.

4 *Cladium filum-Melaleuca gibbosa* (?) association (pl. VI, fig. 15)

Between the Reedy Creek and West Avenue Ranges and adjacent to the Reedy Creek, in the north-western portion of the area, the heath is frequently given a particular physiognomy by the abundance of *Cladium filum* (black butt) and *Melaleuca gibbosa* (?). *Darwinia micropetala, Cladium junceum* and *Leptocarpus Brownii* are common. These regions are particularly wet in winter and the soils variable. Two profiles examined by the author are given below in fig. 8.

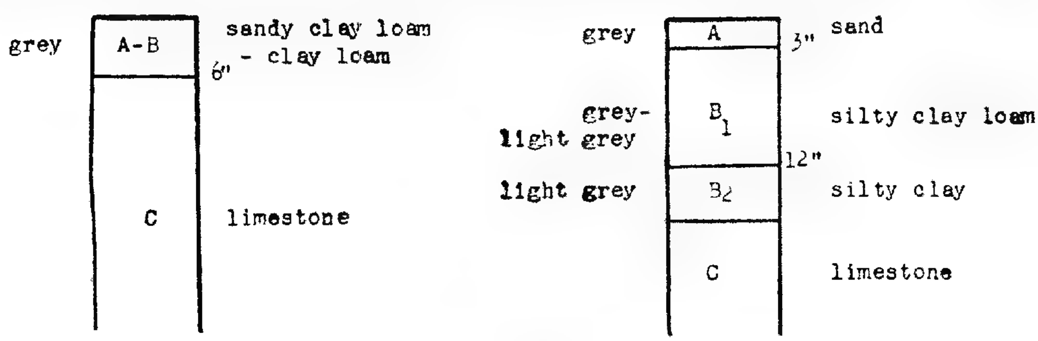

Fig. 8

The modifications in the heath as described above are due principally to edaphic factors, including water relationships. They have not been mapped separately. They can hardly be considered edaphic subclimax associations of the *E. Baxteri* sclerophyll forests in the same way as can the *X. australis-H. rostrata* association. It is probably best to regard all the heath associations as an edaphic complex, but one which has some definite floristic and edaphic links with the *E. Baxteri* edaphic complex.

MALLEE SCRUB

1 *Eucalyptus diversifolia* association (pl. VII, fig. 17-18)

The mallee proper in our Lower South-East is practically limited in distribution to a strip adjacent to the coast between Beachport and Robe. This area receives between 24″ and 26″ of rain per annum. Here, on shallow brown and red-brown soils (terra rossa) and somewhat deeper yellow-brown and yellow sands, over the "consolidated dune" limestone of the Woakwine Range, there is a typical low dense mallee scrub of *E. diversifolia*, which rarely exceeds more than nine feet in height.

Associated with *E. diversifolia* are a number of sclerophyllous shrubs and undershubs, many of which are common to the sclerophyll forest and the heath.

The principal of these are *Banksia marginata, Xanthorrhoea australis* (yacka), *Hakea rostrata, Pultenaea laxiflora* var. *pilosa, P. acerosa* var. *acicularis, Hibbertia sericea, Daviesi brevifoli, Astroloma humifusum, Dillwynia floribunda, Hakea* sp. (probably *H. vittata*), *Pimelia glauca, Thomasia petalocalyx* and *Acacia* sp. (probably *A. myrtifolia*). *Lepidosperma carphoides* and *L. concavum* are frequently prominent. Other plants occurring, and more or less important, include *Halorrhagis tetragyna, Correa rubra, Scirpus nodosus,* the twining *Comesperma volubile* and the climbing *Billardiera cymosa.* The principal grass is *Stipa* sp.

Acaena Sanguisorbae is very conspicuous on the shallower soils. *Stackhousia monogyna* has an important seasonal aspect.

Dodonaea sp., *Bursaria spinosa* and *Melaleuca pubescens* are sometimes present, and occasionally may become locally important.

On the coastal side of this association there may be a considerable admixture with coastal plants like *Acacia longifolia* var. *Sophorae* (locally called boobyalla) and *Leucopogon parviflorus* (white currant).

Eucalyptus leucoxylon var. *macrocarpa* as a somewhat stunted form has been recorded in some hollows where water-relationships are improved.

On most of the shallow soils associated with the isolated consolidated dunes which occur scattered throughout all the more inland sand ranges (*i.e.,* east of the Woakwine Range) *Eucalyptus fasciculosa* (pink gum) is widespread. It is approximately limited in the south by the 25″ rainfall isohyet, above which it is replaced by *E. obliqua,* or where the soils are too shallow by societies of *Banksia marginata* and/or *Dodonaea* sp. It forms a rather open, savannah-like association and sclerophyllous shrubs and undershrubs are relatively rare. *Bursaria spinosa, Banksia marginata, Dodonaea* sp. are often present; the latter two frequently forming dense societies. *Xanthorrhoea australis* is usually abundant at the margin of the consolidated dune, where there is some admixture with sand. *Astroloma humifusum* and *Acaena Sanguisorbae* are usually prominent. The principal grasses are *Danthonia setacea, D. semiannularis* (?), *Neurachne alopecuroides* and *Koeleria Michelii.* The association, however, is not very consistent, varying principally with variations in soil depth, and it has not been practical to map in these isolated small areas on the vegetation map.

Towards the northern limits of County Robe, particularly on the consolidated dunes of the Bull Island-Reedy Creek area, *E. diversifolia* (mallee) is associated with *E. fasciculosa* (pl. VII, fig. 18). As we proceed further north *E. diversifolia* becomes more important in this edaphic habitat, finally displacing *E. fasciculosa* altogether. *E. fasciculosa* is a species with a very wide potential habitat.

Savannah Communities

1 *Melaleuca pubescens* association (pl. VII, fig. 19)

Before considering the more important savannah communities dominated by the eucalypts, it will be more convenient to describe the association dominated by *Melaleuca pubescens* (dry-land tea-tree).

This association is most important on the very shallow soils of the Woakwine Range, south of Beachport, and the belt of mallee just described (see vegetation map). It also occurs on a small coastal range of consolidated dunes towards Nelson (Victoria), on portion of Stuart's Range (west of the Naracoorte Plain) and some consolidated dunes at Bull Island (here, however, there occurs also *E. fasciculosa*).

Melaleuca pubescens in this habitat is a small tree, about 15 feet high, frequently with a dense canopy. The association, however, is a very open one. *Bursaria spinosa* is sometimes conspicuous, but the associated plants are practically confined to grasses and herbaceous annuals and perennials. Like most savannah communities it has been used for grazing since early settlement, and there is consequently a large number of introduced grasses and clovers.

The principal grasses are *Stipa tenuiglumis, Danthonia semiannularis, Festuca rigida, F. Myuros, Koeleria Michelii, K. phleoides, Aira caryophyllea* and *Bromus villosus*. Other plants conspicuous in spring include *Helichrysum apiculatum, Vittadinia triloba, Cynoglossum australe, Arenaria serpyllifolia* (thyme-leaved sandwort), *Brachycome debilis, Hydrocotyle* sp., *Geranium* sp., *Myosotis australis, Sherardia arvensis* (field madder) and *Juncus bufonius*. *Acaena Sanguisorbae* is abundant on the very shallow soils.

Melilotus indica (King Island melilot) and *Trifolium procumbens* (hop clover) are usually abundant where the association has been regularly grazed.

The soils are very shallow sandy loams over "consolidated dune" limestone, but where they become deeper (usually in valleys) *Casuarina stricta* and/or *Xanthorrhoea australis* and *Pteridium aquilinum* may be locally important. Very rarely *Acacia melanoxylon* occurs on deeper soils.

On the coastal side of the Woakwine Range there is admixture with plants of the coastal complex like *Leucopogon parviflorus* and *Acacia longifolia* var. *Sophorae*. Other coastal species like the grasses *Koeleria phleoides* and *Lagurus ovatus*, which are very abundant, and the shrubs *Sambucus Gaudichaudiana* (white elder) and *Solanum aviculare* occur.

This association adjacent to Beachport becomes intermixed with mallee and finally gives way to it altogether, although it re-occurs again near Mount Benson. The association is undoubtedly allied to a *Melaleuca pubescens* association in the Curramulka-Minlaton-Yorketown area on Yorke Peninsula (South Australia), where associated with *M. pubescens* on very shallow soils over limestone are *Bursaria spinosa* (native box), *Casuarina stricta* and many grasses (principally *Stipa* spp. and *Danthonia* sp.). There is also a great admixture of mallee. This association, however, has not yet been studied by ecologists.

M. pubescens also occurs sparingly towards the edge of some of the grey rendzina country, as north-west of Lucindale, and occasionally on the margins of the Naracoorte Plain (rendzina).

Although so different structurally, the *Melaleuca pubescens* association is undoubtedly closely linked edaphically with the *E. diversifolia* association, and the equilibrium between them is probably a relatively unstable one.

2 *Eucalyptus camaldulensis* association (pl. VII, fig. 20; pl. VIII, fig. 21-22)

This association is developed on the meadow podsols and is the association *par excellence* of the Kalangadoo Sand.

Unfortunately, it has been greatly modified by man, who has imposed an artificial drainage system. It was a typical savannah dominated by *E. camaldulensis* (red gum, better known as *E. rostrata*), with numerous gum saplings and a ground flora chiefly of grasses and cyperaceous and juncaceous plants.

A great deal of the area is at present being intensely developed under subterranean clover (*Trifolium subterraneum*) and perennial rye-grass (*Lolium perenne*). Other pasture species used are cocksfoot (*Dactylis glomerata*), white clover (*Trifolium repens*) and *Phalaris* (*P. tuberosa*).

The Kalangadoo Sand is naturally poorly drained and subjected to much excess water in winter and spring, and low-lying swampy areas are frequent. Most of these dry up in summer, and very few remain as permanent swamps or waterholes. Although these soils are waterlogged in winter, they dry out considerably in the summer.

The principal grasses are *Danthonia geniculata*, *Poa bulbosa* and *Briza minor*. Others occurring less abundantly are *Aira caryophyllea*, *Rottboellia compressa* (mat grass), *Microlaena stipoides*, *Hordeum maritimum*, *H. murinum* and *Eragrostis diandra*. *Holcus lanatus* (fog grass) is sometimes abundant.

There are a great number of other monocotyledonous plants belonging to the Cyperaceae, Juncaceae, Amaryllidaceae and Centrolepidaceae, which are most prominent in the lower-lying and consequently wetter places. These include *Cyperus tenellus*, *Scirpus setaceus*, *Juncus pallidus* (pale rush), *J. capilatus*, *J. pauciflorus*, *Carex tereticaulis*, *Luzula campestris*, *Hypoxis glabella*, *Centrolepis aristata* and *Brizula gracilis*. Other species frequently present are *Lepidosperma concavum*, *Bartschia latifolia*, *Drosera peltata*, *Utricularia dichotoma*, *Rutidosis multiflora*, *Crassula macrantha*, *Leontodon hirtus* (lesser hawkbit) and the common introduced composite *Hypochoeris radicata* (rooted cat's ear or dandelion).

Xanthorrhoea australis (yacka) is often abundant, but occurs chiefly on the more marginal areas where the soils are transitional in nature. Here there are many shrubs like *Bursaria spinosa*, *Banksia marginata*, *Acacia mollisima* and *A. melanoxylon* associated. Small societies dominated by *Pteridium aquilinum* (bracken fern) are frequent on the higher and slightly better-drained areas.

The association is best known to the author in the Kalangadoo-Penola area. South of Kingston, on modified shallower but low-lying soils, *E. camaldulensis* is somewhat stunted and there is a modified ground flora. On the higher land, east of the Naracoorte Range, "gilgais" are not uncommon and the soils may have affinities with the red-brown earths. Here *Melaleuca* sp. (probably *M. pubescens*) and *Casuarina Luehmannii* (bulloak) sometimes occur as co-dominants. *Eucalyptus leucoxylon* (blue gum) is not uncommon. When more fully understood these variations can undoubtedly be grouped within an "edaphic complex"—they are indeed separate, but very closely allied, associations.

Small low-lying black soil swamps (wet in winter and spring) are frequent about the Kalangadoo area. The floristics are variable, depending upon the degree of swampiness. In late spring, after these swampy areas have more or less dried up, *Myriophyllum elatinoides*, *Schoenus apogon*, *Centipeda Cunninghamii* and the grasses *Calamagrostis filiformis* and *Polypogon maritimus* are common. *Poa caepitosa* occurs in the less swampy black soil areas.

3 *Eucalyptus ovata-Xanthorrhoea australis* association (pl. VIII, fig. 23-24)

On some of the meadow podsols (*e.g.*, Riddoch Sand) and extending onto the rendzinas in part, is a savannah association which is given a characteristic physiognomy by the dominance of *E. ovata* (white or swamp gum), and in a lower stratum, *X. australis* (yacka). The soils are all low-lying and prior to drainage must have been very wet in winter and spring. *Casuarina stricta* (sheoak) and *Banksia marginata* are sometimes present and may more or less replace *E. ovata*. *Bursaria spinosa*, *Acacia melanoxylon* and *Viminaria denudata* occur sparingly.

Of the ground flora the principal species are grasses, *Danthonia* spp. (prob. *D. geniculata* and *D. semiannularis*), *Hypochoeris radicata*, *Erythraea Centaurium* and *Mentha* sp. are usually common.

In the wetter low-lying parts *Chorizandra enodis*, *Lepidosperma lineare* and *L. concavum* are abundant.

The association has been greatly affected by man and is difficult to assess fully from those remnants remaining. West of the Mount Burr Range adjacent to Tantanoola, on a somewhat deeper phase of the Riddoch Sand, *X. australis* is replaced to some extent by *Lomandra longifolia*.

There is a large ecotone between this association and the heath in the Hundred of Riddoch.

On the east side of the Reedy Creek-Conmurra Plain and adjacent to the Reedy Creek Range, on variable soils (some have affinities with the Riddoch Sand), there is a great mixture of species, which because of the frequent prevalence of *X. australis* is best considered here. Plants recorded include *Eucalyptus fasciculosa, E. leucoxylon, Melaleuca pubescens* and *Casuarina stricta*, the grasses, *Danthonia semiannularis, Briza minor, Hordeum maritimum* and *Themeda triandra*, while *Cladium junceum* and *Lepidosperma lineare* occur freely (pl. IX, fig. 27). The area is a very complex one because the soils are very variable and it cannot (at present) be satisfactorily grouped with any of the main associations. But at least in part there are some affinities with the *E. ovata-X. australis* association, and on the vegetation map the whole area has been mapped in with this association.

4 *Eucalyptus leucoxylon-Eucalyptus fasciculosa* association (pl. IX, fig. 26)

South-west of Bool Lagoon and in a narrow strip running south from Lucindale there is a rather variable association: *E. leucoxylon* (blue gum) and, less abundantly, *E. fasciculosa* occur. There is considerable variation within the association and detailed analyses, in connection with a survey of the soil types involved, is needed before the correct status of the community can be determined. The actual area though, is small, and the association or associations relatively unimportant. *X. australis* is usually abundant, and *Banksia marginata* is also frequently present. The principal grasses of the ground flora are *Themeda triandra* (kangaroo grass) and *Danthonia* sp.

5 *Gahnia trifida-Cladium filum* association (pl. IX, fig. 25)

On most of the rendzina soils trees were almost entirely absent, and a savannah of which the principal plants were *Gahnia trifida* (cutting grass), *Cladium filum* (thatching grass or black butt) and the grass *Poa caespitosa* (locally called "white tussock") occurred. Being treeless, if we except the ubiquitous *Banksia marginata* (honeysuckle), it was only natural that following drainage it should have been rapidly and almost completely developed. In the past it has been used chiefly for agricultural purposes, particularly barley-growing, but of latter years seeded pastures and sheep and dairying are becoming important. In view of the extensive development that has taken place, it is absolutely impossible to gather a satisfactory picture of the natural vegetation assemblages of these low-lying swampy rendzina plains. Little more can be done than mention the most common species occurring in the isolated pieces of vegetation that have escaped destruction.

There is little doubt that *Gahnia trifida, Cladium filum* and *Poa caespitosa* were the most important and consistent species, but it is also certain that their relative abundance varied considerably. Considering the varying salinity of the soils, it is to be expected that modifications in floristic composition were common. From the original survey records, information concerning the occurrence of dense societies of *B. marginata* (honeysuckle) on some of these "plains" was obtained. Only a very occasional honeysuckle is left of this so-called "honeysuckle forest."[2] The author macroscopically examined the soils of such an area defined by the early surveyors, but could see no difference, in field examinations, of the

[2] This is no doubt the "honeysuckle country" mentioned by Tennyson Woods in his "Geological Observations in South Australia."

profiles in the "honeysuckle forest" area, and an adjacent area delineated by the surveyors as "cutting grass flat." Nor did there appear to be any difference in microtopography.

Most of the plants associated are wet habitat species like *Leptocarpus Brownii, Juncus maritimus* var. *australiensis, Cladium junceum, Centrolepis polygyna, Scirpus antarcticus,* and *Schoenus nitens. Danthonia semiannularis* is fairly frequently present. In the more or less saline areas *Distichlis spicata* (emu grass) is often abundant. *Cladium filum* appears to be more tolerant to salinity than does *Gahnia trifida.*

Melaleuca pubescens occurs sparingly on some rendzina soils, *e.g.,* a small occurrence on very shallow dark grey soils allied to the rendzinas north-west of Lucindale township.

Other Communities

The Vegetation of the Volcanic Hills—The volcanic soils are limited (see soil map) and most of the larger areas have been farmed or in other ways the original vegetation entirely destroyed. *Eucalyptus ovata* (white gum) occurs occasionally, and *Acacia melanoxylon* (blackwood) and *A. mollisima* (black wattle) have been recorded. There appears to be some similarity with Patton's "Basalt Plains association" (14). The distribution of the volcanic soils is shown on the soil map, but because of the difficulties mentioned above no differentiation is made on the vegetation map.

Swamps

In an area like the Lower South-East, where natural drainage is impeded, swamps and semi-swamps are very common and vary considerably. They are far too variable and complex to be considered here and warrant particular and more detailed study. As yet the only ones described are the isolated *Myriophyllum-Sphagnum* bogs near Mount MacIntyre (6), and recently one of the large coastal fens.[3] Because of its large extent mention should be made here of a large swamp occurring at the western edge of the Conmurra-Reedy Creek Plain. The area dries out in summer but in winter and spring is covered with from one to two inches to a foot of water. The soil is dark grey, heavy, shallow over limestone, and exceedingly saline. A surface sample taken by the author had a pH 8·77, 25% sodium chloride and ·67% total soluble salts. The dominant plant is *Melaleuca halmaturorum* (salt-water tea-tree)—a small tree about 8-10 feet high. Common in the ground flora are *Apium australe, Centrolepis polygyna, C. aristata, Triglochin mucronata, Polypogon maritimum, Calamagrostis filiformis* and *Poa lepida. Loranthus miraculosus* var. *melaleucae* is a common parasite on the salt-water tea-tree.

THE ORIGIN OF THE FLORA AND VEGETATIONAL DYNAMICS

Positive earth movements in Pleistocene and Recent times resulted in the recession of the sea from the Lower South-East, west of the Naracoorte Range. About the same time warping and faulting in the basement complex in the old Murray gulf was profoundly affecting the course of the Murray River, and block-faulting and downward movements in the Gulf Regions of South Australia formed the rift valleys of St. Vincent and Spencer Gulfs. This latter prevented further easterly invasion from the endemic centres of south-west Western Australia. Wood (27) has analysed the flora of the Fleurieu and adjacent peninsulas, and shown that the flora is composed almost equally of species from the east and west. He demonstrates the early spread of the western species and the later migrations from the east. Later migration from the west has been prevented by the gulf formation. This is entirely endorsed by the South-Eastern flora.

(3) Eardley, C. M. 1943 Trans. Roy. Soc. S. Aust., **67,** (2)

In the Lower South-East colonisation of the newly-elevated area was almost entirely from the east—from the old early Pleistocene land surface. The subsequent imposition of a severe arid cycle (4) must have had profound effects on the stability of the vegetation. An analysis of the species of Australian origin collected by the author is given in Table III.

TABLE III

AN ANALYSIS OF THE FLORA OF THE LOWER SOUTH-EAST

Total number species (Australian) recorded	212
Limited to eastern Australia and South Australia	136
Occurring in both east and west Australia	52
Endemic to South Australia	23
Limited to South Australia and Western Australia	1 (a grass)

The colonisation from the east is well illustrated by the *Eucalyptus camaldulensis* association which has obviously invaded the area by way of the Marambro, the Naracoorte and the Mosquito Creeks—particularly the latter. It occurs on all the meadow podsols defined by the Kalangadoo Sand, and has established itself on a small area of Riddoch Sand in the transition zone where these two allied soil types grade gradually into each other.

There is evidence from the edaphic side, and considering that colonisation has been from the east, that the *E. ovata-X. australis* has spread at the expense of some of the *Gahnia trifida-Cladium filum* association. The former association occurs on the Riddoch Sand, but has occupied a large area of shallow rendzina soils, both north of Hatherleigh and near Furner (cf. soil and vegetation maps). But there are slight modifications in floristic composition in the two habitats, *e.g., Poa caespitosa* is usually present on the rendzinas. This invasion, however, which appears to have been proceeding very slowly, was suddenly and for all time ended when artificial drains were built. Land development since has steadily taken place, and is still proceeding.

The dry sclerophyll forest, associated with the podsolised sands of the series of strand ranges, has apparently reached relative stability. It is suggested that very small land movements, either positive or negative, have little effect on the ranges, whereas in the lower lying areas, with their exceedingly gradual fall to the west and north-west very minor seismic fluctuations have a considerable effect on drainage and so actual soil-water relationships. This would, no doubt, reflect on the stability of plant communities associated with them.

Since land development began many cosmopolitan herbs and grasses have been introduced and are frequently conspicuous in the ground flora in the savannah communities. Where important, they have been mentioned in the descriptions of the association.

DISCUSSION

The general ecology of the vegetation of the Lower South-East of South Australia has been described. The area is a very complex one, and the field for more detailed work is an open one. This study, however, throws an interesting light on general soil-vegetation-climate relationships, which have never been well presented or well understood. The arguments of varying schools pro and contra climatic climaxes and climatic climax succession, and the interpretation and misinterpretation by other workers of their hypotheses, have led to a great deal of confusion amongst ecologists, particularly, as pointed out earlier, in relation to terminology.

EDAPHIC CONSIDERATIONS

In the area described in this paper the relationship between soils and vegetation is for the most part remarkably clear cut. Where an association occurs on a modified soil or differing soil type, e.g., *E. camaldulensis* association, on Kalangadoo Sand, on the higher modified soils east of the Naracoorte Range or on shallow soils south of Kingston, there is always accompanying modifications in floristic composition. This was also so for variations within the heath soils, where the floristic variations were described as separate associations which could be linked into an edaphic complex, and again for the dry sclerophyll forest edaphic complex. The transition from meadow podsol (Kalangadoo Sand) to podsolised sand, and the sharp change in associated vegetation association and formation is well illustrated in pl. IX, fig. 28.

The only case in which the transition from association to association was not linked with obvious edaphic changes was in the case of the possible invasion of some of the rendzina soils by the *E. ovata-X. australis* association. But because of seismic fluctuations the communities of the low-lying plains with their poor drainage and varying salinity are not considered to have reached a relative stability comparable with the better drained types. Ecotone areas are essentially edaphic transition zones. The general relationships are in complete agreement with the conclusion that Wood (1939) has reached as a result of his wide experience with South Australian plant communities—"the edaphic complexes and formations . . . . are determined in the one climatic zone essentially by soil conditions."

The edaphic control of the distribution of the principal associations in portion of the north-west of South Australia has already been established, and some variations within the associations themselves explained on edaphic grounds (7).

The evidence from ecological studies elsewhere in Australia, which has recently been summarised (5), neglecting the invasion of eucalypt forest by rain forest (Blake, 1938), is also in general agreement with Wood's conclusions. Admittedly the soils are inadequately dealt with in most of the early Australian ecology, and the opinions expressed are based on superficial observation. Too much value should not be placed upon them, but they are useful as supporting evidence. In the absence of information concerning soil profiles and soil variation, and indications of the nutrient levels and soil reaction, the conclusion of Fraser and Vickery (12) against edaphic control in the Upper Williams River and Barrington Tops Districts (New South Wales) is not admissable.

Elsewhere edaphic factors are being recognised as more and more important. Clements, Long and Martin (8) have found that the dwarf and procumbent forms of dunes are not due, as is generally assumed, to aerial factors, but to edaphic factors (both water and nutrient).

An association may occur on more than one soil type in a climatic zone. In such cases, however, there are always (from the author's experience) modifications in floristic composition and the soils are allied. They are, in reality, separate associations. Soil variations in the South-East can be correlated with floristic variations, and separate associations linked within Wood's edaphic complex satisfactorily demonstrate the environmental relationships.

Water relationships frequently compensate for edaphic variations. This applies especially to species or groups of species rather than whole associations. For example, in eastern Australia (Brough, McLuckie and Petrie 1924, Fraser and Vickery 1938, Blake 1938) rain forest occurs on elevated basaltic soils, while in the narrow valley bottoms on poorer soils, where edaphic water relationships are compensating there is modified rain forest. Within the 10-inch isohyet in western Queensland (Blake 1938), on the gravelly downs, the vegetation of the *Astrebla pectinata* association tends to restrict itself to the margins of the crabholes where water relationships are better. In the north-west of South Australia (Crocker and Skewes (7)) the occurrence of numerous species like *Acacia aneura* (mulga), *Kochia pyramidata* and *Acacia Burkittii* on different edaphic habitats is due to compensating moisture factors.

Within one climatic zone, then, the distribution of vegetation is controlled by edaphic factors, although abnormal water relationships may be compensating and result in species and groups of species occurring in two different edaphic habitats.

Climatic Considerations

The effect of climate on vegetation has always been difficult to assess because of the great edaphic variability, which has usually been only poorly understood. Indeed, climate, until recently, was considered by pedologists to be all-important in influencing soil morphology to the almost complete disregard of geological history. The better understanding of soil fertility, especially the light thrown on it by the opening up of the minor (micro) element field, has tended to a more balanced view.

In the South-East the dune range remnants are arranged almost at right angles to the climatic zones, and pass through several of them. The same soil type is more or less continuous from regions with a rainfall of more than thirty inches per annum in the south, to those receiving about 20-22 inches at the northern part of County Robe, and continues northwards to approximately the 17-inch isohyet. They extend over climatic limits ranging from Davidson's Warm Temperate Semi-humid Zone, with $P/E > 0{\cdot}5$ for nine months of the year, to his Warm Temperate Semi-arid Zone, with $P/E > 0{\cdot}5$ for six months of the year. In the most northerly regions the dune ranges are less regular, but over the whole range one soil type occurs—re-sorted, previously leached, deep siliceous sands of the Mount Burr sand type. The opportunities for fundamental studies on the effect of climate are indeed unique.

The effect on the floristic composition and structure of the *E. Baxteri* (stringybark) dry sclerophyll forest as we proceed from the Mount Burr Range region to the northern portion of County Robe has aleady been pointed out. We pass gradually from the highly developed forest in the south, where the dominant *E. Baxteri* is approximately 50 feet high, to the more open forest in the northerly regions, with depauperate stunted *E. Baxteri* and modified associated plants. The change is a very gradual one—the dominants gradually become lower and associated plants slowly drop out, other more arid species appearing. As we proceed further north the *E. Baxteri* becomes more dwarfed and mallee-like in appearance and, finally, about the 19-inch isohyet reaches the limits of its climatic range (at least on this soil type) and disappears altogether. Before this it was mixed with *E. angulosa* (mallee), and occasionally *E. diversifolia* (white mallee), which now take its place. Most of the common sclerophyllous shrubs of the Mount Burr forest have disappeared; exceptions are *Leptospremum myrsinoides, Xanthorrhoea australis, Lepidosperma carphoides, Hibbertia* spp., *Banksia ornata* and a few others. New associated species like *Leptospermum coriaceum, Phyllota pleurandroides, Casuarina pusilla, Hypolaena fastigiata* and *Adenanthos terminalis* are prominent. Further north, about the 17½-inch isohyet (*e.g.*, Coonalpyn), *E. diversifolia* is more prominent, and *E. leptophylla* also occurs associated with *E. angulosa*.

The climate, therefore, affects a gradual modification of the floristic composition and structure of plant communities. In the more arid regions of the State it has already been recognised (25) that climate, in conjunction with migration of species, has a sifting effect on the vegetation, in a gradual progression, with increasing aridity, through a series of communities—savannah woodland, mallee, tree steppes and finally shrub steppe. It has also been considered by Wood (26) that only by selecting arbitrary climatic zones can definite associations be delimited in this case. In the South-East this is definitely so on the "range" sands, but the soils over the range Wood has indicated are by no means as constant in profile or nutrient levels, and with detailed soil survey work edaphic relationships would probably in many cases permit of more accurate association and formation delineation. But in any case the influence of climate on structure and composition of plant communities is a modifying one.

It is not strictly true, then, in the circumstances, to say that in the one climatic zone associations and formations are controlled by edaphic factors, but rather that this is so in the one *climatic horizon*. So that, in any extensive association, even under conditions of absolute edaphic uniformity, modifications in floristic composition must be expected—varying, of course, with the rapidity of climatic changes—that is, whether the climatic zones are narrow or broad.

If uniform soil types were widespread over climatic zones or numerous "climatic horizons," it would be possible to build up "climatic climax" associations in the sense suggested by Wood (1939). One could further build up "climatic complexes" analogous to edaphic complexes. In practice edaphic variation is usually so great that this is unnecessary. Climatic complexes of this type have been satisfactorily employed, however, in one instance (1), and will be necessary when extending this study into the Upper South-East.

Reviewing the ecology of the mountainous regions of the Eastern States, and the difficulties experienced by all workers there, it is obvious that topographical climatic changes are producing continuous modifications in structure and composition of the communities, masking most edaphic relationships. It is clear, too, that in these cases we are not dealing with associations in the true sense (floristic variation is too great), but rather with "climatic complexes," and many of the problems met by Pryor (20) and Pidgeon (15), with their "forest types," could be overcome, and the relationships of the communities better expressed in terms of edaphic and more particularly climatic complexes.

Summarising, it may be re-stated that most of the difficulties in Australian ecology have been due to a poor perspective as to the relative importance of edaphic and climatic factors, and especially to the great disregard of the edaphic conditions. Because species possess variable potential environments (both edaphic and climatic) the effect of climate on a natural assemblage of plants is to modify both structure and specific composition, and climatic changes are, except in special cases, like sharp rain shadows, always gradual. Major soil variations, on the other hand, are usually sharp and clear cut, and depend principally on geologic history, but are modified by climate. Edaphic factors, therefore, cause sudden and profound changes in composition and structure, and are responsible for the distribution of formations and associations within any climatic horizon.

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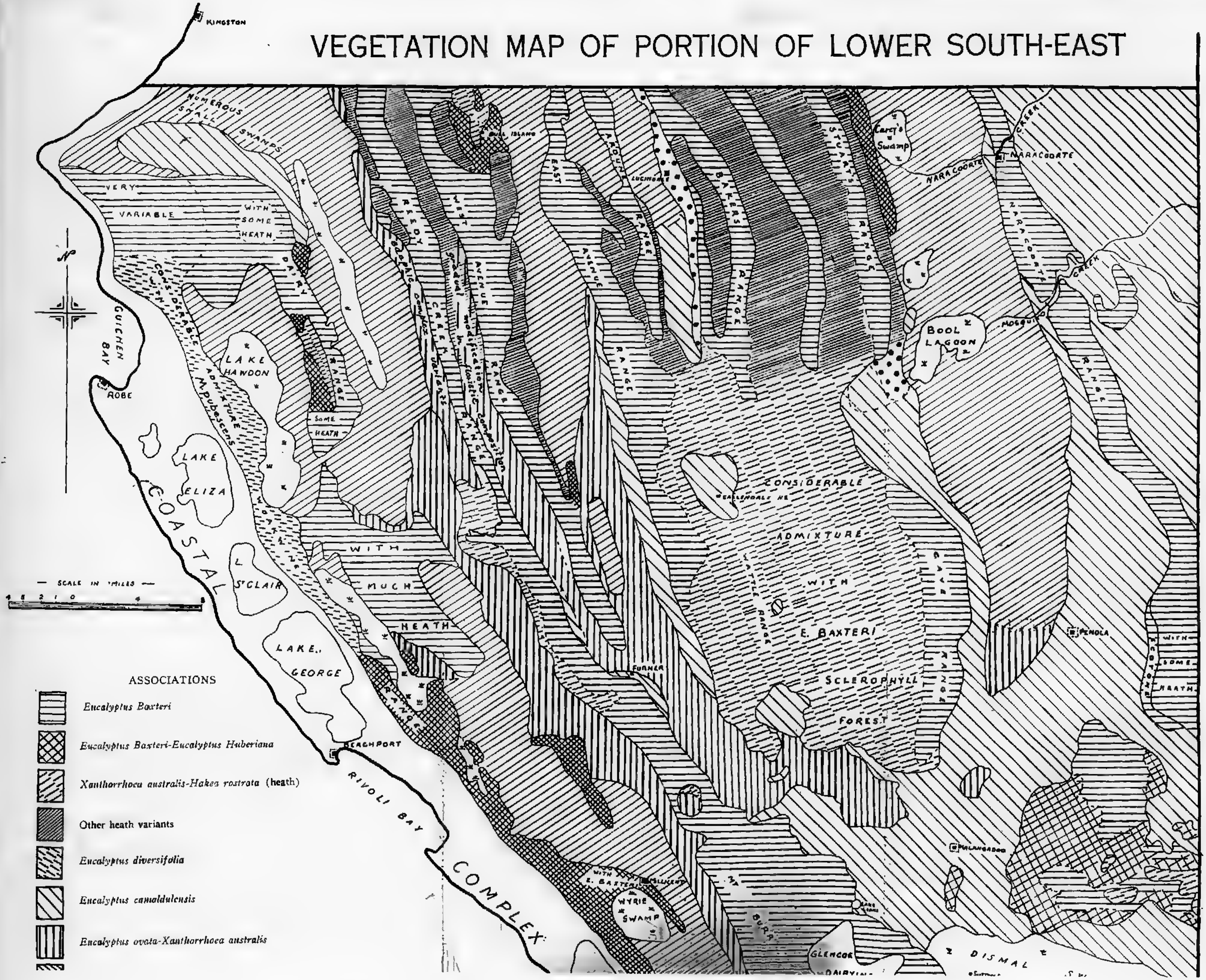
VEGETATION MAP OF PORTION OF LOWER SOUTH-EAST
KINGSTON
NUMEROUS SMALL SWAMPS
VERY VARIABLE
WITH SOME HEATH
GUICHEN BAY
ROBE
LAKE HAWDON
LAKE ELIZA
L. ST CLAIR
LAKE GEORGE
COASTAL
CONSIDERABLE ADMIXTURE
M. pubescens
SOME HEATH
WITH MUCH HEATH
BEACHPORT
RIVOLI BAY
COMPLEX
WYRIE SWAMP
MILLICENT
WITH E. BAXTERI
GLENCOE
DISMAL
BOOL LAGOON
NARACOORTE
NARACOORTE CREEK
MOSQUITO CREEK
CAREY'S SWAMP
BULL ISLAND
LUCINDALE
PENOLA
FURNER
MILLICENT
CONSIDERABLE ADMIXTURE WITH E. BAXTERI SCLEROPHYLL FOREST
BAKERS RANGE
STUART'S RANGE
EAST AVENUE RANGE
WEST AVENUE RANGE
REEDY CREEK
DAIRY RANGE
CAVE RANGE
WITH SOME HEATH
VICTORIA
SCALE IN MILES
ASSOCIATIONS
Eucalyptus Baxteri
Eucalyptus Baxteri-Eucalyptus Huberiana
Xanthorrhoea australis-Hakea rostrata (heath)
Other heath variants
Eucalyptus diversifolia
Eucalyptus camaldulensis
Eucalyptus ovata-Xanthorrhoea australis

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EXPLANATION OF PLATES V-IX

Plate V

Fig. 9 *Eucalyptus Baxteri* association on Mount Burr Sand in the Mount Burr Range area. *Banksia marginata, Xanthorrhoea quadrangulata* and *Pteridium aquilinum* are prominent in the photograph. Rainfall, 30 inches per annum.

Fig. 10 *E. Baxteri* forest on deep podsolised sand. The typical sclerophyllous undershrubs include *Pteridium aquilinum*, *Xanthorrhoea australis* and *X. quadrangulata. Eucalyptus Huberiana* sparingly present. Mount Burr Forest Reserve. Rainfall, 30 inches per annum.

Fig. 11 *E. Huberiana* association. Mount Burr Range. Soil, approximately 18" yellow-brown sand over limestone.

Fig. 12 Depauperate *E. Baxteri* dry sclerophyll forest on leached siliceous sands very closely allied to the Mount Burr Sand, east of Lucindale (Baker's Range). *X. quadrangulata Isopogon ceratophyllus, Banksia ornata, B. marginata* and *Leptospermum myrsinoides* are the chief sclerophyllous undershrubs. Annual rainfall, 23 inches.

Plate VI

Fig. 13 Depauperate *E. Baxteri* forest on leached siliceous sands, West Avenue Range, near Bull Island. *Xanthorrhoea australis* is very prominent in the foreground. Annual rainfall, 24 inches.

Fig. 14 *Xanthorrhoea australis – Hakea rostrata* association. The species conspicuous in the foreground include *X. australis, Casuarina paludosa* var. *robusta, Isopogon ceratophyllus, Banksia marginata. Epacris impressa*, etc.

Fig. 15 *Cladium filum – Melaleuca gibbosa* (?) association between Reedy Creek and West Avenue Ranges adjacent to the Kingston-Bull Island road.

Fig. 16 *Eucalyptus fasiculosa – Banksia marginata* association south-east of Lucindale. Other plants included *Acacia verticillata, Hakea rugosa, X. australis, Melaleuca gibbosa* and *Leptospermum myrsinoides*.

Plate VII

Fig. 17 *Eucalyptus diversifolia* (white mallee) association on Woakwine Range near Beachport. *Xanthorrhoea australis* and *Banksia marginata* are here the most prominent of the associated sclerophyllous undershrubs.

Fig. 18 *E. diversifolia* and *E. fasiculosa* on a consolidated dune between Reedy Creek and Bull Island.

Fig. 19 *Melaleuca pubescens* association on Woakwine Range opposite Beachport. *Acaena Sanguisorbae* is here abundant.

Fig. 20 *Eucalyptus camaldulensis* association between Hynam and Naracoorte.

Plate VIII

Fig. 21 *E. camaldulensis* association near Wattle Range H.S. Meadow podsol soil type.

Fig. 22 *E. camaldulensis* association near Kalangadoo. Soil type, Kalangadoo Sand. Chief grass is *Danthonia geniculata*. *Juncus pallidus* (pale rush), *J. capitatus* and *Scirpus calocarpus* are also prominent.

Fig. 23 *Eucalyptus ovata – Xanthorrhoea australis* association between Hatherleigh and Konetta H.S. Soil, rendzina affinities.

Fig. 24 *E. ovata – X. australis* association on Riddoch Sand (a meadow podsol). Hd. Riddoch.

Plate IX

Fig. 25 *Gahnia trifida* (cutting grass) on black (rindzina) soil of the Millicent Clay type.

Fig. 26 *Eucalyptus leucoxylon – X. australis* association near Lucindale. *E. fasiculosa* is also present.

Fig. 27 *Eucalyptus fasiculosa – X. australis* associated on a shallow meadow podsol (Riddoch sand affinities) west of Reedy Creek Range. *Lepidosperma lineare* in the foreground.

Fig. 28 Transition between Kalangadoo Sand (meadow podsol) and Mount Burr Sand (normal podsol) near Mount McIntyre. The transition is sharp and paralleled by changes from the *E. Baxteri* dry sclerophyll forest on the Mount Burr Sand (background) to *E. camaldulensis* savannah on the meadow podsol. (Photograph, C. G. Stephens.)

Fig. 10

Fig. 12

Fig. 9

Fig. 11

[illegible]

Fig. 16

[illegible]

[illegible]

Fig. 18

Fig. 20

Fig. 1

Fig. 2

Fi . 28

Fig. 25

Bernard C Cotton

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A SPECTROCHEMICAL EXAMINATION OF SOME IRONSTONE GRAVELS FROM AUSTRALIAN SOILS [1]

By A. C. OERTEL and J. A. PRESCOTT

Summary

In a previous communication (Prescott 1934) an account was given of the chemical nature of a range of ironstone gravels associated with certain soils from Western Australia and South Australia. The principal feature of this record was the characteristic presence in these gravels of iron oxides corresponding to 22 to 66% of Fe_20_3, and the low amount of manganese present. Similar results have since been recorded by Beater (1940) for concretions present in Natal coastal soils. and by Joachim and Kandiah (1941) for some concretions present in Ceylon soils.

A SPECTROCHEMICAL EXAMINATION OF SOME IRONSTONE GRAVELS FROM AUSTRALIAN SOILS [1]

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In a previous communication (Prescott 1934) an account was given of the chemical nature of a range of ironstone gravels associated with certain soils from Western Australia and South Australia. The principal feature of this record was the characteristic presence in these gravels of iron oxides corresponding to 22 to 66% of Fe_2O_3 and the low amount of manganese present. Similar results have since been recorded by Beater (1940) for concretions present in Natal coastal soils, and by Joachim and Kandiah (1941) for some concretions present in Ceylon soils.

The chemical nature of such gravels or concretions is of interest in throwing light on soil-forming processes, particularly in the case of ironstone gravels present in soil residuals associated with the laterite characteristic of certain uplifted peneplains and presumably formed under climatic conditions different from those existing at present.

The present communication records the results of a re-examination of the ironstone gravels previously mentioned using the spectrograph to determine the detectable constituents both in the original gravels and in their hydrochloric acid extracts. The examination of the hydrochloric acid extracts was made by a quantitative method based on the addition to selected samples of known amounts of the elements to be estimated. The use of a rotating stepped sector wedge and the addition of the element cadmium to the extracts to serve as an internal standard enabled the selected samples to be used as standards for the analysis of the other samples. The details of the method as standardised in these laboratories will be given elsewhere.

The elements selected for quantitative estimation in the hydrochloric acid extracts were: silver, boron, cobalt, chromium, copper, gallium, germanium, manganese, molybdenum, nickel, lead, tin, vanadium and zinc. It was found that the quantity of boron present was of the same order of magnitude as that present as impurity in the carbon electrodes, and no attempt was therefore made to estimate this element quantitatively. Germanium was found to remain in the residue even when added to the sample. Tin, although present in the original samples, was not detected in the extracts or the residues. The estimation of this element in hydrochloric acid extracts of soils needs further investigation.

The quantitative estimations as given in Table I are believed to be correct to within 25%.

Preliminary Qualitative Examinations

Small sub-samples of each sample of gravel were arced between graphite electrodes. With the exception of boron and zinc all the above-named elements were detected in at least some of the samples. Cobalt was detected in only two of the gravels. An unexpected result of this preliminary examination was the easy detection of molybdenum in nearly all the samples. The complete qualitative examination of an ironstone gravel (No. 2954) from the Warburton Ranges, containing 66% of Fe_2O_3, showed the presence of aluminium, barium, calcium, chromium, cobalt, copper, gallium, germanium, iron, lead, magnesium, manganese,

[1] A contribution from the Division of Soils, Council for Scientific and Industrial Research.

molybdenum, nickel, potassium, silicon, silver, sodium, strontium, tin, titanium, vanadium and zinc.

In three cases the soils associated with the gravels were also examined. They included the soils associated with the gravel (No. 1850) from Kuitpo, South Australia, a soil sample associated with a gravel (No. 1961) from Birdwood, South Australia, and the soil sample associated with the above-mentioned gravel No. 2954. This survey showed that the elements gallium, lead and molybdenum were present in considerably higher concentrations in the gravel than in the associated soil samples, whereas the elements cobalt and titanium were present at considerably lower concentrations in the gravel than in the associated soils.

Examination of the Hydrochloric Acid Extracts

The extraction of the gravels was made with concentrated hydrochloric acid of constant boiling strength on the water bath for 48 hours, as in the standard examination of soils with special precautions to avoid contamination. Ten of the gravels previously examined were selected as being sufficiently representative. The results of the quantitative examination of these extracts for 14 elements are recorded in Table I. The values for iron, aluminium and titanium are taken from the original published analyses. The amounts of chromium and vanadium in these samples may be compared with the amounts recorded by Simpson (1912) in his analyses of Western Australian laterites from Kalgoorlie and Coolgardie. They are of the same order. Bertrand (1942), in the examination of 20 soils, found quantities of vanadium over the range, 0·3 to 6·8 parts per 100,000.

In order to give some perspective to these results, Goldschmidt's figures for the abundance of these elements in the earth's crust are given. There is evidently no change in order of magnitude associated with the relative concentration or otherwise of these elements in the ironstone gravels, but there is a suggestion that cobalt, copper, manganese and nickel are not concentrated in these gravels whereas gallium, molybdenum, lead, vanadium and zinc may be. This confirms the evidence of the preliminary qualitative examination of some of these and other gravels and their associated soils.

A qualitative examination of the residues after extraction showed that although most of the iron had been extracted by treatment with acid, by no means were all of the elements listed in Table I completely extracted.

Table I

Elements		Fe	Al	Ti	Ag	Co	Cr	Cu	Ga	Mn	Mo	Ni	Pb	V	Zn
Sample No.	Locality	%	%	%	Parts per 100,000										
Western Australia—															
2306	Gibson Desert	21.6	3.6	0.2	— (2)	—	60	1.8	10	18	2.5	2.0	4	100	24
2310	,, ,, ...	34.3	2.9	0.2	—		40	3.5	6	90	4.0	1.2	6	100	15
2296	,, ,, ...	30.0	3.0	0.2	0.02	—	12	2.0	8	25	3.0	0.6	5	50	18
	Mingenew	27.9	1.5	0.2	—	1	2	10.0	1	3	2.0	5.0	5	10	12
3068	Gingin	26.5	5.2	0.2	—		5	1.8	3	2	1.2	1.0	3	12	18
South Australia—															
2481	Hawk's Nest	28.7	3.5	0.2	—	—	6	1.8	6	14	2.5	5.0	6	60	15
2485	,, ,, ...	35.0	4.9	0.2	—	—	8	1.0	4	7	1.2	2.5	5	25	12
1850	Kuitpo	37.8	4.3	0.2	—	—	6	1.4	4	6	6.0	0.8	4	25	24
2962	Waitpinga	31.4	2.3	0.3	—	—	2	0.7	3	18	2.0	1.0	2	30	7
	Alawoona	24.3	1.1	0.1	0.06	2	2	1.4	1	4	1.2	2.0	1	16	6
Abundance in earth's crust (3)		5.1	8.8	0.6	0.01	4	20	10	1.5	93	1.5	10	1.6	10	4

(2) Where no values are given, the element was not detected.

(3) Goldschmidt (1937).

The Ratio of Molybdenum to Iron

In view of the fact that the detection of molybdenum in the samples had proved to be easy, it was of interest to attempt to determine whether there had been a concentration of molybdenum in these gravels parallel with that of the iron or in greater proportion. The relatively high concentration of molybdenum in iron concretions from Wyoming, to the amount of 2 and 1·5 parts per 100,000 has also been noted by Stanfield (1935). Dingwall, McKibbin and Beans (1934) were unable to detect molybdenum spectrographically in a group of Canadian soils, but Watson (1943) found quantities of molybdenum over the range 0·2 to 1·9 parts per million in a number of soils from the South Island of New Zealand. Sandell and Goldich (1943) found the average molybdenum content for 22 American igneous rocks to be 2·4 parts per million. These values may be compared with the 15 parts per million of Goldschmidt. Spectrograms of 83 actual soils from South Australia, New South Wales and Queensland were examined for molybdenum, but this element was detected in only eight cases.

In order to compare the relative concentrations of iron and molybdenum in these soils with those of the gravels, the relative intensities of lines in the spectrograms due to the two elements were compared. The known ratios of Mo to Fe in the hydrochloric acid extracts enabled the factor to be ascertained connecting these relative intensities with actual ratios. This factor was found from the average of ten observations to be 6×10^{-5}. In Table II are given the ratios of Mo to Fe in the original gravels.

Table II

Ratio of Mo to Fe in Ironstone Gravels

Sample No.	Locality	Ratio
Western Australia—		
2306 - -	Gibson Desert	19×10^{-5}
2310 - -	,, ,,	10×10^{-5}
2296 - -	,, ,,	12×10^{-5}
	Mingenew	24×10^{-5}
South Australia—		
2481 - -	Hawk's Nest	24×10^{-5}
2485 - -	,, ,,	30×10^{-5}
1850 - -	Kuitpo	19×10^{-5}
2962 - -	Waitpinga	24×10^{-5}
	Alawoona	8×10^{-5}

In the case of the eight Australian soils mentioned above this ratio was found to range between 5×10^{-5} and 10×10^{-5}, as compared with the value of 30×10^{-5} derived from Goldschmidt's table. The evidence is therefore in favour not only of an absolute concentration of molybdenum in these gravels, but also of a concentration relative to the iron probably of a twofold order.

Discussion

The mobility of iron in the soil profile is determined principally by the fact that ferrous hydroxide is precipitated in the neighbourhood of pH 5·5, and that iron therefore is mobilised under reducing conditions more acid than this, but less acid than the precipitating value for ferric hydroxide at pH 2-3. The elements which show no evidence of concentration in these gravels are precipitated as hydroxides at the following hydrogen ion concentrations:

Chromium -	pH 5·3	Cobalt - -	pH 6·8
Copper -	pH 5·3	Silver - -	pH 7·5
Nickel - -	pH 6·7	Manganese -	pH 8·5

and would be expected to be leached from the soil readily at all hydrogen ion concentrations more acid than pH 5 except for chromium which might form chromates under certain conditions. Phosphorus and vanadium are known to be concentrated in iron concretions and limonite (Lindgren 1923) as phosphate and vanadate and similar concentrations could be expected of molybdate and chromate, and probably of zincate and plumbate. In view of the fact that gallium hydroxide is readily dissolved by aqueous ammonia, its behaviour may be expected to be parallel with that of zinc, so that the concentration of gallium in these gravels can be readily understood.

Summary

Ten ironstone gravels from Western Australia and South Australia have been examined spectrochemically and the proportions of fourteen elements in these gravels determined quantitatively in their hydrochloric acid extracts. Cobalt, copper, manganese and nickel are probably not concentrated with the iron, but gallium, molybdenum, lead, vanadium and zinc appear to be so concentrated. Chromium is in an intermediate position.

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ECOLOGY OF THE SAND FLATS, AT MORETON BAY, REEVESBY ISLAND, SOUTH AUSTRALIA [1]

By L. W. STATCH, M.Sc., F.R.M.S.
(Communicated by H. H. HALE

Summary

Because of the necessarily limited period of observation, the present study presents roughly the state of the populations of the sand flats at Moreton Bay only during the month of December 1930. Records of abundance for the larger members of the fauna were obtained by averaging series of counts over selected average quadrats, each being a square meter in area. The smaller organisms were evaluated from quadrats of nine square decimeters. Numerous counts of the surface fauna were taken and a typical sample 2.5 cm. in thickness and nine square decimetres in area, taken from 6 mm. below the surface of the sand was obtained to determine the penetration of the apparent surface fauna, the sand being sieved off through fine cloth and the organic residue being preserved for examination in the laboratory.

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By L. W. Stach, M.Sc., F.R.M.S.
(Communicated by H. M. Hale)

[Read 13 July 1944]

Methods

Because of the necessarily limited period of observation, the present study presents roughly the state of the populations of the sand flats at Moreton Bay only during the month of December 1936. Records of abundance for the larger members of the fauna were obtained by averaging series of counts over selected average quadrats, each being a square metre in area. The smaller organisms were evaluated from quadrats of nine square decimetres. Numerous counts of the surface fauna were taken and a typical sample 2·5 cm. in thickness and nine square decimetres in area, taken from 6 mm. below the surface of the sand, was obtained to determine the penetration of the apparent surface fauna, the sand being sieved off through fine cloth and the organic residue being preserved for examination in the laboratory.

The Habitat

Development and Relations—Moreton Bay (fig. 1) is a shallow inlet about half a mile long on the north coast of Reevesby Island. It is backed by a ridge of sand dunes connecting two low, travertine-capped, granitic outcrops which terminate this local habitat to the east and west. The sand dunes protect the bay from the strong prevailing southerly winds, while the granitic outcrop forming Winceby Island, about a mile to the north, breaks the strength of the north winds, thus affording a great measure of protection from wave action. The sand flats are built up and are extended northward by sand blown from the dune ridge. The wind-blown sand assists the tide in the holding and burial of tidal scour, consisting principally of the marine angiosperm, *Posidonia australis* J. Hooker, the attrition and decay of which provides the bulk of the organic debris of the sand flats. The tidal scour is concentrated towards the eastern half of the bay, the western half always being remarkably clean. The sandy bottom extends to a depth of five or six feet below low water mark, beyond which it is replaced by a dense growth of *Posidonia australis*, extending to the east and west and across to Winceby Island.

This *Posidonia* bank limits the extension of the intertidal sand-flat community to greater depths owing to the alteration of the substratum through biotic factors, the principal one being the matting effect of the rhizomes of *Posidonia* preventing penetration of the substratum by at least the larger members of the intertidal infauna.

Qualitative examination of the *Posidonia* banks both to the north of Moreton Bay and off the west coast of Reevesby Island permits the designation *Adelcidaris - Uniophora - Posidonia* association for this community, but owing to lack of

(1) This paper, based on observations made during the McCoy Society's Expedition to Sir Joseph Banks Islands in December 1936, was completed in 1937, but owing to the author's absence from Australia presentation has been delayed. Circumstances do not permit reference to pertinent literature on marine ecology published since preparation of this manuscript.

quantitative work its character will not be discussed further. It may be noted, however, that this community corresponds to the subtidal *Strongylocentrotus-Asterias* biome of North America as described by Newcombe (1935, 238) and was observed to control in a similar manner the subtidal extension of a lociation of the mussel, *Brachyodontes erosus* Lamarck, occurring on a local development of gravel and sand substratum off the east end of Lusby Island. Notes on the echinoderm elements of this association are contained in another report (Stach 1938, 329, 330).

Detailed Description—From high tide mark, the beach slopes regularly and rapidly to the 1′ 6″ contour. Beyond this is a series of shallow inshore lagoons (bounded by the 2′ 6″ contour) separated by low ridges connecting with the barring outer sand flats and emptying by shallow channels with a very gradual fall to the sea at low water. Hayman and Henty (1939, pl. X, fig. 1) have published a photograph of portion of Moreton Bay showing the dune ridge with inshore lagoon C in the foreground. As the tide recedes the water drains away

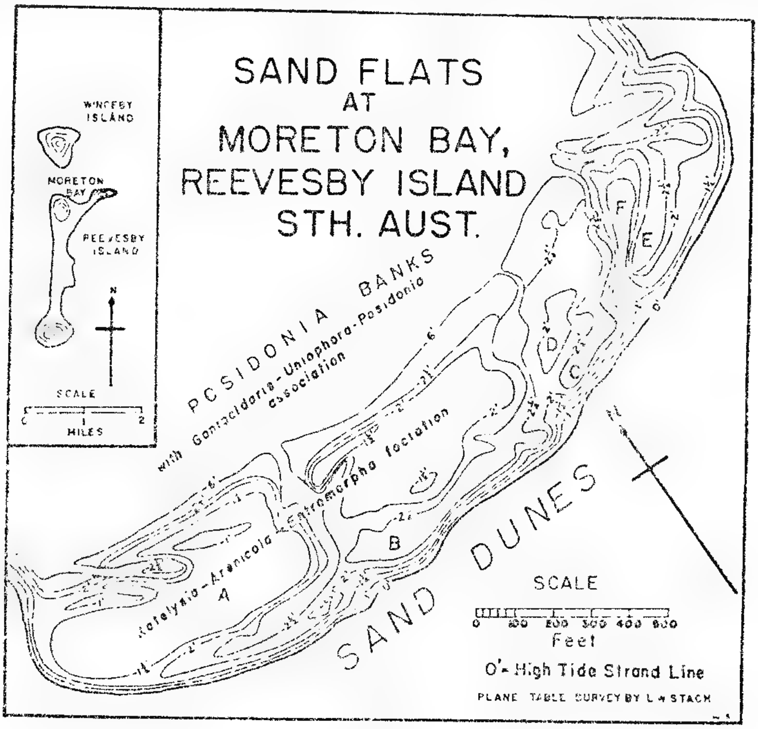

Fig. 1 [2]

until, when the tide is fully out, a thin film of water about a quarter to half an inch deep covers the floors of the inshore lagoons. The broad sand flats barring the lagoons fall within the 1′ 6″ and 2′ contours over the inshore half of their area and fall away regularly and rapidly to low water mark, at the 6′ contour.

The largest unbroken areas of sand flat occur in the western half of the area (fig. 1, A), most of which rises above the 1′ 6″ contour. The thickness of sand in the long lagoon in the western half of the bay (fig. 1, B) exceeds one foot. In the lagoon to the east of this (fig. 1, C) sectioning revealed 6″ of sand overlying at least 9″ of coarse shell debris, principally composed of valves of *Katelysia scalarina* Lamarck and *Soletellina biradiata* Wood. Just on the seaward side of

[2] For *Goniocidaris* read *Adelcidaris*.

this lagoon and within the 2′ contour (fig. 1, D) a section in the sand flat showed 15″ of sand overlying coarse shell debris. The next lagoon to the east (fig. 1, E) showed in section 1′ of yellow-grey sand followed by 2″ of dark grey-brown fibrous, decayed organic matter, derived from *Posidonia australis*, overlying 5″ of sand passing into coarse shell debris. On the seaward slope of the sand flats in the eastern half of the bay there is over 2½″ thickness of sand.

Composition of the Community

The community under consideration may be regarded as a faciation (*vide* Shelford 1932, 111) within the sandy beach association of the intertidal biome, as yet undetermined, of southern Australia. The composition of what is here termed the *Katelysia* - *Arenicola* - *Enteromorpha* faciation is given as follows:

Dominants—*Katelysia scalarina* Lamarck, *Arenicola loveni sudaustraliensis* Stach.

Co-dominant—*Enteromorpha crinita* J. Agardh.

Sub-dominants—Cf. *Salinator* sp., *Estea* sp., *Zeacumantus* sp.

Influents—*Lysiosquilla vercoi* Hale, Nassariids (*Niotha pyrrhus* Menke, *Parcanassa pauperata* Lamarck), *Upogebia* sp., *Cominella lineolata* Lamarck, *Soletellina biradiata* Wood. *Haematopus fuliginosus,* nereid worms.

Sub-influents—*Callianassa ceramica* Fulton and Grant, *Glycera* sp., *Tellina* sp.

Secondary animals—*Philyra laevis* Bell, *Exosphaeroma laevis* Baker.

This faciation is essentially an infaunal community, the co-dominant and the birds being the only strictly epifaunal members. The apparent surface fauna, consisting almost exclusively of mollusca, the larger species of which are scavengers and carnivorous feeders provided with heavy shells, should be regarded as an exposure of the infauna, because of the much denser subsurface population, rather than as an epifauna, as is shown by a comparison of the tables of the surface and subsurface populations given below:

Organism	Dimensions	Quadrat A	Quadrat B
Cf. *Salinator*	1·5 m.m. x 1·0 m.m.	4320	3600
Estea	1·0 m.m. x 0·04 m.m.	3300	4100
Zeacumantus	18·0 m.m. x 6·0 m.m.	65	280
Nassariids	12·0 m.m. x 8·0 m.m.	11	15
Cominella	18·0 m.m. x 10·0 m.m.	2	0
Katelysia (adult)	40·0 m.m. x 30·0 m.m.	0	50
Katelysia (young adult)	14·0 m.m. x 11·0 m.m.	0	10
Katelysia (juvenile)	2·5 m.m. x 2·0 m.m.	0	12780
Tellina	16·0 m.m. x 9·0 m.m.	0	6
Lysiosquilla	40·0 m.m. x 6·0 m.m.	0	(5)
Upogebia	18·0 m.m. x 3·0 m.m.	0	(20)
Arenicola	350·0 m.m. x 25·0 m.m.	0	(4)
Amphipoda, etc.	3·0 m.m. x 1·5 m.m.	0	60

In the above table, Quadrat A represents the average number of individuals of the populations of several quadrats of one square metre of the surface of the inshore lagoons. Quadrat B gives the result of a calculation of the subsurface population. This was arrived at by counting the total population from a selected average area of nine square decimetres taken from about 6 mm. below the surface, the sample being approximately 2·5 cm. in thickness. The total numbers of individuals of species from this sample were then adjusted according to the size of the individuals, the result representing the number of individuals present in a layer roughly equal in thickness to the average dimensions of the individuals. The numbers in parentheses represent the average of counts of individuals from surface evidence such as castings and burrows.

Habits and Relations of Community Members

Katelysia scalarina—This strictly infaunal member is common in most shallow-water sand facies of the south-east Australian coast and occurs in large numbers in the faciation described above. The large number of juveniles indicates that a breeding period had just concluded. The adults all bear a tuft of *Enteromorpha crinita* attached near the ventral margins of the valves and usually projecting through the sand, thus enabling them to be seen readily from the surface. The *Katelysia* population is kept in check by the carnivorous mollusca which bore through the valves and feed on the contents.

Arenicola loveni sudaustraliensis Stach 1944—The ecology of this lugworm has been treated in detail elsewhere (Stach 1944), and a brief summary of conditions tending to maximum population will suffice here. The greatest population occurred in lagoon E (fig. 1), where sectioning revealed one foot of sand overlying a feeding stratum of two inches of dark, grey-brown, fibrous, decayed organic matter, derived from *Posidonia australis*, followed by five inches of sand passing into coarse shell debris. The concentration of the population is also greater in the lagoons since, on the higher flats, the period of exposure and consequent drying out of the sand is of much longer duration between high tides. The body cavities of all specimens dissected were found to be crowded with eggs or sperms while, on the seaward margin of the sand flats, large clavate gelatinous egg-masses were seen extruded from the lugworm burrows. The oyster-catcher (*Haematopus fuliginosus*) was often observed to peck off the tails of lugworms extruding their castings.

Enteromorpha crinita—This green alga, the only one occurring abundantly on the sand flats, was found in small tufts near the ventral margin of the valves of living *Katelysia*. It was also abundant, together with numerous other algae, on the travertine outcrops at the eastern margin of Moreton Bay but, owing to the scarcity of suitable fixed substratum, all species except *E. crinita* appear to be excluded from the sandy habitat. Occasionally it was found rooted on empty valves of several species of pelecypods lying just below the surface of the sand. Its place in the economy of the faciation is not clear, but it may be a food source for cf. *Salinator* and *Estea*.

Cf. *Salinator* sp., *Estea* sp.—These minute gastropods were found in great abundance in the inshore lagoons and very rarely on the barring outer sand flats. Their food supply is not known, but they were often seen in clusters on tufts of *Enteromorpha crinita*, while their abundance below the surface of the lagoons suggests that they may feed on organic matter contained in the sand. Possibly they form part of the diet of the red-capped dotterel (*Charadrius alexandrinus ruficapillus*) which was commonly seen on the shores of Moreton Bay.

Zeacumantus sp.—This common turreted gastropod, typically occurring on fine sand with a high organic content, was found very prolifically beneath the surface of the sand to a depth of 5 cm., where it was apparently feeding on organic debris.

Lysiosquilla vercoi—This crustacean lives in a burrow descending vertically for about two or three inches and about a quarter inch in diameter. When the aperture to the burrow is covered by water the animal rises to the aperture and remains with only the carapace projecting. It was observed on numerous occasions to snap off portions of the foot of Nassariids and *Zeacumantus* with its raptorial appendages, as they passed over the mouth of the burrow. The sooty oyster-catcher (*Haematopus fuliginosus*) appears to vary its diet with *Lysiosquilla*.

Nassariids (*Niotha pyrrhus, Parcanassa pauperata*)—These widely distributed gastropods of the sand facies burrow beneath the surface of the sand flats and are probably the principal biotic control of the dominant *Katelysia*. Just below the surface of the sand many valves are found with a hole bored through, for which the Nassariids are apparently responsible; they, in turn, suffer from the attacks of *Lysiosquilla*.

Cominella lineolata—This gastropod is typically found in sandy habitats with a high organic content and appears to be a scavenger. It was observed, together with some Nassariids, feeding on the tail of a lugworm probably caught by the sooty oyster-catcher.

Soletellina biradiata—This comparatively large pelecypod is of common occurrence in the sandy facies of the south-east Australian coast. In contrast to *Katelysia*, which was rarely found below five or six inches under the surface, it was only met with at depths greater than one foot, where it occurred quite abundantly.

Haematopus fulginosus—The sooty oyster-catcher was seen quite commonly on the sand flats feeding both on the lugworm and on *Lysiosquilla*.

Upogebia sp.—This small crustacean was of common occurrence; it excavates a narrow vertical burrow of little depth with the aperture at the summit of a low cone of sand up to two inches in diameter. Its relation to the other members of the association is not clear.

Nereid worms—Two or three species of very slender habit were occasionally met with.

Callianassa ceramica—One specimen only was collected; it was taken from a depth of over one foot from the surface of one of the inshore lagoons.

Glycera sp.—This polychaete was also of rare occurrence, one specimen being obtained from the same situation as *Callianassa ceramica*.

Tellina sp.—This pelecypod occurred rarely in association with *Katelysia* and bears the same relations to the community as the dominant.

Philyra laevis—This common crab, together with the isopod *Exosphaeroma laevis*, had obviously strayed from the shallow rock pools among the travertine outcrops bounding the eastern end of Moreton Bay where they both occur commonly. Only one specimen of each was seen.

Summary

The principal factors determining the development of this *Katelysia*-*Arenicola*-*Enteromorpha* faciation are the large amount of organic debris (derived principally from the decay of *Posidonia australis*) contained in the sand and the protection of the sand flats from the effects of wave action. These factors permit the abundant development of the dominants *Katelysia* and *Arenicola*. The co-dominant has spread to this facies apparently because it is the only alga which can adjust itself to the only available substratum, *viz.*, valves of pelecypods. With the establishment of the passive dominants, an invasion of carnivorous forms follows, bringing with them in turn their predators. During this stage, also, minor elements add to the variety of this faciation of the intertidal biome.

To the east and west of Moreton Bay the faciation is cut off by a shallow rock-pool facies which limits the depth of sand available for the dominants, while

the seaward extension is inhibited by the development of banks of *Posidonia australis*, the rhizomes of which mat together and form a substratum sufficiently impenetrable to exclude the dominants.

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NOTES ON THE REGENERA.TION OF MURRAY PINE (CA.LLITRIS SPP.)

By L. W. STATCH, M.Sc., F.R.M.S.
(Communicated by H. H. HALE

Summary

Owing to the advance of settlement in the far north-west of Victoria, large belts of Murray Pine (*Callitris robusta*) have been lost in the process of clearing land for the cultivation of cereals. Although scattered and extensive patches of this species are still intact throughout the unoccupied Crown Lands towards the South Australian border, the only large area that can be claimed as State Forest is the Yarrara pine belt. The escape of this area from the inevitable destruction that is connected with land settlement is all the more remarkable when it is realised that this forest of 27,959 acres was actually surveyed into allotments ready for clearing. However, the combined influence of the Forests Commission, the local branch of the Australian Natives' Association, and the Press succeeded in saving the area[1]. Approximately 80% of the area carries *C. robusta* as the predominant species, 10% *Casurina lepidophlioa* and 5% mallee, mainly *Eucalyptus oleosa* and *E. gracilis*. The remaining 5% comprises small timberless spaces of a plain-like character which support shrubs, grasses, and other seasonal herbage. The lack of natural regeneration or capacity for vegetative spread of the *Callitris* genus indicated the desirability of investigation and experiment, because it was recognised that in the absence of regeneration, cut-over areas would remain quite nonproductive so far as timber was concerned.

NOTES ON THE REGENERATION OF MURRAY PINE (CALLITRIS spp.)

By W. J. Zimmer
(Communicated by R. L. Crocker)

[Read 13 July 1944]

Introduction

Owing to the advance of settlement in the far north-west of Victoria, large belts of Murray Pine (*Callitris robusta*) have been lost in the process of clearing land for the cultivation of cereals. Although scattered and extensive patches of this species are still intact throughout the unoccupied Crown Lands towards the South Australian border, the only large area that can be claimed as State Forest is the Yarrara pine belt. The escape of this area from the inevitable destruction that is connected with land settlement is all the more remarkable when it is realised that this forest of 27,959 acres was actually surveyed into allotments ready for clearing. However, the combined influence of the Forests Commission, the local branch of the Australian Natives' Association, and the Press succeeded in saving the area.[1] Approximately 80% of the area carries *C. robusta* as the predominant species, 10% *Casuarina lepidophloia* and 5% mallee, mainly *Eucalyptus oleosa* and *E. gracilis*. The remaining 5% comprises small timberless spaces of a plain-like character which support shrubs, grasses and other seasonal herbage. The lack of natural regeneration or capacity for vegetative spread of the *Callitris* genus indicated the desirability of investigation and experiment, because it was recognised that in the absence of regeneration, cut-over areas would remain quite unproductive so far as timber was concerned.

Habitat Factors

The soils of the region exhibit the usual red-brown colouration, texture and alkalinity associated with pine soils in the north-west.

The average annual rainfall of the region amounts to slightly more than 10 inches. The annual net evaporation is over 80 inches. This area comes within the zone of winter rainfall, and the summers are dry with a high evaporation rate. The irregularity of the rains is, however, a feature of this region, and this irregularity undoubtedly influences considerably the regeneration of the indigenous vegetation. An average rainfall of 10 inches has proved adequate to sustain the xerophytic shrubs and trees of this area. While the light rains do not penetrate far below the surface before they are lost by evaporation and transpiration, it is evident that supplies of soil moisture do accumulate at the lower depths. From here it is unable to rise again to the surface, and can thus be lost from the soil only by transpiration. During the course of an examination of these north-western soils, the writer observed that the roots of the trees and shrubs travelled downwards into sufficient dampness to enable growth to be supported through drought periods which frequently occur. At depths exceeding eight feet the soil was found to be moist, even after long intervals of light rainfall. It is considered that the heavier falls which occur from time to time replenish the soil moisture to a depth from which it is unable to rise by capillarity to the soil surface. In the light of Keen's observations[2] this moisture could only be used by roots which have penetrated to the zone of accumulation.

(1) Victoria Govt. Gaz., 114, 2 October 1929.

(2) B. A. Keen, "The Limited Rôle of Capillarity in Supplying Water to Plant Roots." Proc. 1st Int. Congress Soil Sci., 1, 504-511 (1927).

Table I shows the mean monthly rainfall at Mildura from 1911-1937 inclusive, and the frequency with which the rainfall for each month is considered to have been effective. The mean minimum and maximum temperatures at Mildura for 40 years are given in Table II.

TABLE I

Monthly Rainfall at Mildura (Victoria)

Rainfall	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec	Total
Mean, 40 years	.51	.74	.74	.60	1.08	1.28	.83	1.11	1.04	1.01	.77	.85	10.86
Mean, 1911-37	.75	.87	.74	.54	1.07	1.21	.90	1.06	.94	.94	.85	.77	10.64
No. of years rainfall for month effective, 1911-37 (³)	2	4	2	2	12	15	15	11	4	4	4	-	

(³) Based on reference of monthly rainfall to monthly evaporation.

TABLE II

Monthly Temperature at Mildura

	No. of Years	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean
Mean Min.	40	61.6	62.0	56.1	49.8	45.0	41.3	39.5	41.8	45.6	50.1	55.2	59.1	50.6
Mean Max.	40	91.6	91.9	84.6	76.0	67.0	60.8	58.5	63.9	69.7	77.3	85.0	89.5	76.4

INFLORESCENCE OF CALLITRIS

In common with other conifers, *Callitris* spp. bear naked ovules in a cone. The integument forms a hard seed coat. It appears that the carpellary leaves, which support the ovules, are stimulated to vigorous growth and form woody coverings around the seeds. These are the six valves of the cone. The first leaves -the cotyledons, are in a whorl of two within the embryo. Although the male flowers generally appear in a rudimentary fashion in March, the pollen is not sufficiently developed for dispersal until November, when a copious liberation takes place. On account of their exceedingly minute nature, the pollen grains are readily distributed by wind. The female flowers receive the pollen and the development of the female cone immediately commences. The cones become ripe after a period of twelve months and the seeds are liberated in November or December, when the summer heat causes the cone valves to separate. On hot, windy days the winged seeds can often be seen falling from the trees like a shower of rain.

SEED CHARACTERISTICS

During an examination of hundreds of seeds it was found that the usual number of wings is two, but that three 3-winged seeds are also present in cones of normal development. The 3-winged seeds occupy a central position, being formed on the smaller cone scales or valves, one to each valve (see fig. 1). The production of the third wing appears to be due to the space left by the 2-winged seeds which are formed on the valves directly against the columella, the third wing thus pushing its way in towards the corner of the columella. The species examined possess but a single columella, the faces of which are arranged opposite the three largest cone valves. The three smaller cone valves, therefore, occupy a position directly opposite the corners of the columella. Some cones of *Callitris propinqua* from Kulkyne contained six 3-winged seeds, and this is a departure from the usual phenomenon of three 3-winged seeds per normal cone. It is suggested that the extra wings are an outgrowth of the integument of the ovule which is made in an effort to ensure firmness throughout the growth of the cone together with the process of seed development. These Kulkyne cones were extraordinarily large. In this case the usual three 3-winged seeds were borne on the three smaller cone valves, one to each valve, the third wing intruding into the space between the triple ovule formation on each of the larger cone valves. The additional three

3-winged seeds were borne on the larger cone valves, one to each valve, the central seed of the triple ovule formation directly adjoining the columella carrying the third wing (fig. 1). These facts appear to suggest that the function of the columella is, in part, to provide a buttress for the pressure which is exerted on the seeds by the incurving valves as they gradually close together.

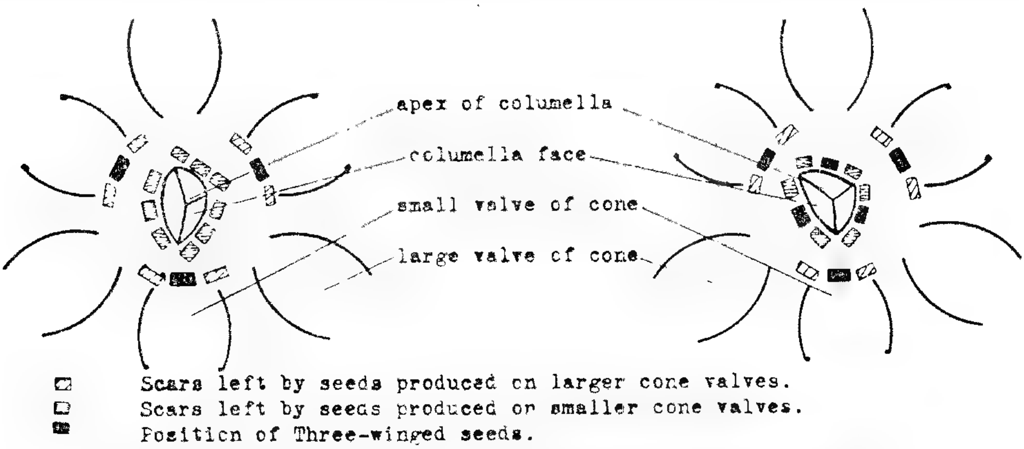

Fig. 1 Showing typical cone of *Callitris*, with three 3-winged seeds (left) and a cone of *Callitris propinqua* with six 3-winged seeds (right).

Seed Tests

With the object of ascertaining the percentage fertility of the seeds of different *Callitris* spp., cones were collected locally and from the Terricks State Forest, 40 miles north of Bendigo. The complete series comprised five cones from five trees in different areas and they belonged to three species, namely, *C. robusta*, *C. propinqua* and *C. verrucosa*. On account of the impossibility of separating fertile seeds from infertile ones by ocular means, every seed, no matter how insignificant in appearance, was tabulated, because it was found that shrivelled seeds were sometimes fertile, while robust seeds of good appearance were frequently sterile. By adopting this method the chances of error were reduced. A total of 5,433 seeds was tested, and of these 1,261 germinated, giving viability over the series of 23·2%. A full statement of the results of these investigations is given in Table III.

The following features are to be noted:

1 There was considerable variation from tree to tree in the percentage fertility.
2 The viability over the complete series was in general low.
3 The highest value obtained in the series was 58·7%.

These figures, however, show that seed sterility is not responsible for the general absence of regeneration in the forest.

The investigations were carried a stage further by applying variations of temperature and moisture to selected seeds of *C. robusta*. The object was to demonstrate what influence, if any, the heat from the sun's rays had on exposed seeds, as well as to determine what effect was likely to be brought about by summer showers that might provide conditions favourable for the commencement of germination. In other words, was it possible that summer rains might initiate germination, followed, however, by death due to the extremes of temperature and increased dryness of the surface soil? A summary of the results of these tests is given in Table IV.

Table III

Showing particulars of Germination Tests with Seeds of *C. robusta*, *C. propinqua* and *C. verrucosa*. Tree Dimensions and Origin of Seeds Tested.

Group No.	Tree No.	Species	Origin of Seeds	Butt diameter in inches	Height in feet	EACH TREE: Seeds tested	EACH TREE: Number germinated	EACH TREE: Percentage germination	Greatest number in one cone	Smallest number one cone	TOTALS FOR EACH GROUP: Seeds tested	TOTALS FOR EACH GROUP: Number germinated	TOTALS FOR EACH GROUP: Percentage germination
1	1	*C. robusta*	Yarrara	7	30	200	43	21.5					
	2	,,	,,	6	15	247	83	33.6					
	3	,,	,,	8	25	346	82	23.6	89	46			
	4	,,	,,	6	25	206	121	58.7					
	5	,,	,,	10	30	189	101	53.4			1,188	430	36.1
2	1	*C. robusta*	Timberoo	12	30	225	75	31.1					
	2	,,	,,	3	12	149	39	26.1					
	3	,,	,,	9	30	290	29	10.0	75	37			
	4	,,	,,	12	35	208	76	36.5					
	5	,,	,,	10	30	198	7	3.5			1,070	226	21.1
3	1	*C. propinqua*	Kulkyne	18	42	313	51	16.2					
	2	,,	,,	15	40	218	24	11.0					
	3	,,	,,	10	28	331	66	19.9	90	48			
	4	,,	,,	12	36	301	111	36.8					
	5	,,	,,	12	35	295	55	18.6			1,458	307	21.0
4	1	*C. verrucosa*	Konardin	5	20	154	27	11.0					
	2	,,	,,	5	13	212	25	11.7					
	3	,,	,,	7	13	165	19	11.5	58	34			
	4	,,	,,	½	5	193	35	18.1					
	5	,,	,,	¾	6	199	66	33.1			923	172	18.6
5	1	*C. robusta*	Terricks	10	25	128	27	21.0					
	2	,,	,,	9	30	163	17	10.4					
	3	,,	,,	12	35	160	57	35.6	57	29			
	4	,,	,,	11	30	136	22	16.1					
	5	,,	,,	13	28	207	3	1.4			794	126	15.8
						Final Result of Series	-	-			5,433	1,261	23.2

Table IV

Showing Maximum Shade Temperatures during Tests and Percentage Germination obtained

Maximum Shade Temperatures (January-March 1933)

No. of Days

	71-80° F	81-90° F	91-100° F	101-110° F	111-115° F
January - -	5	12	5	7	2
February - -	4	13	5	5	
March -	7	10	6	7	1

Germination after Exposure to direct Heat of Sun

Cone No. - - -	1	2	3	4	5	6	7	8	9	10
No. of seeds - -	61	62	50	59	60	56	62	57	58	61
No. germinated -	27	0	21	24	8	23	21	22	25	28
% germination - -	44.2	0.0	42.0	40.6	13.3	41.0	33.8	38.5	43.1	45.9

Mean percentage germination — 33.6%

Germination after Moistening followed by Drying

Cone No. - -	1	2	3	4	5	6	7	8	9	10
No. of seeds - -	55	60	60	58	57	58	61	58	60	58
Hours of moisture - -	2	4	6	8	10	12	16	20	24	48
No. germinated - -	30	23	31	26	22	17	33	37	16	24
% germination - -	54.5	38.3	51.6	44.8	35.0	29.3	54.0	63.7	26.6	41.3

Mean percentage germination — 44.2%

A tree was selected and the seeds obtained from this tree were found to be 42·5% viable. Twenty additional cones were picked from this tree and these were divided into two lots of 10 cones each. The seeds from each cone were counted and tabulated separately. The seeds belonging to 10 of the cones were placed outside under the direct heat of the summer sun, precautions being taken to prevent rain from falling on the seeds. The degree of heat received by the seeds is indicated by the order of the maximum shade temperatures given in Table IV.

On 30 March the seeds were removed and tested for germination by seeding in boxes and watering in the open. The value obtained was 33·6%. This indicated that the seeds could tolerate the intense heat of summer without their viability being impaired.

The seeds from the other 10 cones were submitted to a moisture time schedule which ranged from a period of two hours subjection to moisture with a progressive increase to a maximum of 48 hours duration. At the termination of each period of treatment, the seeds were recovered and allowed to dry out thoroughly. After they had dried completely, they were tested for germination. The value obtained in this case was 44·2%.

Regeneration Experiments

These experiments provide evidence to support the view that the hard crust of the soil surface was the prime cause of failure of the seedlings to appear. It appeared reasonable to suppose that if a seed bed were artificially created, sufficient moisture would be conserved in the soil to bring about sufficient germination.

During May 1933 an initial attempt to secure regeneration was essayed. An area of one acre carrying several seed trees was enclosed with wire netting and the surface soil broken into a fine condition. Following a single fall of 230 points in November 1933, 24 seedlings appeared beneath the mother trees in December, but on account of root competition the seedlings failed to establish and, at the end of March 1934, all of these had died.

During March 1934 the average shade temperature over 11 consecutive days was 104° F. The work was persisted with, however, and in May 1934 the area was again harrowed. In November 1934, 88 seedlings appeared, and again in late spring of 1935 further seedlings brought the total in this small plot to more than 190.

On 30 April 1938 the number of young trees was 188; it can thus be observed that loss had been negligible. On 1 January 1938 these young trees were measured. The following height classes give an indication of the growth rate:

Height class - -	0–6″	6–12″	12–18″	18–24″	24–30″	30–36″	36–72″
No. of young trees -	21	59	62	26	15	4	1

It is significant that regeneration ceased in the plot after the soil re-assumed the crusty nature which is invariably associated with virgin soils in that region.

The germination of the seed is interesting. The seed coat bursts close to the micropyle, and by the growth of the axis the radicle is protruded and curves down into the soil. By elongation of the cotyledons, their basal portions are pushed out of the seed together with the apex which lies between them; the apical portion of the cotyledons remains within the endosperm till the whole of the contained food materials has been absorbed and used by the developing embryo. Ultimately the cotyledons are withdrawn from the seed and rising into the air form the first green leaves. These differ considerably, however, from the foliage subsequently formed.

In August 1937 a further experimental plot of eight acres was prepared along similar lines to those employed in the first attempt. In November 1937, 65 seedlings appeared. With the exception of two, which were situated beneath the seed trees, all of these were alive and presented a particularly vigorous appearance when last observed in April 1938. The dryness of the ground occasioned by the seed trees is no doubt responsible for the death of the two seedlings mentioned.

It is important to note that the regeneration of certain native shrubs and trees such as *Dodonaea attenuata, Cassia eremophila, Acacia ligulata* and *Myoporum platycarpum* also occurred readily. These species survived the dry summer conditions and developed strongly. The conclusion to be drawn from the results of these experiments is that natural regeneration can be achieved, provided suitable conditions of the surface soil are provided and both rabbits and live stock are excluded. The rate of growth is not rapid, but it is very necessary that areas from which timber has been removed should be permitted to regenerate. Measurements taken from trees of a known age and which have grown under natural conditions show that a height of 18 feet, with a butt diameter of six inches, can be expected in 14 years. The knowledge that regeneration will take place provided suitable measures are taken, permits the formulation of a definite scheme for the future management of areas which have grown native pine.

It would appear that so long as the seedlings survive the summer following their appearance they can be considered to be well established. Protection from rabbits and stock is vital, and the creation of a seed bed by the breaking of the surface crust of soil is necessary in order to conserve soil moisture and provide a suitable medium for germination. This also encourages the seedlings of perennial grasses (*Stipa* spp.) and seasonal herbage, which provides shade and shelter. It has been contended by some authorities that the growth of these latter species should be prevented because of the drain upon soil moisture. The *Stipa* spp., however, die down in early summer and the amount of moisture removed during the hot summer months is negligible. The dry stalks of these and the annual plants shade the tiny pines from the fierce summer heat, as was well demonstrated in Plot 1. It was also observed that seedlings competed successfully with a dense growth of *Inula graveolens*.

Seedling Development

The primary root of the pine seedling immediately commences to penetrate deeply into the soil. The following particulars relate to a seedling which appeared in November 1937 and was measured in March 1938, when 120 days old. Its height was $5\frac{1}{2}$ inches and the main axis had developed eight alternate lateral branchlets, none of which exceeded one inch in length.

The basal portion of the leaves was decurrent, one-third of the total length of the foliar blade, and extended from the point of issue on the stem to the point of issue on the whorl below, thus covering the stem between the free leaf blades. The decurrent parts of the leaves do not form contact along their edges, so that a groove is formed in which the stomates are protected. As the seedlings become older the free portion of the blade gradually diminishes until the major portion of the blade is decurrent to the stem.

The main axis of the root developed to a depth of 32 inches, with very little lateral formation.

On account of the rapidity of development of the primary root it can be seen that root competition from shallower rooted plants is of little account, and seasonal herbage which finishes its short life cycle before the severe conditions of summer set in, is unable to remove moisture during the summer months.

Experiments with broadcast sowings indicated that deep covering of the seeds is undesirable. Seeds sown $\frac{1}{2}$ inch, 1 inch, 2 inches and 3 inches below the surface were able to form cotyledons which reached the surface of the soil, although the percentage of field germination fell away considerably at 3 inches.

The cotyledons of seeds sown at depths of 4 inches and 6 inches failed to reach the surface and perished in spite of the fact that the germination had been quite good.

It was also found that Murray pine developed fertile seeds at a comparatively early age. Seeds from a 12-year-old tree gave a germination of 20·5%.

A Transect Study of the Flight of Seeds

Successful examples of natural regeneration in Victoria are so uncommon that an opportunity was taken in 1938 to record information resulting from such an occurrence near Mildura.

Rabbit-proof fencing permitted seedlings to become established within the enclosure. Outside the fence, where rabbits and hares were able to find access,

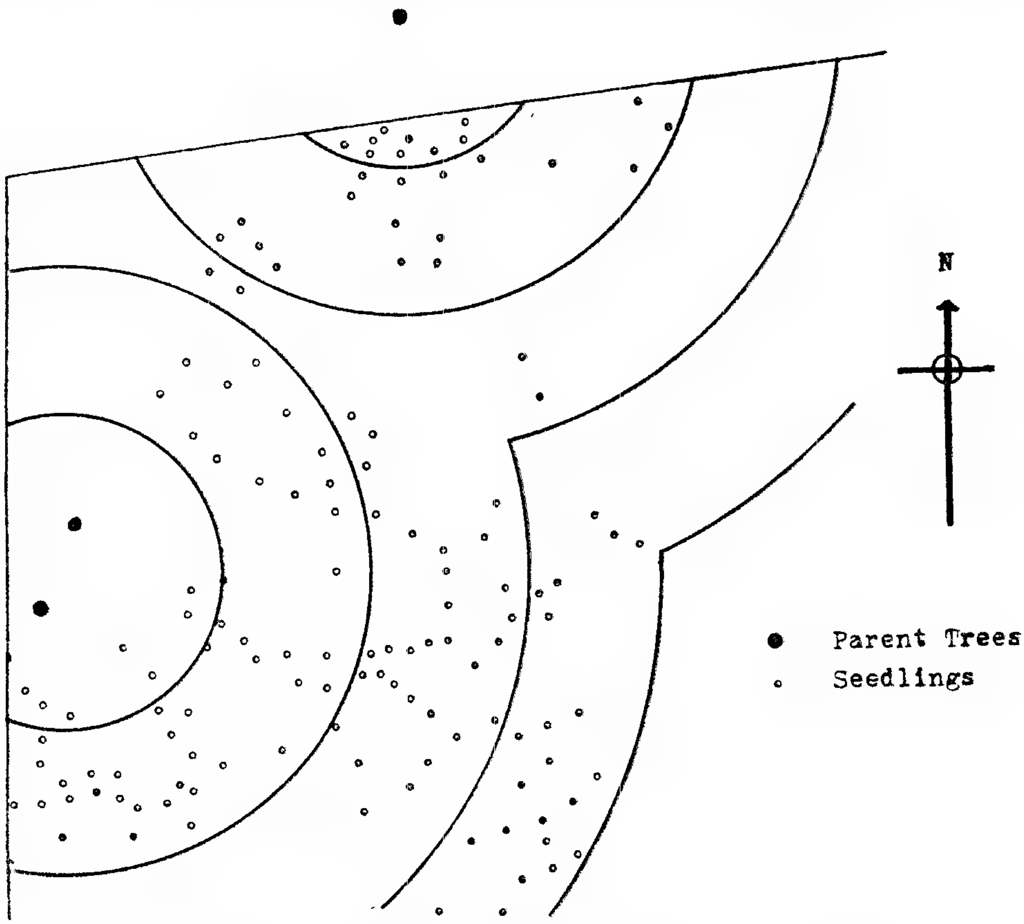

Fig. 2 Showing dispersal of seedling trees from three parent trees.

no regeneration occurred. The data obtained from this study indicates the distance apart that primary belts of this species should be established in the event of measures being taken to restore denuded areas of timber in the mallee. Where broadcast seeding is necessitated by the complete absence of seed trees, the belts should be approximately 8 chains apart and placed to suit the topography and soil conditions of the region concerned.

A plan of the area, drawn to scale, is given in fig. 2, and the following information refers to this instance.

A study was carried out in November 1938. The average height of the young trees was 13 feet. Regeneration has commenced in 1934, and the number of seedling trees was 138. These were distributed as follows:

Distance from parent tree—

Less than 1 chain	1-2 chains	2-3 chains	3-4 chains
16	63	36	23

The area seeded by three parent trees was approximately two acres. The following classification shows the number of young trees within different height classes:

Height in feet - -	1	2	3	4	5	6	7	8	9	10
No. of young trees -	1	1	1	2	1	7	2	5	7	13

Height in feet - -	11	12	13	14	15	16	17	18	19	20
No. of young trees -	8	15	15	16	13	5	10	3	5	8

Summary

Observations on the natural regeneration of Murray Pine (*Callitris* spp.) in the Yarrara belt of the far north-west of Victoria are recorded.

The region is characterised by very irregular rainfall, averaging slightly more than 10 inches per annum, with an annual net evaporation rate of more than 80 inches.

The principal characteristics of the seeds are described, and their germination has been investigated. Seeds of three species, *C. robusta, C. propinqua* and *C. verrucosa,* totalling 5,433 in number, gave an average percentage germination of 23·2%, shrivelled and undersized seeds being included in those tested. There was much variation in percentage germination from tree to tree; the highest value obtained for any series was 58·7%. It has been shown that the general absence of natural regeneration by *Callitris* is not due to seed sterility, but to unsuitable conditions of the surface soil, usually in the form of a hard crust, and in addition, to the depredations of both rabbits and livestock.

It would appear that so long as the seedlings survive the summer following their appearance, they are able to resist extreme conditions of drought and may be considered as well established, provided they are protected from the grazing influences of rabbits and stock. The primary root of the pine seedling penetrates rapidly and is capable of attaining a depth of 32 inches with very little lateral formation after a period of 120 days from germination.

Where broadcast seeding is necessitated by a complete absence of seed trees, belts approximately 8 chains apart should enable intervening strips to regenerate from the natural flight of the seeds. Belts should be placed to suit topography and soil conditions and require to be protected from both livestock and rabbits.

PALAEOZOIC IGNEOUS ROCKS OF LOWER SOUTH-EASTERN SOUTH AUSTRALIA

By D. MAWSON and W. B. DALLWITZ

Summary

The contribution to the knowledge of the igneous rocks of the South-Eastern District of South Australia deals with outcrops located in the region between the upper Coorong to Kingston on the south side and Keith to Bordertown on the north; excepted only are the adameilite and gianodiotite occurrences already described in an earlier contribution. The latter have been included in our map, fig. 1, in order to make complete the record for that area.

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By D. Mawson and W. B. Dallwitz

[Read 10 August 1944]

Plates X and XI

This contribution to the knowledge of the igneous rocks of the South-Eastern District of South Australia deals with outcrops located in the region between the upper Coorong to Kingston on the south side and Keith to Bordertown on the north; excepted only are the adamellite and granodiorite occurrences already described in an earlier contribution. The latter have been included in our map, fig. 1, in order to make complete the record for that area.

ADAMELLITES AND GRANODIORITES

The outstanding example of this suite is that opened up in the Highways Department's Taratap Quarry. For a petrological description of this granodiorite see Mawson and Parkin (5).

There are several minor occurrences within a mile or so of the quarry in the scrub country to the north-east of the adjacent salt swamp. One tiny outcrop is on the fence line of the Prince's Highway half-a-mile south-east of the quarry. We could not find evidence of the existence of the patch shown on Dr. Wade's map (7) as located about 5 miles south-east of the Taratap Quarry. One patch is on the sea beach somewhat less than 1½ miles to the west-north-west of the quarry. A number of small outcrops are located in the line of the Reedy Creek swamp water course, appearing at intervals between 13 and 17 miles to the north of the quarry, as indicated on the accompanying map (see also pl. X, fig. 1).

QUARTZ-KERATOPHYRES

Rocks of this nature appear to underlie the Tertiary to Recent sediments over a considerable area, but outcrops are few and scattered. The outcrops recorded extend in a roughly north and south direction, appearing at intervals from the Papineau Rocks (21 miles east-north-east of Kingston) to Didicoolum, a distance of over 25 miles. In one area rocks of this group have suffered a considerable degree of metamorphism under severe shearing stress reducing them to the form recognised as porphyroid.

The rocks to be described in this group have a chemical composition which determines them as rhyolites, but are overwhelmingly sodic. They contain very little potash and are abnormally low in mafic constituents. Though they contain some porphyritic albitic feldspar, the base is felsitic. Thus they are palaeotypal, leucocratic, soda-rhyolites. In some outcrops minute lath-shaped albites appear in flow alignment reminiscent of trachytic structure, and this first suggested the term keratophyre as relevant. An analysis of the freshest material from the main outcrop showed their high silica content, which refers them to the quartz-keratophyres of some petrologists, the term which we have adopted for descriptive purposes herein.

The Papineau Rocks Locality

A notable outcrop of dark felsitic quartz-keratophyre occurs on Section 173 of the Hundred of Minecrow (see pl. X, fig. 2). This outcrop is known as the

Papineau Rocks (see map below). The exposed area which we examined is about 250 yards long and 100 yards across. It extends in an almost true north and south direction. It emerges from the Pleistocene and Recent sands of the Ardune Range on the northern edge of a swamp flat which was dry at the time of our visit. The floor of the dry lake which is part of a swamp channel between the East Avenue Range [1] and the Ardune Range is elevated only about 100 feet above sea level. The summit of the outcrop of igneous rock rises 140 feet above the lake floor.

In the map accompanying Dr. Wade's report (7) two distinct outcrops of igneous rock, both hatched to represent feldspar-porphyry and situated within one mile of each other are indicated as existing in this locality. Not being aware at that time that a second outcrop had been indicated, we, in our brief look around from the high ground in that vicinity, missed seeing any second outcrop that may be there. That some other outcrop does exist within a few miles of this locality is

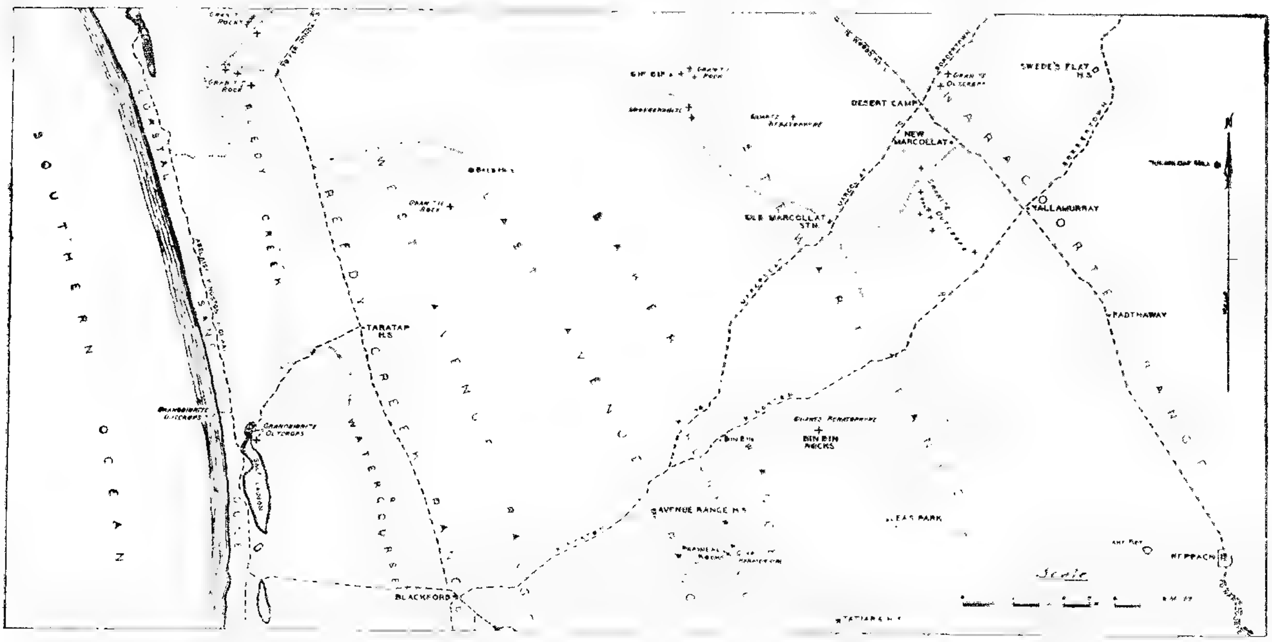

Fig. 1

indicated by the fact that we have found in the rock collection of the late Walter Howchin a specimen [4473], labelled "Kingston District," of a grey porphyry closely related but distinct from any that we have met with.

The northern end of the outcrop is least affected by secondary changes; from there, material catalogued as rock [5779] was collected for petrological examination. This is a dark, faintly greenish-tinged grey rock with sparse crystals of feldspar, discernible in the hand specimen, embedded in a felsitic groundmass.

A microscopic examination discloses that the porphyritic crystals make up only about 7 per cent. of the whole rock. They consist entirely of plagioclase which is very close in composition to pure albite. It is only very little clouded.

(1) The popular use of the term "Range" in the geography of the South-Eastern Region of South Australia refers to topographical features which are low but persistent for a considerable distance across the otherwise flat featureless country. They are no more than ancient, Pleistocene to Recent, vegetated and fixed sand dunes.

The average length of the individuals is about 1 mm., but some up to 3 mm. are present. Glomeroporphyritic aggregates of plagioclase are common. One such group observed consists largely of feldspar arranged in an intersertal pattern, with calcite, leucoxene, epidote, chlorite and iron ore occupying the interstices. Complex twinning is a feature of the feldspars in combinations of all four types; Carlsbad, Manebach, Baveno and albite are sometimes encountered. No definite potash feldspar could be found.

The groundmass, while it is completely crystalline, is very fine-grained, the average grain-size being about 0·06 mm. There can be recognised quartz, faintly clouded feldspar, epidote, medium-green chlorite, leucoxene, black iron ore (often bordered by leucoxene), calcite and occasional needles of apatite. The latter have been observed within the albite phenocrysts.

Although there is abundant epidote, coloured light brown and yellowish-brown, both in the groundmass and in the phenocrysts, the feldspar is not visibly

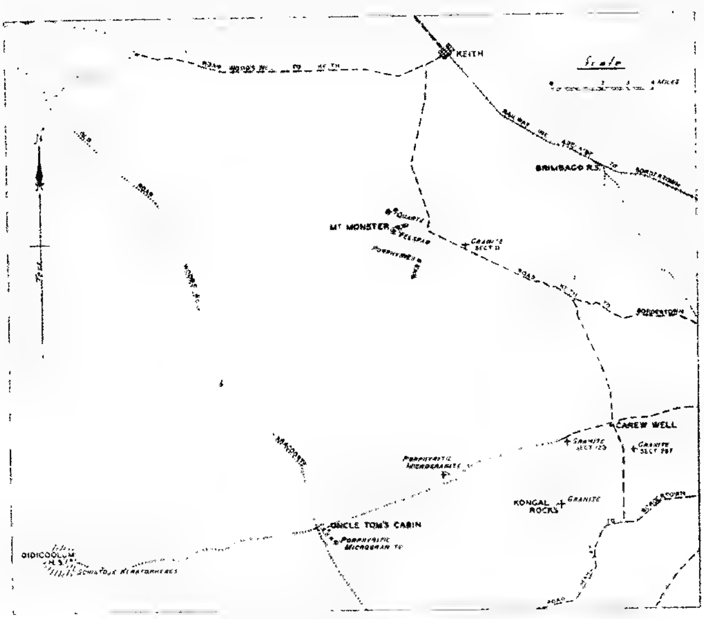

Fig. 2

altered. Thus it is suggested that this mineral, together with the chlorite, leucoxene and a small quantity of calcite, is a product of recrystallisation (perhaps late-magmatic) wherein plagioclase and a ferromagnesian mineral were made over to the minerals named and a more acid plagioclase (albite). Probably nearly all the lime shown in the analysis is present in the epidote. The specific gravity of this quartz-keratophyre is 2·680, and a chemical analysis is given in the table on page 194, where there also appears the chemical composition of another quartz-keratophyre from the South-East of South Australia (see p. 194). The molecular proportions of potash and soda are: 7·3 of K_2O and 88·7 of Na_2O.

For comparison are included published analyses of a "soda-rhyolite" from Canada, "soda-rhyolite" from Wales, "quartz-keratophyre" from Greece and an "alsbachite" from Switzerland, all of which are very similar in composition to that now being described. For further comparison, there is also included in the table, analyses of a soda-rich aplitic differentiate from the granite of Port Elliot, South Australia, and an analysis (second grade) of an example of the "porphyroid" of Western Tasmania.

The norm of our rock is as follows:

Quartz	38·46	Magnetite	1·86
Orthoclase	4·06	Ilmenite	0·61
Albite	46·63	Apatite	0·19
Anorthite	5·14	Fluorite	0·11
Corundum	0·30	Calcite	0·10
$MgSiO_3$ (en)	0·98	Water	0·65
$FeSiO_3$ (hy)	0·92		
			100·01

From this norm the C.I.P.W. classification is I, 3, 2, 4, (Alsbachose).

	I	II	III	IV	V	VI	VII	VIII
SiO_2	76·40	75·22	77·44	79·64	78·48	75·61	75·73	76·02
Al_2O_3	11·94	12·29	10·55	11·44	10·26	12·62	12·70	14·60
Fe_2O_3	1·28	1·25	2·24	0·11	1·81	1·10	2·25	0·27
FeO	1·33	1·73	0·34	0·30	0·25	1·00		0·08
MnO	0·09	—	trace	0·08	—	—	—	—
MgO	0·39	0·28	0·09	0·15	0·53	0·98	0·60	0·04
CaO	1·30	1·38	0·99	0·71	1·07	2·18	2·00	0·34
Na_2O	5·50	6·13	6·23	6·40	5·39	5·10	3·48	7·08
K_2O	0·69	0·48	0·71	0·38	0·37	0·68	2·04	0·96
H_2O+	0·57	0·75	0·58	0·30	0·96	0·38	1·20 (3)	0·34
H_2O-	0·08	0·09	0·33	0·16	0·03	0·04		0·15
TiO_2	0·32	0·30	0·20	0·50	0·52	0·35	—	0·07
P_2O_5	0·08	0·03	0·17	0·08	trace	0·32	—	—
F	0·05 (2)	—	—	—	—	—	—	—
CO_2	0·05	—	—	0·02	0·08	—	—	—
	100·07							
Less O for F	0·02	—	—	—	—	—	—	—
Total	100·05	99·93	99·91	100·27	100·02	100·36	100·00	99·95

I Quartz-keratophyre [5779] of Papineau Rocks, South Australia. Analyst, W. B. Dallwitz.

II Quartz-keratophyre [443] of Marcollat, South Australia. Analyst, E. R. Smith, Department of Geology, University of Adelaide.

III "Soda-Rhyolite" of Copper Island, Behring Sea. Analyst, W. Zygmuntonska. See ref (9), p. 76.

IV "Soda-Rhyolite" of Skomer Island, Wales. Analyst, E. G. Radley. See ref. (9), p. 76.

V "Quartz-keratophyre" of Epidauros, Greece. Analyst, A. Lindner. See ref (9), p. 76.

VI "Alsbachite" of Ruseinschlucht, Switzerland. Analyst, L. Hezner. See ref (9), p. 98.

VII "Porphyroid" of the West Coast, Tasmania. Analyst, W. F. Ward. See ref. (6),

VIII "Soda-aplite" of Port Elliot. Analyst, W. R. Browne. See ref (2).

(2) Determined by E. R. Segnit.

(3) Loss at red heat.

Autometamorphosed Quartz-keratophyre

Two specimens [5780 and 5781] were collected from the southern end of the outcrop, where the rock has lost its even grey colour and is mottled greenish-grey and pink on a rather coarse scale. Here the phenocrysts of feldspar are flesh-coloured. These effects are ascribed to late-magmatic changes. Both of these rocks are essentially similar to [5779] and differ from each other only in degree of autometamorphic change. Thus in [5781], which is an example of the more greatly changed type, the pink feldspars embedded in the dark-coloured parts of the rock stand out more distinctly.

In rock [5780] the groundmass consists largely of equidimensional un-oriented albite grains (average size, 0·05 mm.), and differs from that of [5779] in containing very little quartz. Other important minerals present are green chlorite, calcite and epidote, and some larger pseudomorphous masses of brown leucoxene; a few grains of partially replaced black iron ore remain. The chlorite, calcite and epidote are very unevenly distributed: this feature and the different secondary reactions going with it appear to account for the mottling evident in the hand-specimen. The epidote is mostly brownish-grey, but some of it has a strong yellowish tinge and a spherulitic arrangement. A more or less spongy development is characteristic of the calcite, chlorite, and epidote. This is most noticeable in the carbonate mineral, in which areas 4 mm. or more in length, consisting of many grains, extinguish simultaneously. This calcite is very abundant in some parts of the slide, while it is completely absent in others: a fact which again emphasises the patchy nature of the changes in the rock. Varying amounts of chlorite are always found with the calcite. Very small needles of apatite are present, but are extremely rare.

Feldspar phenocrysts are more abundant than in [5779]. Synneusis texture is rather common. The feldspar is again very close to pure albite, and some of it contains occasional flecks of orthoclase; here, and in the groundmass as well, it is slightly clouded. Complex combinations of twins, *e.g.*, Carlsbad, Manebach and albite are not uncommon. One grain was observed to be divided into four sections by a combination of Carlsbad and Baveno twinning.

The microscopic examination of [5871] reveals that calcite is very abundant making up 30% or more of the whole, and has often crystallised into grains up to 1 mm. across. Associated therewith are numerous small grains of newly-formed, water-clear albite, which is a by-product of the breakdown of the original feldspar in those areas. Epidote is scarce. Euhedral porphyritic feldspars are considerably more abundant than in [5780]. They are quite densely clouded, while the original groundmass feldspar is rather less altered. In some cases, clear, secondary albite, identical with that found with the calcite, borders the phenocrysts which show simple twinning much more often than multiple. Complex twinned crystals are not common.

Another specimen [4431], collected by N. B. Tindale, is almost identical with our rock [5780]. However, calcite is absent in the microscope slide and there appears one large grain of purple fluorite in the hand specimen.

Bin Bin

H. Y. L. Brown (1, p. 268) makes reference to what must be another occurrence of keratophyre. His statement is as follows: "Bin Bin Islands, four miles north-east of a deserted station, where an outcrop of felsite and feldspar porphyry is backed on the west side by blue metamorphic quartzite. . . . ."

As the place name Bin Bin does not appear on the county map, reference was made to Brown's original sketch plan accompanying his field notes, still preserved at the Mines Department. The approximate location of Brown's "Bin Bin Islands," taken from the above source, is indicated in the map illustrating this present contribution. On the recently published military map of the area the name Bin Bin appears situated some four miles to the west of Brown's location, and evidently has reference to a spot associated with pastoral occupation.

It is probable that Brown's "blue metamorphic quartzite" is a fine-grained flinty keratophyre, for he uses the same descriptive term for the keratophyre at his Gip Gip occurrence (*vide postea*). Apparently the quartz-keratophyre of this occurrence occupies one or more low rises in the flat swampy country about six miles north-west by north of the Papineau Rocks.

Marcollat

A further occurrence of quartz-keratophyre was found at a point about seven miles from Old Marcollat Station buildings in a direction somewhat west of north. This appears to be the outcrop visited by H. Y. L. Brown and mentioned as "Gip Gip" in his record. The locality appearing as "Jip Jip" on the Survey Plans of the Lands Department is, however, some four miles to the north-west of Brown's Gip Gip. Brown describes the rock as "bluish metamorphic quartzite, with disseminated iron pyrites."

Here we found the outcrop very small indeed, nearly circular and about 100 yards across. It rises as a low island mass to a height of about 30 feet above the level of the bed of a dry swamp flat. There is a cut of a few feet in depth blasted in its summit where miners, in the year 1896, gouged in search of gold.

In the neighbourhood of this old working, the keratophyre is shattered and recemented as a coarse breccia [5890] in which mineralizing solutions have circulated, introducing frequent specks and grains of pyrrhotite up to 3 mm. in diameter. An assay made for us by T. W. Dalwood, of the Mines Department, showed gold to be absent.

Very fresh rock is obtainable from the dump heap resulting from the mining operations. From this coarse breccia we culled for laboratory examination a fragment [4432] measuring about 9 inches in diameter which has the appearance of being original rock unaltered by subsequent mineralizing solutions.

This rock [4432] was found to be a diopside-bearing quartz-keratophyre. It is outwardly very similar to the keratophyre [5779] already described, which occurs 17 miles away to the south-south-west. As observed in the hand-specimen it differs mainly in being of a lighter grey colour and by being traversed by schlieren composed of mottled, turbid feldspar and a dark chloritized ferromagnesian mineral. Pyrrhotite has been introduced along some of these schlieren, evidently lines of strain which permitted the invasion of secondary gases and solutions.

Microscopically examined, this rock is found to be somewhat different from that [5779] of the more southerly occurrence already described. In it the porphyritic crystals are almost twice as abundant as in the latter. These porphyritic individuals consist of idiomorphic feldspar, and to a considerably less extent of buff-coloured diopside ($Z \wedge c = 39^\circ + : 2V$ medium). Synneusis texture is common in the feldspar, which consists largely of almost pure albite in which Carlsbad twinning is more abundantly represented than the lamellar type commonly associated with albite. A puzzling feature is the presence within the feldspar individuals of an optically positive and lower D.R. form: either merely albite of different orientation than the host or patches of an unidentified feldspar. The feldspar is slightly clouded and often contains a few flakes of greenish-white chlorite and a little diopside.

No quartz could be detected in the groundmass which consists of elongated plagioclase microlites up to 0·17 mm. long, showing some tendency to parallel arrangement. Abundant specks of leucoxene and chlorite are also present.

Of the accessory minerals, the most important is greenish-white chlorite derived from the diopside; then follows dark brown leucoxene showing aggregate polarization and a suggestion of octahedral shape which probably indicates pseudomorphism after titaniferous magnetite, some of which remains and is usually bordered by leucoxene; rarely minute needles of apatite are also present.

For a chemical analysis of the material of this selected specimen we are indebted to E. R. Smith, B.Sc. This appears in the table on page 194. The norm is as follows:

Quartz - - -	32·76	Hy. - - -	1·58
Orthoclase - -	2·67	Ilmenite - -	0·61
Albite - - -	54·49	Magnetite - -	1·86
Anorthite - -	3·34	Apatite - -	0·08
Wo. - - -	1·39	Water - - -	0·84
En. - - -	0·70		
		Total - -	100·32

C.I.P.W.: I, 4, 2, 5 (Mariposose).

Schistose Quartz-keratophyres of Didicoolum

Keratophyres related to the foregoing, but dynamically metamorphosed, occur in a third locality, namely in the vicinity of the abandoned hutments of the one-time sheep station of Didicoolum located some 25 miles north-north-west of the Papineau Rocks of Section 173, Hundred of Minecrow.

In Wade's report (7) the neighbourhood of Didicoolum is hatched as a patch of "Quartzite and mica schist." H. Y. L. Brown, in 1896, after a visit to inspect mining prospects in that locality, recorded (1) that there is there "An outcrop of rocks containing quartz veins and pyrites; strike N. and S.; dip, vertical."

At Didicoolum we found schistose rocks occupying a considerable area, but these are for the most part buried beneath Pleistocene to Recent sand ridges. All four specimens of bed rock which we collected in this area evidence a very considerable degree of metamorphism under shearing stresses. All have reached the biotite stage, but slight retrograde metamorphism has caused the development of chlorite in three of them.

Schistose Quartz-keratophyres [5873], [5874], and [5875] are metamorphosed representatives of the quartz-keratophyres already described. The first two are grey, owing respectively to finely disseminated chlorite and biotite. The third is a mottled dark grey and buff rock, which owes its appearance to the concentration of biotite into large lenses. All have developed in them a rude cleavage, due to the roughly parallel orientation of the micaceous minerals.

A few unbroken, clouded, porphyritic crystals of plagioclase remain in all three. Their compositions could not be determined accurately, but measurements of maximum extinction-angles in the symmetrical zone consistently indicated albite; these angles varied from 12° in [5874] to 16·5° in [5875]. The sign throughout is positive and R.I. close to that of balsam. The groundmass in each consists of finely crushed feldspar, quartz and pale biotite (bleached and altered to chlorite in [5873]), together with variable but small amounts of brown and yellow-brown granular or radiating epidote (c.f., epidote in rock [5879]) often in aggregates and streaks, and a little zircon. In addition [5875] and [5874] contain sericite, [5873] and [5874] black iron ore, and [5875] an occasional grain of apatite. The biotite is completely unaltered in [5874], but a little chlorite has developed in [5875]; in the latter colourless epidote also occurs in the residual plagioclase phenocrysts, around which biotite-rich bands usually wind. The quartz in all three rocks is partly scattered and partly segregated into irregular pockets, some of which are roughly lenticular.

The fourth rock specimen collected [194], a *biotite-plagioclase-orthoschist*, represents a more basic rock, in all probability a quartz-diorite which has been subjected to the same process as the three rocks just described. The minerals present are abundant plagioclase and finely-divided biotite, epidote, quartz, black iron ore and apatite. Only very few (somewhat saussuritized) plagioclase phenocrysts remain; they are optically positive and all R.I.'s are conspicuously greater than that of balsam, so that their anorthite-content is at least 38%, and, judging by the curvature of the isogyre in an optic axis figure, probably considerably more. Crushed augen of plagioclase and quartz are conspicuous. Chlorite is present in small quantity, while epidote is rather plentiful and sometimes occurs in fair-sized pockets. False cleavage has been developed as an effect of shear.

PERIOD OF VULCANISM

In the region under review, owing to paucity and isolation of the outcrops of pre-Tertiary rocks which emerge through the ubiquitous veneer of Miocene to Recent sediments, no field evidence is available clearly linking these quartz-keratophyres with either of the local granitic suites, namely the adamellite-granodiorite magma situated to the south or the soda-potash granites which occupy a large area to the north. However, since highly albitic differentiates are associated with the former suite at Encounter Bay (2) and Cape Willoughby (Kangaroo Island), it is more than likely that these highly sodic quartz-keratophyres of the South-East are also linked with the adamellite-granodiorite magma illustrated locally at the Taratap Quarry. The age of the keratophyres is thus likely to be that of the granodiorites which has been indicated (5) as probably Middle-Cambrian.

It is interesting to note that in the Heathcote district of Victoria there are pre-Ordovician soda-rich volcanic rocks interbedded with *Dinesus* bearing beds regarded (3) as of Middle-Cambrian age.

The Porphyroid Series of Western Tasmania is mainly of the nature of a quartz-keratophyre which has undergone varying degrees of metamorphism under shearing stresses. These felsitic rocks extend in a long line with axial direction parallel to that of the West Coast Range. Specimens forwarded by W. T. Twelvetrees (6) were examined and reported upon by Professor H. Rosenbush in the year 1898. He classed them as porphyroids or flaser-porphyries. In his description, epidotization and calcitization are recorded, and peculiar nests of albite are specially remarked upon. Rosenbush further states that in one specimen "nothing is left of the original groundmass; it has been converted to sericite, quartz and albite . . . . the chlorite indicated original pyroxene rather than biotite." An analysis by F. W. Ward (the Government Analyst of Tasmania of that time), which appears in Twelvetrees' paper, is included herewith in the table on page 194. A glance at microscopic preparations of some of the Tasmanian porphyroids further convinced us of their essential similarity with our South Australian examples.

L. K. Ward (8) states that after the eruptive period which produced the porphyroids, marked by both extrusive and intrusive phases, there was an absence of igneous activity in Tasmania until the close of the Silurian or perhaps some portion of the Devonian. He also states that a period of marked crustal movement appears to have followed closely upon that of the porphyroid eruption.

Fortunately, there is some direct palaeontological evidence as to the age of the Porphyroid Series of Tasmania, for it is associated with the Dundas slates which contain the fossil *Hurdia*, which appears (8) to indicate a Middle to Upper-Cambrian age.

Thus there is good reason to regard the quartz-keratophyres and porphyroids of South-Eastern South Australia as equivalents of the Porphyroid Series of Tasmania, and probably of Middle Cambrian age. The shearing stresses which reduced the quartz-keratophyre to the state of porphyroid were doubtless associated with great crustal upheaval which affected South Australia in Middle-Cambrian time.

POTASH-SODA GRANITES

Rather frequent outcrops of an even-grained, pinkish-coloured granite are distributed throughout an area of some 100 square miles in the Kongal Rocks-Yallamurray region. Also a white granite of somewhat different character appears alongside the Duke's Highway some nine miles east of Keith. All these outcrops, with the exception of that at Kongal Rocks, are inconspicuous. They are located in a region elevated little above sea-level and of only very minor topographic relief.

This area of scattered granite outcrops is clothed with a stunted forest growth and only rarely are there patches of better grown trees. Such vegetation is, however, in marked contrast with the low scrubby growth on so much of the neighbouring country situated to the west and south-west.

These pink granites are found to be so similar petrologically to those already described (5) outcropping to the south of Coonalpyn, that there appears to be no doubt as to their consanguinity. Thus, the outcrops in this area are regarded as part of a large batholith which includes also the granites of Murray Bridge and Coonalpyn.

Section 123, Hundred of Wirrega

An unusually fresh and typical example of this group of rocks occurs as a low whaleback outcropping about 200 yards to the south of the road. This locality is about two miles west of Carew Well. The rock, which is exposed over a length of about 25 yards, is intersected by two fine-grained aplite [5803] veins of normal type, the major one being six inches in width. There was also observed traversing the outcrop a local irregular schliere composed of the normal flesh-coloured feldspar [5799], which is as coarse or coarser grained than that of the parent granite; it contains very little biotite and no quartz.

In the hand specimen this granite [5785] is seen to be of coarse but fairly even grain. The obvious mineral constituents are a pinkish-buff coloured potash-feldspar, faintly smoky quartz, yellowish-white plagioclase and lustreless biotite. These minerals are not quite evenly distributed, the feldspars tending to be grouped in aggregates poor in quartz. Occasionally plagioclase forms a shell around the potash-feldspar.

The texture is typically granitic and roughly seriate, for the grains of potash-feldspar are generally coarser than those of plagioclase, and the latter still coarser than those of quartz. The grains of quartz occupy areas as large as the potash-feldspar crystals, but these areas consist of composite grains. However, the above relationships of size do not always hold, since very large grains of plagioclase and quartz are not uncommon.

The "potash-feldspar" is found to be a composite one, varying between perthite and antiperthite, according as the plagioclase is less or more abundant. It is usually anhedral and its average grainsize is about 0·5 cm., though some grains approach 1 cm. The plagioclase constituent is in long, wavy, branching and confluent wisps, often twinned, and always in optical continuity throughout any one composite grain.

A rim of clear plagioclase partially borders some of these grains, and this material may be in optical continuity with that in the interior of the grain; furthermore, the included soda-lime feldspar is occasionally in optical continuity with an adjoining plagioclase crystal. Usually both the orthoclase and plagioclase in the composite grains are clouded, but the latter very much less so than the former; indeed, the plagioclase is not infrequently quite clear.

In contradistinction to the "potash-feldspar," the plagioclase occurs in subhedral to euhedral grains, some of which are quite markedly zoned; the inner parts of these are usually clouded through mild saussuritization, while the outer parts are almost or quite clear. The theoretical composition ($Ab_{93}An_9$), as deduced from the analysis, is almost exactly the same as that determined by means of symmetrical extinction-angles ($Ab_{92}An_8$); this is not surprising in view of the simple mineralogical composition of the rock. In a few cases grains of the albite are included in the "potash-feldspar."

There is nothing unusual about the quartz. It contains gas-liquid inclusions. The boundaries of the grains are usually quite irregular.

Biotite, which is pleochroic from deep brownish-green to golden-yellow, probably makes up no more than about 3 to 4% of the whole. Its lustreless appearance may be due to partial change. One book shows very pronounced sieve-structure, the included minerals being quartz and fluorite. Leucoxene has separated from the mica, while feldspar in its vicinity is slightly stained with iron oxide.

Black iron ore, fluorite, sericite, chlorite, allanite, and more rarely calcite and zircon are the accessories. Nearly all of the fluorite, some of which has a purple tinge, is embedded in biotite, while very small quantities of chlorite and sericite are included in the plagioclase, the latter as a component of incipient saussuritic alteration. One small crystal of altered allanite of a golden-yellow colour was found in biotite.

The approximate mineral percentages in this rock are best gauged from the norm. Actually the composite feldspar preponderates over the albite crystals to the extent of about four or five to one, but the great abundance of albite in the former accounts for the normative percentages of plagioclase and orthoclase. On account of its paucity in lime this rock is a potash-soda-granite rather than an adamellite.

	I	II	III
SiO_2	76·81	76·74	73·77
Al_2O_3	12·38	12·00	13·06
Fe_2O_3	0·28	1·13	0·72
FeO	0·78	0·43	1·43
MnO	0·01	trace	0·05
MgO	0·09	0·03	0·12
CaO	0·53	0·49	0·89
Na_2O	3·79	4·23	3·55
K_2O	4·70	4·19	5·44
H_2O+	0·34	0·47	0·57
H_2O-	0·14	0·18	0·11
TiO_2	0·11	0·10	0·18
P_2O_5	0·02	0·04	0·08
ZrO_2	—		0·01
Cr_2O_3	—	—	nil
BaO	—	0·02	0·06
SrO	—	—	0·01
CO_2	0·03	0·06	0·16
F	0·10	0·20	0·04
Cl	—	—	trace
SO_3	—	—	nil
S	—	—	0·02
	100·11	100·31	100·27
Less O for F	0·04	0·08	0·02
Total	100·07	100·23	100·25
Spec. Grav.	2·603	2·584	2·613

I Potash-soda granite [5785] from Section 123, Hundred of Wirrega, South Australia. Analyst, W. B. Dallwitz, Department of Geology, University of Adelaide.

II Potash-soda Micro-granite [5885] from Hundred of Willalooka, South Australia. Analyst, E. R. Segnit, Department of Geology, University of Adelaide.

III Potash-soda Aporhyolite [4426] from Mount Monster, near Keith, South Australia. Analyst, W. B. Dallwitz.

The chemical composition of this granite as determined by one of us (Dallwitz) is given in the table on page 200. The molecular proportions of potash and soda are 50·0 of K_2O, 61·1 of Na_2O. The norm is as follows:

Quartz	35·53	Magnetite	0·45
Orthoclase	27·80	Ilmenite	0·15
Albite	31·96	Apatite	0·06
Anorthite	1·50	Fluorite	0·19
Corundum	0·60	Calcite	0·09
$MgSiO_3$ (en.)	0·20	Water	0·48
$FeSiO_3$ (hy.)	1·06		
		Total	100·07

C.I.P.W. Classification: I, 4 (3), 1, 3 (Liparose-Alaskose).

Kongal Rocks

About three miles south of the granite outcrop just described is a much more extensive development of a very similar granite. This locality is known as Kongal Rocks. The outcrop measures about 500 yards by 250 yards and rises above an already elevated region, indicating a considerable extension of the granite below the surrounding area.

The specimen [4409] of Kongal granite is of a type closely similar both to [5785] and to [4410]. In granularity it is perhaps nearer to the latter, but the feldspars perhaps more closely correspond with those of the former. Some grains of light-coloured plagioclase are distinguishable in the hand-specimen, but the bulk of the feldspar is perthite. A distinctive feature is the blackness of the smoky quartz—more so than in the case of any other of these potash-soda granites. The ferromagnesian mineral is preponderantly biotite, though odd grains of amphibole are macroscopically visible. Grains of colourless fluorspar are visible in the microscope slide.

Occasional narrow veins of an even-grained aplitic microgranite traverse the granite of Kongal Rocks. These approach true aplites in character but contain rather more ferromagnesian mineral (biotite) than is admissable for such. Rocks [4434] and [4435] are examples of these veinstuffs; both are of similar mineral constitution but the former is coarser grained than the latter. They are constituted of quartz, orthoclase, a little microperthite and some highly albitic plagioclase and a very little biotite; the latter is pleochroic from yellow to bronzy-brown, with remarkably strong absorption. No fluorspar was noted in these vein rocks.

Section 297, Hundred of Wirrega

Here granite is exposed on a sloping hillside to the east of the road. It occupies an area about 400 yards by 150 yards. This is a hornblende-biotite potash-soda granite, related to [5785 and 4409], but is also very similar to [4410 and 5894].

In the hand-specimen available [4413] there is a marked deficiency in ferromagnesian constituents. Some grains of hornblende are showing, but no biotite.

Granite North-East of Desert Camp

On rising ground to the east of the road, about one mile north-east of Desert Camp, patches of granite are exposed. Other small outcrops were met with within the next half-mile further to the north, confirming our view that a considerable area of granite probably underlies the elevated block country to the east of this locality.

A representative specimen [4410] of the rock outcrop at one mile north-east of Desert Camp proves to be a hornblendic potash-soda-granite. It bears a general resemblance in the hand-specimen to the foregoing [5785]; it has, however, suffered somewhat from weathering, resulting in fairly general limonitic staining and the assumption by the feldspar of a pale buff colour.

Under the microscope it is observed that though this rock is broadly the same as [5785], there is an important distinction in that amphibole and pyroxene are the dominant ferromagnesian minerals. These comprise both hornblende, with X = greenish-brown, Y = very dark greenish-brown, and Z almost opaque, and subordinate aegirine-augite in which $Z \wedge c = 58°$ or more. Both these minerals are extensively, and in some cases almost completely, replaced by haematite.

No separate, subhedral grains of albite were found. The small amount of plagioclase not in perthite and antiperthite is interstitial between grains of those feldspars; as clear albite and chequer-albite, it forms pockets and narrow, bordering shells. In the intergrown feldspars, which occasionally show Baveno twinning, the plagioclase is clear and the orthoclase clouded.

Biotite is rare; it occurs marginal to black iron ore and associated with haematite. Other minerals present are allanite, zircon and a little chlorite. The allanite is fresh, slightly pleochroic and zoned, the core being a deep rich brown and the border golden-brown. No fluorite was observed in the single section available.

Hornblendic Granites of the Yallamurray – New Marcollat Area

The track from New Marcollat Head Station to Old Marcollat Head Station, at one-and-a-half miles south-west of the former, passes on the east side of a granite [5826] outcrop. This rises 20 feet above the plain, is 400 yards long by 155 yards across, and is directed in a S10°W (true) direction. Beyond this point, after crossing to the east side of the track and walking in a general southerly direction for about one mile, a further outcrop [4411, 4412 and 5894] several hundred yards in length is met with; continuing south and somewhat to the east for a further mile, brings one to still another granite outcrop. It is probable that there are others again beyond that. One such outcrop which we did not visit is indicated on the Survey Department's map of the Hundred of Marcollat, as existing within three miles of the Yallamurray homestead in a south-west direction. All of these are petrologically very similar types and closely resemble [4410] described above, though perhaps somewhat coarser grained. They are hornblendic potash-soda-granites. Aegirine augite has not been observed in them, but fluorite is present. Occasional subhedral grains of albite are present. Allanite, if present, is very rare. Needles of apatite are not uncommon in specimen [4411].

Section 11, Hundred of Stirling

The most northerly locality where granite was met with in the area now under consideration is on the north side of the road nine miles south of Keith. The outcrop visited is meagre, and the rock was found to be considerably weathered. It is possible that a further examination of this area may reveal a more extended outcrop than that examined by us.

This granite [4414] is in appearance distinct from others discussed in this paper. It is a light grey allotriomorphic granite of a medium-coarse but even granularity. The feldspars are white to faintly flesh-coloured. The quartz is without the strong smoky character common in most of the granites extending from Murray Bridge to the South-East.

The microscope slide reveals that the strongly microperthitic character of the larger feldspars so common in the other granites is wanting. Here the soda feldspar is mainly present as medium to acid oligoclase in small to medium-sized crystals, some of which are continued in an outer zone of orthoclase. To a limited degree only, does plagioclase embedded in the orthoclase appear to have arisen by exsolution from original homogeneous feldspars.

The ferromagnesian mineral is biotite, which for the most part has been much affected by chloritization. The original mineral is strongly pleochroic from light yellow to a deep greenish-brown. Zircon is common as small grains and rods in the biotite. There are present occasional well-defined rods of apatite.

Though varying from the foregoing granites in some respects, there are not sufficient grounds for regarding this occurrence as other than of the same period of crustal injection.

POTASH-SODA MICROGRANITES

Apart from very minor aplitic micro-granite veins traversing some of the granite outcrops described under the previous section, there are some notable occurrences of microgranite in the region under consideration.

Rocks of this nature were met with in several places located to the west of the potash-soda granite area, more particularly centred around Uncle Tom's Cabin. They are in a widespread region of very low scrubby vegetation, most of which is not more than several feet in height. However, in the immediate neighbourhood of outcrops of these igneous rocks, or where the latter are located at shallow depth below the sand and limestone formations of Tertiary to Recent age, there are patches of eucalypts reaching the dimensions of a stunted forest growth.

Hundred of Willalooka

A large mass (see pl. XI, fig. 1) of porphyritic microgranite forms a low hill located some five or six miles to the west-north-west of Kongal Rocks. It is on the north side of and a quarter of a mile from the track leading from Bordertown to Uncle Tom's Cabin. The surrounding country is quite flat and occupied by low heath-like scrubby vegetation growing to some two to three feet in height, in which stunted banksia is an outstanding element. This granitic outcrop, which is no more than a couple of hundred yards across, is mainly a broad flat rock raised 45 feet above the surrounding plain, but this is surmounted near its southern edge by a knob which reaches to a total height of 90 feet above the plain. The rock is notably red in colour and porphyritic.

Macroscopically examined, this porphyritic, granophyric, potash-soda, biotite-microgranite [5885] is medium-grained and consists of pinkish-red feldspar, semi-vitreous to smoky quartz and fine-grained biotite. Occasional feldspar crystals are well over 1 cm. in length. As seen under the microscope, the texture is decidedly porphyritic. Feldspar, quartz, and biotite phenocrysts are embedded in a matrix of fine-grained feldspar and quartz. The ratio of phenocrysts to matrix is about two to one.

Most of the feldspar is considerably clouded and has a pale brownish tinge in reflected light, due to finely-disseminated iron oxide. It appears that, among the feldspar phenocrysts, potash-bearing varieties—orthoclase, orthoclase partly inverted to microcline, microcline-perthite and perthite—are predominant, while in the groundmass plagioclase is greatly in excess and may even exclude the others altogether. In the compound feldspars the plagioclase is in the form of straight-sided tongues whose disposition suggests that the potash-feldspar may have been attacked by late-magmatic soda-rich solutions and partially replaced. The great abundance of plagioclase in the matrix lends support to this idea. This latter feldspar is very often in the form of graphic intergrowths with quartz; thus the groundmass has a granophyric character. The graphic intergrowths frequently form a complete shell around phenocrysts, especially those of quartz.

The composition of the plagioclase could not be determined in the slide, but as indicated by the norm it must be about 100% albite. As no calcite could be found in the section at hand and, on the assumption that none is present, the plagioclase cannot be more basic than $Ab_{97}An_3$.

The quartz, which is sometimes subhedral, contains abundant gas-liquid inclusions. The feldspar crystals are subhedral to euhedral. An average value for the size of the porphyritic minerals is about 2 mm., though many grains are up to 5 mm. across.

Biotite makes up about 2½% of the rock. It must be a highly ferriferous mica in view of the very low value of MgO in the analysis. The mica is pleochroic from very dark greenish-brown to yellow-green with a brownish tinge. In some places haematite has separated from it as a result of partial decomposition.

Other minerals present are fluorite, black iron ore and a little, altered, golden-yellow allanite. Small grains of the first of these are often an intense purple, while patches of larger grains are also strongly coloured. Oxidation of the iron ore has given rise to rather marked strains in the vicinity of that mineral.

A chemical analysis by E. R. Segnit appears in the table on page 200. The molecular proportions of potash and soda are: 68·2 of Na_2O and 44·5 of K_2O.

The norm is as follows:

Quartz	35·64	Haematite	0·32
Orthoclase	25·02	Apatite	0·10
Albite	35·63	Fluorite	0·39
Corundum	0·30	Calcite	0·10
$MgSiO_3$ (en.)	0·10	Water	0·65
Magnetite	1·16		
Ilmenite	0·15	Total	100·56

C.I.P.W. Classification: I, 4 (3). 1. 3 (4) (Liparose).

Uncle Tom's Cabin

In the neighbourhood of Uncle Tom's Cabin (also in the Hundred of Willalooka), an outstation of the former Didicoolum sheep station, there is a line of granitic outcrops trending in a direction 65° to the east of south (true). The surrounding country is mainly a flat expanse of low heath-like scrub; localities where granite occur, either appearing at the surface or where it lies beneath shallow sandy surface formations, are marked by the appearance of patches of trees whose existence is made possible, no doubt, by the conservation of ground-water on the irregular surface of the granite. A well put down through the sandy surface formation at Uncle Tom's Cabin taps water 15 feet below on the surface of the granite.

The outcropping granite belt is about 200 yards wide and extends in a broken line for over three-quarters of a mile. In that distance there are four rock masses rising to a maximum height of somewhat more than 50 feet above the surrounding plain. There is a general uniformity in the character of the rock of all the outcrops, though portion [5887] of number three outcrop from the north end is somewhat lighter in colour than the others. Also, there are represented transitional types between the more characteristic, porphyritic microgranite type and an almost normal plutonic granite.

The rock [5886] from the most north-westerly outcrop is porphyritic, potash-soda, hornblende-biotite, microgranite. Embedded in a fine-grained groundmass there are crystals of flesh-coloured and some yellow-coloured feldspar, smoky and vitreous quartz and some dark ferromagnesian mineral. Certain of the feldspars are roughly tabular and over 1 cm. in length. The ratio of phenocrysts to groundmass is in the order of between 1·5 and 2 to 1.

Although the general structure of this rock is related to that of [5885] there are three notable differences, namely, that here the feldspar phenocrysts are about three times the diameter of the quartzes, whereas in [5885] they are not much larger; also, the groundmass is more or less even-grained and is not noticeably granophyric; finally there is here a second generation of feldspars, which is not altogether absent in [5885], though much less easily distinguishable.

The average grain-size of the several minerals of this rock is as follows: porphyritic feldspars, 6 mm. x 4 mm., though some exceed 1 cm. in length; porphyritic quartz, 1·5 mm., but many grains up to 3 mm. in diameter; second generation feldspars, about 1 mm. but variable; groundmass (quartz and plagioclase), 0·2 mm.

This rock is even more rich in soda than [5885] because nearly all of the large porphyritic feldspar is anhedral to subhedral antiperthite, whose plagioclase-component appears to have an anorthite content of 5% or less; zoned plagioclase and a little perthite are also among the larger crystals. The soda-lime feldspar, whose composition ranges from acid oligoclase in the cores to albite in the periphery, sometimes occurs in glomeroporphyritic groups. Crystal intergrowths and complex twinning are not uncommon in the antiperthite, which, in addition, always shows excellent albite twinning and sometimes pericline. The second generation feldspars are predominantly albite (An_5 or less) which may be slightly zoned, but antiperthite and perthite are fairly well represented. All of the feldspars are generally very much clouded, but least change has taken place in the second generation plagioclase (which may be almost free from it) and in the outer zones of the large subhedral phenocrysts of that mineral. Evidence in this rock again points to a progressive enrichment of the mother-liquor in soda as crystallization proceeded, for the second generation feldspars are largely albite, while one large crystal of plagioclase-poor perthite was seen to be bordered by a strongly-developed antiperthitic shell of varying width. It, therefore, appears that the bulk of the antiperthite and perthite was formed from slightly perthitic potash-feldspar by the action of soda-rich liquid.

The quartz contains a few gas-liquid inclusions; it is occasionally found in graphic intergrowth with late-crystallizing plagioclase.

Biotite and minor amounts of hornblende make up about 6 or 7% of the rock. The mica, which is usually in aggregates, is pleochroic from almost black with a greenish tinge to golden-brown when fresh; when bleaching has taken place, the colour-change seen is from dark greenish-brown to yellow. One grain of hornblende was observed to be pleochroic from deep red-brown to golden-brown, but this seems to be exceptional, for most grains have X = greenish-brown, Y = Z = very dark greenish-brown. Apart from occurring in fair-sized books, biotite, in very small flecks which sometimes have common orientation, is rather evenly distributed in many of the grains of antiperthite; some of these flecks have changed to green chlorite.

Of the remaining minerals, fluorite, calcite, black iron ore, zircon and pale yellow-brown, slightly pleochroic altered allanite often accompany biotite. The hornblende is veined and partly or wholly replaced by oxides of iron, probably goethite and some haematite; a few scattered streaks of the latter are found in the light-coloured minerals also. Sericite and a little calcite have been developed in the plagioclase crystals, especially the early-formed ones.

A lighter-coloured rock [5887], in the hand-specimen differing mainly from the foregoing [5886] in that the feldspars are near-white in colour, not reddish, occurs in the third outcrop from the north-west end of the Uncle Tom's Cabin locality. This porphyritic, potash-soda, hornblende-biotite-microgranite [5887] has not been analysed, but it is probably less sodic than rock [5886].

Evidence for this is that the first generation of feldspars, which are slightly-perthitic crystals of orthoclase, are much less extensively replaced by late-magmatic perthite and antiperthite. However, some of the smaller ones, and even some of the larger ones, have been completely made over, but the changes have been rather patchy. The groundmass of this rock is somewhat finer-grained and relatively more abundant than is the case of [5886].

As far as could be determined, the plagioclase in the antiperthite is about An_7. Some of the large phenocrysts of plagioclase are bordered by antiperthite, and perthite whose plagioclase-constituent is in optical continuity with that in the phenocrysts. Occasionally marginal plagioclase bears the same relationship to perthite and antiperthite.

Other minerals present are quartz, hornblende, biotite, black iron ore, goethite, allanite, fluorite, zircon and a few needles of apatite.

Biotite, pleochroic from very dark almost opaque reddish-brown to golden-yellow, is quite subordinate to the hornblende, whereas the reverse holds in [5886]. The hornblende occurs in very irregular grains which tend to be poikilitic towards the granular quartz and feldspar of the groundmass. Its pleochroism is as follows: X = light greenish-brown, Y = very deep greenish-brown, Z = deep brownish-green; in one large grain of this mineral there is a lighter green core of amphibole. An interesting feature of the amphibole and mica is that they are never bordered by or included in the large feldspar crystals, but always occur in the groundmass. This fact supports the suggestion that a considerable amount of re-hashing went on during the last stages of consolidation, and it may also account for the very irregular outlines of the grains of hornblende and biotite.

Goethite often borders and seams the hornblende of which it is an alteration-product, and also occurs in small flecks in the groundmass and phenocrysts. It is very difficult or impossible to distinguish it from biotite in many cases, for their colours are almost identical. It, too, is undoubtedly a late-magmatic product.

Allanite has the same mode of occurrence as the ferromagnesians. Its outlines are usually quite irregular; generally it is fresh and pleochroic in shades of golden-brown, but marginally it may be altered and show aggregate-polarization. Some of the smaller grains have suffered complete change. The crystals of zircon are up to 0·15 mm. across; they are often embedded in hornblende, wherein they give rise to pleochroic haloes.

Another part [5892] of the same outcrop (No. 3) is of a warmer-toned granite than [5887], and not unlike [5886] but less porphyritic in appearance. In it, microperthite is much more conspicuous than is the case in [5887]. Hornblende, pleochroic from medium yellow to dark green, is a conspicuous constituent, but biotite is scarce. Small grains and rods of zircon are common, mainly in association with ferromagnesian minerals. Several distinct grains of fluorspar were also detected. Occasional calcites are to be seen with sharp and clear-cut boundaries and the appearance of being primary constituents of the rock.

Johannsen (4, p. 238) in discussing "calcite granite" makes reference to several records where calcite occurring in granite has been regarded as a primary mineral. The literature quoted indicates, amongst other things, the impossibility of calcite forming as an original crystallization in magmas, like granites, which are supersaturated with silica.

In the case of our rock [5892] which is fresh and unweathered, the calcite is certainly not secondary in the fullest sense, namely, resulting from mineral changes effected after complete and final cooling of the crystallised magma.

Actually the identity of our mineral as calcite has not been completely determined, but it has been established as a carbonate mineral of the calcite group.

In slides of rock [5892] there are to be seen "calcite" individuals up to 0·6 mm. in diameter which are perfectly homogeneous and optically continuous, with sharp line contacts against adjacent quartzes, which latter are idiomorphic against the calcite. The calcite formation is thus subsequent to the crystallization of the quartz. Elsewhere in the microscope sections calcite is seen in optically continuous individuals, apparently as arrested replacements of biotite; it forms tongues penetrating and extending along the cleavages of the latter mineral.

The phenomena presented suggest that the calcite has developed as an autometamorphic reaction-mineral during the final pneumatolitic stage of magma solidification. Some of the evidence suggests that it is possibly original fluorspar which has been reduced to calcite by reaction with alkaline carbonates.

Specimen [5891] exemplifies the rock from No. 4 outcrop at Uncle Tom's Cabin. In character it represents a transition between the porphyritic microgranite [5886] and a normal plutonic granite. The ferromagnesian mineral is almost exclusively hornblende; only odd wisps of biotite are to be seen. Zircon is plentiful. Several patches of magnetite and a tiny scrap of allanite are present. Some tiny isotropic spindles embedded in the biotite appear to be fluorspar.

Gip Gip Rocks, Hundred of Peacock

Along the brow of some high ground located about 11 miles to the north of Old Marcollat homestead, and recorded as Gip Gip Rocks on one of the maps of the Hundred of Peacock (Jip Jip in some of the older records), granitic rocks outcrop in several places. We were unable, on account of limited time available during our visit, to fully investigate this area, but specimens from two of the outcrops were collected. They are both much weathered. The first [4416] resembles somewhat the rock [5885] located five miles east of Uncle Tom's Cabin, but is a nearer approach to a medium fine-grained biotite granite. The other specimen [4433] is an aplitic biotite-microgranite very similar to [4434], which latter is a narrow band cutting across the Kongal granite mass.

POTASH-SODA QUARTZ-PORPHYRIES

Mount Monster

At Mount Monster (pl. XI, fig. 2), situated seven miles S.S.W. of the town of Keith, there is a boldly outcropping mass of quartz-porphyry. Within a mile to the north and two miles to the south-east of the central mass there are other outcrops of porphyry differing in petrological character from that of Mount Monster itself.

The chemical analysis of this latter rock [4426] is stated in the table on page 200. The molecular proportions of potash and soda are 57·8 of K_2O, 57·3 of Na_2O. The norm is as follows:

Quartz	30·04	Ilmenite	0·41
Orthoclase	32·25	Apatite	0·34
Albite	29·87	Fluorite	0·09
Anorthite	2·78	Calcite	0·35
Corundum	0·25	Pyrite	0·04
$MgSiO_3$	0·30	Water	0·68
$FeSiO_3$	1·66		
Magnetite	0·93	Total	99·99

C.I.P.W. Classification: I, 4, 1 (2), 3 (Liparose-Toscanose).

The Mount Monster porphyry is a reddish-brown rock with, as its most outstanding character, a great abundance of (about 50% by volume) porphyritic crystals.

The devitrified base is of a liver-brown colour. The quartzes are smoky and the porphyritic feldspars are pinkish-buff coloured.

In microscope slide the orthoclase individuals, which are abundant, are seen to be largely rendered "dusty" when observed in transmitted light. Plagioclases, which are less abundant, have also suffered in the same way. Where suitable for optical tests, the plagioclase has the characters of nearly pure albite ($Ab_{95}An_5$); this is in close correspondence with the norm. The ferromagnesian mineral is biotite but most of it has been altered to secondary minerals, mainly chlorite. Accessories are zircon, fluorite (rare), black iron ore with marginal leucoxene, some brown allanite which has suffered partial breakdown to secondary products and, finally, there has been noted one cluster of calcite.

As it is intended at a later date to investigate the petrological characters of the several other porphyries of the Mount Monster area, further discussion will be reserved until then. In the meantime, all that it is now necessary to emphasise is that the chemical analysis and other petrological characters link these Mount Monster rocks with the fluorite-bearing potash-soda granites already shown to be so widely developed in the South-East of the State.

SUMMARY

The location of occurrence and the petrological description of many igneous rocks, including potash-soda granite, potash-soda microgranite, quartz-keratophyre, whose outcrops are distributed through over 1,000 square miles of South-Eastern South Australia, have been given in some detail in the foregoing account. All are believed to be of pre-Ordovician age. The fluorite bearing granites are an eastern extension of those already known from Murray Bridge and the Coonalpyn region. The quartz porphyries are microgranites or effusive equivalents of the same granites. The quartz-keratophyres are taken to be palaeotypal, leucocratic, soda-rhyolites of middle to late Cambrian age.

In one area, Didicoolum, these keratophyres have suffered shearing stresses and are presented as localised analogues of regional metamorphism. These sheared and otherwise metamorphosed keratophytic rocks are believed to represent South Australian equivalents of the "porphyroid series" of Western Tasmania.

Fig. 1 Whale-back outcrop of Adamellite in the Reedy Creek swamp water-course, located 4 miles east of the head of the Upper Coorong.

Fig. 2 Soda-Rhyolite Outcrop, Section 173, Hundred of Minecrow

Fig. 1 Outcrop of potash-soda microgranite located 5 miles east of Uncle Tom's Cabin.

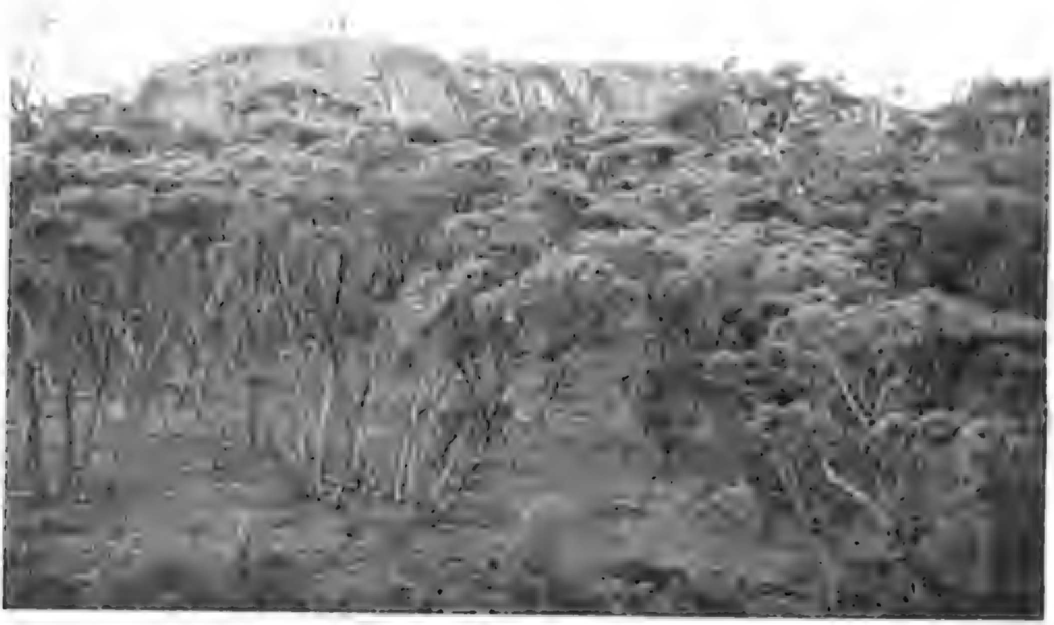

Fig. 2 Outcrop of potash-soda quartz-porphyry at Mount Monster

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A FURTHER ACCOUNT OF THE MURID, PSEUDOMYS (GYOMYS) APODEMOIDES FINLAYSON

By H. H. FINLAYSON

Summary

This is small native mouse, allied to the Western Australian albocinereus, was discovered by Mr. Walter Harvey in the upper South-Eastern district of South Australia in April 1929. Three years later further species having been obtained, the present writer published a preliminary description of the new species under the above name. in Trans. Roy. Soc. S. Aust,. 1932, 56, 170. Since then additional field work, observation of the animal in captivity, and the building up of a much more adequate series of preserved specimens have provided data for the following more extended account. This, while still incomplete in some respects, permits of detailed comparison with other species similarly treated and may lead to a juster estimate of its relation to its allies when these, in turn, are sufficiently known.

A FURTHER ACCOUNT OF THE MURID, PSEUDOMYS (GYOMYS) APODEMOIDES FINLAYSON

By H. H. Finlayson

[Read 10 August 1944]

Plates XII to XV

This small native mouse, allied to the Western Australian *albocinereus*, was discovered by Mr. Walter Harvey in the upper South-Eastern district of South Australia in April 1929. Three years later further specimens having been obtained, the present writer published a preliminary description of the new species under the above name, in Trans. Roy. Soc. S. Aust., 1932, **56**, 170. Since then additional field work, observation of the animal in captivity, and the building up of a much more adequate series of preserved specimens have provided data for the following more extended account. This, while still incomplete in some respects, permits of detailed comparison with other species similarly treated and may lead to a juster estimate of its relation to its allies when these, in turn, are sufficiently known.

The writer records his appreciation of the co-operation of Mr. Harvey, in all matters attending the field work upon the animal, the results of which have been much enhanced by his ready and generous help.

Distribution and Habits

Practically the whole series obtained so far has come from a comparatively small area on Mr. Harvey's holding in the Hundred of Coombe, and the only extension of range which is definitely based upon specimens taken is at Pringatoola, 27 miles west-south-west of Coombe and within eight miles of the Coorong coast. Less definite but still reliable evidence, derived from the presence of its characteristic burrows and tracks and middens thereon, indicate its occurrence at several other points in the counties of Cardwell and Buckingham, both east and west of the railway. Combinations of topography, soils and vegetations quite similar to that of the type habitat at Coombe are to be found over a wide area in the Murray Mallee and South-Eastern Divisions of South Australia and adjacent tracts of other States, and it seems certain that it will eventually prove to have a wide distribution herein; so far, however, neither observation nor enquiry supported by the submission of specimens, have disclosed the animal beyond the above mentioned counties.

The type locality at Coombe lies just within the limits of the South-Eastern District, but in topography and general aspect is quite similar to much of the so-called Ninety Mile Desert, further north in Chandos and Buccleuch. The general relief is lower; the considerable east and west limestone ridges of the Upper Desert are absent and the sandridges with their characteristic serrate profiles are replaced by lower undulations or isolated hills. There is a fairly sharp partition of soils into reddish loams of moderately firm texture and pure white sand, with corresponding local differences in vegetation. The loamy flats are now frequently cultivated, but primitively support a sparse savannah of the so-called Desert Gum (*Eucalyptus fasciculosa*), which here tends to be considerably larger than further north and commonly attains to 30-40 feet in height, and in some favoured oases to considerably more; the floor is here open, sparsely grassed, but frequently carries abundant Triodia (*T. basedowi* and *T. irritans*). The white sand tracts support a dry type heath with honeysuckles (*Banksia marginata* and dwarf *B. ornata*), bulloak (*Casuarina pusilla*), needle bush (*Hakea ulicina*), yacka (*Xanthorrhea australis*), white mallee (*Eucalyptus angulosa*) and broom (*Baeckea* spp.) as the chief of the taller shrubs, while in the undergrowth the more prominent species are, *Adenanthos terminalis*, *Brachyloma ericoides*, *Astroloma conostephioides*, *Daviesia brevifolia*, *Leucopogon woodsii*, *Correa rubra*, *Thomasia petalocalyx*, *Hibbertia* spp., *Calythrix* cf. *tetragona*, *Leptospermum myrsinoides*, *Kunzea pomifera* and *Lepidosperma laterale*.[1]

Dense, uniform mallee communities of large extent are not a characteristic feature, as they are further north. The annual rainfall of 20 inches is considerably higher than in the Desert, and the heath undergrowth tends to be denser and richer in species.

So far the new species has been taken only in the sandy heath country, where it lives in scattered isolated colonies, with much apparently suitable country unoccupied. Its mode of life is very unobtrusive; it is almost strictly nocturnal, does not invade houses nor camps nor cultivated ground, and even in the immediate vicinity of its living sites it is seldom sufficiently numerous to cause any appreciable disturbance in the vegetation in feeding, or to make obvious pads. The sand heaps at its burrows at certain times of the year are practically the only external evidence of its presence which can be seen, and these, except when newly thrown up, are usually quite inconspicuous. Nevertheless, in spite of this obscurity, it seems somewhat remarkable that in a district that has been settled and farmed for eighty years it should not have been noticed before; none of Mr. Harvey's neighbours had cognisance of it, and the results of enquiry elsewhere have always been negative.

It is satisfactory to be able to record (as a rare good deed of a rather sinister domestic figure) that the original specimen was brought in by a house cat. Attempts at trapping were shortly afterwards undertaken, but the species proved very difficult to take in this way, both with ordinary baits which are generally successful with local murids, and special foodstuffs, and lures such as rhodium and anise oils were unavailing. The next few specimens to be got were found accidentally trapped in empty post-holes, a fate which it sometimes shared with *Dromicia concinna*, which occupies the same heaths. This fortunate accident suggested the deliberate use of pitfalls as a method of capture. The venture was quite successful, and nearly all subsequent catches were got by this device. The method followed was to sink ordinary post-holes about nine inches square and three feet deep, at random in the heath; when a catch was made, the holes were multiplied until as many as twenty in an acre were in use. In this way, ten have been taken in a night, and in most cases the catch was found alive and quite uninjured. The captives usually accepted their fate, temporarily at any rate, with resignation, and sought additional shelter by excavating a cavity into the wall of the hole at the bottom, whence as many as five close-packed adults have been removed in the morning; a few, however, escaped from time to time by the feat of climbing the vertical friable walls, and still others by driving nearly vertical shafts from the shelter pocket to the surface.

There is a marked periodicity in the success of the pitfall; the holes have been left uncovered at all times of the year, but practically all catches have been concentrated into the period of autumn and early winter, and within this period again there is unmistakable evidence of heightened activity immediately before or during

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(1) I am indebted to Miss Constance Eardley, of the Botany Department of the University of Adelaide, for naming the collection of plants made at Coombe; a few species were indeterminate through absence of flowers or fruit, but the above list includes all which are quantitatively important in the habitat of *apodemoides*.

rains and at times of unsettled weather—a trait of the species strikingly confirmed later in captivity. During the summer months it virtually disappears at Coombe, but whether through some change of habits placing it beyond easy observation, or through a definite exodus to other areas, is still uncertain.

The animal is an expert burrower and makes elaborate and relatively large warrens in which, during the cold weather, the whole of the daylight hours are spent, and in which the young are born and reared. The chief external evidence of a burrow site is a heap of white sand thrown up behind a circular aperture of about one inch in diameter, both commonly at the base of a heath banksia. This entrance, however, is but a temporary one, opened in autumn for renovation of the interior, and it is soon afterwards closed from within by a long sand plug. The real entrances are at a considerable distance from this one and unlike it, are very inconspicuous and take the form of circular popholes communicating with nearly vertical shafts. The general topography and architecture of the warren is shown in the scale diagram (fig. 1) of a comparatively elaborate one excavated at Coombe in June 1933. The following itemized description will serve as a legend for this diagram:

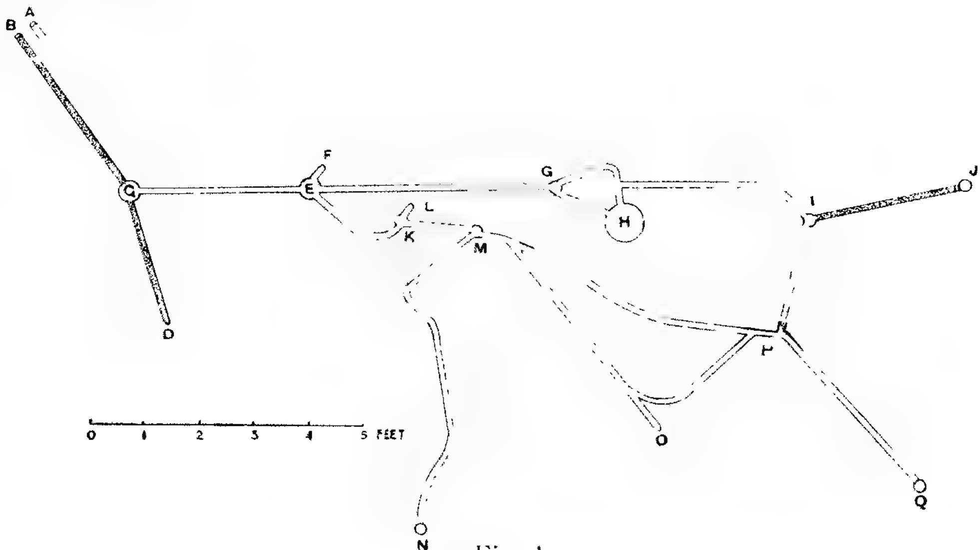


Fig. 1

A, trial opening, abandoned. B–C, the opening drive; horizontal diameter one inch, vertical diameter 1½ inches; descending evenly from ground level at B to 18 inches at C; this drive is now disused and functions as a dump, being loosely packed with sand from other parts of the galleries. C, a circular chamber, approximately three inches in diameter, such as commonly occurs elsewhere at major junctions. C–D, the first lateral drive descending to two feet at D, and sand plugged like B–C. C–E–G–I is the main longitudinal drive, maintaining a nearly constant direction except opposite the nest, where there is an acutely angled bypass; it descends to a maximum depth of about two feet six inches at the nest. E. G. I. K. M. are circular chambers of varying size, analogous to C. F, L, O are short drives used as dumps and loosely packed with sand. H is the nest chamber; it is a spherical cavity with a diameter of six inches and has two short independent tunnels connecting with the main drive, and can thus be completely by-passed by the ordinary traffic of the warren. The nest almost fills the sand cavity and is beautifully fashioned of finely shredded bark fibre, derived from a plant not yet identified, but apparently not occurring in the immediate vicinity of the burrow. In the centre of the mass is an inner cavity, smoothly lined with carefully adjusted leaves of *Banksia marginata*, and when opened it was found to be occupied by four nestlings of about 10 days' growth. I–J is a continuation of the main drive which has been used as a sand dump in the same way as B–C; it rises slightly towards J, where it suddenly terminates in a nearly vertical shaft, leading directly to the surface two feet above; both vertical shaft and pophole are open, but of course isolated from the rest of the system and non-functioning. E–M–P–Q is the main lateral system and, with its branches, is similar to the main gallery, but over its middle course is from three to six inches deeper. The drives, P–Q and M–N, rise slightly towards their extremities, where they are converted abruptly into nearly vertical shafts, reaching the surface two feet six inches above the points Q and N, in the form of circular apertures of one-and-a-half inches diameter; these two popholes were the only functioning entrances and exits discovered, and presumably are used indifferently for both purposes.

Apart from the nest chamber, no other cavities suggesting living quarters were found, and, apart from the breeding nest, there was a complete absence of vegetable matter which might serve as fodder or bedding; the tunnels everywhere showed clean, smooth sandy floors free from excrement, and the nest was dry and non-odorous. Defaecation on the surface is sometimes concentrated upon middens, as mentioned above. The circular chambers at the junctions of passages are possibly made in the first place to facilitate the work of burrowing, and then left to facilitate traffic, though if this is so it is curious that this feature is not always present, even at three-way junctions. The combined lengths of all galleries in this warren, including the three vertical shafts, was approximately 60 feet, and the estimated weight of the moist sand displaced 40-50 pounds; a work of considerable magnitude for so small and delicate a creature. The volume of the sand in the dumps external to the warren was, unfortunately, not ascertained, but that it does not represent the whole volume displaced is clear from the obvious use made of unwanted passages, for the accommodation of part of it. The plug of replaced sand was always found to have a looser texture than the virgin consolidated soil, and a slightly different colour also, so that there was little difficulty in following the course of these packed tunnels by visual inspection during the digging.

Each excavation appears to be originally the work of one breeding pair, but the part-grown young of one or more litters may share the shelter with the parents. Seven individuals is the maximum number taken so far from one system. When young examples taken in a pitfall are released near a burrow, they will not enter unless they are satisfied that it is their own domicile. Uncertainty still prevails as to the duration of occupation of the burrow. Excavation of new holes and renovation of old ones is first noticed in early autumn, when the dumps of recently turned white sand at the entrance hole are, for a time, rather conspicuous. As this time also marks the beginning of the chief reproductive period, there seems no doubt that the two activities are correlated, and that the excavation is made primarily as a shelter for the young. Investigation of the warrens in summer is not sufficiently complete to prove that a general vacation of the same takes place, but there is much evidence in support of this, and at Coombe, the only examples taken on the surface in daylight have been in midsumer. At the Coorong site of Pringatoola, where it was trapped in late November, there was no evidence of burrowing, though it was so plentiful as to form noticeable pads in some favoured spots, with well-used circular middens; features never seen at Coombe.

Observations on the animal in captivity show that it is rather intolerant of heat and, as the local summer is a severe one, it is difficult to see why it should forsake the coolness of its underworld for the discomfort of the surface. It is possible, of course, that the move is involuntary and forced upon it by changes in the texture of the drying sand; similar considerations have been shown to operate powerfully on the burrowing habits of some old world Muridae.

The natural enemies of the species at Coombe are probably chiefly predatory night birds. Burrows partly dug out by foxes have, however, been observed, and Mr. Harvey on one occasion found a small brown snake (*Demensia textilis*) within, and on another a spotted Pardalote (*Pardalotus punctatus*). Neither this snake, taken *in situ*, nor others taken at random in the district, contained *apodemoides* in the stomach, though they did contain house mice.

In general aspect the mouse is exceedingly delicate and attractive and remarkable for the prevailing pallor, not only of its pelage but of all exposed epidermal areas as well, which are nearly destitute of pigment and appear bright pink in life. In size and bulk, *apodemoides* is somewhat larger than an average house mouse, but is very dissimilar in general appearance and mannerisms. The build is rather squat as to body but with light slender appendages; the squatness is especially characteristic of some subadult phases, but in all is exaggerated, as is also the apparently large size of the head, by the erect and profuse pelage.

Observed in captivity, its slow movements and some of its postures are by no means graceful; when deliberately investigating its surroundings in a new cage, it has a curious pottering uncertain gait and the long slender tail is carried in a rather odd way, well clear of the ground and sometimes arched over the back. When startled, however, or otherwise excited, it is capable of movements of lightning-like rapidity and great precision—in both respects recalling *Notomys*. As noted above, examples on more than one occasion made their escape from vertical three-foot holes by climbing the sides, but in captivity it shows little inclination or aptitude for climbing. Much of its time, when stationery, is spent reared up on its haunches, when it assumes a comical, almost globular shape; its feeding is usually done so, and, if of suitable size, each particle such as a grain of seed or a berry, is taken delicately in the two hands and brought up to the mouth for the incisors to work upon, which they do with the utmost precision and speed and control, rejecting in the case of a wheat grain the whole of the husk, so that the cages soon become carpeted with discs of bran. Its feeding, indeed all its activities, are interrupted abruptly and frequently, for the toilet of the coat, which it keeps in immaculate condition; the toilet is done largely by the manus and incisors, the mystical vibrissae receiving especially frequent attention.

In temperament it is both brisk and adaptable, docile and confident. Its nonchalance in the pitfall has already been mentioned; when removed by hand it showed little resentment and made no serious attempt to bite. When transferred to box cages and compelled to live in radically strange surroundings and upon a totally new and unaccustomed diet, it retained a cheerful activity with every evidence of comfort and content.

The cages used for parties of from five to ten were airy boxes three feet by three feet by two feet, with two glass sides and two of wire gauze to facilitate observation and ventilation and cooling, respectively. Shelter and nesting boxes with light hinged lids, and packed with wood-wool and cotton for nesting material, were provided, and were at once approved and adopted by the mice, but their sense of security evidently demanded emergency exits, which they promptly supplied by driving popholes through the deal walls. The cages were kept under a roofed shelter in a comparatively subdued light, and under these conditions they frequently left the nest during daylight for short tours of the cage, but all their main activity remained definitely crepuscular and nocturnal and involved an immense amount of coming and going, as the quantity of sand shifted plainly showed. The floor of the cages was covered with a layer of sand two inches deep.

and it was early discovered that a moist atmosphere was greatly appreciated. On several occasions when the sand dried out it was hosed lightly to remoisten it, and the effect on the colony was electrical; the mice left the shelter box *en masse*, though it was broad daylight, and engaged in a most animated display of acrobatics. The chief evolution was a lightning-like looping of the loop, by springing from the floor to a wall, thence to the roof, thence to the opposite wall and down to the floor, each impact, though of scarcely perceptible duration, being sufficient for attaining a new impetus; the looping was repeated a dozen times or more in a continuous series without pause.

They quarrelled very little among themselves, and a dozen might safely be left to share the same quarters; such bickering as did go on was of a mild kind and usually resulted in nothing more serious than tail shortening. One or two cases of fratriphagy were noticed amongst aged specimens, but as no animosity had been apparent beforehand, it was possibly due to a temporary protein deficiency in the diet. The staples of the diet adopted were mixed grain and hard fruits, with an occasional ration of nuts, honey and fat bacon; this proved acceptable and adequate for the maintainance of all normal activity, including reproduction and the rearing of young. Water was always provided in the cages, and in hot weather was frequently drunk, though in the natural habitat it can seldom be available.

The feeding habits of the animal in the wild have not yet been determined by observation; most of the specimens handled had been kept alive for some days pending transit, during which time they were necessarily fed upon an artificial diet, so that a study of stomach contents could disclose nothing, and in the few examples that were taken dead the material contained no recognisable fragments. It may safely be inferred, however, that it is normally graminivorous and frugivorous rather than phytophagous. In trapping, it was noticed that under stress of deprivation it readily lapses into carnivority, partially eaten specimens having several times been found with the living in pitfalls which had not been promptly emptied, and this trait was later confirmed in captivity, as mentioned above. The small vegetation of its habitat is rich in species which fruit and seed freely, such as *Casuarina pusilla*, *Brachyloma ericoides*, *Lepidosperma laterale*, *Kunzea pomifera* and *Triodia* spp., and there is no doubt that these provide the mainstay of its diet.

The animal is rapidly debilitated by high temperatures, and most of the deaths sustained in the captive series occurred during heat waves in mid-summer.

In the wild, several ectoparasites occur, the chief of which is a *Laelaps;* this is very difficult to eradicate in captivity, though it may be kept in check by frequent dusting with pyrethrum; in moderate numbers it apparently works no detriment to the hosts. The animal has no characteristic smell.

Reproduction and Development

Of the entire series of 69 examined, 33 are males, 33 females and three undetermined; fully adults totalled 20, and in the remainder, subadults of medium growth predominate markedly over earlier stages and nestlings; the latter having been obtained by excavation of burrows and by breeding in captivity. The pitfall method of trapping chiefly adopted precludes an adequate representation of the more immature stages, since these are not independently active at night, and is unable, therefore, to indicate accurately the prevalence of reproduction at any one time. Incidentally, it is noteworthy that of adults taken in pitfalls, females are three times as numerous as males.

Sufficient evidence has been obtained, however, to show that the main natural breeding season falls in autumn and early winter. The earliest new-born litters observed were in the third week of May, but advanced nestlings have been found in June also, and knowledge of the life cycle subsequently obtained indicates that these must have been produced as early as the beginning of May, with mating therefore in April. On the other hand, some young collected in November, must by the same argument have been littered as late as mid-August. The apparent absence of a natural breeding season in summer depends largely upon negative evidence, all activities of the species being much more obscure in the hot weather. However, the batches trapped in October and November contained no pregnant females, and of the many females kept in captivity only one became pregnant during the hot months. In captivity, males have been observed attempting intercourse as early as the tenth week, but all pregnant females observed, both in the wild and in captivity, have been fully adult.

In the number of embryos produced there is considerable variation, from four to seven having been observed in *utero;* in the latter case five occupied the right and two the left horn; superior development of the right horn has been observed also in recently evacuated uteri in which the number of young was unknown. Litters of as few as three and as many as six thriving nestlings have been taken, but the normal complement seems to be four, as with most Pseudomyds. Whether a single female may produce more than one litter in a season has not been ascertained.

Testis enlargement in the male is restricted to a very short period, probably only from March to April. Of 20 adult or advanced subadult males trapped between May and November only one showed any scrotal prominence, and this was a subadult. An interesting feature in the series of males reared in captivity is the markedly superior gonad development of subadult as compared with fully adult males. In the wild this has already been noted in some Central Australian species.

Three litters of young have been successfully reared in captivity; two of these were born in captivity of females pregnant when taken, while the third was removed from a nest when about three weeks old. Two of the mothers with normal-sized litters were assiduous in their attentions to the nestlings and, although very gentle and permitting themselves to be touched and handled without resentment, became much agitated when the young were removed. The third, with six young, was overtaxed and apparently unable to nourish them all adequately, and within a few days ejected two young from the nest. They were found stiff and cold on the cage floor, but when restored to the nest quickly recovered, only to be thrown out again the next night; they struggled on for seven days under this nightly rejection before succumbing, and in general all nestlings observed have shown great vitality. They adhere very firmly to the nipples of the dam, and when startled into leaving the nest hurriedly she frequently dragged them with her over the cage, but not as a routine matter as recorded for *Conilurus*, etc.

The females occasionally made a shrill chirruping bird-like call, and the young a more feeble squeak, but both young and parents were less vocal than some other local murids similarly kept and observed.

For the first three months the nestlings were weighed and examined weekly, and the following condensed summary gives the main facts of their development so observed; the weights quoted are averaged for the members of the three litters:

At three days—Weight 3 grammes; eyes shut; dorsum haired nearly black; belly nearly nude, pink and with sharp demarkation from dorsum.

At two weeks—5·5 grammes; coat close, coarse and very dark; belly fur developing fast; white to base.

At three weeks—7·0 grammes; head and body 50 mm; tail 38; pes 14·5; manus 6·5, ear 6; eyes open; dorsal fur 9 mm. long, still dark and shaggy; belly completely furred with the middle areas now dark-based; ears closely adpressed to head; tail sparsely furred but already sparsely sprinkled with dark brown dorsally.

At four weeks—9·0 grammes; dorsal fur more erect and the pale subterminal band just appearing.

At five weeks—10·0 grammes; dorsal coat erect and fluffy and showing much of the basal slate colour and the pale subterminal band.

At six weeks—13 grammes; time of weaning was not observed but the young were now much abroad both day and night, and eating grain and other hard foods.

At seven weeks—14 grammes; moult begun.

From eight to fourteen weeks—Weights were: 14·5, 16, 16, 16·5, 17, 17, 19 grammes, respectively.

At fifteen weeks—Moult completed; most of the young were now heavier than the parents, but still retained many signs of immaturity, especially in the head and body length and in the ear, which was decidedly smaller, and in the thin fluffy ungrizzled coat.

At twenty-three weeks (one example)—Head and body 77 mm.; tail, 80; pes 19·5; ear 15.

In the development of these nestlings an anomaly was met with in the marked precocity of one example, which at an early stage was left (by a series of accidents) the sole survivor of the original litter. At the fifteenth week this example weighed 22·5 grammes, and at the eighteenth week had head and body 76 mm., pes 20, ear 16, outstripping in linear dimensions the young of full litters by five weeks. The point is of some interest as affording a possible clue to the causation of at least part of the apparently capricious variation in dimensions so frequent in several Australian rats.

The growth changes were not followed up into adult life, but it seems unlikely that the mean adult dimensions in nature could be attained in less than nine months, and twelve months is more likely. Evidence derived from the duration of captivity (which has exceeded two years in some cases) and the maturity of such examples when taken, suggests a specific life-span of about four years.

External Characters

The series examined consists of 69 specimens, of which a large proportion have been examined in the flesh before preservation. Twenty are fully adult, and the rest form a developmental series which bridges the gap to the naked nestling stage. Of the total, 25 have been kept under observation in captivity for periods up to 30 months. There is little evidence of change in structural characters having been effected in this way, but for reasons of orthodoxy the statements which follow on the external characters of the species are drawn entirely from the strictly feral material.

Bodily size small to medium, the head and body length averaging 85 mm. and reaching 93 mm., and the live weight about 16 grammes. Build moderate; appendages slender and long. The relative head size is much as in such forms as *Ps.* (*Leggadina*) *hermannsburgensis*; the ratio, head and body length: skull length, about 1:30 as in that species, but the fur contour has an enlarging effect. The fur profile of the head is convex with a prominent erect tuft in the anterior nasal region, due to an opposition ridge just behind the rhinarium. The eye rather prominent with a diameter from canthus to canthus of 3·5 mm., approximately; well fringed with black lashes. Mysticial vibrissae very strongly developed; the longest bristles about 35 mm.; the anterior members white, the posterior black, and the intermediate (and longest) black with white tips. The supraorbitals, 22 mm. long, and entirely black; genals weak or lacking. The ear very large; length to 18 mm.; breadth across the trough of pinna to 9 mm. The development of the ear exceeds that of the eremian *minnie* and approaches that of the less specialised species of *Notomys;* its length is about 20% of the head and body length. The substance of the ear is thin and membranous, and pale except at the extreme margin, where slight epidermal darkening takes place; in life it is a delicate pink, as are all exposed areas of epidermis.

Manus, length to 8·5 mm., breadth transversely across palm from base of second digit to 3·5 mm. and third digit 3 mm.; rather slender in general proportions, but (as is frequently the case) appearing stouter in many subadults in which the palmar structures are plumper and broader than in calloused adults. The palm pale pink and unpigmented; its central area markedly granular, the granularity extending to the basal portion of the underside of the digits, where the transverse ridges are broken into rows of granules and are not continuous as is usual. The grooving of the digits is deep and prominent, averaging eight upon the third digit. Claws rather stout, their free projection about equal to the apical pads; moderately fringed, but the hairs not quite reaching the claw tip. Ulnar carpal vibrissae large—reaching 7 mm. Palmar pads of moderate size and development; conspicuous more from the granularity of the surrounding areas than by their own relief, which is but moderate in adults; the outlines of the pads are well defined anteriorly but are sometimes indefinite posteriorly, where the relief is much lower. In a few subadults the pads are very strongly developed, with their anterior portions lifted free of the palm, and their margins somewhat angular, as in *Leporillus*. All pads smooth or very faintly striate.

The detailed shape and relative development of the pads is subject to much variation. The carpals are always much larger (though variably so) than the interdigitals and are relatively narrow. The outer is longer than the inner, and most frequently has at least twice its area; the inner has a well-marked accessory fold adjoining the pollux. The first [2] interdigital is usually round, but may be subtriangular or bell-shaped; the second or median interdigital is rather constantly pyriform, and the third which is shaped (and varies) like the first, has usually either a small satellite at its postero-external corner, or a low heel formed by the conjunction of two smaller satellites; quite frequently, however, both these accessories are absent. In point of relative size, there is a marked tendency for the median interdigital to be dominant and the laterals subequal; when the laterals depart from subequality, $3 > 1$ more often than $1 > 3$. Subequality of all three interdigitals is rare, but is more frequent in subadults than adults.

Variation of all the pads, both carpals and interdigitals, is to a large extent truly individual, and most of the variants may be found in nestlings of 17 days' growth. While these differences are confusing when a few examples only are compared, systematic examination of the whole series leaves no doubt that the arrangement most characteristic of the species is: outer carpal > inner carpal > second interdigital > third interdigital = first interdigital.

Pes—Length to 22·5 mm., breadth transversely across the sole from the base of first digit, to 3·5 mm., and the third digit to 5 mm. General form decidedly long and slender, the length averaging 25% of the head and body and the

[2] In these papers the pad which is actually and functionally the first interdigital on the pollical side of the palm, is so numbered in descriptions and formulae, but it is probably homologous with the second interdigital of the primitive pentadactyle manus.

length ÷ breadth ratio, ca. 7·0. The width of the sole maintained posteriorly, not tapering markedly to heel which does not project conspicuously beyond the malleoli. The posterior plantar surface is nearly smooth or with the usual transverse crease lines, but the interdigital portion is characteristically verrucose, as in the manus. The undersurface of the digits well grooved, the third digit carrying ten grooves and the ridges basally broken into rows of granules as in the manus. In some nestlings the undersurface of the digits and the interdigital basin carry scattered hairs. Nails stout; their projection and fringing as in the manus.

Pads of moderate size and prominence; more distinctly striate than in the manus and remarkably constant in general shape and proportion, and thereby in sharp contrast to the manus. The inner metatarsal, narrow and much elongated but with its posterior termination low and vague; it is commonly three to four times the length of the outer metatarsal which is small and rounded or oval; in two examples only is there a departure from this condition, and in these the metatarsals are subequal. The first interdigital large and bell-shaped, the second broadly pyriform or oval and usually differing conspicuously from the third which is smaller and of narrower shape, and the fourth broadly oval or bell-shaped, rarely with a conjoined satellite, and usually subequal or slightly larger than interdigital one.

The pad formula therefore is: Fourth interdigital = first interdigital > second interdigital > third interdigital > inner metatarsal (in area) > outer metatarsal.

The *tail* is almost always longer than the head and body, averaging 118% in adults and 114% in subadults; there are, however, one or two cases of subequality in the feral series, and in the captive series tails shorter than the head and body are not uncommon; there is a suspicion, however, that such cases are due to mutilations which have healed without obvious defect. The tail is slender and evenly tapering and capable of considerable flexure in life. The tip is well covered with the steadily lengthening tail hairs which exceed it by 3 mm.; there is no exposed calloused knob. Scale counts are rather variable, averaging middorsally ca. 19 per centimetre.

Testes relatively small and never greatly swollen; scrotum lightly furred white, and its epidermis unpigmented.

Mammae—Posterior 9 mm. from clitoris; anterior 9 mm. from posterior.

The *vulva* is usually completely occluded in virgin females, and a similar condition may develop in adult females after parturition, if they are denied access of the male. In two cases observed in captivity, it was found that 21 weeks after the birth of litters which were reared in the absence of the male parent, the vulva was almost completely sealed externally by what appeared to be a considerable tissue connection between the labiae.

PELAGE

The original description, which was founded on 14 living or just dead examples holds good with little modification for the whole series, but the additional material permits of some amplification of the first account.

In the limited area from which specimens have been so far obtained the species proves to be one of very constant pelage. Sexual and seasonal variation is scarcely demonstrable, age variations are only marked at early growth stages, and such differences as do occur, therefore, may be regarded as of individual origin and varying incidence of the moult. About 5% of the series are slightly warmer and less glaucus in tone than the type series described; in the coldest blue-grey examples, the colour of the subterminal zone of the fur is near Ridgway's "Tilleul Buff" and the tips of the guard hairs are cold black, resulting in a general dorsal colour near "Mouse Grey"; in the warmer coloured coats the subterminal zone is near "Vinaceous Buff" and the guard hairs terminate in brownish-black.

The ventral fur at base is normally plumbeous throughout, but in one or two examples white-based fur occurs on gulo-sternal and abdominal areas. The ear, when furred grey-brown as described originally, is moderately well contrasted with the dorsal coat; sometimes, however, the ear back is haired with a grizzle of near black and silver, and is then less so. There is in a large proportion of examples a supra calcaneal darkening (formerly overlooked) caused by a grizzling of the white hairs of the lower leg with black or blackish-brown; the effect is usually slight, however, and never forms a prominent marking. The darkening of the dorsum of the tail is very variable; in a few examples it is sufficiently marked to attain a fairly sharp contrast with the whitish sides and lower surface, but usually takes the form of a sparse grizzling of blackish hairs along a narrow dorsal strip extending from two-thirds to three-quarters of its length; the pencilling ceases very abruptly and the terminal one-third to one-quarter is pure white on all surfaces. While the darkest tails are all of adult or aged examples, white tails are less characteristic of immaturity than was thought, and most examples of half-growth show a noticeable pencilling of the dorsum.

The rearing of three litters in captivity enabled the following facts on the early development of the pelage to be ascertained. Within three days of birth the dorsum (which is already pigmented a deep slate) is sparsely haired with black or near black, while the non-pigmented ventrum is pink and hairless and with sharp demarcation. At two weeks the dorsal fur is dense enough to obscure the skin and is close and coarse, while the belly fur which is entirely white is much thinner, though developing fast. At three weeks the dorsal coat is 9 mm. long and shaggy, the first lifting from the prone adpressed condition having begun and the belly fur darkening at the base over the central parts of the area. Even at this early stage (head and body 50 mm.) the coat is already bipilous, though the long black contour hairs are much more numerous than the second pile. At four weeks the second pile is much better developed and has a distinct though dull ashy middle zone, a brownish tip and a short plumbeous basal zone. This condition leads on by increase in amount and length of the second pile and increase in the proportion of the basal blue zone, to the fluffy, erect, blue appearing pelage characteristic of immaturity up to about the head and body 70 mm. stage. This immature pelage is very similar in composition to that of adults, but is sparser, finer and more erect and therefore with a greater exposure of the basal leaden zone; its guard hairs are fewer and both piles are spun out to very attenuated tips, which in the main pile are more frequently brown than in adults, while on flanks and rump a sprinkling of white tips occurs.

The first *moult* begins at about the seventh or eighth week and may not be completed until the fifteenth; spreading downward from the nape its progress can be readily followed by the pale line of demarcation caused by the more prominent ashy subterminal zone of the new coat, as well as by its greater density and grizzling.

In the wild, the adult pelage is evidently subject to heavy attrition, which has the effect of breaking off the points of the black guard hairs and of thinning out the main pile, so that ultimately, in adults, a partial return to the glaucus immature condition is effected. This is made good by a second annual moult, which is well illustrated by one adult example in captivity (in November), in which the entire dorsal epidermis is obscured by a dense carpet of the emerging ashy renewal coat. Although this is the only example actually observed at the change, study of the entire feral series shows that worn and thin pelages are to be found together with rich recently renewed ones on the same dates both in winter and summer, justifying the inference that the time of moult is governed by individual rather than seasonal factors.[8]

In captivity, quite marked changes are induced in the pelage even in one life cycle. At five weeks captive litters are conspicuously darker and longer furred than wild born ones at the same stage, and both distinctions are retained and accentuated as growth continues. Six advanced subadults at the head and body 78 mm. stage show much richer pelage than in any feral examples; the over-all length of the coat (15 mm.) is about the same, but the proportion of guard hairs reaching this length is greater and the main pile is 2 mm. longer and the general density higher. Further, the basal plumbeous and terminal zones are darker and the subterminal zone is more strongly contrasted and richer coloured.

Immersion in 80% alcohol for ten years has produced marked changes in colouration in all but a few of the series so preserved, and a large proportion of these would scarcely be suspected of specific identity with field skins; in particular, the characteristic glaucus tone of the natural pelage disappears very rapidly.

Flesh Dimensions (feral specimens only)

The following figures give, in millimetres, the range and mean values for the dimensions of (1) a group of adults selected as free from any obvious immaturity in external characters, (2) a group of subadults of decidedly inferior bulk, (3) a long-furred independent nestling, (4) a short-furred nestling of approximately 17 days' growth.

	1		2		3	4
	3 ♂	6 ♀	11 ♂	9 ♀	♂	♀
Head and body -	86–80 (84)	93–80 (87)	76–70 (71·5)	78–65 (68·5)	50	45
Tail - - -	108–97 (101)	113–90 (99·5)	96–72 (82)	90–70 (78·5)	70	36
Pes: length -	22·5–21 (21·5)	22·5–20 (21·0)	21–18·5 (19·5)	20–18·5 (19·5)	18	13
Pes: breadth -	—	3·5–3·0 (3·1)	3·5–3·0 (3·3)	3·5–3·0 (3·1)	—	2·8
Manus: length -	—	8·0–8·0 (8·0)	8·5–8·0 (8·2)	8·0–7·5 (7·7)	7·5	6·0
Manus: breadth -	—	3·5–3·0 (3·3)	3·0–2·8 (2·9)	3·0–2·8 (2·9)	2·8	2·8
Ear: length -	18·5–16 (17)	18–16 (17)	17–15 (15·5)	17–13·5 (15)	14	6
Rhinarium to eye	13–13 (13)	14–11 (12)	12–10 (11)	11·5–9 (10·0)	—	7
Eye to ear - -	12–10 (11)	11–9 (10)	11–8·5 (9)	10–8 (9·0)	—	6
Weight (in grms.)	16–12·5 (13·8)	18·5–18 (18)	9–8 (8·5)	8–7 (7·5)	—	—

The dimensions quoted for the species in the original description are well within the range of the adult group, but slightly below the mean values and decidedly below the maxima as now ascertained. The general level of variation in these selected groups of adults and subadults is actually higher in most items than in the eremian *hermannsburgensis;* but the individual and capricious variation involving major anomalies in development as shown by the concurrence of maxima and minima in the same example, such as occurs in several series of Central Australian rats recently reviewed, is absent. Here the occurrence of maxima for pes, ear and tail is always associated with a high head and body value and high body weight, and conversely immaturity can nearly always be detected by low values for ear and tail. The earsize is an especially useful first criterion of immaturity; even advanced subadults may usually be readily recognised by the smaller area of the pinna.

[8] I have demonstrated a similar state of things in the rock wallaby, *Petrogale penicillata herberti.* Trans. Roy. Soc. S. Aust., **55**, (1931), 84

Sexual differentiation in dimensions is very slight and, in adults, of doubtful significance; examination of the subadult series, however, seems to suggest that at some intermediate stages the male develops more rapidly than the female; but the data is insufficient to establish this.

The extraordinarily rapid development of appendages at the fourth or fifth week of life, while the head and body length remains almost constant, is well shown by a comparison of the two nestlings; in the more advanced (4), at the stage of early erect pelage, when the head and body length is still only 59% of the adult average, the pes is already 86%, the ear 82%, and the tail 70%, of their final values.

The effect of captivity upon the linear dimensions of wild born examples is slight, the only demonstrable change being a failure to attain the normal mean ear length of feral examples; young reared entirely in captivity may, as already indicated, attain much greater body weight, but whether their ultimate linear measurements are similarly increased is uncertain, no captive born example having yet reached complete maturity.

Skull Characters

A series of 22 skulls has been examined, all removed from animals of known external characters, dimensions and history; half of them are derived from animals kept in captivity for varying periods, but as with external characters, the following account is based on the feral series alone.

The salient features of the skull in a general view, are its lengthened nasal region, over-all narrowness, and very fragile zygomata. The ossification is light. The general dorsal aspect is fairly constant throughout the series, but there are one or two examples in which an arrested development of the anterior root of the zygoma accentuates the leptoprosopic character, and one such anomaly (the only fully adult example available at the time) was responsible in the original description for the phrase "very peculiar" as applied to its shape; this is now seen to be somewhat over-stated for the series as a whole. Immature skulls, with shortened facial region, are quite similar in general dorsal appearance to the more bulbous forms of *hermannsburgensis*.

Muzzle region as originally given; the point contact with the frontals is variably developed, but usually the termini take the form of characteristic prongs, distinctly separated and penetrating the labyrinth of the fronto-nasal suture. The width of the nasals increases fairly evenly towards a distal maximum, with a slight constriction at the beginning of the terminal third. The maxillary fossae are unusually well developed in old skulls, and the opening of the bursa is conspicuous dorsally. The anteorbital fossa rather large in adults much smaller in immature skulls—the external wall bent strongly inwards. The zygomatic outline varies considerably; in the majority the anterior width is not markedly less than the posterior, and the outline tends to parallelism or even slight concavity, with smooth angles both before and behind; in others, however, the arches are more prominently thrown out from the skull and decidedly wider posteriorly. In the interorbital constriction variation in width is largely individual and not strongly influenced by age; the supraorbital edges, however, show the customary bevelling with advancing development. Lacrymals narrow; their free margin often irregular. Braincase of the suddenly expanded type, and fairly constant in development and shape. Interparietal of moderate size; not spanning the braincase, and its shape crudely rectangular rather than subtriangular and with its interior margin often irregular.

In lateral view, the upper profile is low and little arched and the occiput smoothly rounded, without angularity at the lambda. The margin of the zygomatic plate slopes forwards as stated, but the angle of slope varies considerably, in general being steeper in adults than in young skulls; the condition under all three of these heads very similar to what may be seen in *waitei*, *hermannsburgensis* and *patrius*. The posterior palate is conspicuously wide and flat; the anterior palatine foramina also large, both long and widely open, tapering towards the incisors and in adults with the maximum width nearly always posterior to the midpoint; posteriorly the foramina always reach beyond the anterior margin of M^1 and sometimes reach the lingual cusp of the first lamina. The mesopterygoid fossa large and wide open; in adults the walls are parallel or nearly so, but in young skulls the maximum width is at the palatal margin. The parapterygoid variable; in fully adults the fossa is distinctly developed with a sunken floor and raised ectopterygoid margin (as in the original description); in others (usually subadult) the floor is flat and much less enclosed; the fenestration of the floor of the parapterygoid fossa is remarkably variable also. Bulla decidedly small for the size of the skull and little inflated; its age change, as described under *hermannsburgensis*.

Dentition weak; upper incisors variably ophisthodont; upper molar rows straight and nearly parallel; gradation in size from M^1-M^3 moderate, as in *Pseudomys* s. str.

General structure of molar crowns much as in *Notomys*, the buccal cusp of the first lamina of M^1 obsolete and much reduced on the others. Contrary to the original description, the posterior displacement of the lingual cusp of the first lamina of M^1, is now seen with more suitable material, to be considerable and the obliquity of this lamina is equal to that of *hermannsburgensis* and *patrius* of the group *Leggadina*. There are no supplementary cusps on either upper or lower molars. Mandible weak. Sexual variation inappreciable.

Skull Dimensions

The following figures give, in millimetres, the skull dimensions of (1) four adult males all showing appreciable wear on the first lamina of M^1, and extracted from animals free from any immaturity in external characters, (2) three adult females in the same age group, (3) one subadult female of head and body length 70 mm.

	1		2		3
Greatest length	26·8–25·5 (25·9)	;	26·8–25·0 (26·0)	;	23·2
Basal length	22·1–20·6 (21·4)	;	22·4–20·0 (20·8)	;	18·5
Greatest Zygomatic breadth	12·3–11·8 (12·1)	;	12·4–11·7 (12·1)	;	11·4
Braincase: breadth	11·7–11·5 (11·6)	;	12·1–11·4 (11·7)	;	11·2
Interorbital breadth	4·0–3·7 (3·9)	;	4·0–3·7 (3·9)	;	3·9
Nasals: length	10·0–9·0 (9·5)	;	10·5–8·8 (9·7)	;	8·2
Nasals: greatest breadth	2·5–2·3 (2·5)	;	2·5–2·4 (2·4)	;	2·1
Palatal length	13·7–13·0 (13·3)	;	13·9–12·6 (13·3)	;	11·7
Palatilar length	12·2–11·9 (12·1)	;	12·5–11·0 (11·7)	;	10·3
Ant. Palatine Foramina length	6·0–5·0 (5·5)	;	5·9–5·0 (5·4)	;	5·0
Ant. Palatine Foramina breadth	1·7–1·5 (1·6)	;	1·8–1·7 (1·8)	;	1·4
Bullae: length	3·7–3·5 (3·6)	;	3·7–3·5 (3·6)	;	3·2
Upper molars	3·9–3·6 (3·7)	;	3·9–3·6 (3·8)	;	3·9

In the feral series the agreement in dimensions between examples of the same basal length is close, and these, in turn, are roughly proportional to body size, the variation in this latter group being about 5% in the case of the head and body: skull length, ratio. In the captive series, although little or no structural change can be detected, anomalies in both the above groups of metrical relationships are more marked. Molar wear in both moieties of the series is variable, and if unsupported by other evidence is unsatisfactory as a criterion of age.

RELATIONSHIPS

Material for direct and detailed comparison with *glaucus* and *albocinereus* (apparently the nearest allies of the present species) is still lacking, so that the recorded dimensions remain the chief criteria by which the identities of the three species may be judged. The slight modification to the original figures for *apodemoides*, necessitated by examination of the new series, does not appreciably alter the previous assessment of its position.

The flesh dimensions of *glaucus* may now be completely merged in those of *apodemoides*, but the figures for the skull of the former are all higher except that of the anterior palatine foramina, which is slightly below the mean for *apodemoides*.

With respect to *albocinereus* of Western Australia, the effect of the new data is to close the gap metrically between *apodemoides* and the typical *albocinereus*, so that the South Australian animal is intermediate between the two described varieties of the latter. A large anterior palatine foramen seems characteristic of *apodemoides;* both the maximum length (6·0) and the mean (5·4), exceeding that of the decidedly larger *albocinereus typicus* skull.

EXPLANATION OF PLATES XII TO XV

PLATE XII

A typical habitat of *Pseudomys (Gyomys) apodemoides:* a general westerly view from a ridge near the eastern boundary of the Hundred of Coombe, South Australia.

PLATE XIII

Three views of adult examples of *Pseudomys (Gyomys) apodemoides*, in captivity. (x 0·75 ca.) (The tail shortening in the upper example is traumatic.)

PLATE XIV

A, B, C, Dorsal aspects of the skull of *Pseudomys (Gyomys) apodemoides*, as shown by an immature ♂ example of head and body length 67 mm., by an average adult ♂, and by a very aged ♂, respectively, and illustrating the progressive age changes in the cranial and facial regions. (x 2·8, 2·6, 2·4.) D, Palatal aspect of the skull of the average adult ♂ figured at B. (x 2·6.) E, Lateral aspect of the same. (x 2·6.)

PLATE XV

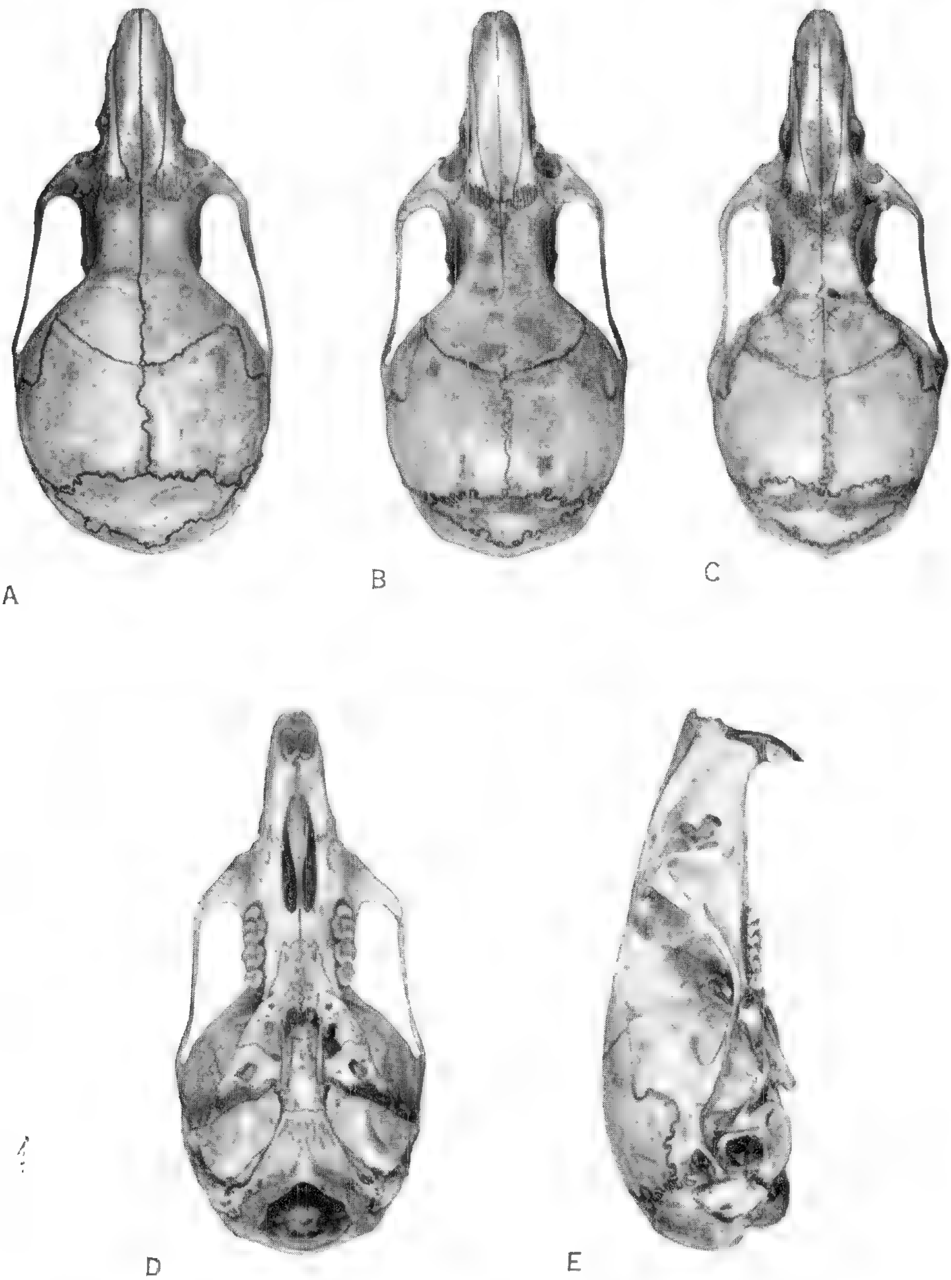
A, B, free margin of the zygomatic plate in an immature ♂ example of head and body length 67 mm., and in an aged ♀, respectively, showing age changes in this feature. (x 9·0 ca.). C, Unworn upper molars of the right side in an aged ♀ (x 9·0 ca.). D, Worn upper molars of the right side in an aged ♀ (x 9·0 ca.) E, Worn upper molars of the right side in a similarly aged example of *Pseudomys (Leggadina) patrius* Thomas and Dollman. (x 9·0 ca.) for comparison of the obliquity of the laminae with C and D. (The supplementary cingular cusp has been deleted.) F, Right pes of an adult ♀ (x 3·3 ca.) G, Right manus of an adult ♀ (x 4·0 ca.), weak type. H, Ditto of another adult ♀ (x 4·0 ca.), stout type.

Photo by H. H. Finlayson

A typical habitat of *Pseudomys (Gyomys) apodemoides*

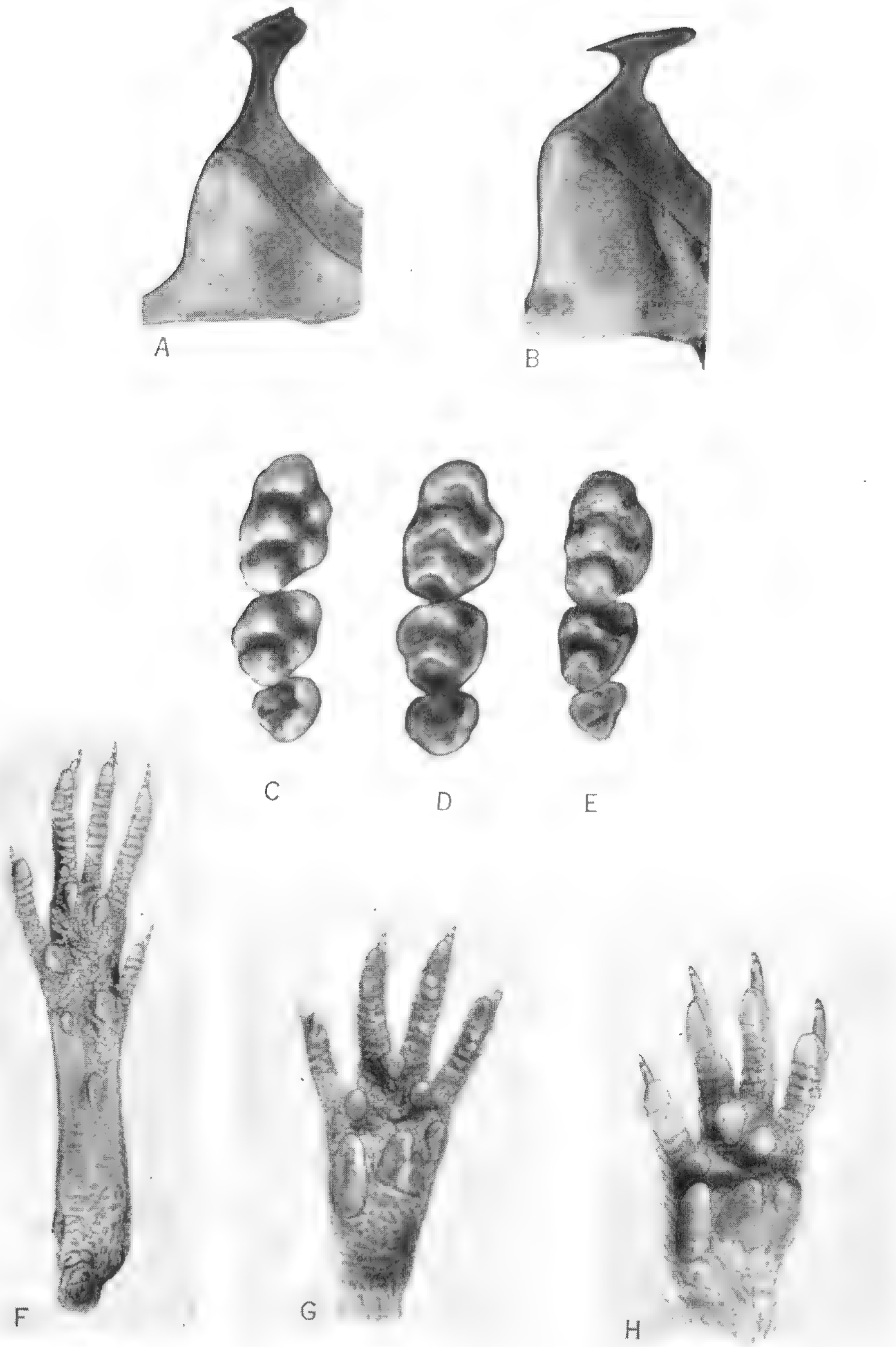
Photo by H. H. Finlayson

Views of *Pseudomys* (*Gyomys*) *apodemoides* in captivity



Skull characters of *Pseudomys* (*Gyomys*) *apodemoides*

Photo by H. H. Finlayson



Skull characters, pes, and manus of *Pseudomys (Gyomys) apodemoides*

Photo by H. H. Finlayson

AUSTRALIAN CUMACEA NO. 8
THE FAMILY BODOTRIIDAE

By HERBERT M. HALE, Director, South Australian Museum

Summary

Herein are recorded further new species, secured mainly by the Fisheries Division of the Commonwealth Council for Scientific and Industrial Research in the shallow waters off eastern Australia.

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THE FAMILY BODOTRIIDAE

By Herbert M. Hale, Director, South Australian Museum

[Read 10 August 1944]

Fig. 1-38

Introduction

Herein are recorded further new species, secured mainly by the Fisheries Division of the Commonwealth Council for Scientific and Industrial Research in the shallow waters off eastern Australia.

A satisfying natural classification of the Cumacea does not seem possible, at least at present. The genera and the grouping of the genera are based largely upon the loss or reduction of parts; this seems unavoidable in an Order embracing forms which, on the whole, are unadventurous in their departures from a basic uniformity. While the pleopods and the exopods of the peraeopods in their number serve in part as generic indicators, the ultimate result of placing undue emphasis upon these factors is exemplified in the classification proposed by Stebbing in 1913, who, using them freely as criteria, separates a relatively large number of families from the older ones, many containing only a few species. Acceptance of this system does not seem to be justified, particularly as it is reasonable to suspect that futher loss convergences will be found to occur (see also Hansen, 1920, 3).

Family BODOTRIIDAE

In a recent discussion of the species of *Cyclaspis* (Hale, 1944), that genus was placed in the subfamily Bodotriinae, having the characters of the Bodotriidae as formerly limited.

It has become increasingly evident that the family Vaunthompsoniidae, unless possibly one restricts it to the type genus, is by no means easily separable from the Bodotriidae and that probably the two families should be united (Hansen, 1895, 57; Calman, 1910, 616; Zimmer, 1913, 444, etc.). It is now submitted that there is support for the division of the Bodotriids into two subfamilies, the Bodotriinae and Vaunthompsoniinae, limiting the former to those genera which completely lack exopods on all peraeopods excepting the first. This again associates *Heterocuma* and *Cumopsis* with the *Vaunthompsonia* group of genera.

Other characters for possible subdivision of the family present themselves, but the writer still feels that this would be premature.

As *Bodotria* is the oldest genus of the whole assembly and it is often held that a family should take its name from the earliest described genus included in it, the long quoted Bodotriidae is here retained although Sars' Vaunthompsoniidae has precedence of proposal.

Subfamily BODOTRIINAE

Genera: *Bodotria* Goodsir, 1828; *Iphinoe* Bate, 1856; *Cyclaspis* Sars, 1865; *Stephanomma* Sars, 1871; *Eocuma* Marcusen, 1894; *Cyclaspoides* Bonnier, 1896; *Zygosiphon* Calman, 1907.

No trace of exopods on any but the first pair of peraeopods. There is more often than not a reduction in number of the free thoracic somites and the endopod of the uropod is often undivided.

A two-jointed endopod is found in the uropod of *Iphinoe* (where as far as known it is constant), in *Bodotria* (where it is inconstant and in the single species of *Zygosiphon*.

The second antenna of the female is in general more rudimentary than in the Vaunthompsoniinae. The lamellae of the branchial apparatus are apparently never digitiform and on the whole do not show the reduction in number which occurs in *Vaunthompsonia* and *Bathycuma* spp. (see Zimmer 1908, 165, etc.), and in *Gephyrocuma*, although in *Zygosiphon* they are few, particularly in the female (*fide* Calman).

Iphinoe resembles *Vaunthompsonia* more than do the other genera, all of which have characters never occurring in the Vaunthompsoniinae. Some slight additional support for its association with the Bodotriinae is afforded by *I. pellucida* sp. nov. which has abdominal articular pegs as in *Cyclaspis*.

Three of the genera, *Cyclaspoides*, *Stephanomma* and *Zygosiphon*, are monotypic. The last-named is sharply differentiated by the wide separation of its branchial siphons, *Cyclaspoides* by having only two of the pedigerous somites free. *Stephanomma* appears to be a *Cyclaspis* in which the fusion of the pseudorostral suture, sometimes found in the highly calcified members of the last-named genus, is very complete (Calman 1907, 14). The other four genera occur in both Hemispheres and, as might be expected, are represented in Australian seas.

Genus Bodotria Goodsir

Bodotria maculosa sp. nov.

Adult Male (South Australian form). Integument firm, moderately calcified but not brittle; finely reticulate.

Carapace with dorsal edge scarcely arched, rugose; one-fourth of total length of animal, depressed, about one-fifth as wide again as depth, which is a little more than half its length; median carina low; sides with a prominent longitudinal ridge, below which is a less marked carina which curves up posteriorly to meet the main ridge; above the latter the carapace exhibits a coarse squamose-reticulate patterning formed by large, shallow pits; the lower lateral carina is emphasised by a line of shallow pits immediately above it. Antennal notch deep and narrow, tooth subacute. Pseudorostral lobes wide and truncate anteriorly and reaching apex of ocular lobe, which is as wide as long with nine prominent yellowish lenses.

First pedigerous somite concealed; second about as long as fourth or fifth but longer than third; on each somite there is a strong median carina, elevated posteriorly on the third to fifth somites, and a prominent lateral carina formed by the upper edge of a pronounced subquadrangular area on the lower half.

Pleon stout, the first five somites each with dorsal carina, and with faint lateral ridge, which becomes successively less distinct.

Margins of thoracic appendages and uropods more or less serrate. First antenna with first joint of peduncle stout, longer than rest of appendage; second joint longer and stouter than third; main flagellum stout, two-jointed, shorter than third peduncular joint.

Basis of third maxilliped half as long again as rest of limb and with apical lobe rather wide; ischium unusually long, distinctly longer than merus or carpus which are dilated apically; dactylus downbent in subchelate fashion.

First peraeopod stout, the carpus barely reaching to level of antennal tooth; basis about half as long again as rest of limb, not produced apically; carpus a little longer than merus, twice as long as the unusually short propodus and more than three times as long as the dactylus, which is two-thirds as long as propodus; dactylus with a stout terminal spine as long as itself and two or three short setae.

Basis of second peraeopod barely longer than remaining joints together; merus longer than carpus, equal in length to dactylus and twice as long as propodus; dactylus with no lateral spines, longer than the longest of its three terminal spines, which is twice as long as the others.

Basis as long as remaining joints together in third legs, shorter in fourth and fifth pairs; propodal seta not quite reaching apex of dactylus; a single carpal seta (at base of which is an insignificant bristle) not reaching beyond middle of length of dactylus.

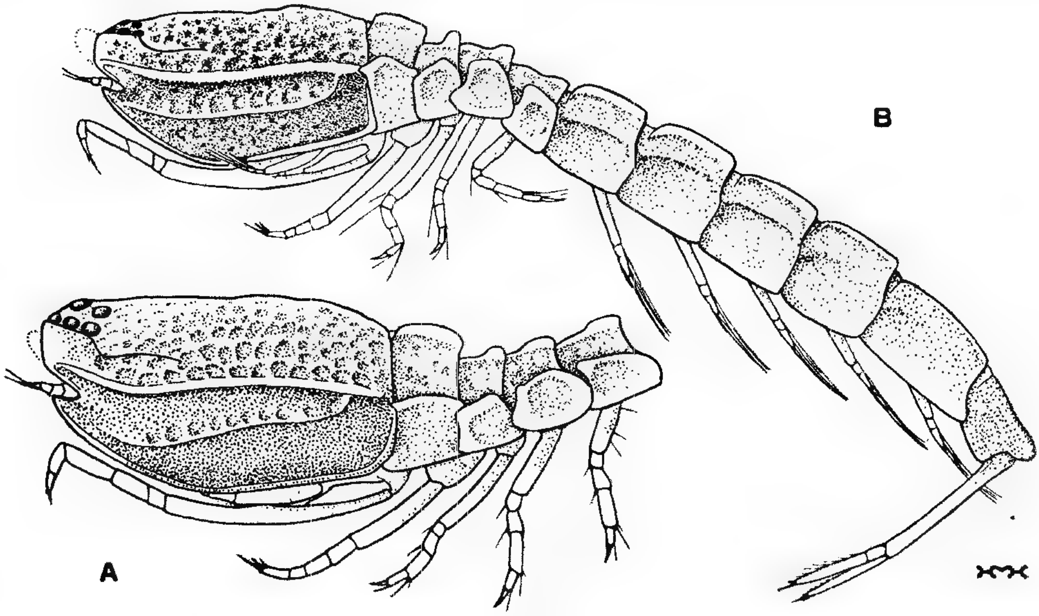

Fig. 1

Bodotria maculosa. A, Side view of cephalothorax of type male of South Australian form. B, Side view of type of New South Wales form. (Both x 40).

Peduncle of uropod one and three-fourths times as long as telsonic somite and with a fringe of plumose hairs on whole length of inner margin; endopod single-jointed, equal in length to telsonic somite, slightly longer than exopod, and with eleven spines on inner margin and a long and a short spine on truncate apex; exopod with plumose hairs on inner margin and with a long and a short terminal spine on truncate apex.

Colour yellow in alcohol, marked with numerous black spots (ground colour orange during life).

Length, 4·2 mm.

Loc.—South Australia: Spencer Gulf, Memory Grove, 3 fath., 8 to 8.30 p.m. (K. Sheard, Feb. 1941), and Dangerous Reef, 4 fath., "Whiting bottom" (*type loc.*, K. Sheard, Mar. 1941, 8 to 8.30 p.m.); and Stickney Island, 3 fath. (K. Sheard, Feb. 1944); St. Vincent Gulf, Corny Point, 2 fath., over sand (K. Sheard, Feb. 1941, 8 to 8.30 p.m.), and Rapid Bay (E. Hanka, H. Cooper and A. Rau, Jan. 1944); Kangaroo Island, Antechamber Bay, 4 fath., 8 to 8.30 p.m. (K. Sheard, April 1941). Type in South Australian Museum, Reg. No. C.2365.

The specimens, all males, were taken by submarine lights. The colour spots vary in number and disposition, but the bright ground colour is of assistance in sorting material.

The spines on the endopod of the uropod vary from nine to twelve.

Adult Male (New South Wales form). Differs from the above in the following characters. The size is smaller and the colour in alcohol is white with dark spotting; the squamose pitting of the carapace is more pronounced. The thoracic appendages are slightly more slender with longer spines and setae. In the first peraeopods the dactylus is not much shorter than the propodus and the main terminal seta is longer than the dactylus. The longest dactylar spine of the

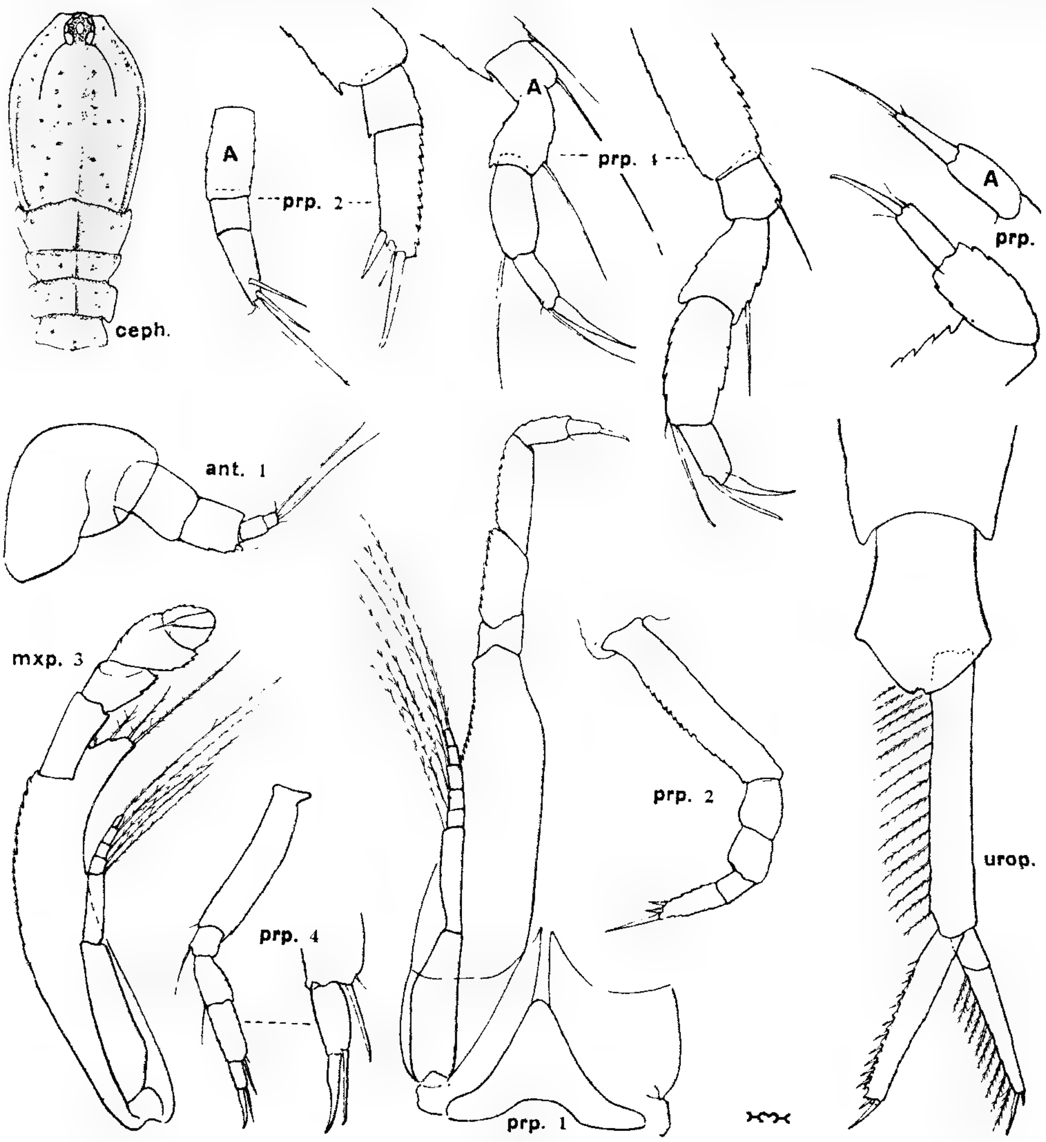

Fig. 2

Bodotria maculosa, paratype male of South Australian form; ceph., cephalothorax from above (x 20); ant. 1, first antenna (x 175); mxp. 3, third maxilliped (x 82); prp. and urop., peraeopods, and uropod with telsonic somite (x 82); terminal joints of peraeopods (x 175). A, Terminal joints of peraeopods of New South Wales form (x 175).

second peraeopods is longer than the propodus and dactylus together, and the main carpal and the propodal seta of the last three pair of legs reach quite to the tip of the dactylus (cf. 2 and 2 A, all to same magnification).

Length, 3·5 mm.

Smaller examples, 1·5 mm. to 1·9 mm., have the upper lateral carina of the carapace strong but the lower less apparent, it being defined by the edges of a row of pits which are less marked than in the adult. The rami of the uropods are three-fourths as long as the peduncle.

Loc.—New South Wales: off Port Hacking, 50 metres on sand (*type loc.*), and off Wata Mooli, 35 metres on sand (K. Sheard, June 1942, and "Cronulla" Trawl Station 2, July 1943). Type in South Australian Museum, Reg. No. C.2448.

B. maculosa resembles *arenosa* Goodsir, but is separated at a glance by the posteriorly elevated dorsal carinae of the last three pedigerous somites, the wider form, the relatively shorter peduncle of the uropods, etc.

B. pumilio Zimmer (1921, 119, fig. 4-7) is also similar in appearance but the adult is smaller (2 to 2·25 mm.) and, according to Zimmer's figure of the male, the carinae of the last three pedigerous somites are not elevated posteriorly.

Genus Eocuma Marcusen

Eocuma agrion Zimmer

Eocuma agrion Zimmer 1914, 176, fig. 1-2.

Zimmer's specimens were taken at Fremantle (Perth), South-western Australia. The species also occurs at Cronulla (Sydney) on the eastern coast (Hale and Sheard, submarine light, 8 feet, September 1942 and January 1944).

In life the colour is yellowish, the pleon being semi-transparent, and the deep pitting of the carapace is conspicuous. The uropods are held wide apart; the rami of each are also spread to form a wide V, the exopod directed upwards and the endopod downwards. The pleon is very flexible.

These specimens agree with the original description excepting that the size is larger and the tiny second peraeopods have not the five joints (apart from coxa) shown in Zimmer's small fig. 2 d. In both sexes they consist of basis plus two other joints, each of which is about the same length as the basis; there are two unequal terminal setae, one being longer than any of the aforementioned three joints.

Zimmer describes the female of this curious species in detail and briefly mentions a damaged male.

Adult Male. Integument thin, calcified and brittle. Pitting varying on pleon but always distinct on carapace.

Carapace plus the fused pedigerous somite fully one-fourth of total length; depressed, and with its depth less than half length; cornua larger than in female; antennal notch widely open and angle rounded. Ocular lobe much wider than long, slightly constricted at base; corneal lenses not darkly pigmented; there is a large tumid central lens and two on each side. Pseudorostrum shorter than in female; there is a tubercle alongside a pit at the termination of each pseudorostral suture.

Free pedigerous somites depressed, wider than in female (see figures).

The pleon is much stouter than in the female; the telsonic somite has two median dorsal conical projections (the hinder one the larger) and is subtruncate posteriorly.

The first antenna has the third peduncular joint longer than second and half as long as first, which is expanded in distal half; the short flagellum is four-jointed, the accessory lash single-jointed.

There are about 17 closely packed, long lamellae in the branchial apparatus.

Third maxilliped much as in female.

First peraeopod with basis nearly one-third as long again as rest of limb.

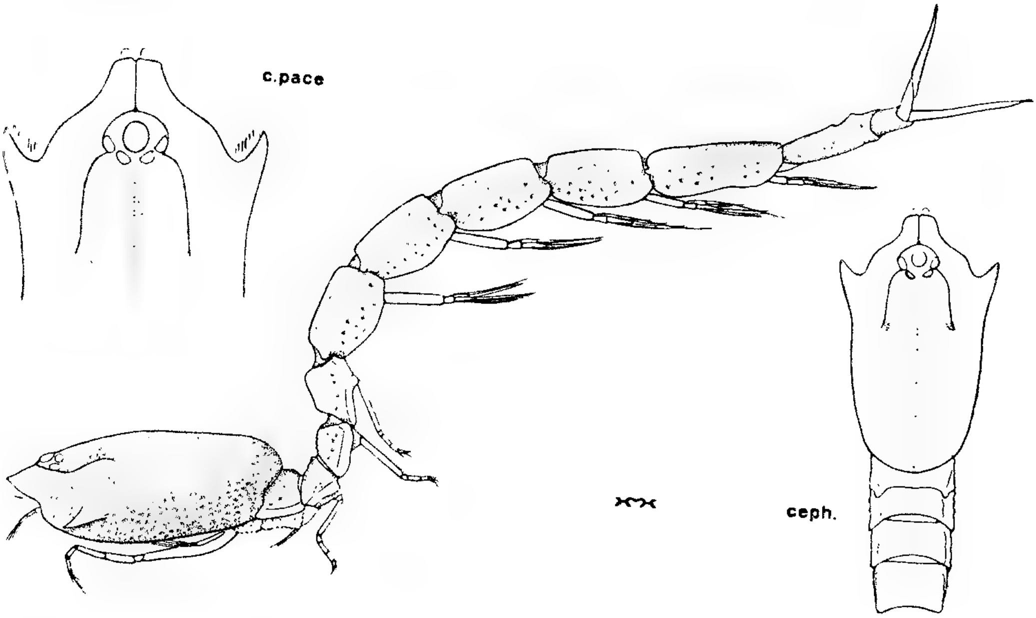

Fig. 3
Eocuma agrion, male, from the side and (ceph.) cephalothorax from above (x 18); c. pace, anterior portion of carapace from above (x 30).

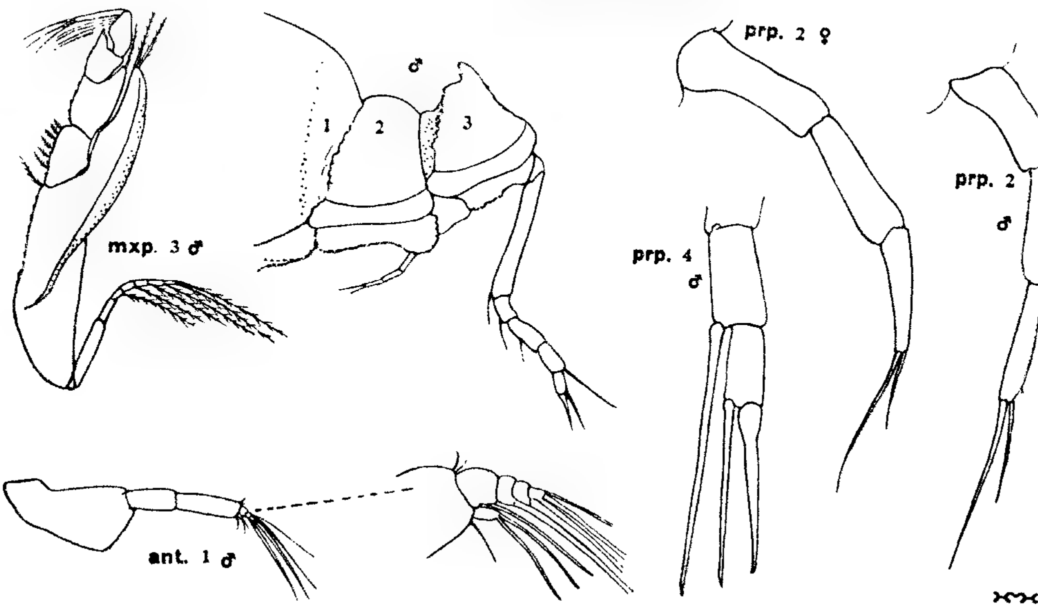

Fig. 4
Eocuma agrion; ant. 1, first antenna (x 160; flagella x 320); mxp. 3, third maxilliped (x 70); 1, 2 and 3, first to third pedigerous somites (x 54); prp. 2, second peraeopod (x 320); prp. 4, terminal joints of fourth peraeopod (x 160).

Third to fifth peraeopod with one stout carpal seta which, with that of propodus, reaches to the level of the tip of the slender dactylus.

Peduncle of uropod as deep as telsonic somite and less than one-third as long as rami.

Length, 6 mm. to 8 mm.

Genus IPHINOE Bate

Iphinoe pellucida sp. nov.

Ovigerous female. Integument rather thin, although lightly calcified, with faint pitting.

Carapace with dorsal edge scarcely arched, with a slight angle between ocular lobe and the distinct pseudorostrum; one-fourth of total length of animal, and with depth about two-thirds its length and about equal to greatest breadth; subtriangular as seen from above, the sides evenly rounded; a very fine though

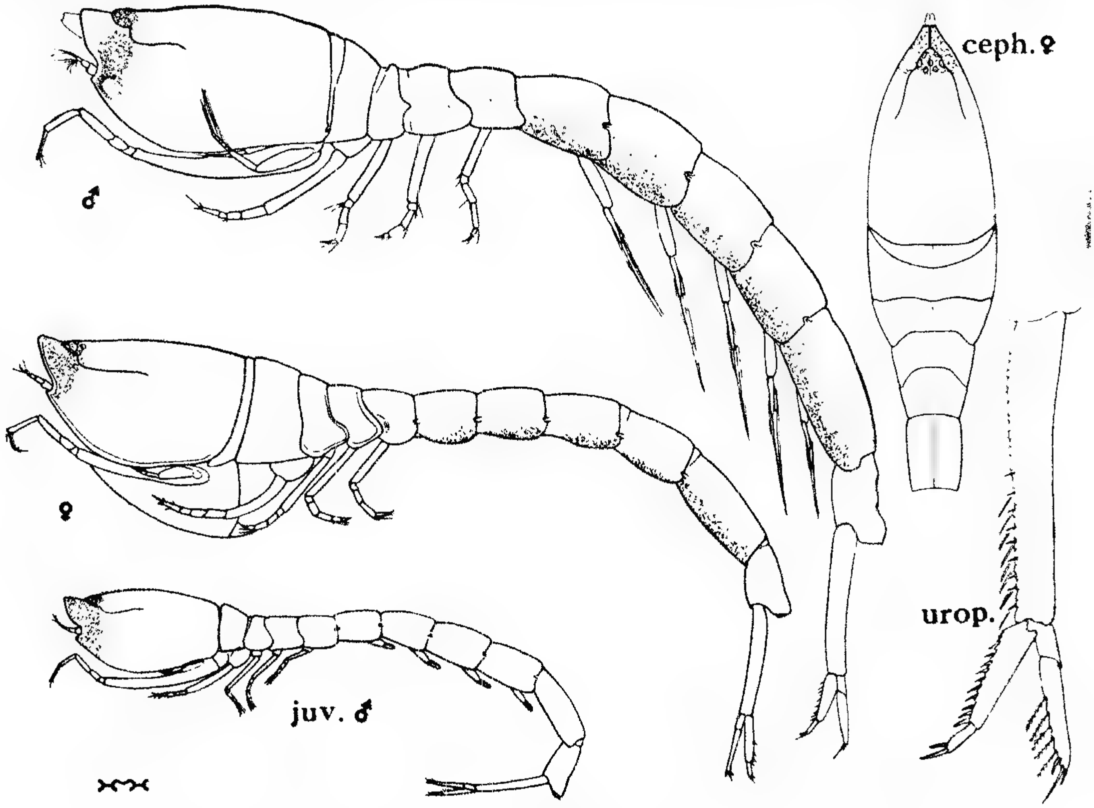

Fig. 5

Iphinoe pellucida, allotype adult male, and paratypes ovigerous female and young male, from the side (x 27); ceph., cephalothorax of ovigerous female from above (x 27); urop., uropod of adult male (x 67).

distinct dorsal carina; an indistinct depression on each side of anterior portion of median carina. Antennal notch wide and shallow; antennal tooth obtuse. Pseudorostral lobes meeting in front of ocular lobe for a distance equal to length of latter (about one-tenth of carapace). Ocular lobe as wide as long, with seven colourless lenses, the median one not sharply defined.

Five pedigerous somites exposed, the first short, but visible for whole of depth; second somite longer than third, fourth or fifth; all somites with a fine median carina.

Pleon with fine median carina on each somite including telson; first to fifth with distinct lateral articular pegs.

First antennae with basal joint almost as long as remaining joints together; second and third subequal in length, each as long as the two-jointed flagellum.

Basis of third maxilliped nearly twice as long as rest of limb, with outer lobe long and triangular; merus, carpus and propodus dilated.

First peraeopod with carpus attaining level of antennal tooth; basis a little longer than remaining joints together; carpus and propodus subequal in length, each nearly twice as long as dactylus, which is longer than the longest of its half-dozen terminal setae.

Basis of second peraeopods longer than rest of limb; merus as long as carpus and propodus together and barely longer than dactylus; the last-named has a stout terminal spine almost as long as itself, two short flanking spines, and a short spine on each side at middle of length. Fossorial legs sparsely armed, with propodal and carpal setae not reaching to apex of dactylus; one stout seta plus a very short one on carpus.

Peduncle of uropod slender, with closed serrations on inner edge; more than half as long again, as the exopod; endopod a little longer than exopod, distinctly two-jointed, the first segment almost three times as long as the second, serrate and armed with four stout spines on inner edge; second segment serrate on inner edge and with a long and a short terminal spine; exopod with three spines at apex, the middle much the longest, and half the length of the second segment.

Colour: milky, translucent with a sooty band across anterior portion of carapace.

Length, 4·66 mm.

Adult Male. Differs from the female in the narrower carapace and pedigerous somites and the deeper pleon. The first pedigerous somite is less exposed; inner margin of peduncle of uropods with serrations rather more pronounced and with two series of spines in posterior half, the upper short, at right angles to margin, the others oblique and serrate; first joint of endopod with about ten spines on inner edge and second with minute inner spines and two unequal terminal spines; exopod with three distal spines as in female (the inner is really subdistal) and a few plumose setate on inner margin.

Length, 4·6 mm.

Young Male. The juvenile male illustrated has tiny serrations on the dorsal crest of the carapace behind the ocular lobe and the first pedigerous somite is almost completely concealed. Differs otherwise in usual immature characters—uropods relatively a little wider, etc.

Loc. Tasmania: off Babel Island, 0-50 metres ("Warreen" Station 29, 1939). New South Wales: stomach of Morwong or Jackass Fish (*Dactylopagrus macropterus*) (A. C. Simpson, July 1939); off Wata Mooli, 70 metres ("Cronulla" Trawl Station 4, July 1943); off Eden, 30 metres, trawled on coarse sand (K. Sheard, October 1943); four miles east of Port Hacking, 80 metres on mud (K. Sheard, trawled, May 1944); Ulladulla, 75 metres (*type loc.*, K. Sheard, trawled, June 1944). Types in South Australian Museum, Reg. No. C.2539 and 2540.

A large number of specimens is available. The pigmentation of the anterior part of the carapace, although more extensive in some examples than in others, is a very characteristic feature; there is usually also pigmentation at the lower edge of the first five pleon somites. The colouration, shape, and extended pleon of preserved material render it easy of recognition amongst a mass of small Crustacea.

Some ovigerous females are over 5 mm. in length, others smaller than the type. The paratype female in fig. 5 is 4 mm. in length, and young from the marsupium are 0·8 mm. in length.

Lateral articular pegs are present on the pleon as in most if not all of the species of *Cyclaspis*—indeed, but for two characters, the suppression of the ischium of the second legs and the two-jointed endopod of the uropod, *I. pellucida* would be referable to that genus.

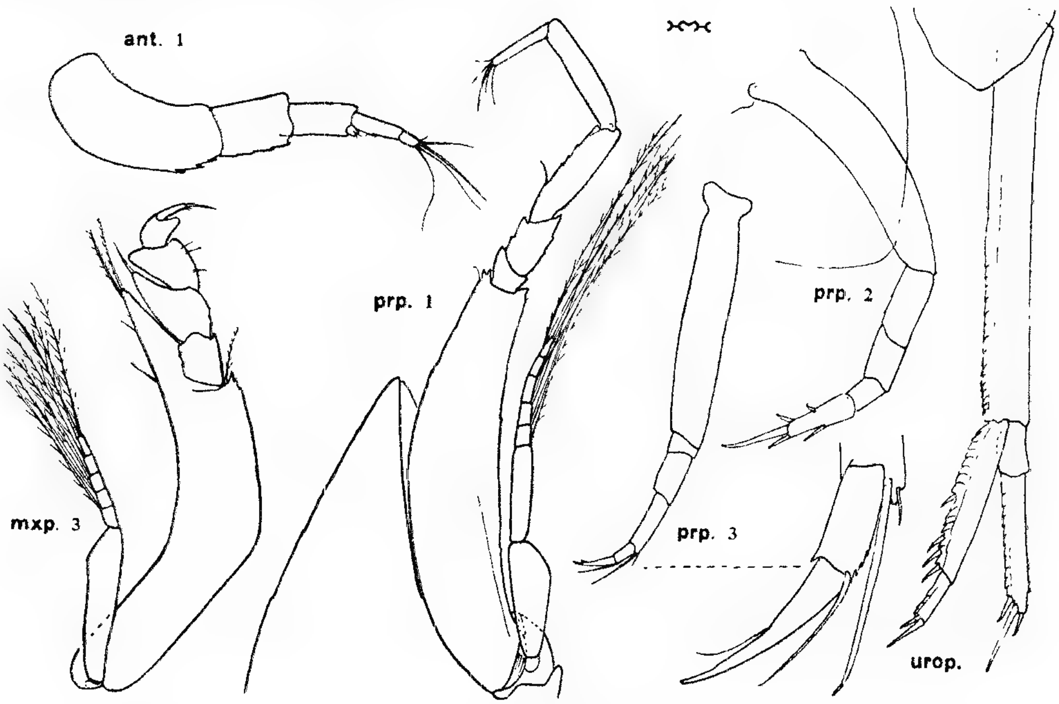

Fig. 6

Iphinoe pellucida, paratype ovigerous female; ant. 1, first antenna; mxp. 3, prp. and urop., third maxilliped, peraeopods and uropod (x 82; terminal joints, x 350).

Although the general facies is very different, the only concise characters separating *Iphinoe* from *Bodotria* seem to be the complete absence of lateral carinae on the compressed carapace and the rather prominent pseudorostrum.

Like *crassipes* Hansen, *pellucida* has the first joint of the endopod of the uropod much longer than the second; it is readily separated by the different proportions of the first pair of peraeopods and other features.

Subfamily VAUNTHOMPSONIINAE

Exopods on at least the first three pairs of peraeopods.

Always five pedigerous somites are exposed and the endopod of the uropod is two-jointed. The second antenna of the female is often 3-jointed, and in most genera the terminal, more or less conical, joint is distinctly separated off.

Key to Genera of Subfamily Vaunthompsoniinae

1 Basis of third maxilliped greatly expanded interiorly. First peraeopods with joints curiously expanded 2

Basis of third maxilliped not expanded interiorly. First peraeopods not so modified. 4

2 Pleon unusually short, never more than two-thirds as long as cephalothorax. First antenna strongly geniculate, with joints of peduncle subglobose. *Gephyrocuma* Hale

Pleon not unusually short, at least as long as cephalothorax. First antenna not strongly geniculate, and joints not at all globose 3

3 Telsonic somite subtruncate, scarcely produced posteriorly. Basis of third maxilliped with large inner distal lobe and basis of first peraeopod with no distal lobe .... *Zenocuma* gen. nov.

Telsonic somite well produced posteriorly. Basis of third maxilliped with no inner distal lobe and basis of first peraeopod with distal lobe. *Pomacuma* gen. nov.

4 Second peraeopod with a distal brush of setae on propodus and dactylus, but no spines. Fourth peraeopod of female with small exopod ... .. *Leptocuma* Sars.

Second peraeopod without brushes of setae on terminal joints, but with spines on at least dactylus. Fourth peraeopod of female without exopod . 5

5 Dorsal plate of telsonic somite subtruncate posteriorly and not at all produced between bases of uropods 6

Dorsal plate of telsonic somite rounded or somewhat angular posteriorly and produced between bases of uropods 7

6 Dorsal plate of telsonic somite truncate posteriorly. Endopod of pleopods with narrow external process. External distal portion of basis of third maxilliped not produced and bearing about five stout plumose setae .... *Cumopsis* Sars.

Dorsal plate of telsonic somite excavated posteriorly . Endopod of pleopods without external process. External distal portion of basis of third maxilliped produced as a prominent lobe capped with two stout plumose setae. *Heterocuma* Miers

7 Third maxilliped with external distal portion of basis not at all, or not strongly, produced and with ischium short (much wider than long); merus much longer than ischium but shorter than carpus .... *Vaunthompsonia* Bate

Third maxilliped with external distal portion of basis prominently produced and with ischium at least as long as wide, subequal in length to merus and carpus 8

8 Eye present. Pseudorostral lobes not reaching beyond ocular lobe 9

Eye absent. Pseudorostral lobes reaching forward and beyond level of front of ocular lobe 10

9 Fourth peraeopod of male with exopod ... . *Glyphocuma* gen. nov.

Fourth peraeopod of male without exopod .... *Sympodomma* Stebbing

10 Pseudorostral lobes meeting in front of ocular lobe. Telsonic portion of last pleon somite much shorter than rest of somite .. .. *Bathycuma* Hansen

Pseudorostral lobes not meeting in front of ocular lobe. Telsonic portion of last pleon somite as long as rest of somite .... *Gaussicuma* Zimmer

The Australian species which have come to hand are of considerable interest. Although investigation of our waters is by no means comprehensive as yet, it is evident that this subfamily is well represented but does not equal the Bodotriinae in number of species and individuals because of the ever present *Cyclaspis*, which is the dominant genus of the family, at least on sandy bottoms. It seems also that *Vaunthompsonia* itself is rare and that the important elements group themselves around three main types, represented by *Sympodomma* Stebbing, *Leptocuma* Sars and *Gephyrocuma* Hale. The last of these comprise what might be termed the "operculate" genera and are here dealt with first.

The Operculate Genera

In these the first pair of peraeopods can be folded to form the major part of an operculum which bridges the space between the infero-lateral folds of the carapace, and closes the cavity of the latter from the exterior; these limbs and the third maxillipeds also are curiously expanded and otherwise modified.

Zimmer (1921, 4) described a single young male, which he did not dissect, of the first of such species from North-Western Australia, referring it temporarily to *Vaunthompsonia;* what appears to be his species—*australiae*—is now available from eastern Australia.

The present writer (Hale 1936, 412) subsequently proposed a genus, *Gephyrocuma*, for the reception of a second operculate species, which possesses first legs very much as in Zimmer's form (excepting that the basis lacks a distal lobe) but which has the third maxilliped very different, the basis of that appendage being not only more widened interiorly, but at the anterior end sweeping forward and inward to form a broad, truncate lobe. Another species of this genus is described herein.

There is also before me a large species related to the small *Gephyrocuma* and with similar third maxilliped but with other differences warranting generic separation; for this a new genus, *Zenocuma*, is erected. A further species is accommodated, with Zimmer's *australiae*, in a third genus, *Pomacuma* nov.

The basis of the third maxilliped and first peraeopod is widened and more or less twisted, or flanged, in all three genera. In the first peraeopod the ischium is in the form of a rounded lobe with an exterior excavation. The articulations between ischium, merus, carpus and propodus allow for a complete folding of the appendage (Zimmer refers to it as subchelate). The inner portions of the carpus and, to a lesser extent, the propodus, are dilated, and in the carpus lamellate. The proximal portion of the dactylus is swollen on the upper or outer face. There is a dense distal brush of long plumose setae on the inner side of the propodus and on that of the dactylus, while there is a row of plumose setae on the carpus.

The development of plumes of setae on the terminal joints of the first legs is by no means unique in the Cumacea, although the operculate genera are unusually well endowed. The "grasping motions" of *Gephyrocuma pala* (Hale 1943, 341) suggest that the algal debris found in the stomach and massed around the mouth may be collected in the same way as is the food of Porrellanid crabs and non-parasitic Cirripedia. It should be mentioned that amongst smaller material found beneath the maxillipeds of *Pomacuma* is a grain of sand 0·25 mm. in diameter.

The operculum is differently formed in each of the genera.

A female example of *Zenocuma*, with the operculum in position (see fig. 7, A-D) has the joints of the first peraeopods and third maxillipeds in the following relative positions.

The basis joints of the third maxillipeds meet completely in the midline, and form a vault or bridge in the form of a half-cylinder, tapering to the rear and open at the anterior end. The inner portions of the basis and ischium of the first peraeopods overlap the outer edges of the maxillipedal vault; the lamellate inner portions of the carpal joints overlie the inner edges of the propodi; the outer edges of basis, merus and carpus lie against the infero-lateral folds of the carapace; the rounded inner proximal end of each carpus fits into the scooped outer face of the lobe of the ischium. The outer portion of each basis of the first peraeopods is flanged, so that when it lies against the infero-lateral fold of the carapace a narrow ventral gutter results, tapering towards the front; the exopod of this limb, together with that of the third maxilliped, lies in and fills this gutter, the plumose setae being folded together like the hairs of a wet camel-hair brush. (In the figures the exopods are not shown in this position.)

The propodi of the first peraeopods are placed together but are actually in contact only towards each end, a slight curvature of the joints leaving a narrow gap through which the first antennae may protrude (fig. 7, B and C).

In *Gephyrocuma* the relationship of third maxillipeds to first peraeopods is much as in *Zenocuma* but the proximal thirds of the propodi of the first legs curve against the peduncles of the first antennae which here are stout, swollen and geniculate, filling the gaps below the pseudorostral lobes (fig. 7, E), the flagella being thrust beneath the overhanging portions of the latter.

With the operculum in operation in both *Zenocuma* and *Gephyrocuma,* the dactylus with its setae, and the propodal setae (folded together like a fan) are all housed inside the maxillipedal vault, the anterior opening of which is plugged by the swollen distal ends of the propodi; the plumose geniculate palp of the third maxilliped is also covered by the inner lobe of the basis of that appendage.

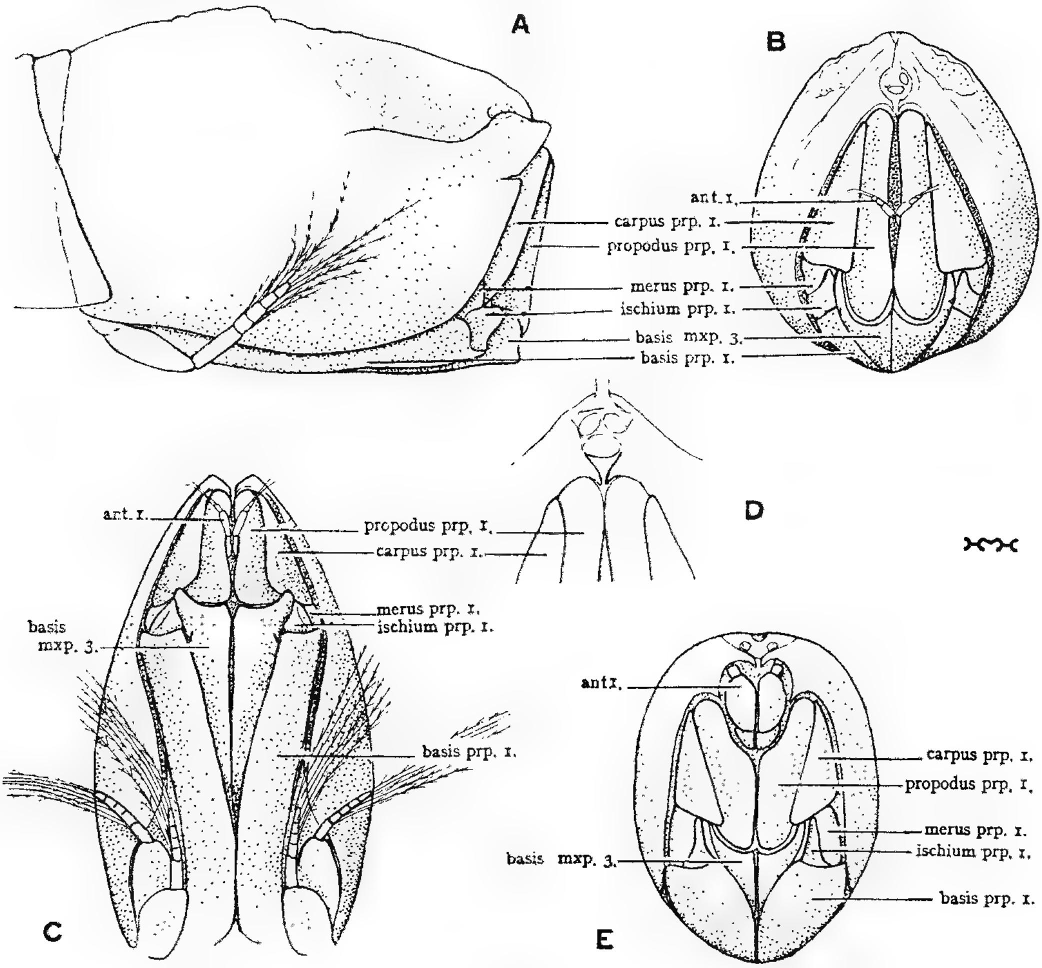

Fig. 7

Zenocuma rugosa, paratype female; A, B and C, carapace and appendages from side, front and below: in C, the body is tilted slightly upwards (x 26); D, oblique frontal view, below ocular lobe (x 45). E. Carapace and appendages of *Gephyrocuma pala* from the front (x 45).

As stated above, the basis of the first peraeopod of *Pomacuma* differs from the other two genera in possessing a distal lobe, but that of the third maxilliped, though a good deal widened interiorly, lacks such lobe. In this genus the basis joints of the first legs meet intimately in the mid-line of the body for their whole length when the limbs are folded; they are closely applied to, and completely conceal, the shorter third maxilliped basis joints and project beyond them. Here the distal lobe of the basis of the first peraeopod plays the same part as the maxillipedal lobe of the other genera, the anterior end of the propodus of the same peraeopod fitting against it. As in *Zenocuma* and *Gephyrocuma* the exopods of the third maxillipeds and first peraeopod fit into a gutter between the basis joints of the last-named and the inferò-lateral folds of the carapace; the palp of the third maxilliped is far less geniculate than in the others and is extended well forward, covered by the carpo-propodal part of the first legs.

Further modifications resulting from these arrangements will be noted in the descriptions and fig. 8 to 16. The three genera could be placed in a separate subfamily because of the character of the third and fourth thoracic appendages but, as described above, these are not really identical in all of them.

Genus **Zenocuma** nov.

Female. Form superficially as in *Vaunthompsonia* but integument rather highly calcified.

Carapace with pseudorostral lobes extending in advance of moderately large ocular lobe but diverging so that their anterior ends are well separated; antennal notch a closed, but not fused, slit. Five pedigerous somites exposed, the first short. Pleon as long as cephalothorax; telsonic somite subtruncate posteriorly the distal margin bisinuate and scarcely at all produced medianly.

First antenna normal, with accessory flagellum single-jointed. Second antenna relatively large, three-jointed, the two terminal joints subequal in length.

Mandible robust, with lacinia and molar process long and stout.

Second maxilliped slender, not at all expanded.

Third maxilliped with well-developed exopod; basis with an external distal lobe which almost reaches anterior end of merus and is furnished with a series of long, stout, plumose setae; interiorly the joint is greatly broadened, particularly distally where it sweeps forward to form a truncate arched lobe which is one-fourth as wide as total length of joint; there is a series of a dozen or so broad, tapering but short plumose setae on proximal half only of the inner margin. Remaining joints forming a geniculate "palp"; ischium short; carpus expanded in proximal half and propodus widened distally, the widened portions with series of long plumose setae; dactylus with plumose setae. (It is not possible to show all the setae in the drawings.)

First three pairs of peraeopods with well-developed exopods (peduncle and jointed flagellum); fourth with rudimentary single-jointed exopod capped with a few setae.

Basis of first peraeopod slightly expanded towards the anterior end which is subtruncate and a little excavate, rounded externally; there is a stout spine near distal end of inner margin and posterior to it, after an interval, is a row of other spines interspersed with plumose setae; ischium with inner lobe; merus articulating at outside of ischium; carpus expanded proximally with series of plumose setae.

Carpus of second peraeopod little shorter than merus.

Endopod of uropods two-jointed, the distal segment very short; inner margin of exopod with slender "serrate" spines.

Genotype *Zenocuma rugosa* sp. nov.

The male is as yet unknown. The female has the exopodal furniture just as in the related *Pomacuma* gen nov., and *Leptocuma*, as recognised by the writer for six Australian species. In both of these and in *Gephyrocuma* Hale (which has essentially the same modification of third and fourth thoracic appendages as *Zenocuma*) the exopods do not differ in the sexes and there are five pairs of pleopods in the male; one would be inclined to believe that this is the case in *Zenocuma* also, but the assumption cannot be accepted with any degree of confidence when Calman's *Leptocuma minor* is borne in mind (see notes under *Leptocuma* herein.)

One species only is available.

Zenocuma rugosa sp. nov.

Female. Carapace as seen from the side little arched but rugose for whole length, particularly in posterior half, owing to development of a median carina which is wide and fused-tuberculate and flattens out posteriorly; a rather deep dorsal excavation on each side of carina on anterior half, the lateral edges of which are tuberculate and the interior of which has one or two low tubercles; the

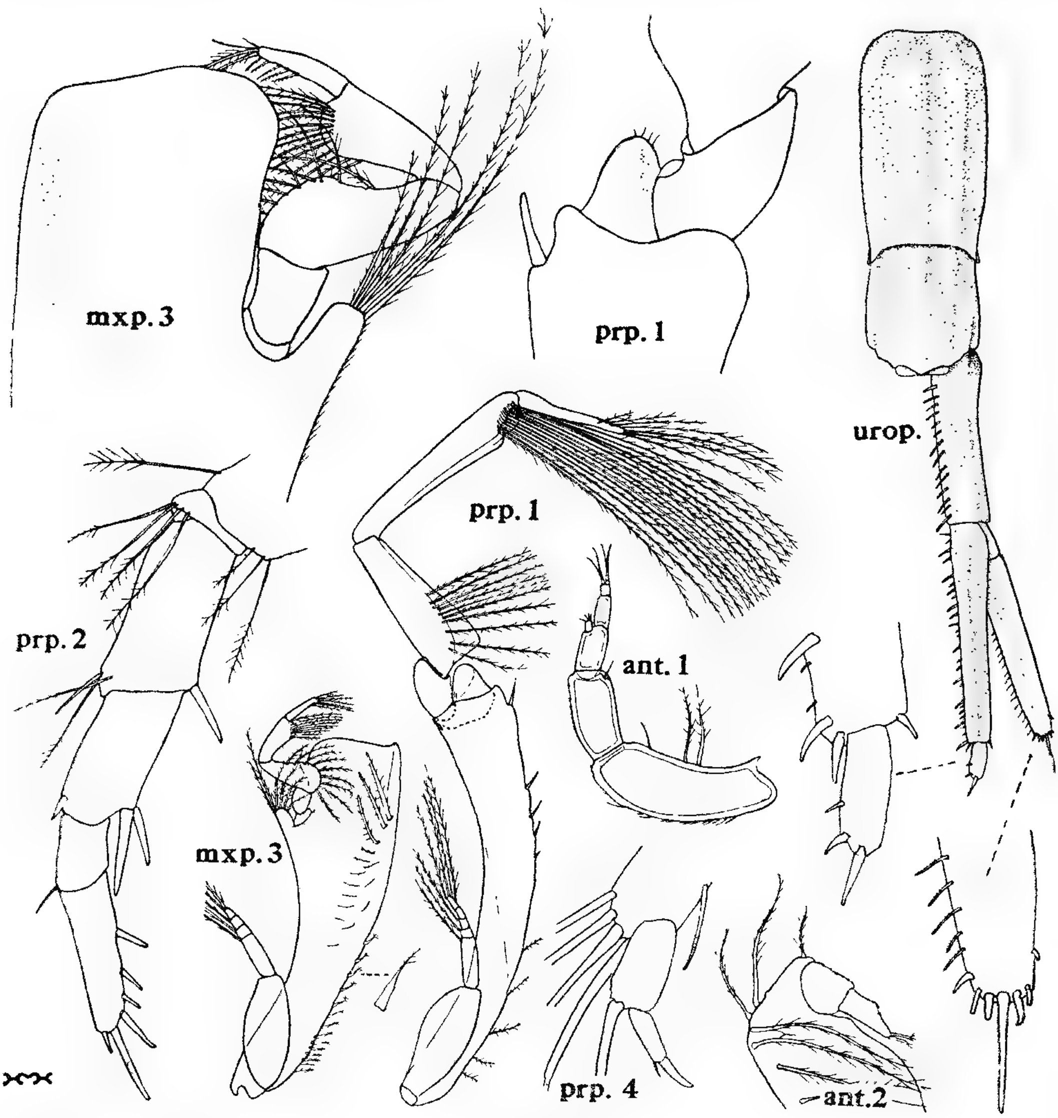

Fig. 8
Zenocuma rugosa, paratype female; third maxilliped and first peraeopod (x 19); distal end of basis, etc. (x 50); ant. and prp., antennae and distal joints of second and fourth peraeopods (x 50); urop., uropod, with fifth pleon and telsonic somites (x 19; distal ends of rami, x 62).

whole carapace is plump but compressed, less than half as long again as deep and a little longer than pedigerous somites together. Pseudorostrum shorter than ocular lobe; pseudorostral lobes subtriangular and narrowly rounded anteriorly when viewed either from above or from the side, just meeting at front of ocular lobe, then flaring outwards so that they are widely divergent; the inner parts in front of eye-lobe are bent downwards, producing a short longitudinal crease. Ocular lobe bilobed in front, about as wide as long, blackish, with lenses obscure but three can be discerned on each side and a central one still less defined.

Pedigerous somites two to five elevated on posterior half when viewed from side; first smooth; dorsum of second with a faint transverse elevation and a pair of longitudinal carinae; back of third to fifth with a transverse ridge (that of third with a pair of median tumidities) which joins a faint longitudinal dorso-lateral ridge; on the fifth, and still less distinctly marked on fourth, is a lateral ridge just below the dorso-lateral; the second somite, as usual in the group, over-laps the carapace in front and is in turn over-ridden by the anterior pleural portions of the third; posterior pleural parts of third and fourth produced back-wards in the form of a large rounded lobe.

Each of pleon somites one to five with on each side a dorso-lateral carina, two lateral carinae and an infero-lateral ridge; these are least pronounced on first and second, then become conspicuous; there is in addition a median dorsal carina which is not well defined until the third somite, thence to the fifth it is distinct; telsonic somite with median carina on proximal third only, also a dorso-lateral and a lateral ridge on each side; it is not much longer than wide, not much more than half as long as fifth pleon somite, with posterior margin bisinuate on each side, scarcely produced and widely triangular in the middle.

First joint of peduncle of wide superior antenna as long as second and third joints together with flagellum; second joint nearly twice as long as third; flagellum two-jointed, the first segment more than twice as long as second.

Second antenna relatively large, its terminal joint subconical, longer than second and with well-developed apical sensory appendages.

Mandible with ten or eleven spines in the row, successively stouter from in front backwards; molar process as long as distal portion of trunk anterior to it.

Basis of third maxilliped twice as long as palp if stretched out, its greatest width nearly one-third of its length; carpus distinctly more than twice as long as merus and one-third as long again as propodus; dactylus little longer than merus.

First peraeopod with basis much shorter than rest of limb; propodus more than one-third as long again as carpus and nearly twice as long as dactylus; distal plumose brush of propodus equal in length to propodus and dactylus combined.

Second peraeopod with basis stout, not as long as remaining joints together; carpus equal in length to dactylus, not much shorter than merus, and more than twice as long as propodus; dactylus with four stout spines on inner margin (the first and last a little larger than the middle two) and two very unequal distal spines, the longer almost half as long as the joint; the figure shows the other stout and slender spines, and plumose setae.

Third to fifth peraeopods stout; basis of third subequal in length to remainder of limb, that of fourth and fifth only half as long or less; carpus with four strong distal fossorial setae (as well as a comb of short setae) which with propodal seta reach well beyond the blunt dactylar claw, which has a short outer seta at its base.

Uropod with peduncle and endopod strongly ridged longitudinally, the former a little longer than telson and two-thirds as long as endopod, which is more than one-eighth longer than exopod; its inner margin bears spines which are mostly of the same size; first joint of endopod more than five times as long as second, with an inner row of unequal spines and a single spine at outer distal corner; second joint of endopod with only one inner spine and with two or three unequal spines at rounded apex; exopod with a row of slender compound ("serrate") spines on inner margin followed by a single short strong spine and four or five which may be regarded as apical, one being much longer than the others; on outer margin near apex is a single small spine.

Colour cream or dark orange-yellow with brown chromatophores on carapace, and a darker brown marking at each postero-lateral corner of excavation on back of carapace; eye black; very fine chromatophores on pleon. The portion-

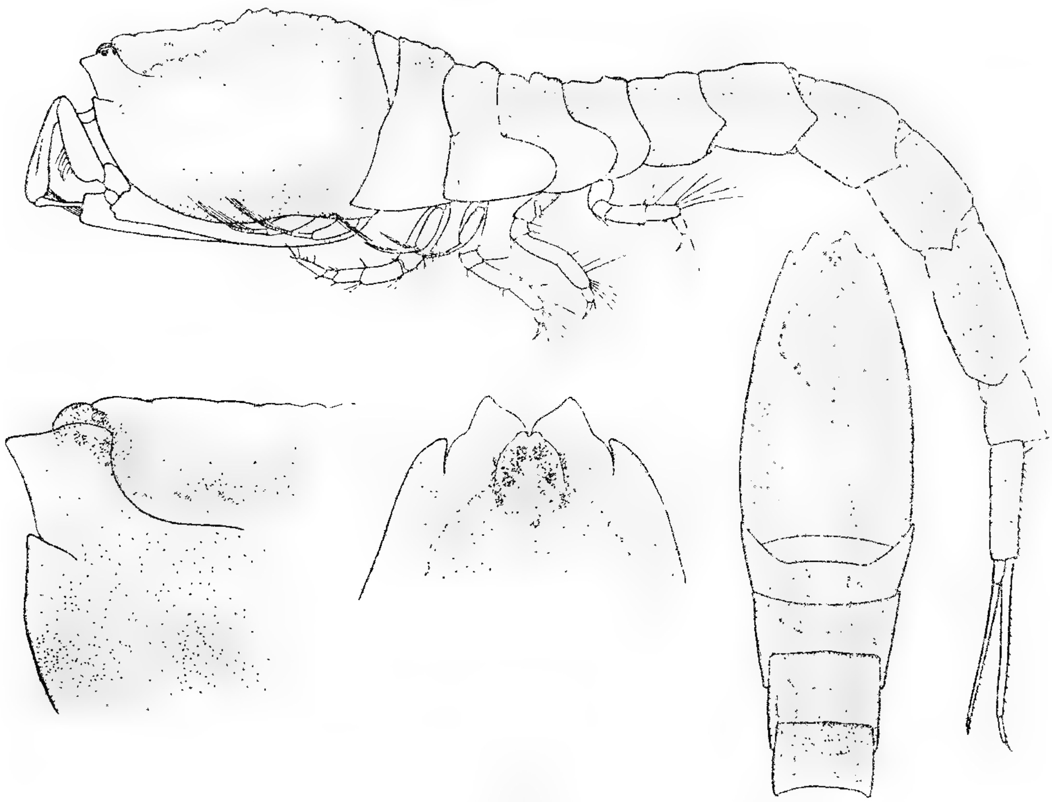

Fig. 9
Zenocuma rugosa, type female; lateral view and cephalothorax from above (x 10); anterior part of carapace from the side and from above (x 20).

of the first peraeopods and third maxillipeds exposed when the operculum is in position are boldly mottled with dark brown.

Length, 14·5 mm.

Loc.—New South Wales: off Jibbon, 35 fath., in coarse sand (K. Sheard, Feb. 1940); off Eden, 30 metres, trawled in coarse sand (K. Sheard, Oct. 1943); Ulladulla, 75 metres, trawled in sand (*type loc.*, K. Sheard, June 1944). Type female in South Australian Museum, Reg. No. C.2535.

At each of the above localities this form was taken in company with *Pomacuma australiae*, as well as a dozen or more other species of Cumacea; it stands out from *Pomacuma*, not only by its larger size, but because of the gaping pseudorostral lobes, subtruncate telsonic somite, unequal rami of the uropods, etc.;

the jutting basis of the third maxilliped is also very apparent when the anterior appendages are partly opened, as they often are in preserved material (fig. 9).

Genus **Pomacuma** nov.

Female. Form superficially as in *Vaunthompsonia;* integument little calcified.

Carapace with pseudorostral lobes extending in front of moderately large ocular lobe and meeting in the mid-line; antennal notch, as in *Zenocuma,* a closed slit. Five pedigerous somites exposed, the first short. Pleon longer than cephalothorax; telsonic somite well produced posteriorly, the distal margin rounded.

First antenna normal, with accessory flagellum single-jointed. Second antenna three-jointed, like that of *Zenocuma.*

Mandible with long lacinia and long, stout molar process.

Epipod of first maxilliped with a dozen or more wide lamellate gill-lobes with thickened edges.

Second maxilliped slender.

Third maxilliped with well-developed exopod; basis with a short external distal lobe bearing a fan of plumose setae; the joint is widened interiorly and is truncate distally but is not forwardly produced; there is a series of plumose setae on the whole length of inner margin, the distal ones about as long as those of external lobe; remaining joints much as in *Zenocuma,* but the palp is rather less markedly geniculate (full series of plumose setae not shown in figures).

First three pairs of peraeopods with well-developed exopods; fourth pair with rudimentary single-jointed exopod capped with a few setae.

Basis of first peraeopod widened distally where a large forwardly directed lobe is produced interiorly ("Oberseite" of Zimmer) reaching to the level of anterior end of oblique articulation of ischium and merus; remaining joints as in *Zenocuma* and *Gephyrocuma.*

Carpus of second peraeopod much shorter than merus.

Endopod of uropod two-jointed, the distal segment very short; inner margin of exopod with plumose setae.

Male. Pleon relatively slightly longer than in female.

Second antenna reaching to end of pleon, the longest joints of flagellum only half as long again as wide.

Thoracic exopods as in female. Five pairs of pleopods.

Genotype *Pomacuma cognata* sp. nov.

This genus is related to *Zenocuma* but the important differences in the structure of the basis of the third maxilliped and first peraeopod, and in the pseudorostrum and telsonic somite are very apparent without dissection.

It may be noted also that *Pomacuma* has plumose setae on the whole of the inner margin of the basis of the third maxillipeds, and they are of different type from those occurring on proximal half only in *Zenocuma;* further, this basis, although less expanded than in the last-named genus, still is about one-fourth as wide as long owing to its relative shortness due to absence of a distal lobe; it does not project beyond the anterior end of basis of the first peraeopod.

Two well defined species are available from off eastern Australia. One of these, excepting for a few trivial differences, closely resembles Zimmer's Western *Vaunthompsonia* (?) *australiae* and so is referred to that species; in any case *australiae* is undoubtedly congeneric with *cognata.*

Key to Species of Pomacuma

Carpus of third maxilliped more than half as long again as propodus. Dactylus of second peraeopod more than three times as long as propodus and with ten spines on inner margin. Uropod with peduncle equal in length to first joint of endopod and with a row of spines on distal third of outer margin of exopod. Pleon ridged . . . . *cognata* sp. nov.

Carpus of third maxilliped less than half as long again as propodus. Dactylus of second peraeopod less than three times as long as propodus and with only about seven spines on inner margin. Uropod with peduncle distinctly shorter than first joint of endopod and with no long row of spines on outer margin of exopod. Pleon smooth . . . . . *australiae* (Zimmer)

Pomacuma cognata sp. nov.

Ovigerous Female. Integument glossy, with very fine reticulate pattern and superficial pitting.

Carapace as seen from side slightly arched dorsally; it is half as long again as deep and not quite as long as pedigerous somites together; the outline is rugose

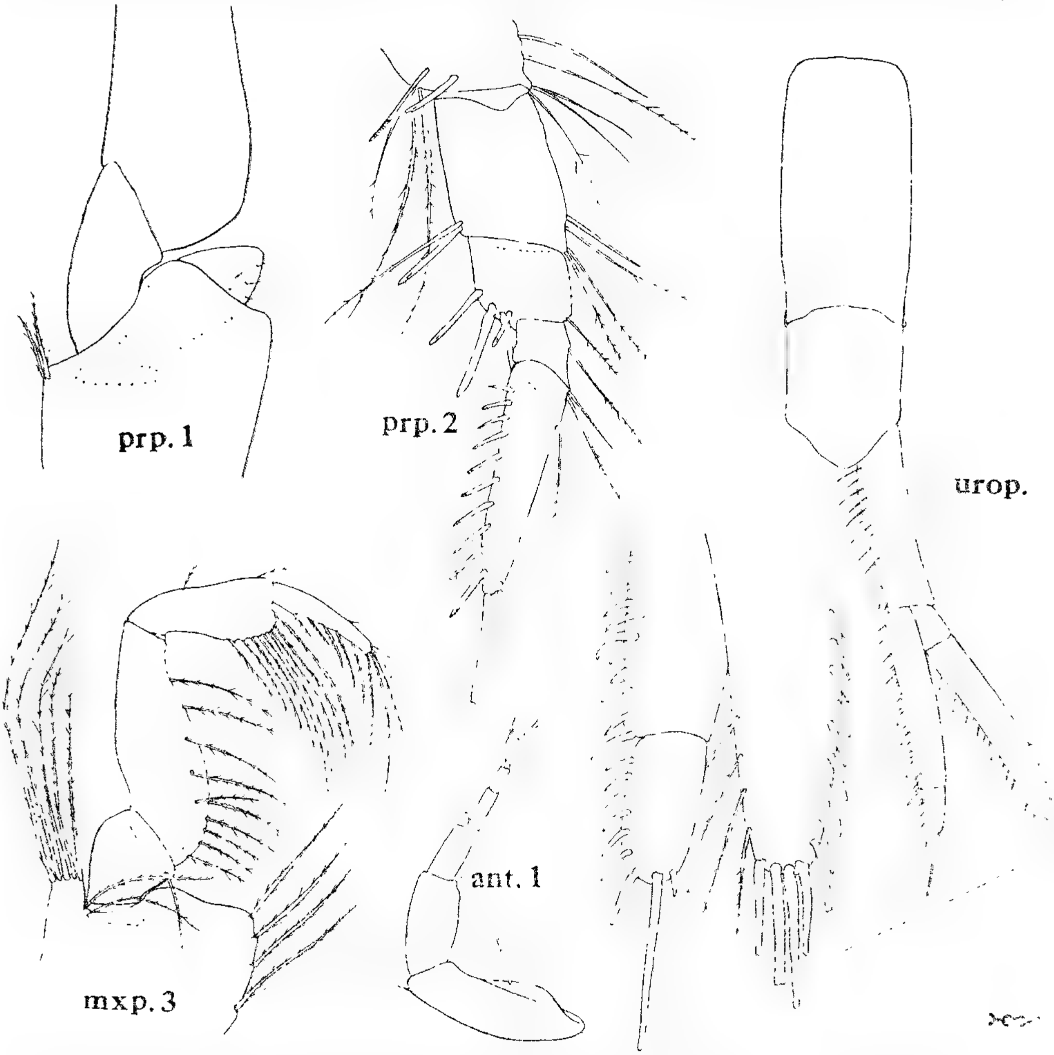

Fig. 10

Pomacuma cognata, type ovigerous female; ant. 1, first antenna (x 86); mxp. 3, palp and distal end of basis of third maxilliped (x 86); prp. 1, merus, ischium and distal end of basis of first peraeopod (x 86); prp. 2, second peraeopod, basis not shown (x 86); urop., uropod, with fifth pleon and telsonic somites (x 26; distal half of rami, x 80).

in posterior half owing to the tuberculation of a well-developed median carina, which is flanked on each side in anterior half by a depression; the latter has tuberculate edges and inside it are two rows of ill-defined large tubercles; sides with sparse, small low rounded tubercles. Pseudorostral lobes each slightly produced in front, so that pseudorostrum has a somewhat pointed appearance. Ocular lobe as wide as long, black with the corneal lenses not easily made out.

Pedigerous and pleon somites with sculpturing essentially as described for *Zenocuma rugosa* but not so strongly marked. Telsonic somite nearly half as long again as wide and less than two thirds as long as fifth pleon somite; its produced posterior part comprises one-fourth of its length.

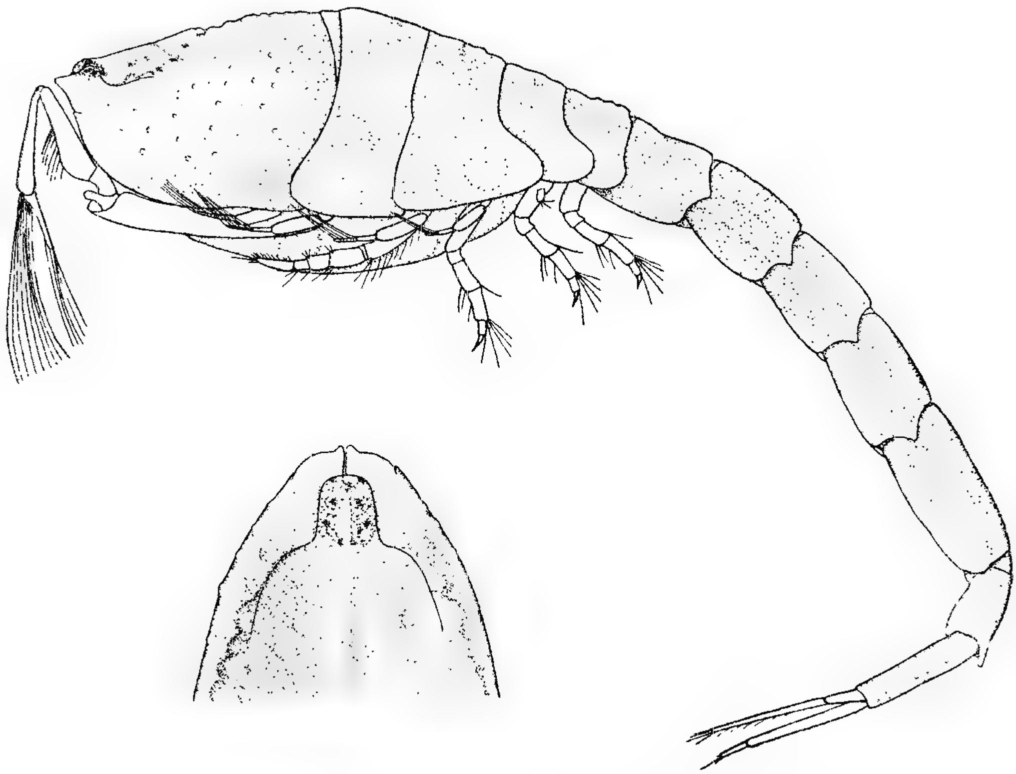

Fig. 11
Pomacuma cognata, type ovigerous female: lateral view (x 17) and anterior part of carapace from above (x 46).

First joint of upper antenna nearly twice as long as second which is more than half as long again as third and longer than the stout two-jointed flagellum.

Third joint of second antenna capped with short but well developed sensory appendages.

Mandible with about 17 spines in the long row.

Carpus of third maxilliped nearly two and two-thirds times as long as merus, fully two-thirds as long again as propodus and more than twice as long as dactylus.

First peraeopod much as in *australiae*, but with joints of slightly different proportions.

Dactylus of second peraeopod distinctly more than three times as long as propodus, two and two-thirds times as long as carpus, and almost half as long again as merus; its inner margin bears a row of ten spines (see note under *australiae*), and distally it has a long spine and a shorter one; other furniture is shown in the figure of this limb.

Posterior peraeopods robust, with four stout distal carpal setae reaching well beyond tip of dactylus.

Uropod with peduncle as long as first joint of endopod and with a row of spaced spines on inner edge; endopod equal in length to exopod, with first joint almost four times as long as second and with many unequal, closely-set spines on inner margin; longer terminal spine of second segment distinctly longer than the latter; rounded distal end of exopod with four slender blunt-ended spines and outer margin with nine spines on distal third, successively increasing in length from first backwards.

Colour, biscuit brown with darker indefinite shadings.

Length, 8 mm.; ova, 0·28 mm. in diameter.

Loc.—New South Wales: off Coffs Harbour, 30° 18′ S., 153° 16′ E., 50 metres (K. Sheard, June 1941). Type in South Australian Museum, Reg. No. C.2482.

This species turned up only once in the hauls made off eastern Australia which may indicate that it is not so abundant there as is the second species referred to the genus.

POMACUMA AUSTRALIAE (Zimmer)

Vaunthompsonia (?) *australiae* Zimmer, 1921, 4, fig. 1-7.
Leptocuma australiae Hale, 1936, 409.

Female. Integument glossy with very fine reticulate pattern.

Carapace seen from the side almost evenly arched dorsally, very slightly sinuate on posterior half; median carina distinct, clear cut in front half, where on each side is a smooth, shallow but quite apparent excavation; sides smooth; it is plump, as wide as deep, less than half as long again as depth and barely as

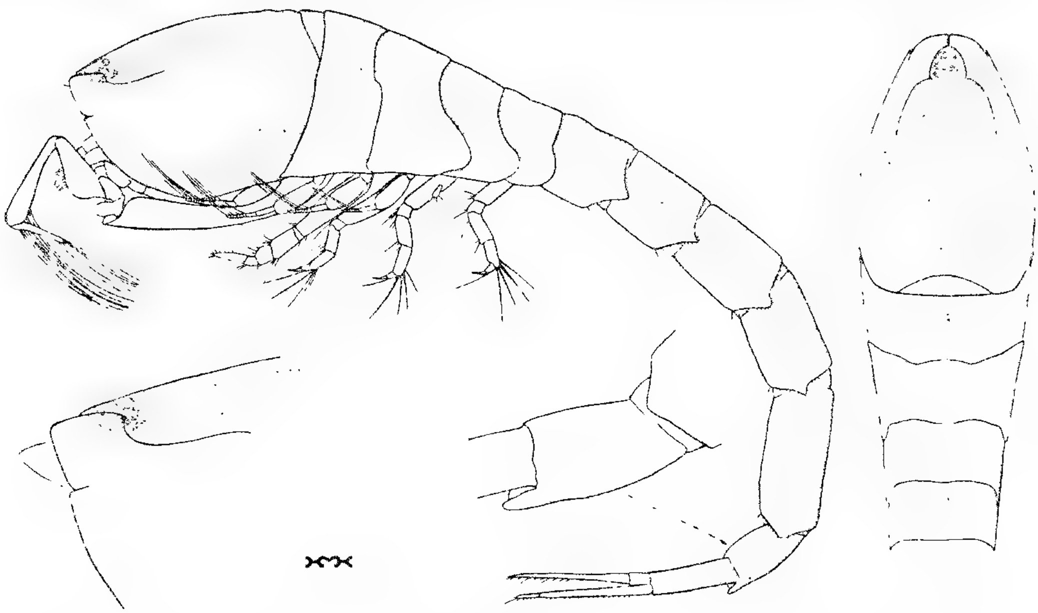

Fig. 12
Pomacuma australiae, female; lateral view and cephalothorax from above (x 15); telsonic somite and anterior part of carapace from the side (x 36).

long as pedigerous somites together. Pseudorostral lobes roundly and obliquely subtruncate in front, not at all pointed and meeting in advance of eye-lobe for a distance equal to barely half the length of the latter. Ocular lobe as long as wide, rounded in front, very slightly constricted at base, black, with eye lenses apparently as described by Zimmer but their definition confused by pigment.

Pedigerous and pleon somites smooth, rounded.

Telsonic somite rather less than half as long again as wide and less than two-thirds as long as fifth pleon somite which is only slightly narrowed towards the rear; produced distal portion fully one-fourth of total length of somite.

Antennae as in *cognata*.

Basis of third maxilliped more than half as long again as palp when fully extended; carpus barely more than twice as long as merus, not quite half as long again as propodus, and about twice as long as dactylus.

Basis of first peraeopod as long as rest of limb, with plumose hairs on outer edge including distal end (two or three) and with spines and plumose setae on inner edge, leaving distal part and lobe unarmed; ischium, including lobe, about as long as merus; propodus more than half as long again as carpus and twice as long as dactylus.

Dactylus of second peraeopod about two and one-third times as long as propodus, less than twice as long as carpus and scarcely longer than merus; its inner margin bears a row of five to seven spines, and there is a long distal spine and a short one; other furniture see figure.

Posterior peraeopods robust, with four distal carpal setae which with propodal seta reach well beyond tip of dactylus.

Uropod with peduncle six-sevenths as long as first joint of endopod and with a few spines on inner margin; endopod equal in length to exopod, its first joint nearly five times as long as second, with short spines on inner margin, interspersed with longer spines; second joint, as in *cognata*, with a row of inner spines which successively increase very slightly in length, but with the longer terminal spine of the rounded distal end shorter than the joint; apex of exopod with three or four blunt, stout, very unequal spines and with only one small, stout, subdistal spine on outer margin.

Colour translucent, with brown chromatophores which are often massed to form an irregular pattern, the most consistent markings being situated at the posterior ends of dorsal excavation of carapace. Sometimes the second and third pedigerous somites have the back brown and a brown patch on each pleural part, while the posterior half of the first pleon somite is darkened. The eye is always bluish-black.

Length, subadult, 8·7 mm.

Adult Male. The same slight irregularity of the dorsal contour of the carapace is present, but is barely discernible. First antenna of slightly different proportions (second peduncular joint twice as long as third, as shown by Zimmer), with flagella more robust and generously furnished with sensory setae; the main flagellum appears to be three-jointed, but the last "joint" may, as surmised by Zimmer, represent the bases of the terminal sensory appendages. The last joint of the peduncle of the second antenna is fully two-thirds as long again as the penultimate; the proximal joints of the flagellum are as wide as long, or wider, but soon become relatively more elongate but never very much so as in *Vaunthompsonia*.

The uropods differ from those of the female in having a greater number of marginal spines (second series well developed on peduncle), those of the second endopodal joint being interspersed with smaller spines, etc.; the plumose hairs on the exopod are longer and the distal spines of that ramus a little more robust.

Length, 9 mm.

Loc.—Queensland: off Fraser Island, 24° 20′ S., 153 02′ W. ("Warreen" Station 31, Sept. 1938). New South Wales: off Broughton Island, at surface (D. L. Serventy, midnight, Dec. 1938); off Jibbon, 35 fath., in coarse sand (K. Sheard, Feb. 1940); off Wata Mooli, 70 metres ("Cronulla" Trawl Station 4, July 1943); off Eden, 30 metres, trawled in coarse sand (K. Sheard, Oct. 1943); Ulladulla, 75 metres, trawled in sand (K. Sheard, June 1944).

Hab.—North-Western and eastern Australia.

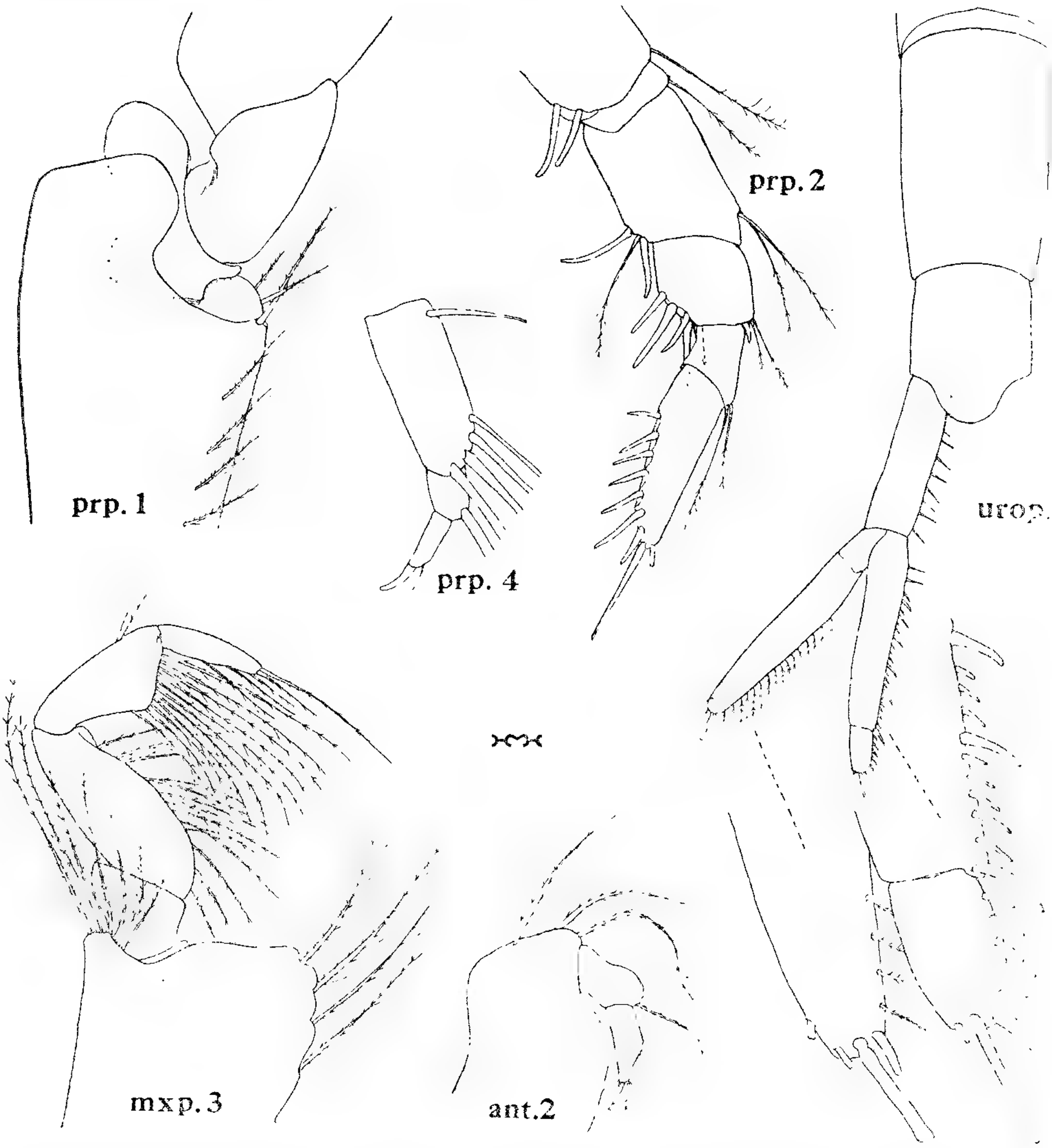

Fig. 13

Pomacuma australiae, female; ant. 2, second antenna; mxp. 3, palp and distal end of basis of third maxilliped; prp. 1, merus, ischium and distal end of basis of first peraeopod; prp. 2, second peraeopod, basis not shown; prp. 4, distal joints of fourth peraeopod (all x 86); urop., uropod with fifth pleon and telsonic somites (x 26; distal half of rami, x 100).

Zimmer regarded his species as representative of a new genus because of the structure of the third maxilliped and first peraeopod. He did not dissect his single young male, but illustrates the basis of this maxilliped as truncate at the level of the insertion of the palp. Although he shows the dorsal margin of the carapace as perfectly smooth, there is little doubt that the eastern specimens are correctly referred; the proportions of the joints of third maxillipeds and peraeopods, as far as shown, seem much the same, and there are six inner spines on the carpus of the second legs. There are, however, some differences; Zimmer states that the

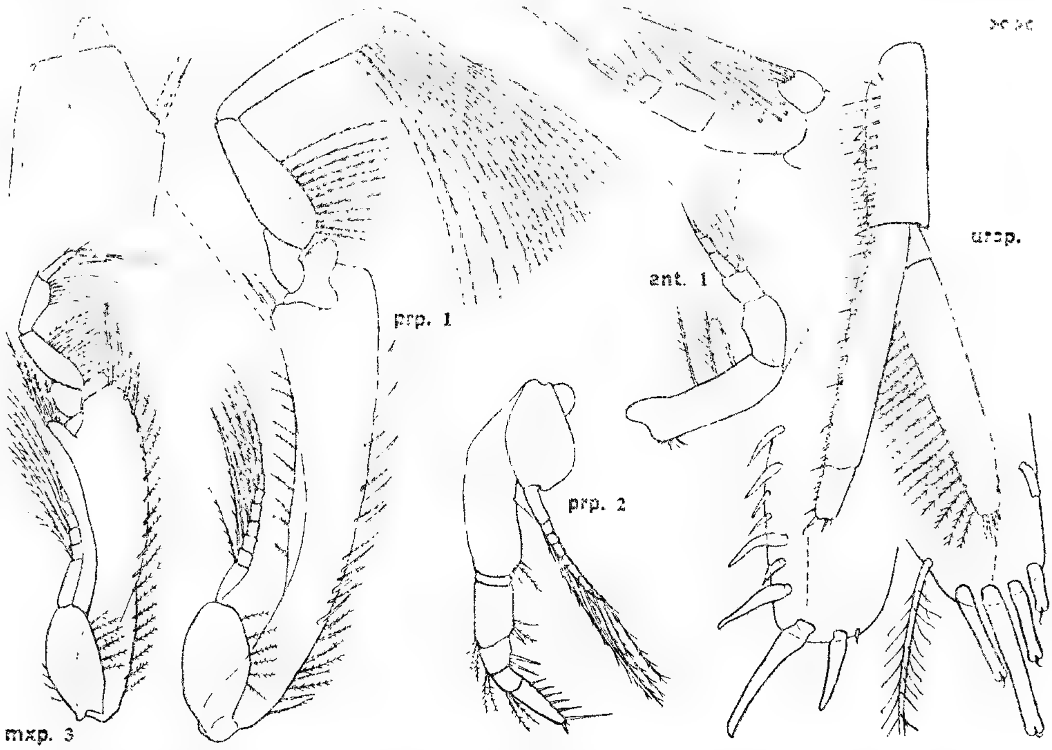

Fig. 14

Pomacuma australiae, adult male; ant. 1, first antenna (x 52; flagella, x 170); mxp. 3, third maxilliped (x 32); prp., peraeopods (x 32; lobe of basis of first, x 52); urop., uropod; apices of rami (x 170).

telsonic somite is not much produced posteriorly and shows it as so in his fig. 7; also, he figures three small subapical spines on the outer margin of the uropodal exopod. He remarks incidentally the characteristic blunt terminal spines of this ramus, which differ slightly from those of *cognata*. The several types of composite setae and other projections occurring in Cumacea, and loosely referred to as "spines" for taxonomic purposes, are worthy of special studies such as have been applied elsewhere.

Genus Gephyrocuma Hale

Gephyrocuma Hale, 1936, 412; and 1943, 340.

Ocular lobe wide and not distinctly separated off from frontal lobe; lenses very large. Antennal notch so widely open that no distinct incision or antennal angle is evident.

Pleon reduced, at most only about two-thirds as long as cephalothorax in the male, shorter in the female.

First antenna strongly geniculate, with joints of peduncle globose. Second antenna of female indistinctly three-jointed, the third segment elongate and with a minute terminal jointlet (fig. 17, ant. 2).

Basis of third maxillipeds without external apical lobe but with very large inner lobe.

Basis of first peraeopod distinctly twisted, with no distal inner lobe.

Exopods of peraeopods identical in both sexes; well developed on first and second pairs, and rudimentary on third and fourth. On the third pair the exopod is either single-jointed, or with peduncle and first joint only of flagellum developed.

Uropods with short peduncle and with endopod two-jointed, the first segment much longer than the second.

Key to Species of Gephyrocuma

Exopod of third peraeopod with two joints. Endopod of uropod without spines on inner margin .... *pala* Hale

Exopod of third peraeopod single jointed. Endopod of uropod with a row of spines on inner margin ... . *repanda* sp. nov.

Gephyrocuma repanda sp. nov.

Adult Male. Integument thin and fragile, somewhat polished.

Carapace as seen from the side with dorsal margin evenly and slightly convex; little more than one-third of total length of animal; twice as long as depth, which is equal to the width; dorsal carina scarcely apparent. Pseudorostral lobes meeting in front of the ocular lobe for a distance equal to about one-third of the length of the latter; wide and truncate anteriorly. Ocular lobe much broader than long, with nine large lenses, five of which, together with the greater part of the lobe, are pigmented. Margin below front of pseudorostral lobes slightly concave.

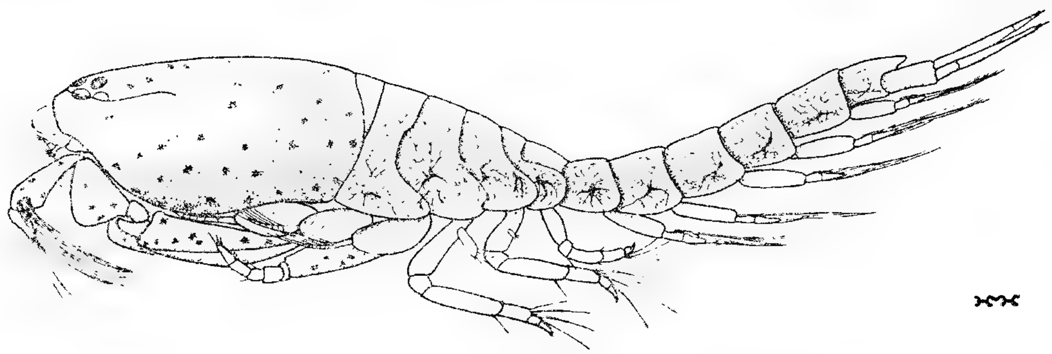

Fig. 15
Gephyrocuma repanda, type adult male (x 32).

Pedigerous somites all exposed, together two-thirds as long as carapace; first somite short, concealed on sides; postero-lateral portions of each of second, fourth and fifth somites produced backwards as a rounded lobe; second to fourth not differing markedly in length.

Pleon more than two thirds as long as cephalothorax; third to fifth somites somewhat deeper than the others.

First antenna very stout; joints of peduncle almost globose, the diameter in the second and third being equal to the length; first segment of peduncle as long as rest of appendage; flagellum three-jointed and accessory flagellum small, stout and knob-like.

Second antenna long, the flagellum reaching beyond end of telson.

Epipod of first maxilliped with four stout digitiform gill-lobes, two of which are smaller than the others.

Basis of third maxillipeds with width of inner lobe equal to one-third of length of joint; two short plumose setae on inner edge; the carpus of the extended geniculate palp does not quite reach level of distal end of basis.

First peraeopod with its massive basis distinctly longer than rest of limb; carpus a little shorter than propodus, its greatest width two-thirds its length; dactylus short and stout, less than half as long as propodus.

Basis of second peraeopod three times as long as wide, more than half as long again as remainder of limb; ischium distinct; merus as long as dactylus and longer than carpus or propodus, the last-named, nevertheless, not much shorter than the dactylus; the dactylus has three rather stout distal spines.

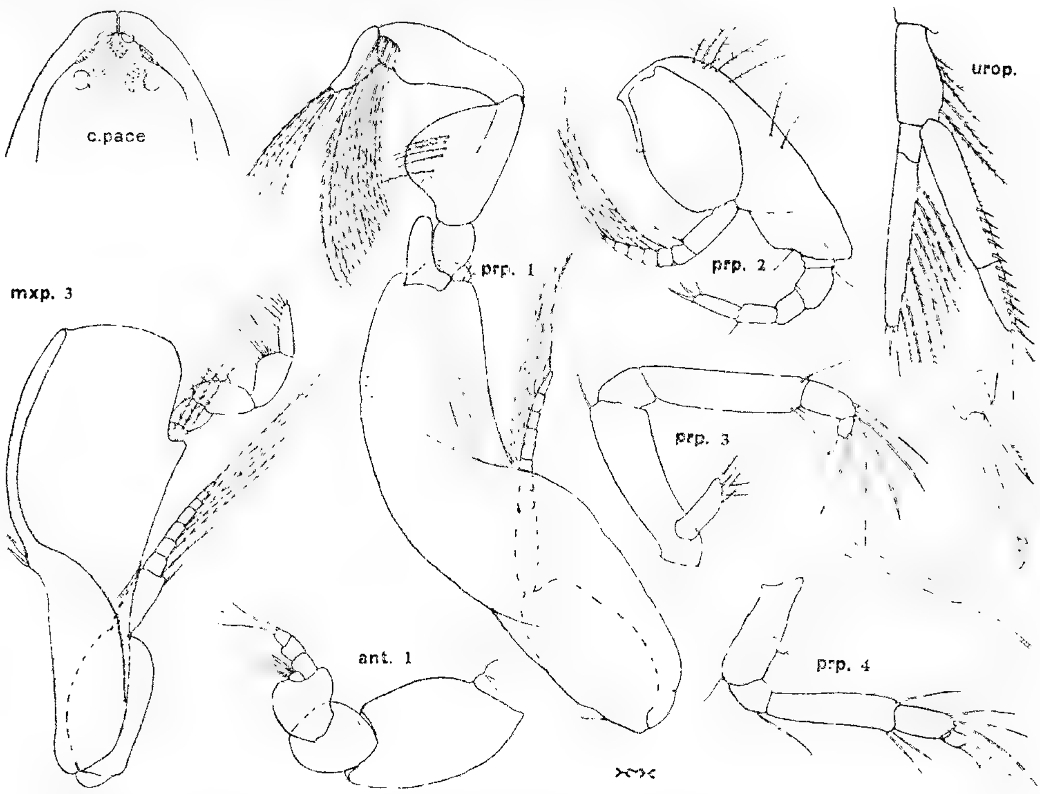

Fig. 16

Gephyrocuma repanda, paratype adult male; c. pace, anterior portion of carapace (x 30); ant. 1, first antenna (x 155); mxp. 3, prp. and urop., third maxilliped, peraeopods and uropod (x 75; spines and seta, x 330).

Merus of third peraeopods barely shorter than basis, that of fourth and fifth pairs much longer than basis; propodi and dactyli short and stout; three distal carpal setae, the longest reaching well beyond tip of dactylus; exopods of third and fourth legs rudimentary, without trace of flagellum (fig. 17, B).

Peduncle of uropods stout, only about half as long as exopod and with a row of long plumose setae on inner margin; endopod a little longer than exopod; its first joint is more than twice as long as the second and its inner margin bears spinules and, on the distal half, a row of short stout spines; second joint with an inner row of half-a-dozen stout spines and with a terminal spine; exopod with three unequal apical spines and a row of long plumose setae on inner margin (fig. 17, B).

Colour translucent with orange chromatophores (artificial lighting), which appear black after preservation, arranged as shown in fig. 15.

Length, 3·25 mm.

Juvenile Male. The pleon is shorter than in the adult male, but is much longer than the pedigerous somites together.

Length, 2 mm.

Non-ovigerous Female. The pleon, though relatively smaller than in the adult male, is much longer than the pedigerous somites together.

Length, 2·5 mm.

Loc.—New South Wales: Cronulla, 8 feet, on coarse sand (*type loc.*; H. M. Hale and K. Sheard, submarine light, Sept. 1942 and Jan. 1944); Port Hacking, 50 metres, on coarse sand (K. Sheard, June 1943); off Wata Mooli, 35 metres, on sand ("Cronulla" Trawl Station 2, July 1943); Jibbon, 45-50 metres, on coarse sand ("Cronulla" Trawl Station 10, Aug. 1943); Ulladulla, 75 metres (K. Sheard, trawled, July 1944). Type male in South Australian Museum, Reg. No. C.2474.

Most of the examples are adult males secured at Cronulla; the single female was taken off Jibbon.

In fig. 15 the concavity shown in the outline of the carapace below the pseudo-rostrum is that into which the carpo-propodal articular areas of the first peraeopod fit when the operculum is in operation. The projecting distal end of the basis of the third maxilliped may be seen below the ischio-carpal part of the first leg; this is even wider than in the genotype, as is also the carpus of the first peraeopod. The carpus and propodus of the first leg accordingly form a wider angle when folded, the triangular lamellate part of the carpus overlapping slightly the outer distal portion of the maxillipedal lobe; the peraeopod fits so intimately against the maxilliped that it is not easy to detect the margins.

The fragile integument collapses on partial drying.

Gephyrocuma pala Hale

Gephyrocuma pala Hale, 1936, 412, fig. 5-6; and 1934, 340, fig. 8-9.

This, the genotype, apart from the smaller size, shows many constant differences from the New South Wales species.

Male. The pleon is shorter, at most barely longer than the pedigerous somites together. The subconical accessory flagellum of the first antenna is larger. The distal spines of the second peraeopods are longer, and are four in number, while the exopods of the third and fourth legs are much larger, that of the third pair consisting of two joints, peduncle and first segment of the flagellum. The distal spines of the rami of the uropods are not so stout; the second joint of the endopod is more than half as long as the first, and neither segment has spines on the inner margin (cf. A and B in fig. 17).

Both species have up to five short and stout plumose setae on the inner margin of the basis of the third maxilliped.

Ovigerous Female. Much as previously described for the subadult of this sex, and differing from *repanda* as above. The pleon is barely as long as the pedigerous somites together. The flagellum of the first antenna is two-jointed.

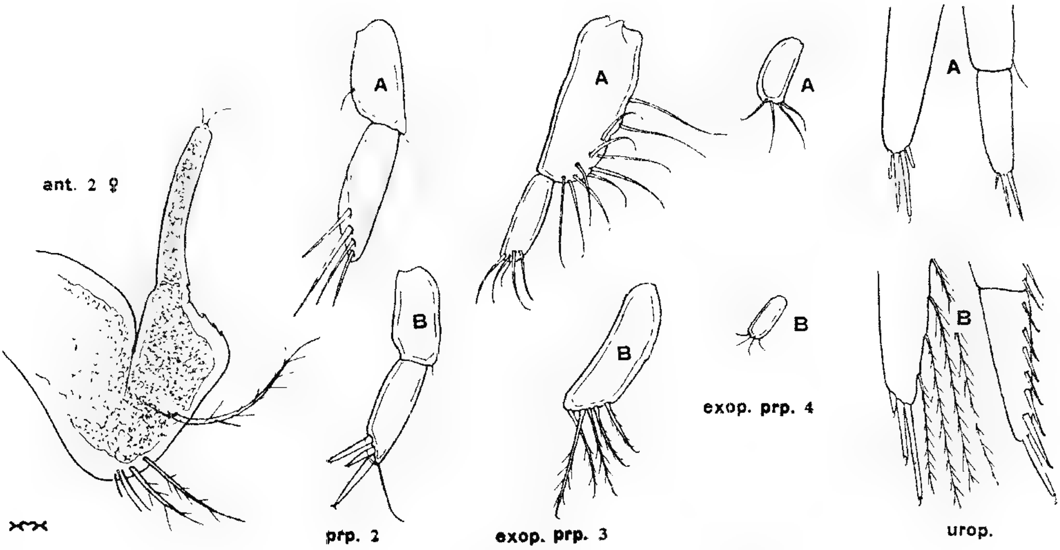

Fig. 17

ant. 2, Second antenna of female of *Gephyrocuma pala* (x 280). prp. 2, exop. prp. 3-4 and urop. Distal joints of second peraeopods and distal half of rami of uropod of (A) *Gephyrocuma pala*, (B) *G. repanda* (x 140).

The ova are relatively very large, 0·2 mm. in diameter or about one-third the greatest depth of the body.

Length, 2·3 mm.

Loc.—This species occurs on sandy beaches in St. Vincent Gulf, South Australia, sometimes in great numbers, but for long periods may be absent or rare.

Genus Leptocuma Sars

Leptocuma Sars 1873, 24; Stebbing 1913, 53 (syn.).

The genotype (*L. kinbergii*) was described from the female; it and two females subsequently identified with the species (Calman 1907, 30; and 1912, 616) were taken in the South Atlantic. Calman also referred to the genus a species (*minor* Calman 1912, 616, fig. 14-20) from the North Atlantic, and the female of this would seem to be congeneric with Sars' species; the male of *minor* has only three pairs of pleopods, and exopods are well developed on the first four pairs of peraeopods. Later, the present writer tentatively placed in the genus two Australian species (*pulleini* and *sheardi*); the females of these also cannot be satisfactorily separated generically from *kinbergii* as described by Sars, but the males have five pairs of pleopods and the exopod of the fourth peraeopod rudimentary as in the female.

Vaunthompsonia (?) *australiae* Zimmer was also temporarily referred to *Leptocuma* (Hale 1936, 408), but has been shown above to belong elsewhere.

Four further species, congeneric with *pulleini* and *sheardi*, perhaps congeneric with *kinbergii*, but certainly not with *minor*, are now described.

All six Australian species differ from *minor* in the following characters also. The pseudorostral lobes, as in *Vaunthompsonia*, extend a little in front of the ocular lobe but do not meet. The mandibles are robust and have a dozen or more spines ("only about six" in *minor*). The branchial lobes are thin and leaf-like and are much more numerous (eleven to nineteen plus one reflexed instead of about seven plus one). The basis of the third maxilliped is not at all produced distally, but on the contrary the external angle is rounded and slopes backwards;

the fan of distal plumose setae is arranged in two series, only one of which is shown in fig. 18. In the pleopods there is no narrow process on the outer margin of the endopod. Only a fuller description of the genotype will clarify the situation.

The Australian species apparently agree with both *kinbergii* and *minor* in the structure of the second peraeopods, which are unusual in that there is a brush of distal setae on the propodus and dactylus, but no spines. The first antennae have the accessory flagellum single-jointed. The second antenna of the female is three-jointed (the first and largest joint itself indistinctly divided). The telsonic somite is well produced posteriorly and its apex is rather angular. In the third maxillipeds the ischium is short and the merus is not as long as the carpus.

The second antennae of a large but subadult female of *vicaria* sp. nov., as shown in fig. 18, B. juv., are not distinctly divided into joints, whereas in ovigerous females (fig. 18, A and B) there is a long basal joint (indefinitely divided into two) and the last of the other two joints is conical and longer than the second.

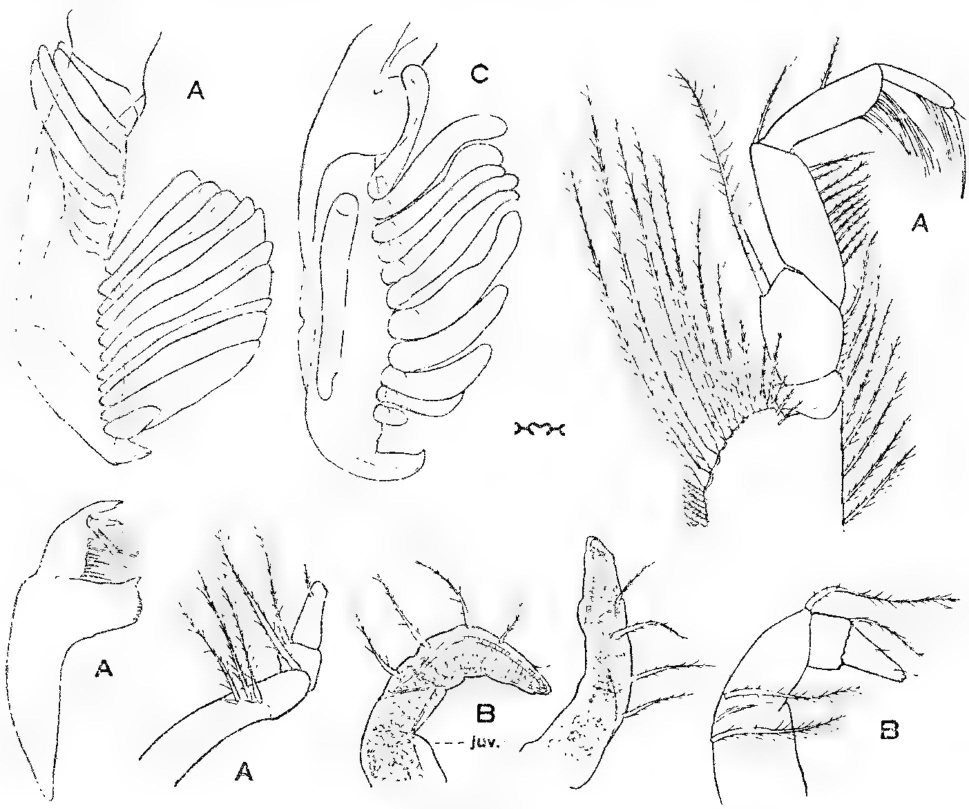

Fig. 18

Leptocuma, branchial apparatus, distal part of third mandible, and female second antennae; maxilliped: A, *pulleini*, ovigerous female; B, *vicaria*; C, *sheardi*, adult male.

The ocular lobe is wide, moderate or large in size. The joints of the flagellum of the second antenna of the male are elongate.

The integument, as in *Vaunthompsonia*, is scarcely calcified. The third somite of the female is produced forward on each side to form a lobe overlapping the second, and the antero-lateral parts of the fourth somite of the male are similarly expanded to override the third.

The Australian species fall into two well-defined sections, the differences being detailed in the following key.

Key to Australian Species of Leptocuma (Adults)

1 First peraeopod with a prominent *simple* spine at distal end of inner margin of basis, preceded by several shorter spines, and with a well-developed brush of setae at distal end of propodus. Setae of third to fifth peraeopods very numerous. Uropod with first joint of endopod shorter, or barely longer, than second. Over 13 mm. in length. 2

First peraeopod with a *serrate* spine at distal end of inner margin of basis, preceded by one longer spine, also serrate; with sparse setae at distal end of propodus. Setae of third to fifth peraeopods not very numerous. Uropod with first joint of endopod much longer than second. Less than 8 mm. in length 3

2 Second peraeopod reaching to or beyond distal end of basis of first leg, and with carpus two-thirds as long again as merus .... *pulleini* Hale

Second peraeopod reaching only to about middle of length of basis of first leg, and with carpus subequal in length to merus .... *vicaria* sp. nov.

3 Dorsal margins of pedigerous somites, as seen from the side, undulating. One of the terminal spines of endopod of uropod geniculate (female) or hooked (male). Pleon with obvious lateral and dorsal carinae .... *obstipa* sp. nov.

Dorsal margins of pedigerous somites smooth. Terminal spines of endopod of uropod straight (barely curved). Pleon smooth, or with scarcely distinguishable traces of carinae 4

4 Size under 5 mm. Second joint of endopod of uropod much more than half length of first .... *serrifera* sp. nov.

Size about 7 mm. Second joint of endopod of uropod about half as long as first, or less 5

5 First peraeopod with propodus much longer than dactylus. Second peraeopod with propodus and dactylus subequal in length .... *sheardi* Hale

First peraeopod with propodus scarcely longer than dactylus. Second peraeopod with dactylus fully one-third as long again as propodus .... *intermedia* sp. nov.

Leptocuma pulleini Hale

Leptocuma pulleini Hale 1928, 38, fig. 7-8; and 1936, 409.

Adult Male. Carapace about one-fifth of total length of animal, its depth equal to its width and one-half of its length; seen from above it has the form (as in the ovigerous female previously described) of a cylinder truncated at each end;

Fig. 19

Leptocuma pulleini, adult male (x 11).

dorsal carina as in female, low and fading posteriorly. Ocular lobe larger than in female, slightly wider than long and with a tiny incision at apex; there are three prominent lenses arranged in a triangle, the centre one pigmented and having

F

the appearance of including a pair of oval lenses; on each side there are three much smaller lenses. Pseudorostral lobes rather widely truncate in front; as usual in the genus, extending in advance of ocular lobe but with inner (medial) margins bent down and not meeting in front of eye-lobe. Antennal notch so widely open as to be obliterated; angle rounded.

Pedigerous somites two to five with a faint median dorsal carina; again as usual in the genus, the anterior margins of the second, third and fouth somites are fringed with short bristles, and there is a similar row on the posterior edges of the fourth and fifth.

Pleon somites with faint dorsal carina and with indications of lateral carinae on second to fourth; first four somites with a fringe of rather long setae posteriorly.

Flagellum of first antenna four-jointed and with two tiny terminal jointlets, apparently bases of the sensory appendages.

Mandible with about 18 spines.

First peraeopod with carpus reaching well beyond antennal angle; basis with long plumose seta at external distal angle and with inner distal spine longer than ischium; on the distal half of inner margin, posterior to the apical spine is a row of shorter spines of two different lengths; propodus more than one and three-fourths times as long as dactylus and a little longer than the carpus.

Second peraeopod reaching forward beyond end of basis of first; basis only about three-fifths as long as terminal joints together; carpus two-thirds as long

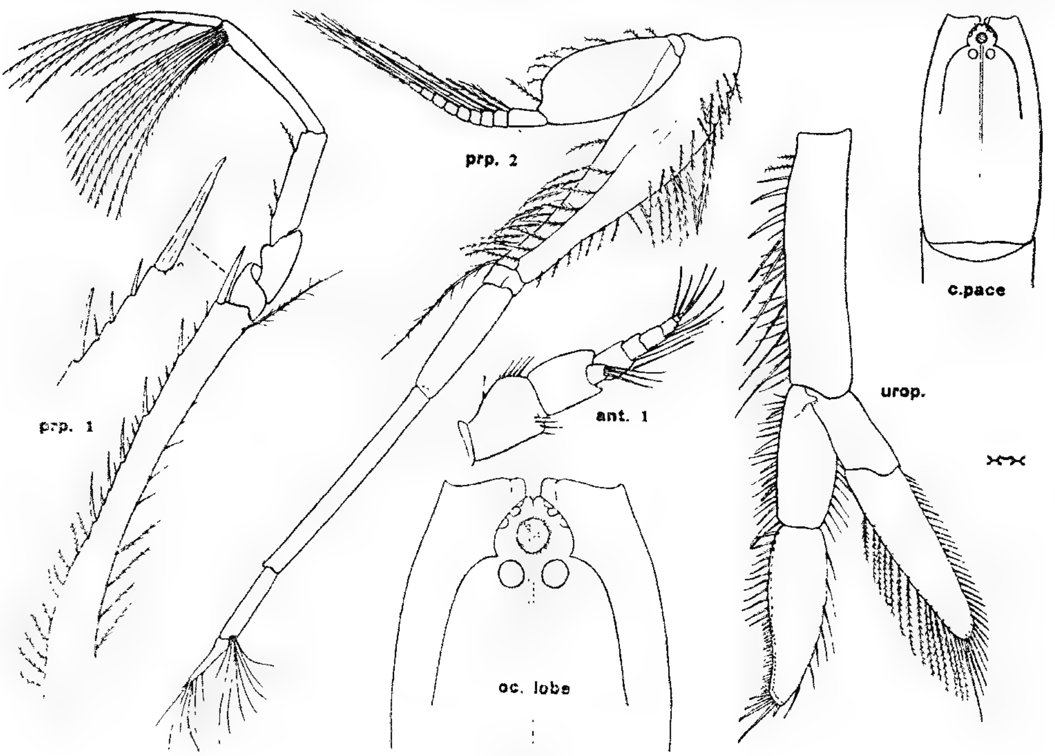

Fig. 20

Leptocuma pulleini, adult male; c. pace, carapace from above (x 11); oc. lobe, anterior portion of carapace (x 29); ant. 1, distal peduncular joints and flagella of first antenna (x 72); prp. and urop., peraeopods and ventral view of uropod (x 36; spines, x 72).

again as merus and more than two and one-half times as long as propodus, which is longer than the dactylus.

Third to fifth peraeopods with a large number of flexible setae on ischium, merus and carpus (ten or more) and the usual one on propodus; basis with plumose setae. The rudimentary exopod of the fourth has the vestigial second joint as in the female.

Uropod with peduncle shorter than either telsonic somite or rami, with a few stout spines and two series of stout setae on inner margin; endopod distinctly longer than exopod; as in the female the second segment is one-fourth as long again as first, but the armature is not the same, there being on the distal half of the second joint a comb of spines which are shorter and of different type from those on the proximal part.

Colour, white, with sparse stellate spots (night).

Length, 13·5 mm.

Loc.—New South Wales: Cronulla, 8 feet, on coarse sand (H. M. Hale and K. Sheard, submarine light, Sept. 1942 and Jan. 1944).

Ovigerous Female. Described in detail previously. There are several spines on the inner margin of the basis of the first peraeopod. Examination when not immersed in alcohol and partly dry reveals the presence of very low, smooth but distinct dorso-lateral, lateral and infero-lateral carinae on the pleon, the last-named ridges most apparent on the first four somites.

Hab.—South Australia and New South Wales.

The first recorded specimens of this species were collected in June 1886 by the late Dr. Robt. Pulleine, and, despite searching, it has not been taken since in South Australia. Two adult males were secured in New South Wales; one is a little smaller than that described and figured, but otherwise agrees in detail. The discrepancy in size between examples from the two localities is considerable, the immature male recorded from South Australia being 19 mm. in length and the ovigerous female still larger (24 mm.), but I can find no other character to separate them.

Leptocuma vicaria sp. nov.

Ovigerous Female. Carapace about four and one-half times in total length and not quite as long as first four pedigerous somites together; its depth is equal to width and more than half its length; viewed from either above or from the side the carapace tapers markedly to the front; there is a median dorsal carina very distinct on anterior three-fourths of length and (unlike that of *pulleini*) slightly serrate in appearance. Ocular lobe small; lenses present but not well defined, although nine or ten separate small areas are indistinctly discernible; there is a small incision in the apex of the lobe. Pseudorostral lobes narrow anteriorly with inner margins, in front of eye-lobe, bent strongly downwards. Antennal notch distinct (not so widely open as in female of *pulleini*) and angle subacute.

Second to fifth pedigerous somites with dorsal median carina and with the one or two shallow longitudinal furrows (usually present in all species) on sides.

First five pleon somites with median dorsal carina, slightly tuberculate dorso-lateral, lateral and infero-lateral carinae; telsonic somite with dorso-lateral and lateral carinae.

First antenna with flagellum three-jointed; first joint of peduncle much longer than second, which is nearly twice as long as third; accessory flagellum short.

Second antenna, see fig. 18, B.

Third maxilliped as in *pulleini*.

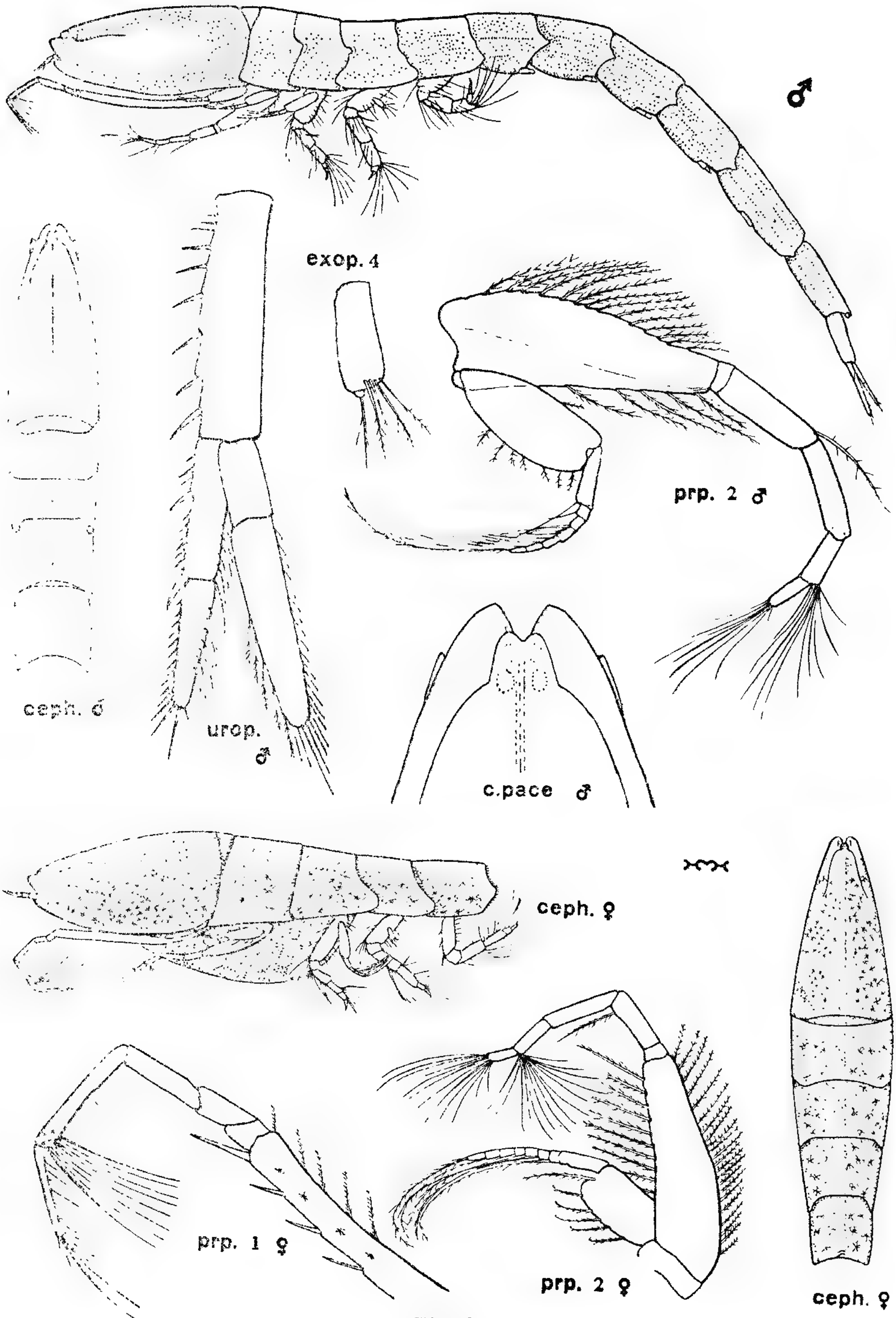

Fig. 21

Leptocuma vicaria. Type ovigerous female; ceph., cephalothorax from side and above (x 7½); prp., peraeopods (x 25). Allotype male; from the side and (ceph.) cephalothorax from above (x 8); c. pace, anterior portion of carapace (x 40); prp. 2 and urop., second peraeopod and uropod (x 40); exop. 4, exopod of fourth peraeopod (x 50).

First peraeopods with basis not nearly reaching to level of antennal angle, nearly half as long again as rest of limb, and with three shorter spines preceding the distal inner spine, which is longer than the ischium; plumose setae on both margins; propodus less than one-half as long again as dactylus and much longer than carpus.

Second peraeopod reaching only to middle of length of basis of first; basis barely longer than rest of limb; carpus subequal in length to merus and distinctly less than twice as long as propodus, which is longer than the dactylus.

Third to fifth peraeopods much as in *pulleini*.

Peduncle of uropod shorter than telsonic somite or rami, its inner margin with six strong spines and, near proximal end, three slender spines; endopod shorter than exopod, the second segment barely longer than the first, which has ten spines on inner margin, the third and particularly the distal being larger than the others; second joint with a score of inner spines successively increasing in length and longest terminal spine fully half the length of the joint; inner margin of endopod with a row of setae not differing markedly in length; second segment of exopod more than two and one-half times as long as first (thus relatively longer than in *pulleini*) and with a gradated series of composite setae on outer margin, the longest terminal ones one-fourth or more the length of joint.

Colour pale brown, densely spotted with dark stellate markings.

Length, 17·5 mm.

Subadult Male. General form even more slender than in female. Carapace with sharply defined carina, and tapering as described but more than twice as long as width or depth. Ocular lobe larger, a little wider than long, with apex more markedly bilobed than in female, but with lenses not distinct. Antennal notch and angle as in female, but doubtless the notch opens in the adult; the antennal angle is visible when the animal is viewed from above.

Similar ridges are present on the pedigerous and pleon somites.

The first antennae have the flagellum only two-jointed at this stage.

The peraeopods have fewer setae (due to immaturity). The basis of the second peraeopod is slightly shorter than the rest of the limb. The rudimentary exopod of the fourth pair has the second vestigial joint found in the female and in both sexes of *pulleini*.

The uropods resemble those of the female; but it is probable that the spines become more specialised in the adult male; the first joint of the endopod is very slightly longer than the second.

Length, 15·5 mm.

Loc.—New South Wales: 24 miles east of Pt. Hacking, surface (allotype male, K. Sheard, Oct. 1940); off Wata Mooli, 35 metres on sand (type female, "Cronulla" Trawl Station 2, March 1943); off Jibbon, 40 metres ("Cronulla" Trawl Station 6, July 1943) and 45-50 metres, on coarse sand ("Cronulla" Trawl Station 10, Aug. 1943). Types in South Australian Museum, Reg. No. C.2451 and C.2501.

At the point where the allotype male and other specimens were taken at the surface the water is 600 metres in depth.

Although obviously allied to *pulleini*, *vicaria* can be readily separated at all stages by the entirely different proportions of the second peraeopod and the more prominent dorsal carina of the carapace. In young individuals (10 mm. or less) the carapace is shaped as in the adult of *pulleini*, *viz.*, it is not markedly narrowed towards the front as in adult examples or those more nearly approaching maturity.

In very small specimens the setae of the peraeopods are much less numerous and the characteristic brushes on the propodus and dactylus of the first legs are represented by only three or four setae.

Amongst other smaller points of difference, the eye-lenses are not so distinct as in *pulleini,* the endopod of the uropod is shorter than the exopod instead of longer than it, and its segments are subequal in length; the second joint of the exopod of the uropod is relatively longer and the terminal joints of the first peraeopods are of different proportions.

Leptocuma obstipa sp. nov.

Ovigerous Female. Carapace robust, less than one-fourth of total length of animal; depth equal to width and not quite three-fourths of its length; dorsal carina distinct; there is a long shallow depression on each side of the carina for about three-fourths of its length and this accentuates the ridge; posterior to these hollows the carina bifurcates; on posterior half of carapace is a pair of short ridges

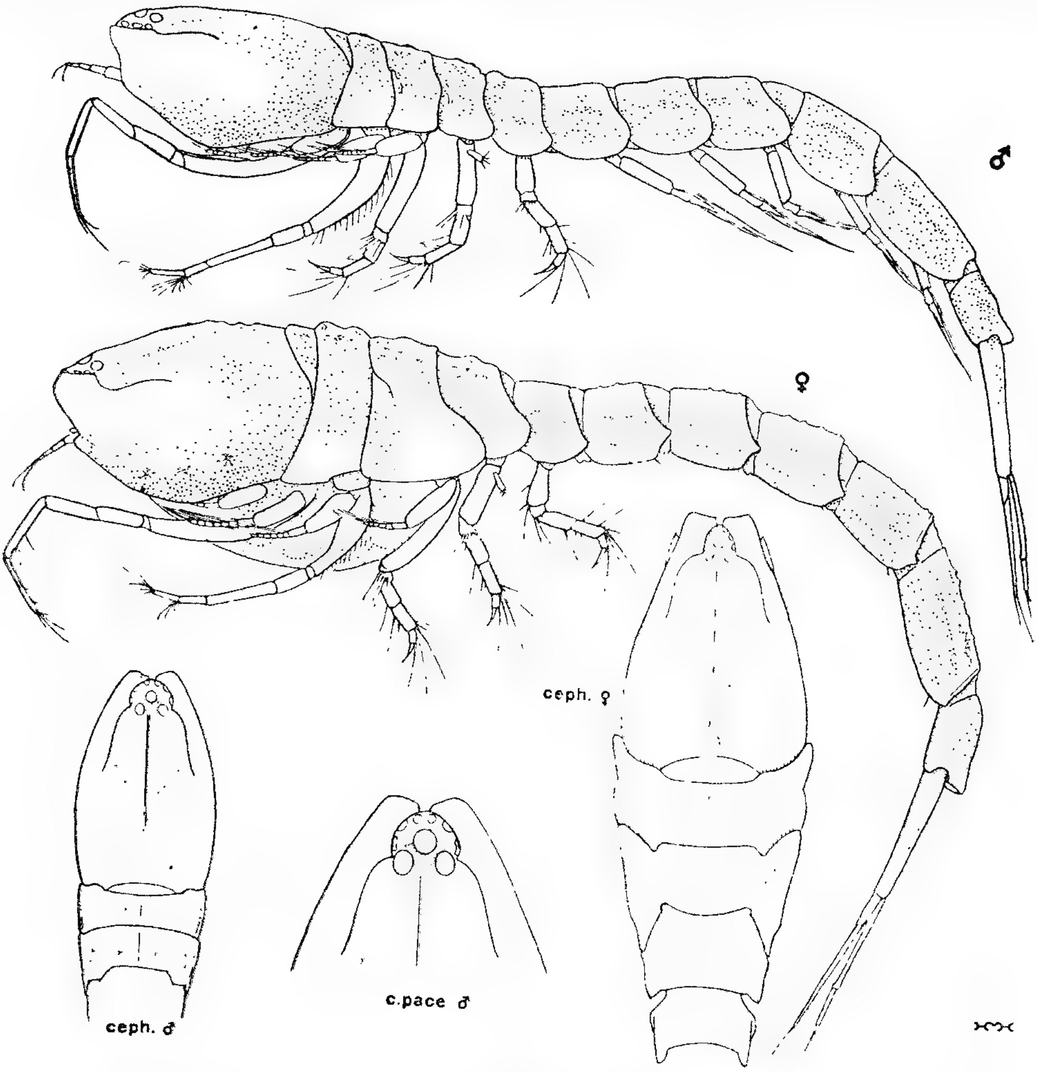

Fig. 22
Leptocuma obstipa, type female and allotype male: lateral views and (ceph.) cephalothorax (x 19); c. pace., anterior portion of carapace (x 30).

which, as seen from the side, are undulating. Ocular lobe pigmented, as wide as long and with nine colourless lenses, the median one larger than the others. Antennal notch moderately wide, a little obtuse, and angle rounded.

The five pedigerous somites together are longer than the carapace and half as long as the pleon; lateral parts of third somite overlapping second in front and fourth behind; each has a median dorsal ridge and a low undulating dorso-lateral carina; on the fourth and fifth somites there is also a low lateral tumidity.

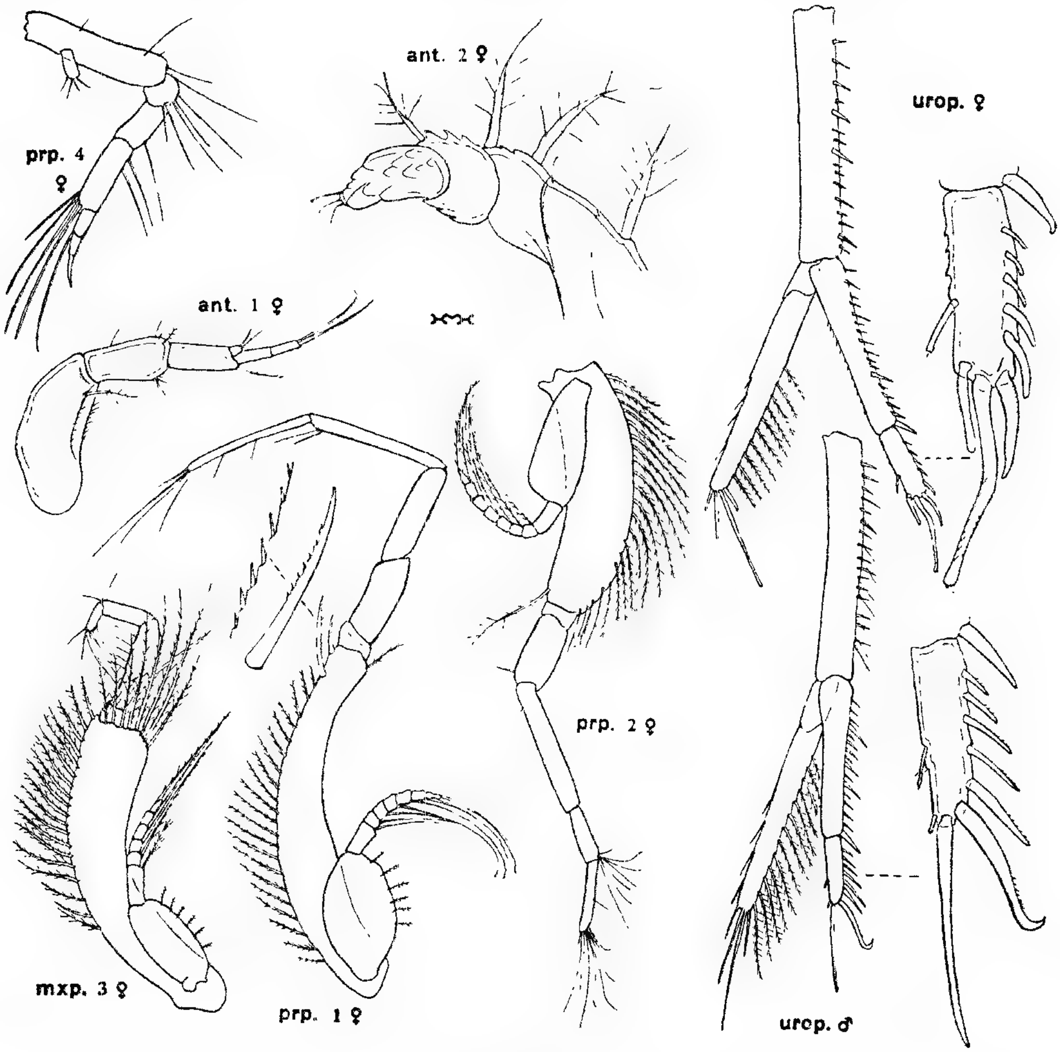

Fig. 23

Leptocuma obstipa, paratype ovigerous female and allotype male; ant. 1, first antenna (x 83); ant. 2, second antenna (x 175); mxp. 3, prp. and urop., third maxilliped, peraeopods and uropods (x 42).

First five somites of pleon with median dorsal carina and a sparsely tuberculate dorso-lateral carina on each side; there are also two tuberculate lateral ridges; the lower not well marked.

First joint of peduncle of first antenna as long as second and third segments together; second longer than third which is as long as the two-jointed flagellum.

Third maxilliped with basis generously furnished with stout plumose setae, there being eight or so at the subtruncate distal end.

First peraeopod with carpus reaching level of antennal angle; basis five-sevenths as long as terminal joints together; inner margin with plumose setae; dactylus slender, almost as long as propodus, which is one-third as long again as carpus.

Second peraeopod not reaching distal end of merus of first; basis as long as rest of limb without dactylus, its inner margin with long plumose setae; propodus three-fourths as long as dactylus and distinctly less than half as long as carpus.

Third to fifth peraeopods with four distal carpal setae, two longer than the others and reaching, with propodal seta, well beyond tip of dactylus.

Peduncle of uropod much longer than telsonic somite and equal in length to each ramus; inner edge with a row of sixteen unequal spines; exopod with plumose setae on inner margin, a few adpressed spines on outer edge and four unequal terminal spines, the longest half as long as second joint of ramus; first joint of endopod with spines much as in *serrifera*, but nearly two and a half times longer than second joint; second joint with five curved spines successively increasing in length on inner margin and three, unequal, on the rounded distal end; the middle and longest of these terminal spines is as long as the segment, is of plicate appearance, rounded apically and is geniculate.

Colour white with sparse brown chromatophores, which form a conspicuous marking on the second and third pedigerous somites.

Length, 7·5 mm.; ova, 0·3 to 0·4 mm.

Adult Male. Body proportions much as in female but build considerably more slender. The carinae of pedigerous somites and pleon are much more feeble but are still faintly tuberculate; seen from the side the thoracic somites have the undulating appearance characteristic of the species.

Carapace narrow, with the sides as seen from above evenly rounded; its depth is equal to the width and not a great deal more than half its length. Ocular lobe larger than in female and wider than long; the three median lenses are large and conspicuous. Antennal notch very widely open and "angle" obtusely rounded.

Pedigerous somites differing from female as usual in the group.

Peduncle of uropod as long as exopod but a little longer than endopod; the second joint of the last-named has five serrate spines on inner margin and two distal spines; the longer of these is curved and is longer than the joint, the other is hooked and serrate; other armature of uropods much as in female but longer.

Length, 6·8 mm.

Loc.—New South Wales: off Jibbon, 35 fath., in coarse sand (K. Sheard, Feb. 1940); off Wata Mooli, 70 metres ("Cronulla" Trawl Station 4, July 1943); off Jibbon, 45-50 metres, coarse sand (*type loc.*, "Cronulla" Trawl Station 10, Aug. 1943). Types in the South Australian Museum, Reg. No. C.2488, C.2489.

Only one male is available. A series of ovigerous females from the three localities all have the bent terminal spine on the endopod of the uropod, as figured. This and the slight irregularity of the dorsal outline enable one to separate the species with ease.

Some smaller ovigerous females (length, 7 mm.; ova, 0·4 mm.) have the above characters but the propodus and dactylus of the first peraeopods are relatively shorter; the propodus is as usual scarcely longer than dactylus, but it is also barely longer than the carpus.

Leptocuma serrifera sp. nov.

Ovigerous Female. Integument thin, very finely reticulate, smooth and polished.

Carapace short and robust with dorsal edge scarcely arched, appearing slightly uneven owing to insignificant sinuations; less than one-fourth of total length of animal; its depth is equal to its greatest width and is more than three-fourths its length; seen from above the curved sides diverge from the moderately wide front; the median dorsal carina is obsolete. Ocular lobe wider than long, pigmented and with distinct lenses. Antennal notch shallow and angle obtusely rounded; a shallow oblique furrow to rear of notch.

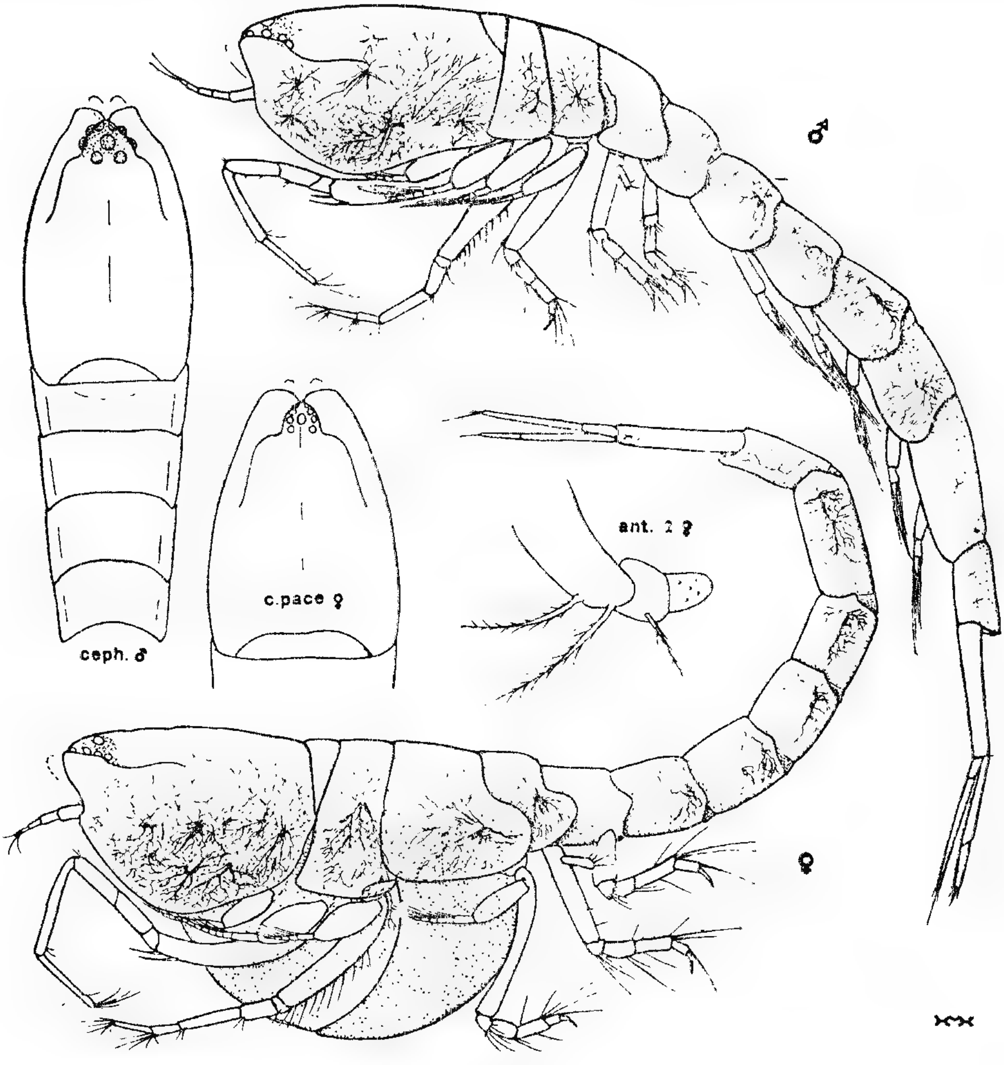

Fig. 24

Leptocuma serrifera, type ovigerous female and allotype male; lateral views. (ceph.) cephalothorax and (c. pace) carapace (x 30); ant. 2, second antenna of female (x 160).

The five pedigerous somites are without carinae, together they are fully half as long as the pleon and much longer than the carapace; third and fourth somites with rounded postero-lateral lobe, and hinder margin of fifth a little backwardly produced on sides.

Pleon slightly tapering, the somites subcylindrical and, excepting fifth, subequal in length; without dorsal or other ridges.

First antenna slender; first joint of peduncle shorter than second and third together; second barely longer than third and as long as the two-jointed flagellum: accessory lash single-jointed.

Mandible with about 12 spines in the row.

Basis of third maxilliped more than half as long again as remaining joints together; margin immediately exterior to palp sloping backwards and with long plumose setae; inner margin with long setae on proximal half and shorter plumose setae on distal half.

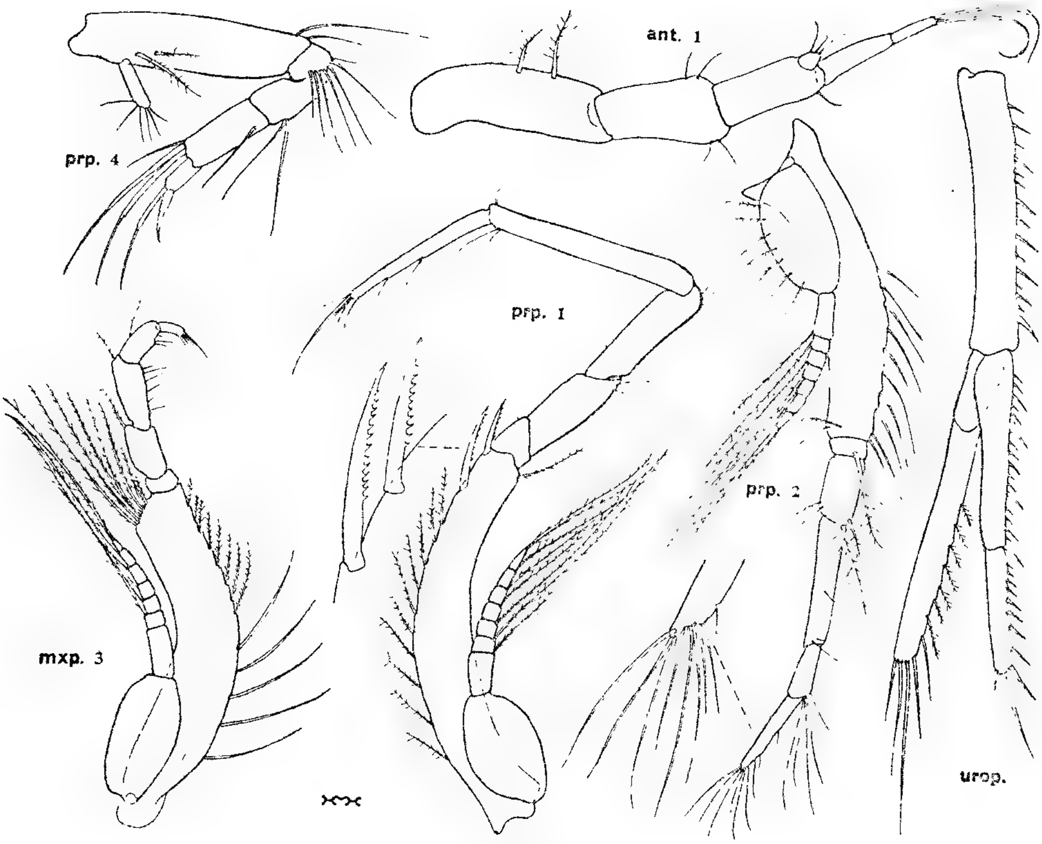

Fig. 25

Leptocuma serrifera, paratype ovigerous female; ant. 1, first antenna (x 155); mxp. 3, prp. and urop., third maxilliped, peraeopods and uropod (x 74; spines of basis of first leg and tip of dactylus of second, x 155).

First peraeopod with carpus reaching to level of antennal angle; basis only about four-sevenths as long as the long terminal joints together, and with a plumose seta at external angle; inner (inferior) margin with a row of plumose setae; dactylus long, but only three-fourths as long as the propodus, which is more than half as long again as carpus; merus not much shorter than carpus.

Second peraeopod reaching to distal end of merus of first; basis almost as long as rest of limb, its inner margin with long flexible setae similar to the fossorial setae of the posterior peraeopods; carpus much longer than ischium and merus together; propodus fully two-thirds as long as dactylus and almost half as long as carpus.

Third to fifth peraeopods with two distal carpal setae of equal length and a third much shorter; together with the propodal seta the longest reach very much beyond the tip of the dactylus.

Peduncle of uropod slender, considerably longer than telsonic somite, but shorter than the equal rami; inner margin with a row of 15 unequal spines, half-a-dozen of which are prominently longer than the others; exopod with short plumose setae on inner margin and with several terminal setae, one conspicuously the longest and more than half as long as the ramus; first joint of endopod little more than half as long again as second and with eighteen inner unequal spines; second joint with about eight finely serrate spines, successively and regularly increasing in length, on inner edge, and with three unequal finely serrate distal spines, the longest barely more than half the length of the longest apical seta of exopod.

Colour pale yellow, with conspicuous sprawling chromatophores.

Length, 4·4 mm. (ova, 0·15 mm. in diameter).

Adult Male. Carapace with dorsal outline not exhibiting the slight irregularity apparent in the female; one-fourth of total length of animal, its depth equal to width but rather less than two-thirds its length; seen from above the curve of the sides is more pronounced, the greatest width being at the middle of the length. Antennal notch more widely open (represented merely by a shallow concavity) and antennal angle very obtusely rounded, almost imperceptibly angular. Ocular lobe and lenses about one-third as large again as in female.

The five pedigerous somites together are not quite half as long as the pleon and are equal in length to the carapace; the third locks into a rebate in fourth and is not considerably expanded posteriorly.

Last pedigerous and first four pleon somites produced postero-laterally on each side to form a rounded lobe.

First peraeopod a little longer than in female, and with joints of same proportions.

Uropod slightly longer; peduncle and rami of same proportions but spines and setae longer.

Length, 4·2 mm.

Loc.—New South Wales: Cronulla, 8 feet, on coarse sand (K. Sheard, submarine light, Sept. 1942). Types in South Australian Museum, Reg. No. C.2484-C2485.

Differs from *sheardi* in (1) the smaller size; (2) the relatively longer propodus of the first peraeopod; (3) the relatively longer dactylus of the second peraeopod; (4) the different proportion of the endopod of the uropod; (5) the fewer carpal setae on the fossorial legs.

Leptocuma sheardi Hale

Leptocuma sheardi Hale, 1936, 409, fig. 3-4; and 1937, 65.

Only the longer of the two distal serrate spines of the basis of the first leg was noticed in the original description; the shorter one may be concealed behind the ischium. The female was described previously in some detail.

Adult Male. Carapace with depth less than two-thirds of its length; the median dorsal carina appears as three fine parallel lines extending from the large median eye-lens to level of posterior ends of pseudorostral sutures; beyond this it bifurcates and quickly fades out. Ocular lobe pigmented, large, wider than long and with nine lenses; three are larger than the others and arranged in a triangle, the others three on each side of the lobe. Antennal notch very widely open (more so than in female) and angle rounded and obtuse.

Pedigerous somites without ridges; third somite not backwardly produced postero-laterally to form a rounded lobe as in female.

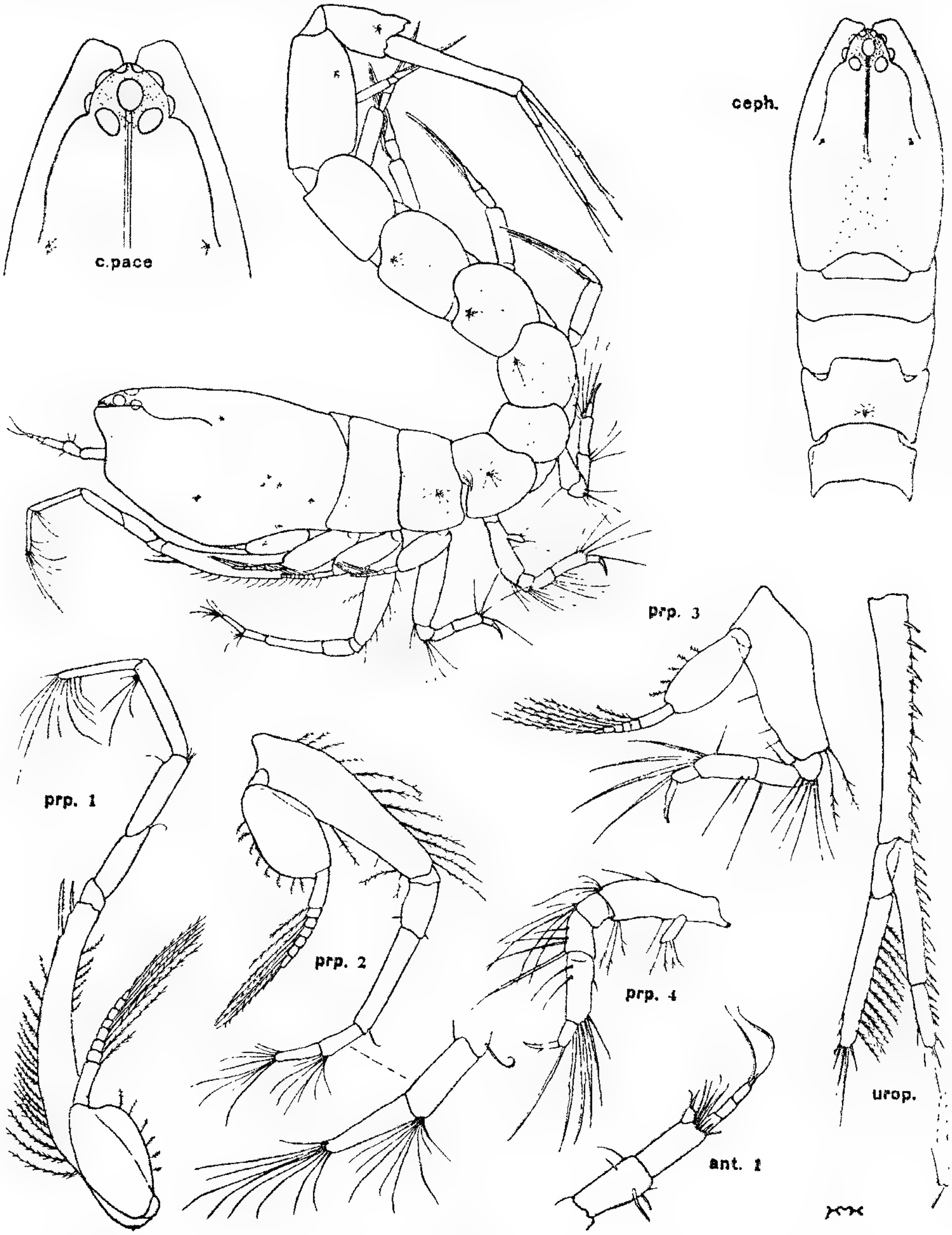

Fig. 26

Leptocuma sheardi adult male; lateral view and (ceph.) cephalothorax from above (x 19); c. pace, anterior half of carapace (x 30); ant. 1, distal peduncular joints and flagella of first antenna (x 78); prp. and urop., peraeopods and uropod (x 39; terminal joints, etc., x 78).

First to fourth pleon somites with postero-lateral portions rounded; median and dorso-lateral carinae can be discerned on the fourth and fifth somites but are very faint.

First antenna with the main flagellum three-jointed (two in female) and with a brush of sensory filaments at its base.

Mandible with about 12 spines.

First peraeopods slightly longer than in female; basis not much shorter than rest of limb; dactylus three-fourths as long as propodus, which is not much longer than carpus: ischium and merus together as long as carpus; the dactylar setae number 10 or so.

Second peraeopods not reaching to distal end of merus of first; basis as long as rest of limb without dactylus, with a row of inner plumose setae; dactylus barely longer than propodus and distinctly less than half as long as carpus.

Third to fifth peraeopods with a fan of long subdistal carpal setae, four on the third pair and five on the fourth and fifth. Fourth with rudimentary exopod single-jointed.

Peduncle of uropod a little longer than the equal rami, with about 15 or 16 spines, half of which are conspicuously stouter than the others; first joint of endopod a little more than twice as long as second (not quite twice as long as second in female); armature of rami as in female but plumose spines of exopod more numerous.

In specimens taken at night the colour markings (see previous notes) may be contracted to single stellate spots, as shown in the figure.

Length, 7 mm.

Hab.—The species has been taken only in South Australia, occurring in the southern parts of St. Vincent and Spencer Gulfs and also in Antechamber Bay, Kangaroo Island; it has been netted at the surface at night and to a depth of 7 fathoms.

Leptocuma intermedia sp. nov.

Adult Male. Very like the male of *L. sheardi* but with the following differences.

First peraeopod with dactylus almost as long as propodus. Second peraeopod with dactylus fully one-third as long again as propodus and distinctly

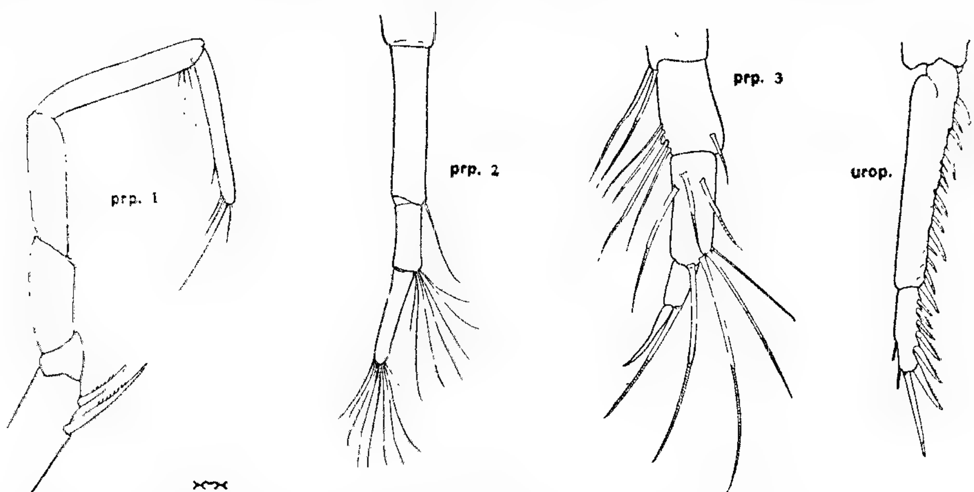

Fig. 27

Leptocuma intermedia, type male; prp. and urop., terminal joints of peraeopods and endopod of uropod (x 66).

more than half length of carpus. First joint of endopod of uropod more than two-and-one-half times longer than second.

Length, 6·6 mm.

Loc.—New South Wales: Cronulla, 8 feet, on coarse sand (K. Sheard, submarine light, Sept. 1942). Type in South Australian Museum, Reg. No. C2496.

This form was taken with *serrifera* at Cronulla, a locality rich in species of Cumacea; apart from the larger size it differs in the very different proportions of the carpus, propodus and dactylus of the first peraeopods, and in the much shorter distal segment of the endopod of the uropod as well as other small details.

Genus VAUNTHOMPSONIA Bate

A single imperfect specimen is described below because it represents the only record of the genus in the Australian region. It is closer to the genotype than is *meridionalis* Sars, the only species which has the external distal part of the third maxilliped at all produced. Also, in the last-named species there are only nine spines on the short distal portion of the mandible, the branchial lobes are digitiform and reduced to four, and the telsonic somite is only slightly produced posteriorly; as is apparently usual in the genus, the third maxilliped has the ischium short, and the carpus as long as it and merus together, while the accessory flagellum of the first antenna is single-jointed.

Zimmer (1908, 165; and 1921, 131) is of the opinion (not shared by the present writer) that *Bathycuma* should be regarded as a subgenus of *Vaunthompsonia*.

The adult of both sexes is known only in the genotype, *cristata* Bate; in this species the dorsal median carina of the female is finely dentate, that of the male unarmed.

Vaunthompsonia nana sp. nov.

Adult Male. Integument thin, smooth and polished.

Carapace with dorsal margin curving upwards from tip of pseudorostrum to above ocular lobe, thence to hinder end almost straight; one-fourth of total length of animal, slightly compressed and with depth equal to about two-thirds of length; dorsum rounded, very obscurely angular along the mid-line but without longitudinal ridge; inferior margin finely toothed on anterior half; seen from above the front third of the carapace is subtriangular in shape, thence the sides are almost parallel. Infero-lateral margins evenly concave, there being no true antennal notch; antennal "angle" rounded. Pseudorostral lobes extending in front of ocular lobe which is as wide as long, with nine lenses, four lateral pale ones, and five large and black.

First pedigerous somite partly exposed; second over-lapping third and carapace at postero-lateral and antero-lateral corners inferiorly.

Pedigerous and pleon somites of equal width (excepting first pedigerous) without ridges but with faint suggestion of angular rounding at mid-line and dorso-lateral areas.

Pleon not much longer than cephalothorax; first four somites of equal size and with inferior and postero-lateral margins finely crenulate; telsonic portion of last somite subtriangular in side view and also as seen from above, and with a pair of terminal setules.

Peduncle of first antenna with first joint as long as second and third together; second not longer but considerably thicker than third, which is as long as the three-jointed flagellum; accessory lash as usual single-jointed.

Mandible with thirteen spines in the row.

Third maxilliped with basis not at all produced at apex, with plumose hairs on inner margin and with a series of stout plumose setae at external apical angle; merus slightly dilated distally and with an external apical spine; carpus equal in length to propodus, and also to ischium and merus together; dactylus short, with a stout apical spine and short setae.

Basis of first peraeopods short, with a few plumose setae on inner margin and a short plumose seta and a long spine near external apical angle; exopod wider than basis; rest of limb missing.

Second peraeopod damaged.

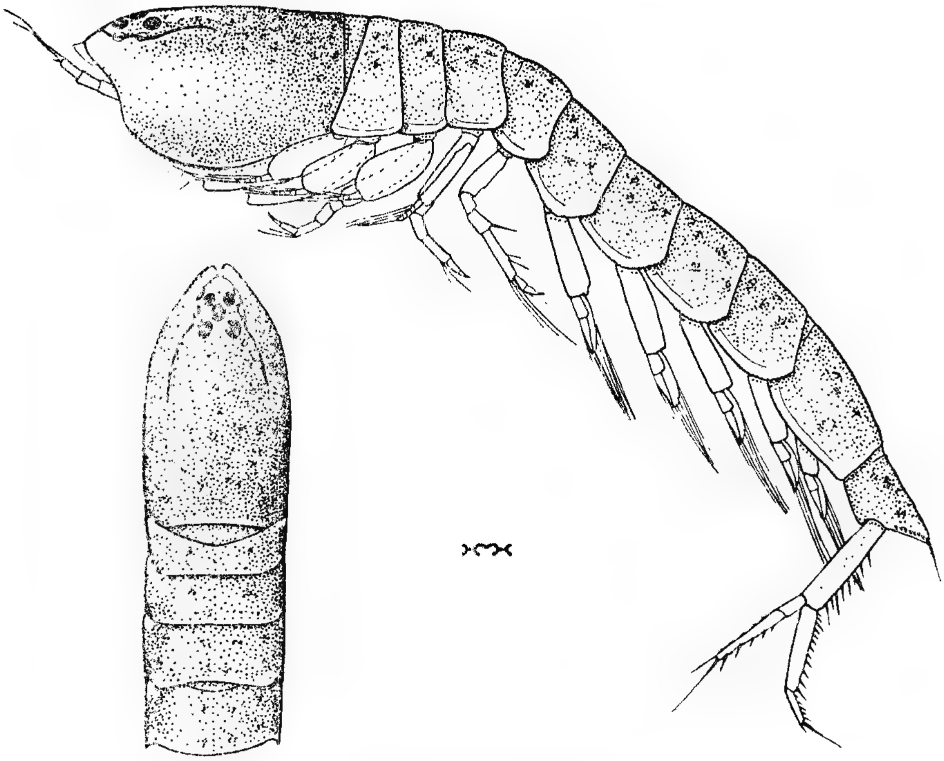

Fig. 28
Vaunthompsonia nana; lateral view and cephalothorax of type male (x 65).

Carpus of fossorial legs at least as long as ischium and merus together, successively increasing in length, so that in the fifth pair it is as long as the basis; two distal carpal setae, the longer reaching beyond level of tip of dactylus; third with basis longer than rest of limb and narrower than the base of the large exopod; fourth and fifth with basis shorter than remaining joints together. Peduncle of exopod of fourth more than half as wide as basis.

Peduncle of uropod as long as telsonic somite, and as exopod, with a series of eight unequal spines; exopod four-fifths as long as endopod, with first joint half length of second which has five short spines on outer margin, five longer ones on inner edge and two apical spines, the longer equal to the segment in length; first joint of endopod more than twice as long as second, with a dozen spines on inner margin; second joint of endopod with four inner and three apical spines, the longest longer than the joint (fig. 29 for relative lengths of armature).

Colour yellowish, generously marked with black pigment, particularly on the dorsum.

Length, 1·9 mm.

Loc.—South Australia: Rapid Bay (H. Cooper and E. Hanka, submarine light, Jan. 1944). Type in South Australian Museum, Reg. No. C.2444.

This is the smallest species to be referred to *Vaunthompsonia*. Its smooth streamlining and well-developed natatory appendages suggest that the male is a particularly efficient swimmer.

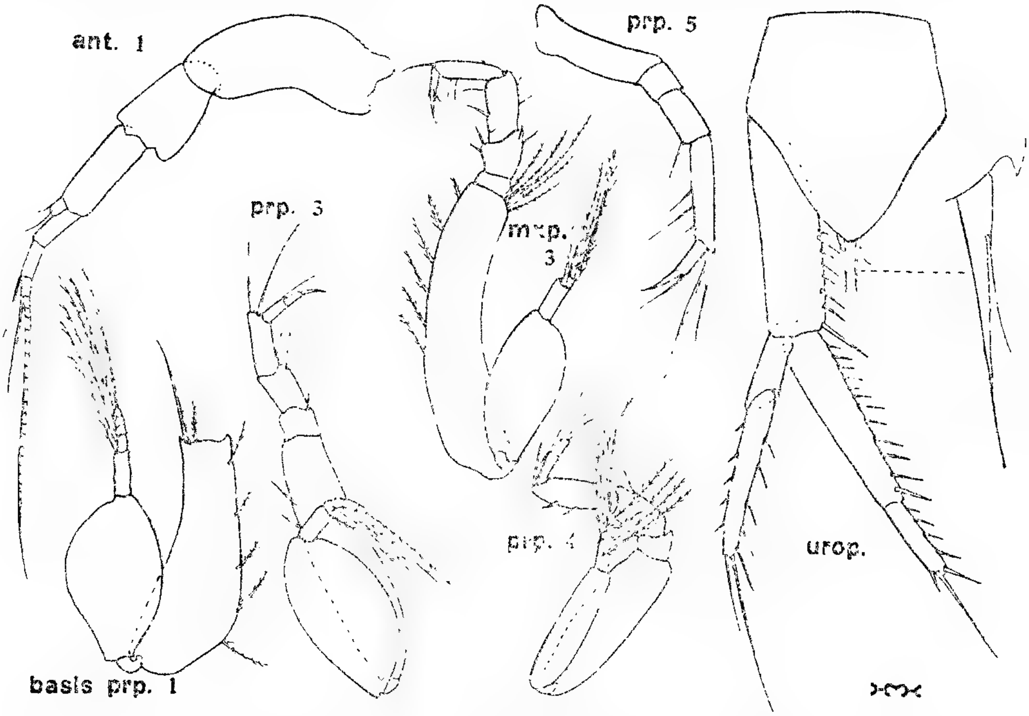

Fig. 29

Vaunthompsonia nana, type male: ant. 1, first antenna (x 210); prp. and urop., peraeopods, and uropod with telsonic somite (x 100).

It seems to be close to *arabica* Calman (1902, 29, pl. vii, fig. 20-24—Suez and Aden), but the carapace is of different shape, the basis of the first peraeopods is still shorter and stouter; also the proportions of the joints of the last pair of peraeopods seem to be distinctive. The first and second legs may show other differences.

Gen. **Glyphocuma** nov.

Pseudorostral lobes not extending in front of ocular lobe, which is narrow or moderately wide.

Basis of third maxilliped with large external distal lobe, dentate on inner edge and reaching to or beyond front end of merus, which is not or scarcely expanded.

Male with exopods (having peduncle and jointed flagellum) on first to fourth peraeopods, those of the fourth pair sometimes small. Female with exopods on first three pairs only.

First antenna with accessory flagellum two-jointed. Second antenna of female three-jointed, with the conical distal joint distinctly separated off.

Mandibles elongate, with a long row of spines approaching a score in number.

Telsonic somite well produced posteriorly, its apex rounded and very slightly excavate.

Genotype *Sympodomma bakeri* Hale.

The female second antennae of two species and of ? *Sympodomma africana* are shown in fig. 30. They are apparently very much as in *Bathycuma elongata* Hansen, excepting that the conical terminal joint is articulated. The large first and second joints are not very distinctly separated, and the distal part of the second is divided off by a faint suture.

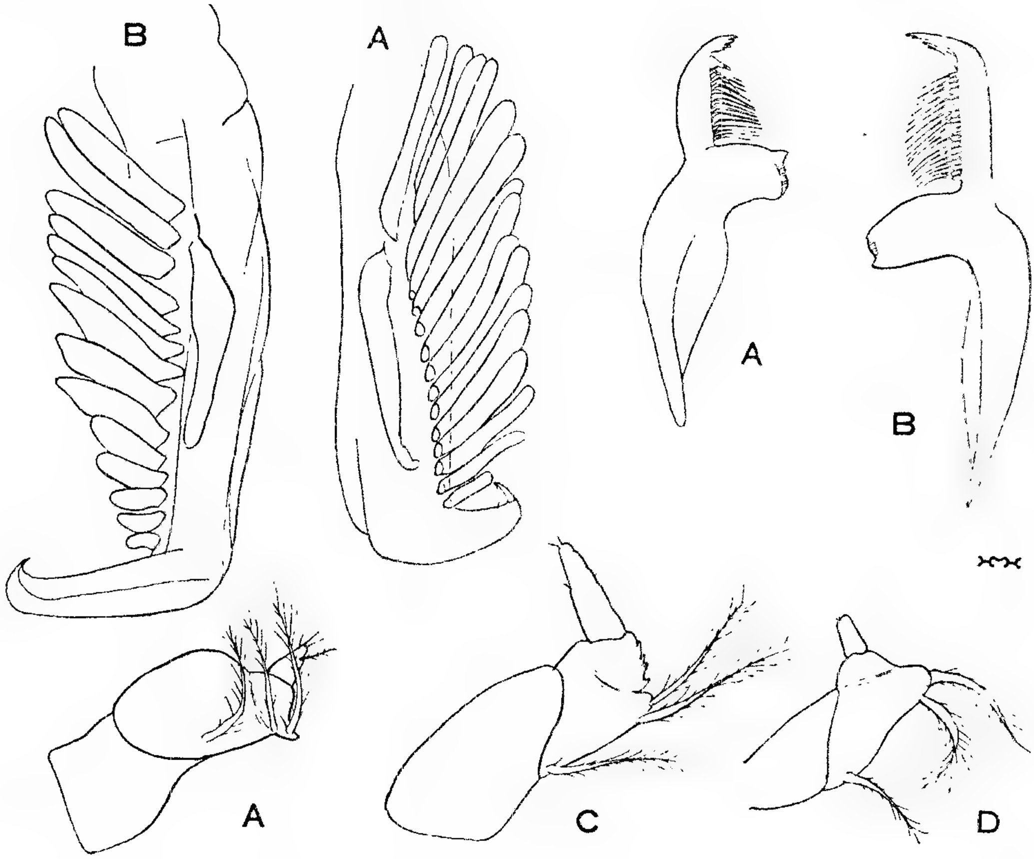

Fig. 30

Glyphocuma, branchial lamellae, mandibles and female second antennae; A, *bakeri*; B, *inaequalis*; C, *dentata*. D, Second antenna of female of ? *Sympodomma africana*.

The branchial lamellae are delicate, leaf-like and overlapping; they are arranged on the narrow epipod in a long row of more than a dozen, and with one separate and reflexed.

The large distal lobe of the third maxilliped has two conspicuous plumose setae; the ischium is long and does not differ much in length from the merus, carpus, propodus or dactylus.

This genus is close to *Sympodomma* but differs in having an exopod on the fourth peraeopod of the male, and apparently in having the merus of the third maxilliped less expanded externally. It somewhat resembles *Heterocuma* but in that genus the crest of the carapace is not incised in the female, the third maxilliped has the carpus widened as in *Cyclaspis*, the terminal joint of the second antenna of the female is tiny, the telsonic somite is very different, and the joints of the flagellum of the male second antenna, as in *Cumopsis*, are extremely short. In *Glyphocuma* (and apparently also in *Sympodomma*) the joints of this flagellum are nowhere much longer than wide, indeed, the proximal segments are twice as wide as long.

Sexual dimorphism—In the four species referred here, the ovigerous female and immature male have the crest of the carapace finely or coarsely serrate, or incised with the resultant projection or projections angular. Adult males are available for all; and these have the armature of the dorsum obliterated. The antennal notch is distinct in females but is obliterated (or "widely open") in the adult male.

The tendency of the antero-lateral portion of the fourth pedigerous somite of the male to override the third somite is in this genus emphasised in the adult, the pleural plates being produced forwards on each side into a lobe, defined above by a notch. In the female the overlapping of the second somite by the anterior pleural part of the third is also rather pronounced.

Key to Females of Species of Glyphocuma

1 Anterior half of crest of carapace cut into nine or more small teeth 2
Anterior half of crest of carapace with one or two incisions, but no row of teeth. 3

2 Carapace twice as long as deep, with dorsal teeth inconspicuous; antennal notch narrow; ocular lobe projecting well beyond pseudorostral lobes and with corneal lenses not confined to anterior portion .... *bakeri* (Hale)

Carapace less than twice as long as deep, with dorsal teeth large; antennal notch wide; ocular lobe not projecting beyond pseudorostral lobes and with the small corneal lenses restricted to anterior portion .... *dentata* sp. nov.

3 Carapace slender, with two dorsal incisions, the second with two or three denticles; ocular lobe narrow, more than twice as long as wide, apically rounded when seen from above .... *inaequalis* sp. nov.

Carapace robust, with one dorsal incision and two or three denticles; ocular lobe as wide as long, apically angular when seen from above .. *serventyi* sp. nov.

Key to Males of Species of Glyphocuma

1 Body slender, the carapace more than twice as long as deep 2
Body rather robust, the carapace less than twice as wide as deep 3

2 Main corneal lenses large and conspicuous; dorsal edge of carapace barely sinuate. Exopod of fourth peraeopod less than half as long as basis and with flagellum two-jointed .... *bakeri* (Hale)

Main corneal lenses indistinct, not large; dorsal edge of carapace markedly sinuate. Exopod of fourth peraeopod almost as long as basis and with flagellum five-jointed .... *inaequalis* sp. nov.

3 Ocular lobe narrow, more than twice as long as wide, with corneal lenses confined to anterior end which is rounded, or only minutely produced. *dentata* sp nov.

Ocular lobe as wide as long, with corneal lenses reaching to base; anterior end as seen from above angular and projecting beyond pseudorostral lobes. *serventyi* sp. nov.

Glyphocuma bakeri (Hale)

Sympodomma bakeri Hale, 1936, 396, fig. 3 and 4.

Adult Male (10 mm., Spencer Gulf, South Australia). Integument well calcified and brittle; when dried it does not contort or shrivel. Carapace one-fourth of total length of animal, slender and compressed; its depth is less than half the length; surface generally smooth except for the distinct median dorsal carina, which becomes less prominent posteriorly; the mid-line shows no trace of the small teeth present in the female, and the dorsal margin, as seen from the side, is barely arched and almost imperceptibly sinuate. Antennal notch widely open (or rather, the notch is completely obliterated) and angle very obtuse. Ocular lobe one-and-one-half times as long as wide; in front it is produced and narrowly subtriangular, carinate anteriorly—the little ridge extending to its apex, which thus appears acute as seen from above; three large pale corneal lenses arranged in a triangle, a smaller pair near apex, and two more on each side of lobe; the median lens is of somewhat quadrate form; the lobe is blackly pigmented, as shown in the figure. Pseudorostral lobes crenate in front, not reaching apex of eye-lobe.

Pedigerous somites together as long as carapace and a little less than half as long as pleon; the somites are angular (roof-shaped) dorsally with the median carina fine but distinct; there is a rather large pit near the rounded antero-lateral

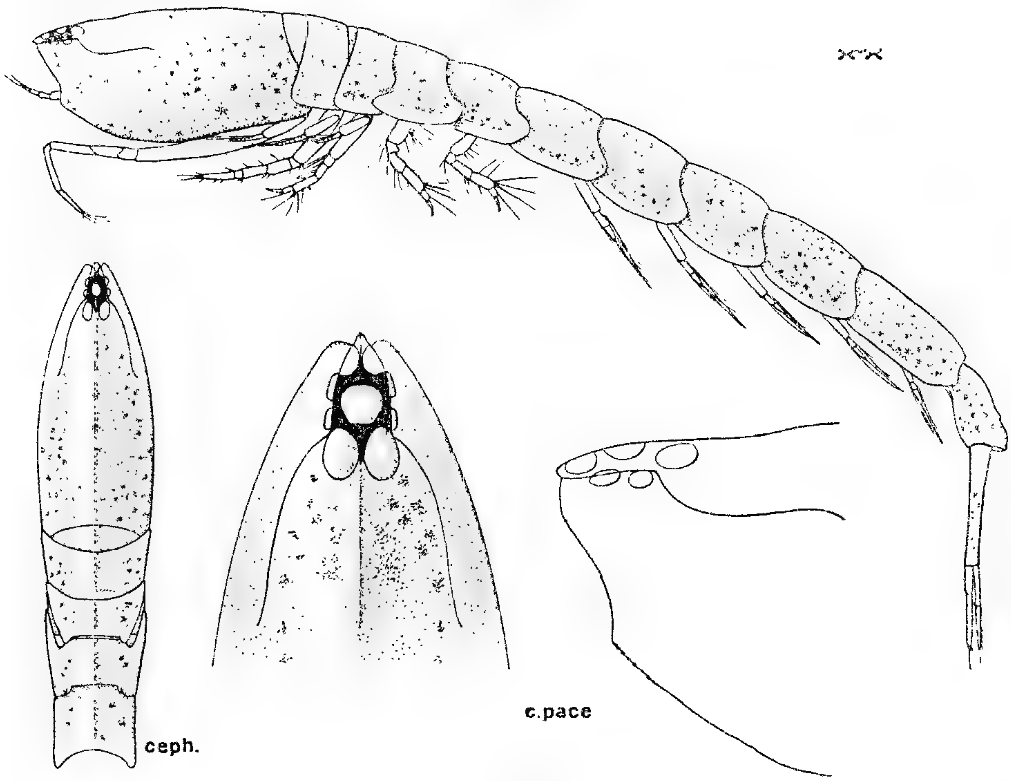

Fig. 31

Glyphocuma bakeri, adult 10 mm. male; lateral view and (ceph.) cephalothorax from above (x 13); c. pace, anterior half of carapace from above and from the side (x 33).

angle of the third, which overlaps the second on the sides; overriding anterior pleural part of fourth subtriangular and narrowly rounded.

The pleon is almost smooth except for a dorsal carina, which is moderately distinct on the first to fourth somites but becomes abruptly stronger on the fifth and telsonic somites.

First antenna with third joint of peduncle a little longer than second, which is half as long as the first joint; flagellum two-jointed (incompletely three-jointed); accessory flagellum two-jointed as in female.

Mandibles with about 16 spines in the long row.

Basis of third maxilliped three times as long as palp, with the dentate distal lobe reaching to beyond middle of length of carpus and furnished with two long and stout plumose setae (as well as smaller plumose setae); ischium, merus, carpus and propodus differing little in length.

First peraeopod with carpus barely reaching beyond antennal angle; the slender basis equal in length to the remaining joints together and with short plumose setae on both margins; ischium with a distal tooth and plumose seta on inner side; carpus equal in length to propodus and half as long again as dactylus.

Basis of second peraeopod barely as long as the rest of limb, margined with plumose setae, and with a short external distal spine; merus and carpus subequal in length, each shorter than dactylus, which is three times as long as propodus; the merus has two distal outer spines and one at middle of inner margin; the carpus has two spines on inner margin, one being distal, and four of different

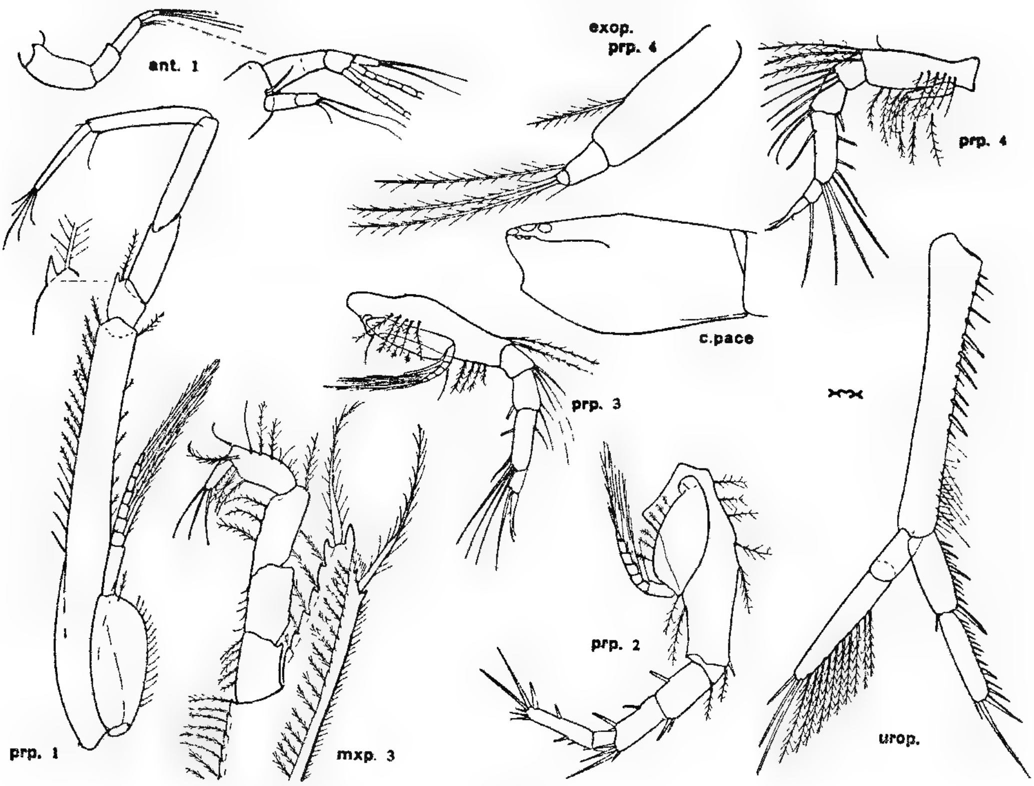

Fig. 32

Glyphocuma bakeri, adult 10 mm. male; ant. 1, first antenna (x 53; flagella, x 125); mxp. 3, palp and distal part of basis of third maxilliped (x 53); prp. and urop..; peraeopods and uropod (x 30); exop. prp. 4, exopod of fourth leg (x 125). c. pace, Carapace of 12 mm. male (x 9.).

lengths at the external apical portion; dactylus with one or two spines on each margin and a cluster of six distally, the longest about as long as the joint.

Outer distal slope of carpus of third to fifth legs with three long setae and one shorter one, the longest reaching well beyond apex of dactylus; inner and outer margins of carpus with one or two setae. The exopod of the fourth peraeopod is barely half as long as the basis of its limb and has only two joints in the flagellum; the setae are restricted to three long plumose bristles, on the flagellum and one on inner margin of peduncle.

Peduncle of uropod slender, one-fourth as long again as telsonic somite, and more than half as long again as rami; exopod a little longer than endopod, with the longest of its three slender terminal spines more than half as long as the ramus; second segment of endopod a little longer than first and equal in length to its longest distal spine.

Colour pale yellow with brown chromatophores (see figure).

Adult Male (12 mm., St. Vincent Gulf, South Australia). The dorsal margin of the carapace, as seen from the side, is slightly angular at about the middle of the length, otherwise as with the smaller males.

Females (10 mm., from Spencer Gulf, South Australia, and with fully developed marsupium) agree in all essentials with the subadult female previously recorded, and are likewise boldly spotted with dark pigment. The dorsal carina is almost crest-like at the anterior part of the carapace, where the number of teeth into which it is cut are constant in number within a small range, approximately a dozen being present in all.

Ovigerous Female (10 mm., Portland, Victoria). Integument well calcified. Colour grey with black chromatophores on thorax and mottlings on pleon.

Loc.—South Australia: St. Vincent Gulf (*type loc.*, W. H. Baker, 1910), Brighton (Misses P. Mawson and L. M. Angel, and K. Sheard, submarine light, Oct. 1941); Spencer Gulf, Port Lincoln, 2 fath. (K. Sheard, submarine light, Oct. 1941 and Feb. 1944); Kangaroo Island, Antechamber Bay, 4 fath. (K. Sheard, submarine light, April 1941). Victoria: Portland, 8 feet, sandy bottom (H. M. Hale, submarine light, Aug. 1944).

This species was originally described from a single female, but the submarine light method of collecting proves that it is not uncommon in South Australia. A haul taken at Port Lincoln on 17 February 1944 is of particular interest; about one-tenth of the catch (which of course consisted of many different organisms) was preserved. Included in this sample *G. bakeri* is represented by over six hundred males and a score of females, all approximately 10 mm. in length. The males are all highly calcified, and are much paler in colour than the females. The latter are, in striking contrast, greyish with conspicuous colour spotting (Hale 1936, fig. 3); they have all recently moulted, the integument being soft and quickly collapsing on drying. The large marsupium is empty, and the fully developed yellow ovaries (eggs, 0·3 mm.) are visible through the thin exoskeleton (compare *Cyclaspis usitata* Hale 1944, 124).

At Brighton the larger males, 12 mm. in length, were abundant in October 1941, but no females were then taken.

The plumose hairs on the basis of the third to fifth peraeopods tend to collect flocculent debris in preserved material and so to conceal the exopods; these setae are arranged in two series which may "sandwich" the exopod, particularly that of the fourth peraeopod, which is smaller than in the male of the other three species and has only a rudimentary two-jointed flagellum in both 10 mm. and 12 mm. examples. It is very like the exopod occurring on the second and third peraeopods in *Heterocuma intermedia* (Fage 1924, 364, fig. 1), differing only in having a second tiny joint in the flagellum.

Glyphocuma dentata sp. nov.

Ovigerous Female. Integument thin and delicate, scarcely at all calcified.

Carapace somewhat less than one-fourth of total length of animal; depth distinctly more than half the length; subtriangular as seen from above, widest near posterior end, where it is as broad as deep; upper contour slightly arched; dorsum with a median longitudinal carina, on anterior half cut into about ten teeth the last minute and on posterior half rather rugose; anterior part of inferior margin, immediately behind antennal tooth serrate; on each side of the front half of the mid-line there is a shallow depression delimited by a low lateral tumidity; antennal notch moderately deep and open and antennal tooth subacute. Ocular lobe about three times as long as wide, rounded anteriorly and with nine small lenses in frontal part, eight grouped around a central one; the first two of the dorsal teeth are situated on the lobe. Pseudorostral lobes very oblique in front, extending almost to apex of ocular lobe.

Pedigerous somites together equal in length to carapace, each with a median dorsal carina; first overlapped by second but visible for whole depth; second somite widest the others successively decreasing in breadth, so that, viewed from above, the cephalothorax is sub-oval in shape.

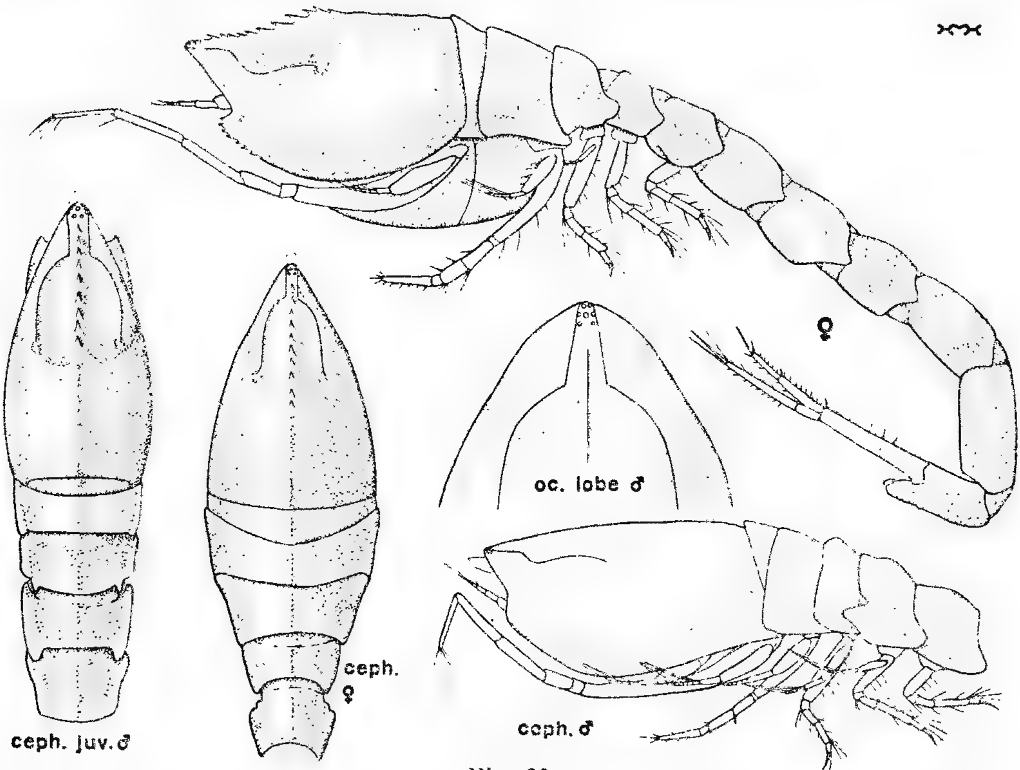

Fig. 33

Glyphocuma dentata; lateral views and (ceph.) upper view of cephalothorax of type ovigerous female and allotype adult male (x 19); oc. lobe, ocular lobe of adult male (x 33); ceph. juv., cephalothorax of subadult male from above (x 19).

Pleon somites each with a fine dorsal carina; postero-lateral margins of first to fourth angularly produced backwards, those of fifth less markedly angular; all but fifth approximately equal in length; telsonic somite produced between bases of uropods.

First antenna with second and third joints of peduncle subequal in length, together almost as long as first joint and each shorter than the two-jointed flagellum; accessory lash two-jointed.

Mandible with usual long spine row of 18 to 20.

Basis of third maxilliped twice as long as rest of limb, and with well-developed external apical lobe, reaching distal end of the slightly dilated merus.

First peraeopod long and slender, the carpus extending to beyond the antennal tooth; basis not much more than two-thirds as long as rest of leg, distally subtruncate and with some plumose setae and (at middle third) three spines on inner margin; propodus nearly one-fourth as long again as carpus, which is as long as the dactylus.

Second peraeopod with basis shorter than remaining joints together; ischium very short; merus as long as carpus, with two distal spines; carpus with distal spines and one on inner margin; dactylus elongate, four times as long as propodus and as long as carpus and propodus together; with short lateral spines and four distal, the longest of which is only one-fourth the length of the dactylus.

Third to fifth peraeopods with three setae at distal end of carpus, the longest reaching beyond tip of dactylus.

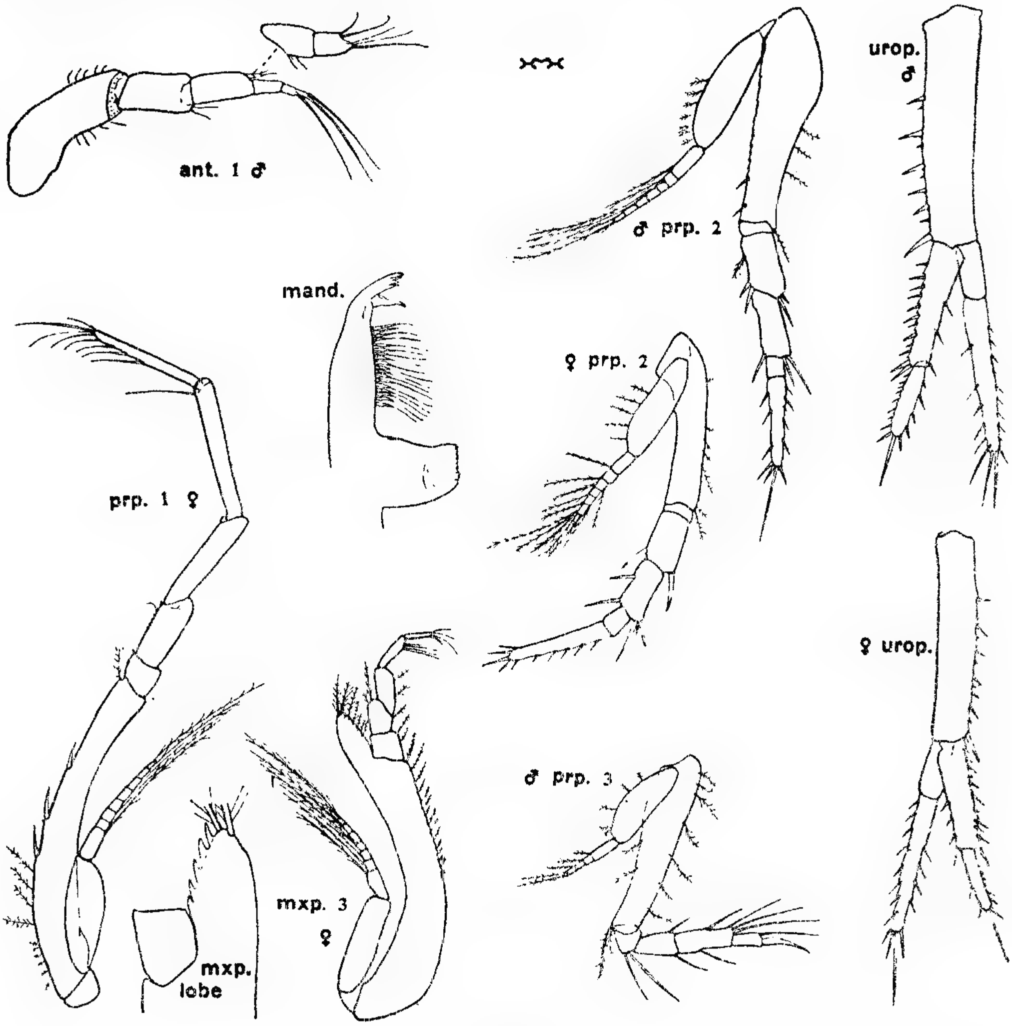

Fig. 34

Glyphocuma dentata, paratype ovigerous female and subadult male; ant. 1, and mand., first antenna and mandible (x 85); mxp. 3, prp. and urop., third maxilliped, peraeopods and uropods (x 32); mxp. lobe, external distal lobe and ischium of third maxilliped, plumose setae omitted (x 170).

Peduncle of uropod a little longer than telsonic somite, and than exopod. with half-a-dozen spines, alternating with shorter spines, on inner margin and a more prominent spine at inner apical angle; first joint of endopod half as long again as second, with ten unequal spines on inner edge, several on outer, and a more prominent spine at inner distal angle; second joint of endopod with a row of short spines successively increasing in length on inner margin and a few on outer, and with a terminal spine as long as the joint; exopod a little longer than endopod, its second segment with spines on both margins and with the longest terminal spine as in endopod.

Colour: pale translucent yellow spattered with brown all over body, leaving margins of carapace and somites pale; darker on front of carapace and with a large brown marking above each pseudorostral suture and a smaller one below it. Eye darkly pigmented. Legs translucent. Ova dark yellow.

Length, 7 mm.

Adult Male. Carapace more slender than in female and lacking all trace of dorsal teeth, the upper edge being very faintly sinuate; there is a small shallow subcircular depression above the end of each pseudorostral suture, and below this a small tumidity immediately behind end of suture; median carina distinct, sharply defined anteriorly. Antennal notch very obtuse (widely open) and angle rounded; margin of carapace posterior to angle with obsolete serrations. Ocular lobe slightly widened at base, twice as long as breadth and with lenses small and situated near the apex.

Pleural portions of first pedigerous somite not at all exposed.

First peraeopod not quite so long as in female.

Second peraeopod with basis almost as long as rest of limb and terminal spine of dactylus nearly as long as its joint.

Last pair of pleopods abruptly smaller than the first four.

Endopod of uropod almost as long as exopod.

Colour as in female.

Length, 7·1 mm.

Submature Male. Males about as long as the adult but with the pleopods not fully developed exhibit the above sexual differences excepting that the dorsal teeth of the carapace are still present (fig. 33, ceph. juv.).

Loc.—New South Wales: off Cape Three Points, 25-32 fath., sticky mud and shell ("Thetis" Station 13, Feb. 1898); off Jibbon, 46-55 fath., sand to mud ("Thetis" Station 38, Mar. 1898); 5 miles east of Port Hacking, 100 metres, on mud (type female, "Cronulla" Trawl Station, July 1943); 4 miles off Eden, 70 metres (K. Sheard, Oct. 1943); 4 miles east of Port Hacking, 80 metres, on mud (K. Sheard, trawled, May 1944); Ulladulla, 75 metres (allotype male, K. Sheard, trawled, June 1944). Types in South Australian Museum, Reg. No. C.2464 and C.2542.

The largest examples, taken off Eden, are just over 8 mm. in length.

This, like *inaequalis*, is a common species in the localities cited. It is noted for both that the "Cronulla" examples retained represent only portions of a haul.

The dorsal teeth of the carapace of female and subadult male vary in number between nine and twelve. As in the other species of the genus, the full development of the swimming apparatus of the male coincides with the loss of the armature of the carapace.

Glyphocuma inaequalis sp. nov.

Ovigerous Female. Integument smooth and rather polished, with very fine reticulate pattern.

Carapace less than one-fourth of total length of animal; slender, twice as long as depth which is equal to the greatest width; seen from above the sides are slightly curved and diverge evenly to the rear; dorsum with a prominent carina

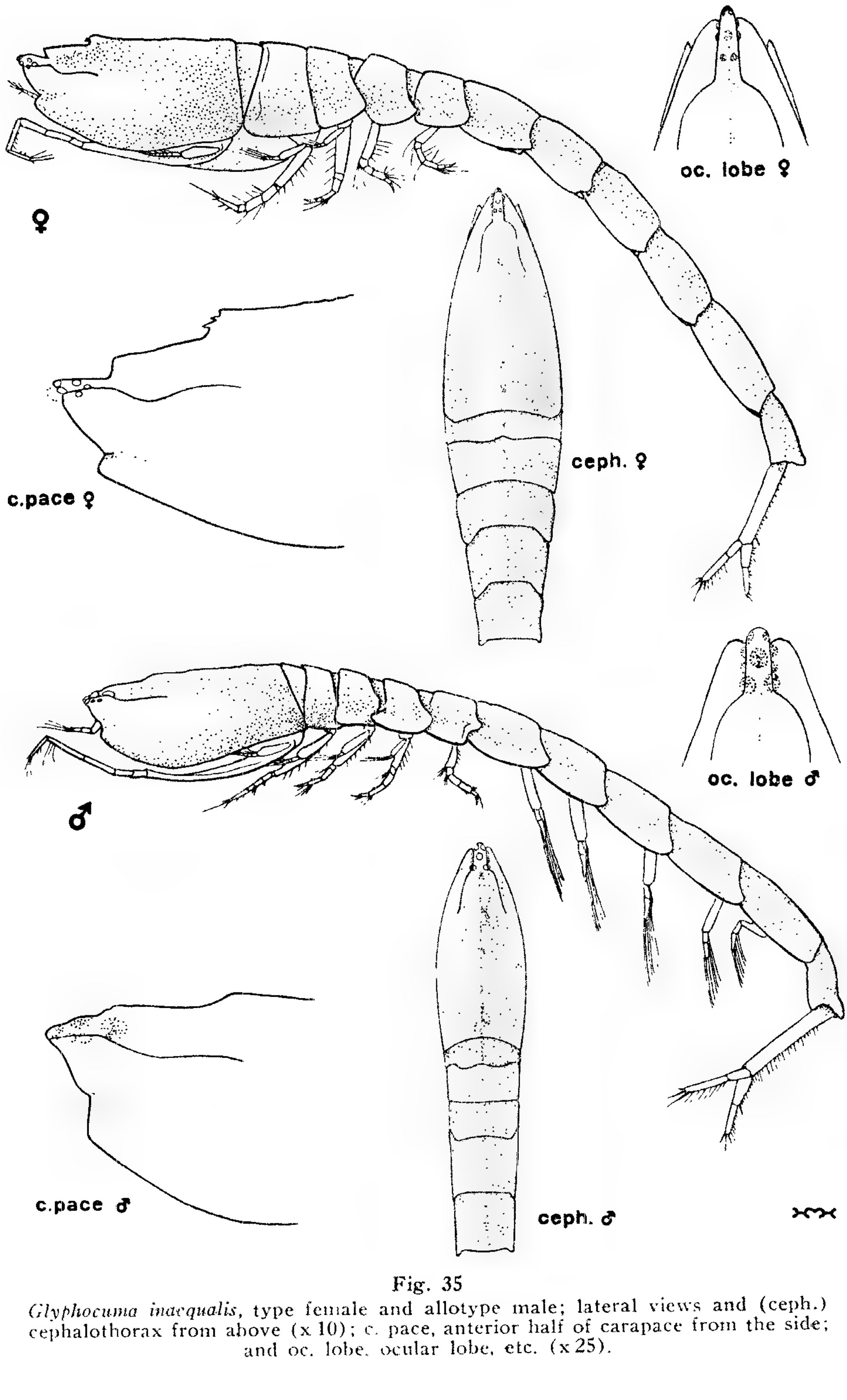

Fig. 35
Glyphocuma inaequalis, type female and allotype male; lateral views and (ceph.) cephalothorax from above (x 10); c. pace, anterior half of carapace from the side; and oc. lobe, ocular lobe, etc. (x 25).

from apex of ocular lobe to hinder margin; seen from the side the dorsal margin is elevated to form a short and abrupt declivity immediately posterior to the ocular lobe and again at the first third of its length (see fig. 35, c. pace); the edge of the second incision is cut into two denticles; for the posterior two-thirds the dorsal margin is almost straight, slightly uneven. Antennal notch widely open and angular; antennal tooth rounded. Ocular lobe narrow, about three times as long as greatest width (basal) narrowly rounded in front and with nine pigmented but not sharply defined lenses. Pseudorostral lobes rounded anteriorly and not reaching apex of ocular lobe.

Pedigerous somites together longer than carapace, and half as long as pleon; each with low dorsal carina; second somite longer than any of the others, its rounded antero-lateral portion overlapping the first somite and the extreme postero-lateral angle of carapace; postero-lateral portions of third to fifth somites a little produced backwards, and rounded.

Pleon somites each with a median dorsal carina, all but fifth of about equal length; telsonic somite scarcely produced between bases of uropods.

First antenna with third joint of peduncle shorter than second, which is half as long as first; flagellum two-jointed, not as long as third peduncular segment; accessory flagellum two-jointed.

Mandible with the usual long row of 18 or 19 spines.

Third maxilliped with basis nearly three times as long as rest of limb and with the external apical angle strongly produced, the lobe reaching to level of the slightly expanded distal portion of merus.

First peraeopod long, the carpus extending beyond level of antennal angle; with the slender basis a little longer than remaining joints together and having short plumose setae on both margins, and one at external distal angle; carpus and propodus subequal in length, each shorter than dactylus, which is about as long as merus.

Second peraeopods with basis shorter than rest of limb, with plumose setae on both margins, and a short apical spine; ischium short with one spine; merus as long as carpus with a subapical spine on each margin; carpus with two spines (one apical) on inner margin and two, unequal, at outer distal angle; dactylus more than twice as long as propodus, with three apical spines (the longest as long as propodus and dactylus together), two on outer margin and one on inner.

Basis of third legs as long as rest of limb, of fourth shorter, of fifth much shorter; outer apical portion of carpus with three setae and inner margin with two or three; the longest fossorial setae reach beyond apex of dactylus.

Peduncle of uropod slightly longer than telsonic somite, the inner margin with short spines of different lengths; endopod as long as exopod, the first joint a little shorter than second and with a row of spines on inner edge, and one specialised, at outer distal angle; of the inner spines, one at middle of length is prominent and one at inner distal angle is particularly strong; second joint of endopod with a spine two-thirds length of segment and two shorter spines at rounded apex and a row of spines on inner margin; exopod two-thirds as long as peduncle with half-a-dozen short plumose setae on inner margin, a few short spines on outer margin and five apical spines the largest half as long as exopod.

Colour: spattered with dark brown, leaving carapace and somites margined with the pale creamy-white ground colour; also there are pale circular areas scattered all over the body and particularly well defined on the carapace.

Length, 13·5 mm. (ova, 0·34 mm.).

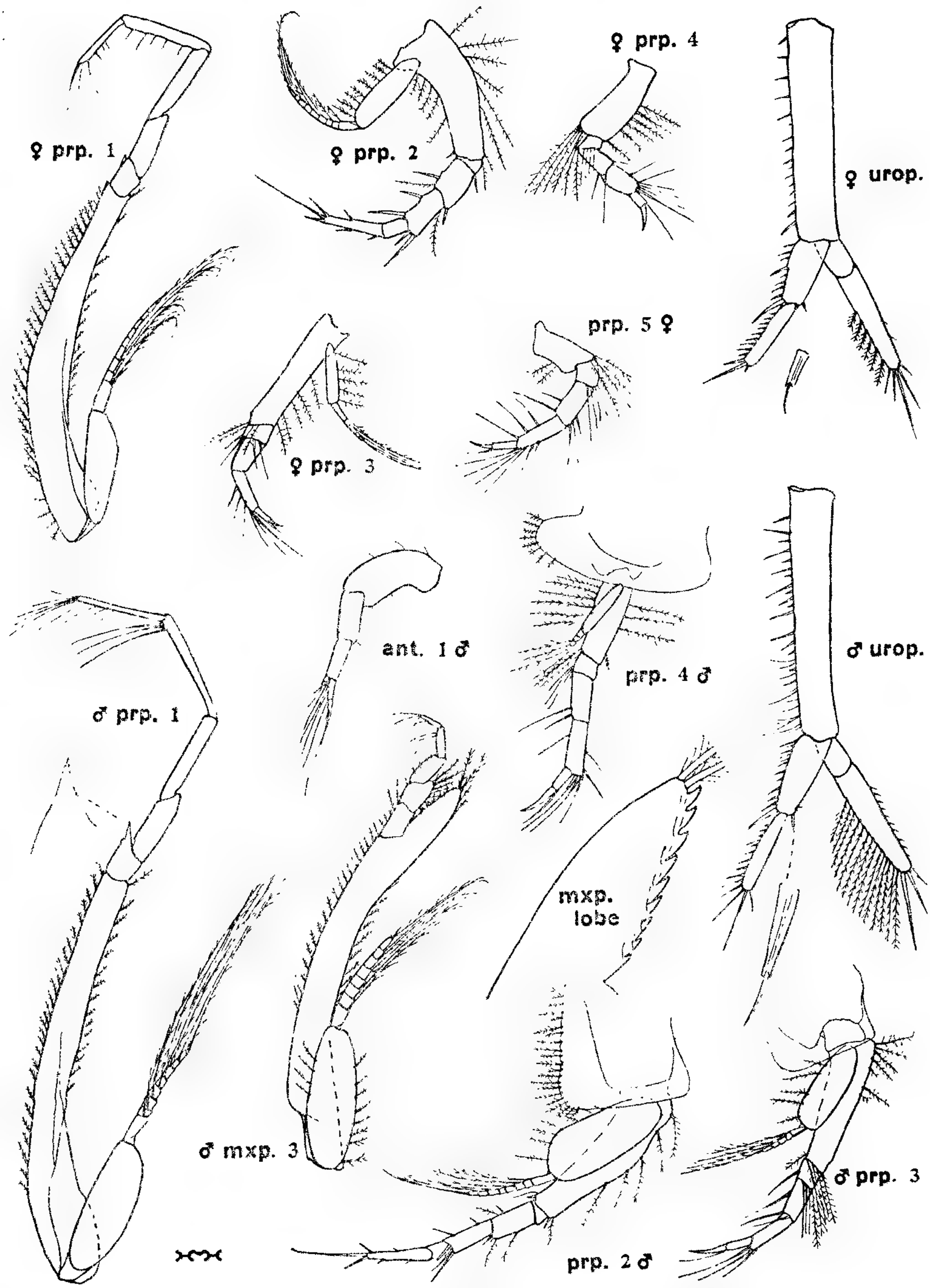

Fig. 36
Glyphocuma inaequalis, type ovigerous female and paratype male; ant. 1, first antenna (x 40); mxp. 3, prp. and urop., third maxilliped, peraeopods and uropods (x 25); mxp. lobe, external distal lobe of third maxilliped, with setae omitted (x 210).

Adult Male. Form not differing much from that of female but carapace more compressed (less than half as wide as long); incisions of dorsal edge more oblique, thus appearing less pronounced, and without denticles in second. Ocular lobe a little wider and the lenses larger, with distinct granules. Antennal notch more widely open.

Second pedigerous somite not longer than any of the others.

First peraeopod longer, with carpus shorter than propodus and about as long as dactylus; propodus with a few long subapical setae, and dactylus with more abundant setae; ischium with a tooth at inner distal angle.

Second peraeopod with basis as long as rest of limb, but otherwise much as in female.

Uropod with peduncle proportionately longer and with endopod slightly longer than exopod; outer distal spine of first joint of endopod larger and exopod with a greater number of plumose setae.

Colour decidedly paler than that of female with small separated brown spots; the pale circular areas without dark pigment are nevertheless well defined.

Submature Male. Immature males, about as long as the adult but with pleopods not quite fully developed, have dorsum of carapace as in the female; it is likewise remarkably uniform, the only variation being in the number of denticles (two or three) in the second dorsal incision.

Length, 12·5 mm.

Loc.—New South Wales: off Jibbon, 3 to 2¾ fath., sand to mud ("Thetis" Station 38, Mar. 1898); Broughton Island, Shallow Station (K. Sheard, 11 p.m. to 12 midnight, Dec. 1938); off Jibbon, 35 fath., in coarse sand (K. Sheard, Feb. 1940); off Coffs Harbour, 50 metres (K. Sheard, trawled, June 1941); 5 miles east of Port Hacking, 100 metres on mud ("Cronulla" Trawl Station, July 1943); off Wata Mooli, 70 metres ("Cronulla" Trawl Station 4, 9 a.m., July 1943); Jibbon Station, 70 metres (*type loc.*, "Cronulla" Trawl Station 3, July 1943); 4 miles east of Port Hacking, 80 metres, on mud (K. Sheard, trawled, May 1944); Ulladulla, 75 metres (K. Sheard, trawled, June 1944). Tasmania: off Babel Island, 0-50 metres ("Warreen" Station 29, 1939). Types in South Australian Museum, Reg. No. C.2453 and C.2454.

This form, evidently not uncommon, is readily recognised by the slender form and the distinctive shape of the dorsal margin of the carapace in both sexes.

Glyphocuma serventyi sp. nov.

Ovigerous Female. Integument thin but firm, finely reticulate.

Carapace one-fourth of total length of animal; its depth is equal to three-fourths its length, and is scarcely more than the greatest width; seen from above it is widest posteriorly and tapers to the front; dorsal margin in lateral view scarcely arched but abruptly incised at first third of length, the incision with two small denticles, one of which is minute; there is a distinct median dorsal carina, single anteriorly but bifurcating and diverging posterior to the incision; the thin anterior portion of the carina bends abruptly downwards at front of ocular lobe, from above presenting the appearance of a triangular point projecting beyond the pseudorostral lobes; at the posterior end of each pseudorostral suture there is a low tubercle. Antennal notch rather deep and narrow; antennal angle acute; there is a shallow groove behind the notch and the inferior margin of the carapace behind the tooth is serrate for a short distance. Pseudorostral lobes not quite reaching to end of eye lobe, narrowly subtruncate in front. Ocular lobe slightly longer than wide, with pigmented lenses, three arranged in a triangle larger and more conspicuous than the others.

Pedigerous somites with an almost indiscernible median dorsal carina; together they are almost as long as carapace and seen from above the second is much the widest; the postero-lateral portions of the third to fifth are not greatly backwardly produced.

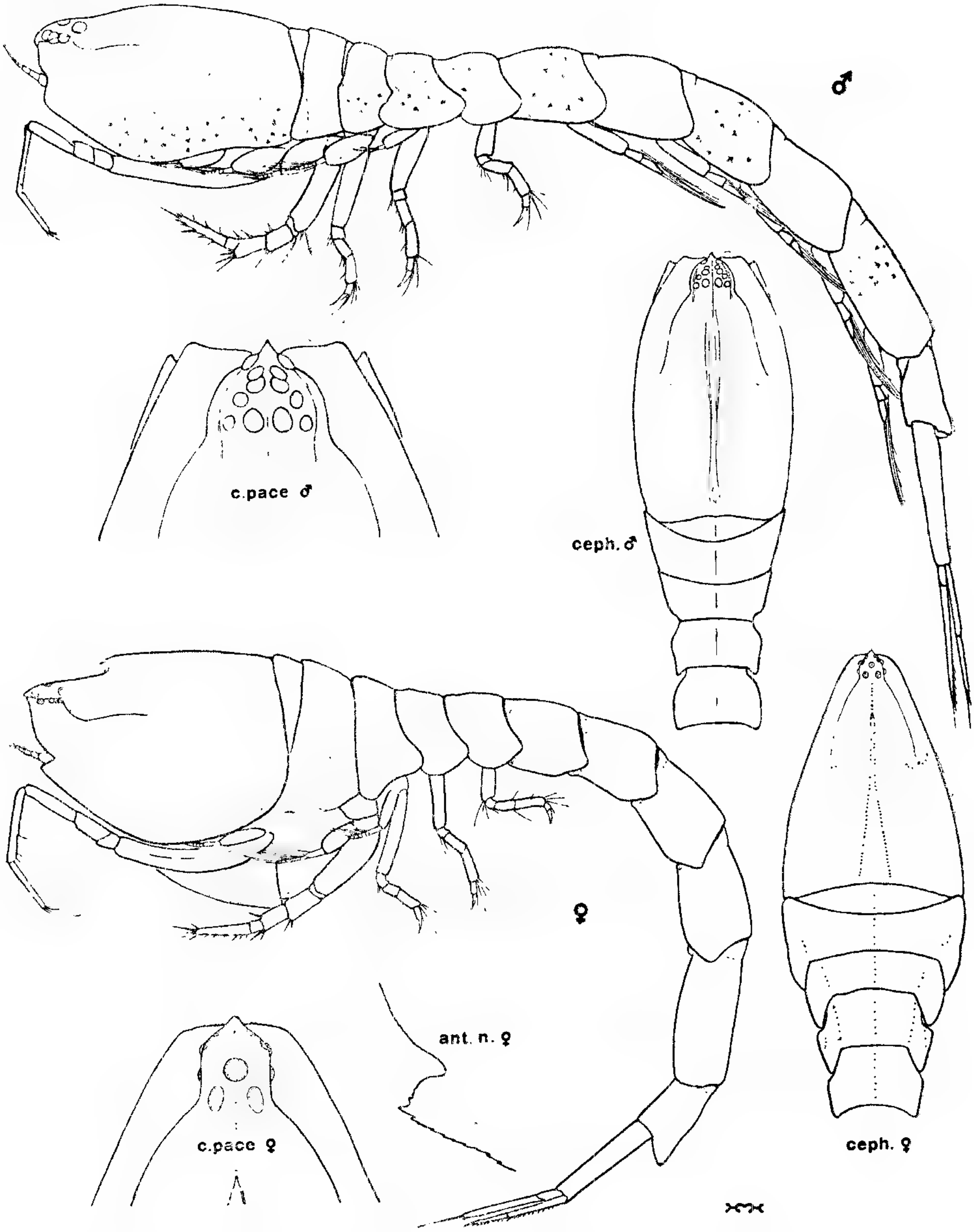

Fig. 37
Glyphocuma serventyi, type female and allotype male; lateral views and (ceph.) cephalothorax from above (x 16½); c. pace, anterior portion of carapace (x 33); ant. n, antennal notch and angle, slightly flattened (x 33).

Pleon with an obsolete dorsal carina, the somites excepting fifth subequal.

First antenna with massive first peduncular joint as long as rest of appendage, and with second shorter than third; both flagella two-jointed, the accessory lash as usual very short.

Mandible with long row of 18 or 19 spines.

Basis of third maxilliped (including lobe in the measurement) twice as long as palp, serrate and with plumose hairs on distal half of inner margin; the external lobe reaches to the level of the distal margin of carpus, is strongly dentate on inner edge and is capped with a pair of plumose setae stouter than the other fringing setae.

First peraeopod with carpus reaching just beyond level of antennal tooth; basis not produced apically and with a plumose seta at external distal angle; inner margin with the usual plumose setae and three spines, the last subapical; the remaining joints together are half as long again as the basis; propodus one-third as long again as dactylus which is subequal in length to carpus.

Second peraeopod with basis much shorter than rest of leg; ischium distinct; merus and carpus of equal length, together about as long as dactylus; merus with one or two distal spines on each side; carpus with two spines on inner margin and a cluster of four at external distal angle; propodus very short; dactylus with marginal spines and a distal cluster of five unequal spines the longest little more than half length of the joint.

Third to fifth peraeopods with three carpal setae, decreasing in length, the longest, like propodal seta, not reaching beyond tip of dactylus; basis of third pair longer than rest of limb, of fourth and fifth shorter.

Peduncle of uropod little longer than either telsonic somite or exopod, and with a row of about 14 stout spines, alternately short and longer, on inner edge; exopod slightly longer than endopod, twice the length of the longest of its four terminal spines and with few setae on inner margin; first joint of endopod three-fourths as long again as second with a row of unequal inner spines and a spine at each distal angle, that on the inner side the stouter; second joint with half-a-dozen short spines, successively increasing in length and with two short and one long apical spine, the latter fully as long as the joint.

Colour: white, mottled with dark grey.

Length, 8·3 mm.

Adult Male. There is no trace of an incision in the scarcely arched, slightly sinuate dorsal profile of the carapace; the latter is as wide as deep, narrower than in female and with the sides evenly curved; not at all subtriangular as seen from above; the median carina is double for the greater part of its length (a furrow with raised edges, and emphasised as a shallow pit near posterior margin). Pseudorostral lobes sinuate and rather widely truncate in front and with a few low tumidities posteriorly. Ocular lobe depressed along sides, wider than long and with lenses larger and more conspicuous than in female, but projecting similarly in front of pseudorostral lobes as a triangular point. Antennal notch shallow and widely open; antennal angle obtuse.

Third maxilliped as in female.

First peraeopod with basis not much shorter than remaining joints together; the whole limb scarcely longer relatively than in female, although the carpus and propodus are a little longer in proportion to the other joints; ischium with a sub-apical inner tooth.

Second peraeopods with basis stout and almost as long as rest of limb; spines more robust but otherwise as in female.

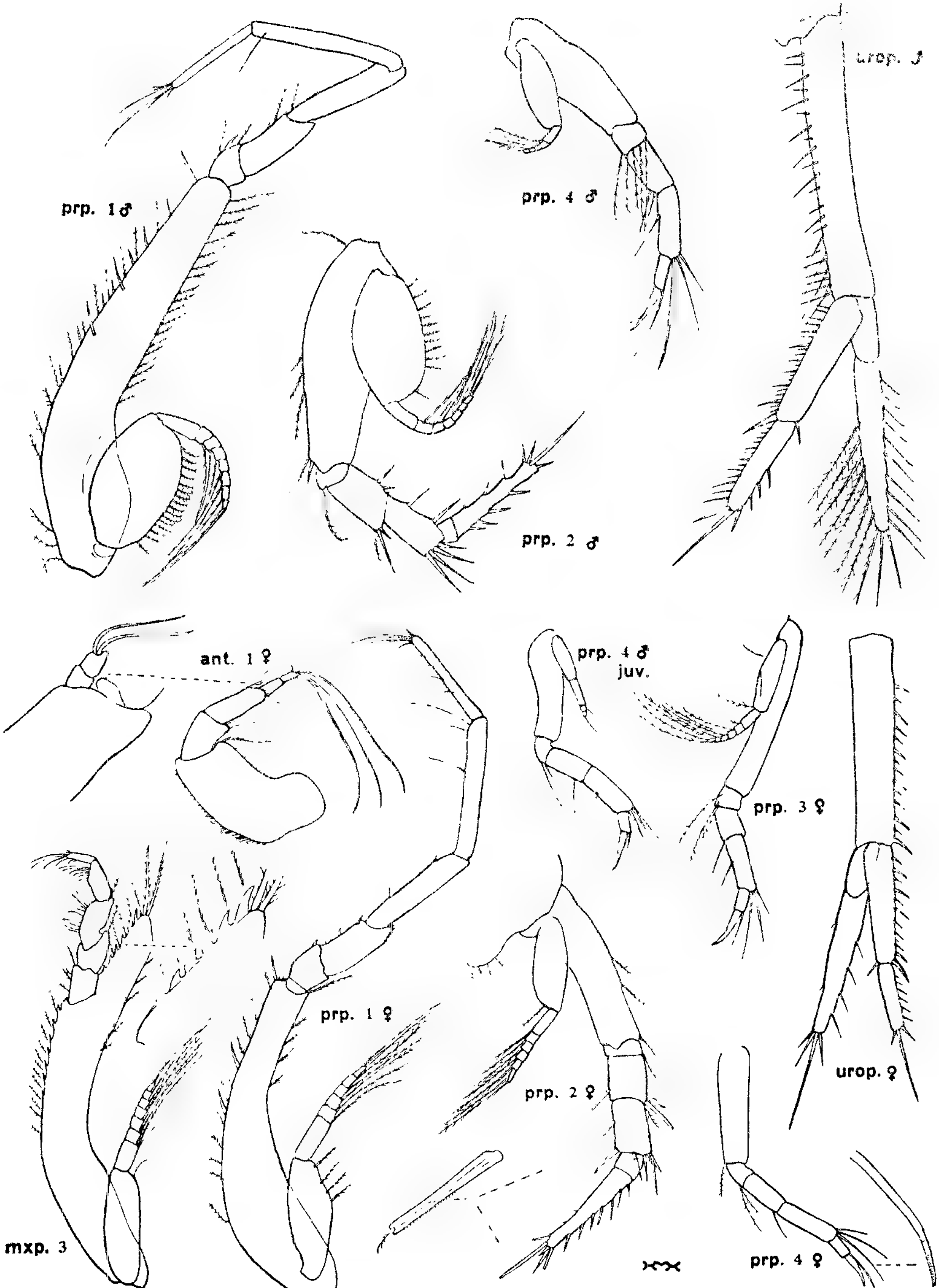

Fig. 38
Glyphocuma serventyi, paratype female and allotype male; ant. 1, first antenna (x 84; accessory flagellum, x 400); mxp. 3, prp. and urop., third maxilliped, peraeopods and uropods (x 34). prp. 4 juv., fourth peraeopod of young male.

The flagellum of the exopod of the fourth peraeopods is short and five-jointed, with setae not very long.

Peduncle of uropod distinctly longer than either telsonic somite or uropod, with longer and slightly more numerous spines; endopod with twice as many marginal spines as in female and with first joint less than half as long again as second, which has the longest terminal spine shorter than the joint.

Length, 8·5 mm.

Subadult Male. A large but immature male has the dorsal margin of the carapace incised and with two small teeth as in the female; in addition, there is a small denticle midway between the incision and apex of ocular lobe. The exopod of the fourth peraeopod has a three-jointed flagellum and the pleopods are not fully developed and lack setae. The first peraeopod is a little shorter than in the adult, the basis of the second peraeopod (as in the female) is much shorter than rest of limb, and there are other slight differences due to immaturity.

Length, 8·5 mm.

Loc.—Tasmania: Long Island, off Cape Barren Island (allotype male, D. L. Serventy, submarine light, Nov. 1939) and off Babel Island, 39° 55′ S., 148° 31′ E. ("Warreen" Station 29, 1939). New South Wales: off Jibbon, 35 fathoms on coarse sand (type female, K. Sheard, Feb. 1940). Types in South Australian Museum, Reg. No. C.2476 and C.2479.

This species is named after Dr. D. L. Serventy, Biologist on the "Warreen." It is distinguished by the deep carapace, projecting point at apex of ocular lobe and other obvious features.

Genus SYMPODOMMA Stebbing

Sympodomma Stebbing, 1912, 138; and 1913, 15.

As noted above, in the known species of *Glyphocuma*, females and immature males always have the crest of the carapace serrate or incised, but this armature is obliterated or smoothed out in the fully developed male. The few recorded specimens of *Sympodomma* suggest that this obtains here also.

Five species have been placed in Stebbing's genus. One of these, *anomala* (Sars), must, in view of *Glyphocuma*, be regarded as doubtfully referred, as it is known only from the female; this has dorsal teeth on the carapace. The immature males and females described for *diomedeae* (Calman) and *africana* Stebbling have a dentate crest. *S. weberi* (Calman) is known from an adult male, which has the dorsum of the carapace unarmed but slightly, though distinctly, sinuate. The fifth species, *australiensis* Foxon is the only other in which the mature male is recorded, and here also the dorsum is without serrations according to Foxon's fig. 5, but the female is stated to have "a marked dorsal ridge, which terminates anteriorly in a sharp tooth over the typical elongated ocular lobe, and the ridge is armed by a few hairs and three or four small denticles." (Foxon, 1932, 388.)

Stebbing depicts 10 or 11 leaflets in the branchial apparatus of his *africana*. In the figures of this species, and of Calman's *weberi* and *diomedeae*, the merus of the third maxilliped is shown as rather more expanded than it is in the species herein placed in *Glyphocuma*.

ERRATA

P. 270, in key to males, second line: for "wide" read "long."

P. 284, after last line, add: "represent a new species, but description awaits more material."

SUMMARY

It is suggested that two subfamilies, the Bodotriinae and Vaunthompsoniinae, be recognised. The genus *Cyclaspis* of the first-named was reviewed previously (Hale 1944), and herein *Bodotria maculosa* and *Iphinoe pellucida* are described as new.

In the Vaunthompsoniinae two new genera, *Zenocuma* and *Pomacuma*, allied to *Gephyrocuma* Hale, are proposed; the first peraeopods in these three genera can be folded to form the major part of an operculum which seals the cavity of the carapace from the exterior. Also, *Glyphocuma*, gen. nov., allied to *Sympodomma* Stebbing, receives four species, the sexual dimorphism of which is recorded, while the genus *Leptocuma* Sars is discussed and a key is given to all the genera included. Species described as new are *Zenocuma rugosa*, *Pomacuma cognata*, *Gephyrocuma repanda*, *Leptocuma vicaria*, *L. obstipa*, *L. serrifera*, *L. intermedia*, *Vaunthompsonia nana*, *Glyphocuma inaequalis*, *G. dentata*, and *G. serventyi*.

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RECENT AUSTRALIAN SPECIES OF THE FAMILY RISSOIDAE (MOLLUSCA)

By BERNARD C. COTTON, Conchologist, South Australian Museum

Summary

In the following paper an attempt is made to father together all species of Australian Recent Rissoidae and to allot them to their proper genera. Australian authors have not previously separated the families Rissoidae, Rissoinidae and Litiopidae in the same way in which they are now recognised. We find under Rissoidae such genera as *Diala* which belongs to Litiopidae, *Cithna* belonging to Cyclostremidae, *Rissolina, Stiva* and *Rissoina* belonging to Rissoinidae where the New Zealand *Nozeba* also belongs, and *Heterorissoa* placed by Thiele in Rissoellidae. New species from the dredgings made by the late Sir Joseph Verco and species collected by the author and others are described. It is pretty certain that many more species remain to be discovered in shell sand and alive on the various weeds and sea-grasses around our coast, even in the shallow waters accessible to the amateur collector. As it is almost impossible for students to classify the Rissoids or even find access to much of the literature concerning them, it is hoped that this preliminary survey with its keys, brief diagnoses and original references will encourage further study both in the Recent and fossil fields. With regard to the latter, much work will have to be done, and no doubt the species will form good indicators of strata. Small mollusca of this type can be obtained in quantity, undamaged by the drill, which so often destroys the larger forms.

RECENT AUSTRALIAN SPECIES OF THE FAMILY RISSOIDAE (MOLLUSCA)

By Bernard C. Cotton, Conchologist, South Australian Museum

[Read 14 September 1944]

Plate XVI

Introduction

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Key to Genera of Australian Rissoidae

a. Shell moderately elongate.
 b. Shell not scalariform.
  c. Aperture not separated from the body whorl or duplicate.
   d. Aperture edge thin, often reflexed, much thickened internally, no exterior varix.
    e. Smooth or weakly developed axials .... *Estea*
    ee. Axials of elongate nodules .... *Subestea*
  cc. Aperture edge thickened by means of an external varix.
   f. Sculptured.
    g. Sculpture not clathrate.
     h. Axial ribs dominant .... *Haurakia*
     hh. Spiral sculpture dominant.
      i. Spiral cords .... *Lironoba*
      ii. Spiral incised lines.
       j. Aperture circular, thickened within .... *Botelloides*
       jj. Aperture ovate, not thickened within .... *Subonoba*
    gg. Sculpture clathrate.
       k. Protoconch spirally lirate, dull .... *Merelina*
       kk. Protoconch smooth, glossy .... *Linemera*
   ff. Smooth or nearly so.
       l. Aperture entire, shell not truncate, solid.
        m. Smooth, whorls convex, aperture simple, rotund .... *Notosetia*
        mm. Smooth, whorls flattened, aperture slightly channelled below, aperture ovato-pyriform .... *Dardanula*
       ll. Aperture discontinuous, effuse, shell truncate at the apex, transparent .... *Eusetia*

cc. Aperture separated from the body whorl or duplicate.
n. Cylindrical, protoconch large, globose, smooth .... *Epigrus*
nn. Normal shape, protoconch not smooth.
o. Protoconch stippled with very fine lines .... *Scrobs*
oo. Protoconch engraved with a honeycomb pattern .... *Notoscrobs*
bb. Shell scalariform .... *Anabathron*
aa. Shell very elongate, about four times as long as wide.
p. Axially sculptured .... *Caenaculum*
pp. Spirally sculptured .... *Attenuata*

Estea Iredale 1915

Estea Iredale 1915, Trans. New Zealand Inst., **47**, 451

Genotype: *Rissoa zosterophila* Webster 1905—Devenport, near Auckland, New Zealand.

Shell minute, oval, elongate, subrimate, dull, smooth, no sculpture; spire conical, higher than the aperture; outlines slightly convex; whorls rather rapidly increasing, flattened, periphery subangled, base rounded, suture not much impressed; aperture slightly oblique, oval, angled above, peristome continuous, but much thickened internally, sharp, very little expanded; columella short, arcuate, callous; operculum colourless and presenting a malleated appearance on the inner surface; protoconch conical, small, of two flat smooth whorls.

Distribution—New Zealand, Australia, Tasmania. Fossil, Tertiary.

Remarks—Distinguished by the smooth shell, the protoconch and shape of aperture, which is perpendicular, circular, with peristome reflected all round. This heterogenous group may represent a number of genera. In any case, there are so many and varied species allotted here that it seems almost impossible and futile to attempt to key them before they have been further studied. There appear to be at least seven groups represented in Australia.

(a) Species which are quite smooth and polished like *approxima*.
(b) Species which are sculptured with microscopic axial accremental striae like *tasmanica*.
(c) Species which have weak axial folds like *frauenfeldi*.
(d) Species with strongly thickened and reflexed aperture lip like *incidata*.
(e) Species with comparatively little thickened and reflected aperture lip like *janjucensis*.
(f) Species with a very blunt apex like *tiara*.
(g) Species with comparatively sharp apex like *rubicunda*.

Gatliff and Gabriel, in figuring the species *Rissoa bicolor* Petterd, point out that the protoconch, under microscopic examination, "shows that the two-whorled protoconch is minutely granulated, these granules being symmetrically arranged in about twelve spiral rows, which are more clearly defined on the second whorl." A similar sculpture or texture is referred to in this paper under the genus *Merelina*.

Estea approxima (Petterd 1884)

Rissoa cyclostoma rosea Tenison Woods 1884, Proc. Roy. Soc. Tasm., 153, not Deshayes 1863 or Hutton 1873

Rissoa approxima Petterd 1884, Journ. Conch., 138, 4.

Rissoa woodsi Pritchard and Gatliff 1902, Proc. Roy. Soc. Vict., 104.

Locs.—Tasm.: Blackman's Bay (type loc. *rosea*), Tamar Heads (type loc. *approxima*); Vict.: Western Port (type loc. *woodsi*); S. Aust.: shell sand from

Guichen Bay, Robe, Largs Bay, St. Francis Island, Venus Bay, also Gulf. St. Vincent, 14 fathoms.

Remarks—Smooth polished and thin lipped. Tasmanian North Coast specimens may be quite white, rose-red, brown or partly white and partly red and brown.

Estea bicolor (Petterd 1884)

Rissoa bicolor Petterd 1884, Journ. Conch., 4, 137.

Locs.—Tasm.: North Coast (type loc.), Derwent Estuary, Cape Raoul, 50 fathoms; Vict.: Portsea; S. Aust.: Beachport 110 fathoms, Cape Borda 62 fathoms, Gulf. St. Vincent and Spencer Gulf; N.S.W.: Cape Three Points 41 to 50 fathoms.

Remarks—Distinguished by the white band beneath the suture. South Australian specimens show variations from the type as follows:

(1) More blunt at the apex, suture more impressed, whorls more convex, mouth with more expanded lip and rounder.

(2) Whorls more rapidly increasing, minute rimate perforation, aperture projecting beyond the level of the spire whorls.

(3) Whorls less rapidly increasing, mouth not so expanded, not so bevelled on the inner margin.

Estea columnaria (Hedley and May 1908)

Rissoa columnaria Hedley and May 1908, Rec. Aust., Mus., 7, 117, pl xxii, fig. 9.

Locs.—Tasm.: seven miles east of Cape Pillar 100 fathoms (type loc.); Vict.

Remarks—Distinguished by the very elongate shape, variable colour, axials fine, close set accremental striae.

Estea frenchiensis (Gatliff and Gabriel 1908)

Rissoa frenchiensis Gatliff and Gabriel 1908, Proc. Roy. Soc. Vict., 379.

Rissoa cylostoma Tenison Woods 1877, Proc. Roy. Soc. Tasm., 152, not Recluz 1843.

Locs.—Vict.: Western Port 6 fathoms, Port Phillip, Puebla Coast; Tasm.: Long Bay (type loc.), Blackman's Bay; S. Aust.: shell sand from Robe, Normanville, MacDonnell Bay, St. Francis Island, Cape Borda 62 fathoms; N.S.W.: Port Jackson.

Remarks—Subturreted, tumid in the middle, suture margined with a white line. This species has a comparatively greater diameter than *approxima*.

Estea incidata (Frauenfeld 1867)

Sabanaea incidata Frauenfeld 1867, Novara Exped., Moll., 12, pl. ii, fig. 19.

Locs.—N.S.W.: Botany Bay (type loc.); Tasm.: South and East; Qld.; Vict.

Remarks—Remarkable for its thickened and expanded aperture peristome.

Estea erma n. sp.

(Pl. xvi, fig. 1)

Holotype: Reg. No. D.14184, South Australian Museum.

Shell conical, thick, polished ruby brown, smooth, whorls five, flat and angled at the suture without a peripheral channel; no spiral punctuations; peristome of aperture thickened. Height 1·2 mm., diameter 0·7 mm.

Locs.—S. Aust.: Cape Borda 62 fathoms (type loc.), Backstairs Passage 22 fathoms; Tasm.: North Coast; Vict.

Remarks—Differs from *incidata* in being smaller, having the apex less blunt and no spiral punctuations. One variety has an incision at the very angulate periphery, and another near the base. This may be the species recorded as *incidata* in Victoria and Tasmania.

ESTEA IRAVADOIDES (Gatliff and Gabriel 1913)

Rissoa iravadoides Gatliff and Gabriel 1913, Proc. Roy. Soc. Vict., **26**, 67.

Locs.—Vict.: dredged off Wilson's Promontory (type loc.), Western Port 8 to 10 fathoms; Tasm.: Thouin Bay 40 fathoms.

Remarks—Distinguished by the numerous regular spiral lirae.

ESTEA JANJUCENSIS (Gatliff and Gabriel 1913)

Rissoa janjucencis Gatliff and Gabriel 1913, Proc. Roy. Soc. Vict., **26**, 67, pl. viii, fig. 2.

Locs.—Vict.: Jan Juc, Puebla Coast (type loc.), Western Port 8 to 10 fathoms; Tasm.: Penguin, North Coast in shell sand; S. Aust.: Outer Harbour shell sand, Beachport 40 fathoms.

Remarks—Distinguished by the rather large, roundly pyriform aperture, laterally extended to the right and with a complete peristome. The sculpture in *relata* is even weaker.

ESTEA PRAEDA (Hedley 1908)

Rissoa praeda Hedley 1908, Proc. Linn. Soc. N.S.W., **33**, 468, pl. x, fig. 35.

Locs.—N.S.W.: Middle Harbour (type loc.).

Remarks—The shell is distinguished by the massive perpendicular ribs numbering 11 on the body whorl, and stopping at the periphery, leaving the base smooth; apex smooth.

ESTEA PULVILLA (Hedley 1906)

Rissoa pulvilla Hedley 1906, Proc. Linn. Soc. N.S.W., 30, 526, pl. xxxii, fig. 25.

Locs.—N.S.W.: Manly (type loc.).

Remarks—Distinguished by the polished surface with microscopic growth lines and two spiral brown colour bands, separating this species from *tasmanica* which it otherwise somewhat resembles.

Estea amblycorymba n. sp.

(Pl. xvi, fig. 2)

Holotype: Reg. No. D14185, South Australian Museum.

Shell minute, subcylindrical, thin, shining, white and polished under 10 x magnification; very finely spirally and axially striate under 50 x, striae a little more pronounced around the base; whorls four, flatly convex, widely marginate round and below the sutures with an opaque white band; protoconch flattened, of one and a half depressed whorls, giving the shell a flat-topped appearance; aperture in the plane of the axis, pyriform, peristome reflected and entire. Height 2·1 mm., diameter 1·0 mm.

Locs.—S. Aust.: Gulf St. Vincent 14 fathoms (type loc.), Backstairs Passage 22 fathoms, Streaky Bay, Beachport 40 and 110 fathoms.

Remarks—The species is unique in having the dull white band below the suture and the axial and spiral microscopic sculpture. The body whorl is comparatively larger in proportion to the spire than any other *Estea* described.

ESTEA TASMANICA (Tenison Woods 1876)

Eulima tasmanica Tenison Woods 1876, Proc. Roy Soc. Tasm., 29.

Locs.—Tasm.: Long Bay 6 fathoms (type loc.), Pirate Bay, Derwent Estuary 10 fathoms, east coast 10 to 100 fathoms; S. Aust.: Cape Borda 62 fathoms, Newland Head 26 fathoms; Vict.

Remarks—Bears some relation to *pulvilla* Hedley from New South Wales.

ESTEA TIARA (May 1915)

Amphithalamus tiara May 1915, Proc. Roy. Soc. Tasm., 96, pl. vii, fig. 35.

Locs.—Tasm.: Thouin Bay 40 fathoms (type loc.).

Remarks—This species is evidently one belonging to the *pertumida* type with blunt and flattened apex, which in this case is so flattened that the small tip on the top of the second whorl makes the whole protoconch look like a turban crowning the shell.

ESTEA TUMIDA (Tenison Woods 1876)

Diala tumida Tenison Woods 1876, Proc. Roy. Soc. Tasm., 147

Locs.—Tasm.: Swansea (type loc.), King Island; S. Aust.: Beachport 40 and 150 fathoms, Cape Jaffa 130 fathoms; Vict.: Western Port.

Remarks—Distinguished by the almost obsolete oblique axial plaits, and the colour banding of yellow above and below the sutures.

ESTEA FRAUENFELDI (Frauenfeld 1867)

Rissoa frauenfeldi Frauenfeld 1867, Novara Exped., Moll., 10, pl. ii, fig. 13.

Locs.—N.S.W.: Sydney, Port Jackson (type loc.); Qld.

Remarks—Distinguished from *olivacea* by the axial sculpture which is obsolete on the upper whorls and pronounced on the body whorl in this species. In *olivacea* the sculpture becomes obsolete on the body whorl.

Estea relata n. sp.

(Pl. xvi, fig. 3)

Holotype: Reg. No. D14186, South Australian Museum.

Shell subacute, conical, solid, fawn-coloured; whorls six, slightly convex, suture deeply incised; penultimate and body whorl weakly axially plicate; aperture oval; lip thickened. Height 3 mm., diameter 1·4 mm.

Locs.—S. Aust.: Gulf St. Vincent 14 fathoms (type loc.).

Remarks—This species is related to *frauenfeldi* approximating to the drawing by Frauenfeld of the less strongly sculptured variety which he gives together with the typical form in his original description. This species *relata* is more solid with strongly developed aperture and peristome.

ESTEA PERPOLITA May 1919

Estea perpolita May 1919, Proc. Roy. Soc. Tasm., 61, pl. xv, fig. 13.

Locs.—Tasm.: Thouin Bay 50 fathoms (type loc.), Cape Pillar 100 fathoms.

Remarks—Distinguished by its rounded whorls, flattened summit and high polish, differing from *rubicunda* in being shorter and blunter.

Estea pertumida (May 1915)

Amphithalamus pertumida May 1919, Proc. Roy. Soc. Tasm., 96, pl. vi, fig. 33.

Locs.—Tasm.: Thouin Bay 40 fathoms (type loc.), Cape Pillar 100 fathoms.

Remarks—Distinguished by the swollen whorls, particularly the whorl following the protoconch. The whorls are also constricted abruptly at the base towards the suture, somewhat like those of *obeliscus.*

Estea puer May 1921

Estea puer May 1921, Check List Moll., Tasm., 51.

Rissoa pupoides May 1915, Proc. Roy. Soc. Tasm., 93, pl. v, fig. 26 (not *pupoides* Stimpson 1851).

Locs.—Tasm.: Port Arthur 50 to 70 fathoms (type loc.).

Remarks—Known only from the type locality. This species is remarkable for its pupaeform shape. Its deeply impressed suture somewhat recalls *pertumida* and *obeliscus.*

Estea rubicunda (Tate and May 1900)

Rissoa rubicunda May 1900, Trans. Roy. Soc. S. Aust., **24**, 100.

Locs.—Tasm.: Derwent Estuary (type loc.); Vict.: Western Port.

Remarks—Related to *perpolita* but is less blunt at the apex as well as showing the other differences mentioned under *perpolita.*

Estea kershawi (Tenison Woods 1877)

Rissoina kershawi Tenison Woods 1877, Proc. Roy. Soc. Vict., 57.

Locs.—Vict.: Western Port; Tasm.: North Coast Channel 10 fathoms (type loc.).

Remarks—Distinguished by the axial riblets covering the whole of the whorl.

Estea labrotoma May 1919

Estea labrotoma May 1909, Proc. Roy. Soc. Tasm., 61, pl. xv, fig. 14.

Locs.—Tasm.: Frederick Henry Bay, taken from roots of the giant kelp (type loc.).

Remarks—Distinguished by the thick and well reflected peristome, which has a deep indentation where it joins the body whorl.

Estea microcosta May 1919

Estea microcosta May 1919, Proc. Roy. Soc. Tasm., 61, pl. 15, fig. 12.

Locs.—Tasm.: seven miles east of Cape Pillar 100 fathoms (type loc.); S. Aust.: Beachport 40 and 200 fathoms; Vict.

Remarks—Distinguished from *kershawi* by the much more numerous and finer ribs, rounder mouth, and more cylindrical form.

Estea obeliscus (May 1915)

Rissoa obeliscus May 1915, Proc. Roy. Soc. Tasm., 92, pl. v, fig. 4.

Locs.—Tasm.: Port Arthur 50 to 70 fathoms (type loc.), Schouten Island 40 fathoms; Vict.

Remarks—Distinguished by the elongate shell and the comparatively numerous whorls which show a rather sudden constriction at the bottom, running abruptly in towards the suture beneath. There is also an umbilical chink.

Estea olivacea (Frauenfeld 1867)

Alvania olivacea Frauenfeld 1867, Novara Exped., Moll., 11, pl. ii, fig. 14.
Rissoa diemenensis Petterd 1884, **4**, 138.

Locs.—N.S.W.: Sydney (type loc.), Botany Bay, Manly Beach; Tasm.: Tamar Heads, Table Cape (type loc. *diemenensis*), Derwent Estuary, King Island, Bass Straits; S. Aust.: Port MacDonnell, Outer Harbour in shell sand, Gulf St. Vincent 14 fathoms, Beachport 200 fathoms, St. Francis Island 15 and 20 fathoms; W. Aust.: 80 miles west of Eucla 80 fathoms; Qld.; Vict.

Remarks—Distinguished by the axially ribbed shell, emarginate by an impressed spiral just below the suture forming nodules on the top of the ribs. This widely distributed shell is now added to the Western Australian fauna.

Subestea n. gen.

Genotype: *Alvania seminodosa* May 1915—Tasm., Thouin Bay 40 fathoms.

Shell small, shining, pale yellowish, elongate; whorls five, rounded, suture well impressed; spire whorls bear about nine nodulous-like ribs which become weaker and narrower as they descend, and almost disappear about the middle of the body whorl; a few faint spirals on the base; aperture rather broadly pyriform, oblique, surrounded by a well-defined margin; protoconch of one-and-a-half whorls, at first smooth and later developing about five faint spirals.

Distribution—Australia.

Remarks—The genus is distinguished by the sculpture of nodulous-like ribs and the protoconch.

Key to Species of Subestea

a. Shell wide and roundly subangulate at the periphery of the body whorl	*salebrosa*
aa. Shell normal in shape and not subangulate at the periphery of the body whorl.	
b. Axial ribs stopping before the base is reached ...	*seminodosa*
bb. Axial ribs extending unto the base	*flindersi*

Subestea salebrosa (Frauenfeld 1867)

Rissoa salebrosa Frauenfeld 1867, Novara Exped., Moll., 11, pl. ii, fig. 15.

Locs.—N.S.W.: Sydney (type loc.); Qld.; Vict.

Remarks—Distinguished from *seminodosa* by the comparatively wide shell subangulation of the body whorl and rather subdilate aperture.

Subestea seminodosa (May 1915)

Alvania seminodosa May 1915, Proc. Roy. Soc. Tasm., 94, pl. vi, fig. 30.

Locs.—Tasm.: Thouin Bay 40 fathoms (type loc.).

Remarks—This genotype species is much smaller than *flindersi* and has a simpler sculpture, there being no interstitial pustules between the major nodules at the suture.

Subestea flindersi (Tenison Woods 1876)

(Pl. xvi, fig. 12)

Rissoina flindersi Tenison Woods 1876, Proc. Roy Soc. Tasm., 154.

Locs.—Tasm.: North West Coast (type loc.); S. Aust.: MacDonnell Bay, Gulf St. Vincent, Largs Bay, Sceales Bay, St. Francis Island 35 fathoms; W. Aust.: Hopetown; Vict.

Remarks—A South Australian specimen of this species is figured, taken from shell sand at Glenelg. They are very closely allied to the Tasmanian specimens in the May Collection.

HAURAKIA Iredale 1915

Haurakia Iredale 1915, Trans. New Zealand Inst., **47**, 449.

Genotype: *Rissoa hamiltoni* Suter 1898—Lyall Bay, near Wellington, New Zealand.

Shell thin, axial sculpture dominating, sometimes crossed by spiral threads, which may continue to the base or stop at the periphery of the body whorl; aperture round and subvertical, peristome continuous; protoconch smooth and globose with convex whorls.

Distribution—Australia, New Zealand, Tasmania. Fossil, Tertiary.

Remarks—The genus closely resembles *Turboella* Gray 1847 but is distinguished by the rounder aperture and less concave columella. Although regarded sometimes as a synonym of *Turboella* Gray = *Pusillina* Monterosato, the genus has been accepted as distinct by all Australian and New Zealand conchologists.

KEY TO SPECIES OF HAURAKIA

a. Base spirally ribbed ... *strangei*
aa. Base smooth or with merely spiral threadlets or axials.
- b. Base with spiral threadlets.
  - c. Strong axial ribs and weaker spirals.
    - d. No spiral band running round the top of the whorls. ... *supracostata*
    - dd. A spiral band running round the top of the whorls .. *profundior*
  - cc. Weak axial ribs and strong spirals.
    - e. Body whorl sculptured all over.
      - f. Ribs not arched .. *nocarensis*
      - ff. Ribs arched .... *demessa*
    - ee. Body whorl smooth in the middle ... *mediolaevis*
- bb. Base smooth or with axials only.
  - g. Base with axials *liddelliana*
  - gg. Base smooth . . *descrepans*

HAURAKIA STRANGEI (Brazier 1894)

Rissoa (Apicularia) strangei Brazier 1894, Proc. Linn. Soc. N.S.W., **19**, 173, pl. xiv, fig. 11.

Rissoa lineata Petterd 1884, Journ. Conch., 137 (non Risso 1826).

Locs.—N.S.W.: Watsons Bay (type loc.); Tasm.: North Coast (type loc. *lineata*), Frederick Henry Bay, Kelso; Vict.: S. Aust.: Gulf St. Vincent 14 fathoms, Beachport 40 fathoms, shell sand from MacDonnell Bay, Guichen Bay, Robe, Streaky Bay, St. Francis Island, Reevesby Island, Venus Bay, Port Elliston, Carawa; W. Aust.: 80 miles west of Eucla 80 fathoms, Hopetown, King George Sound.

Remarks—The following varietal forms may be observed amongst Southern Australian specimens:

(1) There may be no spirals in the body whorls.

(2) One spiral just below the suture causing tuberculation of the axials; another just above the suture marking the end of the axials with a small tubercle.

(3) There may be several spirals which cross and slightly tuberculate the axials, as many as 18 in the penultimate spire whorl.

HAURAKIA SUPRACOSTATA May 1919

Haurakia supracostata May 1919, Proc. Roy. Soc. Tasm., 62, pl. xv, fig. 16.

Locs.—Tasm.: Frederick Henry Bay (type loc.), North Coast, Thouin Bay 40 fathoms, King Island; Vict.

Remarks—Distinguished by the deeply impressed suture and the comparatively few axial ribs fading at the periphery.

HAURAKIA PROFUNDIOR (Hedley 1907)

Rissoa profundior Hedley 1907, Rec. Aust. Mus., **6**, 358, pl. lxvii, fig. 15.

Locs.—N.S.W.: 35 miles east of Sydney 800 fathoms (type loc.).

Remarks—Distinguished by the spiral band running round the top of the six whorls.

HAURAKIA NOVARENSIS (Frauenfeld 1867)

Alvania novarensis Frauenfeld 1867, Novara Exped., Moll., 11, pl. ii, fig. 16.
Rissoa (Alvania) trajectus Watson 1886, **15**, 596, pl. xliv, fig. 6.

Locs.—N.S.W.: Sydney (type loc.); Qld.: Torres Straits 3-11 fathoms (type loc. *trajectus*), Caloundra; Tasm.: Thouin Bay 40 fathoms.

Remarks—Distinguished by the comparatively greater development of the spirals.

HAURAKIA DEMESSA (Tate and May 1900)

Rissoa (Apicularia) demessa Tate and May 1900, Trans. Roy. Soc. S. Aust., **24**, 98.

Locs.—Tasm.: Thouin Bay 40 fathoms (type loc.), Frederick Henry Bay.

Remarks—There is a variety from Thouin Bay 40 fathoms in which the shell is slightly wider and the spirals less marked.

Haurakia mediolaevis n. sp.
(Pl. xvi, fig. 4)

Holotype—Reg. No. D.14187, South Australian Museum.

Shell ovate, thick, white, not colour banded; whorls five slightly convex, gradate, finely spirally lirate; lirae crossed by weak axial lirae; aperture ovate, columella slightly arcuate; outer lip thickened by a varix; middle of each whorl smooth, or nearly so, through the axials and spirals becoming more or less obsolete. Height 2·5 mm., diameter 1·5 mm.

Locs.—S. Aust.: Cape Jaffa 300 fathoms (type loc.); Tasm.: Thouin Bay 40 fathoms; W. Aust.: Cottesloe (Henn.)?

Remarks—Differs from *H. novarensis* in the weaker sculpture becoming obsolete on the middle of the whorls, and in being unicoloured white or horn without any colour banding of any sort. The species is rare and dredged only at the two localities named. This, and not *novarensis*, may be the species recorded from Cottesloe, Western Australia, by Henn.

HAURAKIA LIDDELLIANA (Hedley 1907)

Rissoa liddelliana Hedley 1907, Proc. Linn. Soc. N.S.W., **32**, (3), 494, pl. xvii.

Locs.—Qld.: Mast Head Reef, Capricorn Group 17-20 fathoms (type loc.); Vict.

Remarks—In this species the axials extend on to the base.

HAURAKIA DESCREPANS (Tate and May 1900)

Rissoa (Pusillina) descrepans Tate and May 1900, Trans. Roy Soc. S. Aust., **24**, 93.
Rissoa incompleta Hedley 1908, Proc. Linn. Soc. N.S.W., **33**, 468, pl. x, fig. 36.

Locs.—Tasm.: Cape Pillar 100 fathoms (type loc.), Pilot Station 10 fathoms; N.S.W.: Middle Harbour, Sydney (type of *incompleta*); Vict.; S. Aust.;

Beachport 40 fathoms, Cape Borda 60 fathoms, Streaky Bay; W. Aust.: Hopetown.

Remarks—Some South Australian specimens have a tendency to develop a weakly defined rib at the bottom of the axials somewhat resembling a spiral basal rib at the periphery, and in some specimens the apical whorls are of a vinous brown and the next whorls of increasing lighter colour.

Lironoba Iredale 1915

Lironoba Iredale 1915, Trans. New Zealand Inst., **47**, 450.

Genotype—*Rissoa suteri* Hedley 1904, Foveaux Straits, New Zealand.

Shell small, ovate, imperforate, gradate and solid; typical sculpture of broad flat spiral ribs; sometimes the ribs are weaker but the spiral sculpture is always dominant; aperture oval, oblique, peristome much thickened; protoconch smooth in one series (typical) and spirally lirate in another.

Distribution—New Zealand, Australia, Tasmania. Fossil, Tertiary.

Key to Species of Lironoba

a. Outer lip rounded, not produced at the base of the columella.	
b. Strong spiral keels.	
c. Keels wider than the interstices.	
d. Keels numbering six	*freycineti*
dd. Keels numbering eight	*archensis*
cc. Keels narrower than the interstices.	
e. A smooth area at the top of the whorl	*agnewi*
ee. Smooth area narrow or obsolete.	
f. Keels five on the body whorl	*australis*
ff. Keels seven on the body whorl	*wilsonensis*
bb. Weak spiral keels.	
g. Whorls rounded.	
h. Keels irregular	*sulcata*
hh. Keels regular.	
i. Keels ten	*multilirata*
ii. Keels eight	*lockyeri*
iii. Keels seven	*layardi*
gg. Whorls angulate.	
j. Weak spiral riblets group to form an angulation	*unilirata*
jj. Strong spiral riblets group to form an angulation.	
k. Base with spiral riblets	*praetornatilis*
kk. Base smooth	*imbrex*
aa. Outer lip rounded, but produced at the base of the columella	*schoutanica*

Lironoba freycineti (May 1915)

Rissoa freycineti May 1915, Proc. Roy. Soc. Tasm., 94, pl. v, fig. 28.

Locs.—Tasm.: Thouin Bay 40 fathoms (type loc.).

Remarks—Distinguished by the six and sometimes seven strong rounded keels on the body whorl, separated by grooves almost as wide.

Lironoba archensis (May 1913)

Rissoa archensis May 1913, Proc. Roy. Soc. Tasm., 47, pl. ii, fig. 5.

Locs.—Tasm.: Arch Island, D'Entrecasteaux Channel (type loc.), Thouin Bay 40 fathoms.

Remarks—Distinguished from *freycineti* by the more numerous keels of the body whorl.

Lironoba agnewi (Tenison Woods 1877)

Rissoa agnewi Tenison Woods 1877, Proc. Roy Soc. Tasm., 152.

Locs.—Tasm.: Blackman's Bay (type loc.), Frederick Henry Bay, Schouten Island 40 fathoms; N.S.W.; Vict.

Remarks—Distinguished by the smooth arc at the top of the whorls and the four keels of the body whorl. Shells picked out of shell sand by me from Robe, South Australia, bear some resemblance to this species but are not sufficiently well preserved to determine whether they belong here or to *lockyeri.* They probably belong to the latter species.

Lironoba australis (Tenison Woods 1877)

Cingulina australis Tenison Woods 1877, Proc. Roy. Soc. Tasm., 147.

Rissoa tenisoni Tate 1899, Trans. Roy. Soc. S. Aust., 23, 233, *nom. mut.*, not *Cingulina australis* Sowerby.

Locs.—Tasm.: Badger Island Bass Straits (type loc.), King Island, Frederick Henry Bay, North Coast; Vict.; S. Aust.: Beachport 200 fathoms, Cape Borda 55, 60 and 62 fathoms, Cape Jaffa 49 fathoms, shell sand from Lacepede Bay, MacDonnell Bay, Holdfast Bay, Guichen Bay, Robe.

Remarks—Distinguished by the five elevated spiral keels of the body whorl. The species is neither *Rissoa* nor *Cingulina*, so the name *australis* stands.

Lironoba wilsonensis (Gatliff and Gabriel 1913)

Rissoa wilsonensis Gatliff and Gabriel 1913, Proc. Roy. Soc. Vict., 26, 68, pl. viii, fig. 4.

Locs.—Vict.: Wilson's Promontory (type loc.); Tasm.: Thouin Bay 40 fathoms, Cape Pillar 100 fathoms; S. Aust.: Neptune Island 104 fathoms, Cape Borda 62 fathoms.

Remarks—Distinguished from *australis* by the more numerous keels on the body whorl and the less acuminate shell. South Australian shells agree with the cotype.

Lironoba sulcata n. sp.

(Pl. xvi, fig. 5)

Holotype—Reg. No. D.14188, South Australian Museum.

Shell small, rather narrow and elongate, solid, white; whorls convex, slowly increasing in size, four in number; sculpture of numerous irregular fine spiral keels starting after a fairly wide smooth area below the suture, and present right on to the base, the upper two well separated, then the rest more crowded, the interstices giving a sulcate appearance to the shell; aperture well defined, round, entire, lip thickened tending to become a little effuse and very slightly produced below the columella; entire surface microscopically spirally regularly scratched; protoconch paucispiral, depressed smooth whorls giving a truncate appearance to the top of the shell. Height 3 mm., diameter 1·5 mm.

Locs.—S. Aust.: Cape Borda 62 fathoms (type loc.), Gulf St. Vincent 14 fathoms.

Remarks—This peculiar species occurred in number in dredge sifting from the type locality. The irregularly placed spirals, distant at first and then more crowded and running right over the base, together with the microscopic spiral scratches distinguish this species.

LIRONOBA MULTILIRATA (May 1915)

Rissoa multilirata May 1915, Proc. Roy. Soc. Tasm., 93, pl. v, fig. 27.

Locs.—Tasm.: North Coast, Frederick Henry Bay (type loc.); S. Aust.: Kingston shell sand, Cape Jaffa 130 fathoms.

Remarks—Distinguished by the flatly rounded keels of the body whorl, numbering ten, separated by narrow grooves, and smooth base.

LIRONOBA LOCKYERI (Hedley 1911)

Rissoa lockyeri Hedley 1911, Zool. Res. Endeavour, **1**, 103, pl. xviii, fig. 22.

Locs.—S. Aust.: 40 miles south of Cape Wiles 100 fathoms (type loc.), St. Francis Island 15, 20, 35 fathoms, Cape Jaffa 130 fathoms, Spencer Gulf 40 fathoms, Cape Borda 62 fathoms.

Remarks—Distinguished from *layardi* by its greater size, tendency to a wider smooth area below the suture and at the base, and in having eight instead of seven keels. It was known previously only from the type locality.

LIRONOBA LAYARDI (Petterd 1884)

Rissoa layardi Petterd 1884, Journ. Conch., 138.

Locs.—Tasm.: North Coast (type loc.), Schouten Island 40 fathoms, Frederick Henry Bay, D'Entrecasteaux Channel, Storm Bay 24 fathoms, North West Coast; Vict.?

Remarks—Distinguished by the fine, regular spiral keels numbering seven on the body whorl. An examination of South Australian specimens previously identified by various local conchologists as *agnewi* and *layardi*, and specimens taken by me at Robe in shell sand, proves them to be variants of *lockyeri*.

LIRONOBA UNILIRATA (Tenison Woods 1878)

Rissoina unilirata Tenison Woods 1878, Proc. Roy. Soc. Tasm., 123.

Locs.—Tasm.: Frederick Henry Bay (type loc.) shallow water to 100 fathoms; S. Aust.: Cape Borda 55 fathoms, Neptune Island 104 fathoms, Beachport 150 fathoms; Vict.?

Remarks—Distinguished by the spiral riblet sculpture forming a single or double keel on the upper whorls, producing an angulation, the body whorl generally but not always destitute of riblets or may have only one.

LIRONOBA PRAETORNATILIS (Hedley 1912)

Alvania praetornatilis Hedley 1912, Rec. Aust. Mus., **8**, 139, pl. xli, fig. 16.

Locs.—N.S.W.: Broughton Island, Port Stephens 35 fathoms (type loc.).

Remarks—Distinguished from *imbrex* by the less exsert spire whorls and the spirally ridged base.

LIRONOBA IMBREX (Hedley 1908)

Rissoa imbrex Hedley 1908, Linn. Soc. N.S.W., **33**, 469, pl. x, fig. 33.

Loc.—N.S.W.: Middle Harbour (type loc.).

Remarks—Distinguished from *praetornatilis* by the lack of spiral riblets on the base and the more elongate shape of the shell.

LIRONOBA SCHOUTANICA (May 1913)

Rissoa schoutanica May 1913, Proc. Roy. Soc. Tasm., 47, pl. ii, fig. 6.

Locs.—Tasm.: Schouten Island 40 fathoms (type loc.); S. Aust.: Cape Borda 55 fathoms; Vict.: Ninety Mile Beach 140 fathoms.

Remarks—Distinguished from all other species of *Lironoba* by the massive aperture, the lip of which is produced below the columella, and the broad, heavy shell with few strongly developed keels. This is a new record for South Australia.

BOTELLOIDES Strand 1928

Botelloides Strand 1928, Arch. Naturgesch., **92,** 1926, A. 8, 66.

Botellus Iredale 1924, Proc. Linn. Soc. N.S.W., **49,** (3), 244; not *Botellus* Spix and Martius 1823 or Moniez 1887.

Genotype: *Onoba bassiana* Hedley 1911—Devenport, North Tasmania.

Shell subcylindrical, rounded at each end, whorls wound obliquely on the last two-thirds of the length; earlier whorls smooth, later bearing fine incised spiral grooves; aperture circular, columella excavate, outer lip grooved within and bevelled to a sharp edge.

Distribution—Australia and Tasmania.

Remarks—The thickening of the aperture within and its small and circular shape, the pupoid shape of the shell and its heavy structure, distinguish this genus from *Subonoba*.

KEY TO SPECIES OF BOTELLOIDES

a. Shell gradually widening towards the body whorl .... *bassianus*
aa. Shell not widening but cylindrical.
b. Sides of whorls rather flattened .... *borda*
bb. Sides of whorls somewhat convex .... *glomerosa*

BOTELLOIDES BASSIANUS (Hedley 1911)

Onoba bassiana Hedley 1911, Zool. Res. Endeavour, **1,** 108, pl. xix, fig. 25.

Locs.—Tasm.: Devenport (type loc.), Thouin Bay 40 fathoms; S. Aust.: Beachport 40, 49, 100, 110, 150 and 200 fathoms, Cape Borda 55 and 62 fathoms, Cape Jaffa 130 fathoms, St. Francis Island 35 fathoms, Newland Head 20 fathoms, Gulf St. Vincent 14 fathoms, Backstairs Passage 22 fathoms; W. Aust.: King George Sound, Bunbury, Rottnest beach, dead; Vict.: Port Fairy; N.S.W.: Twofold Bay and Green Cape 25 to 70 fathoms.

Remarks—This species is larger and more solid than the other two members of the genus, and the shell widens towards the body whorl. This is an addition to the Western Australian Mollusca.

Botelloides borda n. sp.

(Pl. xvi, fig. 6)

Holotype—Reg. No. D14189, South Australian Museum.

Shell solid, oblong, subcylindrical, rounded at each extremity; surface smooth and polished with numerous delicate spiral incisions; whorls very flatly convex; suture slightly sunken and slightly constricting the previous whorl; body whorl slightly longer than the rest of the shell; aperture very small and round, thickened within. Height 3·75 mm., diameter 1·5 mm.

Locs.—S. Aust.: Cape Borda 55 fathoms (type loc.), Gulf St. Vincent 14 fathoms, Beachport 40 fathoms; Vict.: Wilson's Promontory.

Remarks—This species is distinguished from *glomerosa* by its greater size and comparatively greater length to width. It differs from *bassiana* in its more cylindrical shape.

BOTELLOIDES GLOMEROSA (Hedley 1907)

Onoba glomerosa Hedley 1907, Proc. Linn. Soc. N.S.W., **32,** (3), 459, pl. xvii, fig. 23.

Locs.—Qld.: Mast Head Reef, Capricorn Group (type loc.), Noosa; Vict.

Subonoba Iredale 1915

Subonoba Iredale 1915, Trans. New Zealand Inst., 47, 450.

Genotype: *Rissoa fumata* Suter 1898—Te Onepoto, near Littleton, New Zealand.

Shell minute, subcylindrical, thin, imperforate, translucent; sculpture of numerous close spiral incisions; whorls rapidly increasing in size, moderately convex, sutures impressed; aperture slightly oblique, ovate, angled above, peristome continuous, sharp, slightly thickened, basal lip slightly effuse; protoconch papillate, of one-and-a-half smooth and convex whorls.

Distribution—New Zealand, Australia.

Remarks—The aperture, by its oval shape and lack of internal thickening, distinguishes this genus from *Botelloides*.

Subonoba mercurialis (Watson 1886)

Rissoa (Onoba) mercurialis Watson 1886, Challenger, Zool., 15, 600, pl. xlv, fig. 12.

Locs.—Qld.: off Wednesday Island, Cape York 8 fathoms (type loc.).

Merelina Iredale 1915

Merelina Iredale 1915, Trans. New Zealand Inst., 47, 449.

Genotype: *Rissoa (Alvania) cheilostoma* Tenison Woods 1877—Long Bay 20 fathoms, Tasmania.

Shell minute, turreted, yellow, or white, conspicuously latticed throughout; aperture produced, bilabiate and entire; peristome continuous, variced, with subsutural sinus; protoconch paucispiral, depressed, inrolled at the tip, with a weak terminal varix where it adjoins the shell; under 50 x magnification the protoconch shows a minutely porous surface and the very fine dense punctures give the effect of running together into spiral lines or grooves.

Distribution—Australia, Tasmania, New Zealand, Lifu, Kermadec Island.

Remarks—The spirally grooved protoconch distinguishes this genus from *Linemera*.

Key to Species of Merelina

a. Elongate, greatest width less than half the height.
  b. Latticed sculpture with three spirals on the body whorl . *cheilostoma*
  bb. Latticed sculpture with four spirals on the body whorl ... *gracilis*
aa. Ovate, greatest width less than half the height.
  c. Sculpture a close reticulation .... *australiae*
  cc. Sculpture a wide reticulation.
    d. Body whorl with two spirals .... *hulliana*
    dd. Body whorl with more than two spirals.
      e Body whorl with four spirals .. .. *cyrta*
      ee. Body whorl with five spirals .... *eucraspeda*

Merelina cheilostoma (Tenison Woods 1877)

Rissoa cheilostoma Tenison Woods 1877, Proc. Roy. Soc. Tasm., 152.
Alvania elegans Angas 1877 (August), Proc. Zool. Soc., 174, pl. xxvi, fig. 15.

Locs.—Tasm.: Long Bay 20 fathoms (type loc.), Thouin Bay 40 fathoms, Frederick Henry Bay, North Coast; N.S.W.: Port Jackson (type loc., *elegans*), Balmoral; Qld.; Vict.; S. Aust.: Beachport 40 and 150 fathoms, Gulf St. Vincent 14 fathoms, Cape Borda 55 fathoms, shell sand from MacDonnell Bay, Kingston, Guichen Bay.

Remarks—Most South Australian and North Tasmanian specimens are worn, and are a little narrower than the typical Peronian specimens.

MERELINA GRACILIS (Angas 1877)

Alvania gracilis Angas 1877, Proc. Zool. Soc., 174, pl. xxvi, fig. 16.
Rissoa devecta Tate 1899, Trans. Roy. Soc. S. Aust., **23**, 235.

Locs.—N.S.W.: Port Jackson (type loc., also of *devecta*); Vict.; Qld.; Tasm.: Derwent Estuary, South East 10 to 100 fathoms; S. Aust.: Neptunes 104 fathoms; W. Aust.: Rottnest Island, King George Sound.

Remarks—Flindersian records are from single beach rolled specimens of doubtful determination.

MERELINA AUSTRALIAE (Frauenfeld 1867)

Cingula australiae Frauenfeld 1867, Novara Exped., Moll., 14, pl. ii, fig. 23.
Rissoa ochroleuca Brazier 1894, Proc. Linn. Soc. N.S.W., **1**, 174, pl. xiv, fig. 12.
Merelina (*Apicularia*) *apicilirata* Tate and May 1900, Trans. Roy. Soc. S. Aust., **24**, 99.

Locs.—N.S.W.: Sydney (type loc.), dredged off Green Point, Watson's Bay (type loc. of *ochroleuca*); Tasm.: North Coast, D'Entrecasteaux Channel (type loc. *apicilirata*); Qld.; Vict.: Kilcunda.

Remarks—Tasmanian specimens in the May collection are typical, but I have been unable to discover any South Australian specimens. A very poor and worn specimen from Rottnest, Western Australia, somewhat resembles this species, but more material would be required before it is added to the Western Australian list.

MERELINA HULLIANA (Tate 1893)

Rissoa (*Alvania*) *hulliana* Tate 1893, Hand List S. Aust. Moll., 7, *nom. mut.* for *Dunkeria fasciata* Tenison Woods 1876, Proc. Roy. Soc. Tasm., 146, *non* Requiem 1848.

Locs.—Vict.: Bass Straits (type loc.); Tasm.: South and North Coast; S. Aust.: Gulf St. Vincent, MacDonnell Bay, Robe, Kingston, Guichen Bay in shell sand.

Remarks—Distinguished by the wide latticed sculpture and broad shell. In life the shell is translucent and has two yellowish spiral bands, one below the suture, the other at the periphery.

Merelina cyrta n. sp.
(Pl. xvi, fig. 7)

Holotype: Reg. No. D14190, South Australian Museum.

Shell minute, turreted, latticed all over; translucent, shining golden yellow, with a white band in the middle of the spire whorls, including the central space and the rib on either side; whorls seven, four spiral lirae crossed by twelve axial, oblique and curved costae on the penultimate; number of axials variable; mouth effuse at the front of the outer lip and labrum slightly sinuous in profile; base has six or seven spiral ribs. Height 2·5 mm., diameter 1·3 mm.

Locs.—W. Aust.: King George Sound (type loc.), Great Australian Bight west of Eucla 100 fathoms, Yallingup, Hopetown, Rottnest, Albany, Ellenbrook; S. Aust.: Beachport 40 fathoms, Cape Borda 55 fathoms, 62 fathoms; Neptune Island 104 fathoms, Investigator Straits 20 fathoms, St. Francis Island, 6, 15 and 35 fathoms, Gulf St. Vincent 14 fathoms, shell sand from Port River, Franklin Island, Sceales Bay, Guichen Bay, Largs Bay, St. Francis Island, West Coast, Glenelg.

Remarks—Compared with *M. hulliana* the present species is less solid, more attenuated, seven whorls instead of six; penultimate whorl with four spirals instead of two; eleven axial costae instead of six or seven and these are more oblique and more curved, but may vary from twelve to twenty; the more effuse mouth at the front of the outer lip, and the more sinuous labrum in profile; the base has six or seven spiral ribs instead of three or four. The following variations may be noted:

1 The two smooth apical whorls are ruddy chestnut, whereas most have a white apex.

2 Most are white, but many have a white band in the middle of the whorls, the rest of the shell being a golden yellow; some have an infrasutural darker band.

3 The respective validity of the axial costae and spiral lirae varies in different examples.

4 The number of axial costae vary in number; in some cases about twelve to fourteen, in others twenty to twenty-four.

5 In some the central spiral lira is prominent and its tubercles are opaque white like a row of pearls.

Merelina eucraspeda (Hedley 1911)

Rissoa hulliana eucraspeda Hedley 1911, Zool. Res. Endeavour, 1, 103, pl. xviii, fig. 21.

Locs.—S. Aust.: 40 miles south of Cape Wiles 100 fathoms (type loc.), Beachport 110 fathoms, Cape Borda 62 fathoms, Neptune Island 104 fathoms.

Remarks—Not bicarinate as in *M. hulliana*, where two spirals encircle the whorls forming the bicarination. In the present species five or six spirals encircle the body whorl and base. It was previously known only from the type locality.

Linemera Finlay 1924

Linemera Finlay 1924, Trans. New Zealand Inst., **55**, 483.

Genotype: *Linemera interrupta* Finlay 1924 = *Rissoa gradata* Hutton preocc.—New Zealand.

Sculpture clathrate, protoconch adpressed, smooth, glossy, and dome-shaped, with inconspicuous sutures, instead of being projecting, spirally grooved, dull, and paucispiral, with deep sutures; aperture with thin edge, sometimes thickened behind with a simple varix, without a second projecting rim inside, a subsutural sinus, rather effuse at base; chink-like umbilicus generally present.

Distribution—New Zealand, Australia and Tasmania. Fossil, Tertiary.

Remarks—Distinguished from *Merelina* by the protoconch, and from *Haurakia* by the tendency to a slight indentation and a stronger spiral rib near the suture, otherwise the sculpture recalls *Haurakia*.

Key to Species of Linemera

a. Elongate, greatest width less than half the height .... *suprasculpta*
aa. Ovate, greatest width more than half the height.
  b. Sutures not very deeply excavated.
    c. No spiral beaded rib on the shoulder of the whorl.
      d. Spiral sculpture more prominent than the axial .... *filocincta*
      dd. Spiral sculpture less prominent than the axial .... *verconiana*
    cc. A spiral beaded rib on the shoulder of the whorl.
      e. Sculpture well developed .... *sculptilis*
      ee. Sculpture weak .... *occidua*
  bb. Sutures very deeply excavated .... *thouinensis*

Linemera suprasculpta (May 1915)

Alvania suprasculpta May 1915, Proc. Roy. Soc. Tasm., 95, pl. vi, fig. 31.

Locs.—Tasm.: Thouin Bay 40 to 50 fathoms (type loc.); S. Aust.: Guichen Bay, Beachport 40 and 200 fathoms, Port MacDonnell, Cape Jaffa 49, 90 and 130 fathoms.

Remarks—Distinguished by the regular reticulate sculpture with spiral lirae in the square meshes, and by the high and narrow shape of the shell.

Linemera filocincta (Hedley and Petterd 1906)

Rissoa filocincta Hedley and Petterd 1906, Rec. Aust. Mus., **6**, 217, pl. xxxvii,

Locs.—N.S.W.: Narrabeen 80 fathoms, off Sydney 300 fathoms (type loc.); Tasm.: General 40 to 80 fathoms; S. Aust.: Port MacDonnell; Vict.: Ninety Mile Beach 40 fathoms.

Remarks—In the early part of the shell the axials predominate, but later and on the body whorl the spirals become more prominent than the axials. In *verconiana* the axials are more dominant throughout the shell.

Linemera verconiana (Hedley 1911)

Rissoa verconiana Hedley 1911, Zool. Res. Endeavour, **1**, 104, pl. xix, fig. 23.

Locs.—S. Aust.: 40 miles south of Cape Wiles 100 fathoms (type loc.), Beachport 40 fathoms, Cape Borda 55 fathoms, Cape Jaffa 130 fathoms; W. Aust.: 120 miles west of Eucla 300 fathoms.

Remarks—The species is distinguished from *filocincta* by the stronger sculpture, particularly the axials which extend right down to the base and are stronger than the spirals. It was known previously only from the type locality.

Linemera sculptilis (May 1919)

Merelina sculptilis May 1919, Proc. Roy. Soc. Tasm., 62, pl. xv, fig. 15.

Loc.—Tasm.: Thouin Bay 50 fathoms (type loc.).

Remarks — Distinguished from *filocincta* by its flatter whorls, more numerous axials, strong beaded spirals on the shoulder, channelled sutures, sharp outer lip, discontinuous peristome.

Linemera occidua n. sp.

(Pl. xvi, fig. 8)

Holotype: Reg. No. D.14191, South Australian Museum.

Shell solid, ovate, yellow coloured, imperforate; whorls five including two smooth, rounded, depressed whorls forming the protoconch; suture well defined by a shallow channel; adult whorls crossed by regular strong spirals which get stronger towards the base of the body whorl, these in turn crossed by about 20 axials which fade out on the base of the body whorl; both above and below the suture a spiral of small nodules is defined by an incised spiral line a little deeper than those lines cutting the rest of the whorls, except the strong ones of the base; about a dozen spirals cross the body whorl; aperture ovate, outer lip thickened by a weak varix; colour pattern consisting of a spiral golden band at and below the suture, cut into wide axial flames by the ground colour; round the umbilical region is a narrow golden band, and a tendency to spirals of minute golden dots on the spirals of the base and lower body whorl. Height 2·1 mm., diameter 1·0 mm.

Locs.—W. Aust.: Hopetown (type loc.); S. Aust.: Carawa, West Coast.

Remarks—This species bears some resemblance to *sculptilis* but is easily separated by the smaller size, golden flames and lines, much weaker sculpture and the somewhat thickened outer lip.

Linemera thouinensis (May 1915)

Alvania thouinensis May 1915, Proc. Roy. Soc. Tasm., 94, pl. v, fig. 28.

Locs.—Tasm.: Thouin Bay 40 fathoms (type loc.), D'Entrecasteaux Channel.

Remarks—Distinguished by the deeply excavate sutures. Some specimens from D'Entrecasteaux Channel are variants with more numerous ribs.

Notosetia Iredale 1915

Notosetia Iredale 1915, Trans. New Zealand Inst., 47, 452.
Genotype: *Barleeia neozelanica* Suter 1898—Stewart Island, New Zealand.

Shell minute, ovate-conical, imperforate, subpellucid, white, thin, smooth and shining; sculpture of fine oblique growth lines and a few (in the genotype) spiral striae around the umbilical area; protoconch small, globose, of one-and-a-half smooth, convex whorls, suture impressed, slightly channelled, margined by a thin thread; aperture vertical, oval, angled above, peristome discontinuous, sharp, not thickened, basal lip effuse; columella vertical, slightly concave and callous; a thin callosity on the parietal wall.

Distribution—New Zealand, Australia, Tasmania. Fossil, Tertiary.

Remarks—The distinguishing features are the almost smooth surface, though it may be faintly spirally lirate, convex whorls and simple, round, thin-edged aperture. A species bearing some resemblance to those of this genus was described as *Rissoa pertranslucida* May 1912, but it has since been correctly placed as a *Lissotesta* under family Liotiidae.

Key to Species of Notosetia

a. Colour banded.
  b. Axial bands .... *simillima*
  bb. Spiral bands.
    c. Bifasciate with brown .... *nitens*
    cc. Alternately bifasciate with cream and brown .... *procincta*
aa. Not colour banded.
  d. Translucent white.
    e. Pink spot on base .... *muratensis*
    ee. No pink spot .... *pellucida*
  dd. Purple or rose coloured
    f. Aperture subovate .... *purpureostoma*
    ff. Aperture round .... *atropurpurea*

Notosetia simillima (May 1915)

Rissoa simillima May 1915, Proc. Roy. Soc. Tasm., 93, pl. v, fig. 26.

Locs.—Tasm: Schouten Island 40 fathoms (type loc.), Port Arthur 50 fathoms, 70 fathoms.

Remarks—May does not mention the type locality or any other definite locality in his original description, merely stating that "it seems to be well distributed on our continental shelf." (*i.e.*, Tasmania). Cotypes in the South Australian Museum are labelled "Schouten Island 40 fathoms." The species is distinguished from *nitens* by the axial banding.

NOTOSETIA NITENS (Frauenfeld 1867)

Setia nitens Frauenfeld 1867, Novara Exped., Moll., 13, pl. ii, fig. 22.
Rissoa (*Cingula*) *atkinsoni* Tenison Woods 1877, Proc. Roy. Soc. Tasm., 153.

Locs.—N.S.W.: Botany Bay (type loc.); Tasm.: Long Bay (type loc. *atkinsoni*), South and East shallow water down to 10 fathoms; Vict.

Remarks—The bifasciation, found both in New South Wales shells and Tasmanian shells, described by Tenison Woods as *atkinsoni,* distinguishes this species.

NOTOSETIA PROCINCTA (Hedley 1908)

Rissoa procincta Hedley 1908, Proc. Linn. Soc. N.S.W., **33,** 469, pl. 10, fig. 34.

Loc.—N.S.W.: Middle Harbour (type loc.).

Remarks—Distinguished by the two spiral, alternating bands of cream and pale brown on each whorl, and the simple pyriform aperture.

Notosetia muratensis n. sp.

(Pl. xvi, fig. 9)

Holotype: Reg. No. D.14192, South Australian Museum.

Shell minute, turbinately conical, polished translucent white, unicoloured except for a faint pink blotch in the middle of the base in living specimens; protoconch microscopic, turbinate, paucispiral, rounded, smooth whorls; whorls five, excluding protoconch, rounded, slightly angulate, suture impressed; aperture ovate, a little produced anteriorly, outer lip thin, acute, inner lip reflected into a false umbilicus. Height 1·5 mm., diameter 0·5 mm. Larger specimens reach 2 mm. in height.

Locs.—S. Aust.: Murat Bay (type loc.), Streaky Bay, Fowler Bay, MacDonnell Bay, Largs Bay, Grange, Cape Borda 55 fathoms, Robe, Beachport 200 fathoms, Franklin Island, Venus Bay; Tasm.: North Coast; Vict.: Western Port; W. Aust.: King George Sound, Abrolhos Island.

Remarks—This species differs from *nitens* in being larger and white, having a longer spire and a pink spot on the base in fresh specimens.

NOTOSETIA PELLUCIDA (Tate and May 1900)

Rissoa (*Nodulus*) *pellucida* Tate and May 1900, Trans. Roy. Soc. S. Aust., **24,** 100.

Locs.—Tasm.: Frederick Henry Bay (type loc.); Vict.

Remarks—Somewhat resembling *muratensis* but there is no basal blotch, and the peristome is thickened.

NOTOSETIA PURPUREOSTOMA May 1919

Notosetia purpureostoma May 1919, Proc. Roy. Soc. Tasm., 63, pl. xvi, fig. 18.

Loc.—Tasm.: Penguin in shell sand (type loc.).

Remarks—Distinguished by the purple or rose-coloured shell and the subovate aperture.

NOTOSETIA ATROPURPUREA (Frauenfeld 1867)

Setia atropurpurea Frauenfeld 1867, Novara Exped., Moll., 13, pl. ii, fig. 21.

Locs.—N.S.W.: Botany Bay (type loc.), Bondi; Qld.; Vict.

Remarks—Distinguished by the purple to rose-coloured shell and round aperture.

DARDANULA Iredale 1915

Dardanula Iredale 1915, Trans. New Zealand Inst., **47**, 452.
Dardania Hutton 1882, Trans. New Zealand Inst., **14**, 147, not *Dardania* Stal., 1822.
Genotype: *Dardania olivacea* Hutton 1882.—On seaweed in rock pools, Littleton Harbour, New Zealand.

Shell smooth, whorls flattened or convex, aperture ovate-pyriform, peristome discontinuous and thin, slightly channelled below. Animal with large foot, rounded in front, emarginate behind; opercular lobe small, simple; rostrum emarginate at the extremity; tentacles long and setaceous; eyes large, on swellings at the outer bases of the tentacles; operculum ovate, subspiral, with a long shelly process from below the nucleus.

Distribution—New Zealand, Australia, Tasmania. Fossil, Tertiary.

Remarks—The smooth shell with a tendency to flattened whorls, the slightly channelled aperture and the operculum distinguish this genus.

KEY TO SPECIES OF DARDANULA

a. Unicoloured.	
b. White	*erratica*
bb. Coloured.	
c. Black or purplish	*melanochroma*
cc. Brown	*dubitalis*
aa. Banded or flamed.	
d. Orange bands	*aurantiocincta*
dd. Red axial flames	*flammea*

DARDANULA ERRATICA (May 1912)

Amphithalamus erratica May 1912, Proc. Roy. Soc. Tasm., 48, pl. ii, fig. 7.

Locs.—Tasm.: Seven miles east of Cape Pillar 100 fathoms (type loc.), Gordon 10 fathoms; S. Aust.: Beachport 40 fathoms, Cape Borda 55, 62 fathoms, St. Francis Island 35 fathoms, Venus Bay; Vict.: Wilson's Promontory.

Remarks—Distinguished from *flammea* by being unicoloured and longer, and also in the flatter whorls. South Australian specimens here recorded correspond with cotypes.

DARDANULA MELANOCHROMA (Tate 1899)

Rissoa melanochroma Tate 1899, Trans. Roy. Soc. S. Aust., **23**, 234.
Rissoa melanura Tenison Woods 1877, Proc. Roy. Soc. Tasm., 153, not *melanura* Adams 1850.

Locs.—Tasm.: Blackmans Bay (type loc.); S. Aust.: St. Francis Island 6 and 8 fathoms, Cape Borda 55 fathoms, shell sand from MacDonnell Bay, Robe, Kingston, Venus Bay, Cape Northumberland, West Coast; Vict.: Port Fairy; W. Aust.: King George Sound.

Remarks—Distinguished by the black or purplish though translucent shell, the flatly convex whorls, obtusely angulate base and anteriorly produced aperture.

DARDANULA DUBITALIS (Tate 1899)

Rissoa dubitalis Tate 1899, Trans. Roy. Soc. S. Aust., **23**, 232.
Rissoa dubia Petterd 1884, Journ. Conch., **4**, 137, not *dubia* Defrance 1927.

Locs.—Tasm.: Tamar Heads on rocks at low water (type loc.), North Coast and Cape Pillar; S. Aust.: Cape Borda 55 fathoms, MacDonnell Bay; Vict.

Remarks—Distinguished by the bluish-brown shell, expanded aperture and white labrum.

Dardanula aurantiocincta (May 1915)

Amphithalamus aurantiocinctus May 1915, Proc. Roy. Soc. Tasm., 96, pl. vi. fig. 33.

Locs.—Tasm.: Thouin Bay 40 fathoms (type loc.).

Remarks—Distinguished by the thicker shell, more ovate mouth and the two spiral orange colour bands.

Dardanula flammea (Frauenfeld 1867)

Sabanaea flammea Frauenfeld 1867, Novara Exped., Moll., 12, pl. ii, fig. 22.
Rissoa (*Setia*) *flamia* Beddome 1883, Proc. Roy. Soc. Tasm., 169.
Rissoa beddomei Tate 1899, Trans. Roy. Soc. S. Aust., **23**, 234.
Rissoa sophiae Brazier and Henn 1894, Proc. Linn. Soc. N.S.W., **9**, 174.

Locs.—N.S.W.: Botany Bay (type loc.), Watsons Bay (type loc. *sophiae*), Little Coogee; Tasm.: Blackmans Bay 7 fathoms (type loc. *flamia*), Kelso, Tamar River, Derwent Estuary, North Coast; Vict.: Western Port, Portsea; Qld.

Remarks—Distinguished by the red axial flames.

Eusetia n. gen

Genotype: *Rissopsis expansa* Powell 1930—Mangonui Heads in 6-10 fathoms, New Zealand.

Shell small, thin, transparent and blunt at the apex; protoconch heterostrophe running into following whorls without any line or varix of demarcation, the initial whorl immersed by the volution of the succeeding whorl; whorls slightly convex, body whorl comparatively large; aperture expanded, oblique, rhomboidal, peristome discontinuous, slightly thickened, outer lip arcuate, projecting posteriorly at right angles to the body whorl, rounded basal lip expanded, columella sinuous from the formation of the inner lip.

Distribution—New Zealand, Australia, Tasmania. Fossil, Tertiary.

Remarks—This genus bears little resemblance to *Rissopsis* Garrett (genotype *Rissopsis typica* Garrett), a most peculiar species from Viti and Samoa Islands, which is a long exsert shell with constricted and abnormally narrow whorls with a tendency to oblique, twisted plications more or less obsolete. The resemblance to Australian and New Zealand species is in no way apparent, the apertures here being larger, more expanded and more reflected peristome, though discontinuous. In this genus can be placed the two Tertiary fossils *castlecliffensis* and *fricta* Finlay 1930 from New Zealand, the recent genotype from New Zealand and the Australian species here reviewed.

Key to Species of Eusetia

a. Shell moderately truncate.
  b. Shell smooth.
    c. Body whorl less than half the length of the shell ... *consobrina*
    cc. Body whorl more than half the length of the shell ... *buliminoides*
  bb. Shell spirally marked.
    d. Microscopic spirals ... *columnaria*
    dd. Fine spirals ... *maccoyi*
aa. Shell widely truncate ... *brevis*

Eusetia consobrina (Tate and May 1900)

Rissopsis consobrina Tate and May 1900, Trans. Roy. Soc. S. Aust., **24**, 101.

Locs.—Tasm.: Frederick Henry Bay (type loc.).

Remarks—Distinguished from *buliminoides* by the turreted form, rounded whorls, elongate-oval aperture and shorter body whorl.

EUSETIA BULIMINOIDES (Tate and May 1900)

Rissopsis buliminoides Tate and May 1900, Trans. Roy. Soc. S. Aust., **24**, 101.

Locs.—Tasm.: Frederick Henry Bay 10 fathoms (type loc.); S. Aust., St. Francis Island 35 fathoms.

Remarks—Distinguished from *consobrina* by the larger and longer body whorl.

EUSETIA COLUMNARIA (May 1910)

Aclis columnaria May 1910, Proc. Roy. Soc. Tasm., 18, pl. xv, fig. 27.

Locs.—Tasm.: seven miles east of Cape Pillar 100 fathoms (type loc.); Vict.: Wilson's Promontory.

Remarks—Distinguished by the convex whorls and fine spiral grooves which can be seen under 50 x magnification.

EUSETIA MACCOYI (Tenison Woods 1877)

Rissoa maccoyi Tenison Woods 1877, Proc. Roy. Soc. Tasm., 154.

Locs.—Tasm.: Blackmans Bay (type loc.), Derwent Estuary, D'Entrecasteaux Channel down to 10 fathoms; S. Aust.: Backstairs Passage 22 fathoms, Gulf St. Vincent 14 fathoms, Largs Bay shell sand; N.S.W.

Remarks—Distinguished by the spirally lirate shell.

EUSETIA BREVIS (May 1919)

Rissopsis brevis May 1919, Proc. Roy. Soc. Tasm., 63, pl. xvi, fig. 19.

Locs.—Tasm.: Thouin Bay 40 fathoms (type loc.), Arch Island, D'Entrecasteaux Channel.

Remarks—Distinguished by the very widely truncate apex, and few whorls.

EPIGRUS Hedley 1903

Epigrus Hedley 1903, Mem. Aust. Mus., **4**, 355.

Genotype: *Rissoina cylindracea* Tenison Woods 1878—N.S.W., Port Jackson 45 fathoms.

Shell tall, slender, smooth, cylindrical; aperture oblique, appressed; protoconch of one-and-a-half whorls, large, often protuberant.

Distribution—Australia, Tasmania, New Zealand, Philippines, Tongatabu. Fossil, Tertiary.

Remarks—The genus is allied to *Scrobs* but has not the separated aperture nor the elongate shaped shell of that genus.

KEY TO SPECIES OF EPIGRUS

a. No median spiral rib on the body whorl.
  b. Not microscopically spirally striate.
    c. Last whorl not uncoiled.
      d. Shell 5 mm. or more in length.
        e. Whorls five and a half .... *cylindraceus*
        ee. Whorls seven .... *borda*
      dd. Shell 4 mm. or less.
        f. Length 4 mm. .... *dissimilis*
        ff. Length under 2 mm. .... *badius*
    cc. Last whorl uncoiled .... *protractus*
  bb. Microscopically striate .... *xanthias*
aa. With a median spiral rib on the body whorl .... *semicinctus*

EPIGRUS CYLINDRACEUS (Tenison Woods 1878)

Rissoina cylindraceus Tenison Woods 1878, Proc. Linn. Soc. N.S.W., **2**, 266.

Rissoa ischna Tate 1899, Trans. Roy Soc. S. Aust., **23**, 233, *nom. mut.*, not *Rissoa cylindracea* Krynicki 1837.

Rissoa (Amphithalamus) simsoni Tate and May 1900, Trans. Roy. Soc. S. Aust., **24**, 100, pl. xxvi, fig. 76.

Locs.—N.S.W.: Port Jackson 45 fathoms (type loc.); Tasm.: Derwent Estuary, South and East 10 fathoms; Vict.

Remarks—Distinguished by its comparatively large size, cylindrical shape, and from *borda* by the fewer whorls, five-and-a-half in *cylindraceus* and seven in *borda*.

Epigrus borda n. sp

(Pl. xvi, fig. 10)

Holotype: Reg. No. D.14193, South Australian Museum.

Shell cylindrical, strong, shining, white; whorls seven, flatly convex, sculpture of microscopic oblique striae; suture linear; aperture oval, peristome continuous, adnate to the parietal wall. Height 5 mm., diameter 1·5 mm.

Locs.—S. Aust.: Cape Borda 62 fathoms (type loc.), 55 fathoms, Cape Jaffa 90 fathoms, Neptune Island 104 fathoms, Beachport 40, 130, 150, 200 fathoms; W. Aust.: King George Sound, Hopetown, Cottesloe (Henn.)?

Remarks—Distinguished from *cylindraceus* by the more numerous whorls, seven instead of five-and-a-half, and there is no contraction of the body whorl, the callus at the posterior angle of the aperture is not so large and triangular, and the basal margin is not so effuse, the aperture itself is smaller. It is larger, wider and has a more contracted mouth than *dissimilis*. Its main peculiarity is the tendency to have a constricted narrow spiral area below the suture in earlier whorls becoming obsolete on the body whorl. This is probably the specific name of the specimens recorded by Henn. from Cottesloe as "*ischnus*."

EPIGRUS DISSIMILIS (Watson 1886)

Eulima dissimilis Watson 1886, Challenger, Zool., **15**, 522, pl. xxxvii, fig. 5.

Locs.—N.S.W.: Port Jackson 2 to 10 fathoms (type loc.); Tasm.: North Coast; S. Aust.: Beachport 40 fathoms, Investigator Straits 22 fathoms, Cape Borda 55 fathoms, St. Francis Island 6, 15, 20 and 35 fathoms, shell sand Fowler Bay; Vict.: Port Fairy; Qld.

Remarks—The shell is smaller than *cylindraceus* and *borda* and the aperture is wider but less high.

EPIGRUS BADIUS (Petterd 1884)

Rissoa badia Petterd 1884, Journ. Conch., **4**, 138.

Rissoa verconis Tate 1899, Trans. Roy. Soc. S. Aust., **23**, 233.

Locs.—Tasm.: North Coast (type loc.), Islands Bass Straits, Southern Bays down to 10 fathoms; Vict.: Western Port; S. Aust.: Backstairs Passage dredged 10 fathoms; N.S.W.; Qld.

Remarks—Distinguished by its small size, being under 2 mm. in length.

EPIGRUS PROTRACTUS Hedley 1904

Epigrus protractus Hedley 1904, Proc. Linn. Soc. N.S.W., **29**, 185, pl. viii, fig. 8 to 11.

Locs.—N.S.W.: Chinamans Beach, Middle Harbour (type loc.).

Remarks—The shell is small, only 1·3 mm. in length, and is remarkable in that the last whorl is uncoiled. It is not a monstrosity, as several specimens were taken by Hedley at the type locality.

Epigrus xanthias (Watson 1886)

Mucronalia xanthias Watson 1886, Challenger, Zool., **15**, 523, pl. xxxvii, fig. 8.

Locs.—Tongatabu 18 fathoms (type loc.); Philippines 10 to 20 fathoms; Qld.: Wednesday Island, Cape York, North East Australia 8 fathoms.

Remarks—Distinguished by the elongate and narrow shell and spiral microscopic striae.

Epigrus semicinctus May 1915

Epigrus semicinctus May 1915, Proc. Roy. Soc. Tasm., 96, pl. vii, fig. 36.

Locs.—Tasm.: Thouin Bay 40 fathoms; N.S.W.; S. Aust.: Beachport 40 fathoms.

Remarks—Distinguished by the strong, median keel which develops on the body whorl and extends to the lip; there is another small keel on the base. Otherwise somewhat like *badius*.

Scrobs Watson 1886

Scrobs Watson 1886, Challenger, Zool., **15**, 611.
Genotype: *Rissoa* (*Scrobs*) *scrobiculator* Watson 1886—Port Jackson, N.S.W.

Shell small, strong, lustrous; protoconch roundly and bluntly pointed, sculptured with microscopic stipplings arranged in spiral rows; aperture gibbously round, almost transverse to the axis, encircled by a broad furrow which lies between the outer and inner edge of the continuous peristome; inner lip almost horizontal, crossing the entire front of the body, so as to leave no pillar at all, separated from the body by a level shelf; in this shelf is the circumoral furrow, which widens into a small triangular depression at the intersection of the outer lip.

Distribution—Australia, New Zealand, Tasmania.

Remarks—Distinguished by the mouth separated from the body whorl.

Key to Species of Scrobs

a. Elongate and narrow.	
b. Obovate	*scrobiculator*
bb. Tapered.	
c. Body whorl roundly obtusely angulate	*pyramidata*
cc. Body whorl not roundly obtusely angulate.	
dd. About 2 mm. in length	*petterdi*
d. About 1 mm. in length	*pellyae*
aa. Ovate.	
e. Smooth.	
f. Widely umbilicate	*jacksoni*
ff. Narrowly umbilicate.	
g. A light colour band below the suture	*luteofuscus*
gg. Two bands of pale orange	*capricorneus*
ee. Sculptured.	
h. Axial costae	*costatus*

Scrobs scrobiculator (Watson 1886)

Rissoa scrobiculator Watson 1886, Challenger, Zool., **15**, 611, pl. xlvi, fig. 4.

Remarks—This type species of the genus is of a peculiar pupoid or obovate shape, though it resembles the other Australian and New Zealand species in apertural characters.

SCROBS PYRAMIDATA Hedley 1903

Scrobs pyramidata Hedley 1903, Mem. Aust. Mus., **4**, 354, fig. 77.

Locs.—N.S.W.: Wata Mooli 54 to 59 fathoms (type loc.), Botany 50 to 59 fathoms, Port Hacking 22 to 38 fathoms; Vict.: Ninety Mile Beach 40 fathoms.

Remarks—Distinguished by the roundly obtuse angulation of the body whorl, and the conical shape.

SCROBS PETTERDI (Brazier 1895)

Rissoia (*Amphithalamus*) *petterdi* Brazier 1895, Proc. Linn. Soc. N.S.W., **19**, 697.

Rissoa pulchella Petterd 1884, Journ. Conch., 138, not *pulchella* Risso 1836, Philippi 1836.

Locs.—Tasm.: North Coast and Islands in Bass Straits (type loc.), all round the coast from beach to 4 fathoms; N.S.W.: Botany Bay, Port Jackson; Vict.

Remarks—This minute species is smooth except for the faint growth lines. It is brown-coloured and narrowly umbilicate, narrow in shape and has a prominent aperture and long body whorl.

SCROBS PELLYAE (Nevill 1881)

Rissoa (*Ceratia*) *pellyae* Nevill 1881, Journ. Asiatic Soc. Bengal, **1**, pt. ii, 165.

Locs.—S. Aust.: in sand from near Adelaide (type loc.), Cape Northumberland, Robe, Fowler Bay, Venus Bay, Henley Beach, Glenelg, all in shell sand. Cape Borda 55 fathoms; W. Aust.: Geraldton ? (Verco).

Remarks—The specimens here recorded, and figured for the first time, are in all probability of the species described by Nevill but not listed from anywhere else but South Australia, and not referred to by subsequent workers. It in some ways resembles *petterdi* but is easily distinguished by the extra whorl and a tendency for the aperture to be well separated from the body whorl, even projecting, and by the strong and continuous peristome. Features referred to in the original description are characteristic of our specimens and are here pointed out. Smooth, polished, shining, of a rich chestnut brown colour; spire shortly and ventricosely conical, suture distinct, apex exceedingly obtuse; whorls three-and-a-half, very convex, last whorl produced, regularly ovate, about two-thirds the size of the whole shell, brought forward at the aperture in a highly characteristic manner. The following variations may be noticed in South Australian specimens:

1 Rather smaller, marked inner lip somewhat projecting; apex less blunt; shell more conical and less cylindrical; whorls less convex.

2 Like the previous variety but with a simple mouth, in which the lip is thinner and little separated from the base of the last whorl.

3 Same length, but narrower than the second variety; more cylindrical and with rounder whorls.

SCROBS JACKSONI (Brazier 1895)

Rissoia (*Amphithalamus*) *jacksoni* Brazier 1895, Proc. Linn. Soc. N.S.W., **19**, 695.

Rissoa (*Scrobs*) *badia* Watson 1886. Challenger, Zool., **15**, 612, pl. xlvi, fig. 3, not *Rissoa badia* Petterd 1884.

Locs.—N.S.W.: Sow and Pigs Port Jackson 4 fathoms (type loc.), Port Jackson 2 to 10 fathoms (type loc. *badia*); Tasm.: Pilot Station 10 fathoms, Thouin Bay 40 fathoms; Vict.; S. Aust.: Beachport 40 fathoms, Cape Borda 66 fathoms, Gulf St. Vincent 14 fathoms.

Remarks—Distinguished from *scrobiculator* by the more conical-ovate shell and the more delicate stippling of the protoconch. It is rare in South Australia.

SCROBS LUTEOFUSCUS (May 1919)

Amphithalamus luteofuscus May 1919, Proc. Roy. Soc. Tasm., 63, pl. xvi, fig. 17.

Loc.—Tasm.: Kelso near Tamar Heads (type loc.).

Remarks—Its nearest ally is *jacksoni* but it is more narrowly umbilicate, has a comparatively wider mouth, and a distinctive colour pattern of a light band below the suture on a lustrous red-brown ground colour.

SCROBS CAPRICORNEUS (Hedley 1907)

Amphithalamus capricorneus Hedley 1907, Proc. Linn Soc. N.S.W., 32, 495, pl. xvii, fig. 22.

Loc.—Qld.: Mast Head Reef 17 to 20 fathoms (type loc.).

Remarks—Distinguished by the rich golden colour of the earlier whorls and the two bands of pale orange on the body and later whorls, which are characteristic of this minute shell.

SCROBS COSTATUS (Hedley 1911)

Amphithalamus costatus Hedley 1911, Zool. Res. Endeavour, 1, 104, pl. xix, fig. 244

Locs.—S. Aust.: 40 miles south of Cape Wiles 100 fathoms (type loc.). Beachport 110 fathoms, St. Francis Island 15, 20, 35 fathoms, Gulf St. Vincent 14 fathoms, Cape Borda 62 fathoms.

Remarks—Distinguished by the flat axial ribs. The species was known hitherto only from the type locality.

NOTOSCROBS Powell 1927

Notoscrobs Powell 1927, Trans. New Zealand Inst., 57, 547.
Genotype: *Notoscrobs ornata* Powell 1927—New Zealand.

Shell solid, conical; protoconch dome-shaped of one-and-a-half whorls, sculptured with about twelve spiral rows of round shallow pits which, as they do not also form vertical rows produce a honeycomb effect, adult whorls with plain spiral keels, the uppermost crossed by axial ribs; aperture not separated from body-whorl, peristome continuous, duplicated, inner margin smooth and narrow surrounded by a broad flattened area, widest above and on the parietal wall.

Distribution—New Zealand and Tasmania.

NOTOSCROBS TRIANGULUS (May 1915)

Amphithalamus triangulus May 1915, Pro. Roy. Soc. Tasm., 95, pl. vi, fig. 32.

Loc.—Tasm.: Thouin Bay 40 fathoms (type loc.).

Remarks—Distinguished by the sculpture. There are two New Zealand species, *ornata* and *crosa*.

ANABATHRON Frauenfeld 1867

Anabathron Frauenfeld 1867, Novara Exped., Moll., 13.
Genotype: *Anabathron contabulata* Frauenfeld 1867—Botany Bay, N.S.W.

Shell scalariform, with a carinated shoulder, imperforate, smooth, aperture rounded, peristome continuous; protoconch spirally striate.

Distribution—Australia and Tasmania.

Remarks—Distinguished by the scalariform shell.

KEY TO SPECIES OF ANABATHRON

a. No axial plicae.
 bb. Later whorls not uncoiled.
  c. Spiral keel not massive . . . . *contabulatum*
  cc. Spiral keel massive . . . . *ascensum*
 bb. Later whorls uncoiled . . . . *contortum*
aa. With axial plicae . . . . *emblematicum*

ANABATHRON CONTABULATUM Frauenfeld 1867

Anabathron contabulatum Frauenfeld 1867, Novara Exped., Moll., 13, pl. ii, fig. 20a.

Anabathron contabulatum lene Hedley 1918, Proc. Linn. Soc. N.S.W., **26**, supp., 53, fig. by Frauenfeld *op. cit.* fig. 20b.

Locs.—N.S.W.: Botany Bay (type loc. *contabulatum* and *lene*); Vict.; Tasm.: North Coast shallow water to 50 fathoms, Frederick Henry Bay, Penguin; S. Aust.: Fowlers Bay, Robe, St. Francis Island; W. Aust.: King George Sound; Qld.

Remarks—Remarkable for the development of the sharp spiral keel at the angle of the whorls, giving the shell a scalate appearance. The slightly wider, more swollen variety "*lene*" is more common in South Australia than the typical form.

ANABATHRON ASCENSUM Hedley 1907

Anabathron ascensum Hedley 1907, Proc. Linn. Soc. N.S.W., **32**, (3), 496.

Locs.—Qld.: Mast Head Reef, Capricorn Group (type loc.).

Remarks—Distinguished by the massive spiral keel, second keel on the base, first appearing as a thread above the suture of the last whorl, the fine microscopic striae over-running the whole surface, and the aperture surrounded by a broad and thick varix.

ANABATHRON CONTORTUM Hedley 1907

Anabathron contortum Hedley 1907, Proc. Linn. Soc. N.S.W., **32**, (3), 496.

Locs.—Qld.: Mast Head Reef, Capricorn Group (type loc.).

Remarks—Remarkable in that the last whorl is uncoiled.

ANABATHRON EMBLEMATICUM (Hedley 1906)

Rissoa emblematicum Hedley 1906, Proc. Linn. Soc. N.S.W., **30**, 526, pl. xxxii, fig. 24.

Loc.—N.S.W.: Manly Beach (type loc.).

Remarks—Distinguished by the axial plicae. A specimen from St. Francis Island, South Australia, approaches this species but it is doubtful whether it is this species or a new one. More material is required before it can be decided.

COENACULUM Iredale 1924

Coenaculum Iredale 1924, Proc. Linn. Soc. N.S.W., **49**, 244.

Parascala Cotton and Godfrey 1931, S. Aust. Nat., **13**, (1), 7. Same genotype.

Genotype: *Scalaria (Acrilla) minutula* Tate and May 1900—Tasmania.

Shell minute, thick, cylindroid-turreted, very elongate, suture linear, bounded anteriorly by a spiral thread; sculptured by slender slightly oblique ribs numbering 15 on the penultimate whorl, and somewhat bent at the angulation of the whorls; the interspaces as wide and smooth; protoconch of a four carinated whorl which is convex and wide, and of a small hemispheric tip.

Remarks—This peculiar shell may be distinguished by its protoconch of one whorl and a tip and by its very elongate and narrow shell. Thiele places *Coenaculum*, with a query, as a section of the genus *Aclis* Loven 1846 in the family Aclidae.

COENACULUM MINUTULUM (Tate and May 1900)

Scalaria (Acrilla) minutula Tate and May 1900, Proc. Roy. Soc. S. Aust., **24,** 95.

Locs.—Tasm.: North Coast; N.S.W.: dead in shell sand and alive in dredgings from 20 to 22 fathoms Twofold Bay; S. Aust.: shell sand Gulf St. Vincent, Robe, Arno Bay; Vict.: shell sand Western Port.

Remarks—Readily recognised by its elongate form, peculiar sculpture and protoconch, this shell seems to be fairly widely distributed in shell sand along our coasts.

ATTENUATA Hedley 1918

Attenuata Hedley 1918, Journ. Roy. Soc. N.S.W., **41,** (supplement) 52.

Genotype: *Rissoa integella* Hedley 1904—16 miles east of Wollongong, 100 fathoms.

Shell elongate and slender; sculpture of sharp spiral keels which multiply from three on the first to eight on the body whorl; interstices latticed with faint lines and microscopic spiral scratches; aperture subcircular, outer lip bearing a rather strong varix, inner lip reflected over an umbilical furrow; protoconch globose, spirally grooved, of one rounded whorl constricted at the suture.

Distribution—New South Wales.

Remarks—Distinguished from *Coenaculum* by the dominant spiral sculpture of the shell. The protoconch suggests close affinity with that genus.

ATTENUATA INTEGELLA (Hedley 1904)

Rissoa integella Hedley 1904, Proc. Linn. Soc. N.S.W., **29,** 185, pl. ix, fig. 20.

Locs.—N.S.W.: 16 miles east of Wollongong 100 fathoms (type loc.).

Remarks—The elongate, narrow shell and peculiar spiral sculpture distinguish the species.

SUMMARY

Seventeen genera and 103 species of recent Rissoidae are recorded in this revision of the Australian members of the family. This does not include those genera sometimes placed in Rissoidae but here regarded as Rissoinidae, namely, *Rissoina, Rissolina, Stiva* in Australia, and *Nozeba* in New Zealand, all separated from typical Rissoidae by the semilunar, anteriorly effuse or channelled aperture. By comparison, it may be noted that the recent New Zealand fauna contains 29 genera and 131 species. Fourteen genera are common to both Australia and New Zealand. Two new genera and ten new species are described as listed below. The more important localities are mentioned to show the distribution in the various States, and many new southern Australian localities are here recorded for the first time.

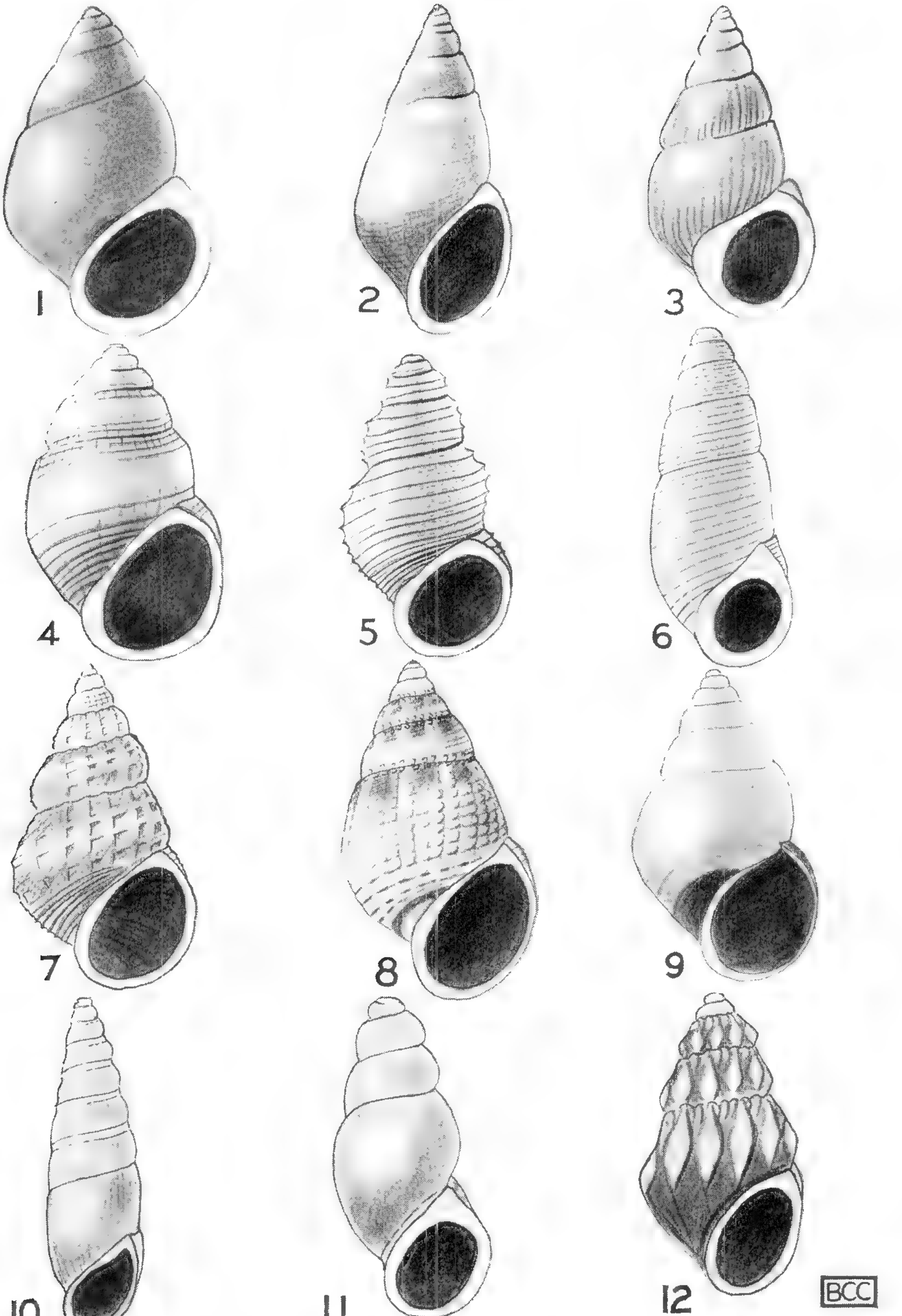
NEW GENERA

Subestea n. gen., genotype *Alvania seminodosa* May 1915.
Eusetia n. gen., genotype *Rissopsis expansa* Powell 1930.

New Species

Estea erma n. sp., South Australia, Cape Borda 62 fathoms.
Estea amblycorymba n. sp., South Australia, Gulf St. Vincent, 14 fathoms.
Estea relata n. sp., South Australia, Gulf, St. Vincent 14 fathoms.
Haurakia mediolaevis n. sp., South Australia, Cape Jaffa 300 fathoms.
Lironoba sulcata n. sp., South Australia, Cape Borda 62 fathoms.
Botelloides borda n. sp., South Australia, Cape Borda 55 fathoms.
Merelina cyrta n. sp., Western Australia, King George Sound.
Linemera occidua n. sp., Western Australia, Hopetown.
Notosetia muratensis n. sp., South Australia, Murat Bay.
Epigrus borda n. sp., South Australia, Cape Borda, 62 fathoms.

Index to Species and Genera



1 *Estea crma* n. sp., holotype, x 42
2 *Estea amblycorymba* n. sp., holotype, x 24
3 *Estea relata* n. sp., holotype, x 17
4 *Haurakia mediolaevis* n. sp., holotype, x 19
5 *Lironoba sulcata* n. sp., holotype, x 15
6 *Botelloides borda* n. sp., holotype, x 13
7 *Merelina cyrta* n. sp., holotype, x 20
8 *Linemera occidua* n. sp., holotype, x 27
9 *Notosetia muratensis* n. sp., holotype, x 32
0 *Epigrus borda* n. sp., holotype, x 10
11 *Scrobs pellyae* Nevill, x 24
12 *Subestea flindersi* Tenison Woods, x 12

THE DISTRIBUTION OF PLAGUES OF AUSTROICETES CRUCIATA SAUSS. (ACRIDIDAE) IN AUSTRALIA IN RELATION TO CLIMATE, VEGETATION AND SOIL

By H. G. ANDREWARTHA
Waite Agricultural Research Institute. University of Adelaide

Summary

The small plague grasshopper, *Austroicetes cruiata* Sauss, has only one generation in a year. This is ensured by the occurrence of an obligate diapause in the egg-stage (Andrewartha 1943, 1944). In eastern Australia egg-laying begins early in November and continues for about five weeks. Within a few days of being laid the eggs enter a stale of diapause which continues during the summer and is finally eliminated during June (Birch 1942). Once diapause has been eliminated the eggs are no longer resistant to drought (Birch and Andrewartha 1942). Consequently, they either hatch during the early spring or, if soil moisture is inadequate for development, they die. The date of emergence of the nymphs may vary between mid-August and late September, depending upon the temperature of the soil in which they are developing (Andrewartha 1944). The nymphs require about six weeks to complete their development; sexually mature adults usually appear towards the end of October.

THE DISTRIBUTION OF PLAGUES OF AUSTROICETES CRUCIATA SAUSS. (ACRIDIDAE) IN AUSTRALIA IN RELATION TO CLIMATE, VEGETATION AND SOIL

By H. G. Andrewartha
Waite Agricultural Research Institute, University of Adelaide

[Read 14 September 1944]

Plates XVII and XVIII

A Introduction

The small plague grasshopper, *Austroicetes cruciata* Sauss, has only one generation in a year. This is ensured by the occurrence of an obligate diapause in the egg-stage (Andrewartha 1943, 1944). In eastern Australia egg-laying begins early in November and continues for about five weeks. Within a few days of being laid the eggs enter a state of diapause which continues during the summer and is finally eliminated during June (Birch 1942). Once diapause has been eliminated the eggs are no longer resistant to drought (Birch and Andrewartha 1942). Consequently, they either hatch during the early spring or, if soil moisture is inadequate for development, they die. The date of emergence of the nymphs may vary between mid-August and late September, depending upon the temperature of the soil in which they are developing (Andrewartha 1944). The nymphs require about six weeks to complete their development; sexually mature adults usually appear towards the end of October.

The life cycle of the species in Western Australia is essentially similar, except that the season is some four to six weeks earlier than in eastern Australia. Thus nymphs may hatch in July and egg-laying may begin late in September. Diapause may be eliminated from the eggs earlier than it is in eastern Australia (Jenkins 1937).

The occurrence of diapause in the egg-stage is a valuable adaptation, since it ensures that the active stages of the grasshopper will not be present during the summer when there would be no food for them, or during the winter when temperature would be too low for satisfactory development. Diapause also limits the distribution of the species, preventing it from colonising areas in which the temperature during the winter is too high to eliminate diapause, or areas in which the rainfall in the spring is unreliable.

Plagues of *A. cruciata* have been recorded from Western Australia (Jenkins 1937), South Australia (Andrewartha 1939), and New South Wales (Key 1938); plagues occur in well-defined areas which are situated on the borders of the wheat belts in those States (text fig. 2 C and 4 B). These areas are not continuous; those in Western and South Australia are separated by a vast area in which the species is not known to occur, even as solitary individuals. The infestation area in South Australia is separated from the infestation area in New South Wales by a large region in which solitary individuals of *A. cruciata* occur, but from which swarms have either not been recorded, or else have occurred rarely in restricted local situations (text fig. 1). It will be shown in this paper that the region which separates the infestation areas in Western and South Australia experiences a climate which is unfavourable for the survival of *A. cruciata*. On the other hand, the region separating the infestation areas in South Australia and New South Wales experiences essentially the same climate as these two infestation areas, but in this case the nature of the soil and vegetation inhibits the widespread development of swarms.

B Influence of Climate

The influence of rainfall is more important than that of temperature in limiting the distribution of plagues of *A. cruciata* in southern Australia. For example, in South Australia records of minimum temperature for the winter period indicate that temperatures adequate for the elimination of diapause occur widely, both to the north and the south of the area in which plagues of *A. cruciata* occur. Similarly, records of maximum temperatures(1) for the spring period indicate that temperatures adequate for the development of the active stages are not

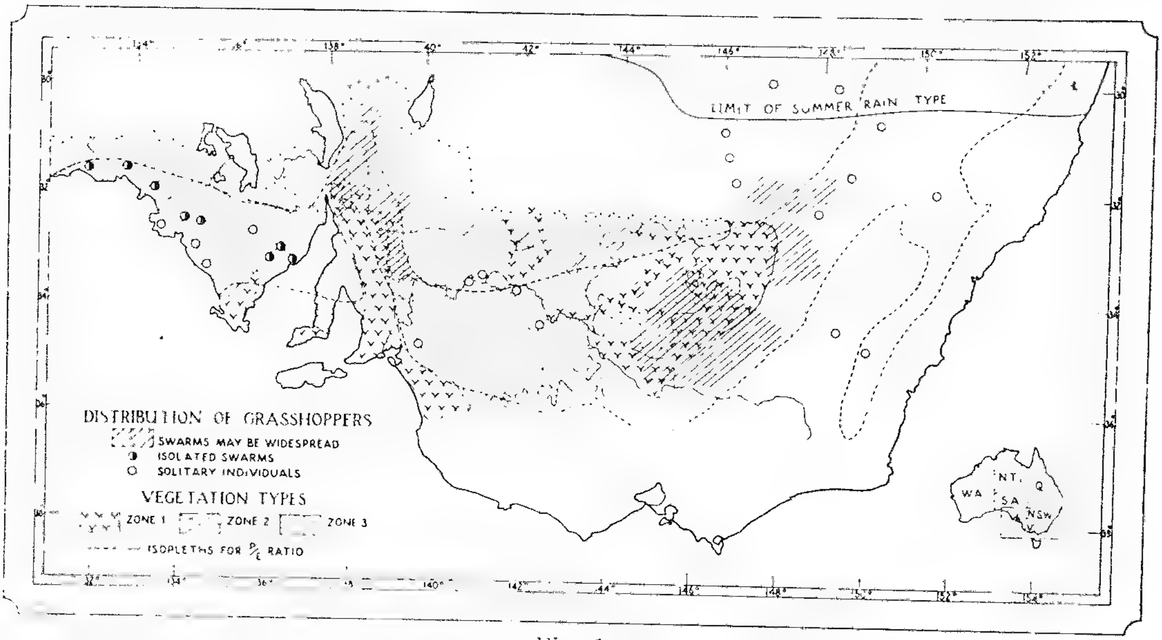


Fig. 1

Part of south-eastern Australia, showing: (a) The zone of favourable climate for *A. cruciata* as indicated by isopleths for P/E ratio. The northern boundary is the isopleth for P/E ratio for October = 0·25, and the southern boundary is the isopleth for P/E ratio for September = 1·0. (b) The distribution of soil favourable to *A. cruciata* as indicated by the distribution of vegetation types. (c) The areas commonly infested by swarms of *A. cruciata*.

restricted to the infestation area for *A. cruciata*. In Western Australia the infestation area experiences minimum temperatures during the winter which are higher than those recorded for the infestation areas in South Australia and New South Wales, but in Western Australia a geographical race of *A. cruciata*, which requires higher temperatures for the elimination of diapause has developed (Andrewartha 1944). So in Western Australia and New South Wales, as in South Australia, temperatures favourable for the elimination of diapause and the development of the active stages occur over a much wider area than that actually infested by swarms of *A. cruciata*, which are restricted by their moisture requirements.

(1) Maximum temperature is a better criterion than mean temperature for making comparisons involving the influence of temperature upon rate of development (Andrewartha 1944 a).

The active stages of *A. cruciata* are present during July to October in Western Australia, and August to November in eastern Australia; and drought during this period may prove critical in limiting the distribution of the species towards the drier parts of Australia. It has been shown that occasional droughts during this critical period are important in limiting the numbers of *A. cruciata* in the infestation areas (Froggatt 1909, Birch and Andrewartha 1941).

The effectiveness of rainfall in promoting the development of plants and animals can be satisfactorily measured by the ratio of rainfall to evaporation; in particular the conception has been developed of a "season" defined by the number of months in the year during which this ratio exceeds 0·5 (Davidson 1936). In southern Australia the season of adequate moisture occurs during the winter. The number of months during which the ratio P/E exceeds 0·5 decreases as the distance inland increases. Consequently, it is to be expected that an isopleth for P/E ratio may be found which may serve to define the limits of the infestation area for *A. cruciata* on its drier side.

The distribution of swarms of *A. cruciata* is known best for South Australia. Consequently, the infestation area for this State was plotted on a map together with isopleths for various values of P/E ratio, calculated from the records for mean monthly rainfall, temperature and relative humidity by methods described elsewhere (Andrewartha 1940). It was found that the isopleth for P/E = 0·25 for October closely followed the boundary of the infestation area (text fig. 1). Other isopleths (*e.g.*, P/E = 0·13 for November) fitted nearly as well. But the former was chosen because it was the best of those tried. It is to be expected that isopleths for different values of P/E ratio for adjacent months should be parallel since there was a high correlation between rainfall, or evaporation, for adjacent months for the stations used in this analysis. The value P/E = 0·25 for October might reasonably have been expected to provide a useful criterion since: (a) Any zone for which the P/E ratio for October exceeded 0·25 would have a higher ratio (probably in excess of 0·5) for June, July, August and September, thus ensuring adequate growth of the annual and herbaceous perennial plants upon which *A. cruciata* feeds; (b) Most of these plants are drought-resistant and require less rain to keep them alive and green than is necessary for active growth. Speargrass (*Stipa* spp.) is particularly adapted to make use of small falls of rain (Birch and Andrewartha 1941).

The isopleth for P/E ratio for October = 0·25 was plotted on a map showing the infestation area in New South Wales.[2] For Western Australia the isopleth P/E for September = 0·25 was used since the season for *A. cruciata* is about four weeks earlier there than in eastern Australia. The isopleths were copied from unpublished maps prepared by Professor J. Davidson, using the methods which he has described (Davidson 1935). The infestation areas in both New South Wales and Western Australia fall, for the most part, inside the climatic zone, of which the boundary on the drier side is defined by this isopleth for P/E ratio (text fig. 1 and 2).

The infestation areas for *A. cruciata* do not extend into the more humid zones nearer the coast. The way in which climate inhibits the development of swarms of *A. cruciata* in these humid zones has not been demonstrated by specific

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[2] The infestation area for New South Wales was taken from maps kindly loaned to me by Dr. K. H. L. Key, who had compiled them in co-operation with the officers of the Pasture Protection Boards of New South Wales (Key 1938). The infestation area for Western Australia was taken from maps kindly loaned to me by Mr. C. F. H. Jenkins, who had compiled them in collaboration with officers of the Agricultural Bank of Western Australia. They covered the period 1935-1941 and gave detailed information on the occurrence of plagues of *A. cruciata* on each farm-holding.

observations. But it is likely that most importance should be attributed to the influence of periods of high rainfall and atmospheric humidity, which create an environment favourable for the development of bacterial and fungal parasites of the grasshoppers. Parker (1930) has quoted several examples where mass destruction of nymphs was brought about in this way. He concludes that wet weather lasting for about five days may initiate an epidemic of fungal and bacterial parasites. Continuous high atmospheric humidity appears to be more important than the amount of rainfall, or the prevailing temperature. Epidemics have occurred at widely different temperatures. In one of the examples quoted by Parker the prevailing maximum temperatures were of the order 70°-80° F., and the minimum temperatures 40°-60° F. In another example the prevailing maximum temperatures were of the order 50°-60° F., and the minimum temperatures 30°-40° F. The latter temperatures are of the same order as those experienced in the infestation areas for *A. cruciata* during the time when the nymphs are present.

The destruction of *A. cruciata* in this way has not been observed; but the expansion and contraction of the area in Western Australia infested by swarms

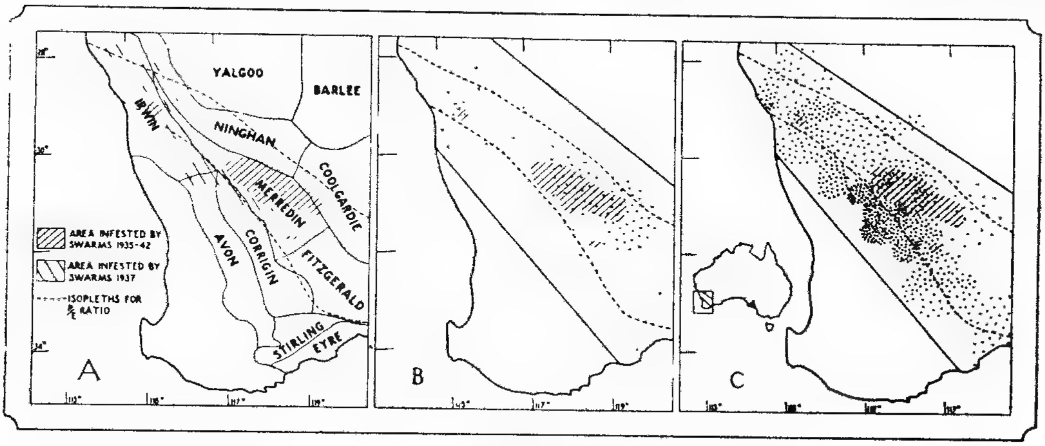

Fig. 2

Part of West Australia A, showing: (a) The zone of favourable climate for *A. cruciata* as indicated by isopleths for P/E ratio. (b) The areas infested by plagues of *A. cruciata* during the period 1935-42. (c) "Soil and ecological regions" (after Teakle). B, showing the distribution of "reverted" arable land in the area where climate favours *A. cruciata*. Each dot represents 5,000 acres. C, showing the distribution of arable land in the same area. Each dot represents 10,000 acres.

during the period 1936-1938 may provide indirect evidence that such an event occurred in 1938 (text fig. 2 and 3). From text fig. 2 it is clear that in 1937 widespread swarms were present in an area normally not infested; isolated swarms occurred over an even wider area than that shown on the map. Since *A. cruciata* is not strongly migratory—about 15-20 miles is the most that it travels in one generation (Jenkins 1937)—it is clear that the swarms had developed from *solitaria* in this zone. They disappeared from this area during 1938, and during this and subsequent years swarms were restricted to the normal infestation area. For 1937, and for several years preceding 1937, the rainfall in this area was below average (Jenkins 1937); in 1938 the rainfall was also below average, but July was abnormally wet. Not only was rainfall for July abnormal (P/E ratio exceeded 2·0 over most of the area which had been infested by swarms in 1937), but also rain was recorded on 10 out of the 15 days between 16-31 July. There is little doubt that this excessively humid period during the latter part of July 1938 was the principle cause for the disappearance of swarms from the area outside the normal infestation area (text fig. 3). Text fig. 3 also shows that there were no such excessively humid periods in the critical months (July-August) of 1936 or 1937, when the grasshoppers were multiplying to plague numbers.

The rainfall during earlier months of the winter (May-June) does not influence the survival of the grasshopper directly, since the egg stage is little affected by exposure to high humidity [3]; but indirectly rainfall during these months may be important since adequate rainfall at this time promotes a dense growth of grasses and other herbaceous plants and thus increases the humidity near the soil surface where the grasshoppers live. This may be a partial explanation for the relationship which Jenkins demonstrated between the increase in swarms of *A. cruciata* and the total rainfall to the end of July (Jenkins 1937).

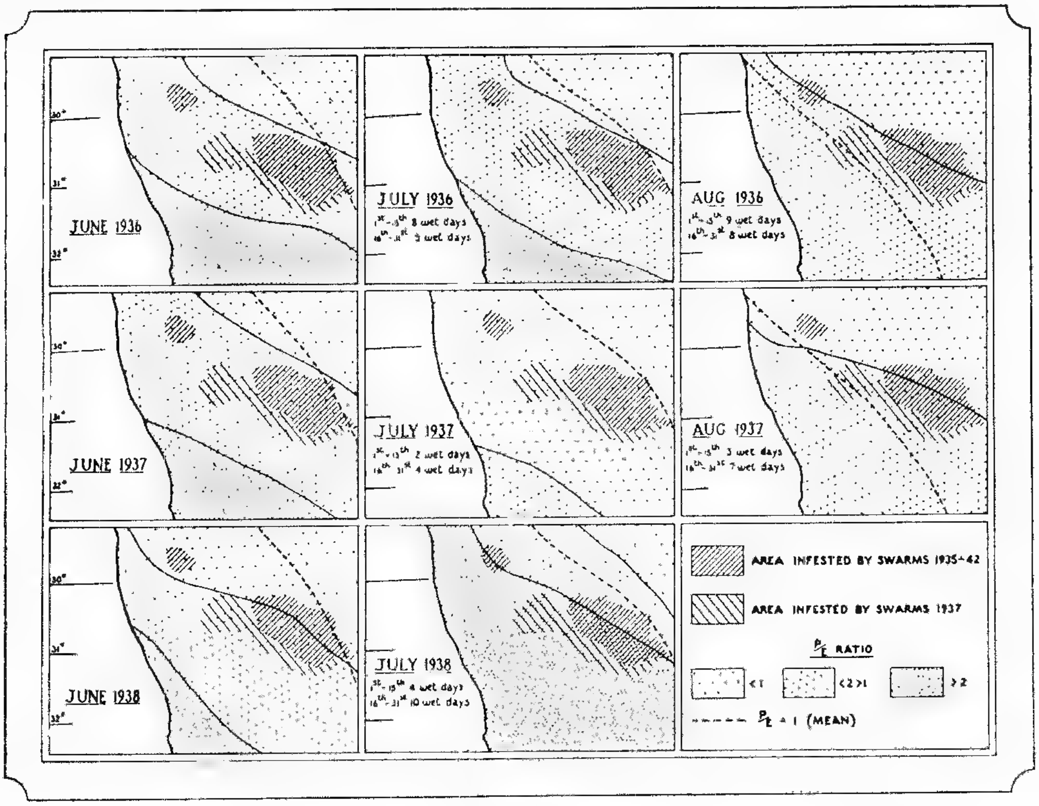

Fig. 3

Showing: (a) the area normally infested by plagues of *A. cruciata* and the abnormal distribution of plagues during 1937. (b) The value for P/E ratio for individual months. Note that values for P/E ratio for July and August were low during 1936 and 1937, and that July 1938 was abnormally humid.

The complexity of climatic factors operating to inhibit the development of swarms in the humid zones makes it difficult to find a single climatic index which may define the limits on the humid side of the climatic zone favourable for the development of *A. cruciata*. Nevertheless, it has been found practicable to use an isopleth of P/E ratio for this purpose.

The infestation area for South Australia was plotted on a map together with various isopleths for P/E ratio. It was found that the isopleth for P/E for

(3) This statement is based on unpublished experiments with the eggs of *A. cruciata* done at the Waite Institute.

September = 1·0 approximated most closely to the southern limits of the infestation area in South Australia. This isopleth was then plotted on a map of New South Wales together with the infestation area for that State. For Western Australia the isopleth of P/E for August = 1·0 was used. The isopleths were copied from maps published by Davidson (1935). It was found that the infestation areas for Western Australia and New South Wales for the most part fell inside one climatic zone defined in this way (text fig. 1 and 2 A).

This method of using P/E ratio gives only an indirect measure of the factors which it is desired to define, namely, the frequency and intensity of spells of humid weather during the time that the grasshoppers are active.[1] The success of the method depends upon the correlation between P/E ratio and the frequency and intensity of periods of humidity high enough to favour the development of fungal and bacterial parasites of the grasshopper.

The use of an isopleth for a single month (September for eastern Australia, August for Western Australia) to define the limits of the infestation areas is reasonable despite the fact that the active stages of *A. cruciata* are present for several months, because (a) there is a high correlation between the P/E ratio for adjacent months, and (b) in southern Australia there is a well-defined wet season in the winter and dry season in the summer; thus the weather becomes progressively drier as the season advances, and consequently the greater hazards from excessive humidity occur early in the season when the nymphs are still in the early stages of development. The latter condition does not hold further north, because the influence of summer rainfall becomes important (Davidson 1936).

Swarms of *A. cruciata* have not been recorded north of about Dubbo in New South Wales, although solitary individuals have been recorded from as far north as the Queensland border (Key 1938). The ecology of *A. cruciata* in these northern areas has not been studied, consequently it has been found impracticable to interpret the climatic factors inhibiting swarm formation in this zone. It is, however, quite unlikely that the same arbitrary criteria which served to delimit the favourable areas for *A. cruciata* in a winter rainfall zone will also serve in a zone where the greater part of the rain falls in the summer. The isopleths for P/E ratio = 1 for September and 0·25 for October, extend northwards into southern Queensland, but they have little significance as indicators of a favourable zone for *A. cruciata* north of about latitude 31° S, which marks the approximate southern limit of the summer rainfall type in this area (text fig. 1). (See Year-book of the Commonwealth of Australia 1940, map opposite p. 39.)

C THE INFLUENCE OF SOIL.

The females of *A. cruciata* require firm, compact soil for egg-laying. Indeed, they sometimes succeed in boring into surfaces which seem incredibly hard for this purpose; for example, they have been observed ovipositing into the surface of a metal road (Andrewartha 1939). But they do not oviposit into loose sandy soil or into soil that has been recently cultivated (Jenkins 1937, Newman 1937). This requirement restricts the distribution of *A. cruciata*. In certain parts of the zone of favourable climate, shown in text fig. 1 and 2, the development of *A. cruciata* is inhibited by the absence of suitable soil for oviposition. The soils in this zone have not been mapped in sufficient detail to be used in this study

[1] This is, of course, a very different use from that for which the conception of P/E ratio was developed, namely, to define the minimum amount of rainfall necessary to maintain soil moisture at an adequate level for the development of plants and animals. It was in this latter capacity that the ratio was used to define the limits of the infestation areas on their drier side. (See above.)

of the distribution of the grasshopper. But the distribution of vegetation types has been studied in more or less detail for all the areas with which we are concerned, and the distribution of vegetation type is related to the distribution of soil type (Prescott 1931); in this case it provides a useful guide to the occurrence of soils favourable to *A. cruciata.*

The distribution of soil and vegetation types in Western Australia has been studied by Teakle (1938). He considers that the area with which we are concerned (see text fig. 2) is a dissected plateau. The original level of the plateau is represented by high-level lateritic sandplain, which is generally about 100 to 200 feet above the level of the valley floors. The process of erosion and dissection has produced broad mature valleys which are characterised by woodland vegetation and "salt-lake" systems (pl. xvii, fig. 1).

The principal soils associated with the woodland vegetation are "mallee" soils consisting of a brown or greyish surface soil resting on a calcareous subsoil. They are all sandy loams, often shallow, with the amount of clay increasing rapidly in the deeper layers. If these soils be cultivated for a period and then allowed to remain idle for a few years, they set firm and are then suitable for oviposition by *A. cruciata.*

The loose sandy soil and the heath "scrub" vegetation which is characteristic of the high-level lateritic sandplain is shown in pl. xvii, fig. 2. The soil is infertile. It will support only poor herbage when cleared and cultivated; when arable land has been left idle for a few years the original heath vegetation tends to re-establish itself. The soils of the sandplain are unsuited to *A. cruciata*, no matter how they be treated.

The precise distribution of vegetation types in Western Australia has not been mapped. But Teakle has divided the State into a number of "soil and ecological regions." The relevant regions are shown on text fig. 2. The infestation area for *A. cruciata* is largely restricted to the Merredin region which is essentially an area of brown and red-brown woodland soils. The western part of the Fitzgerald region, which lies inside the climatic zone favourable to *A. cruciata* but into which the infestation area does not extend, has a larger proportion of sand-heath formation than any other region of the zone of grey and brown calcareous, solonised soils of the low rainfall Eucalyptus woodland (Teakle 1938).

In eastern Australia in the zone where climate is favourable for *A. cruciata*, the distribution of vegetation types has been mapped in greater detail. The distribution shown in text fig. 1 has been adapted from maps prepared by Wood (1937) and Beadle.[5] Zone 1 of text fig. 1 includes the Sclerophyl Forest and Savannah Woodland of Wood, and the Woodland, Savannah Woodland, and Savannah of Beadle. Zone 2 includes certain "Arid Communities" of Wood (namely, *Eucalyptus odorata - E. oleosa - Callitris, Cassia - Dodonea - Eremophila, Myoporum - Atriplex* and *Atriplex - Salicornia*) and the Shrub Steppe of Beadle (*i.e., Atriplex vesicarium* and *Kochia*). Zone 3 includes the Mallee (*Eucalyptus - oleosa - E. dumosa*) and Mulga (*Acacia aneura*) of Wood and the *Eucalyptus oleosa - E. dumosa* and *Casuarina - Heterodendron* zones of Beadle. The boundary of zone 3 in Victoria was taken from a map published by Hills showing the limits of the Mallee in Victoria (Hills 1939).

The vegetation types which have been grouped in zone 3 are usually associated with light soils which are loose and sandy on the surface and consequently

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(5) Mr. N. Beadle very kindly gave me a copy of a map which he had prepared showing the distribution of vegetation types in south-western New South Wales. Mr. Beadle has not yet published this map or the results of his studies in the ecology of this area.

are not favourable for *A. cruciata*. In local situations within this zone the soil may be favourable, for example in South Australia in the Mallee heavier soils may be associated with low lying areas; and in such situations *A. cruciata* may flourish. But in general the soils in zone 3 are not favourable to *A. cruciata*; swarms are less likely to develop under these conditions, and when they do develop they are restricted to local situations (text fig. 1). The vegetation types which have been grouped in zones 1 and 2 are associated with soils which, for the most part, are firm on the surface and are therefore favourable to *A. cruciata*. The boundaries of these two zones mark the limits of the area which is potentially subject to plagues of the grasshopper. At present the distribution of swarms within this area is restricted by the distribution of habitats carrying an abundance of suitable food plants.

THE INFLUENCE OF VEGETATION [6]

The most favourable food plants for *A. cruciata* are certain grasses, particularly *Hordeum murinum* L., *Schismus calycinum* L., *Stipa* spp., *Danthonia* spp., and cereals such as wheat and oats. They also feed readily on certain species of *Medicago*, *Trifolium*, *Erodium* and *Sida*, and less readily on *Echium plantagineum* L. and *Heliotropum europeum* L., which may become common in certain habitats. All these plants are either annuals or low-growing herbaceous perennials. Many are exotics; all are important because they have the ability to invade and dominate areas from which the native vegetation has been removed.

Wherever the original vegetation remains, favourable habitats for *A. cruciata* are restricted in area and widely dispersed. The undergrowth in the woodland associations in Western Australia consists largely of shrubs which are not suitable food plants for the grasshopper. Grasses are not common; they tend to occur only in local situations (Teakle 1938). Similarly, in eastern Australia favourable habitats for *A. cruciata* are not extensive in those areas where the original vegetation remains, since the indigenous trees and shrubs are not suitable food plants for the grasshopper; and grasses and low-growing annuals and herbaceous perennials are not common except in restricted situations. Clearly the presence of large areas which are favourable to the development of swarms of *A. cruciata* is causally related to the history of the utilisation of these areas since they were opened up for agriculture.

In Western Australia, in the climatic zone favourable to *A. cruciata*, the land was developed almost exclusively for wheat-growing. The heavier woodland soils were chosen; very little of the high-level sandplain was cleared. Over most of the area rainfall has proved to be too low and too unreliable for wheat-growing. Facilities for sheep-raising were not available. So, in many cases, farmers abandoned their holdings and the land was allowed to lie idle. The plants which established themselves on this idle land were mostly species which were suitable as food for the grasshopper. In the more southern parts of the area *Hordeum murinum* was the most common species, and there are vast areas in which this species occurs as an almost pure stand (pl. xvii, fig. 3); further north *Stipa* spp. become more common. These areas of "reverted" arable land are highly favourable habitats for *A. cruciata*.

The distribution of these areas of "reverted" land within the climatic belt favourable to *A. cruciata* is indicated in text fig. 2 B. The data were taken from

[6] In the preceding section the distribution of the original vegetation types, before it was modified by the activities of white settlers, was used as a guide to the distribution of soils favourable to *A. cruciata*. This section is concerned with the vegetation which occurs in these areas at present.

the Statistical Register for Western Australia. Table No. 9. The land under crops or recently cultivated was estimated for each statistical district for each year between 1928-1940. The area given for 1940 was subtracted from the area for the year in which this figure reached a maximum. The balance was considered as "reverted" arable land for the purposes of text fig. 2 B. This method (although unsatisfactory for giving an estimate of the absolute quantity of "reverted" land, since there is no guarantee that the same land is referred to each year) gives a useful guide to the distribution of "reverted" land. It is clear that plagues of *A. cruciata* tend to occur in areas where there is a lot of "reverted" land.

In eastern Australia the land was developed both for wheat-growing and for sheep-raising, the former more particularly in the more humid areas (*i.e.*, roughly zone 1 of text fig. 1), and the latter in the more arid areas. The land, which was originally developed for wheat-growing, has had much the same history as that in Western Australia. The rainfall proved inadequate for wheat-growing and wheat was gradually replaced by pasture.

A large number of grasses and other low-growing herbage plants constitute the major part of the flora of these pastures (pl. xviii, fig. 2). For example, the plants which were collected from the representative situations in the grasshopper belt of South Australia are listed below. The species marked by an asterisk were prominent; the others less common or rare. All three situations provided highly favourable habitats for *A. cruciata*. Situation A was a common near Pekina; situation B a stock route near Wilmington; and situation C a paddock near Orroroo.

SITUATION A

**Lomandra dura* Ewart
Triodia irritans R. Br.
Hordeum murinum L.
Danthonia semiannularis R. Br.
Bromus madritensis L.
Koelaria phleoides Pers.
Trifolium tomentosum L.
Medicago minima Grufb.
Echium plantagineum L.
Cryptostemma calendulaceum R. Br.
Atriplex campanulatum Benth.
Calotis hispidula F. v. M.
Convolvulus arvensis L.
Plantago varia R. Br.
Erodium botrys Bertol
Erodium cygnorum Nees
Tetragonia cremaea Ostenf.
Malva parviflora L.

SITUATION B

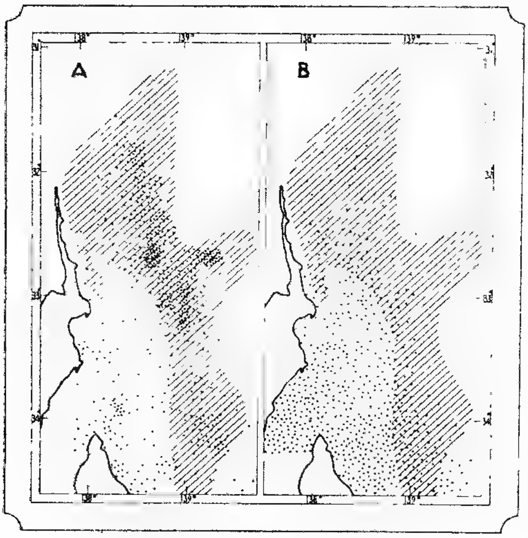
**Stipa scabra* Lindl.
**Danthonia semiannularis* R. Br.
**Hordeum murinum* L.
**Schismus barbatus* Juel
Medicago denticulata Willd.
Atriplex campanulatum Benth.
Chenopodium cristatum F. v. M.
Chenopodium album L.
Bassia patenticuspis R. H. Anders
Euphorbia Drummondii Boiss
Calotis hispidula F. v. M.
Malva parviflora L.
**Echium plantagineum* L.
Heliotropium europaeum L.
Sida sp.

SITUATION C

**Stipa scabra* Lindl.
**Danthonia semiannularis* R. Br.
**Schismus barbatus* Juel
**Hordeum murinum* L.
**Triodia irritans* R. Br.
**Erodium cygnorum* Nees
Atriplex campanulatum Benth.
Papaver hybridum L.
Spergularia diandra Heldr et Sart
**Zygophyllum crenatum* F. v. M.

In the more arid areas the tendency has been for the land to be developed for sheep-raising without first being used for wheat-growing. In some instances, particularly in South Australia, this has led to the destruction of the original vegetation and its replacement by plant communities which provide favourable habitats for the grasshopper. The general facies of the plant communities is much the same as in those communities which occur on "reverted" arable land, but the speargrasses (*Stipa* spp.) are more prominent (pl. xviii, fig. 1).

Thus in South Australia the relationship between the distribution of "reverted" arable land and the distribution of swarms of *A. cruciata* holds only for the more humid part of the infestation area. This relationship is illustrated in text fig. 4 A. The data were taken from the Statistical Register for South Australia and analysed in the same way as the data for Western Australia. Comparable data for New South Wales were not available; but Froggatt recognised as early as 1900 that it was the agricultural development taking place in the woodland areas that favoured the increase of *A. cruciata* (Froggatt 1900).



Text Fig. 4
Part of South Australia A, showing the distribution of "reverted" arable land in relation to the area normally infested by swarms of *A. cruciata*. Each dot represents 1,000 acres. B, showing the distribution of arable land in the same area. Each dot represents 5,000 acres.

Certain of the vegetation associations which occur in zone 3 of text fig. 1 provide good pasture for sheep (pl. xviii, fig. 3). And there are extensive areas in this zone, particularly in New South Wales, where the land has been developed for sheep-raising without destroying, or greatly modifying, the original vegetation. Consequently there are large areas where plagues of *A. cruciata* do not occur even though the climate and the soil are favourable. If, during the future development of these areas the original vegetation should be destroyed either by clearing or by mismanagement or overstocking of the pastures, it is likely that the same succession will occur in the vegetation here as elsewhere in the zone. And an extension may occur in the areas which are subject to plagues of the grasshopper.

Conversely the regeneration of suitable perennial shrubs in the pastures in the areas which are now subject to plagues may be followed by a reduction in the frequency and severity of these plagues. It may, at the same time, lessen the severity of soil erosion and help to stabilise the carrying capacity of the pastures in these areas. This matter has been discussed more fully elsewhere (Andrewartha 1943 a).

Summary

The distribution of plagues of *A. cruciata* in Australia is restricted, in the first place, by climate. Swarms do not develop in areas where the rainfall during the winter and spring is insufficient to keep the herbage upon which the grasshopper feeds green until the egg-laying stage has been reached. The limits of the infestation area on the dry side correspond with the isopleth of P/E ratio = 0·25 for October for eastern Australia, and for September for Western Australia.

At the other extreme, the development of plagues may be inhibited by the too frequent occurrence during the early spring when the nymphs are present, of periods of high humidity which favour the development of fungal and bacterial parasites of the grasshopper. The limits of the infestation area on the wet side correspond with the isopleth P/E ratio = 1·0 for September in eastern Australia and for August in Western Australia.

Within the zone where climate is favourable the distribution of plagues of *A. cruciata* is further restricted by the absence of the type of firm soil which the grasshopper requires for oviposition. The distribution of suitable soil has been inferred from the known distribution of vegetation types.

The distribution of swarms of *A. cruciata* is still further restricted by the absence of favourable food plants. Favourable habitats do not occur extensively in areas where the original vegetation remains because most of the indigenous trees and shrubs are not eaten by the grasshopper. Where the original vegetation has been destroyed, the land has usually been invaded by grasses and other low-growing herbage which are favourable food plants for the grasshopper. There are large areas in the zone where climate and soil are favourable where the development of the land for agricultural and pastoral uses has destroyed the original vegetation and created extensive favourable habitats for *A. cruciata.*

The establishment of suitable perennial shrubs in the pastures of the areas where plagues occur may reduce the frequency and severity of the outbreaks.

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EXPLANATION OF PLATES XVII AND XVIII

Plate XVII

Fig. 1 Characteristic woodland vegetation in the grasshopper belt of Western Australia. The trees are mostly *Eucalyptus longicornis*, the undershrubs *Melaleura pauperiflora*. Note the absence of grasses and other plants which might serve as food for the grasshoppers.

Fig. 2 Characteristic heath scrub on high-level lateritic sand-plain near Dalwallinu, Western Australia. This soil is unsuited to *A. cruciata*, no matter how it is treated.

Fig. 3 A dense growth of barley grass (*Hordeum murinum*) near Koorda, Western Australia. This is characteristic of the "reverted" arable land on the woodland soils in the grass-belt in Western Australia. It is a highly favourable habitat for *A. cruciata*.

Plate XVIII

Fig. 1 Characteristic grasshopper habitat in the more arid parts of the grasshopper belt of South Australia. This land has never been cultivated, but the original scrub vegetation has been destroyed and speargrass (*Stipa* spp.) has become dominant.

Fig. 2 Characteristic grasshopper habitat on "reverted" arable land in South Australia. The chief component of the pasture is barley grass (*Hordeum murinum*).

Fig. 3 Shrub Steppe in South Australia. The dominant plant is a saltbush (*Atriplex vesicarium*), which is good fodder for sheep, but is not suitable as food for the grasshopper.

Fig. 1

Fig. 2

Fig. 3

Fig. 1

SOME SPECIES OF THE CHAETOGNATH GENUS SPADELLA FROM NEW SOUTH WALES

By PATRICIA M. MAWSON, University of Adelaide

Summary

The Chaetognaths described in this paper were collected and recognised as belonging to an unusual group by Mr. Keith Sheard of the C.S.I.R. Fisheries Division, Cronulla. New South Wales. The present opportunity to examine them is due to his courtesy, and it is with pleasure that one of the species has been associate with his name. The material has been deposited in the South Australian Museum. Assistance from the Commonwealth Research Grant to the University of Adelaide is acknowledged.

SOME SPECIES OF THE CHAETOGNATH GENUS SPADELLA FROM NEW SOUTH WALES

By Patricia M. Mawson, University of Adelaide

[Read 14 September 1944]

The Chaetognaths described in this paper were collected and recognised as belonging to an unusual group by Mr. Keith Sheard of the C.S.I.R. Fisheries Division, Cronulla, New South Wales. The present opportunity to examine them is due to his courtesy, and it is with pleasure that one of the species has been associated with his name. The material has been deposited in the South Australian Museum. Assistance from the Commonwealth Research Grant to the University of Adelaide is acknowledged.

All specimens in the collection are apparently bottom-living forms belonging to the genus *Spadella*. They have been taken only at two trawling stations. Of the more northerly of these Mr. Sheard writes: "The Chaetognaths were taken at a depth of about 70 metres about three miles off Port Hacking on fine sand and detritus. That is the zone between the sands and the muds. Ecologically speaking, it lies between the mud zone, characterised by Pagurids of various species, and that dominated by tube-building amphipods. It represents the furthest distance seaward at which the estuarine flathead, *Platycephalus fuscus*, can be taken, and the closest point on shore at which the tiger flathead (*Neoplatycephalus macrodon*) is trawled. No algae come up from this depth." The more southerly station is off Ulladulla (140 miles south of Sydney), where the chaetognaths were taken at 100 metres (45 fathoms) on fine sand. They have not been taken from nearby stations on course sand or mud.

Most of the specimens collected have been identified as *Spadella schizoptera* Conant, but amongst them are representatives of two species apparently hitherto undescribed.

The only species belonging to this genus which has so far been recorded from Australian waters is *Sp. moretonensis* Johnston and Taylor 1919, taken from amongst algae at low tide mark in Moreton Bay, Queensland.

Many of the specimens were cleared in methyl salicylate, and it was found that this caused a considerable and most misleading shrinkage in size; a specimen measuring 5·6 mm. in length in glycerine shrank in methyl salicylate to 4·7 mm., and the tail segment taken as a percentage of the body length fell from 48% to 45%. In the case of *Sp. schizoptera* the lengths mentioned and the figures drawn below are of specimens in glycerine; in *Sp. sheardi* and *Sp. johnstoni* they are, unless otherwise stated, taken from material in methyl salicylate. In all measurements of total lengths the tail fin has been excluded.

Spadella schizoptera Conant 1895

(Fig. 1-3, 6-11, 12-16)

About twenty individuals of *Sp. schizoptera* have been examined, and a more detailed description of the species is now given.

The length of the present specimens varies from 4·1-4·9 mm., the greater number being 4·1-4·4 mm. The head is slightly wider than the body. The tail segment is about half the total body length. Of the two pairs of lateral fins the posterior are entirely on the tail segment and are closely followed by a series of five or six finger-like processes. Intestinal diverticula are not present. Ventral transverse muscles can be seen extending nearly to the anus.

There are only two rows of teeth, corresponding to the anterior rows in *Sagitta* spp.; there are three large recurved teeth in each of these rows. Behind them, ventrally (corresponding, as indicated by Yosii and Tokioka 1939, to the vestibular organ), is a pair of pads bearing numerous denticles. There are 11 pairs of jaws of a simple tapering type, without flanges or serrations. The corona lies partly on the head and partly on the body; its form is best seen in fig. 1. The

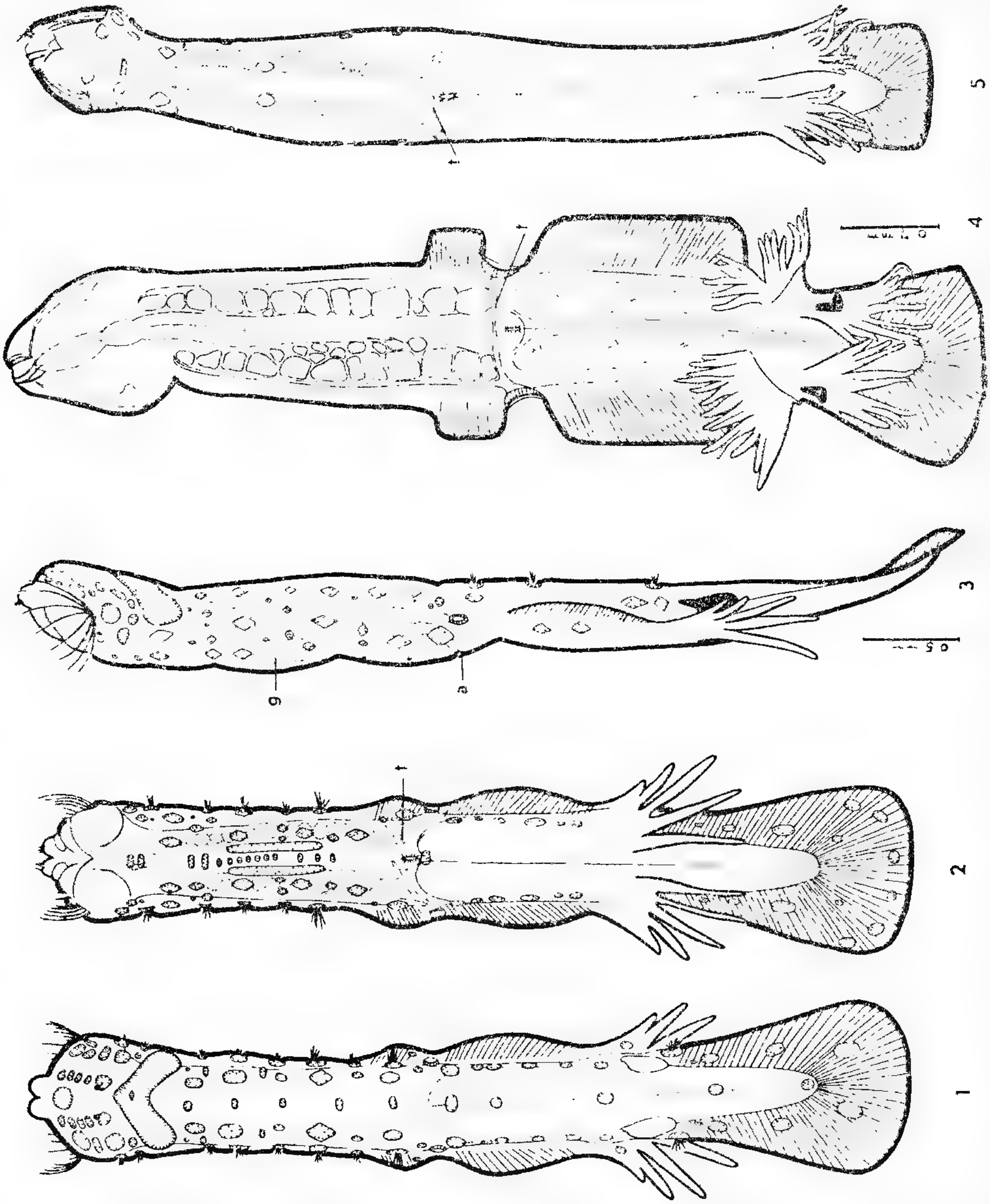

Fig. 1-3, *Sp. schizoptera:* dorsal, ventral and lateral views. Fig. 4, *Sp. sheardi,* ventral view. Fig. 5, *Sp. johnstoni,* ventral view. Fig. 1, 2, 3, and 5 to same scale. a, anus; t, transverse duct from receptaculum seminis; vg, ventral ganglion.

small eyes lie just behind the brain, and in long-preserved specimens the pigment is all but faded. Sensory patches on the body are numerous and are arranged in longitudinal and transverse rows; from most of them project relatively long hairs which arise in each patch from its midline parallel to the width of the animal (fig. 15). In sections of these patches it is seen that each is largely below the epidermis, and consists of numerous cells each with a deeply staining nucleus; many of the cells appear to be connected with the projecting hairs (fig. 14).

The brain was observed only in sections. It is joined to more posteriorly situated lateral ganglia, from which branches are to be seen leading to some of the larger sensory patches on the head; presumably there are finer branches to the smaller sensory patches. The ventral ganglion, large and very obvious in a lateral view of the animal, is hard to see in ventral view, and is apparently over-

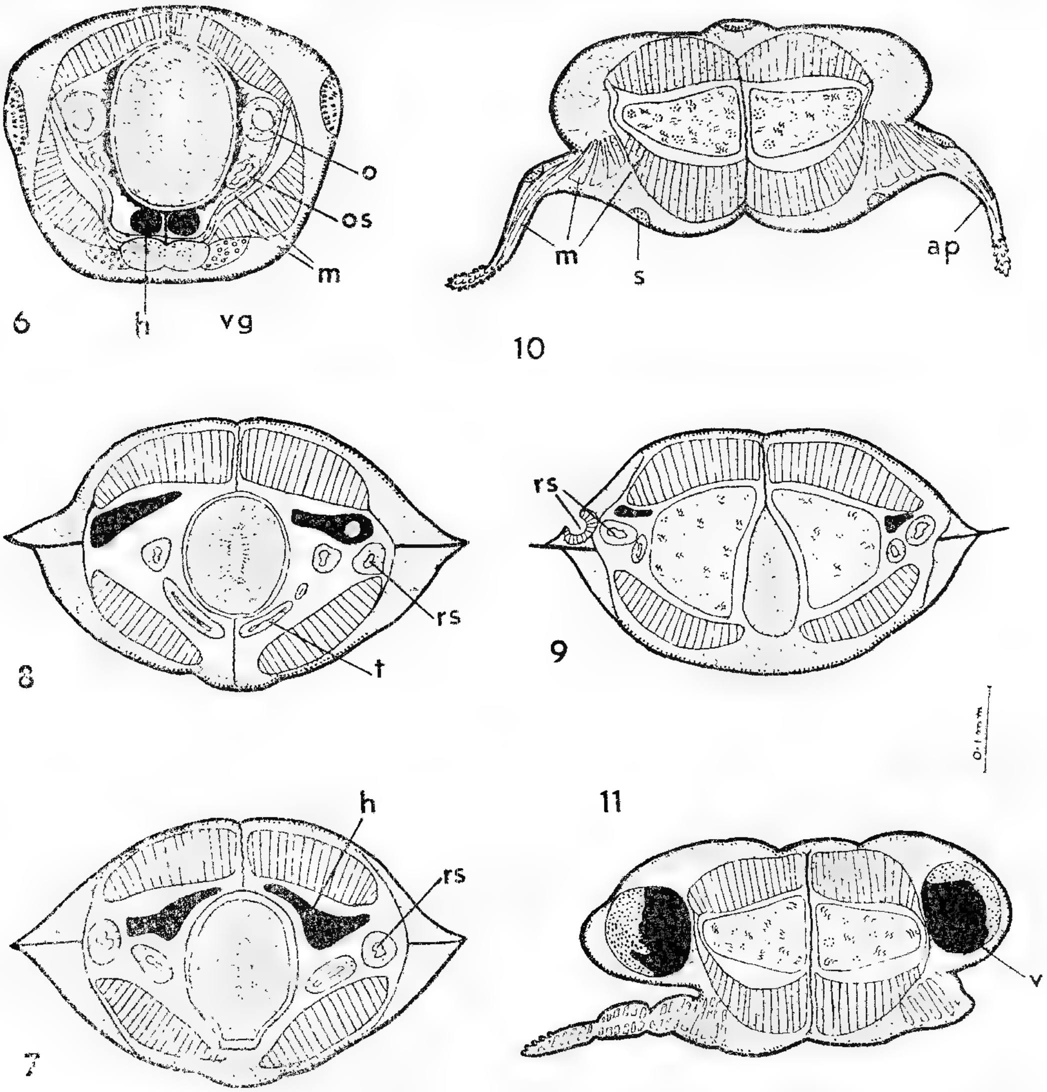

Fig. 6-11. *Sp. schizoptera:* series of transverse sections, numbered in order, 6 being the most anterior. All to same scale. Lettering as in previous figure; in addition: ap, adhesive process; h, homogeneous material; m, muscle; o, ovum; rs, receptaculum seminis; s, sensory patch; v, vesicula seminalis.

lain by numerous sensory patches as shown in fig. 2. In transverse section it is seen to consist, as described by various observers, of median nerve fibres and two lateral masses of ganglion cells.

The anterior fin is very small, about ·08 mm. wide and ·35 mm. long. Its greatest width is at or just behind the centre. Although Yosii and Tokioka in their account (1939) state that anterior fins were not present in their material, their figure indicates a slight expansion in front of the posterior fin. This expansion has a different relationship to the tail septum and to the female opening from that exhibited in our specimens. The anterior fins, as figured by Conant, are distinctly wider than in our animals, though possessing approximately a similar relation to the female opening and the tail septum.

The posterior fin follows almost immediately behind the anterior, commencing at about the beginning of the tail segment. The fin is 0·9 mm. long, and only a little wider than the anterior, and each is closely followed by a ventrally-lying flange produced into five or six finger-like processes. The most lateral of these processes is continued from the outer edge of the fin and is covered for the greater part of its length with small tubercular outgrowths. The number of processes, whether five or six, appears to depend on the degree of separation of the outermost two, these sometimes forming one stout process. As is shown in section (fig. 10, 11), these processes do not contain any fin rays, and are supplied with muscle fibres which pass obliquely from the ventral body wall; they arise from the ventrolateral, instead of the dorsolateral, part of the body. They are therefore not to be regarded as part of the fin. They are apparently mobile and used for adhesion and support (probably in the manner described below for *Sp. sheardi*), whereas the fins are balancing structures not movable separately from the body. Yosii and Tokioka (1939) figure rays passing into the processes as well as into the fins; in the Australian specimens such lines are to be seen, but prove on closer examination to be underlying muscle fibres.

The ovary in older specimens reaches almost to the neck region. Its structure had not been studied in detail. The general arrangement is as shown in fig. 6-8. Apparently on each side the ovaries lie dorsally and the ducts ventrally. On each side between the ovary and intestine, as well as occasionally between the eggs and dorsal to the ovary, is a homogeneous material showing no structure and without an enclosing wall, but connected with an accumulation of a similar substance, more definite in outline, which lies beside the ventral mesentery. This substance has the appearance of a coagulated body-fluid, and is seen in all sections from the posterior loop of the corona (anterior to the ovary) to the region behind the female opening. In fig. 6-8 it is shown for convenience in black, though it does not stain particularly deeply. Leading from each receptaculum seminis is a tube which passes ventrally below the intestine just anterior to the anus and apparently ends blindly at the mid-ventral mesentery. At about its mid-length this tube gives off a short anterior caecum (fig. 13). This corresponds to the structure described by Conant as occurring in *Sp. schizoptera;* but a median tube leading forward, formed by the junction of the two transverse tubes, was not observed in the present specimens, either in whole mounts or in section. The presence of transverse ducts from the receptaculum seminis is not a characteristic of the genus *Spadella*; they do not occur in the type species, *Sp. cephaloptera*, a detailed description of which has been published by C. C. John (1933).

Spadella schizoptera has hitherto been recorded only twice, once by Conant from three specimens captured off the Bahama Islands, and once by Yosii and Tokioka from a single specimen found with *Sp. cephaloptera* collected near Misaki, Japan.

From the figures given by these authors, and those of the present specimens, it is apparent that a variation exists in the extent of the posterior processes. Those seen by Conant and those described above are present in about the third quarter of the tail segment; those of the Japanese specimen reach from about the middle of the tail segment to a point beyond its posterior end. In view of this, and of the damaged condition of the corona and lateral fins in the Japanese material, it is impossible to say whether the latter is an aberrant individual of

Sp. schizoptera. A table in which the significant points of these records are compared will be found at the conclusion of this paper.

Spadella sheardi n. sp.

(Fig. 4, 17)

Five specimens of a closely related chaetognath were taken in company with *Sp. schizoptera* described above. They differ, however, in several significant features.

The lengths of two immature specimens are 3·9 mm. and 4·4 mm. (latter in glycerine), and those of adults ranged between 4·7-6·5 mm. They are distinguished at a glance as being larger and more thick-set than *Sp. schizoptera.* The tail segment is 44-45% of the body length when measured in methyl salicylate, and 48% when in glycerine. In life the body is opaque and faintly mauve; the dorsal surface is marked with brown pigment, which is present mainly in three longitudinal bands and two transverse bands, one at the level of the receptacula seminis and one at the level of the vesiculae seminales. In addition yellow pigment is scattered lightly over the whole body surface. The eyes are small and widely spaced, and are overlain by brown pigment. The fins are relatively wide. Posterior adhesive processes are present, arranged in two groups on each side. When the living animal is at rest in a petri dish it takes up an almost vertical position with the head uppermost, supported by the tail fin flattened out on the bottom of the dish and by the outspread adhesive processes which serve as "props" to support the body. The stance is reminiscent of a kangaroo supported by its tail and hind limbs, and of the nematodes of *Epsilonema* spp., which have been described as resting on the posterior curve of the body, the head projecting in search of food. That the processes have adhesive qualities is shown by gently shaking the petri dish, when the animal sways, but maintains its position on the glass.

In four specimens the jaws are folded; in the remaining worm those on one side are outspread and number 11. They are simple in form, without flange or serration. The anterior teeth, of which there are three on each side, are unusually long, reaching from about a third to a half the length of the jaws. The vestibular pads are sparsely provided with small denticles. The corona is less extensive than in *Sp. schizoptera* and is quite distinctive in shape, as shown in fig. 17. Numerous sensory patches with protecting setae are arranged symmetrically over the body surface.

The anterior fin is, in a specimen 6·5 mm. long, ·35 mm. wide and ·5 mm. in length, and is almost rectangular. It is supported entirely on the trunk. It is followed almost immediately by the posterior fin which is entirely on the tail segment, is 1·5 mm. long, and is of an even width, ·45 mm., throughout its length. In the immature specimens these fins are relatively closer together, but in the adult they are separated by the female opening. The tail fin is spatulate.

Adhesive processes arise from the ventral tail surface between the posterior fin and the seminal vesicles; they are arranged in two groups on each side, an anterior and a posterior. When not compressed by a coverslip the anterior project almost at right angles to the tail, while posterior processes lie along the tail surface. There are about ten or eleven in each group; all are thickly beset with tubercles and contain muscle fibres, as has been described above for *Sp. schizoptera.*

There are no diverticula from the alimentary canal. Ventral transverse muscles are present almost to the anus.

The ovary in the older specimens extends to the neck region. A ventral transverse duct leads from each receptaculum seminis, and in sections the two appear to join at the midline just anterior to the anus. No accessory branch, like that in *Sp. schizoptera,* is given off from this duct. The ducts lie laterally to the ovary.

The features by which this species is most readily distinguished from *Sp. schizoptera* are the stouter build of the body, the shape of the lateral fins and of the corona, and the doubling of the adhesive processes.

Spadella johnstoni n. sp.

(Fig. 5, 18)

One chaetognath amongst those collected near Port Hacking differed from the two species described above in the form of the corona, the position of the adhesive processes, and in the number of anterior teeth. It was first observed alive, swimming with three *Sp. sheardi,* and was easily distinguished from them

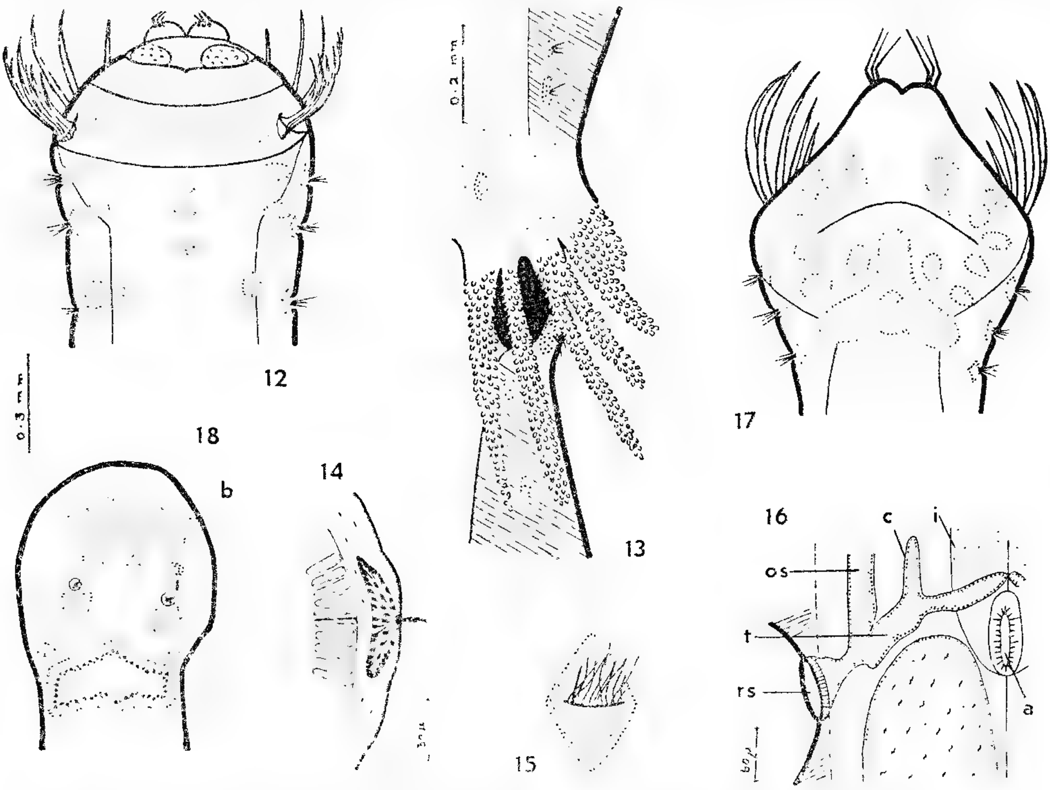

Fig. 12-16, *Sp. schizoptera;* 12, head, ventral view; 13, region of seminal vesicles in ventral view; 14, T.S. of a median dorsal sensory patch; 15, surface view of a sensory patch; 16, optical section in region of receptaculum seminis. Fig. 17, *Sp. sheardi;* head, dorsal view. Fig. 18, *Sp. johnstoni;* head in dorsal view. Fig. 12 and 18 to same scale; fig. 13 and 17; fig. 14 and 15. Lettering as in previous figures; in addition: b, brain; i, intestine.

by the colouring, in which yellow predominated, by the more slender form, and by the position of rest, which was always with the body inclined at an angle of 45° instead of the vertical position consistently adopted by *Sp. sheardi. Sp. schizoptera* has not been observed by me while alive. This difference of position may be due to the presence of only two groups of adhesive processes.

The body length is 4·6 mm., of which the tail segment occupies 2·4 mm., or 52%. The jaws are folded, but there are at least 10 pairs. The anterior teeth, of which there are two pairs, are about half the length of the jaws. The corona lies mostly on the neck; its inner margin is lined by closely-packed brown pigment spots.

The fins are so damaged by the clearing agent that no satisfactory attempt can be made to measure or to draw them. When observed in the living animals they appeared similar to those of *Sp. schizoptera*.

Posterior adhesive processes are present and are arranged in one group on each side. They are at about the same level as the vesiculae seminales, but both structures are much more posteriorly situated on the tail than in *Sp. schizoptera*. The processes are very numerous and the tips of some reach beyond the tail segment.

Ventral transverse muscles have not been observed. There are no diverticula to the alimentary canal. Transverse ducts from the receptacula seminis are present and apparently join in the mid-line. The vesiculae seminales are oval and of a very vivid yellow in the living animal.

In view of the different build of the body and shape of the corona and of the difference in extent of the adhesive processes of this specimen from any hitherto described species of the genus *Spadella*, it has been assigned to a new species, *Sp. johnstoni;* the specific name is given in recognition of the early work on Australian chaetognaths by Professor T. Harvey Johnston.

The main differences between the species described above are summarised in the following table. Abbreviations used are: T % L, length of tail segment expressed as percentage of body length; divertic., intestinal diverticula; no. ad. p., number of adhesive processes; pos. ad. p., position of adhesive processes on tail segment.

	Spadella schizoptera			*Sp. sheardi*	*Sp. Johnstonii*
	Conant	Yos. & Tok.	mihi		
Length ...	4	2·97	4·1-4·9	4·7-6·5	4·6
T % L ...	51	53·7	47-51	44-45	52
Ant. teeth ...	2-3	2-3	3	3	2
Jaws ...	3	7-10	11	11	11
Divertic. ...	absent	present	absent	absent	absent
No. ad. p. ...	2	2	2	4	2
Pos. ad. p ...	3rd quart.	post. half	3rd quart.	post. half	post. quart.

Summary

Two new species of *Spadella*, *Sp. sheardi* and *Sp. johnstoni*, are described from 100 metres depth off the coast of New South Wales, and a description of the closely allied *Sp. schizoptera* Conant from the same locality is added.

Literature

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John, C. C. 1933 Quart. Journ. Micr. Sci., **75,** 625-696

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Yosii, N., and Tokioka, T 1939 Annot. Zool. Jap., 18, (4), 267-273

THE NATURE AND OCCURRENCE OF URANIFEROUS MINERAL DEPOSITS IN SOUTH AUSTRALIA

By DOUGLAS MAWSON

Summary

Now that there is a revival of interest in uranium it seems appropriate for me having been associated with the first publication (15) on the radioactive minerals of Australia and later with the discovery and investigation of two of the most important uraniferous deposits in South Australia, to publish what information I have accumulated relating to the uranium-bearing mineral occurrences within the boundaries of this State. It has been my intention of more fully investigating the Radium Hill and Mount Painter formations, but circumstances have arisen which deem it expedient for me to publish immediately such information as I have now at hand.

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By Douglas Mawson

[Read 12 October 1944]

Plates XIX, XX, XXI

Contents

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URANIUM IN THE MOONTA MINES

Early in the year 1906 Mr. S. Radcliffe, a member of the Mine Staff, discovered electroscopically-active ore coming from the underground workings. At the time of my visit later in the year the active ore had been localised as occurring in two quite distinct places. The first was in the workings of Treuer's Shaft at Moonta. The veinstuff in which the first traces were found was broken in driving at the 50 level south of Treuer's Shaft. Later it was discovered in ore broken by tributors at the 35 level. These workings are apparently on a different lode course. My examination was at a depth of several hundred feet below the surface, where the lode was seen to cut a cross-course; only in the latter or in the vicinity of it was there electroscopically-active mineral. This cross-course, which traverses the wall rock composed of Pre-Cambrian felsitic quartz-porphyry and schists, was observed to range from 2 to 6 inches in width and to be occupied by black, loosely coherent matter principally composed of friable covellite and crystals of smoky quartz. Amongst the constituents recorded in G. J. Rodgers' analysis (16) are uranic oxide to the extent of several per cent. and a little carbon. Radcliffe recorded finding at this locality a uraniferous encrustation of a yellow carnotite-like mineral.

The second place of occurrence in the Moonta Mines is in a cross-course met with in workings connected with Taylor's Shaft. Here also the radio-active ore is carbonaceous to a notable degree. It is, in fact, a hydrocarbonaceous substance of specific gravity 1·5, which yields on proximate analysis 13% of volatile hydrocarbon and 10% of fixed carbon. It is brownish-black and exhibits a lustrous conchoidal fracture. One of the specimens of uraniferous hydrocarbonaceous substance collected at the time of my visit in 1906 has now exfoliated as a result of exposure to the air, and tiny yellow spots of a crystalline secondary uranium mineral have developed, indicating that the uranium is irregularly distributed through the original substance.

A radio-active mass resembling coal, found in a vugh at the 720-ft. level, was proved by Radcliffe to contain 35% of fixed carbon and 5% of volatile hydrocarbon.

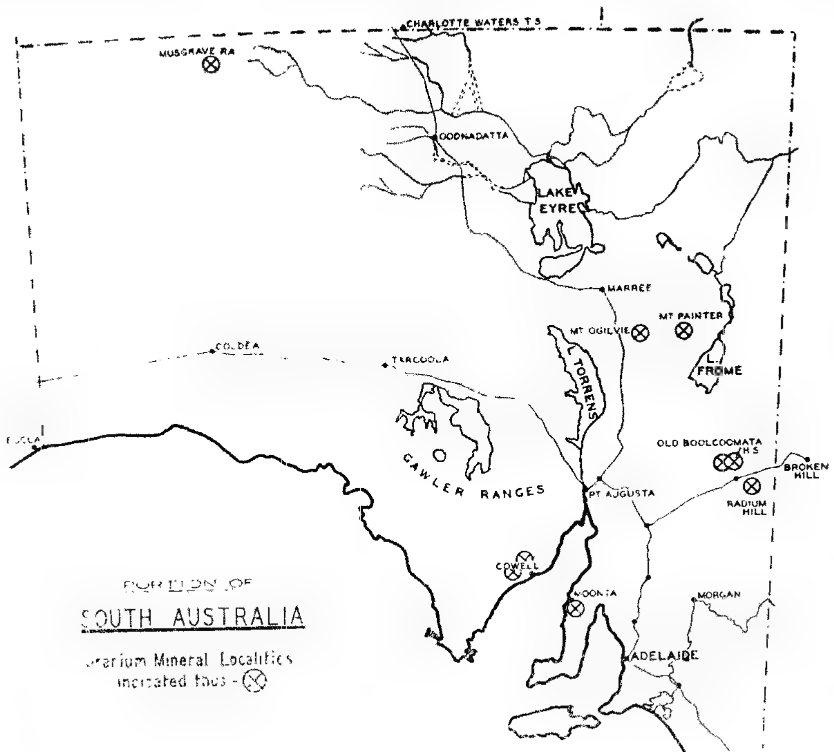

Fig. 1

The most highly uraniferous sample from these Moonta veins tested by Radcliffe contained about 10% U_3O_8, but the usual tenor was scarcely half that figure. This association of uranium embodied in a hydrocarbonaceous substance occurring in a vein formation traversing Pre-Cambrian rocks, recalls occurrences of the kind which have been reported from Canada and Scandinavia.

For some time past the Moonta Mine has been closed down. In the days when it was operating it was worked as a large-scale copper producer, and it was only by accident that radio-active ore was located and recorded. It was then not of sufficient economic importance for the Company to pursue the matter further. It is interesting to note, however, that at the time of Radcliffe's discovery, I was informed by several of the older miners that in the early stages of mining development at Moonta a dump of similar carbonaceous material brought to the surface was eventually disposed of by burning. A further matter of interest is that during the past 20 years some very nice and characteristic specimens of torbernite have been recovered from the old dump heaps at the mine. Examples of these have reached the South Australian Museum.

THE RADIUM HILL LOCALITY

In the older Pre-Cambrian area of the north-east of South Australia there are several locations where uranium-bearing minerals have been found. Of outstanding importance is the long-known occurrence located 20 miles E.S.E. of Olary. Here, on the eastern slopes of a low rise known as Radium Hill, there are several ore bodies outcropping as more or less parallel lodes (text fig. 2); a preliminary report was published by me (8) in the year 1906, and further notes (10) thereon at a later date. The South Australian Mines Department has published much relating thereto, of which a compilation by Mr. Lionel Gee (18), and reports by Dr. L. K. Ward (19 and 20) are of special importance; other references (21 and 22) in the publications of the Mines Department are mainly in the

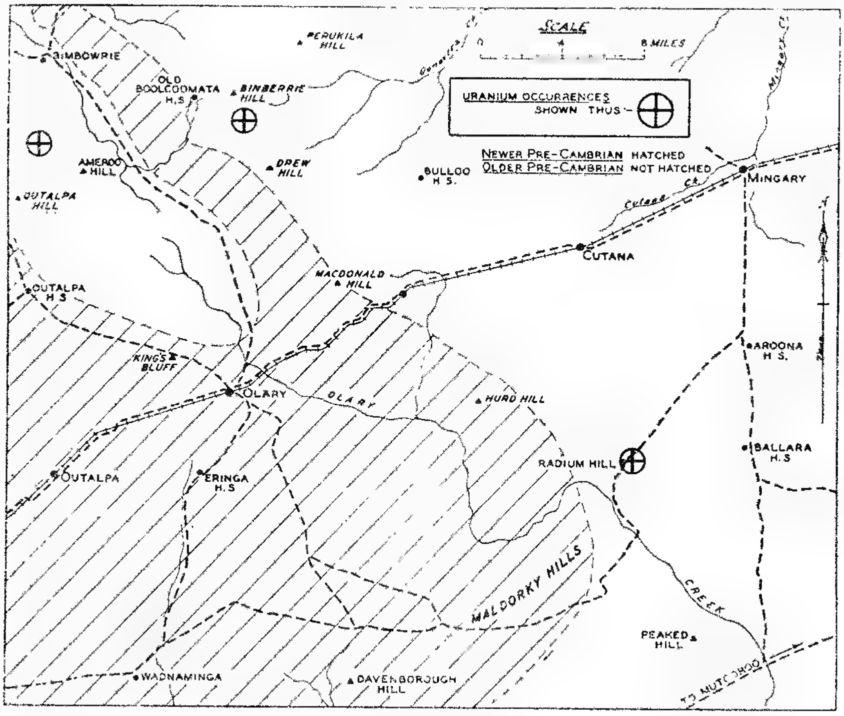

Fig. 2
Map of the Radium Hill and Boolcoomata Area.

nature of progress reports dealing with mining operations. Observations, made by myself during investigations prosecuted in the years 1923-24 have not yet been adequately published, but items of scientific interest then accumulated are incorporated herein.

Geological Features

Nearby to the west of Radium Hill, with its eastern margin sweeping down from the neighbourhood of MacDonald Hill to the Maldorky Range, via Dene's Hill, is a great basin of late Pre-Cambrian sediments with several horizons of tillite (Sturtian) extending upwards from near the base of the formation.

To the east of that basin is an older Pre-Cambrian terrain lying unconformably below the former; included in it is the neighbourhood of Radium Hill. This older Pre-Cambrian area is co-extensive with that lying further to the north in the region of the Boolcoomata Hills and Mingary, and with that of the southern Barrier Ranges. The rocks of this formation in the neighbourhood of Radium Hill have all suffered a considerable degree of metamorphism and, in the main, are presented as crystalline schists and gneisses. The oldest elements are metasediments; they include mica schist, hornblende schist, granulite, kyanite schist, staurolite schist, scapolite-bearing schist, etc. The foliation and gneissic banding is broadly aligned in the direction N. 30° E.

Transgressing these recrystallised sediments in the neighbourhood of the radium-bearing lodes, and exposed in some of the workings, is a soda-granite developed as a small scale intrusion of irregular shape. Where it is more massive it is practically free from foliation, though it bears evidence of cataclasis to a considerable degree. It is probably of late Pre-Cambrian age, comparable with the Umberumberka and Boolcoomata granites. As this granite [2883] is closely associated with the uranium-bearing lodes, it has been subjected to a detailed examination.

Soda-Granite [2883] is a medium to fine, even-grained granite with the usual hypidiomorphic granular texture. Feldspar, which is abundant, conforms in optical characters to albite ($Ab_{92}An_8$). If present, orthoclase is inconspicuous. Quartz, which is the next most abundant constituent, shows the effects of stress by the presence of a faintly discernible system of cracks. Included in the quartz are abundant tiny needles of rutile. Biotite, both chloritized and bleached (some may be muscovite), is plentiful. There are occasional grains of black iron ore and some which show leucoxenic changes, evidently ilmenite. Tiny yellow geniculate twinned crystals of rutile have been observed in the slides. Apatite is also present as an accessory.

The chemical composition of this granite is stated in the table on page 338. Its very high soda content is outstanding. The norm has the following composition:

Quartz	23·76	Magnetite	0·46
Orthoclase	4·62	Ilmenite	0·71
Albite	63·72	Pyrite	0·08
Anorthite	1·70	Apatite	0·07
Corundum	3·88		
Hypersthene	0·71		99·71
			0·62
		Total	100·33

C.P.I.W. classification: I, 4, 1, 5.

Plagioclase-Amphibolite [2882]—The line of foliation of the meta-sedimentary system has been intersected by several basaltic dyke-like intrusions, some of which are several yards in width. One such dyke cuts across the line of the uraniferous lodes, passing to the south of the main workings. But it was probably in existence before the late stages of ore formation were completed. This rock has been completely recrystallised.

A chemical analysis of it is included in the table on page 338. It is to be observed that, like the lodes themselves, this rock is exceptionally rich in titanium and carries a notable quantity of vanadium. The minerals constituting it are mainly labradorite and amphibole, which is pleochroic from light yellow to blue-green with $Z \wedge c = 22°$. There is also an abundance of grains of black iron ore, most exhibiting the form usually assumed by ilmenite; apatite is another accessory. Some minute colourless grains are, apparently, zoizite.

The composition of the norm:

Quartz	3·12	Magnetite	6·73
Orthoclase	1·11	Ilmenite	7·13
Albite	16·80	Pyrite	0·08
Anorthite	42·50	Apatite	0·34
Wo	1·39		
En	14·99	Total	99·77
Hy	6·07		

C.I.P.W. = II (III), 5, 4, 5 (Auvergnose-Hessose).

Another example [2816] of intrusive basic magma makes a more conspicuous outcrop at a point about three miles to the east of Radium Hill, where it has been opened up by prospectors searching for copper, indicated by some staining of the rocks nearby. This is a dark-coloured rock with notable parallelism of the amphibole, and thus best described as a plagioclase-hornblende-schist. The dominant mineral, hornblende, is strongly pleochroic: X = yellow, Y = dark green, Z = blue-green. Plagioclase is abundant, some as basic as labradorite. There is a little granular quartz and some grains of magnetite.

Another dark-coloured rock [2815] from the same locality as [2816] proved on microscopic examination to be a quartz-biotite-hornblende-scapolite-hornfels, in which the scapolite is poeciloblastically disposed. Grains of magnetic, calcite and epidote are present. Evidently this is a thermally metamorphosed, arenaceous, calcareous shale.

	I	II	III
SiO_2	71·56	45·90	39·16
Al_2O_3	17·74	18·99	17·55
Fe_2O_3	0·30	4·60	9·97
FeO	0·86	8·51	5·66
MgO	nil	5·78	15·16
CaO	0·38	9·46	nil
Na_2O	7·54	1·97	2·79
K_2O	0·78	0·21	5·66
H_2O+	0·47	0·62	2·50
H_2O-	0·15	0·18	
TiO_2	0·38	3·77	0·64
P_2O_5	0·03	0·15	.
V_2O_5	—	0·08	trace
MnO	0·01	0·17	trace
Cr_2O_3	—	—	0·62
BaO	nil	nil	.
CO_2	nil	nil	nil
Fl	—	—	0·78
Cl	nil	nil	.
SO_3	nil	nil	.
FeS_2	0·08	0·08	
			100·49
Oxygen equivalent			0·32
Total	100·28	100·47	100·17

I Soda-granite from Radium Hill, S. Aust. Analyst, W. S. Chapman.

II Plagioclase-amphibolite of Radium Hill, S. Aust. Analyst, W. S. Chapman.

III Biotite mica of the Radium Hill Lode. Analyst, R. E. Stanley. This analysis is of the biotite after eliminating 1.6% of rutile needles mechanically contained in it. Note that in Stanley's mean analysis as originally printed there is a type-setter's error, the chemically combined TiO_2 should be 0.63 not 0.03.

Characteristics of the Uraniferous Lodes

At the time of first discovery [1] there were outcropping on the sloping hill-side, four lode formations all roughly parallel and clearly distinguishable, trending with the foliation of the country (see pl. xix, fig. 1). Mining experience has shown that all are very variable in width, ranging from a few inches to several feet, and change their mineral composition notably both vertically and longitudinally within 100 to 200 feet. If followed sufficiently far they can be seen to dwindle and to fade out of existence. In other cases where there has been no apparent lode on the

[1] Subsequent mining operations have now removed or buried under debris the original outcrops in the central area.

surface, useful bodies have been met underground. Mining operations have disclosed dislocation of the ore bodies by movements subsequent to ore deposition.

Outcrops of these lode formations (text fig. 3) appear for quite half-a-mile in the direction of strike, but no single body could be traced at the surface for more than about 250 yards. Mining operations have shown that in the central part of the field they all dip steeply, with an underlay to the east ranging from 20° to 27° from the vertical.

They are epigenetic formations introduced along fracture planes and, at least at one stage in their development, appear to represent deposition from watery magmatic solutions. In this respect they are related to pegmatites though peculiar in character, and furthermore they have undergone a certain degree of subsequent metamorphic change.

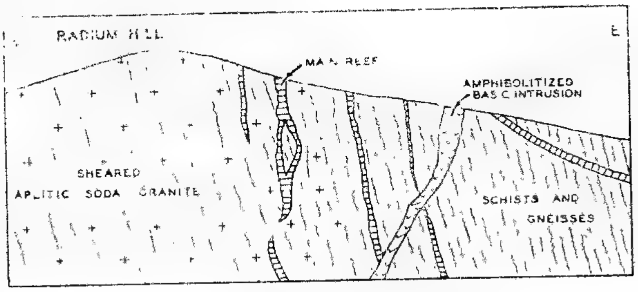

Fig. 3
Diagrammatic Cross-Section of Radium Hill Lodes.

The magma represented by the sheared granite of the locality may have contributed to the formation of the uraniferous lodes, for we have found uranium associated with the normal pegmatites of granite of apparently the same age located about 30 miles to the north-west. The titanium content of the granite is also suggestive of this relationship. The other igneous rock, the amphibolitized gabbro, appears to have greater claims to consanguinity on account of its high content of titanium, vanadium, magnesium and iron. Perhaps the basic intrusive is a lamprophyric derivative of the granite magma.

A common feature of the lodes is their high content of "iron ores" and abundance of black mica. The primary mineral assemblage as exposed in the outcrops is found to vary in the case of each of the lodes, also it varies from place to place in the same lode. Thus a more westerly line of reef was observed to be composed essentially of micaceous hematite and quartz. The main reef, located about 60 yards to the east of the former, outcropped as iron ores (mainly a mixture of martitized ilmeno-magnetite, and a variety of ilmenite containing small quantities of rare earths, uranium, etc.) and black mica with an irregular distribution of reef quartz.

Ten yards further to the east a lode was noted consisting of a mixture of heavy black titaniferous iron ores and black mica. While a fourth vein still further to the east was observed to be mainly titaniferous iron ores and reef quartz.

The information gained in an examination of the outcrops and of the mine workings has shown that in their full development these lodes are primarily composed of vanadiferous, uraniferous, titaniferous iron ores, together with black mica and (less commonly developed) a late-stage contribution of quartz. Associated with the latter is a very little davidite (10). Secondary minerals such as carnotite, arising from the weathering of the primary constituents, are in evidence in the outcrops and extending down in places to depths of about 100 feet.

The more pegmatitic phase of the Main Lode

The central portion of the main lode has characters linking it with the pegmatites. The marginal zones are particularly rich in black mica, which has been derived partly by reaction with the wall rock material. A central portion, which is well defined in some places and which has been derived from residual liquors, is largely composed of reef quartz with embedded ilmenitic mineral. As a very late development, and more marked in some sections of the formation than others, the ilmenitic mineral has broken down by subsequent reaction to a high-iron biotite with release of TiO_2 as rutile or ilmeno-rutile.

It appeared worth while ascertaining the average chemical composition of a large block of this more typically pegmatitic phase of the formation. With this object in view, a length of 180 feet of the lode on the 40-ft level was carefully and systematically sampled. About a ton of material which resulted from repeated cross-section sampling was crushed and reduced by quartering until only 10 lbs. remained. This was submitted for analysis, with the result stated in the table on page 344.

The mineral constituents are principally black mica, the ilmenitic minerals and quartz. On account of the high mica content the norm is quite dissimilar to the mode.

Allocating the rare-earth oxides to the lime quota, coupling vanadic oxide with ferric oxide, and accepting the uranic oxide as pitchblende, the composition of the norm is as follows:

Quartz	41·88	Geikielite	23·29
Orthoclase	16·12	Hematite	9·44
Albite	1·05	Chromite	0·22
Anorthite	2·50	Pyrite	0·18
Corundum	2·65	Pitchblende (UO_2)	0·18
Enstatite	0·60		98·11
		Water	1·30
		Total	99·41

If this were to be expressed in the C.I.P.W. classification it would fall into II, 2, 1, 1

Assessment of Uraniferous Minerals Recoverable

When mining operations were in progress in 1924 we made a fairly exhaustive examination of the exposures in the workings, with a view to obtaining an estimate of the quantity and quality of the ore reserves. The following is a summary of our findings.

Main Lode

South Shaft Workings—At a depth of 56 feet vertically below the surface, this shaft, sunk on the underlay, encountered a flat fault with a drag to the west, but the lode was picked up displaced only about 15 feet. Water in the workings prevented an examination of this displaced extension of the ore body, which was unfortunate, as samples that had been obtained therefrom were found to be more highly uraniferous than usual.

From this shaft, at a vertical depth of 40 feet below ground-level, a drive extended to the north along the lode for a distance of about 18 feet. Three average samples of the cross-section of the ore body gave the following values:

	30″ wide lode 18′ below surface %	30″ wide lode 37′ below surface %	24″ wide lode from N. end of drive 40′ below surface %
Composition (partial):			
SiO_2	30·3	34·8	46·0
Fe	15·7	15·2	13·0
TiO_2	23·1	16·0	16·0
U_3O_8*	0·25	0·10	0·25
Heavy concentrate obtainable:			
Percentage of lode material	30	24	16
U_3O_8 content of concentrate	1·13	0·70	1·10

* The U_3O_8 was estimated electroscopically by comparing the rate of discharge with a sample of Radium Hill ore of known uranium content. The partial analysis of ore samples was done by W. S. Chapman's Department at the School of Mines; the heavy concentrate determinations were made in our University Geological Department.

The Main Shaft—This is located on the main lode, 228 feet north of the South Shaft. At the time of inspection it had bottomed at about 127 feet (vertical depth) below the ground surface; throughout this depth it is well defined but changes in character towards the bottom. At depths of 40 feet and 85 feet, drives extend both to the north and to the south of this shaft. In this shaft, at 7 feet below the surface, the width of the lode is 6 feet and most of the ilmenitic mineral is on the hanging wall side concentrated in a width of 2 feet. The remainder of the lode is principally quartz and mica. At a depth of 18 feet the lode is 5 feet 6 inches wide and the bulk of the ilmenite is concentrated in the centre region.

Below the main level a large horse of mullock is enclosed in the lode dividing the ore body in that vicinity into an east and a west limb. At the contact between the lode matter and the wall rock, and between the lode filling and the horse there is developed a selvage of finer grain than the lode matter and usually 3 inches in thickness, principally composed of an unusually black variety of mica. This is in contrast with the more characteristic mica of the ore body, which is in very coarse flakes and has a distinct bronzy appearance. In this part of the lode where the ilmenitic iron minerals are deficient in the ore, there is usually developed a coarse-grained, quartz-mica rock in which much of the mica is located in distinct patches or pockets.

The lode, with good values of the ilmenitic content, continues down to about the 68-feet level as exposed in the shaft; beyond this point there is a falling off in the obvious ilmenitic element. At the 95-feet level the lode is notably siliceous and the colour of the ilmenitic constituent is of a somewhat reddish-brown, due to high titania content, existing partly as free rutile. Carnotite, which decreases in abundance with increasing depth from the surface, is found in vestiges only in the 95-feet level.

Beyond this point the ore body becomes more micaceous, until at the bottom of the shaft it is constituted very largely of coarse bronzy mica with a limited amount of a grey-black variety of the ilmenitic mineral occurring as nodules up to an inch in diameter (average size, $\frac{3}{8}$ inch). This latter is richer than usual in uranium and vanadium.

The Windlass Shaft—This is an underlay shaft sunk on the main lode 91 feet north of the Main Shaft. On the south side, just below the plat at 39 feet below the surface, a fault face is revealed which dips steeply to the north at an angle of about 30° and reaches the surface about 45 feet north of the collar of the shaft. Below this fault the shaft continues down at a flatter angle to a total depth of 50 feet vertically below the surface. The lower portion of the shaft is not in true lode matter but follows a micaceous apophysis of the lode which is very irregular in width and bifurcates near the limit of the workings.

The filling of these apophyses is principally in the nature of coarse black mica and quartz in the marginal zone, and in the central belt it is almost exclusively coarse black mica; there is a very small quantity, barely 1%, of radio-active ilmenitic mineral. A partial analysis of an average sample taken where the apophysis was observed to be almost entirely composed of mica gave $SiO_2 = 40{\cdot}3\%$, $Fe = 14{\cdot}8\%$. $TiO_2 = 3{\cdot}9\%$, uranic oxide only a trace.

Drives and Stopes of the Main Shaft and Windlass Shaft System

The 40-feet Level—A drive at this level links both shafts and extends well on towards the South Shaft. Throughout this length the lode continues as a well-defined body with distinct walls, and the class of lode matter traversed is of the same general character, except that at the south end it grades towards that met with in the South Shaft. Though the class of ore in this block remains sensibly similar in character, there were observed considerable variations in the proportion of the iron ore constituent, the rich ore occurring in chutes. Over the main area, the width ranges from 3 feet to 6 feet, and even wider where a horse of mullock divides the ore body. Towards the south it dwindles somewhat in conformity with the narrower section in the South Shaft workings.

Average cross-sections of the ore body on this level gave the following values:

	1	2	3	4	5	6	7	8	9
Composition (partial):									
SiO_2	43·0	63·9	56·7	36·6	58·5	63·8	57·8	56·3	45·7
Fe	13·5	6·7	5·8	14·1	7·3	4·8	8·0	10·4	10·8
TiO_2	24·5	9·2	9·8	24·7	9·0	7·2	9·5	15·2	18·8
U_3O_8	0·3	0·2	0·1	0·4	0·05	0·05	0·1	0·2	0·45
Heavy concentrate obtainable:									
Percentage of lode material	40	8	6	32	7	6	11	25	26
U_3O_8 content of concentrate	1·00	1·20	0·96	1·15	0·60	0·70	0·98	1·10	1·75

1 Floor of level at 25 ft. south of Windlass Shaft. Width, 5 ft. 5 in.
2 Floor of level at 50 ft. south of Windlass Shaft. Width, 4 ft. 10 in.
3 Floor of level at 75 ft. south of Windlass Shaft. Width, 7 ft.
4 Floor of level at 15 ft. south of Main Shaft. Width, 3 ft 3 in.
5 Floor of level at 49 ft. south of Main Shaft. Width, 4 ft. 6 in.
6 End of the level at 83 ft. south of Main Shaft. Width, 4 ft.
7 Roof of stope 21 ft. south of Main Shaft. Width, 3 ft. 9 in.
8 Roof of stope 50 ft. south of Main Shaft. Here the width of stope was 7 ft., but sample taken only on the best 2 ft. 7 in.
9 Roof of stope 72 ft. south of Main Shaft. Width, 4 ft. 6 in., with iron ore values only on foot wall side.

The Lower Drive (85 feet vertically below the surface) extends along the lode both to the north and to the south from the Main Shaft: on the north side, at 65 feet, the lode is cut off by a fault face dipping to the S.S.E. a continuation of that met in the Windlass Shaft. The drive continues on in a siliceous gneiss for a short distance beyond the fault. Southward of the Main Shaft the drive continues all the way in ore to a total length of 84 feet. The average width of lode may be taken as about 4 feet, but at this level it carries a distinctly lower proportion of the titaniferous iron ore mineral than in the upper workings. The tenor of the lode material as exposed in the Main Shaft at this level is given in the table on page 343.

Beyond the 85-feet level the Main Shaft continues on the underlay to a total vertical depth from the surface of about 125 feet. At the bottom the ore passes into a mica rock similar to that in the apophyses below the Windless Shaft, though here there are in it definite black ilmenitic nodules. This change may be due to the further extension of the fault met with higher up in the Windlass Shaft. An analysis of an average sample taken over a 2-feet face of the more mineralised section of the micaceous vein filling occupying the bottom of the shaft is stated in the table on page 343.

THE WHIP SHAFT

This is located approximately 810 feet to the north-east from the Windlass Shaft. It is in the neighbourhood of 50 yards to the east of the main lode line as defined by the trend indicated by the excavations already detailed. It can be traced to extend for some distance on either side of the shaft and ranges from 1 foot to 2 feet 6 inches in width. The dip from the vertical is 45° in the upper section of the workings, and deeper down it flattens to 30°. The total vertical depth below the surface at the time of inspection was 58 feet.

Though the lode filling in this case is of the same general type as that of the main workings, the lode channel is distinctly different, being along a fracture plane lying at a considerable angle to the planes of foliation of the gneissic banding of the country rocks.

The jointing in the siliceous gneisses, which constitute the wall rock, strikes in a similar direction to that in the neighbourhood of the Main Shaft, namely, about north-east, and the dip is steep to the east; that is about the same direction and dip as the lode at the Main Shaft. See sketch, fig. 4.

The hanging wall side of the lode is very clearly defined and exhibits a stepped outline which appears to be a counterpart of a roughly stepped arrangement appearing in the footwall. The steps in the roof are smooth and much rounded. More frequently than not the steps in the footwall side are occupied by cracked or shattered rock, partly altered by the introduction of mica and titaniferous iron ore. This metasomatic introduction of mica and ilmenitic minerals extends down in many places along the joint plane on the floor of the lode. Thus is deposited titaniferous iron ore surrounded by black mica in scattered and isolated centres in the gneiss. The latter is in some places notably contorted.

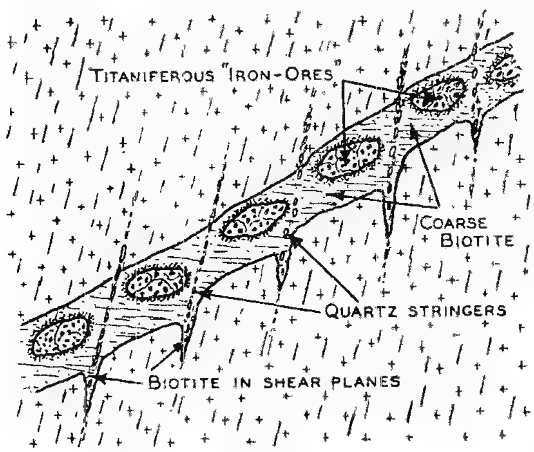

Fig. 4
Diagrammatic Cross-Section
of the Whip Shaft Lode.

For a distance of several inches from the lode the country rock has been considerably affected by the vein solutions, whereby black mica and ilmenitic minerals have been introduced. The lode filling is rich in ilmenitic iron ore and coarse black mica is abundant. To a less extent quartz figures in small patches and blebs, often significantly arranged in the lode above the joint planes of the gneiss, as if the effect on the joint planes had been to facilitate a contribution of quartz to the lode matter. The black mica is abundant throughout, but is frequently massed in horizontal patches extending into the lode from the junctions of joint planes. Also, mica is notably accumulated as a selvage along the hanging wall (roof) side of the formation.

Massive patches of the ilmenitic mineral feature in the lode immediately between the joint planes of the country and more on the roof than on the floor. Indeed, over most of the lode, the concentration of ilmenite mineral on the hanging wall side is most obvious.

The composition of two average samples taken across the lode are stated in the table herewith.

	1	2	3	4
Composition (partial):				
SiO_2	65·0	44·2	36·9	41·4
Fe	3·7	6·92	9·7	11·9
TiO_2	11·0	8·7	27·9	24·3
U_3O_8	0·1	0·9	0·45	0·15
Heavy concentrate obtainable:				
Percentage of lode material	11	1	34	27
U_3O_8 content of concentrate ..	0·68	0·84	1·20	0·75

1 Average sample of the lode in the Main Shaft at the 85-ft. level.
2 Average sample taken over a 2-ft. face of the more mineralized section of the micaceous vein matter at the bottom of the Main Shaft. 125 ft. (vertical) below the surface.
3 Average sample of lode 2 ft. wide, in the Whip Shaft at 31 ft. vertically below the surface.
4 Average sample of the lode 1 ft. 6 in. wide, in the Whip Shaft, at 54 ft. vertically below the surface.

The quantity of Uraniferous Ore available

Already it has been noted that the ore bodies are very irregular, both as regards quantity and quality of the uraniferous mineral contents. Also, the extension of the lodes beyond the limits proved in the mine workings is uncertain; they are affected by faulting and are seen to fade out after no great linear extension. However, the belt of country in which they occur runs for about a couple of miles along the strike, consequently other lodes not obvious at present may be located by the application of geophysical methods.

At the time (1924) of my last stock-taking of reserves definitely in sight, as exposed by mine workings, the quantity of concentrates available was put at over 1,000 tons, having an approximate average composition as follows: Uranic oxide 1%, vanadic oxide 1%, chromic oxide 1%, rare earth oxides 3%, titanic oxide 50%, iron oxides 34%, silica, etc., 10%. Since then some further ore has been mined and shipped away.

The radium content of this ore was found to average an equivalent of 5 mg. of radium bromide per ton for every 1% of uranic oxide present. The radium bromide produced therefrom by the original Radium Hill Company was tested by Sir Ernest Rutherford, who reported "The preparation is free from meso-thorium and other radio-active substances which, without a careful examination being made, are likely to be mistaken for radium."

Minerals of the Lodes

Quartz as the compact reef variety, usually somewhat brownish in colour and sporadic in distribution, enters into the formations in variable amount. One of the subsidiary lodes, with a thickness of only a few inches, was observed to be composed almost entirely of black "ilmenite" imbedded in quartz. Usually it is present in quite small amounts when compared with the biotite and "iron ores."

Biotite in abundance, together with titaniferous "iron ores" constitute an overwhelming proportion of all the lode material. The "iron ore" content, at times the dominant mineral present, may fade to insignificance and the biotite (or biotite with some quartz) occupies almost the whole of the lode.

	I	II	III	IV	V	VI	VII
SiO_2	—	1·15	5·9 (2)	12·70	8·70	54·50	—
TiO_2	54·3	51·85	45·7	45·85	50·98	14·60	—
Al_2O_3	—	—	—	—	0·63	6·74	5–7
Fe_2O_3	13·0	17·87	16·3	17·40	17·29	9·02	19·3
FeO	16·0	17·37	16·5	16·90	8·93	3·15	—
MnO	—	0·24		trace	—	0·05	—
MgO	0·6	trace	—	trace	0·94	5·80	trace
CaO	1·5	0·25	—	0·55	—	0·32	1·0
PbO	1·1	0·40	—	0·16	0·67	present	1·3
ThO_2	—	0·13				—	nil
Ce_2O_3, etc.		1·26					
La_2O_3, etc.	8·3	2·13	6·04	3·27	0·89	0·53	—
Y_2O_3, etc.		1·15				0·32	—
Cr_2O_3		1·60	1·8	0·85	2·34	0·11	—
U_3O_8	4·6 (1)	2·25	2·9	1·60	2·75 (3)	0·19	47·8
V_2O_5		0·93	1·1	0·87	2·00	0·37	16·8
P_2O_5	—	—	—	—	—	present	trace
Na_2O	—	—	1·2	—	—	0·14	1·8
K_2O	—	—		—	—	2·69	5·2
Cl	—	—	—	—	—	0·05	—
SO_3	—	—	—	—	—	0·02	—
FeS_2	—	—	—	—	—	0·17	—
H_2O+	1·5	1·21	1·3	not det.	3·79	0·99	—
H_2O-						0·31	—
Occluded Gases	—	—	—	—	—	—	—
	100·9	99·79	98·74	100·15	99·91	100·07 (4)	98·9

(1) Mainly uranium.
(2) Insoluble siliceous residue.
(3) Another selected specimen contained 3% of U_3O_8.
(4) Absence of CO_2 and BaO proved.

I Analysis (4) of davidite by Dr. W. T. Cooke, University of Adelaide.

II Bulk sample of the brighter titaniferous iron ore from 10 feet below the surface near the Main Shaft. Analysed (5) by T. Crook, Imperial Institute, London.

III The heavy gravity concentrate from a bulk sample of the Main Lode collected near the Main Shaft. Analysed by S. Radcliffe in year 1909.

IV Composition of average concentrates from magnetic separators forwarded for treatment to the Radium Hill Coy's works in Sydney in year 1911.

V The dull black titaniferous iron ore from the South Shaft. Analysis by R. G. Thomas and A. R. Alderman, Department of Geology, University of Adelaide (1924).

VI Average composition of the entire lode matter made on a length of 180 feet at the 40-feet level at Main Shaft. Analysis by W. S. Chapman, School of Mines, Adelaide.

VII Carnotite encrustation with mechanically admixed impurities from the Radium Hill Lode. Analysed (5) by T. Crook, Imperial Institute, London.

The biotite appears in two somewhat different forms. One as observed in the hand-specimen is of a bronzy-black colour and rather coarsely crystalline, as much as 4 cms. across the cleavage flakes. This variety appears to be the earlier formed of the two. The other is finer grained, jet black biotite which is clearly seen to have been developed, in some measure at least, at a later stage of mineralisation by reaction of the lode-forming gases or liquids with the already crystallized "iron ore." Thus the latter contributes some of its iron to the formation of a crop of biotite, leaving "iron ore" residue enriched in titanium; in this way, from original ilmenite there may be developed ilmeno-rutile. Actually, in some portions of the workings, kernels only of red rutile remain located within an aureole of fine black mica.

Iron and magnesium were determined on examples of each of these varieties selected at random, with the following result. Bronzy large flake mica: total iron as Fe_2O_3 = 14·55%, magnesia = 17·57%. Small black mica: Fe_2O_3 = 16·50%, MgO = 10·71%.

An example of the black variety of the Radium Hill lode biotite was more fully investigated by one of our students (17), whose chemical analysis is included in the table on page 338. This jet black, strongly pleochroic variety has the optical properties of biotite. Stanley found it to be rich in mechanically included and axially oriented needles of rutile to the extent of 1·3% by weight of the mica.

Chromiferous Chlorite (?)—A medium to light-green mineral of micaceous habit was met with in extremely small quantity in the upper workings near the Main Shaft. Even at the commencement of mining operations it was difficult to get enough for a full examination, and it is no longer obtainable. It occurred as minute flakes on the face of cavities and cracks in a late-formed, quartzose section of the lode. It contains 6·8% of chromic oxide, some silica, alumina, and lime as well as traces of iron and magnesia. Vanadium and uranium were proved to be absent. The presence of chromium suggests green mariposite, but the mean refractive index is rather low, namely 1·58%. Finally, enough material was obtained to establish that it contains 18·6% of H_2O, which suggests that it is a chromium-bearing chlorite.

"Iron Ores"—The most characteristic feature of these lodes is the abundance of heavy iron ore minerals rich in titanium, some containing small quantities of uranium, chromium and rare earths. In our earlier contributions these have been referred to as "ilmenite," but are now included under the general title "iron ores," which is less specific.

Actually the iron ore complex is a variable mechanical mixture of several minerals including ilmenite, ilmenite-davidite combination, titano-magnetite, martitized magnetite, titano-hematite, ilmeno-rutile, and even rutile; and also, though rarely, minute quantities of davidite. Some of these contain vanadium, which in some cases may be present as the coulsonite molecule (6). Where, however, they are radio-active, due to the presence of uranium, I have inferred that the davidite molecule is present in solid solution. This conclusion has been reached after a study of polished sections of the ore minerals: gradations in physical characters can be observed ranging from ilmenite to pure davidite. A further check has been provided by autoradiographs of polished sections; these also demonstrate a regular progression of radio-active intensity in the ilmenite leading up to that of the crystallized davidite. This method of observation also illustrates graphically the varying concentration of the davidite molecule in the ilmenite (see plate xxi). Certain of these "iron ores" have undergone mineral changes since their first deposition. In all probability such changes were effected partly during a late stage of the original lode-forming activity, but they are to some extent to be attributed to regional metamorphism subsequent to their original deposition.

A variety of ilmenite of bright appearance and comparatively rich in the davidite molecule is illustrated by analysis II of the table on page 344. The composition of a bulk gravity concentrate from the richer portion of the main lode as mined in 1907 is given as III of the same table and analysis IV is of the run-of-mine concentrate shipped to Sydney for treatment during later development.

An average sample of an ilmeno-rutile concentrate from the southern end of the main lode near where it contacts an amphibolite dyke was found by Alderman (1) to contain 60·76% TiO_2, 28·58% Fe and 0·84% V_2O_5.

A partial analysis by R. G. Thomas in 1924 (then of our Department of Geology) of the ilmenitic mineral of a small lode some three-quarters of a mile north-north-east of the main Radium Hill workings yielded 53·3% TiO_2, 42·07% of total Fe recorded as FeO and 1·60% V_2O_5.

At the south end of the main lode the "iron ore" mineral met with below the zone of surface weathering is of a dull sooty black appearance and is much richer in chromium, vanadium and uranium. A chemical analysis is given (V) in table on page 344. Stages both in its weathering and in its reaction to later lode solutions traversing the lode are well evidenced. It is observed to have changed to brown and, finally, in extreme cases, to yellow products which appear to be partly of the nature of leucoxene. This change appears to have been accompanied by the development of some late-formed biotite. Residual leucoxenized pellets embedded in the biotite have been found to be exceptionally rich in uranium present in a mechanically admixed yellow earthy form.

A highly radio-active sooty coating on a joint face traversing siliceous rock at a depth in the southern part of the mine workings (10) is evidently a film of uranic oxide. Another feature of interest in connection with the southern extension of the main lode is that after exposure for several years in a mullock dump at the surface, tiny scales of a yellow mineral developed on the surface of the mica. To the naked eye this mustard-coloured efflorescence resembles carnotite and the phenomena was reported as such (10). However, recent tests show it to be strongly fluorescent under ultra-violet light, which is not the case with carnotite. It appears therefore to be autunite.

Davidite—This name was given to a very rare constituent of the Radium Hill Lode. The chemical composition is given (I) in the table on page 344. In the year 1911, Sir William Crookes, who kindly undertook to examine it spectrographically for scandium reported that it contained a notably high proportion of that element.

Davidite is known in the pure state only from the main lode in the neighbourhood of the Main Shaft. There it has been found crystallised in a rough cuboidal form on drusy faces which, after formation, were encased in reef quartz of a late period of lode formation. From such faces the pure davidite can sometimes be observed to pass back into the common bright ilmenitic mineral of the lode. In such cases the constituents peculiar to davidite grade off *pari passu* with the changes in physical character of the "ilmenite." This gradation indicates that the common bright mineral of the lode may be regarded as in some measure a solid solution of davidite in ilmenite. We have observed tiny bright specks and spots of davidite distributed as local concentrations in the substance of the ilmenite.

Davidite is a pitch-black mineral of adamantine lustre. It is perfectly homogeneous and is found in crystal form. It appears to be a member of the perofskite group. The error of Crook and Blake (5), when they concluded that davidite is non-homogeneous and therefore not a definite mineral substance is explained by the fact that they had worked on a large block of mixed ilmenitic iron ore of the lode, believing that it was that which had been named davidite (10).

If sufficient of this mineral can be got we intend to ascertain its crystallographic structure by X-Ray analysis and to use it as a most suitable mineral for age determination.

Carnotite—Within about 80 feet of the surface certain other minerals have developed as products of weathering. Of these carnotite is the most abundant. It occurs as mustard-like films in crevices, and especially as a coating on the radio-active ilmenite. An analysis (VII) by Dr. Cook of this carnotite encrustation is quoted in the table on page 344.

Other secondary uranium and vanadium minerals also are to be found but only in minute amount, not sufficient to encourage efforts to ascertain their exact nature. Of these, minute flaky crystals of a yellow mineral which react strongly with ultra-violet light are probably autunite.

URANIUM IN THE PEGMATITES OF THE BOOLCOOMATA BATHOLYTH

Recently, in company with Mr. A. W. Kleeman and advanced students engaged in making a mineral survey of the pegmatite following of the Pre-Cambrian Boolcoomata batholyth, we located uraniferous minerals in two localities separated by a distance of about 10 miles. Many years ago, during our student excursions to that area, we stimulated local interest in the commercial possibilities presented by the many splendid examples of coarse pegmatites in the vicinity of the granite masses. As a result, ever since then, the mining of the feldspar of the pegmatites has been continued on a small scale. Lately, beryl to the extent of some tons has been marketed.

On our recent visit several specimens of gummite-like uranium mineral were got in one of these feldspar quarries located about one mile south of the summit of Binberrie Hill.

Autunite and some specks of a highly radio-active mineral like broeggerite were found in a beryl and tantalite-bearing pegmatite located a couple of miles west-north-west of Ameroo Hill on Outalpa Station. A full account of both these occurrences will appear in our forthcoming report on the paragenesis of the minerals of the pegmatites. The localities are indicated on the map, page 336.

OCCURRENCES IN THE NEIGHBOURHOOD OF COWELL

Dr. L. K. Ward has recorded (19) that "Torbernite and autunite are known to exist near the Government Weir across Yeldulkie Creek in the neighbourhood of Cleve. At this place uranium-bearing minerals have been found in traces in joint planes traversing a pegmatite intrusion." This locality is about 22 miles west of Cowell.

To the north-west of Cowell, distant about seven miles and situated in Section 1 B of the Hundred of Minbrie, carnotite encrustations were observed by Dr. R. L. Jack (22) as accidentally met with in developing an asbestos mine in a calc-silicate belt of country. It is recorded "a costean has exposed decomposed rock, possibly an argillaceous sediment, cut by a dyke containing oligoclase felds-par. The joints and cleavages of the decomposed rock carry films of a bright yellow material, which consists of carnotite, evidently secondary in its deposition. One assay yielded 0·3% of uranium oxide, while a second yielded 0·007%."

Both these occurrences on Eyre Peninsula are in Pre-Cambrian formations in the neighbourhood of granite intrusions.

THE MOUNT PAINTER FIELD

Geological Features

Mount Painter is situated in a patch of rugged country of older Pre-Cambrian age near the northern extremity of the Flinders Ranges. The map below illustrates not only its geographical position but, by appropriate hatch-

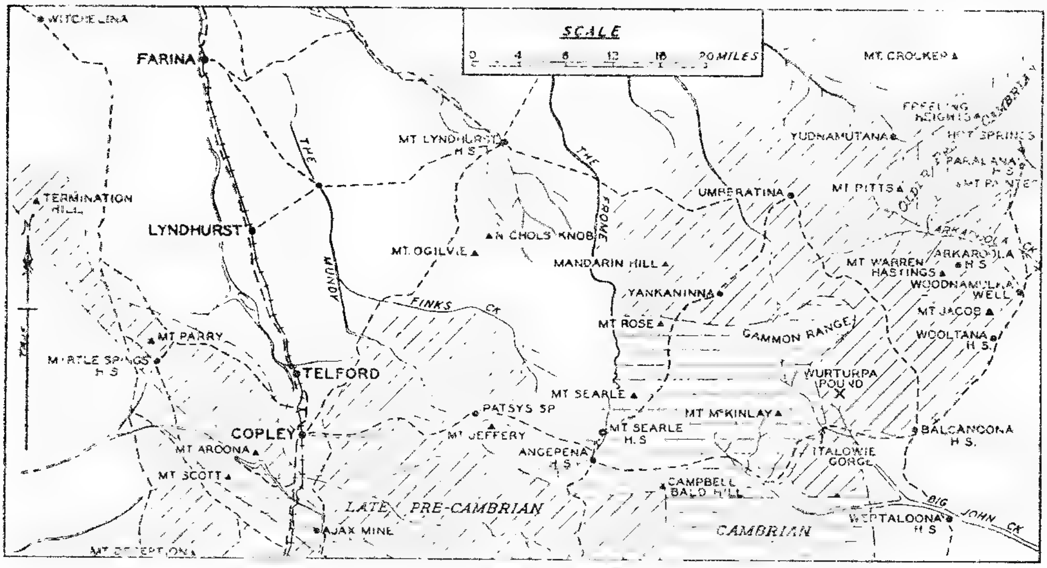

Fig. 5

Portion of the Northern Flinders Ranges with Geological Hatching. This includes Mount Painter and Mount Ogilvie.

ing, the Palaeozoic and pre-Palaeozoic rocks of the surrounding region are distinguished in several groups. In most parts of the map the boundaries of the several terrains are only roughly indicated. This degree of delineation is the result of a number of reconnaissances made in that area, none of which were undertaken to accurately map exact boundaries. Areas occupied by the Pound quartzite are included as Cambrian. The blank areas are either occupied by post-Palaeozoic formations or are insufficiently known to be referred to any particular period.

In the vicinity of Mount Painter the country outside the area indicated as older Pre-Cambrian is occupied by later Pre-Cambrian formations which correspond with the Adelaide Series of southern South Australia. Coming towards Mount Painter, by the Blue Mine track from Umberatana, one passes down successively from the Sturtian Tillite horizon at Red Hill and the Wheal Turner Mine, through dolomitic limestones partly converted to calc-silicate rocks, representing the Beaumont Dolomites and Slates, to a great quartzite equivalent to the Thick Quartzite. This quartzite flanks and unconformably overlies the rugged central country on the west. A similar succession is met with on the eastern margin of the Mount Painter country. Already some account of the geology of that region has been published (see references 9, 11, 12, 13, 14); other contributions incorporating the observations of our more recent visits are in preparation.

I take this opportunity to advise that, in the detail of a succession of sediments published in 1934 (see 14), I later found that the series is broken by an important line of faulting along the junction of formations 10 (chocolate shales) and 11 (Cave Hill dolomite). The beds to the east have been heavily thrown down in relation to those to the west. To the west of McLeach's Well is the Beaumont Dolomite series passing upward to the Sturtian Tillite above. Thus the tillite at Mount Jacob and the tillite at Mount Warren Hastings are of the same age. There may, however, be a still older tillite, as will be mentioned shortly.

The core of the Mount Painter country is occupied by a complex, largely igneous but partly of sedimentary origin, all of which, however, has undergone more or less severe metamorphism, in which, usually, the dynamic factor is abundantly evident. The intrusion of a highly sodic post-Proterozoic granitic magma into the outskirts of this region has long been known and is being dealt with in detail by us at the present moment. Whether, however, any of the igneous rocks of the central belt are post-Proterozoic in age remains to be proved by detailed mapping of the area. It is a fact that many of the notable types of igneous rock of the central belt are met with as erratics in the Proterozoic tillite of the neighbourhood.

In the very centre of the region a massive, coarse breccia and conglomerate formation which has undergone a considerable degree of dynamic metamorphism can be traced for several miles, approximately parallel to the line of the Mount Painter Ridge. It is intersected on the Radium East Creek where "conglomerate" is indicated on the map on page 351. Contained in it are blocks of many types of older rocks which occur *in situ* nearby. In many respects this has the characters of a metamorphosed tillite formation and suggests that it is the Sturtian Tillite involved at some time in the past in some great orogenic disturbance. This may be the case, but there is some evidence which appears to differentiate it from the Sturtian Tillite and suggests that perhaps it corresponds to an earlier glacial period.

In Middle-Proterozoic times great basic volcanic activity developed, as evidenced in the country between the Arkaroola and Wooltana; also at Yudanamutana.

At some time, possibly in late Proterozoic or even in late Cambrian time, the core region became subjected to great dynamic movements which are recorded in remarkable shatter zones in the pink granites and other rocks which constitute the matrices of the uraniferous formations. They follow two main systems: one trends roughly east to west, and the other north to south.

Thus extensive belts of crush conglomerate and crush breccias traverse the oldest rocks, and particularly the pink granites in the region of Mount Painter to Radium Ridge. Later these shatter zones have been invaded by gases and solutions responsible for the uraniferous lodes. Thus quartz, stilbite, fluorspar, fergusonite, monazite, baryta and hematite, as well as some uranium minerals, have been introduced on a notable scale. Splendid examples have been observed in these shatter zones illustrating the metasomatic replacement of the silicate minerals by hematite. Mount Gee, in particular, has been the centre of great hydrothermal activity during the period of mineralization.

My field observations in the central area have been conducted mainly from two locations, namely, Main Camp and Rock Holes Camp, respectively elevated about 1,350 feet and 1,950 feet above sea-level. The crest of Radium Ridge is about 900 feet above Main Camp. Mount Painter itself is about 3,000 feet above sea-level.

Location and Character of the Uraniferous Outcrops

These are illustrated on the map on page 351. Short references to each will be made under the distinguishing numbers recorded on the map.

No. 1 and 2—Excavations in a strongly defined reef which extends down the northern slopes of Radium Ridge at an elevation of about 840 feet above the camp on Radium Creek. The formation is mainly a dense mass of hematite six feet thick which forms the foot wall of a large, notably siliceous, body with drusy cavities which also carries platy hematite. Monazite is abundant in some portions of the reef, and blebs of the dark brown mineral which has been referred to as fergusonite are occasionally visible. Local concentrations of the rarer minerals occur at intervals in the lode, so that small blocks of rock composed almost entirely of monazite and fergusonite are occasionally met with. These latter have associated with them the secondary uranium minerals which have been referred to as gummite and uranosphaerite.

For the recovery of the monazite and fergusonite, commercial operations would necessitate the mining and milling of the whole of the formation followed by magnetic separation. A fergusonite concentrate recovered by this method of treatment from a bulk sample of the richer ore from this locality yielded a product equivalent to 6·5% U_3O_8.[2] In the case of a specially selected and purified sample of the fergusonite the produce had a U_3O_8 activity of 8%.

An average sample taken across the six feet face of solid hematite reef, where monazite but no fergusonite was visible, yielded on magnetic separation a recovery of 0·43% of monazite. The recovery from a hand-picked sample from the same place yielded 1·34% of monazite.

A magnetic and gravity separation of a rich mass of this monazite-fergusonite rock yielded 40% fergusonite, 40% monazite and 20% of hematite and quartz.

Another sample, containing noticeable fergusonite, was crushed and separated electromagnetically for a yield of 80% by weight of iron ore, 10% of monazite and 8% of fergusonite.

No. 3 is an ironstone mass some 60 yards by 20 yards in area capping Radium Ridge at an elevation of 850 feet above the camp on Radium Creek. This mass is composed of platy hematite associated with quartz and a variable amount of violet to black fluorspar; it is studded with small cells representing spaces from which some mineral has been weathered out, and in which scales of torbernite may be located. A cross-section sample of the leached outcrop was found to have a U_3O_8 activity equivalent to 0·27%. Experiments proved that by judicious crushing and electromagnetic separation a fraction having an activity of 1% U_3O_8 can be recovered.

This iron-rich mass dips to the north. A shaft sunk on the underlay side and a drive beneath it traversed weathered granite spangled with torbernite. A hand-picked sample of the better class granitic material from the spoil-heap was

(2) These U_3O_8 values for Mount Painter lode samples were determined electroscopically on their activity in relation to that of a standard Radium Hill mineral of known uranium content. It is, of course, realised that the uranium value thus obtained may, in special cases, especially when dealing with the weathered portion of uraniferous lodes, be considerably in error. For instance, where rapid leaching of the more soluble uranium minerals has been in progress, the radium as sulphate which is extremely insoluble will remain behind in unduly high proportion in relation to the uranium; in which case the electroscopic method will record too high a value for the uranium present.

found to have a U_3O_8 activity value of 0·4%. It was found that a more rigid selection could yield up to 0·7%.

No. 4 is a patch of hematite and vughy quartz with some fluorspar and traces of torbernite, which covers an area of about 50 yards by 20 yards and rests on granitic rock. In nature it is thus comparable with No. 3. This occurrence is at 330 feet above the camp, on a small spur which descends from Radium Ridge. Some black specks in the associated reddish-brown granite gave an indication of slight radio-activity when subjected to the autoradiographic test.

An excavation in the decomposed granite adjacent to the ironstone proved it to carry on a width of two feet a notable amount of torbernite. This 2-feet wide belt is the richest ore in this vicinity and its average grade is 0·37% U_3O_8

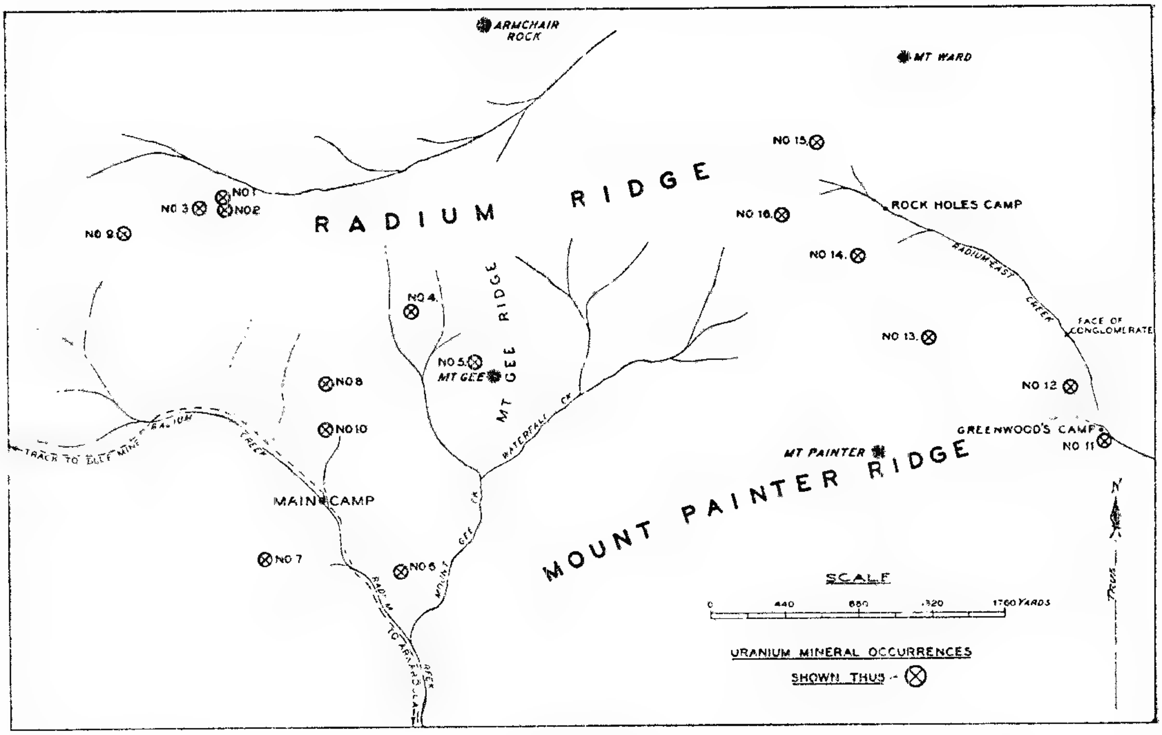

Fig. 6

The Mount Painter Field, with Localities of Uraniferous Occurrences.

value. By selecting only the fines from the crushed sample a value of 0·5% can be got.

No. 5—On the western slope of Mount Gee at 650 feet above the camp, on the line of a massive hematite formation, scattered flakes of torbernite are sparingly distributed through the rock. When quarrying here to a depth of seven feet occasional concentrations of uranium minerals, torbernite and a yellow ochreous substance were met with in vughs.

No. 6 has, up to the present, proved the richest of the finds. Here the outcrop is a manganiferous ironstone mass, with a nearly north to south trend. It is situated on the crest of a spur ridge overlooking and adjacent to Radium Creek. The collar of the shaft sunk on it is 270 feet above the creek bed at the foot of the spur.

The ironstone mass is situated on a north-south crush zone in granitic gneiss. An adit, driven 172 feet into the hillside 100 feet below the collar of the shaft, traverses siliceous gneiss in which are sillimanite-bearing belts.

The main shaft is located just where an east-west dislocation cuts the north-south crush zone. This east-west slip face dips at 60° to the south and is strongly slickensided. Along this face soft argillaceous and ferruginous ores have been met in seams up to 9 inches wide, composed principally of solid autunite. Apart from this the values have been principally confined to the hanging wall side, where thin seams and splashes of uranium minerals recur at intervals on slip and joint faces.

Extensive workings have not succeeded in locating further really rich ore since the slip-face body cut out at about the 50-feet level. The result of mining at No. 6 has been to raise a few tons of high-grade ore, some hundreds of tons of low-grade ore and to leave in the mine, developed ready for stoping, a considerable further quantity of low-grade ore.

At the time of my last visit average samples taken over two different sections of the richer areas exposed in the underground workings, gave respectively an average of 0·8% and 0·32% U_3O_8 activity. Experiments showed that, in the case of the first sample, by partial crushing and selecting the fines which passed through a 20-mesh sieve, a recovery could be made of 25% of the original weight but having an activity of 1·7%. The same treatment on a hand selected sample from the 0·32% ore yielded material of 1% activity.

Other results from this beneficition treatment of average samples from dumps in and about No. 6 workings are as follows: Ore of 0·77% U_3O_8 gave a 15% recovery of 20-mesh sievings of activity 1·7% U_3O_8; 0·63% ore yielded 16% recovery of 20-mesh sievings of activity 2·1% U_3O_8; 0·34% ore yielded 40% of 20-mesh sievings of activity 0·48% U_3O_8; 1·19% ore yielded 34% recovery of 30-mesh sievings of activity 2·5% U_3O_8.

A sample of very hard ore of 0·48% activity yielded a 15% recovery of 30-mesh screenings of activity 0·95%.

No. 7 is located on a steep spur 365 feet above the creek at the camp. The local rock is granitic gneiss with an east to west trend. The main workings are on a fracture zone trending approximately north to south. Alongside the fracture zone is a siliceous pegmatized vein with occasional drusy vughs. Secondary uranium minerals, chiefly torbernite and gummite, associated with concentrations of psilomelane are distributed in the rock adjacent to the vein.

Considerable mining reconnaissance has revealed that the only possible useful formation is to be taken as one foot in width. An average sample of this face gave a uranium activity value of 0·37%; but a greatly improved product could be obtained by beneficiation. By hand picking alone a useful grade of ore could no doubt be got, for some 5% U_3O_8 ore has been recovered and shipped abroad from these workings.

No. 8 is located 400 feet above the camp on a spur descending from Radium Ridge. There is no distinct lode outcrop. The country is granitic gneiss in which there are several drusy quartz stringers each about one inch thick, trending east to west, with torbernite concentrations related to them.

Hand-picked material from the dump, accumulated as the result of mining operations, gave an average value of 0·7% U_3O_8. Experiment shows that by selecting the fines passing through a 20-mesh sieve and by rumbling the coarse material a recovery of 21% of 1·7% U_3O_8 grade can be got. This, it is estimated, would mean the mining of 50 tons of the granitic rock to obtain one ton of the 1·7% grade.

No. 9 is a massive granular baryta-rich formation, possibly 60 feet wide and extending for some distance as a spur from the western end of Radium Ridge. On one side of it is an ironstone selvage bearing a considerable amount of fluorspar. Traces of carnotite were reported in a sample from this mass submitted by W. B. Greenwood to the Mines Department. Also traces of lead were reported. In a cursory inspection I did not observe any uranium minerals at this place, but is should be further investigated.

No. 10 is a locality where Mr. A. C. Broughton (2 and 3) collected slugs of radio-active ilmenite shed on the surface and embedded in mica schist and pegmatite. The rock is reported richest in this ilmenite at the contact of the pegmatite with the schist. Samples submitted by Broughton to W. B. Chapman for analysis have returned U_3O_8 content ranging from 0·30% to5%. The location is given as ½ mile distant, on a bearing W. 10° S. from Mount Gee; and about 1½ miles distant and on a bearing W. 5° N. from Mount Painter.

No. 11—A lode about 8 feet wide extending west into the face of the west bank of Radium-East Creek at a locality known as Greenwood's Camp. The late W. B. Greenwood, who first prospected the area made this spot one of his main camps. The lode is largely composed of platy hematite, and is somewhat cellular owing to removal by weathering of more readily decomposed constituents. Scales of torbernite occur in the cells and on joint planes. Traces of turquois have been met as films in the joint planes. The quality of the ore is low, so that even by severe hand-picking no useful quantity of 1% grade could be got.

At an elevation of 95 feet above the creek, on the opposite bank and separated by a couple of hundred yards, is a cut in the granite face exposing films of secondary iron oxide and occasionally turquois deposited along seams in the rock.

No. 12 is an ironstone formation of very limited proportions located in gneissic rock intersected by quartz and hematite infiltrations. It is situated at a point 153 feet above the creek, on a steep spur, about one-quarter of a mile to the west of north from No. 11. The ore is very low grade, averaging only about 0·1% U_3O_8 activity.

No. 13 is on a steep rock spur composed of conglomerate which has suffered much crushing in the course of dynamic metamorphism. Torbernite, very sparsely distributed in the rock, appears at intervals for several hundred feet down the hillside to the creek.

No. 14—Occasional spangles of torbernite are met with in crushed red granite. Cellular ironstone occupies the fracture spaces in the rock. At this locality flakes of torbernite have been observed in the substance of unfractured blocks of the granite and in vein quartz. The occurrence is of extremely low grade.

No. 15 is a large ironstone outcrop situated some 600 yards to the north-west of Rock Holes Camp and elevated at its summit some 550 feet above it. The ironstone mass rises through crushed granite country and is obviously of the nature of a replacement by solutions which have circulated in the crushed zone. In the case of certain leaders continuing to the west beyond the main body, clear evidence of metasomatic replacement of the feldspar by hematite is to be recognised.

The main mass of hematite-impregnated rock is some 200 yards in length and 50 yards in width. The type of ore here is very similar to that of No. 3. Fluorspar, deep blue to black, appears here and there in the formation, and in at least one place definite blebs of brown fergusonite are to be seen embedded in the hematite; quartz is a plentiful constituent. Torbernite is sparsely distributed throughout the mass and abundant along one zone.

Along the crown of the outcrop is a run of manganiferous ironstone some 30 feet wide, much richer in torbernite than elsewhere. This is evidently a shear zone, and as it trends directly towards No. 3, this locality may be regarded as a continuation of Radium Ridge.

Chippings across the outcrop of this ferruginous mass were crushed and found to have an average radio-activity equivalent to 0·4% U_3O_8. This ore could, of course, yield a useful quota of higher grade material. As the mass amounts to thousands of tons and there is hope of an improved grade in the shear zone below, it should be worth investigation.

No. 16—Torbernite outcrops extend for several hundred yards along the flank of a steep hillside about half-a-mile to the west of and 450 feet above the Rock Holes Camp.

This is a shatter zone in massive aplitic pink granite. Red feldspar and quartz are the most obvious minerals, but tiny grains of platy hematite and specks of other black minerals resembling ilmenite and found by the autoradiographic test to be radio-active are distributed through the rock in small quantities. Occasionally flakes of torbernite are to be seen on broken faces. In shatter zones there is more hematite and torbernite. A highly ferruginous outcrop measuring about 60 feet by 20 feet in superficial area is rich in iron and manganese, and carries some torbernite. An average sample of the torbernite-bearing red granite has less than 0·1% U_3O_8 activity and, therefore, is of no economic value.

Minerals of the Lodes

Hematite constitutes the main mass of some of the lode formations. It is a platy hematite of an unusually tough nature. A sample separated magnetically from No. 2 ore was found to contain no titanium, vanadium or niobium.

Monazite is associated with some of the highly ferruginous ore bodies, usually appearing in small quantity only. However in the occurrence at No. 2 it is abundant in local concentrations. A sample of the monazite from this lode, which we separated from other minerals by electromagnetic concentration, was analysed for me by R. G. Thomas; the result is included in the table below. The presence of iron, niobium, and silica appears to indicate that in the process of separation a pure monazite product was not achieved and that it contained some admixed fergusonite, etc. The small percentage of uranium oxide may also be accounted for as a constituent of the fergusonite. This monazite, it will be noted, is exceptionally low in thoria.

Monazite from the corundum schists, a mile or more to the west-south-west of No. 2, was found (11) also to carry an infinitesimal amount of thoria, namely 0·16% ThO_2 in one sample and 0·20% in another.

Fergusonite—W. S. Chapman referred a greasy liver-coloured constituent of several of the lodes to this mineral. I found it most abundant at No. 2 occurrence, but met with it also on Mount Gee and at No. 15. Chapman's analysis is quoted in the table below. We made partial analyses of samples of this mineral obtained from several localities, and in every case we got results lower in iron and higher in uranium than Chapman's original analysis, indicating either that the mineral varies in composition from place to place, or that the samples were not thoroughly free from foreign admixtures.

Fergusonite concentrate obtained from the No. 2 ore had an activity of that of 6·5% U_3O_8. In the case of specially selected and purified fergusonite its activity was found to be equal to 8% U_3O_8.

Doubtless the chemical composition of this mineral varies with the locality of occurrence in the Mount Painter field.

Recently my colleague, A. W. Kleeman, has kindly provided a check analysis. He utilized material from a rich monazite-fergusonite-hematite mass from No. 2 workings. The analysis was executed with great care and is, therefore, specially valuable. Though the mineral was separated as carefully as possible from other constituents of the rock (chiefly monazite and quartz), Kleeman found evidence that it was contaminated to some extent by mechanically held quartz. This latter was not taken up in the bisulphate fusion and is recorded in his initial analysis as "siliceous residue. The recomputed analysis, having deducted this impurity, is given in column III of the table. Chemically considered, it appears to be a member of either the fergusonite or samarskite group, though it could perhaps fit into the pyrochlore group. Mr. Kleeman is conducting further investigations to settle this point and will publish a fuller account in due course.

	I	II	III
SiO_2 (1)	9·78	6·26	—
TiO_2	nil	nil	0·43
Al_2O_3	—	2·99	0·46
Iron oxide	1·33 (2)	19·41 (3)	21·75 (3)
MnO	—	0·48	0·26
MgO	—	0·13	st. tr.
CaO	—	4·32	1·50
ThO_2	0·30	trace	st. tr.
Ce_2O_3	29·26	1·76	0·29
La_2O_3, etc.	25·60	—	0·12
Y_2O_3, etc.	3·30	7·08	3·75
Nb_2O_5	2·82 (4)	48·08 (4)	51·11
Ta_2O_5			2·00
U_3O_8	0·21	1·20	8·64
PbO	—	—	0·66
SnO_2	—	trace	trace
P_2O_5	27·17	—	—
H_2O+	0·81	6·44	4·57
H_2O-			3·22
	100·58	98·15	98·76

(1) Apparently mechanically admixed impurity.
(2) Computed as Fe_2O_3.
(3) Computed as FeO.
(4) Mainly Nb_2O_5.

I Monzite from No. 2. Analysed by R. G. Thomas. The sample reported to have been contaminated by a little quartz and fergusonite.
II "Fergusonite" from Radium Ridge. Analysed by W. S. Chapman. Sample selected as free as possible from associated siliceous matter, etc.
III "Fergusonite" from No. 2 workings. Analysed by A. W. Kleeman. Recomputed analysis after allowing for elimination of mechanically admixed siliceous impurity.

Autunite is common in the weathered portion of the lodes, but is seen only rarely in the actual outcrops. Some wonderful specimens of it have been got from No. 6 in the deeper working.

Torbernite is the most widely distributed secondary uranium mineral in the Mount Painter field.

In portion of the upper zone of No. 6 the "torbernite" is of a peculiar siskin-green colour. Some of it was examined by A. W. Kleeman, who reports it as closely corresponding to *metatorbernite*

From the No. 6 workings *chalco-uranite* has been reported. Analyses of the uranate minerals from this same locality have sometimes included arsenic present replacing some of the phosphorus, indicating transitions towards *uranospinite* and *zeunerite*.

From the No. 2 workings, and from Mount Gee, *uranophane* and *gummite* have been reported by Mr. W. S. Chapman. A mineral resembling *urano-sphaerite* was found at the No. 2 workings. Carnotite has been recorded by Mr. Chapman both from No. 9 and No. 10 workings. There has, however, been no quantitative determinations of any of these secondary uranium minerals.

Radio-Active Ilmenite.—Broughton has described (2) the occurrence of uraniferous ilmenite from locality 10, where he collected pieces up to three inches in diameter. A representative sample first submitted to W. S. Chapman for analysis was found to contain 34·1% TiO_2, 17·8% total Fe and 3·7% U_3O_8; also the presence of vanadium was recorded. This sample had a conchoidal fracture and was said to show yellow stains of carnotite on the fracture faces. Some of the fragments are stated to show evidence of partial leucoxenization.

A later sample collected by Broughton was reported (3) to contain 20·1% TiO_2 and 0·30% U_3O_8. Finally, a sample submitted to Chapman was found to contain 48% TiO_2 and 5% U_3O_8; iron and the cerium earths were present also. This latter sample was stated to resemble very closely the Radium Hill ore.

The red aplitic granite from certain localities, for instance from No. 16 contains particles of hematite and other black specks, some of which were found by autoradiographic test to be radio-active. These are suspected of being radio-active ilmenite, though some may be even specks of broeggerite.

Fluorite is met with in many of the uraniferous outcrops, but in no case has it been found to be radio-active. Also the absence of rare-earths has been proved in the case of that from the No. 3 occurrence. It ranges from colourless to black, much of it being amethystine or green. Where it is present, it is usually scattered in isolated grains throughout the ore complex.

MOUNT OGILVIE, NORTHERN FLINDERS RANGES

F. M. Krause (7) is responsible for the following statement: "Liebigite is a decomposition product of other uranium ores. An impure variety, mixed with some clayey and ochreous matter and enclosing native gold, occurs at Mount Ogilvie, S.A." This locality is about 42 miles to the west of Mount Painter and is in a region of Proterozoic sediments. Some years ago rich pockets of gold were mined in that area. I have not found any other reference to the discovery of uranium ores in that vicinity. Liebigite is a hydrous-calcium-uranium-carbonate. At my suggestion, Mr. G. A. Greenwood, of Mount Serle Station, paid a visit to the Mount Ogilvie mining field, but failed to locate uranium minerals.

OCCURRENCE IN THE MUSGRAVE RANGES

Recently Mr. A. F. Wilson, on a geological reconnaissance in the vicinity of Ernabella, discovered a radio-active mineral occurring in large crystal masses in a coarse pegmatite. It is only weakly radio-active, but its presence in the pegmatites of the locality increases the hope that other uranium-bearing minerals may be discovered in that extensive region of older Pre-Cambrian rocks. In due course, Mr. Wilson will publish details of his interesting mineral discovery.

ACKNOWLEDGMENTS

The amount of laboratory and field work embodied in these investigations in the Olary and the Mount Painter fields has been very considerable, and much help has been rendered by my students and colleagues. Chief amongst these are R. G. Thomas and A. R. Alderman. A notable contribution has been provided by the analytical section of the Mines Department, mainly during the term of office of Mr. W. S. Chapman. Also in chemical investigations, my colleague, A. W. Kleeman, has recently assisted by checking certain of the analyses. At the time when active development at Radium Hill lodes was at its height Dr. C. T. Madigan kindly assisted in the examination of the lodes. Finally, at all times in the prosecution of field operations in the Mount Painter area, great help has been accorded to me by Mr. Gordon A. Greenwood of Mount Serle Station, and by his brother Bentley of Arkaroola Station. In conclusion, H. E. E. Brock's skilful assistance in providing microscopical preparations and plans has been greatly appreciated.

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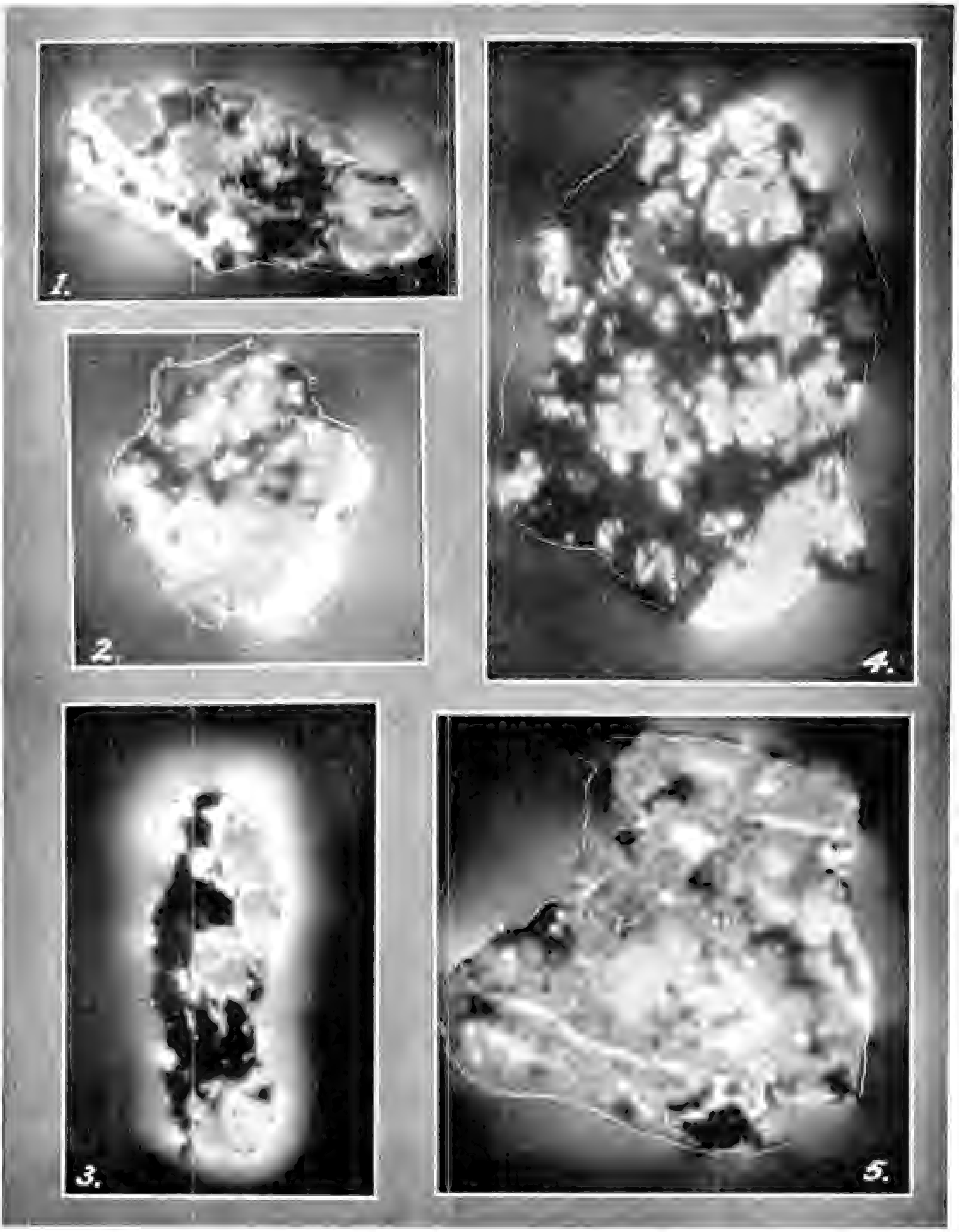
Fig. 1 The Radium Hill Mine soon after its Discovery

Fig. 2 Mount Gee. Viewed from the west.

Fig. 1 No. 6 Workings and Radium Ridge forming the sky-line

Fig. 2 No. 3 Workings on Radium Ridge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EXPLANATION OF PLATES

PLATE XIX

Fig. 1 The mine at Radium Hill, showing the locality as it appeared in the year 1906 soon after its discovery. The main lode extends in a line from the shaft in the foreground to the figure standing on the outcrop in the distance. The picture illustrates the flat nature of the country and the sparsely distributed mulga scrub.

Fig. 2 Mount Gee, viewed from the west. The dark belt outcropping on the slopes is mainly a lode of massive hematite; with it is associated No. 5 workings.

PLATE XX

Fig. 1 Looking north-west from the main shaft sunk on No. 6 workings. Radium Ridge forms the distant sky-line. The figure is that of Mr. Fabian, who was in charge of developments in earlier stages of production.

Fig. 2 No. 3 workings on Radium Ridge.

PLATE XXI

Autoradiographs of polished faces of Radium Hill ore; reproduced natural size.

Fig. 1 Showing, in the upper left-hand corner of the picture, davidite crystals lining a narrow vein traversing heterogeneous iron-ore minerals. The homogeneous character of davidite is reflected in the uniformity of its photographic record. The dark non-active mineral (dark spaces between the davidite crystals) of the vein is quartz. The inactive areas elsewhere are occupied by rutile and hematite. Areas of medium activity are of radio-active ilmenite. At the right-hand bottom corner is ilmenite which by reaction with later lode solutions has lost most of the davidite quota of the peripheral zone, though it remains unaltered in the core area.

Fig. 2 Another example illustrating, in the lower right-hand side of the picture, a late-formed vein of pure davidite traversing the ore complex which in this case is mainly radio-active ilmenite. The latter, particularly in the neighbourhood of the davidite vein, has lost part of its davidite quota. The non-active mineral in hematite.

Fig. 3 The white areas are davidite and the bright films are carnotite. The davidite is mainly at the top left-hand corner on either side of the quartz (inactive). The other black areas are rutile, and non-active iron-ore.

Fig. 4 A record of the dead-black radio-active "ilmenite" from the south end of the main lode. This is the mineral recorded in column v of the table on page 344. The unrecorded areas are occupied by quartz, biotite, rutile, etc. The non-homogeniety of the "ilmenite" is illustrated by variations in the intensity of the record. In this case, where biotite has been developed as a late-formed mineral partly at the expense of the iron from the "ilmenite," the border of the latter individuals is enhanced in activity.

Fig. 5 Here the original mineral was radio-active ilmenite, but it has been affected at a later stage by secondary changes. Where the latter has operated the intensity of activity has been reduced. Kernels of the original mineral are indicated by the uniform lighter areas within. The very bright specks and streaks are secondary ex-solution concentrations of davidite.

OBITUARY NOTICES

FREDERICK CHAPMAN

Frederick Chapman, who passed away on 13 December 1943, at the age of 79, had been an Honorary Fellow of our Society since 1926.

AWARDS OF THE SIR JOSEPH VERCO MEDAL

OBITUARY NOTICES

FREDERICK CHAPMAN

Frederick Chapman, who passed away on 13 December 1943, at the age of 79, had been an Honorary Fellow of our Society since 1926.

Born at Camden Town, London, in 1864, he started his scientific career, and for 20 years continued, as assistant to Prof. Judd at the Royal College of Science, London. During this period he established himself as an authority on the foraminifera.

In 1902 he was appointed palaeontologist to the National Museum, Melbourne, and commenced a long and full study of Australian fossils. In addition to a large number of papers (over 500), mainly on fossil invertebrates, contributed to scientific journals, including our own Transactions, he published, in 1914, "Australasian Fossils." In 1927, on retiring from the National Museum, he was appointed Commonweath Palaeontologist in connection with the search for oil. He was a Fellow of the Geological Society of London, from which Society he was awarded the Lyell Medal; he was also an Associate (*honoris causa*) of the Linnean Society of London.

REV. N. H. LOUWYCK

The Rev. Napoleon Henry Louwyck died on 18 August at the age of 81. He had been a member of our Society since 1920, and was not only a regular attendant at the monthly meetings, but also had contributed to our Transactions. Mr. Louwyck was born at Hauthen, in Belgium, and as a Capuchin monk served in India. In 1900 he left the Catholic Church and entered the Church of England. In 1916 he came to Australia and was priest-in-charge at Yorketown and rector at Yankalilla, retiring in 1937. He was an authority on Egyptology, archaeology and anthropology, and was Past President of the Anthropological Society of South Australia. He privately published several books, such as "In Quest of Truth," "Mental Indefiniteness," etc., using his own small printing press and setting his own type.

AWARDS OF THE SIR JOSEPH VERCO MEDAL

1929 Prof. Walter Howchin, F.G.S.
1930 John McC. Black, A.L.S.
1931 Prof. Sir Douglas Mawson, O.B.E., D.Sc., B.E., F.R.S.
1933 Prof. J. Burton Cleland, M.D.
1935 Prof. T. Harvey Johnston, M.A., D.Sc.
1938 Prof. J. A. Prescott, D.Sc., F.A.I.C.
1943 Herbert Womersley, A.L.S., F.R.E.S.
1944 Prof. J. G. Wood, D.Sc., Ph.D.

ROYAL SOCIETY OF SOUTH AUSTRALIA (INCORPORATED).

Receipts and Payments for the Year ended September 30, 1944.

ROYAL SOCIETY OF SOUTH AUSTRALIA (INCORPORATED)

Receipts and Payments for the Year ended 30 September 1944

RECEIPTS

	£ s. d.	£ s. d.
To Balance, 1 October, 1943		165 14 9
" Subscriptions		124 19 0
" Government Grant for Printing etc.		145 19 4
" Sale of Publications and Reprints:—		
University of Adelaide	28 13 0	
Sundries	32 13 0	
		61 2 6
" Use of Room	3 9 0	
Exchange	– 2 0	
		3 11 0
" Interest — Transferred from Endowment Fund		199 15 3
		£701 1 10

PAYMENTS

	£ s. d.	£ s. d.
By Transactions (Vol. 67, Pt. 2)—		
Printing	211 3 4	
Illustrating	58 13 2	
Publishing	13 19 3	
		283 15 9
" Reprints		58 10 11
" Librarian		32 18 0
" Sundries—		
Lighting	3 14 6	
Cleaning	17 8 9	
Printing, Postages and Stationery	23 17 3	
Library	1 0 0	
Petties	6 5 0	
Epidiascope	1 15 0	
Insurances	6 10 0	
Legal Expenses	1 11 6	
		62 2 0
" Balances—30 Sep. 1944—		
Savings Bank of S.A.	251 2 4	
Bank of Aust., £20 17 8 *Less* Outstanding Chqus. 8 4 10	12 12 10	
		263 15 2
		£701 1 10

ENDOWMENT FUND as at 30 September 1944

(Capital—Stocks, etc., Face Value, £5,969 4s. 10d.; Cost, £5,821 4s. 10d.)

	£ s. d.	£ s. d.
1943 October 1		
To Balance—		
Aust. Inscribed Stocks	5,812 0 0	
Savings Bank of S.A.	9 4 10	
		5,821 4 10
" Interest—		
Inscribed Stocks	196 16 6	
Savings Bank of S.A.	2 18 9	
		199 15 3
		£6,021 0 1

	£ s. d.	£ s. d.
1944—September 30		
By Revenue Account		199 15 3
" Balance—		
Aust. Inscribed Stocks	5,812 0 0	
Savings Bank of S.A.	9 4 10	
		5,821 4 10
		£6,021 0 1

Audited and found correct. The Inscribed Stocks and respective Bank Balances have been verified by certificates.

O. GLASTONBURY, F.A.I.S., A.F.I.A. } Hon.
F. M. ANGEL } Auditors

HERBERT M. HALE,
Hon. Treasurer

Adelaide, 11 October, 1944

LIST OF FELLOWS, MEMBERS, ETC.
AS ON 30 SEPTEMBER 1944

Those marked with an asterisk (*) have contributed papers published in the Society's Transactions.
Those marked with a dagger (†) are Life Members.
Any change in address or any other changes should be notified to the Secretary.
Note - The publications of the Society are not sent to those members whose subscriptions are in arrear.

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Any change in address or any other changes should be notified to the Secretary.

Note—The publications of the Society are not sent to those members whose subscriptions are in arrear.

Date of Election. HONORARY FELLOW

1894. *WILSON, Prof. J. T., M.D., Ch.M., F.R.S., Cambridge University, England.

FELLOWS.

1935. ADAM, D. B., B.Agr.Sc., Waite Institute (Private Mail Bag), Adelaide—**Council**, 1939-42; **Vice-President**, 1942-; **Librarian**, 1942-.
1927. *ALDERMAN, A. R., Ph.D., M.Sc., F.G.S., Div. Indus. Chemistry, C.S.I.R., Box 4331, G.P.O., Melbourne, Victoria—**Council**, 1937-42.
1931. ANDREW, REV. J. R., 5 York Street, Henley Beach, S.A.
1935. *ANDREWARTHA, H. G., M.Agr.Sc., Waite Institute (Private Mail Bag), Adelaide.
1935. *ANDREWARTHA, MRS. H. V., B.Agr.Sc., M.S., 29 Claremont Avenue, Netherby, S.A.
1929. ANGEL, F. M., 34 Fullarton Road, Parkside, S.A.
1939. *ANGEL, MISS L. M., M.Sc., University, Adelaide.
1936. BARRIEN, MISS B. S., M.Sc., University, Adelaide.
1932. BEGG, P. R., D.D.Sc., L.D.S., Shell House, 170 North Terrace, Adelaide.
1928. BEST, R. J., M.Sc., F.A.C.I., Waite Institute (Private Mail Bag), Adelaide.
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1934. BLACK, E. C., M.B., B.S., Magill Road, Tranmere, Adelaide.
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1944. CASSON, P. B., B.Sc., For. (Adel.), Dept. For., Mount Crawford Forest, S.A.
1929. CHRISTIE, W., M.B., B.S., Education Department, Adelaide—**Treasurer**, 1933-8.
1895. *CLELAND, PROF. J. B., M.D., University, Adelaide—**Verco Medal**, 1933; **Council**, 1921-26, 1932-37; **President**, 1927-28; 1940-41; **Vice-President**, 1926-27, 1941-42.
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1930. *COLQUHOUN, T. T., M.Sc., Waite Institute (Private Mail Bag), Adelaide—**Secretary**, 1942-43.
1938. *CONDON, H. T., S.A. Museum, Adelaide.
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1944. CORNISH, MELVILLE, State Bank, Pirie Street, Adelaide.
1929. *COTTON, B. C., S.A. Museum, Adelaide—**Council**, 1943-
1924. DE CRESPIGNY, SIR C. T. C., D.S.O., M.D., F.R.C.P., 219 North Terrace, Adelaide.
1937. *CROCKER, R. L., M.Sc., Waite Institute (Private Mail Bag), Adelaide—**Secretary**, 1943-
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1927. *DAVIES, PROF. E. H., Mus.Doc., The University, Adelaide.
1941. *DICKINSON, S. B., B.Sc., Mines Department, Flinders Street, Adelaide.
1930. DIX, E. V., Hospitals Department, Adelaide, S.A.
1932. DUNSTONE, H. E., M.B., B.S., J.P., 124 Payneham Road, St. Peters, Adelaide.
1944. DUNSTONE, S. M. L., M.B., B.S., c/o Dr. Cardon, Partridge Street, Glenelg, S.A.
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1931. DWYER, J. M., M.B., B.S., 25 Port Road, Bowden. (A.I.F. abroad.)
1933. *EARDLEY, MISS C. M., B.Sc., Waite Institute (Private Mail Bag), Adelaide—**Council**, 1943-
1902. *EDQUIST, A. G., 19 Farrell Street, Glenelg, S.A.

Date of Election.

1917. *Fenner, C. A. E., D.Sc., 42 Alexandra Av., Rose Park, Adelaide—**Council,** 1925-28; **President,** 1930-31; **Vice-President,** 1928-30; **Secretary** 1924-25; **Treasurer,** 1932-33; **Editor,** 1934-37.
1935. *Fenner, F. J., M.B., B.S., 42 Alexandra Avenue, Rose Park. (A.I.F. abroad.)
1944. Ferres, Miss H. M., 8 Taylor's Road, Mitcham, S.A.
1927. *Finlayson, H. H., 305 Ward Street, North Adelaide—**Council,** 1937-40.
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1932. *Gibson, E. S. H., B.Sc., 297 Cross Roads, Clarence Gardens, Adelaide.
1935. *Glastonbury, J. O. G., B.A., M.Sc., Dip.Ed., Armament School, R.A.A.F., Hamilton, Victoria.
1919. †Glastonbury, O. A., Adelaide Cement Co., Grenfell Street, Adelaide.
1927. Godfrey, F. K., Robert Street, Payneham, S.A.
1935. †Goldsack, H., Coromandel Valley.
1939. Goode, J. R., B.Agr. Sc., Box 180, G.P.O., Whyalla, S.A.
1925. †Gosse, J. H., Gilbert House, Gilbert Place, Adelaide.
1910. *Grant, Prof. Kerr, M.Sc., F.I.P., University, Adelaide.
1930. Gray, J. T., Orroroo, S.A.
1933. Greaves, H., Director, Botanic Gardens, Adelaide.
1904. Griffith, H. B., Dunrobin Road, Brighton, S.A.
1934. Gunter, Rev. H. A., 10 Broughton Street, Glenside, S.A.
1944. Guppy, D. J., B.Sc., R.A.A.F.
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1944. Harris, J. B., B.Sc., 3 Airlie Avenue, Prospect, S.A.
1939. Harvey, Miss A., B.A., Dequetteville Terr., Kent Town, Adelaide.
1944. Herriot, R. I., B.Agr.Sc., Soil Conservator, Dept. of Agriculture, S.A.
1927. Holden, The Hon. E. W., B.Sc., Dequetteville Terrace, Kent Town, Adelaide.
1933. Hosking, H. C., B.A., 24 Northcote Terrace, Gilberton, Adelaide.
1924. *Hossfeld, P. S., M.Sc., 132 Fisher Street, Fullarton, S.A.
1944. Humble, D. S. W., 238 Payneham Road, Payneham, S.A.
1928. Ifould, P., Kurralta, Burnside, S.A.
1942. Jenkins, C. F. H., Department of Agriculture, St. George's Terrace, Perth, W.A.
1918. *Jennison, Rev. J. C., 7 Frew Street, Fullarton, Adelaide.
1910. *Johnson, E. A., M.D., M.R.C.S., "Tarni Warra," Port Noarlunga, S.A.
1921. *Johnston, Prof. T. H., M.A., D.Sc., University, Adelaide—**Verco Medal,** 1935; **Council,** 1926-28, 1940-; **Vice-President,** 1928-31; **President,** 1931-32; **Secretary** 1938-40; **Rep. Fauna and Flora Board,** 1932-39; **Editor,** 1943-.
1939. †Khakhar, H. M., Ph.D., M.B., F.R.G.S., Khakar Buildings, C.P. Tank Road, Bombay, India.
1933. *Kleeman, A. W., M.Sc., University, Adelaide.
1939. Leask, J. C., A.M.I.E., 9 Buller Street, Prospect, S.A.
1922. Lendon, G. A., M.D., B.S., F.R.C.P., North Terrace, Adelaide. (A.I.F. abroad.)
1938. *Love, Rev., J. R. B., M.C., D.C.M., M.A., Ernabella, via Oodnadatta, S.A.
1931. *Ludbrook (Mrs. W. V.), N. H., M.A., Elimatta Street, Reid, A.C.T.
1938. Madern, C. B., B.D.S., D.D.Sc., Shell House, North Terrace, Adelaide.
1922. *Madigan, C. T., M.A., B.E., D.Sc., F.G.S., University of Adelaide—**Council,** 1929-33; **Vice-President,** 1933-35, 1936-37; **President,** 1935-36.
1933. Magarey, Miss K. de B., B.A., B.Sc., 19 Ashbourne Avenue, Mitcham, S.A.
1932. Mann, E. A., C/o Bank of Adelaide, Adelaide.
1923. Marshall, J. C., Mageppa Station, Comaum, S.A.
1939. Marshall, T. J., M.Agr.Sc., Ph.D., Waite Institute (Private Mail Bag), Adelaide.
1929. Martin, F. C., M.A., Technical High School, Thebarton, S.A.
1905. *Mawson, Prof. Sir Douglas, O.B.E., D.Sc., B.E., F.R.S., University, Adelaide—**Verco Medal,** 1931; **President,** 1924-25, 1944-; **Vice-President,** 1923-24, 1925-26; **Council,** 1941-43.
1938. *Mawson, Miss P. M., M.Sc., University, Adelaide.
1926. Mayo, The Hon. Mr. Justice, LL.B., K.C., Supreme Court, Adelaide.
1943. McCarthy, Miss D. F., B.A., B.Sc., 70 Halton Terrace, Kensington Park.
1934. McCloughry, C. L., B.E., A.M.I.E. (Aust.), Town Hall, Adelaide.
1944. McGilp, L. K., 294 Seaview Road, Henley Beach, S.A.
1929. McLaughlin, E., M.B., B.S., M.R.C.P., 2 Wakefield Street, Kent Town, Adelaide.
1907. Melrose, R. T., Mount Pleasant, S.A.
1939. Mincham, V. H., Willaloo, via Hallett, S.A.
1925. †Mitchell, Prof. Sir W., K.C.M.G., M.A., D.Sc., Fitzroy Ter., Prospect, SA.
1933. Mitchell, Prof. M. L., M.Sc., University, Adelaide.
1938. Moorhouse, F. W., M.Sc., Chief Inspector of Fisheries, Flinders Street, Adelaide.
1940. Mortlock, J. A. T., 39 Currie Street, Adelaide.

Date of
Election.

1936. *Mountford, C. P., 25 First Avenue, St. Peters, Adelaide.
1944. Murrell, J. W., Engineer and Waters Dept., Port Road, Thebarton, S.A.
1944. Ninnes, A. R., B.A., 62 Sheffield Street, Malvern, S.A.
1930. Ockenden, G. P., Public School, Norton's Summit, S.A.
1913. *Osborn, Prof. T. G. B., D.Sc., University, Oxford, England—**Council,** 1915-20, 1922-24; **President,** 1925-26; **Vice-President,** 1924-25, 1926-27.
1937. *Parkin, L. W., M.A., B.Sc., c/o Nth. Broken Hill Ltd., Box 20 C, Broken Hill, N.S.W.
1929. Paull, A. G., M.A., B.Sc., Eglinton Terrace, Mount Gambier.
1928 Phipps, I. F., Ph.D., B.Agr.Sc., c/o The Flax Production Committee, 409 Collins Street, Melbourne, Victoria.
192[illegible]. *Piper, C. S., D.Sc., Waite Institute (Private Mail Bag), Adelaide—**Council,** 1941-43.
1925. *Prescott, Prof. J. A., D.Sc., A.I.C., Waite Institute (Private Mail Bag), Adelaide—**Verco Medal,** 1938; **Council,** 1927-30, 1935-39; **Vice-President,** 1930-32; **President,** 1932-33.
192[illegible]. Price, A. G., C.M.G., M.A., Litt.D., F.R.G.S., 226 Melbourne Street, North Adelaide.
1942. Pugsley, A. T., B.Ag.Sc., M.Sc., Waite Institute (Private Mail Bag), Adelaide.
1937. *Rait, W. L., M.Sc., Medical School, University of Melbourne, Carlton N. 3, Victoria
1944. Riceman, D. S., B.Agr.Sc., Animal Nutrition Labor., Univ., Adelaide.
1925. Richardson, A. E. V., C.M.G., M.A., D.Sc., 314 Albert Street, East Melbourne.
1944. Sandars, Miss D. F., Dept. of Biology, University, Nedlands, W.A.
1933. Schneider, M., M.B., B.S., 175 North Terr., Adelaide.
1924. *Segnit, R. W., M.A., B.Sc., Assist. Govt., Geol., Flinders St., Adelaide—**Secretary,** 1930-35; **Council,** 1937-38; **Vice-President,** 1938-39, 1940-41; **President,** 1939-40.
1925 *Sheard, H., Victor Harbour, S.A.
19[illegible] *Sheard, K., Fisheries Research Div. C.S.I.R., Cronulla, N.S.W.
1934. Shinkfield, R. C., Salisbury, S.A.
1942 Simmonds, H. W., 130 Fisher Street, Fullarton, S.A.
1938. *Simpson, Mrs. E. R., M.Sc., Warland Road, Burnside.
1924. Simpson, F. N., Pirie Street, Adelaide.
1944. Smith, C. A. N., Waite Institute (Private Mail Bag), Adelaide, S.A.
1941. Smith, J. Langford, B.Sc., Waite Institute (Private Mail Bag), Adelaide. (R.A.A.F.)
1942. Snowball, G. J., B.Sc., Waite Institute (Private Mail Bag), Adelaide.
1941. Southcott, R. V., M.B., B.S., 12 Avenue Road, Unley Park, S.A.
1936. Southwood, A. R., M.D., M.S. (Adel.), M.R.C.P., Wootoona Terr., Glen Osmond, S.A.
193[illegible] *Sprigg, R. C., M.Sc., "Delamere," Delamere Avenue, Springfield.
1938. *Stephens, C. G., M.Sc., Waite Institute (Private Mail Bag), Adelaide.
1932. Swan, D. C., M.Sc., Waite Institute (Private Mail Bag), Adelaide—**Secretary,** 1940-42.
1934. Symons, I. G., Murray Street, Mitcham.
1929. *Taylor, J. K., B.A., M.Sc., Waite Institute (Private Mail Bag), Adelaide—**Council,** 1940-43.
1943. Tesch, J. E., B.Agr.Sc., 3 Mitchell Street, Hyde Park.
1940 Thomson, J. M., 135 Military Road, Semaphore South.
1923 *Tindale, N. B., B.Sc., South Australian Museum, Adelaide—**Secretary,** 1935-36. (R.A.A.F.)
1937. *Trumble, Prof. H. C., D.Sc., M.Agr.Sc., Waite Institute (Private Mail Bag), Adelaide—**Council,** 1942-
1894. *Turner, A. J., M.D., F.R.E.S., Dauphin Terr., Brisbane, Qld.
1925. Turner, D. C., National Chambers, King William Street, Adelaide.
1933 Walkley, A., B.A., B.Sc., Ph.D., Div. Industrial Chemistry, C.S.I.R., Box 4331, Melbourne, Victoria.
1912. *Ward, L. K., B.A., B.E., D.Sc., 22 Northumberland Avenue, Tusmore—**Council,** 1924-27, 1933-35; **President,** 1928-30; **Vice-President,** 1927-28.
1941 *Wark, D. C., M.Agr.Sc., Waite Institute (Private Mail Bag), Adelaide.
1936. Waterhouse, Miss L. M., 35 King Street, Brighton, S.A.
1942. Watson, R. H., Central Wool Committee Testing House, 572 Flinders Lane, Melb., C1.
1939. Weeding, Rev. B. J., Hamley Bridge, S.A.
1931. Wilson, C. E. C., M.B., B.S., "Woodfield," Fisher Street, Fullarton, Adelaide.
1944. Wilson, E. C., M.A., B.Sc., Myrtle Bank, S.A.
1938 *Wilson, J. O., Animal Nutrition Laboratory, University, Adelaide.
1930 *Womersley, H., F.R.E.S., A.L.S. (*Hon. causa*), S.A. Museum, Adelaide—**Secretary,** 1930-37; **Editor,** 1937-43; **President,** 1943-44; **Verco Medal,** 1943; **Vice-President,** 1944-.
1944. Womersley, H. B. S., B.Sc., Hon., 43 Carlisle Road, Westbourne Park, S.A.
1944. Womersley, J. S., 43 Carlisle Road, Westbourne Park, S.A.
1923. *Wood, Prof. J. G., D.Sc., Ph.D., University, Adelaide—**Council,** 1938-40; **Vice-President,** 1940-41; **Rep. Fauna and Flora Board,** 1940-; **President,** 1941-42.
1943. Woodlands, Harold, Box 989 H, G.P.O., Adelaide.

GENERAL INDEX.

[Generic and specific names in italics indicate that the forms described are new to science.]

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PART II