THE

PROCEEDINGS

OF THE

LINNEAN SOCIETY

OF

NEW SOUTH WALES.

FOR THE YEAR

1906.

Vol. XXXI.

WITH SIXTY-NINE PLATES

(And Key Plate xlix. *bis*).

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PART I. (No. 121).

(Issued June 27th, 1906.)

PART II. (No. 122).

(Issued October 3rd, 1906.)

PART II. *(continued.)*

PART III. (No. 123).

(Issued November 19th, 1906.)

PART III. *(continued).*

PART IV. (No. 124).

(Issued March 28th, 1907.)

PART IV. *(continued)*.

LIST OF PLATES.

PROCEEDINGS, 1906.

LIST OF NEW GENERIC TERMS

PROPOSED IN THIS VOLUME (1906).

CORRIGENDA.

Page 68, line 12—for *Bœckia* read *Bæckea*.
Page 69, line 30—for *Goodenia Brownii* F.v.M., read *Dampiera Brownii* F.v.M. (in foliage only).
Page 259, line 10—for *Adelium minor* read *Adelium minus*.
Page 318, line 7—for *M. cylindrica* read
Page 363, line 6—*for* on behalf the *read* on behalf of the.
Page 454—In the explanation of Plate xliii. (and also on the Plate itself) it should be noted that the legends of Figs.1 and 2 have been inadvertently changed (that is to say, the explanation of Fig.1, as printed, applies to the lower figure [Fig.2]; and that of Fig.2 to the upper [Fig.1]).
Page 568, line 22—delete the comma after "titration".

Issued June 27th, 1906.

Vol. XXXI.
Part 1. **No. 121.**

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PART I.

Containing Papers read in

MARCH to APRIL,

WITH SEVENTEEN PLATES.

(Plates i.-v., v.*bis.*-xvi.)

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PROCEEDINGS

OF THE

LINNEAN SOCIETY

OF

NEW SOUTH WALES.

WEDNESDAY, MARCH 28TH, 1906.

ORDINARY MONTHLY MEETING.

The Ordinary Monthly Meeting of the Society was held in the Linnean Hall, Ithaca Road, Elizabeth Bay, on Wednesday evening, March 28th, 1906.

Mr. T. Steel, F.C.S., F.L.S., President, in the Chair.

Mr. JOHN DEAVEY LORD, Public School, Numba, viâ Nowra, N.S.W., and Mr. P. LOCKWOOD, State School, Patersonia, Tasmania, were elected Ordinary Members of the Society.

The Donations and Exchanges received since the previous Monthly Meeting (November 29th, 1905), amounting to 40 Vols., 244 Parts or Nos., 79 Bulletins, 11 Reports, 54 Pamphlets, 4 Catalogues, and 2 Miscellanea, received from 114 Societies, &c., and 4 Individuals, were laid upon the table.

ON A COLLECTION OF CRUSTACEA FROM THE PORT CURTIS DISTRICT, QUEENSLAND.

By F. E. Grant, F.L.S., and Allan R. McCulloch, Australian Museum.

(Plates i.-iv.).

The collection of Decapod Crustacea forming the subject of this paper was made in 1904, in Port Curtis, Queensland, and on and in the vicinity of Mast Head Island, situate some 30 miles from the entrance to that Harbour, by a party of naturalists which included the authors, under the leadership of Mr. C. Hedley, F.L.S.

From the widely different nature of the two localities the specimens fall naturally into two groups—those from the coral reefs of Mast Head Island offering a striking contrast to the estuarine forms from Port Curtis.

The waters of that Harbour are considerably affected by the amount of sediment washed down by the Boyne River, Calliope Creek, and other streams from the neighbouring ranges. It is in many parts on the landward side fringed by extensive flats clothed in part with mangroves. These were found to be rich collecting grounds—the mud being riddled with the burrows of *Uca*, *Metopograpsus*, *Sesarma*, *Axius*, and other estuarine species. Of these the first mentioned were in the greatest numbers and were the most striking—each with its brightly coloured carapace standing in the mouth of its burrow at low tide and incessantly waving its large and unwieldly hand as though beckoning. The amount of life supported by these unpromising mud flats is most surprising, and they would well repay more attention and much more careful search than has yet been given them.

On the seaward side of the Harbour there is a series of large rocky islands. Here, although the water is still affected by the mud, there is a slightly different fauna, which, however, bears a coastal stamp.

Some dredging was done in Port Curtis in depths of 4 to 10 fathoms. The bottom was found to be more or less sandy, with an admixture of mud on the landward side and everywhere with a great quantity of shingle. Here, amongst others, a number of the species collected by H.M.S. "Alert" which visited this coast in April, 1881, and which were described by Miers in the 'Zoology' of that voyage, were retaken.

Immediately to the east of the islands forming the seaward face of Port Curtis there lies a small island called Rat Island. This being situate in the clearer waters unaffected by the land drainage, carries a growth of coral. This was visited by Dr. Pulleine, of Gympie, to whom our thanks are due for placing the collection made at this point in our hands. The specimens have distinctly the facies of the coral fauna, and are in the accompanying comparative list included with those taken from Mast Head Island.

Mast Head Island is situate some 30 miles to the east of Gatcombe Head at the entrance of Port Curtis, and about four miles to the south of the Tropic of Capricorn. It forms one of the Capricorn Group, and is almost at the south end of the Great Barrier Reef. Here a camp was made and eight days were spent in collecting, the conditions being found quite dissimilar from those in Port Curtis.

The island forms part of a typical coral atoll. It is 90 acres in extent, surrounded by the lagoon and fringing reef which it touches at its north-west point, but which on the other side is some six miles distant. The shallow lagoon contains a great amount of living coral, and the surrounding reef, which is uncovered for some hours as the tide goes out, exhibits a large field of strewed coral blocks, many of them loose and others firmly fixed by secondary deposit of lime, requiring a crow-bar to move them, but all presenting an ideal field for the collector.

Beyond the reef the water sinks rapidly to a plateau, having a depth varying from 10 to 25 fathoms, from which the islands of the group rise. By dredging much interesting material was taken, including a new species of *Cryptocnemus*, which is here described.

On the reef the most conspicuous and numerous crabs were *Atergatis floridus* Linn., with its brilliant green and gold carapace, *Eriphia lævimana* Latr., with bright red sealing-wax-like eyes and purple carapace, several species of *Actæa*, *Thalamita*, *Metopograpsus*, &c.; while of the hermit crabs, *Pagurus punctulatus* Olivier, *Clibanarius virescens* Krauss, *Calcinus latens* Randall, &c., were common. Of the Macrura, *Petrolisthes lamarckii* Leach, was to be found under almost every stone, and species of *Alphæidæ* were abundant.

From the coral blocks in the lagoon *Trapezia cymodoce* Herbst, *Xanthodes atromanus* Hasw., *Chlorodopsis melanodactylus* A. M. Edw., and others were taken; and under stones at the extreme high limit of the tide, *Ozius truncatus* M.Edw., *Epixanthus frontalis* M.Edw., and *Chlorodius niger* Forsk. The swift running *Ocypoda ceratophthalma* Pallas, was dug from its burrows on the lagoon beach.

The following lists show comparatively the species taken at the two collecting grounds. They must, however, be regarded in no sense as complete, the time at our disposal being confined to the limits of a summer vacation. Several species which appear to be new records for the Australian coast were, however, taken, and these are marked with an asterisk; a larger number are new records for Queensland, and a few which are new to science are hereafter described. Much more requires to be done on the Queensland coast before our knowledge of its exceedingly rich carcinological fauna can be regarded as even approximately complete.

A paper was recently published by Dr. Calman* dealing with a collection of Brachyura made by Prof. C. Haddon in Torres

* Trans. Linn. Soc. London, (2) Zool. Vol. viii. p.1, 1900.

Straits in 1888. In this paper 88 species are dealt with, and it is interesting to note that of this number we recognise from our collection 37 as occurring in the latitude of Port Curtis, giving them a range of 1000 miles along the Queensland coast.

Mast Head Island & Rat Island. CORAL REEF FAUNA.	**Port Curtis.** ESTUARINE AND COASTAL FAUNA.

BRACHYURA.

Tribe CYCLOMETOPA.

Family XANTHIDÆ.

Liomera cinctimana (White)	*Xantho macgillivrayi* Miers
Atergatis floridus (Linn.)	*Leptodius exaratus* (M.Edw.)
**Lophactæa anaglypta* (Heller)	*Actæa calculosa* (M.Edw.)
,, *granulosa* (Rüp.)	*Pilumnus lanatus* Latr.
Lophozozymus octodentatus (M.Edw.)	,, *terræ-reginæ* Hasw.
Leptodius sanguineus (M.Edw.)	,, *semilanatus* Miers
,, *exaratus* (M.Edw.)	**Actumnus nudus* A.M.Edw.
Etisodes electra (Herbst)	*Cryptocœloma fimbriata* (M.Edw.)
,, *frontalis* Dana	
Actæa affinis (Dana)	
,, *rüppellii* (Krauss)	
,, *tomentosa* (M.Edw.)	
Xanthodes atromanus Hasw.	
,, *lamarckii* (M.Edw.)	
,, *notatus* Dana	
Chlorodius niger (Forsk.)	
* ,, *lævissimus* Dana	
Phymodius sculptus (A.M.Edw.)	
,, *ungulatus* (M.Edw.)	
Chlorodopsis melanodactylus A.M.Edw.	
Cymo andreossyi (Audouin)	
Ozius truncatus M.Edw.	
**Epixanthus frontalis* (M.Edw.)	

Mast Head Island & Rat Island. Coral Reef Fauna.	**Port Curtis.** Estuarine and Coastal Fauna.
Eriphia lævimana Latr.	
Pilumnus labyrinthicus Miers	
,, *terræ-reginæ* Hasw.	
* ,, *spinicarpus* n.sp.	
Actumnus tomentosus Dana	
,, *setifer* (De Haan)	

Family TRAPEZIIDÆ.

Trapezia cymodoce (Herbst)	*Trapezia cymodoce* (Herbst)

Family PORTUNIDÆ.

**Caphyra lævis* A.M.Edw.	*Charybdis spiniferus* Miers
Thalamita stimpsoni A.M.Edw.	*Lupa sanguineolenta* (Herbst)
,, *admete* (Herbst)	,, *granulata* var. *unispinosa* (Miers)
	,, *whitei* (A.M.Edw.)
	,, *sima* M.Edw.

Family PODOPHTHALMIDÆ.

**Gomeza bicornis* Gray	

Tribe CATOMETOPA.

Family OCYPODIDÆ.

Ocypoda ceratophthalma (Pallas)	*Uca dussumieri* (M.Edw.)
	,, *arcuata* (De Haan)
	Macrophthalmus depressus (Rüp.)
	**Metaplax hirsutimana* n.sp.
	Ceratoplax ciliata Stimp.

Family GRAPSIDÆ.

Metopograpsus messor (Forsk.)	*Metopograpsus messor* (Forsk.)
	**Sesarma bidens* (De Haan)

Family PINNOTHERIDÆ.

Pinnixa faba (Dana)	
Xanthasia murigera White	

Mast Head Island & Rat Island. CORAL REEF FAUNA.	**Port Curtis.** ESTUARINE AND COASTAL FAUNA.

Family MICTYRIDÆ.

	Mictyris longicarpus Latr.

Tribe OXYSTOMA.

Family CALAPPIDÆ.

Calappa hepatica (Linn.)	

Family LEUCOSIIDÆ.

Nursia sinuata Miers	
Oreophorus frontalis Miers	
**Cryptocnemus crenulatus* n.sp.	

Family DORIPPIDÆ.

	Dorippe australiensis Miers

Tribe OXYRHYNCHA.

Family MAIIDÆ

Achæus lacertosus Stimp.	*Paratymolus sexspinosus* Miers
**Picrocerus armatus* A.M.Edw.	*Egeria longipes* (Linn.)
Paramithrax peronii M.Edw.	*Paramithrax coppingeri* Hasw.
" *sternocostulatus* A.M.Edw.	*Hyastenus diacanthus* (De Haan)
**Paramithrax longispinis* De Haan	*Hyastenus convexus* Miers
Menæthius monoceros (Latr.)	
Hyastenus convexus Miers	

Family PARTHENOPIDÆ.

Lambrus confragosus Calman	

Tribe DROMIIDEA.

Family DROMIIDÆ.

Cryptodromia lateralis Gray	

Incertæ sedis.

Hapalocarcinus marsupialis Stimp.	
**Cryptochirus coralliodytes* Heller	

Mast Head Island & Rat Island. Coral Reef Fauna.	**Port Curtis.** Estuarine and Coastal Fauna.

MACRURA.

Tribe ANOMOLA.

Family HIPPIDÆ.

Mast Head Island & Rat Island	Port Curtis
	Remipes adactylus (Fabr.)

Family PAGURIDÆ.

Mast Head Island & Rat Island	Port Curtis
**Paguristes hians* Henderson	*Clibanarius virescens* Krauss
**Clibanarius cruentatus* (M.Edw.)	**Diogenes avarus* Heller
**Clibanarius virescens* (Krauss)	**Troglopagurus jousseaumii* Bouv.
,, *tæinatus* (M.Edw.)	*Eupagurus hedleyi* nom.nov.
Calcinus latens Randall	
* ,, *gaimardii* (M.Edw.)	
**Diogenes capricorneus* n.sp.	
**Troglopagurus jousseaumii* Bouv.	
Pagurus punctulatus Olivier	
* ,, *euopsis* Dana	
,, *deformis* M.Edw.	

Family PORCELLANIDÆ.

Mast Head Island & Rat Island	Port Curtis
Petrolisthes lamarckii (Leach)	*Petrolisthes lamarckii* (Leach)
* ,, *tomentosus* Dana	,, *japonicus* var. *inermis* Haswell
Porcellana serratifrons Stimp.	*Porcellana dispar* Stimp.
Pachycheles sculptus (M.Edw.)	*Polyonyx obesulus* Miers
	**Rhaphidopus ciliatus* Stimp.

Family GALATHEIDÆ.

Mast Head Island & Rat Island	Port Curtis
Galathea australiensis Stimp.	*Galathea magnifica* Hasw.
,, *magnifica* Hasw.	,, *elegans* Adams & White
,, *pusilla* Henderson	

A number of Queensland crustaceans were described by Professor Haswell in these Proceedings in 1879-1882, but were unfigured. Some of these we have retaken, and in such cases we have availed ourselves of the opportunity kindly granted us by the Trustees of the Australian Museum of figuring the type specimens in the Museum collection, and we desire to return to them our thanks for the privilege so readily accorded. In all cases the types of species herein described as new will be lodged with that Institution, as also such other of our specimens as are desiderata for their collection.

In conclusion we desire to thank Mr. T. Whitelegge of the Australian Museum for the valuable assistance and suggestions he has rendered us.

BRACHYURA.

Tribe CYCLOMETOPA.

Family XANTHIDÆ.

Liomera cinctimana (White).

1847. *Carpilius cinctimanus* White, in Jukes, Voy. "Fly," ii. Appendix, p.336, pl.ii. fig.3.

Mast Head Island; under rocks.

Atergatis floridus (Linn.).

1898. Alcock, Journ. Asiatic Soc. Bengal, lxvii. (2) p.98.

Mast Head Island; very common under loose coral blocks on the outer reef, but not found in the smoother waters of the lagoon.

Lophactæa anaglypta (Heller).

1861. *Atergatis anaglyptus* Heller, Abhandl. Zool.-Bot. Gesell. Wien, p.6, and SB. Ak. Wien, xliii. p.312, pl.ii. figs. 11, 12.

1898. Alcock, Journ. Asiatic Soc. Bengal, lxvii. (2) p.102.

Mast Head Island; one specimen (♀).

Lophactæa granulosa (Rüppell).

1830. *Xantho granulosus* Rüppell, Krab. Roth. Meer. p.24, pl.v. fig.3.

1898. Alcock, Journ. Asiatic Soc. Bengal, lxvii. (2) p.101.

Mast Head Island; fairly common on the reef.

Lophozozymus octodentatus (M.Edw.).

1837. *Xantho octodentatus* H. Milne Edwards, Hist. Nat. Crust. i. p.398.

1898. Alcock, Journ. Asiatic Soc. Bengal, lxvii. (2) p.106.

Rat Island; a good series taken by Dr. Pulleine.

Xantho macgillivrayi Miers.

1884. Miers, Zool. H.M.S. "Alert," p.211, pl.xx. fig.c.

Port Curtis; a good series dredged from 7 fathoms.

Leptodius sanguineus (M.Edw.).

1837. *Chlorodius sanguineus* H. Milne Edwards, Hist. Nat. Crust. i. p.402.

1898. Alcock, Journ. Asiatic Soc. Bengal, lxvii. (2) p.120.

Mast Head Island; under rocks; also on Rat Island (Dr. Pulleine).

We rely on the minute points of difference given by Alcock for separating this species from the next. As, however, both were associated under the same rocks, it appears to us very doubtful whether a true specific difference exists between them.

Leptodius exaratus (M.Edw.).

1837. *Chlorodius exaratus* H. Milne Edwards, Hist. Nat. Crust. i. p.402.

1898. Alcock, Journ. Asiatic Soc. Bengal, lxvii. (2) p.118.

Mast Head Island, and on the rocky portion of the shores of Port Curtis; common under stones.

The colour markings of this crab are most varied and are of no specific importance.

Etisodes electra (Herbst).

1804. *Cancer electra* Herbst, Krabben und Hrebse, pl. li. fig.6.

1873. *Etisodes sculptilis* A.M.Edw., Nouv. Arch. Mus. Paris, ix. p.236, pl. ix. fig.2.

Mast Head Island; dredged in 17 fathoms.

ETISODES FRONTALIS Dana.

1852. Dana, U.S. Explor. Exped. Crust. i. p.187, pl. ix. fig.3.

Mast Head Island; on the reef.

ACTÆA AFFINIS (Dana).

1852. *Actæodes affinis* Dana, U.S. Explor. Exped. Crust. i. p.197, pl. xi. fig.3.

1882. Haswell, Cat. Aust. Crust. p.45.

Mast Head Island; on the reef.

ACTÆA RUPPELLII (Krauss).

1843. *Aegle rüppellii* Krauss, Südafr. Crust. p.28, pl. i. fig.1.

1897. Alcock, Journ. Asiatic Soc. Bengal, lxvii. (2) p.144.

1900. Calman, Trans. Linn. Soc. London, (2) Zool. Vol. viii. p.7.

Port Curtis.

We rely on Alcock's full description for the recognition of this species. Our specimen carries one bright orange-red marking on the gastric region.

ACTÆA TOMENTOSA (M.Edw.).

1837. *Zozymus tomentosus* H. Milne Edwards, Hist. Nat. Crust. i. p.385.

1882. Haswell, Cat. Aust. Crust. p.44.

Mast Head Island; a good series under rocks on the outer reef.

ACTÆA CALCULOSA (M.Edw.).

1837. *Cancer calculosus* H. Milne Edwards, Hist. Nat. Crust. i. p.378.

1898. Alcock, Journ. Asiatic Soc. Bengal, lxvii. (2) p.152.

1900. Calman, Trans. Linn. Soc. London, (2) Zool. Vol. viii. p.8.

Port Curtis; a good series obtained by Dr. Pulleine.

We rely on the very complete notes of Alcock and Calman (*loc. cit.*) for determining the specific differences of this species from *A. granulata.*

Xanthodes atromanus Haswell.

1882. Haswell, Proc. Linn. Soc. N.S. Wales, Vol. vi. p.542.
1882. Haswell, Cat. Aust. Crust. p.49, pl. i. fig. 1.

Mast Head Island; a good series taken on the outer reef, and dredged in 17 fathoms.

The colour of this species is most variable, ranging from a carapace of deep chocolate, through mottled varieties, to almost white. The colour of the chelipeds is also variable, but all have the characteristic black fingers, the black colour extending far down the palm.

Specimens from 17 fathoms are as a whole much lighter than those taken on the reef.

Xanthodes lamarckii (M. Edw.).

1837. *Xantho lamarckii* H. Milne Edwards, Hist. Nat. Crust. i. p.391.
1898. Alcock, Journ. Asiatic Soc. Bengal, lxvii. (2) p.157.

Mast Head Island; two specimens from outer reef.

Xanthodes notatus Dana.

1852. Dana, U.S. Explor. Exped. Crust. i. p.178, pl. viii. figs. 12*a-b*.

Mast Head Island; under rocks.

Chlorodius niger (Forskäl).

1852. Dana, U.S. Explor. Exped. Crust. i. p.216, pl.xii. fig.5.

Mast Head Island; common.

Chlorodius lævissimus Dana.

1852. Dana, U.S. Explor. Exped. Crust. i. p.215, pl.xii. figs. 4*a-g*.
1898. Alcock, Journ. Asiatic Soc. Bengal, lxvii. (2) p.161.

Mast Head Island; three specimens, of which one is a male, and two are females.

Our specimens, which are readily separable from the young of *C. niger*, agree fairly well with Dana's figure and with Alcock's remarks. In our examples, however, the carapace is sparingly areolate, and there is a noticeable tuft of felted hairs at the base of the fingers on each of the larger chelipeds, a feature which is not referred to by either of the above authors.

PHYMODIUS SCULPTUS (A. M. Edw.).

1873. *Chlorodius sculptus* A. Milne Edwards, Nouv. Arch. Mus. Paris, ix. p.217, pl. viii. fig.4.

1898. Alcock, Journ. Asiatic Soc. Bengal, lxvii (2) p 164.

Mast Head Island; under stones.

PHYMODIUS UNGULATUS (M.Edw.).

1837. *Chlorodius ungulatus* H. Milne Edwards, Hist. Nat. Crust.i. p.400, pl. xvi. figs.6,8.

1898. Alcock, Journ. Asiatic Soc. Bengal, lxvii. (2) p.162.

Mast Head Island; under stones, and dredged in 17-20 fathoms.

CHLORODOPSIS MELANODACTYLUS A. M. Edw.

1873. A. Milne Edwards, Nouv Arch. Mus. Paris, ix. p.229, pl.viii. fig.7.

Mast Head Island; under rocks.

CYMO ANDREOSSYI (Audouin).

1852. Dana, U.S. Explor. Exped. Crust. i. p 225, pl.xiii. figs.2*a-b*.

Two specimens dredged in 17 fathoms off Mast Head Island.

OZIUS TRUNCATUS M.Edw.

1837. H. Milne Edwards, Hist. Nat. Crust. i. p.406, pl.xvi. fig.11.

Mast Head Island; under rocks on the beach.

EPIXANTHUS FRONTALIS (M.Edw.).

1837. *Ozius frontalis* H. M. Edw., Hist. Nat. Crust. i. p.406.

1891. ,, de Man, Notes Leyden Museum, xiii. p.17, Tab.2, fig.4.

A large series of specimens was taken under loose coral blocks high up on the beach on Mast Head Island.

Whitelegge identified examples from Funafuti with *Pseudozius caystrus* Ad. & White,* and added to its known distribution Tasmania, Solomon Islands and Holborn Island. On re-examination of his specimens, they prove to be identical with the present species, a decision in which that author concurs. Here also, as has already been pointed out by Ortmann,† must be referred the forms listed by Haswell as *Ozius* sp.‡

The examples recorded by Whitelegge from Woodlark Island prove to be *Expixanthus subcorrosus* de Man.§

ERIPHIA LÆVIMANA Latr.

1852. Dana, U. S. Explor. Exped. Crust. i. p.249, pl.xiv. figs.7*a-c*.

Mast Head Island; very common under rocks on the outer reef.

PILUMNUS LANATUS Latr.

1884. Miers, Zool. H.M.S. "Alert," p.220, pl.xxi.fig.B.

1900. Calman, Trans. Linn. Soc. London, (2) Zool. Vol.viii. p.16.

Two males and a female dredged in Port Curtis are referred here in consequence of their close agreement with the figure and description given by Miers (*loc. cit.*). That author, however, expresses some doubt as to the correctness of his identification, and, should it prove to be a new species, has suggested *P. humilis*.

Our specimens have distinct though small teeth on the finger of the larger cheliped. Like Calman, we are unable to trace the carpal spines on the ambulatory legs.

PILUMNUS LABYRINTHICUS Miers.

1884. Miers, Zool. H.M.S. "Alert," p.224, pl.xxii. fig.C.

One specimen dredged in 20 fathoms off Mast Head Island.

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* Mem. Aust. Mus. iii. 1897, p.136.

† Zool. Jahrb. Bd. vii. 1890, p.477.

‡ Cat. Aust. Crust. p.64, 1882.

§ *Loc. cit.* p.14, pl.2, fig.3.

PILUMNUS TERRÆ-REGINÆ Haswell. (Plate i. figs.1-1*a*).

1882. Haswell, Proc. Linn. Soc. N. S. Wales, Vol.vi. p.752.
1882. „ Cat. Aust. Crust. p.68, pl.i. fig.5.

Mast Head Island and Port Curtis.

As the figure of this species which has already appeared is in our opinion scarcely adequate for its reidentification, we now submit further drawings taken from the type in the Australian Museum.

The largest specimen in our collection (which is very much larger than the type) has the following measurements:—

Breadth of carapace	15 mm.
Length of carapace	12 mm.

PILUMNUS SPINICARPUS, sp.nov. (Plate i. figs.2-2*a*).

P. cursor Haswell, Cat. Aust. Crust., 1882, p.67; Calman, Trans. Linn. Soc. Lond. (2) Zool. viii. 1900, p.15, in part (nec. *P. cursor* A. M. Edw.).

Anterior portion of carapace carrying scattered stiff hairs which are replaced posteriorly by a scant pubescence. Beneath this the surface is quite smooth.

The front part of the carapace anterior to the lateral angles is strongly convex in an antero-posterior direction, while the posterior part is flat. From side to side the surface is much less convex.

The frontal region is divided into two lobes by a shallow median incision, each lobe carrying a longish tuft of hairs. The inner orbital angles are ill-defined. The orbits are somewhat long for the genus and have a sinuate upper margin which is sparingly granulose, and has no well defined fissures.

The antero-lateral margin, which is regularly arched, is shorter than the postero-lateral, and bears three equal and equidistant spiniform teeth, the first situated at some distance from the nonspinulose outer orbital angle, and the posterior forming the lateral angle.

The postero-lateral margins are only slightly inclined, giving to the posterior margin a width equivalent to that between the outer orbital angles.

In both chelipeds the carpus has on its upper margin a strong forwardly directed spine, and its outer surface bears numerous small tubercles and scattered stiff hairs. The larger cheliped (which is sometimes the right and sometimes the left) has the upper part of the outer surface of the palm sparingly tuberculate and tomentose, and is smooth below, while in the smaller cheliped the outer surface is entirely covered with small tubercles and scattered hairs. In neither have the tubercles any definite linear arrangement. The fingers of both hands carry a few strong teeth, but these are more numerous on the smaller of the two.

The ambulatory legs are long and sparingly clothed with stiff hairs. On the distal half of the upper margin of the merus of the first three pairs there are three sharp forwardly directed spinules. The fourth pair are unarmed.

In colour our species has in adult specimens the anterior part of the carapace mottled with red on a cream ground, the latter extending to the posterior margin. The chelipeds are red and the ambulatory legs banded with red and cream.

The abdomen of both sexes has all the seven joints free.

Length of carapace........	9 mm.
Breadth of carapace..................	11 ,,
Length of second ambulatory leg.............	19 ,,

It has been suggested by Whitelegge* that it might be useful, for the purpose of splitting up this much overloaded genus, to observe whether the terminal segment of the abdomen extends beyond the articular nodules of the first joint of the chelipeds. In our specimens it does so.

We have a good series of specimens taken amongst coral blocks on the outer reef at Mast Head Island.

This species is most nearly allied to *P. cursor* A. M. Edw., from which it is distinguished by the presence of a strong spine on the carpus of the chelipeds, by the three spinules on the merus of the

* Mem. Aust. Mus. iii. 1897, p.135.

three succeeding legs, and by the surface of the carapace being perfectly smooth below the scant pubescence. It has been recorded by Haswell as *P. cursor*, but a reference to his specimens does not, in our opinion. substantiate this identification. One of the specimens mentioned by Calman is no doubt properly referable to our species, but his other specimens and those of the "Alert"* perhaps represent the true *P. cursor* A. M. Edw.

Pilumnus semilanatus Miers.

1884. Miers, Zool. H.M.S. "Alert," p.222, pl.xxii. fig.B.

Port Curtis; a good series dredged in seven fathoms.

The colour of this species in life is a bright red, with long brown hairs. The lower part of the external surface of the hands is white.

Actumnus tomentosus Dana.

1852. Dana, U. S. Explor. Exped. Crust. i. p.243, pl.xiv. figs 2*a-c*.
1898. Alcock, Journ. Asiatic Soc. Bengal, lxvii. (2) p 202.

Off Mast Head Island; dredged in 17 fathoms.

Miers† has united this species with *A. setifer* De Haan, but Alcock (*loc. cit.*) is not in agreement with this. The specimens collected by us clearly display the specific differences pointed out by the latter author.

Actumnus setifer (De Haan).

1851. *Pilumnus setifer* De Haan, Faun. Japon. Crust. p.50, pl.iii. fig.3.
1898. Alcock, Journ. Asiatic Soc. Bengal, lxvii. (2) p.202.

Three specimens dredged off Mast Head Island in 17-20 fathoms.

Actumnus nudus A.M.Edw.

1867. A. Milne Edwards, Ann. Soc. Entom. France, (4)vii. p.265.
1888. de Man, Journ. Linn. Soc. Lond. Zool. xxii. p.49, pl.ii. figs.2-3.

Two specimens (males) dredged in Port Curtis are referred here from their general agreement with the figure and descrip-

* Miers, Zool. H.M.S. "Alert," p.223, 1884.
† Zool. H.M.S. "Alert," p.225.

tion given by de Man. They differ, however, from that author's description in a few minute characters. There are no hairs on the upper surface of the cephalothorax and no distinct granules on the outer surface of the larger cheliped, although the outer surface of the palm of the smaller hand is minutely granular. The number of granulations also on the anterior part of the carapace is larger and their size more minute than is suggested by that author's description. In all macroscopic characters, however, it agrees with his figure.

Alcock has already expressed doubt as to whether this species is correctly included in the genus *Actumnus*, and with this we are in cordial agreement.

CRYPTOCŒLOMA FIMBRIATA (M.Edw.).

1822. *Pilumnus fimbriatus* Haswell, Cat. Aust. Crust. p.66, pl. i. fig.4.

1884. Miers, Zool. H.M.S. "Alert," p.227, pl. xxiii. fig.A.

Port Curtis; one female specimen (Dr. Pulleine).

Family TRAPEZIIDÆ.

TRAPEZIA CYMODOCE (Herbst).

1898. Alcock, Journ Asiatic Soc. Bengal, lxvii. (2) p.219.

Very common amongst the branches of coral in the lagoon, Mast Head Island; also dredged in Port Curtis (7 faths.), and off Mast Head Island (17 faths.)

Family PORTUNIDÆ.

CAPHYRA LÆVIS A.M.Edw.

1873. A. M. Edwards, Nouv. Arch. Mus. Paris, ix. p.173, pl. iv. fig.2.

Mast Head Island; one specimen (♀).

CHARYBDIS SPINIFERUS Miers.

1884. *Goniosoma spiniferum* Miers, Zool. H.M.S. "Alert," p.233, pl. xxiii. fig.c.

Port Curtis; fairly common in the mangrove swamps, and dredged in 7 fathoms.

LUPA SANGUINEOLENTA (Herbst).

1899. *Neptunus sanguineolentus* Alcock, Journ. Asiatic Soc. Bengal, lxviii. (2) p.32.

Port Curtis (Dr. Pulleine).

LUPA GRANULATA var. UNISPINOSA (Miers).

1884. *Achelous granulatus* Miers, Zool. H.M.S. "Alert," p.230, pl. xxiii. fig. B.

Port Curtis; dredged in 7 fathoms

Miers states (*loc. cit.*) that the species recorded by Haswell from Palm Island as *Amphitrite gladiator* is identical with the above.

LUPA WHITEI (A.M.Edw.).

1861. *Achelous whitei* A. Milne Edwards, Arch. Mus. Paris, x. p.343, pl. xxxi. fig.6.

Dredged in Port Curtis (Dr. Pulleine).

THALAMITA STIMPSONI A.M.Edw.

1861. A. Milne Edwards, Arch. Mus. Paris, x. pp.362, 367, pl. xxxv. fig.4.

Mast Head Island, and Rat Island, Port Curtis.

THALAMITA SIMA M.Edw.

1899. Alcock, Journ. Asiatic Soc. Bengal, lxviii. (2) p.81.

Port Curtis; dredged in 7 fathoms.

THALAMITA ADMETE (Herbst).

1899. Alcock, Journ. Asiatic Soc. Bengal, lxviii. (2) p.82.

Mast Head Island; under rocks.

Family PODOPHTHALMIDÆ.

GOMEZA BICORNIS Gray.

1831. Gray, Zool. Miscell. p.39.

1833. Crust. in Griffith's Anim. Kingdom of Cuvier, Vol. xiii. p.296, pl. xxiv. fig.1.

One specimen 7mm. long, a male, was dredged in 20 fathoms off Mast Head Island. There are specimens in the British Museum from Adelaide and King George's Sound.

Miers in the "Challenger" Reports states that this species is "rather common in . . . . Australian Seas"—we cannot, however, trace in literature any definite record of its occurrence on our coast.

Tribe CATOMETOPA.

Family OCYPODIDÆ.

Ocypoda ceratophthalma (Pallas).

1882. Haswell, Cat. Aust. Crust. p.94.

Mast Head Island; common on the beach, boring deep holes in the sand above high-water mark. This species is nocturnal in its habits, and a good series was taken running swiftly on the sands in the moonlight. None were observed moving in the daylight.

Uca dussumieri (M.Edw.).

1852. *Gelasimus dussumieri*, H. Milne Edwards, Ann. Sci. Nat. Zool. (3) xviii. p.148, pl. iv. fig.12.

1887. *Gelasimus dussumieri*, de Man, Journ. Linn. Soc. Zool. xxii. p.108, pl. vii. figs.2-7.

Port Curtis; very common on mud banks amongst mangroves between tide marks.

A large series was taken exhibiting all stages of the growth of the large cheliped in the male. In the smallest specimen, which has the hand 6 mm. in length, the fingers meet along the whole of their trenchant borders. As the specimens become more adult a gape is developed commencing at the base of the fingers and extending proximally with age; for a long time, however, they meet on their trenchant borders for at least a third of their length. The largest specimen taken has the large hand 40 mm. long and the gape at its greatest width 5 mm.

Uca arcuata (De Haan).

1835. *Ocypode* (*Gelasimus*) *arcuatus* De Haan, Faun. Japon. Crust. p.53, pl. vii. fig.2.

1905. Stebbing, Marine Investg. South Africa, p.40.

Port Curtis; on mud banks.

Macropthalmus depressus (Rüppell).

1900. Alcock, Journ. Asiatic Soc. Bengal, lxix (2) p.380.

Port Curtis; on mud flats at the mouth of Auckland Creek.

For the identification of this species we are indebted to Alcock's detailed description, with which our specimen is in accord, except that we cannot trace the "two nearly parallel obliquely longitudinal finely granular lines" behind the branchial groove, to which he refers.

Our specimen (a female) agrees with that in the Australian Museum from Holborn Island identified by Haswell as *M. affinis* Guérin, a synonym of *M. depressus* (*fide* Alcock).

Metaplax hirsutimana, sp.nov. (Plate i. figs.3, 3*a*, 3*b*).

Carapace moderately convex in both an antero-posterior direction and from side to side. Proportion of its length to breadth as 7 : 9. Front little produced, only slightly deflexed, its width between the eyestalks being $\frac{1}{3}$ that of the greatest breadth of the carapace. Lateral margins parallel, armed with three shallow flat teeth, of which the first formed by the antero-lateral angles is the shortest. The last, which is the most obscure, is situated slightly in advance of the middle of the lateral margin, and is more distant from the second than the second is from the first.

Regions only faintly delimited, surface smooth.

The eyestalks do not quite reach the lateral angles of the carapace. The upper margin of the orbits is quite smooth, and the inferior margin minutely crenulate, the crenulations ceasing laterally on a level with the pigmented portion of the eyestalks. Below this there is another sinuous crenulate ridge which does not continue to the lateral margins. The pterygostomian regions are minutely tuberculate.

Epistome narrow, well defined, prominent, but not visible when viewed directly from above.

The outer maxillipeds have the ischium longer than the merus. The former is crossed near its base by an oblique piliferous ridge. There is also on the merus near its inner margin a further oblique piliferous ridge which crosses the line of junction between the two joints and terminates near the outer proximal margin of the ischium. The palp is articulated almost in the centre of the upper margin of the merus.

The abdomen in both sexes is seven-jointed. The last joint in the male is distinctly truncate.

In the male the right cheliped is somewhat larger than the left. The merus is sharply trigonous, each of the angles being minutely crenulate. The outer surface carries a number of scattered tubercles and the upper distal margin is subspinulous. The carpus is strongly carinate above.

The palm also carries a strong carina both above and below. This is continued to the ends of both the mobile and immobile fingers, and is minutely crenulate along its whole length. The fingers, which are spoon-excavate, leave a wide gape between them when closed, but this is entirely hidden by a tuft of strong felted hairs on both sides. On removal of the hair the upper finger is seen to be finely toothed along its distal two-thirds, while the lower is similarly toothed to its base. On the outer surface of the mobile finger there is also a distinct row of tubercles.

In the female the hands are subequal, long and slender, and without the tufts of hair characteristic of the male.

The ambulatory legs are long and much flattened. They carry on the upper edge of the merus a row of granules from which a dense but scattered pubescence arises, and on the outer surface of the merus of the first three pairs there are a number of scattered round tubercles.

A large series was taken on the mud flats at the mouth of Auckland Creek, Port Curtis.

The nearest ally of our species appears to be *M. intermedius** de Man, from the Mergui Archipelago, from which it differs in the presence of the dense matted hairs on the hands, from the nature of the piliferous ridges on the outer maxilliped, and in other features.

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* de Man, Journ. Linn. Soc. London, Zool. 1888, p.166, pl.ix. figs.7-9.

CERATOPLAX CILIATA Stimpson.

1858. Stimpson, Proc. Acad. Nat. Sci. Philadelphia, 1858, p.96.
1886. Miers, "Challenger" Brachyura, p.234, pl. xix. fig.3.
Port Curtis; two specimens dredged in 7 fathoms.

Family GRAPSIDÆ.

METOPOGRAPSUS MESSOR (Forsk.)

1900. Alcock, Journ. Asiatic Soc. Bengal, Vol. lxix. (2) p.397 (= *Goniograpsus thukujar* Haswell, Cat. Aust. Crust. p.99).
Mast Head Island and Port Curtis.

SESARMA BIDENS (De Haan).

1835. *Grapsus* (*Pachysoma*) *bidens* De Haan, Faun. Japon. Crust. p.60, pl.xvi. fig.4 and pl.xi. fig.4.
Port Curtis; on mangrove flats.

Family PINNOTHERIDÆ.

PINNIXA FABA (Dana).

1852. *Pinnothera faba* Dana, U.S. Explor. Exped. Crust. i. p.381, pl. xxiv. fig.4.
1882. Haswell, Cat. Aust. Crust. p.113.
Mast Head Island; common on the outer reef in the mantle of *Haliotis asinina*. Haswell (*loc. cit.*) records its occurrence at Port Denison, associated with *H. coco-radiata*.

XANTHASIA MURIGERA White.

1846. White, Ann. Mag. Nat. Hist. Vol. xviii. p.177, pl. ii. fig.3.
Mast Head Island; in shells of *Tridacna elongata*.

Family MICTYRIDÆ.

MICTYRIS LONGICARPUS Latr.

1806. Latreille, Gen. Crust. et Ins. p.41.
Port Curtis; on mangrove flats.

Tribe OXYSTOMA.

Family CALAPPIDÆ.

Calappa hepatica (Linn.).

1767. Linn., Syst. Nat., ed. xii. Vol.i. pt.ii. 1048.
1896. Alcock, Journ. Asiatic Soc. Bengal, lxv. (2) p.142.

Mast Head Island; on sandy flats within the lagoon.

Family LEUCOSIIDÆ.

Nursia sinuata Miers.

1877 Miers, Trans. Linn. Soc. London, (2) Zool. i. p. 239, (figured by Bell, *op. cit.* Zool. xxi. 18, pl. xxxiv. fig.4, as *N. plicatus*).

We have a good series taken by Dr. Pulleine at Rat Island.

The note given by Miers under the species *N. plicatus* (*loc. cit.* p.240) is by no means clear, but it appears to us to be intended to convey that Bell, in figuring that species, had inadvertently taken a specimen to which his description did not apply; that this figure in consequence represents a new species, to which on page 239 he (Miers) has given the name of *N. sinuata.*

The references given by Haswell in the 'Catalogue of Australian Crustacea,' spp.244 and 245, appear to be reversed.

Oreophorus frontalis Miers.

1884. Miers, Zool. H.M.S. "Alert," p.254, pl. xxvi. fig.B.

Several specimens were dredged off Mast Head Island in 17-20 fathoms.

Cryptocnemus crenulatus n.sp. (Plate ii. figs.2, 2*a*).

Surface everywhere both dorsally and ventrally quite smooth and carrying a high polish. Colour ivory white.

Carapace subpentagonal, broader than long. The margins are turned upwards, giving their dorsal surface a concave appearance. An ill-defined ridge runs backwards from the frontal region, but becomes lost before it reaches the posterior margin. The frontal region is prominent, pointed upwards, and terminates in an obtuse point—its margin is minutely crenulated.

The orbits, which are small, are situated at the apices of obtuse angles formed by the margins of the frontal process and by straight lines leading to the prominent hepatic angles; behind which the anterior and posterior lateral margins are finely crenulate, the crenulations being the termini of a series of fine radial ridges which fade away before reaching the centre of the carapace. The lateral margin is not continued on the dorsal surface of the carapace behind the hepatic region as described in *C. haddoni* Calman.

The margin from the hepatic angle to the anterior lateral angle, and the posterior lateral margin, are subequal in length, and meet almost at right angles. The posterior margin is long, almost straight, and without crenulations.

The antennulary fossæ are transverse.

The third maxillipeds have the bases visible, the ischium is of about the same length as the merus, which is acutely triangular, and projects beyond the bucal cavern, reaching the antennulary fossæ. The exopod is not so broad as the ischium, and only reaches about half its length.

The chelipeds have all the joints, from the merus outwards, carrying a prominent knife-like crest with a crenulate edge. The fingers are grooved, finely serrate, and somewhat overlapping at the tips when closed.

The ambulatory legs have the merus, carpus and propodus with a similar sharp crenulate crest; the dactyli are spinulose.

The abdomen of the male is regularly triangular, elongated and acute. The first segment is exceedingly small and not visible from a dorsal view; the second, third, fourth, fifth and sixth segments are coalescent; and the last segment, which is free, is long and pointed.

Dimensions of type :—

Length from anterior point of frontal process to posterior margin	$4\frac{1}{2}$mm.
Breadth of carapace between lateral angles	6 mm.

Three specimens of this very elegant little crab were dredged in 17-20 fathoms near Mast Head Island, only one, however, being in a sufficiently perfect state for description. Its habitat appears to be the coarse white coral sand in the moderate depths surrounding the reefs—an environment in which its small size, rugose exterior, and brilliant ivory white colour must be of great service to it for purposes of concealment.

The nearest ally of our species appears to be *C. pentagonus* Stimpson, which is figured by Miers,* and from which it differs in the proportions of the carapace and the crenulations of the margins. The hands of that species do not appear to have been figured. From *C. haddoni* Calman, from Torres Straits, it differs in the possession of the very marked crests on the chelipeds, in the crenulation of the margins, in the shape of the front and in other details. From the other described species of the genus, viz., *C. holdsworthi* Miers, *C. grandidieri* A.M.Edw., and *C. obolus* Ortmann, the differences are too marked to be worthy of repetition here.

Family DORIPPIDÆ.

Dorippe australiensis Miers.

1884. Miers, Zool. H.M.S. "Alert," p.258, pl. xxvi. fig. D.

Port Curtis; a good series dredged in 7 fathoms.

The specimens in the Australian Museum referred to *D. astuta* Fabr., and so included by Haswell in his "Catalogue of Australian Crustacea" (p. 136) belong to the above species, the description of which was published subsequent to the Catalogue. *D. astuta* must consequently be excluded from our fauna.

Tribe OXYRHYNCHA.

Family MAIIDÆ.

Achæus lacertosus Stimpson. (Plate iii. fig. 1).

1857. Stimpson, Proc. Acad. Nat. Sci. Philad. p.218.

1895. Alcock, Journ. Asiatic Soc. Bengal, lxiv. (2) p.172.

Mast Head Island; one female specimen.

This species does not appear to have been previously figured. We submit a drawing of a male specimen from Port Jackson, 11mm. long.

* Proc. Zool. Soc. 1879, p.43, pl. ii. fig. 5.

PARATYMOLUS SEX-SPINOSUS Miers.

1884. Miers, Zool. H.M.S. "Alert." p.261, pl. xxvii. fig.B.

Port Curtis, dredged in 7 fathoms; and off Mast Head Island, in 17 fathoms.

EGERIA LONGIPES (Linn.).

1767. *Cancer longipes* Linn. Syst. Nat. ed.xii. Vol. i. pt. ii.

1837. *Egeria arachnoides* H. Milne Edwards, Hist. Nat. Crust. i. p.291.

1895. *Egeria arachnoides* Alcock, Journ. Asiatic Soc. Bengal, lxiv. (ii.) p.223.

Port Curtis; a good series dredged by Dr. Pulleine.

This species has been referred to by Milne Edwards, Haswell, Miers, Alcock, and other leading carcinologists, under the name *E. arachnoides* Rumph.* That author was, however, pre-Linnean, and his nomenclature is consequently inadmissible. Linnæus subsequently (*loc. cit.*) redefined the species, referring to Rumphius' figure as his type, and giving to it the name *Cancer longipes.*

It has been suggested by Miers† that the species *E. longipes*, *E. arachnoides*, *E. indica*, and *E. herbstii* are synonymous, and this view is fully confirmed by Alcock (*loc. cit.*) who states that "all the hitherto described species of *Egeria* may be regarded as identical with the species rather poorly figured in Rumphius' *Amboinische Rariteitkamer.*"

It consequently appears to us that the only tenable specific name is that used by Linnæus as quoted above.

We may here note that Lamarck‡ refers to the species under the name *Leptopus longipes*, giving references to Linn., Fabricius, and Rumphius; and it appears strange that this should not have been followed by subsequent authors.

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* Rumphius, Amboinische Rariteitkamer, pl. viii. fig.4.

† Miers, Zool. H.M.S. "Alert," p.182, 1884.

‡ Lamarck, An. sans Vert. v. p.235, 1818.

PICROCERUS ARMATUS A.M.Edw.

1865. A. M. Edwards, Ann. Soc. Ent. France, (4) v. p.136.

1872. A. M. Edwards, Nouv. Arch. Mus. Paris, Vol. viii. p.244, pl.xii. fig.2, and xiii.

A small specimen was dredged off Mast Head Island in 20 fathoms. It measures 38mm. with the rostral cornua and 25mm. without. It differs from the description and figure only in having the rostral cornua proportionately shorter and by having all the spines knobbed instead of pointed; these are undoubtedly characters varying with age.

The species was originally described from New Caledonia, and the author states that there are specimens in the British Museum from the New Hebrides. A fine specimen (♀) measuring 117mm. in total length is in the Australian Museum from Lord Howe Island, where it was found dead on the beach.

PARAMITHRAX PERONII M.Edw.

1837. H. Milne Edwards, Hist. Nat. Crust. i. p.324.

1853. Jacquinot & Lucas, Voy. au Pôle Sud, Zool. iii. Crust. p.10, pl. i. fig.3.

Mast Head Island.

PARAMITHRAX STERNOCOSTULATUS A.M.Edw. (?)

(Plate iii. figs.2, 2*a*).

1882. Haswell, Cat. Aust. Crust. p.13.

Mast Head Island; one specimen (♂).

This species is quoted by Haswell as of A. Milne Edwards, and he gives *P. gaimardii* of Miers,* as a synonym. We have been quite unable to trace the original description under the name of *sternocostulatus*, and a reference to the Cat. N.Z. Crust. shows *gaimardii* to be of H. Milne Edwards†. It must consequently, if it can be properly applied to our species, antedate the name which we here quote. As, however, a diligent search has failed to discover the missing reference, we are compelled to leave the question of its correct nomenclature undecided.

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* 1876. Miers, Cat. Crust. N. Zealand, p.6.

† 1836. H. Milne Edwards, Hist. Nat. Crust. i. p.325.

We cannot ascertain that it has yet been figured under either name, and take this opportunity of doing so.

The species appears to have a wide range on our coast. It is fairly common in Port Jackson, and there are specimens in the British Museum dredged by the late Mr. J. Bracebridge Wilson in Port Phillip, Vic.

Paramithrax longispinis (De Haan).

1839. *Maja (Chorinus) longispinis* De Haan, Faun Japon. Crust. p.94, pl.xxiii. fig.2.

One specimen (♂) dredged off the reef at Mast Head Island agrees with the quoted figure of this species in all but the following particulars:—There are no knobs on the tips of the spines; there are usually two meral spines instead of only one; and the ridge on the propodus of the chelipeds is not so pronounced nor so sinuous as in the Japanese form. Direct comparison with Japanese examples, however, proves it to be inseparable specifically, though Australian examples may present a varietal form.

Paramithrax coppingeri Haswell. (Plate ii. fig.3).

1881. Haswell, Proc. Linn. Soc. N.S. Wales, Vol.vi. p.750.

An examination of the type of this species (a male) and that of *P. spatulifer* Haswell, in the Australian Museum, enables us to clear up some misconception which has arisen in their identification by recent authors.

P. coppingeri was described by Haswell from Port Molle, and *P. spatulifer* from Port Stephens, the former appearing to take the place of the latter in the more northerly and tropical waters. A specimen of *P. spatulifer*, however, taken by the "Challenger" off East Moncœur Island in Victoria, was unfortunately wrongly identified by Miers, and is figured by him under the name of *P. coppingeri**, and this has led subsequent authors to recognise the last mentioned as belonging to the southern fauna.

Our specimen which agrees with the type was taken in Port Curtis in seven fathoms.

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* 1886. Miers, "Challenger" Brachyura, p.53, pl.vii. fig.3.

The accompanying revised description and figures are taken from the type, a male, in the Australian Museum.

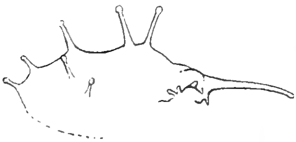

Fig. 1.—Profile.

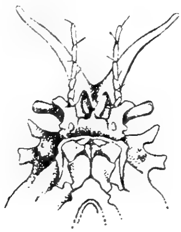

Fig. 2.—Buccal frame.

Fig. 3.—Cheliped.

Carapace armed with long spines, the width slightly more than $\frac{2}{3}$ the length. Regions well defined, very convex, and limited by broad shallow depressions. Hooked setæ arise from minute prominences on the body and ambulatory limbs. Rostral cornua long and slender, tapering, somewhat incurved towards their extremities, which are blunt and rounded; their upper edges are carinate, and extend backwards to the gastric region, forming a deep hollow on the frontal region.

Carapace with ten knobbed spines, two on the mid-line of the gastric region, inclining towards their bases; two on the cardiac region, placed transversely with their bases almost united; two on the intestinal region, the last being on the posterior border; two others are placed obliquely on each branchial region, the hinder almost on the same level as the cardiac pair, and directed upwards and backwards, while the anterior is almost at right angles to the length.

Orbital region prominent, terminating in three slender spines directed outwards and forwards, the middle one a little nearer the first than to the third and curved slightly upwards. Following these are two depressed postorbital spines, the first acute and the second larger and obliquely truncate. Hepatic region with a sub-bifid lobe. Inferior surface with several small tubercles.

Basal joint of external antennæ with a short tooth at the proximal end of its outer border, with a very prominent compressed tooth directed outwards at the distal end of the same border, and a third, somewhat smaller, directed downwards and forwards at the inner distal angle; flagellum longer than the cornua of the rostrum. A median downward process of the front forms a recurved hook.

Chelipeds slender, equal, a trifle longer than the carapace. Merus longer than the palm, though less than twice the length of the carpus, armed below with three flattened spines and four above, that at the distal end being very large and obliquely truncated. Carpus with two denticulated crests, the inner with two and the outer with three teeth, the posterior of the latter being enlarged. A third ridge on the inner surface is more pronounced anteriorly and without spines. Palm smooth, the upper edge almost straight, carinate posteriorly and terminating in an enlarged tubercle, an indistinct groove on the outer face. Fingers about half as long as the palm, almost closing along their entire edges, and with about five teeth on each.

Ambulatory legs slender, the first pair the longest; the meri each with a long slender knobbed spine, which is more strongly developed in the first two pairs; indications of similar processes are on the carpus of the two anterior pairs.

Length to the base of rostral cornua	13mm.
Length of rostral cornua.........	8mm.

Haswell states that this species differs from *C. longispinis* De Haan, in having " none of the supra-orbital spines recurved." This is not correct of the type specimen, which, however, is distinguished from the Japanese species by the much more slender hand.

Acanthophrys aculeatus A.M.Edw.,* judging from the figure given by that author, is apparently identical with *P. spatulifer* Haswell. It has, however, been pointed out by Calman† that the specific name *aculeatus* is preoccupied, and Haswell's name consequently stands.

* 1865. A. Milne Edwards, Ann. Soc. Ent. France (4) v. p.140, pl.iv. fig.4

† Trans. Linn. Soc. Lond. (2) Zool. Vol. viii. p.38, 1900.

MENÆTHIUS MONOCEROS (Latr.).

1882. Haswell, Cat. Aust. Crust. p.9.

Mast Head Island; on the reef.

HYASTENUS DIACANTHUS (De Haan).

1839. *Pisa (Naxia) diacantha* De Haan, Faun. Japon. Crust. p.86, pl. xxiv. fig.1.

Port Curtis; very common at 7 fathoms.

HYASTENUS CONVEXUS Miers.

1884. Miers, Zool. H.M.S. " Alert," p.196, pl.xviii. fig.B.

Two males, measuring 11 and 8mm. respectively, dredged off Mast Head Island in 20 fathoms; and a further series from 7 fathoms in Port Curtis, are referred here. Those from the shallower water are in close agreement with Miers' figure, but the specimens from 20 fathoms differ in the slightly longer proportionate length of the palm; the preocular hood is also slightly shorter.

Family PARTHENOPIDÆ.

LAMBRUS CONFRAGOSUS Calman.

1900. Calman, Trans. Linn. Soc. Lond. Zool. Vol. viii. (2) p.42, pl.iii. figs.27-28.

Off Mast Head Island; dredged in 17 fathoms.

Tribe DROMIIDEA.

Family DROMIIDÆ.

CRYPTODROMIA LATERALIS Gray.

1831. Gray, Zool. Miscell. p.40.

1898. Thomson, Trans. N.Z. Institute, Vol. xxxi. p.170, pl. xx. figs. 1, 2.

Mast Head Island; on the reef.

Incertæ sedis.

HAPALOCARCINUS MARSUPIALIS Stimp.

1856-59. Stimpson, Proc. Boston Soc. Nat. Hist. Vol.vi. p.412.

1899. Calman, Trans. Linn. Soc. Lond. (2) Zool. Vol. viii. p.43, pl.iii. figs.29-40.

Mast Head Island; forming galls on species of *Pocillopora* and *Seriatopora*.

CRYPTOCHIRUS CORALLIODYTES Heller.

1861. Heller, SB. Akad. Wien, xliii. (1) p.366, pl.ii. figs.33-39.
1881. Semper, 'Animal Life,' pp.217, 221-3, figs.64, 68.

Mast Head Island; forming funicular depressions on a species of *Goniastræa*, similar to that figured by Semper.

There are also specimens in the Australian Museum collected by Mr. Hedley at Palm Island.

MACRURA.

Tribe ANOMOLA.

Family HIPPIDÆ.

REMIPES ADACTYLUS (Fabr.).

1837. *Remipes testudinarius* H. Milne Edwards, Hist. Nat. Crust. ii. p.206, pl.xxi. figs.14-20.

Port Curtis; three specimens dredged in 7 fathoms.

Family PAGURIDÆ.

PAGURISTES HIANS Henderson.

1888. Henderson, "Challenger" Anomura, p.79, pl. viii. fig.4.
1905. Alcock, Cat. Indian Decapod Crust. Pt.ii. p.40, pl. iii. fig.2.

Fairly common in depths of 17-20 fathoms off Mast Head Island. Recorded by the "Challenger" from the Philippine Islands.

CLIBANARIUS CRUENTATUS (M.Edwards).

1848. *Pagurus cruentatus* H. Milne Edwards, Ann. Sci. Nat. Zool. (3) x. p.62.
1886. *Clibanarius cruentatus* Filhol, Miss. de l'Ile Campbell, iii. Pt.ii. p.424, pl.lii. fig.4.
1897. Whitelegge, Mem. Aust. Mus. iii. Pt.2, p.143.

Mast Head Island; fairly common on the reef.

Our specimens agree closely in the contour of the carapace and limbs with that figured by Filhol. The nature of the blister-like yellow spots where these are present is also in accordance with Whitelegge's description; they are, however, not so numerous as in the specimens from Campbell Island, and the light-coloured patches on the surface of the carapace figured by Filhol are absent. The pigmentation generally appears to be much darker in the northern form.

CLIBANARIUS VIRESCENS Krauss.

1843. *Pagurus virescens* Krauss, Südafr. Crust. p.56, pl. iv. fig.3.
1852. *Clibanarius virescens* Dana, Crust. U.S. Explor. Exped. i. p.466, pl. xxix. figs.6*a-b*.

Mast Head Island and Port Curtis.

This was the commonest crustacean on the island. It varies much in size, and was found under almost every rock left exposed by the tide on the outer reef.

CLIBANARIUS TÆNIATUS M.Edw.

1848. *Pagurus tæniatus* H. Milne Edwards, Ann. Sci. Nat. Zool. (3) x. p.63.

Mast Head Island.

CALCINUS LATENS Randall.

1839. *C. latens* Randall, Journ. Acad. Nat. Sci. Philad. p.135 *(fide* Dana).
1852. *C. latens* Dana, U.S. Explor. Exped. Crust. Pt. i. p.459, pl.xxviii. fig.11.
1905. *C. latens* Alcock, Cat. Ind. Decapod Crust. Pt. ii. p.58, pl.v. fig.5(cheliped).
1882. *C. terræ-reginæ* Haswell, Proc. Linn. Soc. N.S. Wales, vi. p.57.
1905. *C. terræ-reginæ* Alcock, *loc. cit.* p.57, pl. v. fig.7.

Mast Head Island; a good series.

It has already been suggested by Alcock (*loc. cit.*) that *C. terræ-reginæ* Hasw., may prove to be merely a varietal form of *C. latens.* From a study of a good series of specimens before us, which includes three specimens labelled as types of the former species, this is rendered quite clear. Some of our specimens have the left cheliped with its lower border carinate and serrate, as is typical of *C. latens*; but these shade off by imperceptible gradations to a form having the lower border simple and the outer surface smooth, which characterise the form *C. terræ-reginæ*.

CALCINUS GAIMARDII (M.Edw.).

1848. *Pagurus gaimardii* H. M. Edwards, Ann. Sci. Nat. Zool. (3) x. p.63.

1905. Alcock, Cat. Ind. Decapod Crust. Pt. ii. p.56, pl. v. fig.3.

Mast Head Island; on the reef; two specimens.

DIOGENES AVARUS Heller.

1865. Heller, "Novara" Crust. p.83, pl. vii. fig.2.

1905. Alcock, Cat. Indian Decapod Crust. Pt. ii. p.68, pl. vi. fig.6.

Port Curtis; two specimens dredged in 7 fathoms.

DIOGENES CAPRICORNEUS, sp.nov. (Plate iii. figs.3-3*a*).

Carapace moderately elongated. Cephalothorax somewhat flattened rugose, carrying numerous low tubercles beset with stiff hairs, and two well defined spinules near the cervical groove. Behind this the carapace is naked.

Front not so prominent as the antennal angles of the carapace.

Rostriform process narrow, simple, without spinules on its margin, reaching slightly beyond the ophthalmic scales, somewhat expanded posteriorly.

Eyestalks narrow, elongated, reaching considerably beyond the peduncles of the outer antennæ. Ophthalmic scales with three short spines near the distal end of their upper border. The eyes do not quite reach to the end of the inner antennæ.

Antennal acicle with a well defined spine on its distal outer angle. Flagellum not quite reaching the tips of the chelipeds, sparingly setose.

Left cheliped much more robust than the right, which reaches to the middle of its palm. The merus has a series of minute spines on its upper margin, and is minutely serrulate below. The carpus has three strong forwardly directed spines on its upper margin, a row of three smaller spines on its outer surface near the lower margin, and a strong spine between these two rows at its distal margin. The palm is half as long again as broad; it carries four strong spines on its upper margin, and on its outer surface two rows of spinulæ terminating respectively in the strong spine at the distal margin and in the lower row of spines on the preceding joint. Its lower surface is granulous. The immobile finger is somewhat deflexed, and the mobile finger strongly arched; there is a wide opening between them when closed.

The right cheliped has three strong teeth on the upper margin of the carpus, four somewhat smaller teeth on the upper margin of the palm, and a row of small tubercles on its outer surface. The mobile finger is serrulate on its upper margin and leaves a strong gape when closed against the immobile finger.

Both hands are clothed with stiff scattered hairs.

The second and third legs are sparingly setose. They are subcylindrical, and in length exceed the larger cheliped by the dactylus and half the propodus.

The fourth legs are subchelate, and the fifth pair distinctly didactylous.

Colour white, very faintly banded with red on the second and third legs.

Length of carapace 5mm.

Two specimens were dredged off Mast Head Island, on a bottom of coral sand.

TROGLOPAGURUS JOUSSEAUMII Bouvier.

1897. Bouvier, Bull. Mus. d'Hist. Nat. Paris, pp.231-232, fig.6.

1905. Alcock, Cat. Indian Decapod Crust. Pt. ii. p.75, pl.v. fig. 6.

Port Curtis; four specimens dredged in 7 fathoms; three of these inhabited shells of *Natica conica* and one that of *Purpura pseudamygdala*. In all cases the shells appeared to be too large for their occupants, a peculiarity which, as Alcock has pointed out, appears to be characteristic of the species.

One specimen also was taken on Mast Head Island, differing only in the more marked spinulation of the outer surface of the carpus of the left cheliped, and in having the inner surface of the merus not clothed with hairs.

The genus does not appear to have been previously recorded from Australia, but Alcock's excellent description and figure leave no doubt as to the correctness of the identification.

PAGURUS PUNCTULATUS Olivier.

1811. Olivier, Encycl. Méth. viii. p.641.

1905. Alcock, Cat. Indian Decapod Crust. Pt. ii. p.81, pl. viii. fig.1.

Mast Head Island; common in shells of *Strombus luhuanus*, *S. gibberulus*, *Turbo speciosus*, &c.

PAGURUS EUOPSIS Dana.

1852. Dana, Proc. Acad. Nat. Sci. Philad. p.7, and U S. Explor. Exped. Crust. i. p.452, pl. xxviii. figs.6 *a-c*.

1905. Alcock, Cat. Ind. Decapod Crust. Pt. ii. p.86, pl. ix. fig.2.

Mast Head Island; on the reef.

Our specimens differ only from Alcock's description and figure in *not* having the antennal acicle "extremely short, not reaching to the base of the last joint of the peduncle"; and in the propodus of the third left leg *not* being "more than half as broad as long and with the outer surface flattened." These are, however, minor characters, and as they agree in all other points with the figures quoted, there appears to us no justification for raising them to specific or even varietal rank.

PAGURUS DEFORMIS Milne Edwards.

1836. H. Milne Edwards, Ann. Sci. Nat. Zool. (2) vi. p.272, pl.xiv. fig.2.

1905. Alcock, Cat. Indian Decapod Crust. Pt. ii. p.88, pl.ix. fig.4.

Mast Head Island; two specimens in shells of *Turbo speciosus*.

EUPAGURUS HEDLEYI, nom.nov.

1884. *Eupagurus kirkii* Miers, Zool. H.M.S. "Alert," p.267, pl. xxviii. fig.c (nec Filhol).

A large series dredged in Port Curtis in 4-7 fathoms.

It has already been pointed out by Alcock* that the specific name given by Miers had already been conferred by Filhol on a New Zealand form. We have consequently pleasure in taking this opportunity to dedicate it as above.

It was originally described by Miers from a single specimen taken in the Arafura Sea. From the material before us we are able to supplement that author's description as follows :—

The ophthalmic scale bears a distinct slender apical spine. The larger cheliped has in addition to the "inner and upper" marginal series of spinules, a granular series on the corresponding outer margin commencing at the base of the wrist and continued on the palm to the tip of the immobile finger.

Family PORCELLANIDÆ.

PETROLISTHES LAMARCKI (Leach).

1898. Borradaile, Proc. Zool. Soc. London, p.464, pl.xxxvi. figs.1 *a-b*, 2(with full synonymy).

In view of the very thorough manner in which Borradaile has dealt with this species, and of the large series of names which he has put into synonymy, we have no hesitation in referring as above to a large series of specimens dredged in 7 fathoms in Port Curtis and taken on the reef on Mast Head Island.

As a varietal feature it is noteworthy that the Port Curtis specimens have the whole dorsal surface of a darkish purple colour with deep red spots, and carry a scant tomentum, while the specimens from the reef are much lighter and quite smooth.

PETROLISTHES JAPONICUS De Haan, *var.* INERMIS Hasw.

1851. *Porcellana japonica* De Haan, Faun. Japon. Crust. 1850, p.199, pl. 1, fig.5.

1882. *Petrolisthes inermis* Haswell, Proc. Linn. Soc. N. S. Wales, vi. p.757(nec *Porcellana inermis* Heller).

1884. *Petrolisthes japonicus* var. *inermis* Miers, Zool. H.M.S. "Alert" p.268.

* Cat. Ind. Decapod Crust. Pt. ii. p.175, 1905.

Port Curtis. The species has already been recorded from this locality by Miers (*loc. cit.*).

De Man* has pointed out that Heller described, under the name *Porcellana inermis*, a species which should properly be included in the genus *Petrolisthes*, but with which Haswell's species is not identical. As, however, the latter author's name sinks to varietal rank only, it can still be used in connection with this species.

De Man has also suggested that this species may prove to be synonymous with *P. elongatus* M. Edw., common in New Zealand. A reference to the type, however, shows it to be readily distinguished from that species by its much broader front.

We agree with Miers that *P. inermis* Hasw., is at most but a variety of *P. japonicus* De Haan; the points of difference, however, noted by that author do not prove to be constant in the five specimens (including Haswell's types) which are before us.

Petrolisthes tomentosus Dana.

1852. *Porcellana tomentosa* Dana, U. S. Explor. Exped. Crust. i. p.420, pl. xxvi. fig.10.

Two fine specimens, one of either sex, and the larger being 9mm. in length, were taken on the reef at Mast Head Island under stones. They differ from the original description only in being densely rather than "sparingly tomentose."

Porcellana serratifrons Stimp.

1858. Stimpson, Proc. Acad. Nat. Sci. Philad. p.80.

1888. Henderson, Zool. H.M.S. "Challenger," Anomura, p.110, pl.xi. fig.5.

Mast Head Island; under rocks.

The rugosity of the dorsum of the carapace varies within wide limits, the transverse striæ being in some cases faintly marked and in others prominently so, but in no specimen which we have examined are they absent. The spinulation of the margins also

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* Journ. Linn. Soc. London, Zool. xxii. p.212, 1888.

varies greatly, as does that of the sides of the carapace. The specimens taken by the "Alert"* at Thursday Island are, doubtless, this species.

It is significant that *P. quadrilobata* Miers, † a species described from a unique specimen and one which has not since been retaken, was collected at the same time and place as specimens in the Australian Museum from Port Denison, which indisputably belong to *P. serratifrons.* The differences in the two species occur only in the elongation of the body and in the prominence and armature of the front, circumstances which render it possible that Miers' species represents only an abnormal specimen of that under consideration.

PORCELLANA DISPAR Stimp.

1858. Stimpson, Proc. Acad. Nat. Sci. Philad. Vol.x. p.297.
1884. Miers, Zool. H.M.S "Alert," p.275, pl.xxx. fig.c.

A fair series of specimens was dredged in Port Curtis, but all were much smaller than those usually found in the cooler waters of Port Jackson, where the species is very common.

PACHYCHELES SCULPTUS (M.Edw.). (Plate ii. fig.1).

1837. *Porcellana sculpta* H.M.Edwards, Hist. Nat. Crust. ii. p.253.
1852. ,, ,, Dana, U. S. Explor. Exped. Crust. i. p.412. pl.xxvi. fig.2.
1897. *Pachycheles sculptus* Ortmann, Zool. Jahrb. Syst. x. p.294 (ubi syn.).

Common under stones on the reef at Mast Head Island. There are specimens in the Australian Museum from Cabbage Tree Bay near Sydney.

De Man‡ has expressed the opinion that the species *P. pulchella*|| Hasw., was incorrectly separated from the above. A reference to the type of that species in the Australian Museum and

* Miers, Zool. H.M.S. "Alert," p.277, 1884.
† Miers, *loc. cit.* p.276, pl.xxx. fig.D.
‡ De Man, Journ. Linn. Soc. Lond. Zool. xxii. p. 219, 1888.
|| Haswell, Proc. Linn. Soc. N.S. Wales, vi. p.758, 1882.

a comparison of it with the large series before us and with Dana's figure, convince us that he is in error in this conclusion. *P. pulchella*, which has been well figured by Miers,* differs markedly from that under consideration in the sculpture of the chelipeds, in the rugosity of the dorsum of the carapace, and in other features.

Ortmann (*loc. cit.*) has shown that *P. pulchella* is a synonym of *P. pisum* M.Edw., as is also *P. sculpta* De Man (nec. M.Edw.); and has thrown much light on the synonymy of that species and the one now under consideration.

We are unable to refer to the figure of this species given by Krauss,† and that of Dana being scarcely adequate for recognition, we submit a further drawing of one of our specimens with the following notes.

The frontal and hepatic regions are very rugose, and there are irregular transverse raised ridges on the frontal region and two large ornate bosses on each hepatic region.

The wrists are ornamented with about five rows of tubercles, each of which is margined anteriorly with a fringe of setæ. The palm is similarly ornamented on its outer surface. The fingers are somewhat variable and are ornamented with rows of elongate-imbricate tubercles fringed with setæ, which are more pronounced on the mobile finger.

The front is reflexed and truncate, and has a deep transverse sulcus, which is sometimes only faintly indicated. The carapace varies considerably in width.

Length of carapace	....	5 mm.
Breadth ,,	....	4 ,,
Length of cheliped	....	10·5 ,,

POLYONYX OBESULUS Miers (?).

1884. Miers, Zool. H.M.S. "Alert," p.272, pl.xxix. fig.7.

1893. Henderson, Trans. Linn. Soc. Lond. (2) Zool. v. p.430.

To this species we refer a single imperfect specimen from Port Curtis, dredged in 7 fathoms.

* Miers, Zool. H.M.S. "Alert," p.273, pl.xxx. fig.A., 1884.
† Krauss, Südafr. Crust. p.58, Tab. iv. fig.1, 1843.

From the description given by Henderson it differs in having the ambulatory dactyli biunguiculate only, and in having a very prominent lobe on the distal inner margin of the merus of the cheliped, characters which he assigns to *P. biunguiculatus*. The median frontal lobe, however, is subacute, and is not much produced beyond the laterals, and the carpus is very short and broad. The larger cheliped is lost, but the smaller agrees perfectly, excepting the above-mentioned character, with those of Henderson.

Under the name *P. biunguiculatus* Dana,* a specimen has been recorded by Haswell † from Holborn Island, which, in general appearance, agrees well with Dana's figure, although the median frontal lobe is obtuse and a little more prominent than the laterals, and the dactyli are triunguiculate.

Henderson has expressed his divergence from the view of De Man‡ that *P. obesulus* and *P. unguiculatus* are synonymous, but the above facts certainly favour the views of the latter author.

RHAPHIDOPUS CILIATUS Stimpson.

1858. Stimpson, Proc. Acad. Nat. Sci. Philad. p.241.

1892. Ortmann, Zool. Jahrb. Syst. Bd.vi. p.226, pl. ii. fig.16.

Port Curtis; two specimens dredged in seven fathoms.

Our specimens are in fairly close agreement with Ortmann's figure (*loc. cit.*), differing only in being rather more rugose. The antero-lateral angles are more prominent than figured, and are somewhat tuberculose; the postero-lateral angles are also somewhat more pronounced, giving to the carapace a squarer aspect.

The chelipeds are scarcely so elongate, and the merus is armed with two tuberculate ridges above. The inner margin of the carpus is strongly tuberculate, and there are tubercles on the lower half of the palm and on the dactylus; the digit also is ridged with tubercles.

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* Dana, U.S. Explor. Exped. Crust. i. p.411, pl.xxvi. fig.1, 1852.

† Haswell, Cat. Aust. Crust. p.147, 1882.

‡ De Man, Archiv f. Naturg. p.442, 1887.

Direct comparison, however, with Japanese examples in the Australian Museum, removes any doubt as to specific identity. Ours are small specimens, and the rugosities noticed become less distinct in larger individuals.

Family GALATHEIDÆ.

Genus Galathea Fabricius.

The collection having provided us with material from the Queensland coast near to the localities in which some of Haswell's types were taken, and that author's specimens being available to us for comparison, we have taken this opportunity of revising the whole of the recorded Australian species of the genus.

It appears to us that, after elimination of the synonyms discussed below, the authenticated species recorded from the East Coast of Australia may be set down as six, as shown in the following key:—

A. Rostrum with three lateral teeth.
- B. Striations of carapace continuous on both anterior and posterior half.
  - C. Rostrum broad, two spines on inner border of merus of maxillipeds; fingers moderate...................... *G. australiensis.*
  - CC. Rostrum slender, three spines on inner border of merus of maxillipeds; fingers long.. .... *G. whiteleggii.*
- BB. Striations on anterior half of carapace not continuous.
  - D. Chelipeds robust, carpus short, fingers half length of hand........ .. . . *G. magnifica.*
  - DD. Chelipeds slender, carpus long, fingers more than half length of hand......................... *G. aculeata.*

AA. Rostrum with other than three lateral teeth.
- F. Rostrum with one lateral tooth......................... *G. pusilla.*
- FF. Rostrum with seven small lateral teeth............. *G. elegans.*

The species of this genus are characteristically variable, the variations no doubt being determined by age, environment and other circumstances; and the brief diagnosis of each which we here give must be taken only as characterising *in toto* those specimens which are actually before us and of which figures are given.

GALATHEA AUSTRALIENSIS Stimps. (Plate iv. figs.1, 1*a*).

1858. *G. australiensis* Stimpson, Proc. Acad. Nat. Sci. Philad. p.89.

1884. Miers, Zool. H.M.S. "Alert," p.277, pl.xxxi. fig.A(nec B).

1888. Henderson, "Challenger" Anomura, xxvii. p.118, pl. xii. fig.5.

1900. Whitelegge, Mem. Aust. Mus. iv. Pt.2, p.189.

1882. *G. corallicola* Haswell, Proc. Linn. Soc. N. S. Wales, vi. p.761, and Cat. Aust. Crust. p.162.

1884. Miers, Zool. H.M.S. "Alert," p.278.

1900. Whitelegge, Mem. Aust. Mus. iv. Pt.2, pp.190 and 192.

Mast Head Island; a good series.

Carapace broad, with 7-8 lateral spines. Striations complete, arranged in eight pairs, each with a thick fringe of setæ of moderate length.

Rostrum broad, shorter than the gastric region and armed with three pairs of lateral spines. It is medially grooved and covered with obscure setiferous scales. There are two gastric spines placed just posterior to the line of the inner orbital spines.

Chelipeds robust, spiny and clothed with long hairs and obscure setiform scales. They are $2\frac{4}{10}$ as long as the carapace, including the rostrum. The hand is rather longer than the carapace, and the fingers are much shorter than the palm.

In old males the right hand is much swollen and the fingers are curved, meeting only at the tips, leaving a wide gap when closed. There are two obtuse tubercles near the base of the dactylus and one between them on the digit, on which there is also another near the end. The whole inner margin is finely serrate.

In young males and females the teeth are scarcely discernible, and the fingers meet along their entire edges.

The ambulatory legs are armed normally. They are scaly and clothed with long hairs.

The ischium of the external maxillipeds bears a distinct spine on its outer distal margin and a minute spinule on its inner margin. The ridge on its anterior face has about 21 minute denticles. The inner margin of the merus has two prominent spines, and the outer is triserrate, as is that of the carpus. The merus has setose scales on its upper surface, and from the joints there spring long hairs.

After careful comparison of a good series from Queensland and from Port Jackson, N.S.W., with the four type specimens of *G. corallicola* in the Australian Museum, we are left without doubt that the suggestion of Miers that the above two species are identical is correct. It has already been pointed out by Whitelegge (*loc. cit.*) that Haswell's statement that the spinules are absent on the gastric region is mistaken, while a large series like that before us amply shows that the other characters relied on for differentiating the two species, viz., "having the frontal region rather narrow, the eyes longer and the hands both longer and broader and with very few spines" are highly variable and consequently unimportant for systematic use.

We cannot, however, fall in with the view put forward by Miers (*loc. cit.*), and subsequently adopted by Henderson,* that our species is identical with *G. spinosirostris* Dana, from which it differs in the conformation of the chelipeds and in the armature of the outer maxilliped, the latter a character of recognised specific value.

The species occurs on the Victorian coast, and has been taken by one of us off Port Phillip Heads.†

The specimen figured is a male from Port Jackson.

GALATHEA WHITELEGGII, nom.nov. (Plate iv. figs.2, 2*a*).

1900. *Galathea* sp. Whitelegge, Mem. Aust. Mus. iv. Pt.2, p.191.

Type (imperfect) taken by the S.S. "Thetis" in 54-59 fathoms off Wata Mooli, N.S.W. Another specimen (perfect) is in the Australian Museum from Port Jackson. The species does not occur in our Queensland collection.

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* Henderson, Trans. Linn. Soc. Lond. (2) Zool. Vol.v. p.431, 1893.

† Sayce, Vict. Nat. Vol.xviii. p.155, 1902.

This species was fully diagnosed by Whitelegge as far as possible from material taken by the "Thetis," in which unfortunately the chelipeds were missing. The second specimen fortunately enables us to complete the description.

Carapace elongate The striations are complete and are clothed with long stiff close-set setæ; there are about eight principal ones and an equal number of finer lines. Lateral margins armed with six spines, the first of which is the largest, reaching to the outer angle of the front. There are a pair of gastric spines and one on each hepatic region.

The rostrum is long and narrow. It is as long as the gastric region, covered with setose scales, mesially grooved and armed with three lateral spines, of which the central one is long and acute.

The chelipeds are slender, $2\frac{4}{10}$ as long as the carapace, including the rostrum, covered with pronounced spiniform setose scales and scantily clothed with long hairs, which are thickest between the fingers. The fingers are incurved at the tips, overlapping when closed, and have their inner margins serrate. The dactylus has two large teeth at the base, and the opposing digit has one large basal tubercle followed by a marked excavation. The carpus is shorter than the dactylus, which is scarcely equal to the palm.

The ambulatory legs are scaly, clothed with long hairs and normally armed.

The ischium of the external maxillipeds terminates in small spines at its inner and outer borders. The ridge on its anterior surface is armed with 16 denticles. Merus with setose scales, its inner border armed with three spines. The following joints are scaly.

The nearest ally of this species appears to us to be *G. inconspicua* Henderson,* from which it differs in the more powerful armature of the rostrum and in the more slender carapace.

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* Henderson, Ann. Mag. Nat. Hist. (5) xvi. p.408, 1885, and "Challenger" Anomura, p.122, pl.xii. fig.2, 1888.

Measurements of the specimen figured, which is from Port Jackson, are as follows :—

Length of carapace..................................	5 mm.
Length of chelipeds..................................	11·5 mm.
Length of hand..	5 ,,
Length of dactylus....................................	2·2 ,,

GALATHEA MAGNIFICA Haswell. (Plate iv. figs.3, 3*a*).

1882. *Galathea magnifica* Haswell, Proc. Linn. Soc. N. S. Wales, vi. p.761, and Cat. Aust. Crust. p.162.

1900. Whitelegge, Mem. Aust. Mus. iv. Pt.2, p.189.

1905. *Galathea setosa* Baker, Trans. Roy. Soc. South Aust. xxix. p.267, pl xxxv. figs.2, 2*a*, 2*b*.

Dredged in Port Curtis in 7 fathoms and off Mast Head Island in 17 fathoms (common).

Carapace broad. The striæ on the interior half are broken up into short rounded scales behind which there are four longer and complete ones; all have a thin fringe of short setæ interspersed with longer hairs. The carapace is laterally armed with 6-7 spines, of which there is also a pair on the gastric region.

The rostrum is very broad and long, medially grooved and clothed with scattered setæ. It is armed with a median and three lateral spines, all of which are very acute.

The chelipeds are short and stout, armed with a few spines and thickly beset with very long hairs; the setose scales are obscured and even absent in parts. In old males the left cheliped is much enlarged, and is rather more than twice as long as the carapace, the hand being as long as all the other joints and very broad. The dactylus is nearly equal to the palm in length and much longer than the carpus, which almost equals the rostrum. Both fingers have a prominent tooth near their base. The smaller hand and those of young males and females have similar proportions, but are without teeth on the fingers.

The ambulatory legs are armed normally, scaly and clothed with very long hairs.

The ischium of the external maxillipeds bears a spine on its inner distal margin; the outer, though finely produced, is obtuse.

The anterior toothed ridge has about twenty-eight closely placed denticles. The merus has two prominent spines on its inner margin; its outer margin is smooth. There are several setose scales on the under surface, and all the joints are hairy.

Our examples from more northern waters show only traces of the brilliant colour markings described by the original author. These consist only of a faint purple band on the abdominal segments of some of the specimens, and in all a bright pink band near the tips of the fingers. Otherwise they differ only from the types in the Australian Museum in being much less hairy; the characteristic long hairs are, however, not absent.

The specimen figured was dredged off Mast Head Island in 17 fathoms.

Mr. Baker, of South Australia, has very kindly forwarded us on loan the type specimens of his *G. setosa*, as to which he writes: "To my mind this seems to approach nearer to *G. magnifica* than to any other." In a note following his description he points out certain differences between *setosa* and *magnifica*, but of these colour is the only one constant, and this we cannot regard as a specific character. We have accordingly sunk his name in synonymy as above, a conclusion with which, after having been furnished with specimens taken by us in Port Curtis, he has expressed his agreement.

GALATHEA ACULEATA Haswell. (Plate iv. figs. 4, 4*a*).

1882. Haswell, Proc. Linn Soc. N. S. Wales, vi. p.761, and Cat. Aust. Crust. p.162.

1900. Whitelegge, Mem. Aust. Mus. iv. Pt.2, p.190.

This species did not occur in our collection.

The figure submitted, and the following description, are taken from the type in the Australian Museum, from Holborn Island, Q.

Carapace broad, the striations on the anterior half broken up into short rounded scales, behind which are four complete ones, all fringed with short hairs with a few longer ones interspersed. There are six large lateral spines and a pair on the gastric region.

The rostrum is large, medianly grooved, sparsely scaly, and armed with a central and three lateral spines, all of which are slender and acute.

The chelipeds are short, slender, spiny, and clothed with long hairs; the scales are not very distinct. The hand of the female is equal in length to the carapace, and is as long as the rest of the limb. Dactylus much longer than the palm, which is a little longer than the carpus, which is about the same length as the rostrum. The fingers are slender and not armed with prominent teeth, but are finely toothed along the whole of their trenchant margins, which almost meet when closed.

The ambulatory legs are armed normally and clothed with scattered hairs

The ischium of the external maxillipeds has both its inner and outer distal angles produced as spines, the anterior ridge has 26 sharply pointed denticles. The merus has two prominent spines on its inner margin, and its outer margin is trispinose. All the joints carry scattered hairs.

This species is readily distinguished from *G. australiensis* Stimp., which it somewhat resembles, by the broken striæ on the anterior half of the carapace as well as by the great length of the fingers. There are four specimens in the Australian Museum from Holborn Island and Port Molle, Q , in all of which these characters are constant.

The identity of the specimens taken by the "Challenger" is uncertain. They may possibly represent another species, as suggested by Whitelegge.

GALATHEA PUSILLA Henderson. (Plate iv. figs. 5, 5*a*).

1885. Henderson, Ann. Mag. Nat. Hist. (5) Vol.xvi. p.407.
1888. ,, Rep. Anom. "Challenger," p.121, pl.xii. figs. 1, 1*a* and 1*b*.
1898. Thomson, Trans. N.Z. Institute, Vol. xxxi. p.193, pl.xxi. fig.7.
1900. Whitelegge, Mem. Aust. Mus. iv. Pt.2, p.185.

Mast Head Island; dredged in 17 fathoms.

The accompanying figure and description are taken from an adult male dredged by the late Mr. J. Bracebridge Wilson off Port Phillip Heads, Vic., in which the carapace including rostrum is 6·5mm. long, while the large cheliped has attained a length of 20mm. Specimens previously figured appear to have been either females or immature males.

Carapace broad with eight cross striæ (and in some specimens with intermediate lines) fringed with setæ and scattered longer hairs. There are 7-8 lateral spines and either one or two pairs of gastric spinules.

The rostrum is short, somewhat concave above, and carrying short hairs. It is armed with a small median spine, which has at its base on either side a small spinule.

The antennæ are very short and robust.

The right cheliped of an old male is robust and greatly developed, not very spiny, and rather thickly clothed with long hairs. It is three times the length of the carapace, the palm alone being nine-tenths as long. The finger is much shorter than the palm and does not equal the carpus. There is a single large tooth, the base of each of the fingers, which are much flattened and incurved at the tips, giving to them the appearance of being spoon-excavate.

The ambulatory legs are normal.

The ischium of the external maxillipeds has its inner and outer distal angles produced into spines. The anterior ridge is finely tuberculate, but is not spinose. The merus has one spine only on its inner border, and its outer distal angle is sharply produced. All the joints bear fine hairs.

From the original description, some of our specimens and those taken by the "Thetis" differ in *not* having the carapace "comparatively smooth," and in having a single pair of spines on the gastric region.

GALATHEA ELEGANS Adams & White. (Plate iv. figs.6, 6*a*).

1848. *Galathea elegans* Ad. & White, Crust. in Voy. "Samarang," p.11, pl.xii. fig.7.

1882. *Galathea elegans* Haswell, Cat. Aust. Crust. p.163.

1884. *Galathea elegans* Miers, Zool. H.M.S. "Alert," p.278.
1882. *Galathea deflexifrons* Haswell, Proc. Linn. Soc. N.S.Wales, vi. p.76; and Cat. Aust. Crust. p.163.

Port Curtis; one specimen (♂) dredged in 7 fathoms.

Carapace elongate; the striations, of which there are eight principal ones and about an equal number of minor ones, are continuous from side to side; all are fringed with forwardly directed short hairs. There are six principal lateral spines on each side but none on the dorsal surface.

The rostrum, which frequently shews a tendency to be deflexed, is much elongated, its length from the tip to the first of the dorsal striæ being equal to that of the rest of the carapace. It is medianly grooved in its distal half only, and is everywhere clothed with small scales and short hairs. Its armature consists of a median spine, and a series of seven fine forwardly directed spinules at regular intervals on its lateral margins.

The chelipeds, of which all the joints are cylindrical, are very long, being $2\frac{1}{3}$ times the length of the carapace, rostrum included. They are everywhere clothed with close imbricating scales fringed with short hairs, and on the merus and carpus with sharp spinules. The dactylus and immobile fingers are each about one-half the length of the palm; their trenchant borders, which almost meet when closed, are finely toothed in their whole length.

The ambulatory legs, which are normally armed, are covered with close-set imbricating scales similar to those on the chelipeds, but are without the long hairs characteristic of other species.

The ischium of the external maxillipeds has its inner and outer distal angles produced as spines, the anterior ridge has sixteen sharply pointed denticles. The merus has two sharp spines on its inner margin, and its outer distal angle is produced to a blunt point. All the joints are sparingly scaly and carry long hairs.

The figure submitted is from a specimen in the Australian Museum from Holborn Island, Q.

A great divergence is observable between the Australian examples of this variable species which we have studied and the figure given by Adams & White. Should the examination of a series from the Malay Archipelago and Australia demonstrate that the differences are of a specific value, Haswell's name of *deflexifrons* will stand for our specimens.

Miers (*loc. cit.*), who has compared Australian specimens with the type in the British Museum, has given a detailed description, with which our example is in accord except that the fingers, which are said to be "*rather* shorter than the palm," are with us scarcely half its length. In this it is in agreement with *G. longirostris* Dana, which, however, appears to have a shorter cheliped, "as long as the body."

There is in the Australian Museum an unlocalised specimen in which the rostrum is slightly deflexed, being intermediate between the type of *G. deflexifrons* Haswell, and typical forms of *G. elegans*. It appears to us to afford ample confirmation of the view of Miers that the two species are identical, the one which we have here adopted.

Henderson* has expressed a view that this species is identical with *G. grandirostris* Stimpson, but with this we cannot agree.

The colour of the species is most variable; our specimen from Port Curtis was, when alive, a bright scarlet with a central longitudinal purple band only on the last segment of the abdomen.

EXPLANATION OF PLATES I.-IV.

Plate i.

Fig. 1.—*Pilumnus terræ-reginæ* Haswell.
Fig. 1*a*.— ,, ,, ; larger cheliped.
Fig. 2.— ,, *spinicarpus*, n.sp.
Fig. 2*a*.— ,, ,, ; larger cheliped.
Fig. 3.—*Metaplax hirsutimana*, n.sp.
Fig. 3*a*.— ,, ,, ; buccal region.
Fig. 3*b*.— ,, ,, ; left cheliped with hairs removed.

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* Henderson, "Challenger," Anomura, p. 119, 1888.

Plate ii.

Fig. 1.—*Pachycheles sculptus* (M. Edw.).
Fig. 2.—*Cryptocnemus crenulatus*, n.sp.
Fig. 2*a*.— ,, ,, ; seen from below.
Fig. 3.—*Paramithrax coppingeri* Haswell.

Plate iii.

Fig. 1.—*Achæus lacertosus* Stimpson.
Fig. 2.—*Paramithrax sternocostulatus* A.M.Edw.
Fig. 2*a*.— ,, ,, ; seen from below.
Fig. 3.—*Diogenes capricorneus*, n.sp.
Fig. 3*a*.— ,, ,, ; frontal process, enlarged.

Plate iv.

Fig. 1.—*Galathea australiensis* Stimpson.
Fig. 1*a*.— ,, ,, ; third maxilliped.
Fig. 2.— ,, *whiteleggii*, n.sp.
Fig. 2*a*.— ,, ,, ; third maxilliped.
Fig. 3.— ,, *magnifica* Haswell.
Fig. 3*a*.— ,, ,, ; third maxilliped.
Fig. 4.— ,, *aculeata* Haswell.
Fig. 4*a*.— ,, ,, ; third maxilliped.
Fig. 5.— ,, *pusilla* Henderson.
Fig. 5*a*.— ,, ,, ; third maxilliped.
Fig. 6.— ,, *elegans* Adams and White.
Fig. 6*a*.— ,, ,, ; third maxilliped.

THE FIRST RECORDED OCCURRENCE OF BLASTOIDEA IN NEW SOUTH WALES.

By T. Griffith Taylor, B.Sc., B.E., Assistant Demonstrator in Palæontology and Geology, Sydney University.

The specimens were found during a visit to Clarence Town for the purpose of collecting fossils in the Carboniferous Series at that place. They occur in calcareous sandstone, together with Crinoids (*Actinocrinus*), Trilobites (*Phillipsia dubia*) and Brachiopods such as *Leptœna analoga*, *Orthis resupinata* and *Productus semireticulatus*. The beds dip somewhat steeply to the east towards the Williams River, the layer in which the blastoids were found being marked by a persistent layer of crinoid joints, somewhat weathered and confusedly intermingled together. The district has been surveyed geologically by Mr. J. B. Jaquet, and the beds in question are known as the Glenwilliam Carboniferous Series.

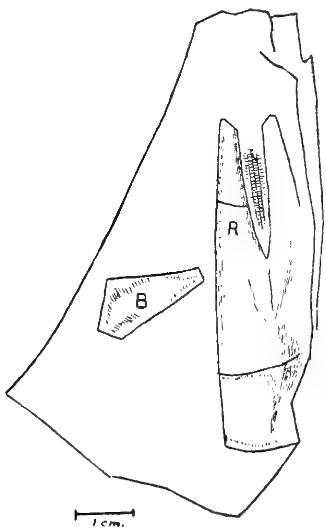


Fig. 1.-Sketch of Specimen A showing large Radial (R) and Basal (B).

The specimens are two in number, and may be distinguished as A and B. They occurred near together in the same block of sandstone, and they both consist of portions of the calyx. A comprises a large Radial or forked plate, with some portion of the ambulacral plates preserved, and at the side a small isolated basal plate (see fig. 1). B consists of the external cast of a Radial plate, which shows very well the prominent bulge below the radial sinus. Also on the same piece of stone occurs a second basal plate of the same general shape as that of specimen A.

There is no trace of a stem, except in so far as a flattening at the distal end of the basal on specimen A may indicate a facet for attachment of a stem.

Basals.—The two isolated plates, one on each specimen, represent basals. They are both quadrilateral and somewhat wedge-shaped, about 2 cm. long by 1·2 cm. at the widest portion near the adoral extremity. The narrow habit of these basals would seem to point to a narrow funnel-shaped basal cup, unless they both happen to be small unpaired basals from different specimens. Reasons for referring them, however, to a blastoid (such as *Metablastus*) with an elongate basal cup will be given later. These plates were very solid, being as much as 3 mm. in thickness near the aboral end.

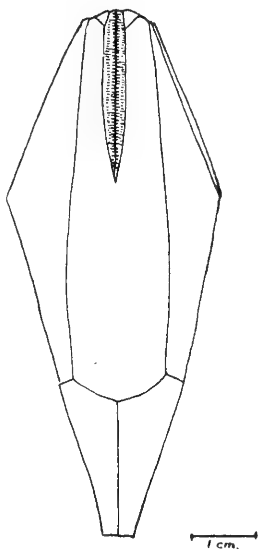


Fig.2-Restoration of Blastoid.

Radials very long and narrow, decreasing slightly towards the adoral end. Length about 5·5 cm., with a ratio limbs/body = $\frac{2}{3}$. Interradial sutures comparatively straight, placed in depressions, sinuses narrow and sublinear, 0·3 cm. wide. Width of radials 2·2 cm. near the aboral end, but narrowing to 1·1 cm. at the adoral end. In profile the radials bend sharply just below the radial sinus, and thus give an angle of 140° between the upper (or ambulacral portion) and lower (aboral) portion (see fig.2). It will be noticed that the radials are nearly thrice the length of the basals. Each of the radials is rounded from side to side in rather a pronounced manner, which would give the complete calyx a definite broadly fluted appearance. The radials (specimen B) appear to be ornamented by concentric striæ.

Two slight ridges running across the radial in specimen A (see fig.1) might be thought to represent a deltoid and basal suture respectively. But the former, about 1·5 cm. from oral end, is not matched on the other limb of the same radial, while the ridge across the lower portion of the radial (1·5 cm. from aboral end) of similar appearance would make the portion cut off too short for a basal. The interradial suture runs *straight* along the edge and would probably not be prolonged to form an inter-basal suture as the former supposition would require. It may be mentioned that in specimen B [in external cast] a somewhat similar crack appears in the lower portion of the radial, but in this latter case the concentric ornamental striæ of the radial obviously cut right across the pseudo-suture in a manner suggesting that the latter is quite accidental.

Ambulacra.—These areas are relatively narrow, and, as stated, decrease from 0·3 cm. very gradually to the aboral sinus. Fig.3 is a sketch of portion of the ambulacra of specimen A. It shows the transverse ridges (between which were the *side plates*) and the food groove down the centre. Sixteen of these ridges (G) are preserved, indicating about 40 over the whole length of the lancet plate. These plates seemed to have covered over the lancet plate, which arrangement would be in accord with the characteristics of the Troostoblastidæ.

Lying outside the side plates, and at a higher elevation, the *outer side plates* conform roughly with the former. The ridges (S) between these outer plates lie over the canal (C) shown in figs.3-4. This canal probably represents that which runs above the hydrospires. The three subsidiary ridges between each pair of larger ridges (S) probably are only ornamental, and may represent three grooves on the lower surface of each *outer side plate.* They are shown on the right of fig. 3.

Transverse sections of A and B were made but did not show what the structure of the hydrospires was like. Two canals (C) mentioned above were cut through, but the internal structure of the blastoid is not preserved in the specimens obtained.

The surface obtained from specimen B by taking an impression in wax is indicated by the broken line in fig.4. A long lancet-shaped area probably represents the under surface of the lancet plate, and its relative position is given in fig. 4.

Systematic Position.—The character of the ambulacra, which are distinctly linear and narrow, serves to separate this genus

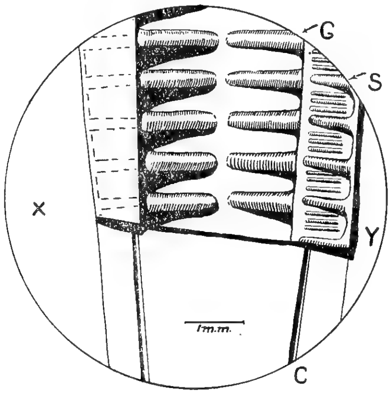


Fig. 3.-(Somewhat diagramatic). Portion of ambulacra. The ridges (G) between the side-plates, and (S) between the outer side-plates are shown; while below X Y (at a lower level) are longitudinal canals (C).

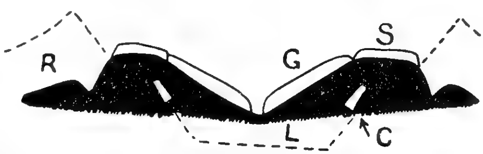


Fig. 4.-Transverse Section of Specimen A, along X Y.

from the Codonoblastids, in which they are somewhat broad and petal-like; and from the Granatoblastids in which the ambulacra stretch far down the ovoid theca.

Hence we are led to place the blastoid in the Division TROOSTOBLASTIDÆ — Family *Troostocrinidæ*, defined (*vide* Lankester, Echinodermata) as blastoids of elongate form with linear ambulacra descending sharply outwards from the much restricted peristome.

This family (Troostocrinidæ) contains three main types, *Troostocrinus*, *Metablastus* and *Tricœlocrinus*.

For convenience in comparison the characteristics of these three blastoids and of the Glenwilliam specimen may be tabulated as follows :—

	Troostocrinus.	*Metablastus.*	*Tricœlocrinus.*	Glenwilliam Specimens.
Shape of Calyx.	Elongated fusiform.	Elongated fusiform.	Pyramidal.	Elongated fusiform.
Basals ...	Basal cup conical, forming ⅓ calyx. Plates convex.	Cup conical. Plates convex.	Cup short and wide, excavated into three hollows.	Cup conical. Plates convex.
Radials.	Limbs very short.	Limbs shorter than body.	Limbs longer than body.	Limbs ⅔ length of body.
Ambulacra.	Plates 20.	Plates 18-60.	Area long and very narrow.	Plates 40.
Age	Silurian.	Silurian to Carboniferous.	Carboniferous.	Carboniferous.
Habitat.....	N. America.	N. America.	N. America, Queensland.	Glenwilliam, N.S.W.

We see from above table that the genus under consideration agrees most closely with *Metablastus.* It differs from *Troostocrinus* in that the sinus of the latter is short, plates twenty, and age is set down as Silurian. The general shape as shown by figure in Zittel (p.195) is somewhat similar however.

With respect to *Tricœlocrinus*, we note the difference in shape of the basal cup, as far as we can reconstruct it; the length of the ambulacra is shorter in the blastoid under consideration, while the figures given by Etheridge (Blastoidea, plate xix. fig.13) are very different from our specimen. Coming to *Metablastus*, which probably is after all only a somewhat later type of *Troostocrinus*, we see a close resemblance, especially with *Metablastus hispanicus** obtained from the Lower Devonian of Spain. The latter is figured on plate 5, fig.21, of Etheridge and Carpenter's Monograph, and in general shape is similar though only about one-third the length of the Australian specimen.

* p.200 E. & C. on Blastoidea.

Other Australian Genera.—The only other blastoids occurring in Australia are those from the Gympie (Carboniferous) Beds of Rockhampton, Q. Both from the descriptions and the figures given by Etheridge in "The Geology of Queensland," there is no doubt that—imperfect as are the specimens under discussion—a genus new to Australia has been discovered. The three are designated *Mesoblastus australis*, *Granatocrinus wachsmuthii*, *Tricœlocrinus carpenteri*, and the characteristics separating the Glenwilliam specimens from these genera have already been discussed.

Conclusion.

A noteworthy characteristic is the large size of the blastoid under discussion. None of those figured in Etheridge and Carpenter's Monograph approach it, except perhaps an allied genus, *Tricœlocrinus obliquatus* (Plate xviii., fig.10), of which a radial only is sketched.

The following is a brief description of the blastoid:—*Calyx* narrow elongate (probably 7-8 cm. in length) with contracted oral surface. Ambulacra of medium length, narrow and linear, and reaching nearly half-way along the radials. Lancet plate covered by *side plates*, latter lying in deep grooves and approaching 50 in number. *Outer side plates* alternating with side plates and with three lateral grooves on under surface of each plate. *Deltoids* certainly small and probably overlapped by radials. *Radials* very long, over $\frac{2}{3}$ of length of calyx, and exhibiting a profile angle of 140°; distinctly convex in cross-section. *Basals* rather short and narrow, forming a conical cup.

Loc.—In the bed of Cherry Creek * about $\frac{1}{4}$ mile north of Berry's farm, Glenwilliam, Clarence Town, N.S.W.

Age.—Carboniferous.

Name.—One of the Troostoblastidæ, provisionally classed with *Metablastus.*

In conclusion I desire to thank Professor David and Mr. W. S. Dun for suggestions assisting the preceding investigation, especially with regard to the structure of the side plates.

* Cherry Creek, $2\frac{1}{2}$ miles north of Clarence Town, is shown on Mr. Jaquet's map of the Williams River area, in the Memoir on the Iron Ore Deposits of N.S.W. (Geol. Survey N.S.W. Mem. No. 2).

NOTES AND EXHIBITS.

Mr. Palmer exhibited four young specimens of *Ceratodus Forsteri*, artificially hatched and reared by Mr. T. Illidge, lately of Gayndah and now of Gladstone, Q. The ova were collected in the Burnett River and proved perfectly fertile. The four examples of the young fish shown exemplified different stages of growth, the largest being seven months old. In previous attempts none of the young fish survived the fourth month, but on the last occasion they were vigorous so long as Burnett River water was obtainable. On removal to Gladstone only tank rain water was procurable, and this quickly affected the fishes to such an extent that to save them from utter destruction they were preserved. None but mature fish have been obtained from the Burnett and Mary Rivers for many years, and it is supposed that in recent times foes to the ova and young fish have greatly increased in these waters; consequently the species cannot be said to be holding its own.

Mr. Palmer also exhibited terminal shoots of an otherwise healthy and vigorous peach tree, which had been apparently punctured by the grub of one of the microlepidoptera, causing excessive gumming and thus killing the terminals of the branches. Though not of common occurrence, it was manifest that this grub might become a very serious pest to fruit-growers.

Mr. David G. Stead exhibited, and offered remarks upon, examples of two species of Mullet—*Mugil waigiensis* Quoy and Gaim., and *M. dussumieri* Cuv. and Val.—from coastal waters of New South Wales; both of which are additions to the fauna. The example (immature) of *M. waigiensis* was obtained by Mr. H. C. Dannevig during November, 1903, from a small lagoon inside the breakwater at Ballina, Richmond River. The specimen (mature) of *M. dussumieri* was forwarded from Clarence River during February, 1905, by Inspector Smithers, who mentioned that it was the smallest amongst a number captured at the same time, some of which were about 2lbs. in weight.

Mr. Stead also drew the attention of biologists to the great utility of Waterproof Indian Ink (Higgins') in the writing of labels for immersion with specimens in formalin.

Mr. T. Griffith Taylor showed some very large fossil gastropods, probably a species of *Cerithium*, recently collected by him from the Miocene beds at Aldinga, South Australia.

WEDNESDAY, APRIL 25TH, 1906.

The Ordinary Monthly Meeting of the Society was held in the Linnean Hall, Ithaca Road, Elizabeth Bay, on Wednesday evening, April 25th, 1906.

Mr. C. Hedley, F.L.S., in the Chair.

Mr. ALEXANDER THOMSON, 130 St. John Street, Launceston, Tas., was elected an Ordinary Member of the Society.

The Chairman announced that, under the provisions of Rule xxv., the Council had elected Mr. Henry Deane, M.A., F.L.S., &c., the Hon. James Norton, LL.D., M.L.C., Mr. J. H. Maiden, F.L.S., and Dr. T. Storie Dixson, to be VICE-PRESIDENTS; and Mr. J. R. Garland, M.A. (56 Elizabeth Street), to be HON. TREASURER, for the current Session. Also that the Council had elected Mr. ALEX. G. HAMILTON to fill an extraordinary vacancy in the Council caused by the removal of Mr. Edgar R. Waite, F.L.S., to New Zealand.

The Donations and Exchanges received since the previous Monthly Meeting, amounting to 4 Vols., 51 Parts or Nos., 23 Bulletins, 1 Report, and 17 Pamphlets, received from 44 Societies, &c., and 2 Individuals, were laid upon the table.

THE BOTANY OF HOWELL (BORA CREEK): A TIN-GRANITE FLORA.

By J. H. Maiden, Government Botanist and Director of the Botanic Gardens, Sydney.

In a Presidential address I had the honour of delivering before this Society, part of it * was devoted to a scheme for a Botanical Survey of New South Wales. This address was accompanied by a botanical map of the State, divided into proposed botanical counties, and it was, as far as I know, the first map of the kind to be published. Some five years previously, in another place, I had formally promulgated this idea of a botanical survey, and in an early issue of the Agricultural Gazette of N.S.Wales will be found an elaboration of the idea, together with a modified botanical map of the State.

Howell, the subject of my present paper, is (so far as I have treated it), a tin-granite area extending in a 2- or 3-mile radius from the Howell township. Howell is on the Bora Creek and is 19 miles south-east of Inverell. It is on the Western New England slope, and is included in my E9, New England County.* It commended itself to me for consideration in that it consists of an unmixed geological formation; I record no plants not collected on what geologists term the "tin-granite."

The record is incomplete, yet I think it will be found useful. Most of the plants have been collected by myself, and Mr. J. L. Boorman, the Collector of the Botanic Gardens, has paid a second visit to this interesting locality. Mr. R. Hart, Headmaster of the local Public School, has sent plants from time to time.

Howell township stands at an elevation of about 2,500 ft. above sea-level, and its situation is very picturesque, with solid

* These Proceedings 1901, with map, p.766.

rounded hills and boulders of granite everywhere. Everything consists of rocks. It is country in which the agility of a goat is an advantage. Abundant rills of water are to be found (at least during the winter months). The plants were collected at elevations between say 2,300 and 2,950 feet.

The prevailing vegetation over a large area is certainly the Wattle (*Acacia*). These are numerous as regards species and, in most cases, profuse in individuals. The result is that the floral effect of these plants in winter and early spring is indescribably beautiful. Perhaps *A. neriifolia* is the most abundant.

The largest *Eucalyptus* is *E. Andrewsi*, and it is rather plentiful. The two Ironbarks are *E. sideroxylon* and *E. Caleyi*, and neither is rare, although most of the trees are second growth. *E. tereticornis* in two or three forms is abundant, while *Eucalyptus Caleyi* was studied and described anew, enabling one to clear up certain difficulties which had gathered around herbarium specimens of New England Ironbarks.

The Rutaceæ are certainly interesting; *Boronia granitica* is new; the form of *Eriosetmon Crowei* is interesting, while *Phebalium rotundifolium* is as abundant as it is beautiful.

The locality for the new variety of *Cryptandra amara* is interesting, while that of *Dodonæa filifolia* is another connecting link between Queensland and the Port Jackson locality Bentham thought must be a mistake.

The papilionaceous Leguminosæ include the gorgeous *Mirbelia speciosa* and the even more beautiful *Hovea longifolia*. A new locality is given for *Daviesia recurvata*.

Amongst the Myrtaceæ *Leptospermum* is abundant, while the rare *Kunzea opposita* is found here.

The common Flannel-flower (*Actinotus*) is not rare, while the blue-flowered *Olearia ramosissima* is a feature.

Prostanthera granitica was found here for the first time, and Proteaceæ are abundant. The list will be extended.

Monotaxis macrophylla, absent from Australian herbaria, was rediscovered.

Casuarina appears to be absent, while *Callitris* is rare. The *Macrozamia* of these parts is *heteromera*. The Glumaceæ call for no special mention, while the Ferns, as is usual on granite, are few.

There is no doubt that the locality is a botanically interesting one, and examination of it may be commended to the student. All the plants enumerated in this paper have been deposited in the National Herbarium, Sydney, and endeavour will be made to have it more complete (it is rather a distant collecting ground) and to compare it with the floras of the few granite areas whose plants New South Wales botanists have catalogued.

RANUNCULACEÆ.

Clematis glycinoides DC.
Ranunculus lappaceus Sm.

DILLENIACEÆ.

Hibbertia stricta R.Br.
acicularis F.v.M.
pedunculata R.Br.
linearis R.Br.

PITTOSPORACEÆ.

Bursaria spinosa Cav.
Cheiranthera linearis A. Cunn.

POLYGALACEÆ.

Comesperma ericinum DC.

STERCULIACEÆ.

Rulingia pannosa R.Br.

RUTACEÆ.

Zieria pilosa Rudge
sp. aff. *granulata* C. Moore, var. *anodonta* F.v.M.
Boronia anemonifolia A. Cunn., var. *anethifolia* Benth. Flowers blush-pink to nearly white; leaves with a strong odour.
granitica Maiden and Betche. (These Proceedings, 1905, p.357).

RUTACEÆ.

Eriostemon myoporoides DC. Up to 6 feet high; habit erect; common.

Crowei F.v.M. A small narrow-leaved form approaching var. *exalata*. Only seen on one spot, 3 miles on Inverell Road from Howell.

Phebalium rotundifolium A. Cunn. Flowers lemon-yellow; up to 3 or 4 feet; a very handsome plant and one of the most conspicuous.

Correa speciosa Sm. Up to 6 feet in sheltered situations.

OLACINEÆ.

Olax stricta R.Br.

STACKHOUSIACEÆ.

Stackhousia linariæfolia A. Cunn. (*S. monogyna* Labill).

RHAMNACEÆ.

Alphitonia excelsa Reissek. (Received from Mr. E. C. Andrews).

Cryptandra amara Sm., var. *floribunda* Maiden and Betche.

SAPINDACEÆ.

Dodonæa viscosa Linn., var. *attenuata*.

viscosa, Linn., var. *cuneata*. Up to 5 feet; common.

filifolia Hook. Very ornamental.

LEGUMINOSÆ.

Mirbelia speciosa Sieb. Very fine; up to 2 feet; flowers purplish-crimson. One of the most gorgeous plants in the bush.

Gompholobium Huegelii Benth.

Jacksonia scoparia R.Br.

Daviesia latifolia, R.Br.

recurvata Maiden and R. T. Baker. (See Note, these Proceedings, 1905, p.360).

Pultenæa stricta Sims.

villosa Willd.

Dillwynia floribunda Sm.

juniperina Sieb.

LEGUMINOSÆ.

Bossiæa buxifolia A. Cunn.

microphylla Sm.

Hovea linearis R.Br.

longifolia R.Br. A beautiful and variable species.

Indigofera australis Willd. The normal form.

australis Willd., var. *signata.*

Swainsona coronillifolia Salisb.

Acacia triptera Benth. Very common.

lanigera A. Cunn. With slender stems up to 10 feet.

juniperina Willd.

var. *Brownei.* Not prostrate, leaves sparse; flowers yellow. A spreading bush of 4 feet.

penninervis Sieb. Tall slender shrubs.

neriifolia A. Cunn. *The* Wattle of Howell. Up to 12 or 15 feet, very bushy, glaucous when young and with pruinose bark; very bushy and graceful; "Bastard Myall," not a bad name.

linifolia Willd., var. *prominens.*

decora Reichb.

? *implexa.* Not in flower; tall shrubs and small trees.

doratoxylon A. Cunn., var. *ovata* Maiden and Betche. (See these Proceedings, 1905, p. 362.)

spectabilis A. Cunn. Timber white all through; no figure; diameter 3 inches. With more spindly and coarser leaves than at Warialda. A different race. Bark pruinose up to 10 ft. The habit of the local specimens of *A. spectabilis* much the same as *leptoclada* but its stems are glaucous.

spectabilis A. Cunn., var. *Stuartii* Benth.

leptoclada A. Cunn. Also a specimen showing stem-fasciation—a phenomenon not common in the genus. An erect species; with long, slender stems up to 12 feet; trunks smooth, yellow, rarely exceeding 1 inch. A soft, beautiful species. The most local species, but there are several acres of it.

LEGUMINOSÆ.

Acacia diptera Lindl. Sturdy, spreading plants up to 10 feet broad and 3 inches in diameter.

HALORAGACEÆ.

Haloragis sp. (leaf only).

MYRTACEÆ.

Darwinia taxifolia A. Cunn. Prostrate; silver-leaved and secund. On faces of bare rocks; sometimes spreading to 20 feet.

Calythrix tetragona Labill.

Thryptomene ciliata F.v.M.

Bœckia densifolia Sm.

Leptospermum flavescens Sm.

scoparium Forst.

arachnoideum Sm.

attenuatum Sm.

Kunzea capitata Reichb.

opposita F.v.M. Rare; a pleasing shrub of 3-5 feet; in moist situations. (See these Proceedings, 1905, p.364.)

Callistemon lanceolatus DC.

Angophora intermedia DC.

Eucalyptus macrorrhyncha F.v.M. Suckers narrow. Also a *grandiflora* form.

Andrewsi Maiden. "Woollybutt" and "Blackbutt." Very large trees.

Stuartiana F.v.M. Very glaucous young trees, and tuberculate young growth. Large trees. Very long leaves!

sideroxylon A. Cunn.

Caleyi Maiden. An Ironbark. (See these Proceedings, 1905, p. 512.)

tereticornis Sm., var. *dealbata*. "Cabbage Gum." Two forms, differing in size of fruit and flatness of rim. Often very glaucous.

MYRTACEÆ.

Eucalyptus tereticornis Sm., var. *brevifolia.* Tall, fairly erect trees, not scrambling as at Wallangarra. Much less common than *E. dealbata.*

UMBELLIFERÆ.

Didiscus incisus Hook.f. Dainty pink flowers and graceful fern-like foliage.

Actinotus Helianthi Labill.

LORANTHACEÆ.

Loranthus pendulus Sieb., on *Eucalyptus Caleyi* Maiden.

RUBIACEÆ.

Pomax umbellata Sol. Up to 2 ft. high in the shelter of rocks!

COMPOSITÆ.

Olearia ramulosa Benth. Up to 8 feet.

ramosissima Benth. Ray florets pale blue to purple. Flowers in the greatest profusion; a glorious plant for gardens.

Brachycome (two species in early flower only).

Cotula australis Hook.

Helichrysum bracteatum Willd.

apiculatum DC.

obcordatum F.v.M.

Senecio lautus Forst. (the form known as *S. capillifolius* Hook.f. See these Proceedings, 1905, p.367).

CANDOLLEACEÆ.

Candollea serrulata Labill. (*Stylidium graminifolium* Sw.).

GOODENIACEÆ.

Goodenia geniculata R.Br.

Brownii F.v.M.

Dampiera sp. (in foliage only).

CAMPANULACEÆ.

Isotoma axillaris Lindl.

EPACRIDACEÆ.

Melichrus urceolatus R.Br.

Brachyloma daphnoides Benth.

EPACRIDACEÆ.

Lissanthe strigosa R.Br.

Leucopogon virgatus R.Br.

muticus R.Br. Up to 6 feet; rather straggly.

neo-anglicus F.v.M. Sturdy, shapely shrubs. Up to 6-8 feet.

Monotoca scoparia R.Br.

GENTIANACEÆ.

Limnanthemum sp.

SOLANACEÆ.

Solanum parvifolium R.Br.

cinereum R.Br.

SCROPHULARINEÆ.

Veronica Derwentia Littlejohn.

LABIATÆ.

Plectranthus parviflorus Willd.

Prostanthera nivea A. Cunn.

granitica Maiden and Betche. (These Proceedings, 1905, p.369.)

POLYGONACEÆ.

Muehlenbeckia rhyticarya F.v.M.

PROTEACEÆ.

Petrophila sessilis Sieb.

Isopogon petiolaris A. Cunn.

Persoonia cornifolia A. Cunn.

Mitchelli Meissn.

Grevillea floribunda R.Br.

triternata R.Br.

Hakea microcarpa R.Br.

Lomatia silaifolia R.Br.

THYMELACEÆ.

Pimelea linifolia Sm.

EUPHORBIACEÆ.

Monotaxis macrophylla Benth. Up to 2 feet; flowers bright yellow; leaves succulent. On the tops of high rocks; very local; a rare species.

Phyllanthus thymoides Sieb.

URTICACEÆ.

Ficus eugenioides F.v.M. Rare; nearly glabrous; on tops of the highest hills.

SANTALACEÆ.

Choretrum Candollei F.v.M.

Exocarpus cupressiformis Labill.

CONIFERÆ.

Callitris calcarata R.Br. The Black Pine. Scarce. I was informed that there is a second species about a couple of miles from the township, but I did not see it.

CYCADACEÆ.

Macrozamia heteromera C. Moore.

HYDROCHARIDEÆ.

Ottelia sp.

IRIDACEÆ.

Patersonia sericea R.Br.

HÆMADORACEÆ.

Hæmadorum planifolium R.Br.

LILIACEÆ.

Dianella sp.

Bulbine bulbosa Haw.

Stypandra glauca R.Br.

cæspitosa R.Br.

Xerotes longifolia R.Br.

Brownii F.v.M.

Xanthorrhœa (?) *bracteata* R.Br. Fine leaves.

PHILYDRACEÆ.

Philydrum lanuginosum Bks.

JUNCACEÆ.

Juncus pauciflorus R.Br.

CYPERACEÆ.

Cyperus dactylotes Benth.

Gahnia Sieberi Bœck.

GRAMINEÆ.

Panicum sanguinale Linn.

Erianthus fulvus Kunth.

Andropogon refractus R. Br.

micranthus Kunth., var. *spicigera*.

Themeda Forskalii Hack. (*Anthistiria ciliata* Benth.)

Arundinella nepalensis Trin. Very abundant in moist situations.

Aristida vagans Cav.

Stipa verticillata Nees.

Dichelachne sciurea Hook.

Echinopogon ovatus Palis.

Eragrostis pilosa Palis.

Brownii Nees.

FILICES.

Adiantum hispidulum Swartz.

Pteris aquilina Linn.

Grammitis rutæfolia R.Br.

The area is not rich in ferns, either in individuals or in species. I do not doubt, however, that there are other species than those enumerated.

GEOLOGY OF THE VOLCANIC AREA OF THE EAST MORETON AND WIDE BAY DISTRICTS, QUEENSLAND.

By H. I. Jensen, B.Sc., Linnean Macleay Fellow of the Society in Geology.

Synopsis.

Part i. Physiography and General Geology.

(Plates v., v.*bis*.-x.)

Part ii. Petrology.

(Plates xi.-xvi.)

Part i. Physiography and Topography

i. Introduction.

In a previous paper* I have already discussed the geology of the Glass House Mountains district. A visit to Queensland in February and March last year inspired me with a strong wish to continue the research, the interesting plutonic and metamorphic rocks of the D'Aguilar Range and the wide assortment of volcanic rocks in the Maroochy River district having specially attracted my attention and aroused my interest.

The present paper deals with an area extending from Cooran near Gympie to North Pine, 14 miles from Brisbane, and from the coast inland to the beds of the Mary and Stanley Rivers, covering in all more than 1,000 square miles. More than five months have been devoted to field work. The result appears on the Plan (Plate v.).

Dense scrubs, the talus slopes obscuring cliff exposures, large swamps, and the dearth of cuttings, quarries, mine-shafts or bores in the district, not to speak of the unsettled nature of much of the country and lack of means of communication, were serious impediments to be overcome.

No proper geological work has been done in the district since the surveys of the late Hon. A. C. Gregory in 1875. The "Geological Map of Queensland" published by the Queensland Mines Department in 1899 is altogether too indefinite as far as this region is concerned.

ii. Physiography and Topography.

(*a*) *The Coastal Area.*—As shown on the Plan (Plate v.) the Trias-Jura rocks of the district form a coastal fringe, widest to the west of Bribie Island and narrowing towards the north and south. This belt belongs to the Ipswich Coal Measures, into which it merges at Brisbane; northwards it is continuous as far as Lake Cootharaba, except for occasional volcanic and intrusive

* These Proceedings, 1903, p.842.

masses. There is no break between the Ipswich and Burrum Coal-Measures, as the Geological Map of Queensland leads one to suppose. Lithologically the sandstones of Caloundra and Landsborough are identical with those of Point Arkwright, Noosa and

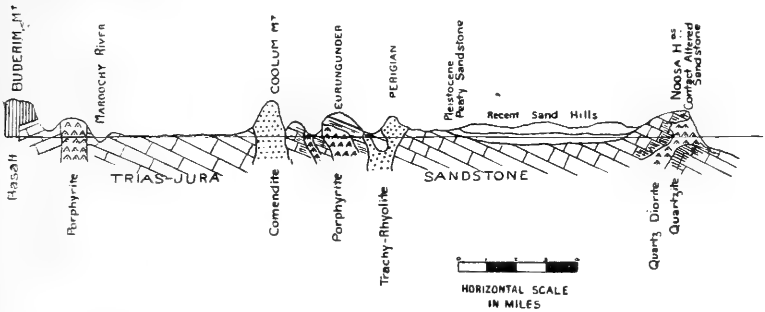


Fig.1.-Section from Buderim to Noosa Heads, along the line MN in Plate v.

Tewantin. In view of these facts, I consider that, until further evidence is available, the Ipswich and Burrum Coal-Measures should be considered identical (Text fig.1).

The soil of this belt of country is sandy and poor. The vegetation is of a forest type. Between Landsborough and Narangba the country is low-lying, sometimes almost flat, more often gently undulating. Between Landsborough and Nambour it is decidedly rugged and much more elevated. The coast is lined with swamps, salt marshes and useless tea-tree flats. True scrubs occur on many of the alluvial soils along the rivers and creeks, as well as on the basaltic hills of Buderim Mt. and Sippy Mt. The so-called "bastard scrubs," with a mixed forest and scrub vegetation, occur in many of the gullies in the rugged country between the Blackall Range and Buderim Mountain.

The Glass House Mountains, Buderim Mountain, Mt. Coolum, Mt. Peregian and many other hills rise abruptly out of the low-lying and flattish sandstone country. About four miles to the north-east of Beerburrum there is an outlying trachytic hill, Barren Mountain, 350 feet high, situated in a most inhospitable part and surrounded by swamps.

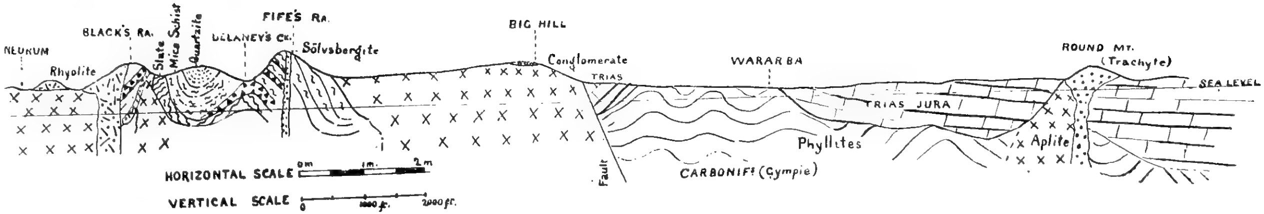


Fig. 2.-Section from Neurum School to the Round Mountain, along the line C D on Plate v.

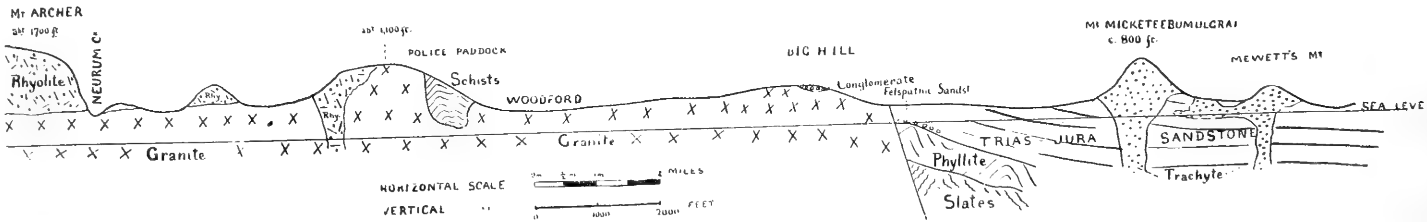


Fig. 3.-Section from Mt. Archer to Mewett's Mountain, along the line M N in Plate v.

About 4½ or 5 miles west of Caboolture the junction between the Palæozoic phyllites and Triassic sediments is encountered. The phyllites form a belt which narrows towards the north-east and widens in a southerly direction. They cut out altogether at Big Hill, where the sandstones abut on Woodford granite.* West of the phyllites we have a belt of pyritiferous slate and mica schist which also widens towards the south. These formations support a forest vegetation and form a good pastoral country. The vanishing of the Palæozoic rocks at Big Hill is probably due to a fault running N.W.-S.E., and having a downthrow to the N.E. of at least 500 and probably more than 1,000 feet. The phyllites, mica schists and slates belong to the Gympie formation. At Terror's Creek, in the Pine River Valley, a mass of granite occurs; this mass is bordered with slate and mica schists which gradually pass into the less metamorphosed shaly phyllites. The alteration of soft phyllites to hard mica schists and slates is evidently due to the great intrusion of granite in Post-Gympie time.

Between Peregian and Noosa Heads enormous sandhills line the coast, some of which reach a height of several hundred feet. The sand is kept together by the fleshy creepers, *Mesembryanthemum æquilaterale* and *Scævola suaveolns.* North of the Noosa River, between Lake Cootharaba and the sea, there is a veritable range of sand reaching a height of 300 feet in Teewah (Seewah) Hill.

(*b*) *The D'Aguilar Range.*—This range extends from the vicinity of Enoggera near Brisbane and Mt.Crossby near Ipswich, on the south, northwards to the Blackall Range, into which it merges to the west of Landsborough. The highest peaks are Mt. Nebo, Mt. D'Aguilar (2,438), Mt. Samson (2,251) and Mt. Mee (1,550). Mt. Kobble-Kobble and Mt. Byron are situated on spurs of it. The part of this range which lies north of Mt. Mee is a mere watershed between the Stanley River and east-flowing streams (height 600 ft.). Between Mt. Mee and Mt. D'Aguilar

* See Text figs.2-3.

the average height is 1,400 feet. The country is very rugged, and the D'Aguilar Range is specially remarkable for the enormous differences in soil, rock-formation and vegetation in different parts. South of Mt. Nebo it is composed of granites and Palæozoic rocks with a fair soil, giving good pasturage. Between Mt. Nebo and Mt. Mee the ruggedness of the range becomes still more marked, sharp peaks towering aloft from it Judging by their steepness and general configuration, I should take them to be composed of trachyte or rhyolite. The soil of this part of the range is often poor through cappings of sandstone, and rhyolite dykes The timber is of the forest type. At Mt. Mee we obtain excellent soils derived from hornblendic schists and basalt. The basaltic cap of Mt. Mee is covered with scrub. Mt. Byron is separated from Mt. Mee by a deep gorge, Sellin's Creek (a branch of Byron Creek), in which the Mt. Mee basalt is clearly seen to overlie the Mt. Byron keratophyre. Mt. Byron has a forest vegetation with an abundance of macrozamias and grass-trees. The soil is poorish, overlying a soda-rhyolite, though occasional patches of scrub occur on basaltic dykes.

From Big Hill northwards the poverty of the soil of the range contrasts markedly with its richness on the fertile Mt. Mee Tableland. A small mass of conglomerate caps the rotten granite of Big Hill on the Caboolture-Woodford road. North of the supposed fault sandstone formation is met with. West of Mt. Tunbubudla a mass of volcanic rock (rhyolite quartz porphyry, dacite and basalt) occurs in the range (Plate v., iii.).

(c) *The Woodford Peneplain.*—Behind the D'Aguilar Range there lies an extensive tract of gently undulating country, through which the Stanley River flows in a shallow bed. This tract has an average altitude of about 500 feet in the Woodford district. The soil is sandy, derived chiefly from rotten granite, and, the country being open forest land, is well adapted for pastoral pursuits. The decomposition of the granites to great depths probably dates from the time when this country was a coastal plain. Since the elevation of the present coastal plain the direction of drainage has altered, so that the northern portions of the D'Aguilar Range, the old coast-line, have become a low watershed (from 600 to 800 feet high). A brief space of geological time will probably see the drainage of a part of this district rediverted into the Caboolture River through the cutting back by Wararba Creek. (See Plate v., and Text figs.2-3).

A spur of Mt. Mee known as Fife's Range (1,400 feet) surrounds the mountain valley known as Delaney's Creek (Plate vi.).

Many other mountains rise out of the plain, *e.g.*, the Mt. Archer group (about 1,700 feet), Mary Smokes Mountain, Mt. McConnell, &c. These are 'mesas' or 'buttes,' which through excessive hardness resisted denudation to base-level, and are composed of rhyolite, porphyry and hard metamorphic rock. Mt. Mee itself is of similar nature, its hard metamorphic rocks having preserved it from base-levelling on the east, and the equally hard volcanic rocks of Mt. Byron and Mt. Archer on the west.

(*d*) *The Blackall Range*.—This range commences a little to the north-west of Mt. Mellum and constitutes, in reality, a broad tableland from 1,200 to 1,750 feet high, known as Maleny. On

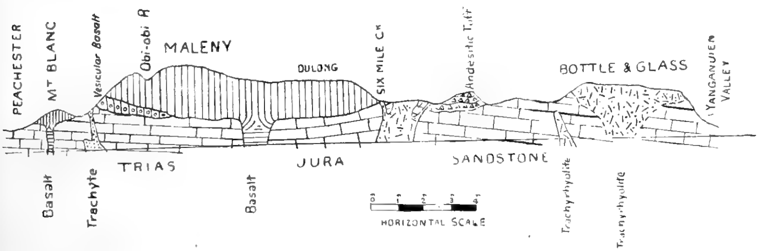


Fig.4.-Section from Peachester to the Bottle and Glass, along O P on Plate v.

the eastern side it has a steep declivity towards the coastal area, frequently marked with precipices of several hundred feet. On the western side the declivity to the Mary River Valley is even steeper and precipices more frequent. The Maleny Tableland (Text fig.4) is basaltic and the cliffs referred to are composed of columnar basalt. Dense scrub once covered the whole area. The basalt variously overlies sandstone and rhyolite. The latter rock itself is frequently seen to overlie or intrude Trias-Jura sandstone. The volcanic rocks cap the Trias-Jura and one another unconformably, often infilling erosion hollows, a fact also noted for the Mt. Mee basalt.

West of the Range the Mary River flows in a valley having, at Conandale, an elevation of about 500 feet. Its tributaries from the Blackall Range have cut deep gorges, and have frequent waterfalls. The main river rises in the Conandale Range and flows through a narrow V-shaped valley cut in the granite country to Kenilworth, where in softer formations (phyllites and volcanic tuffs) it has formed a broad valley with smooth and well rounded hills and slopes.

North of Mapleton the Blackall ceases to be a tableland, and becomes a rugged mountain range, known as the 'The Bottle and Glass.' This is composed of highly disturbed sandstone and acid eruptive rocks, including great masses of tuff and breccia. Forest vegetation prevails. The Bottle and Glass has a height of from 1,000 to 1,200 feet, and comes to a sudden end west of Mt. Eerwah, where the range drops precipitously about 800 feet to form a mere watershed (c.400 feet high) between Belli Creek and the Boonaiah (North Maroochy). The Eumundi Gap, as this

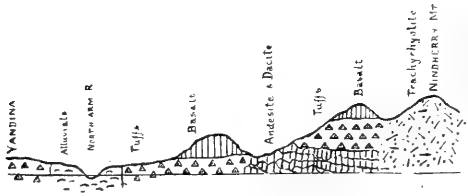


Fig.5.-Sketch Section from Yandina to Nindherry, following an irregular course.

break might be called, probably marks the former course of the Belli Creek and Upper Mary waters. The North Maroochy at Yandina (Text fig.5) has extensive gravel, boulder, clay and other deposits, extending many hundred feet on either side of the river. These immense masses were never brought down by the present insignificant stream. Pebbles of slaty and granitic rock, clearly derived from the western slopes of the Blackall, are found in these deposits, the present river not draining any such rocks. Most of the alluvials brought down by the Maroochy have the characteristics of the weathering products of rhyolitic rock and tuff, such as would be derived from the Bottle and Glass, and Belli Creek. The South Maroochy, the main stream at present, brings down basaltic débris from the Blackall, and we should expect its black soil alluvials to predominate. The fact that they do not is suggestive of a grand river capture. Certain it is that if Kenilworth were some hundred feet higher, the whole drainage of the Upper Mary River would go through the Eumundi Gap into the Boonaiah.

North of the gap the range increases gradually in altitude and swings to the W.N.W., then N., then N.E., describing a semicircle. The soil, which on the Bottle and Glass was poor, is here very good, mostly chocolate-coloured, being composed partly of disintegrated intermediate and basic lavas. East of Mt. Cooroy the formation is again sandstone with trachy-rhyolite dykes, and the range becomes a mere watershed about 300 feet high, running north and south, and separating the Mary River (Six-Mile Creek) waters from those of the Noosa swamps. It has a steep fall to the east, but almost no fall to the west, a feature which was already noticed for the D'Aguilar Range north of Big Hill. To the west of Lake Cootharaba this watershed merges into the Wahpunga Range, whose eastern slopes overlie sandstones, and have a poor soil, while its main mass and western spurs have a rich chocolate soil, frequently scrub-covered, overlying soft pink, bluish, yellow and white phyllites. Many of its higher points have basaltic cappings. The fine agricultural lands of Kin-Kin scrub are situated here.

(*e*) *The Maroochy Volcanic Area.*—The district lying between the Bottle and Glass and the Toolburra Range, and stretching from the Nambour Railway Station to the Cooroy Station, has been the centre of great volcanic activity. Before settlement it was very largely covered with scrubs growing luxuriantly on the tuff and breccia formations which, together with lava dykes, form the predominant country rocks. Along the river banks extensive alluvial deposits are spread in places. The mountains rising from this area are partly decked with forest and composed of solid rhyolite lava, like Mt. Nindherry (see Plate viii., Text fig.5), and partly scrub-covered, like most of Mt. Eerwah, North Nindherry, most of Mt. Cooroy and many of the Eumundi ranges. The scrubs are found on tuff and breccia country (Eerwah), andesite formations (base of Mt. Cooroy), and on the basalts (North Nindherry).

Between the Bottle and Glass and Mt. Eerwah there is a deep valley known as Yanganuien Valley, which, I think, owes its origin to a fault that has thrown down Mt. Eerwah and the whole Eumundi district. Faulting has been very great in the district, but owing to the dense tropical vegetation it is exceedingly

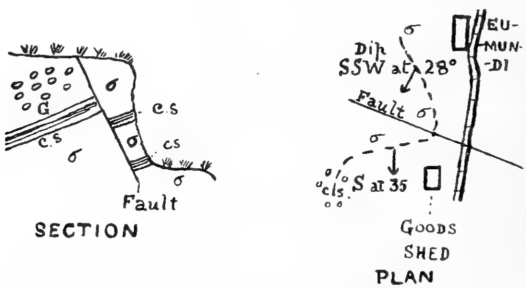


Fig.6.-Plan and Section showing small Fault at Eumundi Railway Goods Shed. σ. sandstone. *c.s.* carbonaceous shale. G. conglomerate sandstone.

difficult to obtain positive proofs. One beautiful little fault may be seen in a cutting a few yards from the goods-shed of the Eumundi Railway Station (Text fig.6).

A good deal of the Maroochy district is devoted to the cultivation of sugar cane.

(*f*) *The Cooran District.*—Most of this country is forest-clad, and its drainage goes to the Six-Mile Creek, a tributary of the Mary River. The timbers are of very divers characters in different parts, many rock formations being represented. The district is gently undulating, and is a raised peneplain of very recent elevation. The average elevation is about 250 feet. At Pomona a peak, Mt. Cooroora, rises abruptly to a height of 1,250 feet; and at Cooran there is a similar peak, Mt. Cooran (950 feet). These are composed of columnar, orthophyric comendite, and recall to mind the Glass House Mountains. Surrounding the base of Mt. Cooroora, and stretching thence in a N.N.E. direction, is a belt of country bestrewn with rounded pebbles and boulders of granite, quartzite, slate and porphyry. This appears to be the outcrop of the basal conglomerates of the coal-measure sandstone.

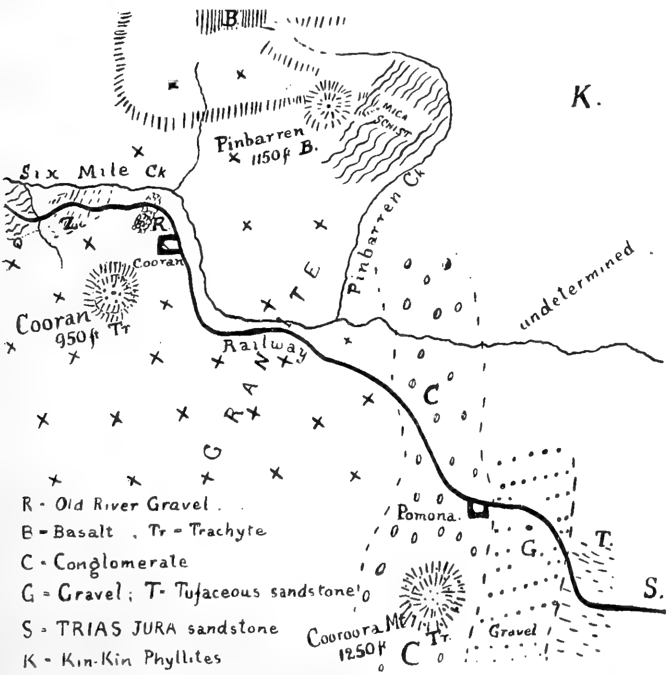


Fig.7.-Plan of country round Cooran.

Going eastward we cross, successively, outcrops of fine gravels, tuffaceous sandstones, and fine-grained sandstone, finding ourselves soon on typical coal-measure sandstone, with exceedingly poor soil stretching to Tewantin on the coast (Text fig. 7). About a mile to the N.W. of Mt. Cooroora we find ourselves on sandy forest country overlying decayed muscovite granite. This formation continues northwards right to the top of the Woondum Tableland, north of Cooran. The lava of Mt. Cooran has burst through it. The Tuchekoi Range has the configuration and vegetation of volcanic formations, rhyolite, andesite and basalt being probably all represented.

Steep (rhyolitic) bluffs are seen to be numerous, whilst more rounded hills, on which pine and cedar figure in the scrubs (basalt), are also abundant.

The Parish of Woondum, N.E. of Cooran, forms a tableland averaging 1,000 feet in height and reaching 1,500 feet in places. On its south-western slope I met with sandy granitic forest country, which is intruded with numerous dykes of trachyte, rhyolite, aplite, quartz porphyry and basalt. Basalt fills irregular erosion hollows on the tableland, and also caps the higher points. Mt. Pinbarren (1,100 feet), south of Woondum, consists of metamorphic rocks, with quartz reefs, to a height of about 700 feet, above which it is volcanic. The extrusive rock consists of trachyte and andesitic basalt. The mountain supports a mixture of forest and scrub, the latter covering all the volcanic rock.

East of Pinbarren the peculiar soft soapy phyllites of the Kin-Kin commence, supporting thick forest in places, and dense vine-scrub in places. The Kin-Kin country is very broken.

The steep western fall of the Woondum Tableland, which extends miles and miles in an almost straight line, suggests a great fault, with the downthrow of its western side. The eastern slopes of the Woondum present the usual erosion features.

This fault antedates the formation of the peneplain, but is, nevertheless, of late Tertiary age, probably coæval with the basalts.

A few hundred yards on the Gympie side of the Cooran Railway Station there is seen in the cuttings a mass of waterworn boulders, pebbles, and gravels, occupying a definite hollow of considerable width (Text fig. 7, R). This is an old river channel, and Mr. Martyn, of Cooran, informs me that a continuation of it is found on the Woondum Tableland; and other similar boulder patches occur, he says, in the direction of Belli Creek. This would seem to prove that, prior to the faulting, the drainage of Woondum took this course into Belli Creek and the North Maroochy.

(iii.) General Geology.

(*a*) *The Metamorphic Series.*—Gregory, in his "Report on the Geology of Parts of the Districts of Wide Bay and Burnett" (1875), considered all the older rocks in areas I am dealing with to be of Devonian age. Jack considered them to be identical with the rocks of the Gympie Goldfield, hence Carboniferous.

The phyllites and slates in the Mt. Mee region are apparently conformable to one another, and the former gradually pass into the latter in the vicinity of granite or diorite intrusions. The slates are evidently derived from the soft phyllites (schists) by metamorphism, through intense heat and vapour-action depending on igneous intrusions. My observations in this respect agree with those of Mr. Rands in his "Report to accompany a Geological Map of the City of Brisbane and its Environs" (1877). The slates and phyllites are probably of Gympie age. Traversing the phyllites in Wararba, on Mt. Mee and at Leacy's Creek, &c., dykes, sills or interbedded sheets of greenstone are common. These are probably the rocks that Gregory took for serpentine. They are epidiorites in composition, and represent altered gabbroic or basaltic rocks.

In the Delaney's Creek Valley and in Fife's Range, there are found mica schists, granulites, highly metamorphic slates and gneisses, abounding in rare minerals like rutile, cyanite, sillimanite and zoisite. These rocks have a very ancient appearance. Dr. W. G. Woolnough, of the Sydney University, considers them comparable only to the oldest Archæan schists of South Australia in nature and facies. They must be at least as old as Devonian, and certainly have no resemblance to the Gympie series. These rocks are cut by dykes of gneiss, greenstone, granite, pegmatite and porphyry, sölvsbergite and basic rock (Text figs.2 and 8). Mt. Delaney is capped above 800 feet with rhyolite. The base of the mountain, which probably overlies Neurum granite, is composed of a very knotted granulite, which becomes less and less knotted as we ascend. The knotted structure is due to metamorphism by the underlying granite. Mt. Mee is partly composed of phyllites, slates and mica schists, partly of glaucophane

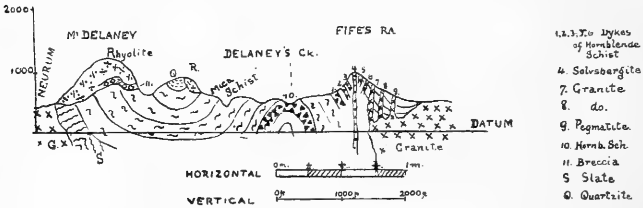


Fig. 8.-Section from Mt. Delaney to Delaney's Creek Store along E F in Plate vi.

schists, anthophyllite schists and later basalts. Some of the hornblendic schists appear to be interbedded with the phyllites. Probably they represent highly altered tuffs and lavas erupted in the period of sedimentation which saw the phyllites deposited. They are probably coæval with the greenstone dykes, and intrude the older strata (Plate vi., and Text figs. 9, 10).

In the Cooran district we meet with the Palæozoic rocks of Gympie age, about one mile west of Cooran, along the railway line. These are very hard, metamorphic slates, quartzites and schists. Similar rocks occur on the Woondum Tableland and round the base of Mt. Pinbarren. They are highly contorted, faulted, and are traversed by quartz reefs and igneous dykes.

The soft shaly Kin-Kin phyllites, not unlike Bendigo graptolite slates in handspecimens, do not seem to be as old as Gympie, but further research is needed. They are highly contorted and rich in quartz veins. The adjoining Burrum strata probably overlie them unconformably.

In the Eumundi-Cooroy railway cuttings (Text fig.11B) the lavas and tuffs, and occasionally tuffaceous sandstones, are seen

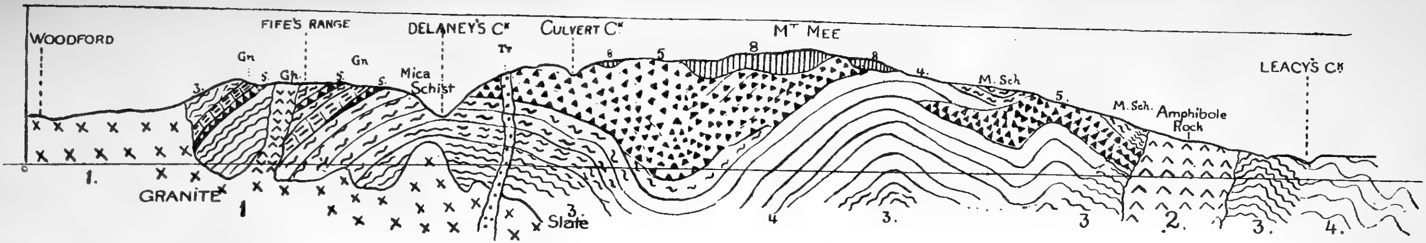


Fig. 9.-Section from Woodford to Leacy's Creek, along I J on Plate v.
1. Granite. 2. Glaucophane Rock and Amphibolite. 3. Slate. 4. Phyllite. 5. Hornblende Schists. 6. Ashy Sandstone. 7. Ordinary Sandstone. 8. Basalt. 9. Trachyrhyolites. Gn. Gneiss. Gp. Graphic Granite.
Horizontal Scale about 2 miles to the inch. Vertical Scale about 2,000 feet to the inch.

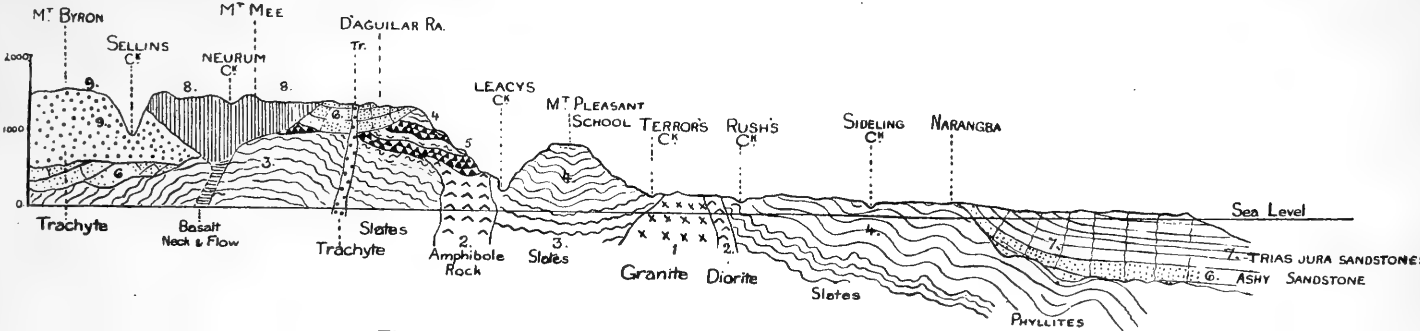
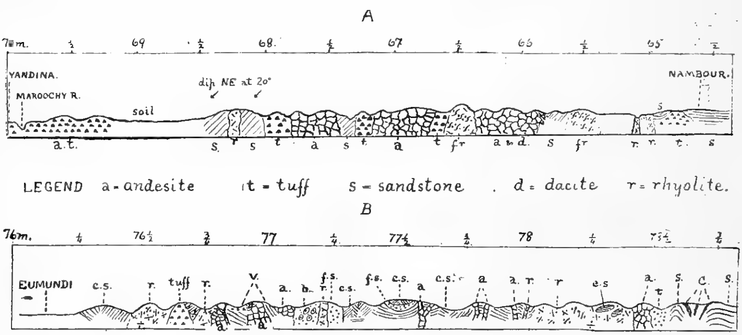


Fig. 10.-Section from Mt. Byron to Moreton Bay, along G H on Plate v.
Horizontal Scale about 4 miles per inch.

to rest unconformably on black slaty-looking rocks (78-m.peg.: Text fig.11B). The latter are very contorted and contain quartz veins, but are, however, unlike any of the Palæozoic rocks. There are chocolate shales belonging to the same series, not unlike some of the Kin-Kin rocks. These rocks are probably carbonaceous shales and tuffaceous mudstones of Trias-Jura or later age, altered by the vast outpourings and injections of rhyolite and monzonite, with which the quartz veins are probably connected.

(*b*) *Sedimentary Rocks.*—The Trias-Jura sandstones are unfossiliferous except for petrified wood. They vary from gritty varieties and conglomerates to fine-grained felspathic varieties. The tuffaceous sandstone with carbonaceous bands at Eumundi is probably later than the typical sandstones met with further eastward on the coast, and to the south at Nambour. Faulting



c.s. chocolate and black slaty shales. *r.* rhyolite. *v.* tuffaceous sandstone. *a.* andesite. *b.* felspathic sandstone with diorite boulders. *f.s.* felspar sandstone. *t.* trachyte. *c.* coal. *s.* sandstone.

Fig.11.-Sections along railway, Yandina-Nambour, and Eumundi-Cooroy.

has here preserved the later formations. A good example of faulting may be seen in a cutting at the Eumundi railway goods-shed (Text fig. 6). Fragments of sandstone are included in the breccias between Yandina and Nambour as at the 69½-mile peg (Plate ix., and Text fig.11A). A curious fault-breccia, supposed to be gem-bearing, exists between Mt. Eerwah and the Bottle and Glass in Yanganuien Valley.

Around Buderim Mountain we have a tuffaceous sandstone, indurated near the basalts, containing soft peaty strata, suggesting a later age than Jurassic. Fossil wood, and obscure casts resembling echinoderms and Maccoyellas, abound in this rock, especially where it outcrops on the Maroochy beach.

Carbonaceous shales are frequently interbedded with the sandstones. *Thinnfeldia odontopteroides* and its var. *falcata* occur in a seam which outcrops in Petrie's Creek at Nambour, and is associated with a thin coal seam. Coal seams have also been observed elsewhere, as between the 78½ and 79-mile pegs in the railway cuttings near Cooroy. (See Text fig. 11B).

All the sandstones exhibit much current bedding, proving deposition in shallow waters subject to frequent changes in the direction of flow. Probably they form an estuarine deposit; the fossil wood was brought down by the rivers and deposited near their mouths.

Alluvial, Aerial, and Fluviatile Deposits.—In a former paper I have already described such deposits at the mouth of the Caboolture River. Text fig. 12 shows the position of sand banks with shells of Potamides, Arca, Natica, and Ostrea. These are hurricane banks (shore banks) which have moved inland by sedimentation at the river mouth, aided perhaps by a slight uplift.

More definite signs of uplift are in evidence along the coast all the way from Caloundra to Noosa Head. All the swampy country in this coastal strip shows definite evidence of being a plain of marine erosion raised above tidal influence. Coolum Mtn., Mt. Peregian, and Noosa Head were probably islands, and Mt. Tinbeerwah a promontory. The swampy tracts of Coolum and around the Noosa lakes are for the most part marine muds. A raised beach with numerous shells occurs on Point Arkwright at a height of 180 feet, and the Blackall Range (the low ridge separating the Six-Mile waters from the swampy coast) west of Tewantin shows signs of marine erosion. It was in fact the old coast-line.

Immense sand dunes stretch along the coast from Mt. Peregian to Noosa Heads, and again from Noosa to Tin-Can Bay. Teewah (or Seewah) Hill, the highest of these, may exceed 300 feet. They are of wind-blown formation, and separate the shore from

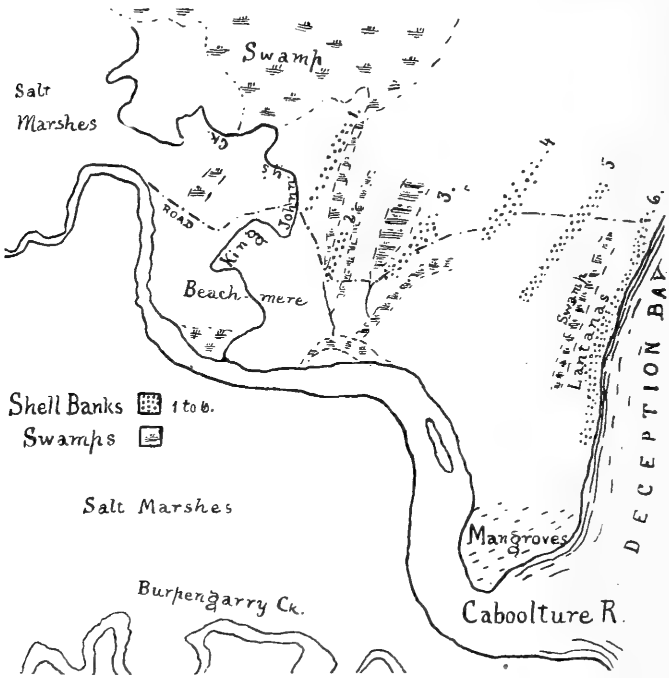


Fig. 12.-Plan showing Shore-banks at the mouth of the Caboolture River.

the saltwater lakes of Weyba and Cootharaba, and from the Coolum swamps.

A black peaty sandstone, often 6-8 feet in thickness, outcrops with a few breaks all along the coast from Mooloolah Heads to Noosa Heads. It contains carbonised wood, and frequently underlies, as well as overlies, marine or estuarine deposits. This is a late Tertiary, Pleistocene deposit, and implies fluctuations in land- and sea-level. The formation probably extended out into the present sea as far as Mudjimbah Island. It was laid down in a swamp or lake which became submerged and subsequently re-elevated, after which the sea cut rapidly into it.

Aboriginal kitchen-middens are also abundant along the Coolum beach.

Distinct from the black, peaty sandstones on the beach are the "black sands" which, after south-easterly gales, contain payable gold. They contain also ilmenite, rutile, spinels, minute rubies, silver, tin, monazite, and white silvery flakes, probably osmiridium. The small rills descending from Mt. Eurungunder contain black sands after rains. It therefore seems to me that they are derived from the porphyrite and dioritic rocks of the district, which probably outcrop under the sea, as well as at Pt. Arkwright and Noosa. The Boonaiah (North Maroochy) River brings down similar sands after rain, probably from the monzonites in the vicinity of Mt. Cooroy. The gold and silver may have the same source, or may be concentrated out of the old North Maroochy alluvials

Recent calcareous conglomerates exist in places. More important are the recent ironstone conglomerates which abound on the coast. Often we find shell-banks or kitchen middens (at Tewantin) turned into ironstone by the precipitation, on organic matter, of carbonate of iron in solution.

Contact Metamorphism.—The alteration of the Trias-Jura sandstones and conglomerates of the district to hard quartzite is commonly observed near the igneous intrusions. Notable instances may be seen at Point Arkwright and Noosa Head (Text figs. 13 and 14).

(*c*) *Plutonic Rocks.*—The oldest plutonic rocks are probably the muscovite granites of Cooran, and the dykes of *augen*-orthogneiss in Fife's Range and the Delaney's Creek Mountains.

The Enoggera granite near Brisbane clearly intrudes the metamorphic Gympie rocks, in which it has effected great hardening, and has given rise to small pegmatite dykes and quartz veins. The most important plutonic rock, the Neurum granite, covers a large area on the Woodford peneplain (Plate v.), and occurs again at Terror's Creek. It is a bluish, tonalitic granite, containing numerous dark fine-grained inclusions; and intrudes the Gympie rocks, as evidenced by great hardening and the injection of pegmatite dykes. The graphic granite aplites of the Delaney's

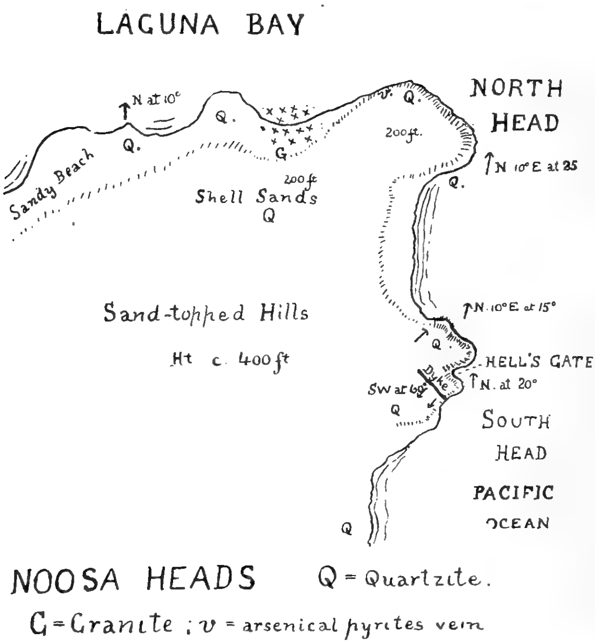


Fig.13.-Plan of Noosa Heads.

Creek and Fife's Range Mountains are probably the last differentiation products of this mass.

The age of the Neurum granite is Post-Carboniferous, probably Permian.

At Jimnah quartz-epidiorites are found. Similar rocks occur at Delaney's Creek, Fife's Range, &c. Some of these may be highly altered plutonic rocks of the gabbro family.

(*d*) *Hypabyssal Rocks.*—Numerous dykes occur in connection with the trachytes, pantellarites and comendites of the Glass House Mountains, the rhyolites of Tinbeerwah, the Bottle and

Glass and the Maroochy district, and the basalts of Buderim and Blackall Range.

The most important hypabyssal rocks are, however, the porphyrites of Point Arkwright, and allied quartz diorites of Noosa Head and Mt. Cooroy.

The Point Arkwright mass is probably a sill or laccolite thrust into the Trias-Jura strata which it has altered to quartzite. The main mass is a bluish diorite like porphyry. At High Cliff, to

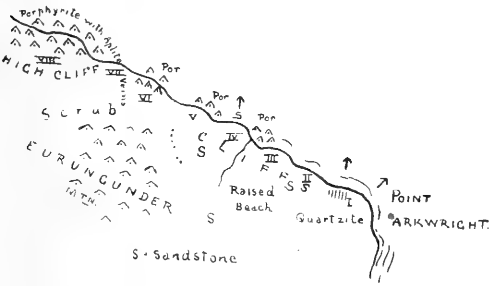


Fig. 14.-Plan of Point Arkwright.

the W.N.W. of Pt. Arkwright proper, the rock has differentiated into a dark porphyrite with numerous, red, aplitic dykes and veins of granophyre. The blue porphyrite contains numerous inclusions, some angular, some oval or round, composed of the more basic minerals of the main rock. These segregations are fine-grained. Other outcrops of the blue porphyrite occur at the base of Mt. Coolum, and at the junction of Eudlo Creek and the Maroochy near Buderim (Text fig. 1).

A spur on Wardrop's land, N.N.E. of the Toolburra Hills, is composed of a granophyre exactly like that of the High Cliff aplitic veins. It is a dyke-like mass intruding sandstone.

At Noosa Head a quartz-diorite occurs intruding Trias-Jura sandstone which it has metamorphosed. It is probably a laccolitic mass. Mt. Cooroy is composed of a reddish rock resembling syenite. In constitution it is a monzonitic quartz-diorite with a fine-grained micrographic base of quartz and felspar. The Cooroy mass is seen, by the existence of the base, to be either a hypabyssal mass or even a volcanic plug. In the railway cuttings

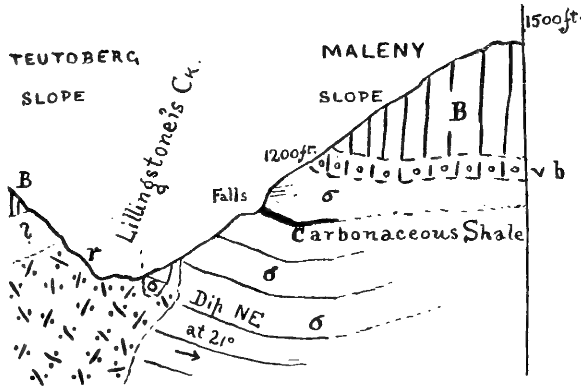


Fig. 15.-Section at Lillingstone's Creek, Blackall Range.
b. Basalt. *v.b*. Vesicular Basalt. *σ*. Sandstone. *r*. Rhyolite.

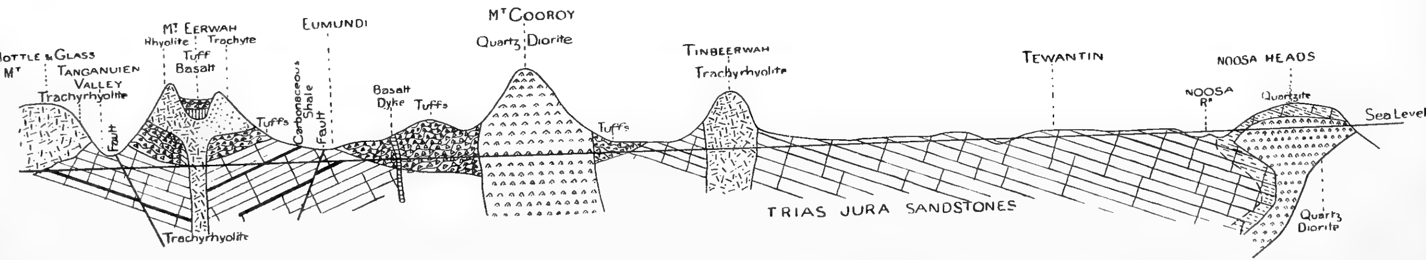


Fig. 16.-Section from Bottle and Glass to Noosa Heads, along Q R in Plate v.

between Eumundi and Cooroy, numerous dacites, having close affinities with the Cooroy mass, are found.

(*e*) *Volcanic Rocks.*—It is advisable to discuss these under four headings, (1) Trachy-rhyolites, (2) the Soda-Trachyte and Pantellarite Series, (3) Dacites and Andesites, (4) Basalts.

(1) Trachy-rhyolites.—Under this heading I include rocks having the colour of trachyte with the facies of rhyolite, and whose exact nature the microscope only doubtfully reveals.

Mt. Eerwah, 3 miles W.S.W. of Eumundi (Text fig. 16), has two peaks, the eastern 1,090 feet high, the western 1,290 feet, separated by a saddle about 850 feet high. The western peak is composed of rhyolitic or felsitic tuff and breccia, the eastern of trachyte. The saddle and lower slopes of the mountain are decked with andesite and andesitic breccia, and covered with dense vine-scrub. Nindherry Mountain and Mt. Wappa are composed essentially of a very fine-grained rhyolite, surrounded by rhyolitic and dacitic tuffs and breccias, and dacite lavas. The felsitic and andesitic tuffs of Yandina contain sandstone inclusions and are therefore Post-Triassic. Abundant rhyolite dykes occur in the Eumundi-Cooroy railway cuttings, and some between Yandina and Nambour.

Rhyolites occur in the Blackall Range at Lillingstone's Creek (Text fig. 15); on the Mapleton Tableland (Portions 69v. and 61v.) west of Nambour, at an elevation of 1,000 feet and surrounded by basalt; at the Bottle and Glass, and in the Tuchekoi Range. A great portion of the Kenilworth district west of Mapleton and the Bottle and Glass is covered with rhyolitic tuffs, breccias and lavas, which partly cover Palæozoic rocks and are covered with basalt in places. In the Bottle and Glass they intrude Jurassic sandstone.

Mt. Tinbeerwah, near Tewantin, is composed of trachy-rhyolite, and sends dykes into the surrounding coal-measure formation.

Mt. Byron (1,600 ft.), south-west of Mt. Mee, forms a large trachy-rhyolite tableland. Dykes of the same rock intrude the sandstones of the D'Aguilar Range, south of Mt. Mee; but whether these trachy-rhyolites belong to the same era of eruption as the felsitic tuffs of Brisbane, or to that of the Glass House

Mountains, is not certain. The latter hypothesis is the more probable.

The Rhyolites and Orthoclase Porphyries of Neurum and Delaney's Creek.—Mt. Archer, Mt. Delaney, Black's Hill and many smaller eminences in this area are composed of a very decomposed orthoclase porphyry, and a rhyolitic rock which exhibits all degrees of texture from obsidian to quartz-porphyry. These rocks are frequently interbedded. Their volcanic origin is proved by (*a*) their association with tuffs; (*b*) frequent banded arrangement and flow-structure; (*c*) amygdaloidal and vesicular structure in places; (*d*) by a breccia sheet consisting of fragments of mica-schist, and granulite cemented with rhyolite, underlying the rhyolite and porphyry capping of Mt. Delaney; (*e*) by the occurrence of pitchstones and obsidian in the masses. These rocks have differentiated from the same magma, and have probably exuded from the same vent. They have cooled rapidly. Many of the spherulitic types owe this structure to devitrification. The columnar types are very like those of the Maroochy district at Nindherry, Eerwah, and Tinbeerwah.

These rocks overlie granites and Palæozoic schists and granulites. Many hundred feet of rock have been removed by denudation since their ejection. The breccia at the base of the Mt. Delaney flow is probably an old river-gravel. The eruptions took place when the country was very rugged; lavas filled the valleys. Base-levelling subsequently formed the Woodford peneplain, and the old valleys, protected by their lava-cappings, resisted erosion.

The period of activity was probably the same as in the Glass House Mountain and Maroochy districts.

(2) The Trachyte Series.—Some new occurrences are mapped on the Plan (Plate v.) at Barren Mountain, Bridge's Hill (i), Bell's Quarry (ii), and west of Tunbubudla (iii) on Battersby's. They are situated on linear fissures or cross-cracks through other important members of the Glass House group. Some new types of very amygdaloidal and vesicular trachyte were met with at Medway's Mountain. The outer members of

the Glass House Mountains, *e.g.*, Mt. Miketeebumulgrai, Mt. Beerwah, Mt. Ngun-Ngun, and Medway's Mountain, are more porphyritic than the more central members, *e.g.*, Mt. Tunbubudla, Mt. Ewin, Mt. Conowrin, &c., which fact may indicate that the magma partially cooled and consolidated in a deep-seated reservoir in which crystallisation commenced at the borders It seems that the more westerly peaks of the Glass House group are the oldest, for they are the larger, as if most energy had been spent on them, and they are composed of true trachyte (*e.g.*, Mt. Beerwah, Mt. Miketeebumulgrai). When these craters became dormant, points of eruption formed east of them on definite fissure-lines, to again yield place to others more and more to the east. The main axis of the group runs from S S.E to N.N.W., through the Round Mountain, Bridge's Hill (i), Miketeebumulgrai, Tunbubudla and Beerwah. Crossing this axis almost at right angles are various lines of fissure on which the volcanic foci are situated. This arrangement of the mountains has a striking resemblance to that of the volcanoes surrounding Fonseca Bay in Central America. Here the main fissure runs N.W.-S.E., and is crossed at right angles by other fissures on which rows of volcanoes are situated, the most westerly of which is always active, the others successively less and less so as we advance in an eastward direction, when finally the most easterly extinct ones are reached.* If the analogy is true the Glass House Mountains lay to the west of a sea or bay.

The arrangement of the columns of the prismatic comendites as at Mt. Conowrin, Mt. Tibrogargan, Mt. Coolum and Mt. Cooran (Text fig. 17) is strongly in favour of the mamelon origin of these heights. They may, however, be plugs injected into now denuded tuff cones; or some may have arisen like the lava plug of Mt. Péléet† and similar plugs on the Deccan.‡

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* See Suess, "La Face de la Terre," Tome i. 'Exemples des Régions Ebranlées.'

† See "Nature," Oct. 1st, 1903.

‡ See Richard Strachey, in "Nature," Oct. 15th, 1903.

To the comendite families belong, in addition to the Glass House Mountain instances, the main masses of Mt. Coolum, Mt. Cooroora and Mt. Cooran. The arrangement of the columns

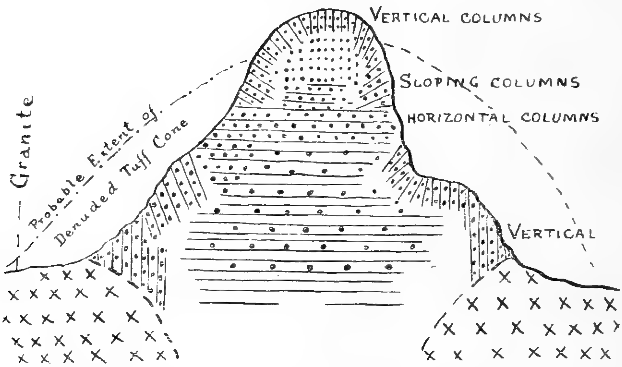

Fig. 17.-Section of Mt. Cooran, indicating the arrangement of the columns in the *comendite* monoliths.

of the last-mentioned is shown in Text fig. 17. Hemi-vitreous varieties of comendite are met with in Coolum Mountain. Here occur also highly vesicular varieties, with geodes full of mesolite crystals.

(3) Andesites and Dacites.—As shown in a previous paper, dacites newer than trachytes occur at Bankfoot House among the Glass House Mountains (Plate xvi., fig. 35). Similar rocks occur around Mt. Wappa, and on the Nindherry Saddle in the Yandina district. Dykes of a basic andesite cut the trachy-rhyolites and quartz-porphyry at Battersby's, west of Tunbubudla (Plate v., iii.).

Andesitic rocks ranging from very basic to acidic, quartzose varieties occur very abundantly in the Maroochy district, and are associated with abundant tuffs and breccias. In most of the railway cuttings between Nambour and Cooroy andesite or its fragmentary equivalent is met with. Dykes of it often intersect rhyolite dykes.

There are probably two series of andesites, the first erupted simultaneously with the intrusions of Point Arkwright porphyrite and Mt. Cooroy monzonite, and closely allied in mineral composition to the monzonite; the second took place after the rhyolites and trachytes, and before the basalts, and varies in constitution from a dacite to a very basic andesite.

The green andesitic breccias found at Yandina, and at Mt. Eerwah, probably belong to the second series, for no trachy-rhyolite dykes have been observed in them though fragments of a trachytic nature abound.

(4) Basalts.—The top of the Nindherry Ridge north of the saddle is basaltic. Basalts cap the Woondum Tableland, Pin-barren Mountain, and many points in the Kin-Kin and Wahpunga Ranges. Here they overlie rocks older than Trias-Jura.

In the Blackall Range we have an extensive area of basaltic rock capping sandstones, rhyolites and trachytes to the thickness of many hundred feet. Dykes of basalt penetrate the sandstone on the eastern slopes of the range. The lowest layer of the Blackall basalt is everywhere highly vesicular and amygdaloidal, and often associated with basic tuff. The more rapid weathering of this layer leads to the undermining of the upper portions, and the formation of steep precipices of columnar basalt round the Blackall tableland. The basaltic lavas here cover an eroded surface, infilling original valleys (Text figs.18 and 19).

Buderim Mountain and Sippy Mountain (a hill S.S.W. of Buderim), are also basaltic, and basalt dykes are frequent in all the district between the Blackall and Mooloolah Heads.

Mt. Mee has a basaltic capping covering an eroded surface of hornblende-schist, mica-schist, and, at Sellin's Creek, trachy-rhyolite

Age and Succession of the Lavas.—(1) Simultaneously with the injection of sills and laccolites of quartz-diorite, porphyrite and monzonite at Noosa, Pt. Arkwright, Cooroy, &c., the first series of andesites and andesitic tuffs were erupted. At Eumundi Railway Station may be seen a conglomerate of rounded porphyrite and andesite pebbles in a sandstone base of apparently

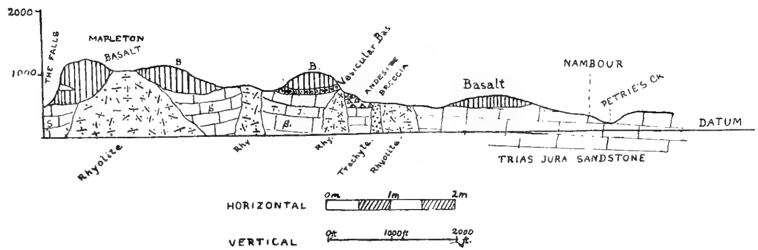

Fig. 18.-Section from Mapleton Falls to Nambour, along S T on Plate v.

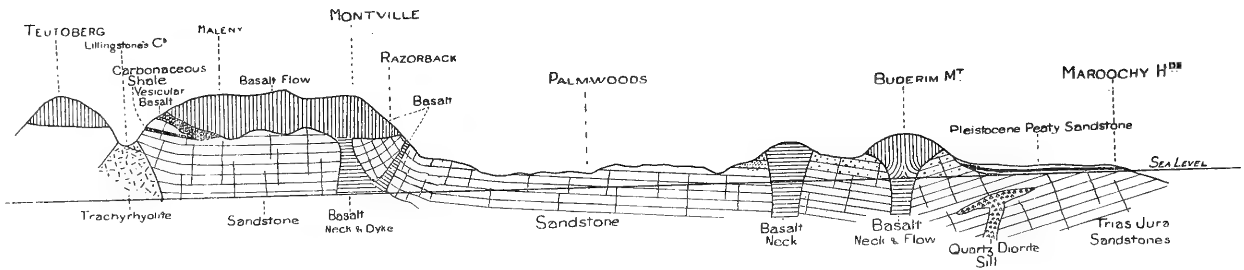

Fig. 19.-Section from Teutoberg to Maroochy Heads, along K L on Plate v.

the same character as that usually occurring in the district, interbedded with carbonaceous shale. This occurrence seems to indicate volcanic action contemporaneously with the deposition of these beds in late Trias-Jura or Cretaceous time.

(2) The trachytes and comendites were later, a period of greater erosion intervening, so that at Coolum the comendite, a volcanic rock, almost overlies a mass of hypabyssal porphyrite exposed by the denudation. The Coolum rock envelopes at Mr. Story's well a mass of porphyrite.

The stratified nature of many of the tuffs and breccias in the Maroochy district shows that this area was a lake or sea-bottom during the first andesite and trachy-rhyolite eruptions. In the Glass House Mountain district the volcanoes were probably near the sea, but not submarine. Very considerable oscillations took place between the andesite and trachy-rhyolite eruptions in the Maroochy district, in the shape of uplifts caused by the earlier intrusions, and faulting relowering parts in the district of greatest activity.

(3) Eruptions of dacite and andesite followed those of trachy-rhyolite, comendite, &c. Great quantities of tuff and breccia were ejected.

(4) Later, in Miocene or Pliocene time, the basalts were extruded.

Unfortunately, I have not been able to obtain any definite fossil evidence of the age of these rocks. Probably the trachytes, rhyolites, dacites, and late andesites were all early Tertiary.

Highly altered andesites of Palæozoic age occur in the Kin-Kin phyllites.

(*f*) *Folding and Faulting.*—(A). Folding: Suess, in "Das Antlitz der Erde," remarks that the folded chains of the Australian continent form part of a mountain system characterised by certain distinctive features. They are all directed north and south, or disposed in a manner such that, in deviating slightly from the meridian direction, as in the north of Queensland, they form a light curve convex to the east. The folding, according to Suess, antedates the Carboniferous, and in Queensland it probably took place before the Culm. The folding force, he thinks, came from the west, and the very old Palæozoic sediments were folded towards the ocean, where a continental massive existed until late geological times.

A glance at the map of Queensland shows the justifiability of these arguments.

The D'Aguilar and Blackall Ranges have the usual meridional direction of Australian mountain chains. They are largely composed of Triassic sediments and volcanic rocks; they are moulded upon an older range of Palæozoic rocks to the westward which conformed to the theory of Suess. The axis of folding of the old metamorphic rocks ran S.S.E.-N.N.W., most of the dips being E.N.E. and W.S.W. The great earth-movements producing it were probably accompanied, or shortly followed, by the intrusions of granitic rocks of Carboniferous or Permian age.

The result of these processes was an elevation, in early Mesozoic times, of an area which became *in part* resubmerged in later Mesozoic times (Trias-Jura), though a great part, including the Woodford peneplain, and terminating southwards in Mt. Mee, remained as a peninsula jutting into the Trias-Jura sea.

That the Woodford peneplain, the Conandale Range, and Yabba country continued during this time as dry land, seems sufficiently proved (*a*) by no Triassic sediments having been noted over this area; (*b*) by the existence of porphyries and rhyolites resting directly on granitic and metamorphic rocks; and (*c*) by the fact that the Trias-Jura sandstones of the Moreton district are very felspathic in places, and seem to have been largely derived from the denudation of the granitic rocks in the back country.

The formation of the Blackall Range and the northern portion of the D'Aguilar Range appears to have been due to an expansion and uplift, accompanied by volcanic eruptions in Cretaceous and early Tertiary times, and a folding movement by which the newly formed Trias-Jura sediments were pushed up against the existing Palæozoic massive, giving rise to a monocline. In this way the easterly (S.E. and N.E.) dips of the sandstones of the

D'Aguilar and Blackall Ranges can be satisfactorily explained. The dips might have been accentuated by a further uplift of the old mountain area Thus a new coastal range was formed to the east of, and parallel to, the old one. The folding movement this time came from the east.

(B). Faulting.—The entire area studied has been subjected to very considerable faulting. The most faulted portion is probably the Maroochy district.

The probable fault at Big Hill on the Caboolture-Woodford road is quite a feature in the district, and the steep granitic slopes have not yet had time to be greatly dissected by the head waters of the Wararba Creek This fault runs approximately N.W.-S.E. The downthrow is to the N.E. The sandstones on the downthrow side have a sharp dip (25° up to 70°) to the N.E., induced probably by the drag, and have mica developed in them.

A curious rock resembling a fault-breccia was located between Mt. Eerwah and the Bottle and Glass, where the remarkable mountain gaps alone suggest a very considerable fault. The fault here probably runs from E.S.E. to W.N.W., and the downthrow would be to the E.N.E.

The steep western slopes of the Woondum tableland appear to be due to another great fault.

A small fault at the Eumundi Railway Station has already been referred to.

Most of the faulting of the area under discussion took place in Tertiary times and therefore still leaves its impress on the physical geography.

In the environs of Buderim Mountain there has been great faulting, probably simultaneous with the basaltic eruptions.

iv. Tertiary Changes of Sea-level.

As has already been shown, the district was elevated above sea-level by an expansion of Trias-Jura sediments in Cretaceous times. Considerable dissection of the elevated portion followed, in the north especially, and subsequently lavas were poured out. At the same time a monoclinal fold produced the coastal range in the early Tertiary periods. The coastline was probably re-submerged so that the folded range formed the new coast. The mountainous region at Woodford was lowered about 300 feet by erosion, leaving the lavas which infilled old valleys standing in relief. It became reduced to the state of a peneplain. In late Tertiary, probably Pliocene, times the district commenced to rise again, and the Woodford peneplain was elevated by degrees to its present position; the new coastal area was eroded to the state of a peneplain, which it is at present, in the southern part, as at Caboolture, and any Tertiary sediments deposited had time to be removed by denudation. Further north, in the Laguna Bay district, the coastal strip was much more recently elevated than in the south, and has at present the characteristics of a raised marine plain; whilst the Cooran district has all the features of a Pleistocene raised peneplain. The elevation here is so recent in the Noosa and Maroochy districts that the rivers and creeks flow parallel to the sea long distances before entering it (see Noosa River, Bota Creek, Maroochy River in Plate v.). The theory of Isostasy alone, without taking other forces into consideration, can explain this recent Pleistocene and Post-Tertiary elevation. The diversion of the drainage of a large area into the Mary and Stanley Rivers which was once drained by numerous small streams, whose positions are marked by old river gravels at Cooran, Eumundi, the Glass House Mountains and the D'Aguilar Range, would lead to an elevation in their former areas of deposition. The diversion of the drainage was, however, in my opinion, aided by an uplift along the axis of the present coastal ranges. The courses of the Mary and Stanley Rivers parallel to the Blackall and D'Aguilar Ranges are an interesting study. The Mary River, between the Conandale Range and Kenilworth, flows in a narrow V-shaped valley through hard granitic rocks, broadening at this point to a U-shaped valley with a meandering stream, flowing through softer phyllites. The whole stream pursues in general a subsequent course, but accidents of surface, like basalt masses, have induced slight departures from the direct path. The stream above Kenilworth may prove to have been captured from the Maroochy River (obsequent). The Stanley River on the Woodford peneplain flows over hard granitic rocks in a shallow bed. It is a recent stream developed by stream capture, aided by the uplift referred to. Evidently the large Brisbane River, flowing mainly through soft Trias-Jura strata, had an advantage over other streams that had to cross a barrier of hard rocks to reach the sea.

As other evidences of recent elevation the raised beach at Point Arkwright deserves special mention. It indicates an uplift of at least 150 feet. The drying up of the coastal swamps, and their gradual conversion into good grazing lands have been observed by many residents of the Moreton and Wide Bay districts, as well as by myself.

Other pieces of evidence in this connection were given in my former paper on the Glass House Mountains.*

v. Conclusion.

From the foregoing it is seen the district under discussion is one of interest from many points of view, in its variety of rocks, its stream development, and its land forms. The following conclusions are offered :—

(1). The D'Aguilar and Blackall Ranges are formed essentially by folding, anticlinal south of Mt. Mee, for the rest monoclinal.

(2). The Glass House Mountains are volcanic, and are situated on systems of intersecting cracks.

(3). A true peneplain of Tertiary age existed behind the present coastal range at Woodford; and great changes in drainage have taken place throughout the district.

(4). All the coastal area has from time to time been submerged in the Tertiary period, and the subsequent re-elevation is still going on; the Maroochy and Noosa districts form clearly a plain of marine erosion, and at Cooran we have a recently elevated peneplain.

(5). The Ipswich and Burrum Coal Measures are not separated by a peninsula of older Gympie rock, but are continuous.

* These Proceedings, 1903, p.842.

I have to acknowledge the kindly interest taken in this work by Mr. Dunstan, the Acting Government Geologist of Queensland, and Professor David, of the Sydney University. For assistance in the field I am indebted to Mr. W. Fawcett Story of Coolum, and to Mr. Pickering, Police Sergeant at Tewantin.

Part ii. Petrology.

In this Part the rock slides examined under the microscope will be dealt with in the same order as the field occurrence of the rocks as described in Part i. of this paper (see Synopsis).

As the specimens were numbered in the order in which they were obtained in the field, no numerical succession must be expected in the order in which they are dealt with.

In the description of igneous rocks the following conventions are observed. First the handspecimen is briefly described; next follows the microscopic examination. The latter comprises a description under the following headings:—(1) Texture, which is dealt with under the subheadings of (*a*) Crystallinity. (*b*) Granularity and grain-size. (*c*) Fabric. This order is adhered to in the descriptions whether the subheadings are mentioned or not.

(2) Constituent minerals in order of decreasing abundance. These are, when advisable, divided into—(*a*) "essential" minerals existing in an amount greater than 10 %; (*b*) "notable" minerals greater than 5 %; (*c*) "diminutive" minerals greater than 2 %; (*d*) "minute" minerals less than 2 %. The accessories are therefore comprised under the heading "minute."

(*a*) Metamorphic Rocks.

Sp. No.61. Cyanite-Rutile Granulite. Loc.: Delaney's Ck. near Woodford (Plate xi., fig.1).

i. The handspecimen is of a yellowish colour, has a characteristic schistose structure, and looks like a typical mica-schist

ii. Microscopic Examination.—(1) The rock is holocrystalline; grain-size variable; fabric schistose.

(2) The essential minerals are quartz, orthoclase, topaz and muscovite. As diminutive and minute constituents we have cyanite, rutile and zoisite. On account of the abundance of quartz and felspar, this rock belongs to the class of metamorphic rocks termed "Granulites."

Name: Cyanite-Rutile Granulite.

Sp. No.61A. Granulitic Mica Schist. Loc.: Mt. Delaney.

i. Handspecimen of a metallic grey colour, with a shining lustre and a fine-grained texture.

ii. (1) Holocrystalline; fine to medium grain-size, schistose fabric.

(2) The essential minerals are orthoclase, muscovite and sericite. Chlorite is present in notable quantity. Magnetite and cyanite are present in diminutive amount.

(3) The cyanite is pleochroic, from colourless to light blue; has a high refractive index and high double refraction, and is developed chiefly in the crushed felspars.

(4) Name: Granulite or Granulitic Mica Schist.

Sp. No. 61B. Muscovite-Granulite. Loc.: Mt. Delaney.

i. The handspecimen has a yellow colour not unlike many mica schists, and a schistose cleavage. Crystals of orthoclase project all over the surface, giving the specimen a knotted appearance like knotted andalusite schist.

ii. (1) Holocrystalline, with variable grain-size and schisty cleavage.

(2) The essential minerals are orthoclase, quartz and yellowish, slightly pleochroic, muscovite. Notable in quantity are sericite, chlorite and topaz. In minute amount as important accessories we have biotite, zoisite and rutile.

(3) The rutile forms a felted mass of minute acicular crystals included in the quartz. Under the low power they appear quite black and dusty, but under the high power they are resolved into clear needles with geniculate twinning frequently developed.

(4) Name: Knotted Muscovite Granulite or Gneissic Mica Schist.

Sp. No.61c. Both macroscopically and microscopically like 61B. Hence this is also a granulite.

The knotted specimens 61B, and 61c, were obtained on Mt. Delaney at a lower level than 61A, that is closer to the great granitic intrusive mass which underlies the mountain. The knotted structure is therefore probably the result of contact metamorphism effected by the granite. From the same cause the sagenitic rutile needles developed in the quartz, and the minerals zoisite, cyanite and rutile in the felspar. The development of topaz may have taken place at the same time. The irregular shape of the quartz and felspar grains in these rocks and the manner in which they occasionally interpenetrate show that the minerals were softened, almost remelted, when the schistosity was produced. The quartzes and felspars are usually squeezed out into long streaky grains.

Sp. No.60. Greenstone. Loc.: Fife's Range on Delaney's Ck. Road.

i. It is a dark rock occurring in the form of dykes not only on Fife's Range, but also in Wararba Parish, on Black's Hill near Neurum, in the Delaney's Ck. Valley, and in larger masses on Mt. Mee. It is evidently an altered igneous rock.

ii. (1) Texture: holocrystalline; even-grained, grain-size medium; fabric, allotriomorphic granular; the adjacent crystals are highly crushed and squeezed into one another by heat and pressure combined.

(2) Essential minerals: (i.) orthoclase felspar with highly irregular outlines; it is crowded with inclusions, some of which, like the magnetite, are primary, and some, like the zoisite, cyanite, and epidote, are secondary. (ii.) Actinolite, a green fibrous hornblende, highly pleochroic in colours from light straw-yellow to deep bluish-green. In notable and diminutive amount we have (iii.) brownish, slightly titaniferous, magnetite, a great deal of which is secondary; a few plates of ilmenite also occur. (iv.) Honey-coloured non-pleochroic epidote with high refractive index and double refraction; it is commonly included in felspar. (v.) Very pleochroic chloritoid minerals with a double refraction

equal to that of serpentine. In minute amount the following occur (vi.) zoisite, (vii.) cyanite, (viii.) apatite.

(3) Name and Affinities.—This rock has the composition of an altered syenite. Greenstone is the most suitable field name. It has affinities with epidiorite, trachydolerite and picrite. There are varieties of this rock in which felspar greatly predominates in amount, while serpentine and calcite occur in notable amount.

Sp. No.70. Hornblende Schist. Loc.: Mt. Mee. (Plate xi., fig. 2).

i. In handspecimen this rock looks like a schistose greenstone containing large phenocrysts of hornblende, which are sometimes tabular, usually finely striated, and six-sided in cross-section. It covers a wide area on Mt. Mee, and occurs also in the Delaney's Creek country.

ii. (1) Holocrystalline and porphyritic. The phenocrysts are large, many exceeding 5 mm. in diameter. The other constituents are fine-grained. These have an arrangement which is not unlike trachytic texture in volcanic rocks.

(2) Essential minerals (in order of decreasing abundance):—Anthophyllite which forms all the phenocrysts referred to. It is practically colourless and almost nonpleochroic. Occasionally it is slightly bluish and pleochroic. It has the typical hornblendic cleavage and high double refraction. The extinction is usually straight, but occasionally low angles are observed. The phenocrysts are six-sided in cross-section, have the prism and pinacoid faces well developed, but are usually irregularly terminated. Occasionally the anthophyllite is intergrown with actinolite. Chlorite and serpentine are both well represented. Felspar and colourless nonpleochroic epidote are present in smaller amount. In notable quantities both actinolite and uralite occur. The uralite occasionally contains grains of augite. The actinolite occurs in the form of long needles. A little tremolite is also present. In minute proportions there is present sillimanite with characteristic cross cracks and medium double refraction. A considerable amount of secondary hematite and limonite is present.

Originally this rock was an augite felspar rock like porphyritic diabase in which the augite has altered to anthophyllite and the felspar to epidote and chlorite.

Name: Anthophyllite Schist.

Sp. No.68. Epidote-Actinolite-Topaz Schist. Loc.: Leacy's Ck., Upper North Pine.

i. Handspecimen a greenish, fine-grained schistose rock with bluish-green specks of chlorite (delessite).

ii. (1) Holocrystalline, very fine-grained and allotriomorphic granular.

(2) Essential minerals are epidote, felspar (orthoclase), actinolite altering to chlorite, chlorite (var. delessite) and calcite. In smaller proportions quartz, topaz, magnetite, sericite and cordierite occur. A minute quantity of sillimanite in minute needles is also present.

Name: Epidote-Actinolite-Topaz Schist.

Sp. No. 102. Epidote-Cordierite-Chlorite Schist. Loc.: Leacy's Ck.

i. In handspecimen this is a fibrous green schist like Sp. No. 68.

ii. Under the microscope it is found to consist of epidote, cordierite, delessite calcite, apatite and magnetite.

Name: Epidote-Cordierite-Delessite Schist.

Sp. No.107. Albite-Chlorite Schist. Loc.: Leacy's Ck.

i. This specimen, obtained near the preceding, is of a somewhat similar appearance.

ii. It contains, however, less epidote and more calcite. Its felspar consists of both orthoclase and albite, of which the latter is the more abundant. Minute needles of sillimanite occur plentifully in the felspar.

Name: Albite Chlorite Schist.

Specimens 68, 102 and 107 are somewhat weathered actinolite schists, in which the original actinolite has been altered wholly or partly to chlorite. They probably represent a highly altered lava of intermediate composition whose constituent felspar has been recrystallised as calcite, albite and orthoclase.

Sp. No.106. Glaucophane Rock. Loc.: Leacy's Ck.

i. The handspecimen is a dark, fine-grained rock, whose main constituents are, respectively, deep bluish-green and light yellowish-green.

ii. Under the microscope it is seen to be a fine-grained, holocrystalline, granular rock, made up essentially of a light-coloured, greenish-blue pleochroic glaucophane in fibrous irregularly-terminated laths, and of a yellowish-brown epidote. Minute quantities of felspar (orthoclase) and tremolite are also present. This rock is therefore a Glaucophane-Epidote Rock.

Sp. No.134. Glaucophane-Epidote Rock. Loc.: near Leacy's Ck. Reserve, Mt. Mee Road.

This is another beautiful glaucophane-schist, in which the glaucophane resembles that of Mt. Mee (Sp.65).

Sp. No. 65. Glaucophane-Epidote Rock. Loc.: Culvert Ck., Mt. Mee (Plate xi., fig.3).

i. In handspecimen a fine-grained, aphanitic dark rock, in which bluish specks may be seen on close inspection or with a pocket lens.

ii. A holocrystalline, fine-grained schistose rock.

Constituent minerals.—The rock is almost wholly made up of epidote and glaucophane, which are present in about equal amounts. The glaucophane is of a beautiful blue colour, highly pleochroic, from deep violet-blue to greenish-blue, light sky-blue and colourless, but green tints are rare. It occurs in irregularly terminated laths. Sometimes a hornblendic cleavage may be recognised. The epidote is of a honey-yellow colour, and slightly pleochroic. Other minerals present are magnetite and tremolite.

An analysis was made of this rock (Anal.xii. p.169) and the norm calculated (Norm xii. p.171). It is noticeable that this glaucophane-epidote rock, unlike most glaucophane-epidote rocks hitherto analysed*, is very high in Fe_2O_3. Indeed, from the fact that the rock contains nearly 50% of glaucophane, and from

* See "A Chemical Study of the Glaucophane Schists," by Henry S. Washington. Amer. Journ. Sci. Vol.xi. Jan. 1901.

the analysis, we may infer that the glaucophane here present is like those of Rhodes, analysed by Foullon,* richer in ferric than in ferrous iron. The high percentage of Fe_2O_3 also shows that the epidote is highly ferriferous.

The glaucophane of Sp. No.106 is closely allied to actinolite. It is greenish in colour, strongly pleochroic in colours from greenish-blue to light green and colourless, and never shows the violet and purple tints visible in the pleochroism of Sp. No.65.

The occurrence of glaucophane in these rocks is interesting for many reasons. Firstly, because glaucophane is a very rare mineral, and this is, perhaps, the first undoubted locality in Australia from which it has been described. Secondly, because it is usually found only in highly metamorphic Archæan formations, and the Mt. Mee rocks have hitherto been considered by the Queensland Geological Survey as not older than Carboniferous. Thirdly, because of the occurrence of serpentinous rocks in the South D'Aguilar Range, and the high nickel content of the glaucophane rocks which call to mind similar associations in New Caledonia; and, fourthly, they are interesting because of the occurrence of riebeckite and arfvedsonite eruptives of a much later age in the same district, showing that it was an alkaline province in Palæozoic times, and became so again in Post-Triassic times.

The glaucophane rocks are intimately associated with anthophyllite schists, greenstones and other hornblende schists on Mt. Mee, and with actinolite-cordierite and chlorite schists at Leacy's Ck. From microscopic as well as from field evidence it is my opinion that all these rocks are altered lavas and tuffs of a basic character. The intense folding which has taken place in them has led to the development of glaucophane, zoisite, cordierite, sillimanite and many other minerals characteristic of highly metamorphic series. The actual glaucophane rocks probably form the pipes whence the lavas flowed.

The norm of the igneous rock from which the glaucophane schist may be derived has been calculated and stated (Norm.xii *a*).

* Sitzb. Akad. Wien, 1891, 100.

(*b*) Sedimentary Rocks.

Sp. No.91. Quartzite. Loc.: Noosa Heads

This rock is of a dark colour, and from handspecimens it is impossible to say whether it is quartzite or microgranite. It overlies the quartz-diorite at Noosa Heads.

Under the microscope it is seen to be allotriomorphic granular, fine-grained, and consisting of irregular crystals of quartz and felspar cemented by a micaceous base. The abundance of felspar and the irregular, subangular shape of the grains serve to show that the sandstone from which the rock is derived was probably tuffaceous. The cement was originally clayey. The quartz diorite intrusion has effected the metamorphism.

Name: Tuffaceous Quartzite.

The sandstone and quartzites overlying the hypabyssal Pt. Arkwright rocks vary in coarseness from that of grit to fine conglomerate. They are, therefore, 'gritty quartzites,' 'quartzite conglomerates,' and sandstone conglomerates.

The sandstones and interbedded shales of Trias-Jura age in the East Moreton and Wide Bay Districts, there is no need to describe in detail. They are almost all of the types usually met with, as in the Hawkesbury Series of New South Wales. Some, however, are very rich in iron and contain ironstone concretions. Some are very tuffaceous. This is especially the case in the Woombye and Maroochy districts; and it is such a sandstone that the Noosa mass has altered to quartzite. The sandstones around Buderim Mountain contain a number of obscure remains of fossils, which are very suggestive of Echinoderm and Maccoyella casts.

The shales found interbedded with the Trias-Jura sandstones are of two main varieties.—(a) Black carbonaceous shales, often containing good fossil remains, such as stems and leaves of *Thinnfeldia odontopteroides* and its var. *falcata*: at Petrie's Ck., Nambour, these fossils are very abundant in an out-cropping seam of coal and carbonaceous shale. (b) Yellow, very soft and fissile clay shales. In these I have never been able to detect fossils. They occur in strata of various thicknesses, varying from a few inches to twenty feet or more.

The yellow, highly folded, phyllites met with west of Caboolture at Wararba, on the Woodford and Mt. Mee Roads, are only slightly metamorphosed. A small quantity of secondary mica is developed in them; otherwise their characters are those of a shale. These rocks are penetrated with quartz veins, and belong to the Gympie Series. Shaly Phyllite seems the most suitable name.

Many of the puzzling rocks met with in the Kin-Kin country and in the Eumundi railway cuttings were sectioned and examined.

Sp. No.113. Clay Shale. Loc.: Road cutting on the Cooran to Kin-Kin Road.

i. Handspecimens vary in colour from pink to purplish. Yellow, grey and bluish varieties are also met with. The rock is extremely fissile, and has a greasy feel like a talcose or steatitic schist. It is highly folded and traversed by quartzy veins. Before the blowpipe it gives the smell of burning organic matter, and the powdered rock gives no Mg. reaction, but a very strong aluminium reaction, with cobalt nitrate.

ii. Under the microscope it is found to be almost wholly isotropic, and therefore it is probably made up mainly of amorphous muddy material. A considerable amount of iron staining is present.

Sp. No.200. Chocolate Shale. Loc : Eumundi Railway cuttings.

i. In handspecimen a soft chocolate-coloured, highly fissile rock with slaty cleavage; it is not unlike the Kin-Kin shale, but is less folded, and the quartz veins found in it appear to bear some relation to the rhyolite dykes. The pressure causing the cleavage was probably lateral, induced by earth-movements connected with volcanic action and the intrusion of dykes.

ii. Under the microscope it has the appearance of a tuffaceous clay shale. It seems to be composed essentially of comminuted felspar, hornblende, chlorite and isotropic material.

Sp. No.201. Black Slaty Shale. Loc.: Eumundi-Cooroy Railway cuttings.

Handspecimen like slate. It cleaves into very thin sheets.

Microscopically it is seen to consist of chlorite and comminuted felspar. Signs of great alteration are wanting.

There is consequently no evidence on petrographical grounds that the Eumundi and Kin-Kin shales should be considered as old as Gympie. From field investigation it appeared that the former are probably Triassic or later, while the latter are probably older.

(*c*) Plutonic Rocks,

Sp. No.76. Tonalite. Loc : Branch of Delaney's Ck., E. of Black's Hill.

i. Handspecimen red, on close inspection seen to be made up of red, yellow, white and bluish-black grains, identified with a lens to be orthoclase, plagioclase, quartz and hornblende.

ii (1) Texture: holocrystalline, medium-grained and moderately even-grained, with a hypidiomorphic granular fabric.

(2) The constituent minerals in order of decreasing abundance may be stated as (*a*) *essential*—plagioclase, quartz orthoclase and hornblende; (*b*) *notable*—biotite; (*c*) *minute* (accessories)—magnetite, apatite, chlorite, kaolin and leucoxene.

(3) The plagioclase is hypidiomorphic and varies from acid labradorite to albite. Commonly the exterior of a crystal is composed of oligoclase or albite, while the interior consists of labradorite or andesine. Shadowy extinction arising from this decrease in basicity from the centre outwards is very common. Zoning is frequently due to the same cause, but zoning due to the regular arrangement of the innumerable dusty inclusions of magnetite, hornblende and chlorite is also very common. Zoning due to incipient decomposition in the centre of the felspar crystals is also seen. The average composition of the plagioclase felspar would probably be that of oligoclase-andesine. The quartz is wholly allotriomorphic and contains numerous dusty inclusions as well as liquid and stationary gas bubbles. The orthoclase is allotriomorphic and partly kaolinised. It frequently forms a microperthitic intergrowth with albite. The hornblende is of a green colour and pleochroic from olive-green to light yellowish-green. It occurs in corroded phenocrysts and contains numerous

inclusions of biotite, magnetite, apatite and leucoxene. Chlorite and dusty magnetite are its decomposition products. The biotite occurs in corroded phenocrysts with ragged ends, and contains numerous inclusions of magnetite. It is often surrounded by secondary chlorite. The primary magnetite is of a brownish tint and gives leucoxene as a decomposition product. Hence it is titaniferous.

(4) Order of consolidation *normal.*

(5) Quartz, orthoclase and plagioclase being nearly equal in amount, this rock is a tonalite or red quartz-mica-diorite.

Sp. No.78. Granite. Loc.: Police Paddock, Woodford.

Handspecimen: colour of weathered boulders bluish; colour of fractured surface pinkish with bluish-black specks.

With a pocket lens the following minerals are recognised—(1) orthoclase of a pink colour, showing Carlsbad twinning, and having a strong tendency to idiomorphism; (2) quartz, quite allotriomorphic; (3) biotite in black shiny flakes; (4) bluish-black hornblende; (5) greenish plagioclase.

The rock is even-grained and medium-grained. A suitable name would be Dioritic Granite.

Sp. No. 77. Granite-Aplite. Loc.: Police Paddock, Woodford.

Colour pale pink; grain-size even, but finer than Sp. No.78. This rock occurs as veins traversing the granite described above (Sp. No.78). The constituents are quartz and orthoclase intergrown in a graphic manner. A little hornblende decomposing to chlorite is present in minute amount. A few specks of pyrites also occur. This rock is an aplitic differentiation product of Sp. No.78.

Sp. No.73. Granite. Loc.: Terror's Ck., Upper North Pine.

This rock is very like that of Sp. No.78 from Woodford, and contains the same constituents. The grain-size is medium, but coarser than in Sp. No.78.

The granite from Big Hill (Durundur Hill) on the Caboolture-Woodford Road is very decomposed, so much so in places as to partake of the nature of arkose. It is coarse-grained, and consists of decomposing crystals of orthoclase and biotite, and quartz grains. Many of the grains are encrusted with manganese oxide, probably derived from the decomposition of a hornblendic mineral. Through decomposition this granite has taken on a stratified appearance which makes it very like sandstone.

Epi-Diorite. Loc.: D'Aguilar Ra., near Mt. Crossby, near Ipswich. (Plate xi., fig.4).

i. This specimen was collected and given to me by Mr. H. L. Thompson. Colour greenish, due to a mixture of light green, greyish-green and yellowish-green plagioclase grains, with greenish-black hornblende crystals. It is phanerocrystalline and coarse-grained.

ii. (1) Texture: (*a*) holocrystalline; (*b*) even-grained and coarse, but the large grains are made up of many small grains of medium size; (*c*) hypidiomorphic granular, inclining to panidiomorphic granular.

(2) Constituents (in order of decreasing abundance)—(*a*) labrodorite, (*b*) actinolite, (*c*) uralite, (*d*) quartz (subordinate in amount), (*e*) brownish ilmenite, (*f*) apatite.

(3) The plagioclase ranges in basicity from $Ab_1 An_1$ to $Ab_3 An_4$, and gives sericite as a decomposition product. The uralite is closely allied to actinolite, into which it appears to be altering. Both these minerals are secondary after some pyroxene. The other minerals are mere accessories.

(4) Order of consolidation *normal.*

(5) Nomenclature.—This rock was originally a quartz gabbro which, by alteration of augite into hornblende, has become a quartz-epidiorite.

(6) Remarks.—Very many interesting gabbros occur in this part of the D'Aguilar Range. They are associated with serpentines and peridotites. Manganese deposits occur in the neighbourhood of Mt. Crossby.

Graphic Granite. Loc.: Woodford. (Plate xi., fig.5).

My section was cut from a specimen collected by Mr. J. M. Newman, B.E., and presented by him to the University Geology Dept.

i. The rock is of a pale yellowish colour, and with a pocket lens one can easily see that it consists of quartz and orthoclase graphically intergrown. The graphic granites which I have met with in the district occur as dykes in the main granite masses and in the metamorphic rocks. They consist of the mother liquor which has been squeezed into cracks in the superjacent granites and sedimentary rocks in the final phases of consolidation of the granite mass.

ii. Under the microscope the rock is seen to consist of a beautiful graphic intergrowth of quartz and felspar. A few minute needles of apatite are included in these minerals.

The felspar is orthoclase and a microperthitic intergrowth of orthoclase and albite. It consolidated simultaneously with the quartz. On account of field occurrence this rock is best named Graphic Granite-Aplite.

Aplite. Loc.: Base of Round Mountain, Caboolture-Woodford Road.

i. The handspecimen is yellowish and resembles metamorphic sandstone. With a lens quartz and felspar are easily identified. The Round Mountain is surrounded by Trias-Jura sandstones on all sides, but at the very base on the south side occurs a small outcrop of this rock which seems to be the summit of an outlier of the Pre-Triassic rocks.

ii. Microscopic examination.—(1) Texture (*a*) holocrystalline, (*b*) medium-grained and even, (*c*) allotriomorphic granular.

(2) Constituents (in order of decreasing amount)—(*a*) plagioclase, (*b*) quartz, (*c*) orthoclase.

(3) The plagioclase forms about 85 % of the total felspar and was found to be all albite. The orthoclase forms 15 % of the total felspar. Felspar forms about 64 % by weight of the rock. The quartz forms the remaining 36 % of the bulk. These three minerals are allotriomorphic, and the spaces between the grains are often filled with a micropegmatitic intergrowth of them.

(4) Some of the quartz consolidated before the felspar commenced. This shows that the magma must have been very dry and supersaturated with silica.

(5) Nomenclature: Aplite.

(6) Remarks.—The magma which gave origin to this rock must have been very alkaline, not unlike the more recent trachytes. The amount of albite is abundant proof of this.

Sp. No.59. Ortho-Gneiss. Loc.: Fife's Range, Delaney's Ck.

i. The handspecimen is brownish and shows a gneissic lamination with augens of quartz.

ii. (1) Texture: a holocrystalline even-grained rock whose constituents are of a medium grain-size and exhibit a foliated structure. The fabric is allotriomorphic granular, and banded.

(2) Constituents.—*Essential*, (i.) orthoclase, (ii.) quartz, (iii.) biotite; *minute*, (iv.) muscovite, (v.) apatite, (vi.) dusty magnetite.

(3) Origin and name—This rock is a granitic vein or dyke which has undergone intense metamorphism with the adjoining sedimentary rocks. The most suitable name is therefore Orthogneiss.

Other closely related gneisses, some of decidedly uneven and variable grain-size, occur on Fife's Range (Sp. No.56 of my collection).

Epi-diorite. Loc.: the Jimnah Goldfield, near Woodford. (Plate xi. fig 6).

The section was made from a specimen collected by Mr. J. M. Newman, B.E. It is a fine-grained black rock.

Microscopic examination. — (1) Texture: (*a*) holocrystalline, (*b*) variable grain-size in specimen, but the greater part of the slide examined was even and fine-grained, (*c*) hypidiomorphic granular to panidiomorphic granular fabric with a schlieric texture, similar materials tending to arrange themselves in bands.

(2) Constituents.—*Essential* (1) plagioclase, (2) green hornblende, (3) uralite: *Accessories*:—(4) magnetite, (5) quartz.

(3) The plagioclase exhibits low extinction angles, but has a greater refractive index than Canada Balsam. It is twinned in accordance with the Carlsbad and Albite laws, and occurs in idiomorphic crystals of small size. It appears to be andesine. The hornblende is a fibrous actinolite with straight extinction,

and shows pleochroism in tints from light green to bluish-green. It is allotriomorphic and apparently an alteration product of uralite. The uralite is secondary after some pyroxene no longer present. The magnetite is partly idiomorphic and party allotriomorphic and dusty, inclosed in uralite and hornblende.

(4) Affinities.—This rock is apparently an altered gabbro which has had its augite changed to uralite and its felspar rendered more acid by the infiltration of silica-bearing vapours. The banded arrangement of the constituents is probably due to the original schlieric structure in the gabbro. The rock should be called Quartz Epidiorite.

Remarks.—Several other slides from this locality were examined, and were found to contain the following minerals:—plagioclase, orthoclase, quartz, uralite, augite and biotite. Many were banded; in some the bands were medium-grained, in others fine-grained. I look upon these epidiorites as having been probably derived from the same magma as the greenstones, glaucophane schists and amphibolites intruding the schists around Mt. Mee and Woodford. Their alteration was probably effected by the great Carboniferous granite intrusion, which probably also introduced the gold and silver of this district. The magma which gave rise to these rocks was of the gabbro composition, and rocks like gabbro, peridiotite, quartz gabbro quartz-diorite, and pyroxenite might have differentiated from it. The amphibolites of the D'Aguilar Range seem to be altered pyroxenites, and the serpentines altered peridotites, so all these varieties are in reality represented.

In Mr. Newman's collection I find, also, a dark rock labelled "Blacks' Reserve, Woodford," which contains quartz, orthoclase, hypersthene, biotite, magnetite and andalusite. It has a gneissic structure, and may be termed "hypersthene-andalusite gneiss."

Sp. No. 95. Granite. Loc.: Cooran, from railway cuttings immediately west of railway station.

This rock is very weathered, and might easily be mistaken for sandstone. Some authors would call this rock arkose. I prefer to use that term for rocks that have been formed by the total disintegration and rearrangement of the original constituents mechanically to form a new rock. The Cooran granite consists essentially of quartz, orthoclase largely altered to kaolin, and muscovite. It is a very acid type of muscovite granite.

The granites of the Woondum Tableland (N.E. of Cooran) are similar but much fresher. They are traversed by numerous veins and dykes of aplite, quartzite and reef-quartz formed in the pneumatolytic period.

General remarks.—It should be remarked, in leaving the Plutonic Rocks, that the earliest igneous intrusions of the district, the gabbroic rocks, were calcic; the next, the quartz diorites, tonalites and granites, of which the Neurum, Terror's Ck. and Woodford granites are examples, are also calcic, but as shown by the nature of the felspars, contain a considerable sodic element, and so form a transition group to the highly alkaline Post-Triassic intrusives. The gabbros were probably Pre-Carboniferous injections; while the granites are of Carboniferous or Permo-Carboniferous age.

(*d*) Hypabyssal Rocks.

Sp. No.36. Granophyre. Loc.: near Wardrop's Selection, the Toolburra Range, near Yandina. (Plate xii., figs 7-8).

i. Handspecimen of reddish colour, somewhat weathered. Close inspection reveals quartz, orthoclase and hornblende.

ii. Microscopic examination.—(1) Texture (*a*) crystallinity, holocrystalline; (*b*) grain-size, variable between fine and medium; (*c*) fabric—allotriomorphic, graphic and micrographic.

(2) Constituents.—*Essential*, orthoclase and quartz; *Minor*, chlorite, hornblende, magnetite and hematite.

(3) Remarks on minerals.—The pinkish orthoclase gives its colour to the rock. It is weathering to kaolin. The hornblende is corroded and is decomposing to chlorite. It is present in only diminutive proportions. The magnetite is undergoing decomposition to hematite.

(4) Nomenclature.—The field occurrence and microscopic structure of this rock prove its position to be amongst the graphic granophyres.

Point Arkwright Rocks.

Sp. No.i. (Plate xii., figs.9-11).

i. This specimen is of a bluish colour, and at first glance not unlike diorite. Phenocrysts of black hornblende and yellowish-green plagioclase are easily recognised imbedded in a fine-grained base, which has a greasy lustre, and gives an oily appearance to the rock.

ii. Microscopic characters. — (1) Texture (*a*) crystallinity, holocrystalline; (*b*) grain-size, variable, porphyritic. The phenocrysts reach a length of from several millimeters to nearly half an inch in the case of hornblende. The base is very fine-grained, microcrystalline to cryptocrystalline. (*c*) Fabric, porphyritic; cryptographic, micrographic and microspherulitic structures are seen in the base.

(2) Constituents (in order of decreasing abundance).—(*a*) plagioclase, (*b*) hornblende, (*c*) orthoclase, (*d*) biotite, (*e*) quartz; *Minor*, (*f*) magnetite, (*g*) sphene, (*h*) calcite, (*i*) apatite.

(3) The plagioclase occurs in idiomorphic, often considerably corroded phenocrysts, and also in the fine base. The phenocrysts are composed essentially of labradorite of the composition Ab_1An_1 though some consist of oligoclase, and most show beautiful zoning, due to decrease in basicity from the centre outwards from labradorite to oligoclase. Many show incipient decomposition, and contain calcite in the centre where the decay commences. Shadowy extinction from the above-mentioned variation in basicity is almost universal. Twinning is very common, and frequently Carlsbad, albite and pericline twinning occur together in the same crystal. As inclusions in the phenocrysts we have glassy material, hornblende and apatite, often zonally arranged. In shape the plagioclase phenocrysts are tabular and rod-shaped. The last kind have a six-sided, almost hexagonal cross-section.

The hornblende occurs in idiomorphic, but highly corroded, phenocrysts, which are decomposing, with the formation of calcite and chlorite. In thick slices (0·04 to 0 06mm.) it is of a brownish-green colour, while in thin slices (0·025mm.) its colour is light green. It is very pleochroic in colours between brownish-green and yellowish-green in thicker slices, and in the same tints, though much fainter in thinner slices. Double refraction, 0·023. Pleochroism : $\mathfrak{a}$ olive-green; $\mathfrak{b}$ greenish; $\mathfrak{c}$ light green.

$$\mathfrak{c} > \mathfrak{b} > \mathfrak{a}.$$

Species, pargasite.

This hornblende is evidently rich in lime, as seen from the decomposition products. Orthoclase is not abundant, but a few clear crystals are met with, possessing a very irregular outline, due to resorption. Most of it occurs, however, in the base in the form of sanidine.

Biotite of a greenish-brown colour is present in idiomorphic plates, and shows the characteristic pleochroism. Magnetite occurs in fair-sized crystals, but is a mere accessory. Sphene, in wedge-shaped and lozenge-shaped phenocrysts, is present in the same proportion as magnetite. Apatite occurs both as thick stunted rods and as fine needles, and is present included in all the minerals except magnetite and sphene. Chlorite, calcite and kaolin are the main decomposition products present.

The base or groundmass is of particular interest. It forms about half the bulk of the rock, and contains a great abundance of perfect lath-shaped microliths of plagioclase (probably albite and oligoclase) and sanidine felspar, having low extinction angles, and too minute for exact determination. Quartz is also present, as well as a little glass. Irregular patches of this base extinguish together, so that it is evident that there are micrographic, cryptographic and pseudospherulitic intergrowths of quartz and felspar. Such intergrowths occur also in masses of definite outline shaped like felspar phenocrysts.

(4) Order of consolidation.

1. Sphene
2. Magnetite
3. Apatite
4. Hornblende
5. Plagioclase phenocrysts
6. Orthoclase phenocrysts
7. Orthoclase, quartz and plagioclase of the base

The constituents of the base crystallised almost simultaneously, although the plagioclase present commenced and finished crystallisation a little before the other minerals, forming definite microliths. Orthoclase (sanidine) and albite crystallised together with the quartz in cryptographic patches.

(5) Nomenclature and affinities.—The texture of this porphyry is that of a hypabyssal rock, the felspar being of two generations, and a groundmass being present. In microscopic structure it shows close resemblance to certain granophyres described by Iddings from Obsidian Cliff, Yellowstone, National Park;* and to some granophyres and rhyolites described by Hague from the Eureka district, Nevada,† in which micropegmatitic phenocrysts, consisting of intergrowths of quartz and sanidine, were noted. Hague also notes certain phenocrysts with irregular boundaries which merge into the groundmass by increasing abundance of inclusions. Both these features are abundant in the typical Pt. Arkwright porphyry. It may therefore be termed Granophyric Porphyrite. The magmatic name as seen from the norm is Andose (p.171). (For analysis, p.169.).

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* U.S. Geol. Surv. Seventh Ann. Rep. 1885-1886.

† U.S. Geol. Surv. Monograph XX. "Geology of the Eureka District."

Sp. No.ii. Porphyrite. Loc.: High Cliff, Pt. Arkwright. (Plate xii., fig. 12).

i. This is a darker rock than the one previously described; yet it contains 61·16 % of SiO_2, that is nearly 2 % more than the typical Pt. Arkwright porphyrite. In the field the mass is intersected by numerous red aplitic veins (Sp. No.121) varying in width from a few inches to several feet. The darker colour of this rock is due to a greater amount of groundmass than in Sp. No.i. This also accounts for the higher SiO_2 percentage.

ii. Microscopic examination—(1) Texture: (*a*) holocrystalline, (*b*) porphyritic with aphanitic base, (*c*) porphyritic with fine granular, micrographic and cryptographic fabrics. The base varies from cryptocrystalline to microcrystalline.

(2) Constituents (*a*) plagioclase, (*b*) hornblende, (*c*) chlorite, (*d*) quartz, (*e*) apatite.

(3) The phenocrysts have all a greater refractive index than Canada balsam, and extinction angles in symmetrical sections vary from 0° to 26°. The felspars are therefore oligoclase andesine and acid labradorite. The hornblendes are like those of Sp. No.i. The base presents the same peculiar features as in Sp. No.i., containing cryptographic phenocrysts made up of an intergrowth of quartz and felspar. A considerable amount of chlorite exists in the base.

(4) Consolidation as in the preceding.

(5) Name: Granophyric Porphyrite.

Sp. No.121 Aplite. Loc.: Pt. Arkwright. (Plate xiii., fig. 13).

i. This remarkable rock occurs in veins intruding the dark porphyrite at High Cliff, Pt. Arkwright. It is reddish and fine-grained and is at first sight taken to be composed wholly of orthoclase. The presence of quartz may be detected with a lens.

ii. Microscopic investigation—(1) Texture: (*a*) crystallinity, holocrystalline; (*b*) grain-size, variable, mostly fine; (*c*) fabric, graphic with also micrographic and cryptographic intergrowths.

(2) Constituents (in order of decreasing amount)—(*a*) orthoclase, (*b*) quartz, (*c*) a small amount of hornblende decomposing to chlorite.

(3) Remarks.—The orthoclase and quartz are intergrown in a graphic manner, and between the larger groups lies a base consisting of micropegmatitic and cryptographic intergrowths of the same minerals. This prevailing eutectic structure shows that the magma consolidated slowly under pressure and was in motion right up to the last phase of consolidation.

(4) The hornblende crystallised first. The quartz and felspar consolidated together.

(5) Nomenclature.—This rock is a granophyric aplite. It contains 69·22 % of silica. It has probably differentiated from the same magma which gave rise to the other Pt. Arkwright rocks and represents the last portions of liquid magma—the mother liquor—which were squeezed into fissures in the already consolidated portions. It is wonderfully like Sp. No. 36, from the Toolburra Range (p. 121).

Inclusions in typical Point Arkwright Porphyrite.—In some portions of the Pt. Arkwright mass there is an extraordinary number of inclusions of a darker colour than the main rock. Some are round, some subangular. The constituents of these are seen under the microscope to be the same as of the main mass, though the relative proportions vary. Usually the inclusions are more fine-grained, and hornblende is a more plentiful constituent but occurs in smaller crystals. Quartz may be present in corroded phenocrysts or wholly absent The inclusions contain usually only one generation of felspar. They appear to represent a portion of the magma which cooled quickly on the outskirts of a magmatic reservoir at a period of rest, prior to the intrusion; and fragments of this consolidated rock were torn off by the magma when activity was renewed, and included in it. The corroded quartz phenocrysts which occur in the inclusions as well as in the main mass are probably allogenic, derived from the sandstones which the igneous rock has intruded.

A specimen closely allied to the typical Pt. Arkwright rock was obtained at Mr. Story's well, near the base of Coolum Mt. The outcrop is surrounded by trachyte on all sides, and is therefore either an included mass, or a portion which was covered over with trachyte and re-exposed by denudation. In either case it is older than the trachyte.

Microscopic examination.—(1) Texture: holocrystalline, variable and, on the average, fine-grained in grain-size, and porphyritic granular in fabric. The phenocrysts were less corroded than in the Pt. Arkwright rocks.

(2) Constituents the same as in Sp. Nos. i. and ii.

(3) The orthoclase may, in reality, be a microperthite. It occurs in phenocrysts which show optical zoning, probably due to alternate layers of albite and orthoclase. Plagioclase is the most abundant constituent, occurring in beautifully zoned phenocrysts containing hornblende and glass intrusions. They vary in composition from that of labradorite at the centre to oligoclase-albite at the exterior.

(4) Name: Porphyrite.

Sp. No.89. Quartz-Diorite. Loc.: Noosa Heads. (Plate xiii., figs. 14 and 15).

i. In handspecimen or massive it is of a bluish colour. The grain-size is variable between medium and coarse. A few specks of pyrites occur in it. This rock has intruded Trias-Jura sandstones at Noosa, and has effected great contact metamorphism.

ii. Microscopic structure.—(1) Texture (*a*) crystallinity, holocrystalline; (*b*) grain-size, moderately even in handspecimen; medium-grained; the average diameter of grains appears in handspecimen to be 2·5 mm., but under the microscope all the grains excepting those of amphibole are composite; hence the average grain-size is finer—about 1·5 mm.; (*c*) fabric, hypidiomorphic granular.

(2) Constituents (in order of abundance)—(*a*) plagioclase, (*b*) orthoclase, and (*c*) hornblende are essential minerals. In notable quantity we have (*d*) quartz, and in minute amount (*e*) chlorite, (*f*) biotite, (*g*) magnetite, (*h*) apatite.

(3) Remarks on minerals.—(*a*) The plagioclase occurs in idiomorphic and hypidiomorphic crystals showing albite, pericline and Carlsbad twinning. These crystals are beautifully zoned, due to diminishing basicity from the centre outwards, as shown

by an examination of their extinction angles. Zoning due to alternate layers of two felspars deposited in crystallographic continuity also occurs; this is visible without crossed nicols. The plagioclase varies from acid labradorite (extinction angle in symmetrical sections 24°-27°) to albite (extn. angle up to 21°). The latter is found chiefly intergrown with orthoclase. (*b*) The orthoclase exhibits Carlsbad twinning and is also zoned; the zoning appears to be due to a layer of albite being deposited round the orthoclase, or to alternate layers of these minerals. The core of many albite and orthoclase crystals has a dusty appearance due to an abundance of minute inclusions of glass and hornblende, or sometimes to incipient decomposition. (*c*) The hornblende is brownish or olive-green, and contains inclusions of magnetite and apatite. Most of the crystals are twinned. Twinning plane, parallel to *a* and *c*.

Double refraction: 0·022. Pleochroism: $\mathfrak{c}$ deep greenish-brown or olive; $\mathfrak{b}$ greenish; $\mathfrak{a}$ light green.

Absorption: $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$

Optic sign positive. Plane of optic axes parallel to *b*. Extinction on edge *b*/*c*, 18°; on other lines bisecting cleavages from 10° to 21°, mostly *c.* 10°.

(*d*) The quartz is interstitial and last to crystallise. (*e*) The biotite is very corroded. Chlorite occurs as an alteration product after biotite and hornblende.

(4) The order of consolidation is normal. There were, however, several stops in the last stages of crystallisation, giving rise to the zoning of the felspars described above. The plagioclase and orthoclase commenced to crystallise almost at the same time, but the latter finished last.

(5) Nomenclature.—In composition and general appearance this rock is a *quartz diorite*, but on account of its many close affinities with the Pt. Arkwright, Eudlo Ck., and Eumundi porphyrites I have described it here. The chemical analyses (anal. p.169) further prove its close relationship to the Pt. Arkwright rock. Its magmatic name is *Andose.*

The Noosa rock consolidated under fine-grained tuffaceous sandstone, while that of Point Arkwright cooled under coarse conglomerates. The heated vapours accompanying the intrusion may therefore have made their escape more easily in the latter place, and the rock cooling quickly would take on a porphyritic, more typically hypabyssal, facies.

Sp. No.150. Porphyrite. Loc.: Boulders embraced in felspathic sand in railway cutting between Eumundi and Cooroy, about 77$\frac{1}{4}$m. from Brisbane.

i. (1) Texture: (*a*) holocrystalline, (*b*) uneven, porphyritic, fine-grained base, (*c*) porphyritic with hypidiomorphic granular base.

(2) Constituents.—These are the same as in the Noosa rock. The hornblendes are somewhat corroded and partly changed to chlorite. Two generations of felspar are present. The base is not so fine-grained as in the Point Arkwright rock.

(3) Name: Porphyrite.

Sp. No.183. Porphyrite. Loc.: Eudlo Ck., near Buderim Mountain.

i. This rock closely resembles those described from Noosa Hd. and Pt. Arkwright.

ii. Microscopic structure.—(1) Texture: (*a*) holocrystalline, (*b*) uneven; fine-grained base in part microcrystalline; (*c*) porphyritic, base hypidiomorphic granular.

(2) Constituents.—Both in nature and relative proportions the same as in the Noosa rock.

Name: Quartz-orthoclase-porphyrite.

Sp. No.142. Monzonite. Loc.: Summit of Mt. Cooroy. (Plate xiii., figs.16-17).

i. Handspecimen a grey to flesh-coloured, medium-grained rock, not unlike Gib Rock Syenite (Bowral) in general appearance.

ii. Microscopic examination.—(1) Texture: (*a*) crystallinity, holocrystalline; (*b*) grain-size, uneven; phenocrysts imbedded in microcrystalline partly micrographic base; (*c*) fabric, porphyritic; phenocrysts, hypidiomorphic; base, partly allotriomorphic granular, partly micrographic.

(2) Constituents (in order of decreasing abundance)— essential (*a*) plagioclase, (*b*) orthoclase; notable (*c*) green amphibole, (*d*) pyroxene; minor (*e*) magnetite, (*f*) quartz, (*g*) biotite, and (*h*) some sphene, apatite and zircon in very minute amount.

(3) Remarks.—The plagioclase is essentially albite and an oligoclase-andesine showing Carlsbad, albite, and occasionally also pericline twinning. Frequently crystals are zoned and the peripheral layers consist of albite and orthoclase. The orthoclase is decomposing, giving kaolin. It occurs both as phenocrysts which are highly corroded and contain inclusions of hornblende, apatite, &c., and in the base forming a micrographic intergrowth with quartz. Both felspars are of two generations. The hornblende is olive-coloured and pleochroic from brownish to bluish-green. It occurs in idiomorphic, often highly corroded fragments. Double refraction about 0 022. Pleochroism same as in Sp.No.89.

A light greenish, very faintly pleochroic diopside is present in the same proportions as hornblende. An equal amount of enstatite is also present. The biotite occurs in corroded crystals with ragged ends. The magnetite is mainly primary, idiomorphic and titaniferous, but a little is secondary and in dusty grains. The zircon occurs in minute acicular rods, while apatite also occurs in needle-shaped crystals.

(4) The order of consolidation is *normal* A eutectic mixture of quartz and orthoclase was the last to consolidate.

(5) The microscopic structure and mineral composition of this rock place it amongst the monzonites or monzonitic quartz-diorites. Its granophyric base, however, shows that it is of a hypabyssal nature. The chemical analysis (Anal.vi. p.168) reveals that much of the felspar is albite. The alkalies are high. The greenish diopside may be soda-bearing and allied to acmite. The norm agrees fairly well with the mode. In handspecimen the rock is like a trachyte, and the chemico-mineralogical examination places it on the border-line between the alkaline trachytic rocks of the district and the alkali-calcic andoses, like the Noosa and Pt.Arkwright rocks. The magmatic name is "adamellose." Perhaps Monzonitic Granophyre is the term which best expresses its constitution.

General Remarks on the foregoing Rocks.

The very close relationship of the porphyrites of Pt. Arkwright and Eudlo Ck. with the Noosa Head quartz-diorite and the Cooroy Monzonite is borne out by field occurrence, microscopic examination, and chemical analysis alike. In the textures there are differences depending on rate of cooling. The Noosa rock evidently crystallised slowly under pressure, while that of Mt. Cooroy had almost finished crystallising when extruded, consisting then of crystals imbedded in a plastic base consisting of a eutectic mixture of quartz and orthoclase. The final consolidation may have taken place under volcanic conditions, as the form of the mountain suggests.

The felspars of all these rocks are very similar. They vary from labradorite of composition $Ab_1 An_1$, to albite and orthoclase. Zoning, incipient decomposition commencing in the centre and in the outermost orthoclase-albite zone, inclusions of a similar nature and arrangement, corrosion and shadowy extinction are features common to all. The Pt. Arkwright porphyrite cooled most rapidly as shown by its much more fine-grained base.

The hornblendes are, in these rocks, of essentially the same character, being a Pargasite somewhat rich in lime, calcite and chlorite being decomposition products. They occur in beautifully idiomorphic crystals, sometimes more or less corroded, on which the faces *m*, *b* and *c* are well developed, while *a* is usually absent. The colour is olive-green; in very thin sections light green.

The Noosa type seems to represent the original magma which gave rise to these rocks. Various stops occurred in consolidation during which alteration in the magma took place, perhaps by the injection of new materials of a more acid and alkaline nature There was continual motion during the formation of crystals in this magma, which probably went on in a deep-seated magmatic reservoir. The Cooroy rock consists of this magma together with a considerable alkaline addition.

The beautiful micrographic intergrowths found in the granophyres from Wardrop's (Sp.No.36) and from High Cliff, Pt. Arkwright (Sp.No.121) (Plate xiii., fig. 13), and their similar mineral composition, bring out their close affinity. These rocks probably represent the magma which augmented in different proportions that of the Noosa type to give the other rocks mentioned. Probably both types of magma have been derived by a process of differentiation from a single magma at a considerable depth. The fact that the more acid portions were extruded last, and are largely eutectic mixtures of quartz and felspar (*e.g.*, Sp.No.121), favours this hypothesis, for in the deep-seated reservoir the last portion to consolidate would be of such a composition with an acid magma. The micrographic granophyres are therefore the "mother liquor" of the original magma which has been squeezed out in the last stages of intrusion. At High Cliff portions of this have been forced into the already cooled porphyrite in the form of aplitic veins and dykes, and at Wardrop's a mass of it appears at the surface, while the more basic products were not met with, though they probably exist at a depth, the aplitic material having burst through not only the porphyrite, but also the superjacent sandstone.

The cryptographic and micrographic base in the Cooroy rock, and the cryptographic base in the Pt.Arkwright porphyrite point to these rocks being made up of a mixture of a dioritic magma with the aplitic differentiation product already discussed. Eutectic conditions prevailed in the final stages of consolidation, proving that the cooling was sudden, and most of the felspar had already fallen out of solution. The granophyre groups and micrographic phenocrysts of the Pt.Arkwright rock are an interesting effect of consolidation under eutectic conditions.

Sp. No. 83. Porphyry. Loc.: Branch of Delaney's Ck., below Black's Hill.

A reddish-brown rock in which, with the naked eye, one may distinguish a few hornblende phenocrysts. The rock is porphyritic in felspar.

Microscopic examination.—(1) Texture: (*a*) crystallinity, holocrystalline; (*b*) grain-size uneven; phenocrysts reaching 7-8 mm., lying in an aphanitic base; (*c*) fabric, porphyritic with a pilotaxitic base.

(2) Constituents (in order of decreasing abundance).—*Essential*: (*a*) albite, (*b*) orthoclase; Diminutive: (*c*) chlorite (after hornblende); Minute: (*d*) magnetite, (*e*) quartz, (*f*) apatite, (*g*) pyrites.

(3) Remarks on minerals.—The albite occurs both as phenocrysts and in the base. Most of the base, however, consists of orthoclase. The hornblende originally present has completely changed to chlorite. Quartz occurs only as interstitial grains.

(4) Order of consolidation normal.

(5) Nomenclature and affinities.—This rock is a highly alkaline soda-bearing "*hornblende porphyry*," not far removed from the *keratophyres*. Owing to decomposition it is impossible to identify it more closely. Rocks of this kind are common, interbedded with true rhyolites, on Mt. Delaney and Mt. Archer. The lavas erupted in this region were alternately of the nature of true rhyolites, and sodic porphyries and keratophyres.

Very typical quartz-porphyries have been obtained from (*a*) Portion 9, Parish of Wararba, and (*b*) the D'Aguilar Range at Battersby's selection, west of Mt. Tunbubudla.

Sp. No.55 Sölvsbergite. Loc.: Fife's Range, Delaney's Ck. Road (Plate xiii., fig.18).

i. Handspecimen: colour bluish-grey to greenish-grey when fresh, decomposing to yellowish-grey. Grain-size aphanitic and very even. It is a compact heavy rock. Dykes of it cut the phyllites, gneisses, and schistose beds of Fife's Range.

ii. Microscopic investigation.—(1) Texture: (*a*) holocrystalline; (*b*) fine-grained, microcrystalline and even, except for a few felspar phenocrysts; (*c*) almost panidiomorphic granular with a tendency to trachytic arrangement.

(2) Constituents (in order of decreasing abundance).—(*a*) felspar, (*b*) ægirine, (*c*) quartz, (*d*) decomposition products, viz., kaolin and iron ores; (*e*) magnetite. Only felspar and ægirine occur in notable quantity.

(3) Remarks.—The felspar occurs in stunted laths. It has a lower refractive index than Canada balsam and is probably mainly orthoclase, with a little anorthoclase and albite. The laths show Carlsbad and Manebach twinning or both together.

A few seem to possess albite twinning. The ægirine occurs in acicular crystals. Quartz is very subordinate in amount and interstitial. The magnetite is present in very minute amount in idiomorphic cubes.

(4) Nomenclature and affinities.—Owing to decomposition it is hard to determine the felspars exactly. The rock seems to be a Sölvsbergite (using the name in Brögger's sense), closely related to Grorudite (Brögger). Rosenbusch terms such rocks "quartz tinguaites" on account of their close structural and mineralogical resemblance to true tinguaites.

In my previous paper reference was made to a tinguaite (hypabyssal "ægirine-syenite") from Butler's Ck., Kilkoy,* which I am now referring to the Sölvsbergites. In mode of occurrence, texture and composition it is extremely like Sp. No.55, the main difference being that the former is quartz-free and contains more ægirine. Nepheline may be present in the Butler's Ck. rock, for it gelatinises with HCl and stains. However, as it is not quite fresh this reaction is not very reliable, the decomposition products of the felspar possibly being capable of gelatinising.

The above-mentioned Sölvsbergites are closely allied to the soda-trachytes and pantellarites of the Glass House Mountains, and were probably intruded at the same time.

(e) Volcanic Rocks.

These I intend to deal with in the following order:—(*a*) Rhyolites; (*b*) Soda Trachyte, Pantellarite, Comendite Series; (*c*) Andesites; (*d*) Basalts; (*e*) Tuffs.

(A) *Rhyolites.*

Mt. Archer Rhyolites.

The chief localities for rhyolites were Mount Archer and the Yandina District.

At Mt. Archer, and likewise at Mt. Delaney close to Mt. Archer, we find mixed up and apparently interstratified with the

* Proc. Linn. Soc. N. S. Wales, 1903, p.869.

rhyolites, masses of red orthoclase porphyry consisting of decomposed albite and orthoclase phenocrysts in a red weathered base, probably essentially orthoclase. This base is, in sections examined, found to be aphanitic but holocrystalline; originally some of it has been glassy, but devitrification has set in. This red porphyry is apparently an old trachyte which has reached the surface in a fluid condition. Its association with rhyolite recalls that of the Maroochy district trachytes with rhyolites, and a similar association at Battersby's, near Woodford, in the D'Aguilar Range.

The Mount Archer rhyolites are, like the orthoclase porphyries, of a reddish colour, sometimes wholly aphanitic, sometimes with phenocrysts of quartz visible in handspecimen. Some are columnar; some are banded and some are not.

Sp. No.74 is perfectly uniform in appearance in handspecimen and might be mistaken for a red fine-grained quartzite. Sp. No.75 exhibits in handspecimen curious markings all over. Whichever way the specimen is broken these markings are seen. They resemble hieroglyphics.

Sp. No.104 (Plate xv., fig.27) presents a different appearance. It is finely laminated, and the laminæ are curving in various ways, giving evidence of flow-structure.

Sp. No.105 is composed of alternate bands of cryptocrystalline quartz and volcanic glass (black pitchstone).

Sp. Nos.75 and 104 were microscopically examined.

Sp. No.75. Texture : the hieroglyphic structure of the handspecimen is seen under the microscope to be due to numerous branching and intersecting veins of microcrystalline quartz, which interlace in the fashion of stockworks. A differentiation of the magma into silica and felspathic material has taken place in consolidation. Crystallisation is subsequent and due to devitrification. The masses enclosed between the quartz veins consist of an aphanitic, cryptocrystalline to microspherulitic base with a few felspar phenocrysts.

The constituents are felspar (orthoclase) and quartz, with some kaolin from the decomposition of felspar, and iron ore from the decay of a little original biotite. Silica percentage 75·20.

Sp. No.104 is a hypocrystalline rock, consisting of a cryptocrystalline to microcrystalline base, occasionally microspherulitic, containing a few phenocrysts, and sometimes little areas of glass. Axiolitic and microspherulitic structures are beautifully represented.

The constituents are orthoclase, quartz and decomposition products (chiefly kaolin). The phenocrysts are very broken and corroded; some are of orthoclase, some of quartz. The base composed chiefly of orthoclase has become nearly entirely cryptocrystalline by devitrification. A few grains of quartz, like those of Sp. No.75, microcrystalline granular, are present.

Both the rocks may be termed Spherulitic Rhyolite.

Sp. No.75B, from Mt. Archer, is a reddish rock which from handspecimens one would judge to be practically quartz-free. This rock is found interbedded with rhyolites on Mt. Archer. Microscopic examination proves it to consist essentially of orthoclase felspar and magnetite. The orthoclase occurs partly in the form of highly corroded phenocrysts, partly as minute laths contributing to form a trachytic base. The magnetite is highly allotriomorphic. Much of it is dusty. It is probably for the most part secondary after hornblende. This rock is practically a decomposed porphyritic trachyte. This demonstrates that at Mount Archer we have true rhyolites and true trachytes (orthoclase porphyries) erupted together, and it appears probable from microscopic resemblances that these rocks were contemporaneous with the Glass House Mountain and Maroochy district trachytes and rhyolites, but have undergone greater subsequent alteration.

Maroochy Rhyolites.

Sp. No.6. Loc.: Nindherry Mtn. near Yandina.

A light-coloured rock varying from white to yellowish-grey, and indistinguishable from a trachyte in handspecimen, but much more aphanitic and harder than the trachytes usually are. So like a chert is this rock in places that it has frequently been taken for cherty Gympie slate. A microscopic examination showed this rock to consist of a hypocrystalline mass, chiefly microspherulitic with small patches of glass; quartz and orthoclase felspar are the constituent minerals with a little magnetite and chlorite as accessories. It is accordingly a Microspherulitic Rhyolite. The whole of Nindherry Mountain is jointed in such a way as to consist of large irregular columns. Silica percentage 72·39.

Sp. No.43. (Plate xv., fig. 28). Loc.: Maroochy River near Dunathan Rock.

This stone has been removed from the river bed to clear the passage for boats to ply between Coolum and Yandina. It is a banded rock showing flow-structure in handspecimen; it is of a yellowish-grey colour with reddish and other coloured bands. Under the microscope it is seen to contain phenocrysts of quartz, highly corroded and frequently twinned on (0001), lying in a cryptocrystalline base consisting of microspherulites and axiolites of granular quartz and lath-shaped microliths of felspar.

Name: Axiolitic (and Microspherulitic) Rhyolite.

Sp. No.145. Loc.: Summit of the W. peak of Mt. Eerwah.

Rock greyish-white to yellowish; very considerably decomposed, highly vesicular and often banded, indicating flow-structure. Under the microscope the rock is seen to consist of an aphanitic, hypocrystalline base in which a few phenocrysts of felspar are found. The latter consists of an intergrowth of orthoclase and albite, due evidently to a secondary change which has gone on in soda orthoclase. The base is cryptocrystalline, with occasional microspherulites, and occasional glassy patches, and consists of quartz and felspar. Ferromagnesian minerals are practically absent, only a few grains of magnetite and biotite being represented.

Name: Felsitic Rhyolite.

Sp. No.46. (Plate xv., figs. 29, 30). A yellowish-grey rather decomposed specimen which contains a considerable amount of kaolin and limonite, and which was taken from "The Mountain," near Wardrop's selection, north-east of Nindherry. The Mountain forms the northern end of the Toolburra Range.

Under the microscope this rock is seen to be of variable texture; one band is microfelsitic; others are porphyritic, having phenocrysts of orthoclase and of corroded elongated quartz crystals lying in a cryptocrystalline base. The quartzes include stunted laths of a basic felspar in a micropœcilitic manner. The base is chiefly felspar. Ferromagnesian minerals are now only represented by hematite and limonite. Beautiful cubes of magnetite were also present in the original rock, now represented by hematite pseudomorphs.

Name: Rhyolite.

The foregoing rocks present certain features in common. The handspecimens have considerable porosity, a fact which indicates that the lava was very hydrous when erupted. Under the microscope we recognize two generations of felspar and quartz, which crystallised in the order mentioned. A re-heating of the magma after the phenocrysts had formed, led to the refusion of the quartz and its extreme corrosion. The re-melted viscous quartz was drawn out into long streaks and, when sufficiently liquid, small crystals of felspar were often enclosed in the quartz in a micropœcilitic manner. These changes took place at the time of eruption and flow.

The scarcity of ferromagnesian minerals in these rocks is suggestive of quartz-keratophyres; owing to the minuteness of the crystallites composing the base, and the decomposition which has set in, it is not possible to decide whether they are true cryptocrystalline rhyolites or quartz-keratophyres.

From the state in which we find the quartz phenocrysts we can conclude that the lava was erupted at a temperature of between 8 0° and 1200°.

Sp. No.15. Loc.: Railway cutting at 66½ m. between Yandina and Nambour (Text fig. 11A, pt. i.).

Weathered handspecimen not unlike trachyte; on fractured fresh surfaces it has, however, a dull vitreous appearance, resembling chert or fine-grained felsitic tuff. It occurs in highly contorted and faulted layers suggestive of older sedimentary rocks.

Under the microscope it is seen to be a cryptocrystalline rock with plagioclase phenocrysts. Microspherulitic and flow-structures are present. The phenocrysts are highly corroded and consist of quartz and plagioclase, the former having almost wholly disappeared. The base consists of quartz and felspar. Hornblende of a very pale fibrous variety is present; it is commonly included in the quartz and felspar phenocrysts.

This rock is apparently a quartz keratophyre; the appearance of folding is probably due to the flow of constituents on a large scale as seen under the microscope on a small scale.

Sp. No.168. A white rock obtained near the 76½ m. between Eumundi and Cooroy.

Under the microscope we see an aphanitic, microspherulitic base consisting of cryptocrystalline to microcrystalline felspar laths and granular quartz. Phenocrysts, highly corroded, often perfectly rounded, occur in this base. Pseudomorphs in chlorite and dusty magnetite after idiomorphic hornblende are present.

Name: Rhyolite.

Sp. No.15 is typical of most of the dykes and other rhyolitic masses between Yandina and Nambour. Sp. No.168 is typical of those between Eumundi and Cooroy.

Sp. No.24. Loc.: Bottle and Glass.

A compact porphyritic greenish rock with large idiomorphic phenocrysts of quartz, orthoclase and microcline. The base is green and aphanitic. The greenish colour is seen by means of the microscope to be due to a greenish glass which fills the interstices between the minute crystals of felspar constituting the base. The silica percentage of this rock is 68·72.

Name: Porphyritic Rhyolite.

Mt. Tinbeerwah, near Tewantin, consists of a very fine-grained, even, microspherulite rock. It is cryptocrystalline to microcrystalline (felsitic), not unlike the Nindherry Rhyolite in general appearance, but no glass appears to be present. Plates of biotite are represented by black, opaque, rodlike pseudomorphs.

It may be termed Felsitic and Microspherulitic Trachy-Rhyolite.

(B) *The Trachytes, Comendites, and Pantellarites*

These rocks consist essentially of glassy felspar (sanidine) with one or more ferromagnesian minerals belonging to the pyroxene and amphibole groups. The ratio of felspar to ferromagnesian minerals is, with a few ex eptions, about 90 % of the former to 10% of the latter. The exceptions are certain trachytes with trachytic structure from Bridge's Hill and Big Hill, in which the percentage of felspar probably is as great as 95 %, and in which the original ferromagnesian mineral has been wholly altered to hematite.

In the felspars three dominant shapes may be recognised—(*a*) the orthophyric, (*b*) the tabular, and (*c*) the columnar (lath-shaped). The orthophyric type prevails in the comendites from Conowrin, Ewin, Coolum, Cooran and Cooroora; and associated with felspars of other habits in some of the other rocks. The tabular type is predominant in the phenocrysts of the Ngun-Ngun and Beerwah trachytes, and in some of the Beerburrum porphyritic trachyte. The columnar prevails in the felspars of Big Hill, Bridge's Hill, Beerwah, Round Mountain and other lavas. Micro-allotriomorphic granular felspars, with a tendency to orthophyric habit, prevail in the fine even-grained riebeckite comendite of Mt. Tibrogargan and Mt. Beerburrum.

The orthophyric sanidines of Mt. Conowrin comendite were found to be enclosed by the faces *B* (010), *C* (001), *x* (101), *y* (201), with occasionally the faces *n* (021) and *m* (110) represented. The square sections are enclosed by *C* and *B*, and sections in the zone *C y* are also almost square when *y* is strongly developed. Twinning is chiefly Carlsbad parallel to *B*. Baveno quartets also occur, and sometimes simple Baveño twinning is represented.

In the Cooran rock the same forms were represented.

Perfectly square and rectangular sections are practically isotropic, while rhomboidal sections generally show the highest colours. Hence the acute bisectrix lies in the direction *a*′, while the plane of the optic axes (𝔞 & 𝔠) lies in the zone *c*, *y*, *x*. Sections perpendicular to the acute bisectrix frequently show the brushes so close together as to appear like a black cross. Hence the sanidine is almost uniaxial. It appears to be slightly negative in optic sign. When lath-shaped sections occur they usually show Carlsbad twinning and low extinction angles. Angles up to 12° have been observed. It may therefore be concluded that some, at least, of the sanidine is anorthoclase (soda-sanidine).

In my section of Cooran comendite one sanidine phenocryst had a border of albite showing pericline twinning.

In my sections of Ngun-Ngun pantellarite, I have identified the felspar phenocrysts as anorthoclase. They are frequently tabular parallel to *b*, and the faces *n* and *m* are here developed at the expense of *x* and *y*, which characterise orthophyric felspars. Simple twinning on the Carlsbad and Baveno plans is common.

Lath-shaped sanidines with the characteristic cross-cracking (parallel to *a*) are beautifully developed in the Round Mountain trachyte.

In the Beerwah trachyte both columnar and tabular habits are represented in the felspars. Those of both habits have developed the faces *C*, *B*, *m*, *y*, *x*. In the light blue silky trachyte from this locality all the felspar has the properties of sanidine. The R.I. is $\angle \cdot$ Canada balsam; Opt. Sign —*ve*; axial plane $\perp^r$ to *b*; 𝔞 = *a*; 𝔟 near *c*. The axial angle is very small, and the interference figure is consequently nearly uniaxial. The extinction angle is occasionally as high as 12° on *b*/*c*. Hence this is a soda-orthoclase. In a somewhat yellowish-grey variety of Beerwah trachyte lath-shaped oligoclase has been found present as well as anorthoclase.

In the microgranular comendites of Tibrogargan, Beerburrum, Trachyte Ra., &c., and the fine-grained orthophyric comendites of Mt. Ewin, &c., as well as in the groundmass of most of the others, the felspar is so fine-grained and often so allotriomorphic that its exact nature cannot be determined with the high power of a $\frac{1}{6}$in. objective. From its glassy appearance and low R.I. and D.R., we can merely say that it is a variety of sanidine.

The coarsely porphyritic trachyte from the S.E. side of Mt. Beerburrum is better suited for exact investigation. The felspar phenocrysts have a refractive index of 1·525, and some crystals are distinctly seen under the microscope to consist of a fine intergrowth of orthoclase with albite or microcline. The usual faces are developed, and in general appearance the phenocrysts resemble orthoclase. However, the optical sign is +, and the axial plane is nearly perpendicular to *b*, $\mathfrak{c} = a'$, $\mathfrak{b} = b'$. Bx_o nearly coincides with normal to *b*. Between crossed nicols a fine crosshatching is seen in some crystals, due to twinning on the albite and pericline laws. Probably microcline-albite-perthite is the best name for this felspar. The structure of these phenocrysts serves to cast light on the shadowy extinction observed in some phenocrysts in other trachytes, unaccompanied by multiple twinning. It is possible that some of the sanidine-anorthoclase is, in reality, a cryptoperthite which the high power cannot resolve, but the ultramicroscopic twinning results in shadowy extinction. While the commonest twinning observed is Carlsbad, Baveno doublets and quartets are not rare, and occasionally we meet with twinning on the Manebach law associated with Carlsbad twinning. Shadowy extinction is very abundant. Often, as in the Round Mountain trachyte, it is due to strain in consolidation, the laths being frequently bent and broken; but often it may be due to ultramicroscopic twinning.

As inclusions in the felspar we met with zircon in minute idiomorphic, sometimes geniculate needles, apatite in needles, dusty magnetite (rare), arfvedsonite, riebeckite, ægirine. In the Ngun-Ngun, Conowrin and Beerwah trachytes, a yellow mineral, probably *Guarinite*, occurs very sparsely included both in the hornblende and felspar. A few minute grains of a peach blossom-red colour, perhaps eucolite, have been observed in the Ngun-Ngun felspars.

The hornblendes of the trachytes vary somewhat; many kinds have been recognised, and they may occur either singly or all together. The species found present are arfvedsonite, riebeckite, cossyrite, barkevicite, and a species intermediate between arfvedsonite and cossyrite.

The black (in thin slices blue-green) hornblende is found in three habits—(*a*) corroded and indistinctly terminated phenocrysts; (*b*) in small columnar or rod-shaped crystals; and (*c*) in arborescent aggregates of rhomboidal grains, all of which are in optical continuity in each aggregate (pœcilitic habit). The first type (*a*) was found to be best developed in Ngun-Ngun pantellarite, and the phenocrysts were found to be of sufficient size and to show cleavages sufficiently well to permit of an optical investigation. The second type appears from the pleochroism (deep blue to greenish-blue) to be riebeckite. It is developed together with ægirine and some arfvedsonite in the comendites of Conowrin, Cooran, Coolum and Cooroora. In lath-shaped sections it appears almost black. The third type is commonly associated with cossyrite of similar habit, and appears from the pleochroism to be riebeckite. It is developed in comendites and pantellarites from Mt. Tibrogargan, Skeleton Cave (Trachyte Range) and the N.E. side of Mt. Beerburrum. It also occurs in some varieties of Coolum comendite. The minute investigation of the first type resulted in the following properties being revealed. The hornblende is greenish-blue in thin slices, opaque in thicker sections The D.R. is 0·027; R.I. 1·7. The cleavage is prismatic, perfect, at 56° nearly. Extinction angle on *b* with *c* 14°. Habit, tabular parallel with *b*. Pleochroism strongly marked. Sections parallel to *c* from deep lavender to greenish-yellow, parallel to *b* olive-green, parallel to *a* deep blue or greenish-blue.

$\mathfrak{c} = c$ deep blue.

$\mathfrak{a} = a$ (nearly) light green, greenish-yellow.

$\mathfrak{b} = b$ lavender.

Absorption $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$.

These properties determine it to be arfvedsonite.

In Ngun-Ngun pantellarite this amphibole often forms a border round deep brown cossyrite. Occasionally it includes magnetite, sometimes guarinite (?). In Beerwah trachyte, and more rarely in Conowrin comendite, the blue hornblende has a nucleus of brownish barkevicite (pleochroism brown to brownish-green).

In Ngun-Ngun pantellarite, grains of an amphibole with a reddish to brown to bluish pleochroism occasionally are seen as a nucleus of a crystal of arfvedsonite. These may be a variety of cossyrite or katoforite. The grains are too rare and minute for determination.

The blue hornblendes in minute rods and dendritic (poikilitic, pegmatitic) aggregates were too small for exact determination.

Cossyrite is far more plentifully distributed in the East Moreton and Wide Bay trachytes than I formerly supposed. It is an abundant minor constituent in the rocks of Ngun-Ngun, Trachyte Range, Beerburrum, Cooran and Coolum. It has a cleavage angle of 66°, is of a deep brown colour and pleochroic, from opaque brown to yellowish-brown. A variety in the Ngun-Ngun trachyte has a purple pleochroism in certain positions. The occurrence of cossyrite and barkevicite in the trachytes shows that titanium was present in the magma. Sphene occurs in the Ngun-Ngun rock in small dendritic prismatic aggregates. In this rock cossyrite occurs both in crystals and as poikilitic aggregates, the latter of which is its usual habit in the other trachytes.

Associated with the hornblendes in most of the trachytes under discussion we have ægirine. This pyroxene occurs in acicular and lath-shaped crystals of a green colour, which exhibit strong pleochroism, from brownish-green to bright sea-green to yellowish-green, and much higher double refraction than the amphiboles. Ægirine is the main ferromagnesian mineral in the rock types from Mt. Ewin, Trachyte Range (Skeleton Cave), The Round Mtn., and part of Conowrin. In the Conowrin rock it is always associated with riebeckite. In the other trachytes ægirine is present in much smaller quantity than the hornblende.

Quartz is a common constituent in some of these rocks. Mt. Cooee comendite contains corroded quartz phenocrysts; in the Ngun-Ngun and Conowrin rocks it is occasionally seen in the base, forming a micrographic or cryptographic (pseudospherulitic) intergrowth with orthoclase. In Coolum comendite spherulites of quartz (chalcedony ?) and felspar (sanidine) occur.

Cryptographic intergrowths of two felspars, apparently both sanidine, are also of common occurrence in the base of the Ngun-Ngun and Conowrin lavas. These are very like the granophyre groups described by Iddings.*

Chemical Investigation of the Trachytes and Allied Rocks.

Beerwah trachyte, Conowrin and Coolum comendites and pantellarites from Trachyte Range (Skeleton Cave) and Mt. Ngun-Ngun have been analysed, and the results, as well as the norms calculated from the analyses, are stated in tabular form on pp.168-171. These rocks were all, prior to chemical investigation, looked upon by me as trachytes. The amount of quartz recognisable as such under the microscope is very small indeed, yet the analyses of the comendites and pantellarites mentioned show that there must be in these rocks a considerable amount of free quartz; it is found to be present mainly in the microfelsitic base, partly in cryptographic intergrowth with felspar. It is consequently necessary to remove these orthophyric rocks from the trachytes, with which I classed them in my previous paper, and to place them with the comendites and pantellarites of Rosenbusch, near which they fall.†

All the above-mentioned rocks are very rich in alkalies, especially soda. Consequently the microscopic evidence that the sanidine is partly anorthoclase has strong chemical support. The mode differs from the norm in that the diopside, hypersthene, magnetite, hematite, and ilmenite molecules have all gone into soda hornblendes, like riebeckite, arfvedsonite, barkevicite and cossyrite.

That both arfvedsonite and riebeckite are present is evident from the analyses. The blue hornblende is practically the only ferromagnesian mineral in these rocks worth considering. If this mineral were only riebeckite we should expect less FeO, as in

* U.S. Geol. Surv. Seventh Ann. Rep. 1885-86 "Obsidian Cliff."

† See 'Elemente der Gesteinlehre' by Rosenbusch, pp.267 to 270.

the ægirine-pantellarite from Trachyte Range (Anal. iv.; Norm iv., pp.168, 170). If all were arfvedsonite the ratio of FeO to Fe_2O^3 should be greater.

The determination of cossyrite and of barkevicite is supported by the proportion of TiO_2 present, these minerals being titanium-bearing. Zirconia is present (see Anals. i. and v.), and its presence gives further evidence that this molecule is essential for the formation of riebeckite.

Fluorine was looked for in the Conowrin rock, and occurs only to the extent of 0·02 %. Murgogi considers it essential for the formation of riebeckite.* In my opinion chlorine has supplied its place in these rocks. The blue hornblendes are therefore chloro-riebeckites and chloro-arfvedsonites.

Chlorine is present in considerable amount (Anals. i. and v.) and is only freed by digestion with nitric and hydrofluoric acids. It is consequently not present in the form of sodalite, which one would hardly expect in so acid a rock, but occurs in some insoluble silicate like the blue hornblende or marialite (a scapolite). The amount of the latter mineral is, however, not sufficient to account for all the chlorine.

Texture.—The trachytes and allied rocks are mostly holocrystalline or nearly so, but holo- and hypo-crystalline specimens are frequently obtained from the same mountain; thus at Coolum Mountain every gradation exists from holocrystalline to hypohyaline. At Mt. Tinbeerwah specimens of trachyte obsidian were obtained. The Conowrin, Round Mountain and other lavas contain occasional small patches of glass in the base.

The fabrics represented are :—

(1) Pilotaxitic : *e.g.*, Round Mountain, Coolum Mountain, &c.

(2) Trachytic : *e.g.*, (*a*) even-grained—Bridge's Hill, Big Hill, &c.; (*b*) porphyritic—Beerwah, Beerburrum.

(3) Orthophyric : (*a*) with small phenocrysts—Mt. Cooràn, Mt. Conowrin, &c.; (*b*) with large phenocrysts—Mt. Ngun-Ngun, &c.

(4) Granular (microgranitic) : Mt. Tibrogargan, Trachyte Range, Mt. Beerburrum (riebeckite trachytes), &c.

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* See Murgogi, Amer. Journ. Sci. August, 1904.

Composition.—From the discussion of the minerals present it is easily seen that the trachytes are highly alkaline and rich in soda. The magma must also have contained zirconium, titanium, and fluorine, as shown by the presence in the rocks of zircon, sphene, guarinite (?), wöhlerite (?) and topaz (?); chemical analysis bears out this conclusion.

As other rather rare constituents present in the trachytes, the following deserve special mention:—zircon, sphene, apatite, magnetite, hematite, and a yellow mineral in small grains. The last-mentioned mineral shows rather high interference colours, reaching yellows and reds of the first order, and is probably marialite (a scapolite mineral). Some of the chlorine (see chem. analyses) is probably contained in it. Minerals resembling wöhlerite, mosandrite, and rinkite have also been noticed, but have not been identified with certainty.

Brown mica occurs in the trachy-rhyolites from the Green Hills (Pt. Arkwright) and Mt. Peregian.

The Trachyte-like Alkaline Volcanic Rocks.— In handspecimen these rocks are very much alike. They are light grey in colour, and finely speckled with deep blue-black amphibole. Often they are full of minute vesicles, a characteristic which is only noticed by the extreme lightness of some specimens

(A) *Those from the Glass House Mountains:—*

(i.) Beerwah Trachyte (Plate xiv. fig. 19). One variety was described in my previous paper. The variety now described also occurs in shingly slabs, and has a bluish colour due to an abundance of blue hornblende. It has a silky lustre.

Microscopic examination.—(1) Texture: (*a*) crystallinity, holocrystalline; (*b*) grain-size, fine aphanitic, but with a few phenocrysts of sanidine and arfvedsonite; (*c*) fabric, pilotaxitic with a strong tendency to flow structure; hence the fabric is really trachytic.

(2) Constituents (in order of decreasing abundance)—(*a*) felspar, (*b*) greenish-blue hornblende, (*c*) ægirine, (*d*) quartz, (*e*) garnet (?), (*f*) magnetite, (*g*) zircon, (*h*) apatite.

(3) The felspar is sanidine, and perhaps partly anorthoclase or wholly so. It occurs in small laths forming the main bulk of the

rock, and more sparingly as tabular phenocrysts. Carlsbad and Baveno twinning only have been noticed. Most of the felspars show shadowy extinction, probably due to strain in consolidation. The felspar forms at least 85 % of the bulk of the rock. The hornblende occurs in corroded phenocrysts. Frequently the blue variety envelops grains of brownish barkevicite or of clear reddish-brown katophorite or cossyrite. From pleochroism, absorption, and extinction angle (see p. 170), this mineral was identified as arfvedsonite. Smaller grains occur abundantly, and these display closer affinities with riebeckite. Hornblende forms an important constituent (between 10 % and 14 %) Ægirine occurs very sparingly in small acicular crystals. Quartz forms an infilling of some of the interstices between crystals. The other minerals are present only in minutest amount. Magnetite occasionally serves as a nucleus for hornblende. Zircon occurs in minute geniculate needles.

(4) Magnetite, zircon, and apatite were the first minerals to consolidate, and occur as inclusions. Ægirine crystallised out next. The amphiboles commenced next, but continued to separate out after the felspar had commenced. Felspar, quartz, and a few minute patches of isotropic mineral (garnet or sodalite ?) were the last to finish crystallising.

(5) Nomenclature.—This rock is a "*soda-trachyte*" ("Arfvedsonite-riebeckite trachyte"). The magmatic name resulting from the calculating of the norm is phlegrose, close to nordmarkose. For analysis see Anal. v., and Norm v. (pp. 168, 170).

(ii.) Conowrin Comendite. (Plate xiv. fig. 20).

i. In handspecimen this is a fine-grained grey rock, with minute black specks. Some specimens show flow-structure.

ii. Microscopic examination.—(1) Texture : (*a*) holocrystalline; (*b*) fine-grained, microcrystalline, having an aphanitic base, with small phaneric phenocrysts less than 1 mm. in diameter; (*c*) fabric orthophyric.

(2) Constituents.—Essentially felspar and riebeckite in a micro- to cryptocrystalline, felsitic base which contains quartz. The felspar occurs in porphyritic crystals; it consists of sanidine

and anorthoclase. The blue hornblende is essentially an almost opaque riebeckite, and occurs in grains and rods of various sizes. Some phenocrysts of a species closely resembling arfvedsonite are also present. A small quantity of ægirine in minute needles is also present. A cryptographic intergrowth of quartz and felspar is common in the base. Spherical pores infilled with chalcedony are present.

(3) The riebeckite and felspar separated out together, except at the last, when there was left a eutectic mixture of felspar and quartz.

(4) Name: Orthophyric Riebeckite Comendite. The chemical analysis showed that this rock is not a true trachyte. The magmatic name derived from the norm is alaskose, closely allied to liparose.

Note.—Some varieties are not quite holocrystalline, containing a little glass in the base. Others show flow-structure. Occasionally patches of micrographic intergrowth of two felspars are met with, apparently two very closely allied forms in different optic orientation, for there is almost no difference of refractive index between them.

(iii.) Vesicular Trachyte. Loc.: Bridge's Hill, near Caboolture. Under the microscope this rock is hypocrystalline, of uneven grain-size, and trachytic fabric. It consists of sanidine (or anorthoclase) showing Carlsbad, and frequently Baveno, twinning; magnetite, ægirine, a bluish or purplish glass, and some decomposition products

(iv.) Pilotaxitic Ægirine Trachyte. Loc.: Mt. Miketeebumulgrai. This is a pilotaxitic, vesicular, ægirine trachyte, very like the previous.

(v.) Riebeckite Trachyte or Comendite. Loc.: Trachyte Range. This is a very fine-grained rock, containing both riebeckite and cossyrite in characteristic dendritic aggregates.

(vi.) Ægirine Pantellarite. Loc.: Skeleton Caves, Trachyte Range.

This is a holocrystalline, very fine-grained and compact rock of a greenish colour and somewhat greasy lustre. It has a pilotaxitic fabric, and consists essentially of sanidine (anorthoclase) and ægirine, with a few phenocrysts of a light bluish soda amphibole (variety of riebeckite), and some fine-grained dendritic aggregates of cossyrite. There is a felsitic base.

This rock was analysed (Anal. iv. p.168), and was found to be very acid and alkaline, having the composition of the family of Pantellarites of Rosenbusch. The norm gives us the magmatic name of liparose.

(vii.) Riebeckite Comendite. Loc.: Mt. Tibrogargan (Plate xiv. fig.21).

This is a fine-grained, hypocrystalline, orthophyric rock, composed of sanidine, riebeckite, a little glass, and felsitic base. The riebeckite occurs in dendritic aggregates of minute crystals.

(viii.) Orthophyric Trachyte (Comendite?). Loc.: North slopes of Mt. Beerburrum.

This is a fine-grained, slightly porphyritic rock, resembling the previous (vii.) closely, both in handspecimen and microscopically. It is orthophyric, and consists of felspar (sanidine-anorthoclase), and dendritic patches of a soda-hornblende, which is pleochroic in colours from brown to bluish-green and yellowish-green. This amphibole, therefore, seems to lie between arfvedsonite, barkevicite, and cossyrite; and may be identical with Brögger's katophorite. There is also a cryptocrystalline base.

(ix.) Porphyritic Ægirine-Riebeckite Trachyte. Loc.: Mt. Beerburrum.

This porphyritic rock forms the main rock of the locality, and has been described in my previous paper. It is porphyritic and has a trachytic base. The felspar phenocrysts consist of anorthoclase. In the base we have sanidine and oligoclase. Ægirine in small needles, a soda amphibole (blue), probably riebeckite, and a very opaque brownish amphibole, probably cossyrite, are present in very small amount.

(x.) Orthophyric Riebeckite Comendite. Loc.: Dyke in railway cutting, ½-m. N. of Beerburrum Railway Station (Plate xiv. fig.22).

This is a beautiful orthophyric riebeckite rock like that from Tibrogargan (vii.).

(xi.) Orthophyric Ægirine Comendite (?). Loc.: Mt. Ewin.

This is a holocrystalline, very fine-grained orthophyric rock, with a cryptocrystalline base. The recognisable crystals consist of sanidines, ægirine, and a little blue soda-amphibole.

(xii.) Porphyritic-Quartz-Riebeckite Comendite (?). Loc.: Mt. Cooee, near Mt. Tibrogargan.

This rock has large, highly corroded, quartz phenocrysts lying in an orthophyric mass. The grain-size of the main mass is fine; the minerals present, in addition to quartz, are isometric felspar crystals (sanidin-anorthoclase), soda amphiboles behaving like riebeckite and cossyrite, a very small amount of highly corroded biotite, and the cryptocrystalline interstitial mass. Both the quartz and the biotite are probably allogenic minerals snatched up from the country rock when the magma rose to the surface.

(xiii.) Orthophyric Pantellarite. Loc.: Mt. Ngun-Ngun (Plate xiv. fig.23).

This is a holocrystalline, porphyritic, orthophyric rock, with a fine-grained microcrystalline to cryptocrystalline base. The constituents are sanidine, anorthoclase, arfvedsonite, riebeckite, and cossyrite. The last-mentioned mineral is found chiefly enveloped by arfvedsonite or intergrown with it. The analysis of this rock (Anal.iii. p.168) shows it to be a pantellarite; and the magmatic name (Norm.iii.) is liparose. Its titanium-content is high.

(xiv.) Ægirine-Trachyte. Loc.: Round Mountain, near Caboolture (Plate xvi. fig.36).

This is a fine-grained, holocrystalline, microporphyritic rock, with a pilotaxitic fabric. The constituents are sanidine, ægirine, a little deep blue amphibole (probably riebeckite), and a green mineral having a crystalline form and cleavage, occurring in rods, but behaving optically like glass, being isotropic.

(xv.) Trachyte. Loc.: Dyke at Big Hill on Woodford-Caboolture Road (Plate xiv. fig.24).

This is a hypocrystalline rock with a trachytic fabric. It is composed essentially of sanidine laths with fluidal arrangement; also laths of a black, almost opaque mineral, consisting probably of magnetite, pseudomorphous after hematite; also a little glass.

(xvi.) Ægerine-Sanidine Trachyte (Sp.No.118). Loc.: Bell's Quarry near Caboolture.

This rock has a trachytic fabric. It is of a darkish grey colour in handspecimen. The constituents are (*a*) sanidine in broken and bent crystals showing Carlsbad twinning and shadowy extinction due to strain; (*b*) beautiful green nonpleochroic acmite in corroded phenocrysts and smaller corroded needles of pleochroic ægirine; (*c*) magnetite in idiomorphic crystals; (*d*) decomposed biotite of yellowish colour from iron ores. A little zircon and apatite are present as minute accessories.

General Remarks.—The foregoing descriptions of the leading types of Glass House Mountain rocks are, I think, sufficient to make their nature understood. Each specimen described is typical of its locality, only minor variations from the type being met with. All the rocks with orthophyric fabric, and consequently with a micro- to cryptocrystalline base, I have called comendites or pantellarites, according as they resembled more closely the one or the other analysed. The cryptocrystalline ('felsitic') base in these rocks must undoubtedly contain quartz (see Norms ii., iii., and iv.) whether the microscope shows it or not.

The order of crystallisation is not quite normal. Riebeckite is occasionally found included in felspar, but frequently again it occurs in the base, forming a graphic intergrowth with sanidine. It practically crystallised simultaneously with, and as long as, the felspar in many of these rocks.

Attempts were made to measure microscopically the relative proportions of sanidine (felspar), and riebeckite (amphibole) in the Beerwah and Conowrin rocks. Calculating all the blue patches as hornblende, about 14 % of this mineral was estimated to be present, about 86 % of the rock being felspar and base.

However, owing to the riebeckite occurring largely in minute grains and partly intergrown with felspar, this method gives far too high a proportion of amphibole. The chemical analyses also render this estimation unnecessary.

(B) *From localities remote from the Glass House Mountain region :—*

Sp. No.122 Soda-Felsite. Loc.: Mt. Byron.

i. Handspecimen of a yellow colour, very fine-grained (aphanitic), with a few phaneric phenocrysts. It resembles trachyte.

ii. Microscopic examination.—(1) Texture: (*a*) crystallinity, holocrystalline; (*b*) grain-size, uneven, with a very fine-grained base; (*c*) fabric, porphyritic, with an allotriomorphic granular base.

(2) Constituents (in decreasing amount)—(*a*) plagioclase and other felspar, (*b*) chlorite, (*c*) kaolin and other decomposition products. The only constituent in more than diminutive quantity is felspar.

(3) The felspar phenocrysts consist of albite. The felsitic base consists largely of plagioclase. That orthoclase also occurs is likely, from the presence of kaolin as a decomposition product, but, owing to the decomposition, it is impossible to ascertain whether orthoclase and interstitial quartz are present or not. A little secondary magnetite occurs with the chlorite; they represent some original hornblende.

(4) Nomenclature.—This rock belongs to the Soda-Felsites or Keratophyres. It is an Albite Keratophyre, closely allied to the alkaline rocks of the Glass House Mountains.

(5) Additional remarks.—The Mt. Byron keratophyre has undergone considerable alteration. It appears to have had originally a glassy base which has subsequently devitrified during earth movements. Hence it probably antedated the folding movement which produced the D'Aguilar Range. It is Post-Triassic intruding Trias-Jura sandstone, and older than the Mt. Mee basalt.

Sp. No.125. Felsitic Trachy-rhyolite. Loc.: Lillingstone's Ck. (branch of the Obi-Obi), Maleny Tableland, Blackall Range.

i. Handspecimen light yellowish-grey in colour, compact, aphanitic and somewhat more vitreous in lustre than trachyte.

ii. Microscopically it is a holocrystalline, micro- to crypto-crystalline, even-grained rock, with a micropegmatitic fabric. Felspar forms the main bulk of it. In addition there is a brownish highly pleochroic mineral, probably a soda-amphibole, sparingly represented in minute grains. The felspar is apparently orthoclase, but may be partly anorthoclase and albite. The grain-size is so extremely fine that the presence or absence of quartz cannot be established with certainty. Hence I term it provisionally Felsitic Trachy-rhyolite.

It intrudes Trias-Jura rock, and underlies basalt.

Orthophyric Comendite. Loc.: Mt. Cooran (Plate xv. fig.25).

This rock forms the pinnacle known as Mt. Cooran at Cooran, about 16-m. from Gympie and 46-m. north of the Glass House Mountains.

i. Handspecimen exactly like Mt. Conowrin rock.

ii. Microscopically it is a holocrystalline, fine-grained, uneven, orthophyric rock. It consists essentially of isometric felspars, and a felsitic base containing minute felspar laths. A deep blue soda-amphibole, and a very dark brown, highly pleochroic hornblende are present in subordinate amount. The isometric felspars belong to the variety sanidine or soda-sanidine (anorthoclase). There are also lath-shaped phenocrysts of this mineral up to 1 mm. in length. They exhibit the characteristic cross-cracks, and twinning on the Carlsbad and Baveno laws. The deep blue amphibole is highly pleochroic, changing from deep indigo-blue to greenish-blue, and in some grains to greenish-yellow. It is probably more closely allied to riebeckite than to arfvedsonite. The dark brown soda-amphibole is allied to cossyrite, and occurs in dendritic aggregates of minute crystals, forming a kind of graphic intergrowth with felspar in the base. Quartz also occurs.

This rock is so like the Conowrin and Coolum comendites that one feels safe in calling it Orthophyric Riebeckite (Cossyrite ?) Comendite.

Note.—In many of the orthophyric rocks like the above, the brown amphibole was the last of the ferro-magnesian minerals to consolidate, forming dendritic intergrowths with the felspar of the base; whilst the riebeckite occurs in grains which consolidated at the same time as the isometric phenocrysts. In others the riebeckite and brown amphibole separated out together, the latter, perhaps, commencing first. In such rocks the brown amphibole may form the nucleus of arfvedsonite phenocrysts, and also occur in dendritic aggregates in the groundmass (*cp.* Beerwah and Ngun-Ngun rocks, pp.140, 145).

In this connection it should be mentioned that most of the orthophyric rocks are, however compact in appearance, minutely vesicular (microlitic). Heating by means of a fire makes them split, crack, and fly asunder with *explosive* violence, as I have frequently experienced while camping out. The minute vesicles probably contain water. The analyses show the presence of zirconium, chlorine, fluorine, titanium, and sulphur. All this points to extensive pneumatolytic action at the time of consolidation.

Probably, owing to the viscosity of the lava, the water and mineralisers were retained by it; and alterations in the relative proportions of the mineralisers during crystallisation determined the formation of different amphiboles at different times. The mineralisers have also served to preserve eutectic proportions in the magma during cooling.

The Comendites of Coolum Mountain, near Pt. Arkwright.—Several types were met with, all closely allied.

Sp. A. (Plate xv., fig.26). This is a fine-grained, bluish-grey, columnar rock. Under the microscope it is seen to be holocrystalline, fine-grained, but uneven, with a pilotaxitic fabric. It contains sanidine in laths and grains, and a dark blue-black amphibole, which is too opaque to show pleochroism, probably a variety of riebeckite. The dark amphibole occurs in long rod-shaped crystals.

Sp. B. The handspecimen is like A. It is a holocrystalline, somewhat porphyritic rock, with a very even-grained microcrystalline base which has a granular (microgranitic) texture. The phenocrysts are isometric and lath-shaped sanidines. The base contains felspar (sanidine); quartz has not been identified in it, but may be present interstitially. The amphiboles present are riebeckite in dendritic (poikilitic) aggregates, and a little brownish hornblende (cossyrite ?), of similar habit.

Sp. C. Handspecimen like the preceding. This is a holocrystalline, fine-grained rock of trachytic fabric. The constituents are isometric and lath-shaped sanidines, sanidine microlites of the base, interstitial quartz, amygdules of spherulitic chalcedonic quartz, and deep blue, almost black, pleochroic soda-hornblende (variety of riebeckite) in rods. The analysis of this rock (Anal. ii. p. 168) shows it to be a comendite. Magmatic name, "Kallerudose," near "Liparose."

Sp. D. A holocrystalline, extremely fine-grained rock, with a microgranitic (granular) fabric.

The constituents recognisable are sanidine, and very fine-grained blue hornblende.

Sp. E. Handspecimen of a bluish colour, with well marked flow-structure.

The blue colour appears, under the microscope, to be due to a bluish glass. The rock is hemi-vitreous. Fluxion-structure is very distinct. A considerable amount of secondary quartz is present.

From the above descriptions it will be seen that the Coolum rocks are fine-grained Riebeckite Comendites, varying from holocrystalline to hemi-vitreous in crystallinity, and from orthophyric to trachytic and microgranitic in fabric.

The comendite from Mt. Cooroora, near Pomona, is, in hand-specimen, like those from Cooran, Coolum and Conowrin. Microscopically, also, it resembles these rocks. Its fabric is orthophyric. The amphibole consists of almost opaque blue-black rods, in extremely thin sections pleochroic from blue to greenish-blue (riebeckite).

Sp. No. 109. Loc.: Mt. Pinbarren.

This specimen is a black rock, light in weight, with a slaggy appearance.

Examined microscopically it is observed to be hemicrystalline, very fine-grained, and to possess a hyalopilitic fabric. In addition to felspar, variety orthoclase, which occurs in acicular crystallites, there is a profusion of apatite needles; a great deal of ferromagnesian mineral has been present, but is now represented only by hematite. The rock is very considerably decomposed.

Name: Devitrified Hypocrystalline Trachyte.

Sp. No.115. Loc.: Emu Mountain (Peregian).

This is a fine-grained holocrystalline, pilotaxitic trachy-rhyolite, very decomposed, so that the amphibole is now replaced by hematite. The amphibole evidently had a dendritic habit like riebeckite and cossyrite, for the hematite replacing it is distributed in this way. The main constituent of the rock is sanidine, of which a few phenocrysts occur, but most of it occurs in the form of minute laths and crystallites. In handspecimen the trachyte of Peregian is exactly like that of Coolum Mountain, columnar, bluish-grey, typical trachy-rhyolite. Brown flakes of biotite are, however, also found in it, as in the Green Hills trachy-rhyolite (Green Hills, Mt. Eurungunder, Pt. Arkwright).

Name: Decomposed Trachy-rhyolite.

(c) *The Andesites.*

There are two kinds of andesites represented. One of these is exemplified by the quartz-andesite or dacite occurring at Bankfoot House in the Glass House Mountains; the other is typical quartzless andesite. A type-specimen of the former kind was described in my last paper. The andesitic rock obtained at Mt. Wappa, and at the saddle of Nindherry, is macroscopically identical with the Bankfoot House dacite.

The following are brief descriptions of some of the rocks obtained.

Sp. No.163. Sodic Quartz-Andesite. Loc.: Railway line near the 78 m. peg, between Eumundi and Cooroy.

i. In handspecimen a bluish-grey rock with pink specks; fine-grained, but not aphanitic; in appearance it resembles a fine-grained syenite.

ii. Microscopic examination.—(1) Texture: (*a*) crystallinity, holocrystalline; (*b*) grain-size, fine; (*c*) fabric, intersertal, pilotaxitic, almost panidiomorphic.

(2) Constituents (in order of decreasing abundance).—(*a*) Lath-shaped felspar, including (i.) orthoclase and (ii.) olioclase with albite twinning and extinction angles up to 5° or 6°; (*b*) idiomorphic cubes of magnetite, (*c*) lath-shaped crystals of ægirine decomposing to chlorite, (*d*) hematite from the decomposition of ægirine; (*e*) quartz (a little), (*f*) apatite, (*g*) kaolin from the decay of the felspar.

Order of crystallisation normal.

Name.—This rock occurs in a fairly large mass, which is probably not of true volcanic origin; yet it has cooled so near the surface that it has as many affinities with the volcanic as with the hypabyssal rocks. Quartz-Andesite seems to be the most suitable name. The ægirine shows that it is rather alkaline.

A closely allied rock is Sp. No.18, which occurs as a large intrusive mass in the cutting at the 66¼ m. peg, on the railway line between Yandina and Nambour.

Sp.No.152. Sodic Quartz-Andesite or Dacite.

Obtained on the railway line between Eumundi and Cooroy, is similar macroscopically. Under the microscope we find it the same in texture, but the constituent minerals are as follows:—(*a*) felspar, comprising andesine and oligoclase; (*b*) magnetite, (*c*) ægirine, (*d*) chlorite, (*e*) augite surrounded by a rim of hematite, (*f*) a little hornblende decomposing to chlorite, (*g*) a little quartz, orthoclase and apatite.

Evidently it is a dacitic rock, closely allied to Sp. No.163.

Sp. No.165. A somewhat decomposed andesitic rock with green specks, occurring as a dyke on the Kenilworth Road, ½ m. from Eumundi. In texture it is like the preceding. In constitution, however, it has been a much more typical andesite. It consists of plagioclase; magnetite and chlorite, both secondary after hornblende; and original magnetite.

Sp. No.167. Andesite. Loc.: Hull's Selection, Mt. Cooroy.

i. In handspecimen a dark, compact, greenish rock with felspar phenocrysts.

ii. Under the microscope, seen to be a hypocrystalline, uneven, but fine-grained rock, with hyalopilitic fabric. The chief constituents are plagioclase, ægirine-acmite, and glass. A considerable amount of apatite and ilmenite is present. The plagioclase has very low extinction angles, occurs in longish laths, and is probably albite and oligoclase. A little orthoclase (sanidine) is present in grains of irregular shape. The augite (ægirine-acmite) is green and slightly pleochroic. It occurs in irregular patches, which ophitically envelop the plagioclase. Plates of ilmenite and idiomorphic magnetite crystals are abundant. Long stout rods of apatite are fairly plentiful. The glass is interstitial. The minerals consolidated in the following order :—magnetite and ilmenite, apatite, plagioclase, augite, orthoclase, glass. This rock probably belongs to the same magma as the main rock of Mt. Cooroy. It is evidently a highly alkaline andesite, or soda-andesite.

Sp. No.164. Pilotaxitic Andesite. Loc.: Dyke in 78-mile railway cutting, between Eumundi and Cooroy.

i. The handspecimen has the appearance of basic andesite, and contains large white phenocrysts of secondary calcite and felspar.

ii. Microscopic examination.—(1) Texture: it is a holocrystalline, uneven-grained, porphyritic rock, with a pilotaxitic ophitic base.

(2) The essential minerals are plagioclase and augite. Ilmenite is an important constituent. Dolomite is plentiful. In minute amount apatite and orthoclase are represented.

(3) The plagioclase occurs in large tabular phenocrysts consisting of labradorite containing magnetite inclusions, and occasionally calcite as a decomposition product. The plagioclase of the groundmass is andesine, and occurs in lath-shaped microlites. The augite occurs in minute grains in the base. It is of a light greenish variety, allied to acmite. There are also a few corroded phenocrysts of diopside. The ilmenite occurs both in larger plates and minute needle-shaped crystals. Leucoxene is present in very considerable amount as decomposition product. The dolomite exists in large somewhat regular masses, which appear to be pseudomorphs after a mineral like hypersthene or olivine. They have often a roughly hexagonal section, and each mass is made

up of numerous small lozenge- or lens-shaped areas. Again these masses of carbonate may be merely amygdaloidal, the regular outline being accidental. I am inclined to favour the former view on account of the normative composition as calculated from chemical analysis.

(4) The order of consolidation was—

1. Magnetite ———
2. Hypersthene (?) ———
3. Labradorite ———
4. Diopside ———
5. Andesine ———
6 Augite (acmite) ———

(5) Nomenclature.—This is a decomposed basic andesite, or perhaps olivine basalt. The chemical analysis (Anal. x. p. 169) places it in the alkalicalcic series. The magmatic name is Harzose, and possibly of the parent rock, Shoshonose.

(D) *The Basalts.*

The detailed description of these rocks is unnecessary. Their distribution is shown on the plan (Plate v.). An analysis was made of basalt from Nindherry Range near Yandina, because of the association here of basic rock with members of the trachy-rhyolite series. The analysis shows that the basalt there is fairly sodic, like the Sydney basalts (auvergnose).

Sp. No.66. Pilotaxitic Basalt. Loc.: Mt. Mee.

This rock is extremely dark, compact and fine-grained in hand-specimen. Under the microscope it is seen to be holocrystalline, even-grained, very fine-grained, with pilotaxitic fabric. The essential minerals are felspar in lath-shaped microlites, isometric grains of magnetite, and granules of augite. Apatite is present in small amount. Greenish-blue, pleochroic chlorite, probably after augite, occurs in fair quantity.

Sp. No.140. Olivine Basalt Loc.: Buderim Mountain.

i. This is a dark compact rock, weathering more slowly than most basalts, giving a red soil rich in iron ore. Red in weathered specimens.

ii. Microscopic structure.—(1) Texture: holocrystalline, even-grained, but for a few olivine phenocrysts, and almost panidiomorphic granular in fabric.

(2) The constituents (in order of decreasing amount) are olivine, magnetite, plagioclase, and augite, all of which occur in considerable quantity.

(3) The olivine occurs both in phenocrysts and in smaller crystals. The phenocrysts sometimes enclose magnetite and felspar. It is partly decomposed to greenish serpentine. The magnetite is intergrown with augite and felspar in the groundmass. The felspar occurs in laths with ragged ends, and sometimes includes magnetite. The augite occurs in small granules interstitially between magnetite and felspar.

(4) The order of consolidation is abnormal. The magma must have been extremely rich in iron ore, which separated all the time during consolidation. It began crystallising first and finished after the felspar. Olivine, magnetite and felspar crystallised together for some time. Augite separated out last.

(5) Name: Olivine-Magnetite-Basalt.

(6) Note.—The felspars are of the microtine habit, and consist of basic labradorite, showing high extinction angles.

Many of the Maleny (Blackall Range) basalts are similar to this rock. The basalt from the Woondum Tableland near Cooran is also similar. A specimen in my collection from the Coorombin road, near Murwillumbah, is also very rich in iron, consisting of magnetite, *albite* and titaniferous augite.

Sp. No.166. Loc.: Basalt dyke at Battersby's (in the D'Aguilar Range), 4-m. west of Mt. Tunbubudla.

Handspecimen black, basaltic-looking.

Microscopic examination.—(1) Texture: (*a*) crystallinity, hypocrystalline; (*b*) grain-size, porphyritic with aphanitic base; (*c*) fabric, hyalopilitic and ophitic.

(2) Constituents (in decreasing order of abundance).—(i) Labradorite occurring both in corroded phenocrysts and in minute laths in the base; (ii) olivine changing to green serpentine (this mineral occurs in phenocrysts); (iii)(*a*) augite partly in the form

of phenocrysts, and in minute granules plentifully scattered throughout the base, (*b*) enstatite in phenocrysts; (iv) magnetite in minute idiomorphic grains abundantly distributed throughout the base; (v) serpentine from the alteration of olivine; (vi) greenish volcanic glass, interstitial between microlites of felspar and granules of augite and magnetite of the base.

(3) Name: Olivine Enstatite Basalt.

Basalt obtained at Sellin's, on the Byron Ck slope of Mt. Mee

Handspecimen is a black rock in which olivine can be seen with the naked eye, and with a pocket lens its abundance becomes very evident.

Microscopic examination.—(1) Texture: (*a*) holocrystalline; (*b*) fine-grained, porphyritic; (*c*) ophitic.

(2) Constituents (in order of decreasing abundance).—(*a*) Labradorite in lath-shaped crystals of highly varying dimensions, some being of the size of phenocrysts, and some very minute indeed; (*b*) augite in rounded granules scattered throughout the rock; several adjacent granules are sometimes in optical continuity though separated by felspar (ophitic structure); variety diopside: (*c*) olivine in hexagonal sections, perfectly colourless except when decomposing to serpentine; granules of augite commonly cluster round the olivine; secondary magnetite is also found round it; (*d*) ilmenite, which is more plentiful than magnetite, occurs in characteristic tables and rods; (*e*) magnetite (i) idiomorphic, (ii) dusty; the former variety is primary, the latter secondary; magnetite is commonly contained as inclusions in all the other minerals including olivine; (*f*) idiomorphic phenocrysts of enstatite; (*g*) decomposition products.

(3) Order of consolidation normal.

Magnetite and ilmenite
Olivine
Enstatite
Augite (Diopside)
Labradorite

Secondary: Magnetite surrounding olivine; serpentine from alteration of olivine and augite.

Name: Olivine Enstatite Basalt.

Sp. No.94. Basalt found capping the Woondum Tableland. This is an ordinary olivine basalt resembling the previous, but containing a greater proportion of magnetite. The olivine is changing to serpentine and dolomite. Augite is very sparingly represented.

Sp.No.1. Olivine Basalt. Loc.: Nindherry, near Yandina.

i. Very dark, compact, heavy rock of typical basaltic appearance.

ii. Microscopic examination.—(1) Texture: (*a*) crystallinity, hypocrystalline; (*b*) grain-size, uneven, fine; (*c*) fabric, hyalopilitic, porphyritic in olivine and augite.

(2) Constituents (in order of decreasing abundance).—(*a*) *essential*, olivine felspar and augite; (*b*) important, magnetite and glass; (*c*) minor, serpentine chlorite, apatite, and dolomite, decomposition products.

(3) Remarks.—The olivine exists in idiomorphic corroded crystals decomposing to serpentine. The augite is of two generations, (*a*) phenocrysts, corroded, and occasionally with hour-glass structure, consisting of a colourless diopside; the cleavage is not well marked; (*b*) minute grains of a yellowish-green augite in the base. The felspar is subporphyritic in laths with ragged ends, and belongs to the labradorites; it has the "microtine" habit. The magnetite is abundant and titaniferous, yielding leucoxene as a decomposition product. The glass is of a greenish colour, and fills cavities and interstices.

(4) Order of consolidation—

(*a*) Olivine ——————

(*b*) Augite (1)

(*c*) Felspar

(*d*) Magnetite ——————

(*e*) Augite (2) ——————

(*f*) Glass ————

(5) Name and Relationship.—Hyalopilitic Olivine-Basalt.

The chemical analysis shows this rock to belong to the "Auvergnoses" in the American classification.

(6) Note.—The order of consolidation in this rock is somewhat abnormal, the magnetite being late in crystallising. This feature

is common to many of the highly ferriferous basalts of the district, *e.g.*, the Buderim, Blackall Range, and Woondum basalts.

The first generation of augite was low in iron and contained no ferric iron. The second generation must have been rich in ferric iron, being yellowish. The glass, probably, is of the augite-acmite composition.

(E) *Tuffs.*

The country lying between Nambour and Cooroy, the Blackall Range, and Nindherry, is very rich in volcanic tuffs and breccias. Tuffaceous and brecciated rocks were represented in two-thirds of the railway cuttings between Nambour and Yandina; and, in addition, all the flat country lying between Yandina and Eumundi, as well as a great portion of the Eumundi Ranges, between Eumundi and Cooroy, is composed of tuffs and breccias. Mt. Eerwah is partly built up of tuffs which seem to be of a trachytic composition; while in Yanganuien Valley andesitic tuffs and breccias are met with. Most of the tuffs of the Yandina-Nambour railway cuttings are of a light colour, greyish-white to pink, and have the appearance of being composed chiefly of felspar. Probably they are trachytic inclusions of boulders, and smaller lumps of sandstone are met with in these tuffs. Owing to the degree of decomposition, as well as to the friable nature of these rocks, no attempt has been made to section more than the one described below.

Sp. No. 162. Loc.: Eumundi-Kenilworth Road, ½ mile from Eumundi.

This specimen is light greenish in colour, otherwise, not unlike a trachyte. A few angular fragments may be seen in it with the naked eye and demonstrate its clastic origin.

Microscopic examination.—Texture: This rock is hemi-crystalline, porphyritic with an aphanitic base, which has a tuffaceous structure.

Constituents.—The rock is wholly composed of felspar and decomposition products after felspar, *e.g.*, kaolin. A little hematite and chlorite appear also to be present. The original felspar before decomposition seems to have been chiefly orthoclase; hence this rock is a trachyte tuff. The phenocrysts are broken, and have their long axes lying chiefly in the same direction as the finer constituents of the rock. Hence they were deposited under water, and here we have petrological evidence verifying field evidence to the same effect. Most of the tuffs of the Maroochy district are bedded, and sometimes contain intercalated shaly bands. The groundmass consists of dumbbell-shaped, boomerang-shaped, comb-shaped, and other fragments, most of them with concave outlines. The rock has thus the typical structure of an acid tuff.

Relationship and Succession of the Volcanic and Hypabyssal Rocks—The gradation of rhyolite into trachy-comendite in the Maroochy district may be taken as evidence of the close relationship and contemporaneity of these rocks. At Mt. Archer too we have rhyolites and orthoclase porphyries of the same age. In the Glass House Mountains we have good evidence, in the form of trachyte inclusions in dacite, that the dacites were erupted later than the trachytes In the Maroochy district there is no evidence that the dacites are later, though the order observed in the Glass House Mountains probably holds here too. The Mt. Cooroy monzonite is closely allied to some of the quartz andesite dykes near Eumundi, and between Yandina and Nambour. It has also, as already shown, affinities with the Noosa and Pt. Arkwright mass; its age is hard to arrive at; it is probably older than the trachy-rhyolites. The quartz andesites and dacites are divisible into two kinds: (*a*) those lithologically resembling the Glass House Mountain dacites; they occur at the Nindherry Saddle (Plate v.) and around Mt. Wappa, and are partly glassy; these are probably subsequent to the rhyolites. (*b*) Those which are holocrystalline with trachytic texture, and closely allied to the Cooroy rock in composition. They are intruded by rhyolite dykes and are therefore earlier than the rhyolites. The Pt. Arkwright rock and the Noosa Hd. Quartz-Diorite are both closely allied in basicity to the earlier andesites, and the fact that the

Coolum trachyte has flowed over and enveloped a mass of this granophyric porphyrite is good evidence of relative age.

The following is the succession obtained :—

(*a*) Porphyrite, tonalite (quartz-diorite), and monzonite intruded at Pt. Arkwright, Noosa Head, and Cooroy. Simultaneously there were eruptions of closely related soda-andesites and quartz-andesites in the Maroochy District: (Cretaceous ?).

(*b*) Eruptions of trachyte, trachy-rhyolites, and rhyolites, mostly highly alkaline, in all the area examined from Mt. Byron (keratophyre) to Mt. Cooran (comendite). These eruptions had their maximum effect in the Glass House Mountain region: (Eocene ?).

(*c*) Eruptions of dacite (Glass House Mountain type*) in the Glass House Mountains and the Maroochy district: (late Eocene?); also andesites of this age.

(*d*) Basaltic outpourings: (Pliocene?).

It was remarked by me previously that in the Glass House Mountains Richtofen's law of volcanic succession did not hold in all respects. Taking the wider area dealt with in this paper, we find that the eruptions followed, generally speaking, in the order of Richtofen's law. An examination of the foregoing petrological work brings one to the conclusion that there were two great periods of volcanic activity. The first was in Pre-Gympie times, and the magma erupted was essentially calcic in composition, giving rise to lavas now altered to greenstone, anthophyllite schist and amphibolite. A sodic and more acid differentiation product of this magma gave rise to the rocks now represented by epidote-glaucophane schist, quartz-glaucophane schist, and glaucophane-albite schists on Mt. Mee.

The great granitic intrusions followed in Carboniferous or Permo-Carboniferous time, and were of a calcic nature; but the predominence of plagioclase over orthoclase in these masses (tonalite, quartz diorite, &c.) hints at the alkaline period to follow.

The second great volcanic period came in Post-Triassic times, and gave lavas of an alkaline nature. At the same time great

* See my previous paper, these Proceedings, 1903.

hypabyssal intrusions of a calcalkalic nature took place. The hypabyssal rocks and contemporaneous lavas were intermediate in composition. The highly alkaline acid lavas followed. Lastly came the basaltic extrusions which were sometimes inclined to the alkaline series (auvergnose) sometimes calcic, but uniformly very ferriferous.

Conclusion.

To recapitulate, then, the main results of my chemico-petrological work may be stated as follows:—

(*a*) The alkaline nature of the petrographical province of the Glass House Mountains has been established. This province has been shown to extend far beyond the Glass House Mountains proper.

(*b*) The nature of the blue amphiboles in the trachytes and pantellarites has been determined by chemical as well as optical examination, and evidence on both accounts has been found for the existence of a chlorine-bearing mineral of the scapolite group as well.

(*c*) The importance of mineralisers like ZrO_2, TiO_2, S and F in the production of riebeckite and cossyrite was first demonstrated by Murgogi, and gets confirmation from my work. Chlorine, however, has largely replaced fluorine in the pneumatolytic processes of this area.

(*d*) Evidence of a petrological character has considerably assisted field evidence in establishing the sequence and relationships of the hypabyssal and volcanic rocks.

(*e*) Very interesting and rare schistose rocks with rutile, glaucophane, anthophyllite, zoisite, and sillimanite have been shown to abound around Mt. Mee.

(*f*) The constant occurrence of nickel in the chemical analyses hints at the district being nickel-bearing; and metalliferous deposits of manganese, nickel and cobalt are likely to be found amongst the serpentinous, gabbroic, and schistose rocks of the D'Aguilar Range.

Finally, I desire to express my cordial thanks to Dr. W. G. Woolnough for his invaluable suggestions and help in the determination of the optical characters of rare minerals, especially in the schistose rocks.

Chemical Analyses.

	I. Comendite (orthophyne) *Loc.*: Mt. Conowrin, Glass House Mts.	II. Comendite (orthophyric) Mt. Coolum, Yandina.	III. Pantellarite (orthophyric) Ngun-Ngun, Glass House Mts.	IV. Pantellarite (orthophyric and ægirine bearing). Trachyte Range, Glass House Mts.	V. Trachyte (trachytic) Mt. Beerwah Glass House Mts.	VI. Monzonite (Quartz Diorite) Mt. Cooroy.
SiO_2	74·20	74·78	72·38	71·56	64·58	62·09
Al_2O_3	11·75	11·94	12·21	11·94	17·52	14·45
Fe_2O_3	1·92	2·46	3·36	4·68	2·56	3·46
FeO	1·30	·88	·69	·46	·96	4·00
MgO	·30	·16	·17	·32	·22	·94
CaO	·19	·07	·18	·28	·39	3·15
Na_2O	4·25	4·77	3·52	4·88	6·41	4·45
K_2O	5·00	3·99	5·20	5·03	6·23	4·56
H_2O +	·27	·28ig	·86ig	·40 g	·30	·34ig
H_2O—	·06	·19	·69	·33	·11	·24
CO_2	·01	n.d.	—	—	·08	·11
TiO_2	·13	·17	·25	·17	·13	1·30
ZrO_2	·38	—	—	—	·21	trace
P_2O_5	abs.	trace	trace	trace	trace	·56
SO_3	abs.	—	—	-	abs.	—*
Cl	·17	—	·01	—	·08	·05
F	·02	—	—	—	—	—
$S(FeS_2)$	·10	—	—	—	·08	·05
Cr_2O_3	abs.	—	—	—	abs.	abs.
MnO	·02	·08	·70	trace	·08	·38
NiO	·03	·03	·04	·01	·03	·09
CoO	abs.	abs.	abs.	abs.	abs.	abs.
SrO	abs.	abs.	abs.	abs.	trace	abs.
BaO	abs.	abs.	abs.	abs.	abs.	trace
Li_2O	abs.	abs.	abs.	abs.	abs.	abs.
Sum	100·12	99·80	100·26	100·06	99·97	100·22
Sp. Gr.	2·62	2·70	2·47 (vesicular)	2·71	2·62	2·70

*, Present only in pyrites.

†, Cl from seawater chiefly; removed by washing.

Note to Chemical Analyses.

The analyses were carried out in the Geology Laboratory Sydney University. The evaporations were done in porcelain utensils on account of lack of platinum dishes; and the reagents used, though the best obtainable, were not quite pure. Therefore as a check I made a number of "blank" analyses, and obtained as a mean result of these blanks the following quantity of impurity in the amount of reagents used for each analysis :—SiO_2 = ·24%; Al_2O_3 = ·07%; Fe_2O_3 = ·19%; Na_2O = ·22%; K_2O = ·07%.

Chemical Analyses.

VII. Porphyrite Pt. Arkwright.	VIII. Qtz. Diorite Noosa Head.	IX. Dacite Bankfoot House, Glass House Mts.	X. Andesite Eumundi.	XI. Basalt Yandina.	XII. Glaucophane Schist. Mt. Mee.	Extra Silica Estimations.
59·27	57·66	62·15	54·24	49·43	49·98	Nindherry
17·80	21·17	16·73	15·41	12·73	11·95	Rhyolite.
2·46	·05	2·90	2·34	5·06	13·91	SiO_2 72·39
3·39	5·11	3·22	5·92	8·47	2·75	——
2·39	1·70	2·70	3·31	6·96	5·53	
5·39	6·57	3·98	4·84	8 59	10·54	Mt. Archer
4·87	3·81	3·58	3·34	3·50	2·63	Rhyolite.
2·51	1·73	2·81	2·62	1·21	·26	SiO_2 75·20
1·18	1·00	1·06	1·67	1·11	1·18	
·31	·05	·14	·72	·73	·03	——
·69	·11	·04	4·44	·28	·02	"Bottle and
·62	·88	·83	1·57	2·26	·80	Glass,"
·05	abs.	trace	p.n.d.	abs.	abs.	Blackall
·44	trace	p.n.d.	trace	·49	p.n.d.	Range,
—*	— *	—	—	abs.	—	Pantellarite
·07†	trace †	trace	·01	trace	trace	SiO_2 68·72
—	—	—	—	—	—	——
·33	·05	·11	·24	trace	·23	
abs.	abs.	abs.	abs.	faint trace	p.n.d.	Pt. Arkwright
·10	·11	·12	trace	·08	·13	Aplite.
·01	·04	·08	·05	·05	·10	SiO_2 69·22
abs.	abs.	abs.	abs.	abs.	abs.	
abs	abs.	abs.	abs.	abs.	abs.	——
abs.	abs.	abs.	abs.	abs.	abs.	Dark
abs.	abs.	abs.	abs.	abs.	abs.	Porphyrite
101·88	100·04	100·45	100·67	100·89	100·04	Pt. Arkwright
2·86	2·78	2·61	2·625	3·18	3·18	SiO_2 61·16

p.n.d., present in small amount insufficient to warrant determination of amount.
—, not determined. ig, determined by ignition.

The figures given in my table of analyses are the results actually obtained from my weighings *minus* the average amount of the substance obtained in a blank. To get my actual laboratory results therefore add the above figures to those in the tables. The sum is increased by ·79% in each case.

For each analysis about 1 grm. of rock powder was used, and the appropriate amount of reagents as recommended by Washington and Hillebrandt, whose methods were followed. As closely equal amounts as possible of reagents were used in each case.

CALCULATED NORMS AND MAGNETIC NAMES OF ROCK ANALYSES.

I. Comendite (Orthophyne) *Loc.:* Mt. Conowrin, Glass House Mts.	II. Comendite (orthophyric) Mt. Coolum, Yandina.	III. Pantellarite (orthophyric) Ngun-Ngun, Glass House Mts.	IV. Pantellarite (orthophyric and ægirine bearing). Trachyte Range, Glass House Mts.	V. Trachyte (trachytic) Mt. Beerwah, Glass House Mts.	VI. Monzonite (Quartz Diorite) Mt. Cooroy.
Q. 34·74 Or. 29·47 Alb. 25·15 Sod. 4·85 ... .. Diop. ·68 Hyp. ·99 Acm. ·46 Fluor. ·08 Ilm. ·15 Mag. 2·55 Zircon ·37 Pyr. ·18 &c. ·33	Q. 31·80 Or. 23 91 Alb. 38·78 Acm. 1·39 Diop. ·216 Hyp. ·232 Hem. ·80 Ilm. ·456 Mag. 1·856 &c. ·47	Q. 31·68 Or. 30·58 Alb. 29·34 An. 1·11 Cor. ·51 ... Hyp. 1·72 Hem. 3·21 Ilm. ·61 Mag. 1·39	Q. 25·08 Or. 29·47 Alb. 33·54 ... Diop. 1·08 Acm. 6·93 Hem. 1·60 Hyp. ·30 Ilm. ·46 Mag. ·93 &c. ·73	Q. 2·76 Or. 36·696 Alb. 53·972 An. ·834 Diop. ·464 Hyp. ·400 Hem. ·640 Mag. 2·784 Pyr. ·120 Ilm. ·152 Cal. ·200 Zirc. ·326 Extra ·52	Q. 11·820 Or. 27·244 Alb. 37·728 An. 5·560 ... Diop. 5·568 Hyp. 2·816 Ap. 1·240 Mag. 5·104 Ilm. 2·532 &c. ·630
100·00	99·90	100·12	100·10	99·90	100·24
Persalic					
CLASS Persalane...	Persalane	Persalane	Persalane	Persalane	Dosalone
ORDER Columbare	Brittanare	Brittanare	Brittanare	Canadare	Austrare
RANG. Alaskase ...	Liparase	Liparase	Liparase	Nordmarkase	Dacase
SUBRANG. Alaskose	Kallerudose	Liparose	Liparose	Phlegrose bordering on Nordmarkose	Adamellose

CALCULATED NORMS AND MAGNETIC NAMES OF ROCK ANALYSES.

VII. Porphyrite Pt. Arkwright.	VIII. Qtz. Diorite Noosa Head.	IX. Dacite Bankfoot House, Glass House Mts.	X. Andesite Eumundi.	XI. Basalt Yandina.	XII. Glaucophane Schist. Mt. Mee.
Q. 7·20 Or. 16·124 Alb. 41·396 An. 18·626 ... Diop. ·896 Hyp. 8·208 Ap. ·910 Mag. 3·712 Ilm. 1·216 Calcite 1·600 Pyr. 1·08 &c. 1·49	Q. 8·82 Or. 10·00 Alb. 31·96 An. 32·80 Cor. 1·12 Hyp. 12·35 Ilm. 1·67 Pyr. ·20 Cal. ·20 &c. 1·05	Q. 16·560 Or. 16·680 Al. 30·392 An. 19·738 Cor. ·510 Hyp. 8·780 Mag. 4·176 Ilm. 1·520 Pyr. ·120	Q. 14·04 Or. 15·57 Alb. 27·77 An. 19·46 ... Hyp. 4·50 Mag. 3·25 Ilm. 3·04 Carb. 10·00 &c. 1·72 S. (Pyr.) ·24	Or. 7·128 Alb. 29·344 An. 15·568 Diop. 18·662 Hyp. 14·224 Oliv. 1·592 Mag. 7·424 Ilm. 4 408 Cal. ·700 Ap. 1·240 &c. 1·84	Q. 12·420 Or. 1·668 Hyp. 9·512 Glauc. 25 988 Epidote 43·646 Titanite 1·360 Pyr. ·360 Hem. 4·320 Extra ·56
102·46	100·18	100·076	99·59	102·13	99·834
Dosalone Germanare Andase Andose	Dosalone Germanare Andase Andose	Dosalone Austrare Tonalase Tonalose	Dosalone originally Germanare Shoshonose, but through Ca, Mg, &Fe, going into carbonates, liberating SiO_2, "Harzose." In order, Austrare.	Salfemane Gallare Auvergnase Auvergnose	Quartz Glauc Sch. Altered from igneous rock. Q. 9·720 Or. 1·668 Al. 22·008 An. 20·294 Di. 24·444 Hy. 2·500 Hem. 9·760 Mag. 6·032 Ilm. 1·520 Pyr. ·360 &c. 1·230 99·53 = Salfemane Order 2 Dolcalcic Presodic

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* Nicols uncrossed.

† Nicols crossed.

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* Nicols uncrossed.
† Nicols crossed.

NOTES AND EXHIBITS.

Mr. D. G. Stead exhibited an example of each of the following species of fishes, all of which are now recorded for the first time from the waters of New South Wales :—*Terapon jarbua* Forsk., from Lake Macquarie, *Caranx (Alectis) gallus* Linn., from Clarence River, and *Genypterus blacodes* Günth., (? = *G. australis* Cast.), from Jervis Bay. Mr. Stead also recorded (as forming an addition to the fauna) the occurrence of *Elagatis bipinnulatus* Quoy & Gaim., on the coast; a fine example measuring 700 mm. had been captured recently off North Head, Port Jackson, and was now in the possession of the New South Wales Board of Fisheries. *E. bipinnulatus* does not appear to have been previously recorded from any portion of the Australian coast.

Mr. Froggatt exhibited living larvæ of the African "Bont Tick" (*Amblyomma hebræum* Koch). The larvæ had just hatched out from a mass of eggs deposited in a tube by a large female tick brought into the office by a gentleman who had received it from a friend at the Cape. He was carrying it about in his pocket in a match box, and might easily have been primarily responsible for the infection of the State with this very serious pest. The Dutch word "bont" means variegated.

Mr. Froggatt also showed a collection of mounted Australian fleas, including examples of the house flea, *Pulex irritans*; the dog flea, *Pulex serraticeps*; the rat flea, *Pulex fasciatus*; the Native Cat and Bandicoot flea, *Stephanocircus dasyuri*; and the Echidna flea, *Echidnophaga ambulans*. The larvæ of several species were also shown, those of the Native Cat having been taken from the marsupial pouch. It is probable that the species infesting marsupials often breed in the pouches of the infested animals.

Mr. Froggatt also called attention to a remarkable statement reported in the last issue of the "Queenslander" (April 21st), from Winton, Q., to the effect that—"Reports received from outside [inland] concur in affirming the terrible mortality caused by sand-flies among marsupials, the latter having entirely disappeared from large areas of country. Scores of carcases have been counted, while other marsupials have been blinded, and are being shot by scalpers at very short range." The extraordinary abundance of the sand-flies would appear to be attributable to very favourable conditions following upon phenomenal rains and floods.

Mr. C. A. Süssmilch exhibited some specimens of *Eurydesma cordata* Morris, obtained from Belford in the Hunter River District. Previously this fossil bivalve mollusc was known to occur only in the Lower Marine Beds (the lowest subdivision of the Permo-Carboniferous System), and has been looked upon as the type fossil for those beds. The main strata at Belford from which these specimens were obtained have been mapped by Professor David as belonging to the Upper Marine Beds. *Eurydesma cordata* would, therefore, appear to have a wider geological range than previously supposed, and no longer can be considered as typical of the Lower Marine Series only.

Mr. T. G. Taylor exhibited a specimen of ægyrine trachyte (Soda-Trachyte Series) obtained by him at Rossival, near Goulburn. The specimen was of interest as a new southern representative of the series.

Mr. F. E. Grant exhibited a collection of Queensland Crustacea in illustration of the paper contributed by Mr. A. R. McCulloch and himself at the last Meeting of the Society.

Dr. Greig-Smith showed a colony of an undetermined bacterium growing upon a plate of saccharose-bean-agar. It had spread out over the dry agar surface in successive small crescentic ridges, simulating the appearance of the plumage of certain birds.

WEDNESDAY, MAY 30TH, 1906.

The Ordinary Monthly Meeting of the Society was held in the Linnean Hall, Ithaca Road, Elizabeth Bay, on Wednesday evening, May 30th, 1906.

Mr. Thos. Steel, F.C.S , F.L.S., President, in the Chair.

The Donations and Exchanges received since the previous Monthly Meeting, amounting to 28 Vols., 91 Parts or Nos., 68 Bulletins, 6 Report, 8 Pamphlets, and 6 Miscellanea, received from 65 Societies, &c., and 2 Individuals, were laid upon the table.

[Printed off June 25th, 1906.]

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NEW AUSTRALIAN SPECIES OF THE FAMILY *AGRIONIDÆ* [NEUROPTERA : *Odonata*].

BY R. J. TILLYARD, B.A.

(Plate xvii.)

In this paper eleven species are added to the list of Australian *Agrionidæ*, bringing the total number recorded from 28 up to 39. Of these, ten are new to science; the eleventh has only been recorded before from tropical Africa, where it is common. All the new species come from North Queensland. Two genera, *Alloneura* and *Ceriagrion*, are added to the Australian list; and one species, placed provisionally in the genus *Ischnura*, will probably form the type of a new genus. Of the new species, two each belong to *Lestes*, *Alloneura*, *Pseudagrion* and *Agriocnemis*, and one each to *Argiolestes*, *Ischnura* (?) and *Ceriagrion*.

All these species were taken by myself during a trip to Northern Queensland in the summer of 1904-5. One or two were met with in abundance, and it is remarkable that they have not been recorded before. Most of the species are, however, exceedingly rare or local, and were only obtained after ceaseless exploration of the same districts for days. The females of two of them are yet to be discovered.

I am greatly indebted to M. René Martin of Le Blanc, France, for his kind aid and advice in identifying many of these species as new; for it will be understood that only one who has a world-wide knowledge of the *Odonata*, and especially of Polynesian species, could with safety be relied upon to determine new tropical species and to fix their affinities.

All the descriptions given were made either from the living insects, or from insects freshly killed, as this is the only possible way of recording the true colours of our *Odonata*.

1. Argiolestes aureus, n.sp.

♂. Total length, 39 mm.; abdomen, 31 mm; wings, 24 mm.

Wings.—Rather broad, rounded at tips; *neuration* black; *pterostigma* broad, rhomboidal, black, 1 mm. *Nodal Indicator* | 2 17-18 | 2 17-18 |

Head.—*Epicranium** orange, a black transverse band between the eyes, enclosing the antennæ and the ocellar area, which are black. *Clypeus* and *labrum* orange. *Labium* and *mandibles* deep black.

Thorax.—*Prothorax* black; on either side a large orange spot followed by two tiny elongated marks, one below and the other behind it, of the same colour. *Meso-* and *metathorax* bright orange above and on sides; interalar space deep black; scuta, scutellæ, and wing-joins touched with orange; this black colouration extends in front of the fore wing joins and forwards along the dorsal ridge, narrowing down almost to a point, thus forming a black spear-head mark cleaving the rich orange of the thorax in two. On either side, near the mesocoxa is a large squarish black patch; there is also a small black spot just below the hind wing-joins. *Underside* marked with black and dull yellowish-brown. *Legs* black, spiny.

Abdomen thin, cylindrical, 9-10 slightly enlarged. Colour metallic black throughout, 2-3 with a basal spot of orange-brown on either side, close up to suture.

Appendages.—*Superior* 1·5 mm., large, black, furcate, slightly separated at bases, tips touching *Inferior* minute. (See Plate xvii., fig. 1*a*).

♀. Considerably larger than ♂. The two specimens measured differed in size as follows:—Total length, *a* 37 mm., *b* 41 mm.; abdomen, *a* 28·5 mm., *b* 32 mm.; wings, *a* 27 mm., *b* 29 mm.

Wings as in ♂.

---

* The term "epicranium" as applied to the *Agrionidæ*, includes the occiput, vertex and ocellar area, and the front.

Head.—Black epicranial band much thicker; sutures of *clypeus* black; *labrum* jet black.

Thorax marked with dark orange-brown, the black intersecting markings more extensive.

Abdomen cylindrical, stouter than in ♂; shining bronzy-black; 2-5 with small brown basal spots. Laterally 8-10 appear much enlarged, 8 ending below in an enormous brownish curved spike over 2 mm. long; 9 carries a thick black spike with its point curving upwards and carrying near the tip two short black filaments, each ending in a minute hair pointing downwards. (See Plate xvii., fig. 1*b*).

Appendages short, pointed, wide apart, black.

Hab.—Kuranda, N.Q.; December, 1904; very rare.

Only three specimens of this species have been taken, one male and two females. They were found flying about the thickly wooded banks of one of the jungle creeks, very far from any settlement. Their flight is weak and they are fond of clinging to twigs, like *Synlestes weyersi;* or settling on rocks with outspread wings, like *Argiolestes icteromelas.* This latter habit is contrary to the general habit of all other *Agrionidæ*, which rest with folded wings. This species has all its wings of the same length, and very blunt and rounded at the tips, giving it a somewhat peculiar appearance. It is easily distinguished from the other two Australian species of the genus by its brilliant orange thorax.

2. Lestes tenuissimus, n.sp.

♂. Total length, 47 mm.; abdomen, 38 mm.; wings, fore 24 mm., hind 23 mm.

Wings.—*Neuration* black; *pterostigma* 1·3 mm., fairly broad, black. *Nodal Indicator*

2	11-13
2	11-12

Head.—*Epicranium* dull fuscous, shading to dull greyish-blue near the eyes; *ocelli* black; *antennæ* long, 2·5 mm., black, basal joint thickened; *postclypeus* dull fuscous; *anteclypeus* very pale greenish-blue; *labrum* pale greenish-blue; *labium* and *mandibles* pale dirty brownish, mouth edged with black.

Thorax.—*Prothorax* very dull fuscous, a bluish spot on each side. *Meso-* and *metathorax* dull bluish-grey above, a broad band of olive-brown covering the dorsal ridge and extending well on to the shoulders and carrying a central projecting spot on each side on either side a narrower dull brown subhumeral band, with a brown spot below it, two elongate triangular black spots pointed towards the wing-joins, and a black mark close to the wing-joins, at the base of the suture. Ground colour of the lateral surface of the mesothorax greyish-blue, of the metathorax, pale greenish-blue. *Underside* very pale dirty brown, a pair of black oval spots close to abdomen. *Legs* dirty brownish.

Abdomen extremely long and thin; 1-2 very slightly thickened, 3-7 very thin, 8-10 slightly thicker. Very dull olive-brown marked with grey, as follows:—1, a large lateral spot on each side, and an elongate transverse anal mark; 2, shaded with bluish-grey on sides and near sutures; 3-9, a narrow transverse basal band next suture; 10, bluish-grey. *Underside* pale grey shaded with dull black near sutures.

Appendages.—*Superior* 1·5 mm., black, forcipate, wide apart at bases, meeting and sometimes crossing near tips, which are straight and pointed. From the inner side of each two small spines project (see Plate xvii., fig.2*a*). *Inferior* very short, thick, blunt, black tipped with dirty brown.

♀. Total length, 42 mm.; abdomen, 34 mm.; wings, fore 25 mm., hind 24 mm.; differs from the ♂ as follows:—

Head.—Paler, basal joint of *antennæ* brown; *clypeus* brown; *labrum* dull olive-green.

Thorax as in ♂.

Abdomen stouter than in ♂; 1-9 cylindrical, 10 swollen, 9 projecting anally underneath, the projection carrying on its upper end two small hooks; 10 short. Colour: 1-9 dark brown, shiny, anal end of each segment darker, a pale thin transverse basal band close up to each suture; 1 and 2 marked with pale greyish-blue as in ♂; 10 pale greyish-blue with a narrow transverse basal black band.

Appendages 0·6 mm., wide apart, straight, parallel, pointed; dull fuscous. (See Plate xvii., fig.2*b*).

Hab.—Redlynch, near Cairns, N.Q. January, 1905. Local. Several pairs of this species were captured round a small isolated water-hole. They appeared to cling closely to the overhanging branches round the sides of the water-hole, and only flew off a few yards when disturbed; others were sitting singly or in pairs on the trunks of the guava trees. This was on a bright sunshiny day, so that this species appears to be a dull, listless insect. I have also received one ♂ from Mackay, N.Q. It is easily distinguished from all other Australian species of *Lestes* by its extremely long abdomen. It appears to have no special affinity with any of the common southern species, but comes nearest to *L. analis.*

3. Lestes paludosus, n.sp.

♂. Total length, 37 mm.; abdomen, 30 mm.; wings, fore 19 mm., hind 18 mm.

Wings.—Lightly suffused with brown; *pterostigma* 1·5 mm., very dark brown. *Nodal Indicator*

2	10-11
2	10-11

Head.—*Epicranium* black; *antennæ* black; *postclypeus* black; *anteclypeus* and *labrum* dirty yellowish-brown; *labium* and *mandibles* very pale dirty brownish.

Thorax.—Fuscous above, with an indistinct paler stripe on each side of the dorsal ridge, slightly metallic in the dried specimen; sides olive-brown shading to pale greyish below. *Legs* dirty brownish.

Abdomen almost cylindrical, 1-2 and 8-10 very slightly thickened. Colour: dark fuscous above shading to pale bluish-grey on sides, duller underneath, paler next the sutures.

Appendages.—*Superior* 1 mm., apart at bases, forcipate, crossing at tips. Several minute spines along the outer ridge; basal half lobed internally, tips much narrower and bent inwards almost at right angles. Black (see Plate xvii., fig.3*a*). *Inferior* separated, very small and blunt; black.

♀. Slightly larger than ♂; wings, fore 20·5 mm., hind 19·5 mm.; differs from ♂ as follows :—

Head.—*Anteclypeus* and *labrum* dull olive-brown.

Abdomen slightly thicker; very cylindrical; 9 enlarged below into a blunt projection.

Appendages short, straight, wide apart at bases, parallel, tips slightly pointed; black. (See Plate xvii., fig. 3*b*).

Hab.—Townsville, N.Q. January, 1905. Very rare.

A single pair of this species was taken by me on the lagoons near the town. It is an extremely dull and uninteresting-looking insect. It is remarkable that this and the preceding species, both of which come from the tropics, should be so lacking in those beautiful blue or metallic green colourations which mark the species of this genus in temperate climates. The present species is easily separated from the preceding by its smaller size and typical *Lestes* shape. It could not possibly be confused with any other Australian member of the genus; in shape it resembles *L. psyche*, but it lacks the beautiful colouring of that species.

A third species of this genus, of which I have received a pair from Mr. F. P. Dodd of Kuranda, N.Q., is probably new to science. They were forwarded to M. René Martin, who is of this opinion; but as the colouration is totally obliterated I have deferred giving a description of this species until I can obtain living specimens, as it is evidently very closely allied to two or three of our southern forms. It is similar to *L. leda* in general appearance, and may be a smaller tropical form of that insect.

4. Alloneura solitaris, n.sp.

♂. Total length, 33-35 mm.; abdomen, 26-28 mm.; wings, fore 18 mm., hind 17·5 mm.

Wings beautifully suffused all over with lemon-yellow; *pterostigma* 0·8 mm., rhomboidal, black. *Nodal Indicator* ‖ 2 12-14 / 2 11-12.

Head.—*Epicranium* jet black, with a narrow transverse band, cream-coloured or light green, between the eyes in front. This band is *not* enlarged where it meets the eyes. *Eyes* black above, paler underneath. *Clypeus* and *labrum* jet black. *Labium* and *mandibles* pale dirty brownish.

Thorax.—*Prothorax* black. *Meso-* and *metathorax* black above, on either side a short narrow bright green humeral ray and two irregular greenish lateral bands separated by a band of black. *Underside* pale dirty brown. *Legs* dull black; coxæ and underside of metafemora pale dirty brown.

Abdomen excessively slender, cylindrical, 1-2 and 8-10 very slightly enlarged. Colour : jet black, marked as follows :— 1, a dull greenish spot on each side; 2, a dull greenish line on each side of the genital appendages; 3, a basal dorsal spot, very small, pea-green, in shape like an inverted trefoil; 4-7, a basal dorsal pea-green spot cleft by the intrusion of the black dorsal ridge; in 5 this spot is about one-third the length of the segment, in 4, 6, 7 it is much smaller; 8, basal half bright green, cleft like the spot in 5, but more widely, the green extending downwards on to the sides of the segment; 9-10 black. *Underside* dull black. The size and colour of these abdominal markings vary greatly in different specimens.

Appendages.—*Superior* very short, black, subconical, separated, pointed downwards. *Inferior* consisting of a pair of minute black hooks, recurved upwards, close together. (See Plate xvii,, fig. 4*a*).

♀. Very similar to ♂. *Abdomen* thicker and more cylindrical; no spot on 8; 10 carries two small hooks below. Colour of epicranial and thoracic bands pale brownish. *Wings* hyaline. *Appendages* very small, black. (See Plate xvii., fig. 4*b*).

The colouring of the markings in the ♂ varies much in different specimens, being sometimes a delicate cream colour, sometimes pale yellow, rarely bluish, but most commonly a delicate pea-green. Specimens also occur in which the rich yellow colouring of the wings is not complete, and sometimes entirely absent. The colouring possibly varies with the age of the insect.

Hab. — Kuranda and Cairns districts, N.Q. December-January. Local.

This remarkable insect is most difficult to capture. It occurs amongst the reeds that fringe the creeks here and there in the dense scrub. As it darts in and out in the most bewildering way it is almost invisible to the eye, owing to the extreme thinness of its abdomen. It is not gregarious, but generally occurs singly or in pairs, and is very sparingly distributed. On nearly every day on which I went collecting I secured one specimen, but only twice did I get a pair, and once a male and two females in one day. This fact suggested the name *solitaris*. It generally frequents the same localities as *Nososticta solida*, a much commoner insect.

This species is the first of the genus to be recorded for Australia. It is essentially a tropical and oceanic genus, all the known species inhabiting Polynesia. The present species is closely allied to *A. salomonis* Selys, from the Solomon Islands.

5. Alloneura coelestina, n.sp.

♂. Total length, 37 mm.; abdomen, 30 mm.; wings, fore 21 mm., hind 19 mm.

Wings beautifully suffused with lemon-yellow all over (more rarely with yellowish-brown). *Pterostigma* 1 mm., black. *Nodal Indicator* ‖2 13-15|
‖2 13 |

Head.—*Epicranium* jet black with a beautiful broad greenish-blue transverse band extending from eye to eye in front, and *enlarged* downwards on each side where it meets the eye. *Clypeus* black, hairy. *Labrum* black. *Labium* and *mandibles* pale dirty brownish.

Thorax.—*Prothorax* black with two greenish-blue spots on either side. *Meso-* and *metathorax* black above, with a pair of beautiful broad olive-green humeral stripes of an elongated oval shape, widest in front; sides with two bright bluish-green stripes separated by a narrow band of black. *Underside* pale dirty grey. *Legs* black; coxæ pale dirty brownish.

Abdomen very thin; 8 cylindrical, 1-2 slightly enlarged, 7-10 increasing gradually in width, but very slightly. Colour black, marked as follows:—1, a blue spot on each side; 2, a greenish-blue elongated spot low down on each side near the genital appendages; 3-8, a small basal dorsal spot of bright blue-green next to suture; 8, an elongated greenish mark low down on each side; 9-10, black.

Appendages.—*Superior* very short, subconical, slightly separated, *bright blue*. *Inferior* minute, bluntly hooked and turned upwards, black. (See Plate xvii., fig.5*a*).

♀. Total length, 35 mm.; bdomen, 29 mm.

Wings suffused with yellowish-brown, except at bases and tips. *Pterostigma* 1·1 mm., black. *Nodal Indicator* $\left\| \begin{matrix} 2 & 13 \\ 2 & 12 \end{matrix} \right|$

Head as in ♂, except epicranial band, which is light yellowish-brown.

Thorax.—Dorsal marks and lateral bands pale brownish.

Abdomen cylindrical, stouter than in ♂; black, sutures marked with dull white; 9 carries underneath a projection reaching beyond the end of the abdomen, the point curving upwards and carrying two fine hooks. (See Plate xvii., fig.5*b*).

Appendages very short, cylindrical, wide apart, tips blunt; black.

Hab.—Redlynch, near Cairns, N.Q. January, 1905. Very rare.

One male and two females were taken close together amongst reeds on the banks of a swift creek in the guava scrub. Habits and flight similar to those of the preceding species.

This species is very closely allied to the preceding, but the following points will at once distinguish the two species clearly:—

A. solitaris.	*A. coelestina.*
1. The transverse epicranial band is narrow, and *is not enlarged* on reaching the eyes.	1. The transverse epicranial band is broader, and *is enlarged* on reaching the eyes.
2. Superior appendages of ♂ *black*.	2. Superior appendages of ♂ *pale sky-blue*.

Besides this, *A. coelistina* is distinctly the larger insect of the two I have named it *coelistina* because of the remarkable colour of the appendages.

6. ISCHNURA FRAGILIS, n.sp

♂. Total length, 27-28 mm.; abdomen, 22-23 mm.; wings, fore 15 mm.; hind 14 mm.

W i n g s.—Very delicate, rather narrow. *Pterostigma* 0·4 mm., rhomboidal, dull olive-brown. *Nodal Indicator* ‖ 2 9-10 / 2 8

H e a d small. *Epicranium* black, carrying behind a narrow bright blue transverse band, enlarged on meeting the eyes. *Eyes* black above, green beneath. *Ocelli* bronze. *Antennæ* black, basal joint thickened. *Postclypeus* green; *anteclypeus* dull bluish, a black band along the clypeal suture. *Labrum* dull bluish. *Labium* and *mandibles* pale dirty brown, tipped with black.

T h o r a x narrow. *Prothorax* black, with very narrow blue collar. *Meso-* and *metathorax* black above, with a pair of thin blue humeral stripes; sides blue. *Scuta* and *scutella* bluish. *Underside* greyish. *Legs* grey.

A b d o m e n slender; 1-2 slightly enlarged, 3-6 very slender, 7-10 slightly enlarged. Colour: 1-8, black with narrow transverse white lines along the sutures; 2, marked with bluish-grey on the sides; 7, partly blue on the sides; 9, bright blue; 10, black above, blue on the sides. *Underside*, 1-6, half of 7, and 10, pale greenish; rest blue.

A p p e n d a g e s.—*Superior* wide apart, very short, rather blunt, slightly divergent, black. *Inferior* minute (See Plate xvii., fig.6*a*).

♀. A slightly larger insect. Total length, 30 mm; abdomen, 25 mm.; wings, fore 17 mm., hind 16 mm.

It differs from the ♂ as follows:—

H e a d.—The blue band at the back of the epicranium wider, but duller. *Postclypeus* deep olive-green; *anteclypeus* and *labrum* pale greenish.

T h o r a x.—Humeral stripes dark green.

A b d o m e n thicker than in ♂, more cylindrical, deep bronze; 1-2 with blue on the sides; sutures of 1-7 banded with white; 8, bronze with very narrow transverse anal and basal blue bands, sides blue; 9, blue with a large bronze basal spot; 10, blue; 9 projects below beyond 10 and ends in a sharp point; 8 also carries a small spine underneath. (See Plate xvii., fig.6*b*).

A p p e n d a g e s wide apart, very minute, slightly pointed.

H a b.—Atherton, N.Q. January, 1905. Rare.

It flits close to the surface of the water amongst the reeds and water plants that fringe the large lagoons and swamps. I found it on the Carrington Swamp in company with *Ischnura delicata*, *Pseudagrion cyane*, *Agriocnemis splendida*, and *A. velaris*, though by no means so commonly as these species. Its small size and swaying flight, about an inch or two above the surface of the water, make it difficult to detect and capture M. René Martin, to whom I forwarded specimens, says of this species :—" Brauer a nommé, du Queensland, sans description, trois espèces, *Ischnura distigina*, *I. cingillum*, *I. æruginosum*. Peut être celli-ci en est une, mais elle n'a pas tous les caractères de *Ischnura*. Je la considère comme une espèce nouvelle à nommer par vous." In this connection it may be remarked that the present species differs from other members of the genus *Ischnura* in the following important points :—(1) small head, narrow thorax, and slender wings not very rounded at tips; (2) it lacks the postocular spots. The typical characters of the genus as exhibited by *I. delicata* or *I. heterosticta* are (1) rather broad head and thorax, rather robust form, wings not remarkably slender, and well-rounded at tips; (2) brilliant postocular spots. In other respects, notably in having the 10th segment of the abdomen in the ♂ turned up anally, and in carrying a small spine under the 8th segment in the ♀, it falls naturally into this genus, and into no other. I have placed it in the genus provisionally, prior to making a more complete study of the differences exhibited.

7. Pseudagrion ignifer, n sp.

♂. Total length, 42 mm.; abdomen, 35 mm.; wings, fore, 25 mm., hind 23·5 mm.

W i n g s generally hyaline, but sometimes tinged with brown, especially towards the pterostigma. *Pterostigma* 0·7 mm., rhomboidal, brown. *Nodal Indicator* ‖2 15| / ‖2 13| The last postnodal of all the wings *not* continuous.

H e a d.—*Epicranium* black behind, front brilliant rust-colour, crossed by a short black transverse line in the middle, and bordered below, next the clypeus, by a second black line. *Eyes* black; *ocelli* placed so that the front ocellus is just on the edge of the rust-colour. *Antennæ* black, basal joints brown. *Clypeus* and *labrum* brilliant rust-colour. *Labium* and *mandibles* pale dirty brownish. *Mouth* edged with black.

T h o r a x.—*Prothorax* black, with a bluish-brown on the sides. *Meso-* and *metathorax* black, with a pair of brown humeral stripes; the sides and underside of mature specimens covered with a bluish-grey bloom. *Scuta* and *scutella* covered with bluish bloom. *Legs* black.

A b d o m e n thin, cylindrical; 1-2 and 8-10 slightly thickened. Colour, black; 1, and sometimes also 8, covered with bluish bloom. *Underside* dull grey or blackish.

A p p e n d a g e s.—*Superior* 0·5 mm., very short and blunt, divergent, black with a brownish central spot above. *Inferior* 0·2 mm , rough, separate, very blunt, brownish. (See Plate xvii., fig. 7*a*).

♀. Total length, 44 mm.; abdomen, 36 mm.; wings, fore 27·5 mm., hind 26 mm.

W i n g s.—*Pterostigma* 0·9 mm., larger and paler than in ♂. *Nodal Indicator* ‖2 14| / ‖2 12| Last postnodal as in ♂.

H e a d —*Epicranium* brown, a small black slanting ray reaching from each of the back ocelli to the eye, a short black central line in front of the front ocellus. *Eyes* black, with a dull brown patch behind inwards. *Antennæ* as in ♂. *Clypeus* and *labrum* brown. *Labium* and *mandibles* as in ♂.

Thorax.—*Prothorax* black, spotted with brown. *Meso-* and *metathorax* deep black, with a thin brown dorsal ray on the ridge, broadest at base, and on either side a broader humeral ray of a beautiful deep brown, followed by a sublateral brown band cut by a black line about 2·5 mm. long from the fore wing-joins; a black point near the hind wing-joins. *Underside* greyish. *Legs* dirty brown.

Abdomen cylindrical, thicker than in ♂, 8-10 swollen below; 9 carrying underneath a brownish projection ending in two small filaments. Colour: black, with metallic green reflections, sutures greyish or brownish. *Underside* dull brown or black. (See Plate xvii., fig.7*b*).

Appendages very short, separate, bluntly pointed, black.

Hab.—Kuranda, Atherton, Cairns, N.Q. December-February. Common at Kuranda.

It is found on all the running streams, generally amongst reeds; does not frequent marshes or still water.

This fine insect, although common, has not been recorded before. It is closely allied to *P. pruinosum* Burm., from which it differs both in colouration and in its appendages. The latter species is found in Java. Amongst our Australian members of the genus the present species must take rank in size and beauty next to *P. Billinghursti* Martin, a beautiful Victorian species somewhat larger than this one. Our other species of this genus are much smaller insects.

8. Pseudagrion aureofrons, n.sp.

♂. Total length, 34 mm.; abdomen, 28 mm.; wings, fore 19 mm., hind 18 mm.

Wings.—*Pterostigma* 0·8 mm., trapezoidal, pale olive-brown.

Nodal Indicator		
	2	11-12
	2	9

Head.—*Epicranium* black behind, with a transverse olive-green ray reaching on to the eyes, where it is enlarged into a round spot; front, near the postclypeus, golden-yellow. *Eyes* black behind, greenish on sides, bright golden-yellow in front; *ocelli* black, a small yellow spot between the front and each of the hind ones. *Antennæ* black, basal joint somewhat clubbed. *Clypeus* and *labrum* brilliant golden-yellow. *Labium* and *mandibles* dull greyish; *mouth* edged with black.

Thorax.—*Prothorax* black, spotted with olive-green. *Meso-* and *metathorax* brilliant golden-yellow above, with a black collar next the prothorax, a black ray along the dorsal ridge, and, on either side, a black humeral ray bordering the yellow. Sides deep blue, shading to greenish above. *Underside* greyish. *Legs* greyish, upper side of femora black.

Abdomen very slender, 1-2 and 8-10 very slightly enlarged. Colour: 1-2 blue, 2 with a black anal spot; suture between 2 and 3 black; 3-7 black, with metallic bronze reflections, a basal transverse greenish band next to the sutures. Sides of 3-5 blue, with an anal black spot extending downwards from the dorsal region; 6-7 black on the sides; 8-10 deep blue, sutures black; 10 with a black dorsal spot.

Appendages.—*Superior* 0·4 mm., divergent, wide apart at bases, straight, pointed, black. *Inferior* very short, bluish-grey. (See Plate xvii., fig. 8*a*).

♀. Unknown.

Hab.—Atherton, N.Q. January, 1905. Very rare.

Four males were taken flying up and down the creek at Atherton, over slowly-running rocky pools. It flies close to the water in a zig zag direction, often crossing from side to side or turning quite round in a semicircle. It is fond of settling, like *Pseudagrion cyane*, on floating leaves of water plants. Until the ♀ of this species can be found some doubt must always exist as to whether it is a true *Pseudagrion* or not, the genus being defined by the absence of the small spine on the underside of segment 8 of the ♀. The ♂ appears to be closely related to that of *P. rubriceps* Selys, a Javan insect. The remarkably vivid colouring of this insect is unparalleled amongst Australian *Agrionidæ*. As it skims along over the pools the incongruity of its colouring strikes one almost as ludicrous, the brilliant golden-yellow, followed by an almost equally brilliant blue, refusing to harmonise, and producing the same effect on the eye as in the case of some brilliantly-coloured tropical bird.

9. Ceriagrion glabrum Burm.

This is a common species in tropical Africa. M. René Martin informs me that Baron de Selys-Longchamps, received specimens of this insect labelled "Queensland," but that he considered some error had been made. It is, at any rate, a remarkable fact that this species should exist in two so widely separated localities. In Australia I took it first at Brisbane, and have since received it from Mackay and Cairns. It is probably exceedingly local, but not uncommon where it occurs. It inhabits the reedy parts of still lagoons and waterholes, and is found climbing up the stalks of the reeds.

This species is about 40 mm. long, head and thorax dull brown, very smooth; abdomen of ♂ a beautiful reddish-pink throughout, appendages short and blunt; abdomen of ♀ brownish.

10. Agriocnemis pruinescens, n.sp.

♂. Total length, 32 mm.; abdomen, 25 mm.; wings, fore 16 mm., hind 15 mm.

W i n g s.—*Pterostigma* very small, rhomboidal, pale transparent brownish, except at the inner inferior angle, which is black. *Nodal Indicator* ‖2 8 | ‖2 6-7| Last postnodal of forewings, and sometimes also of hindwings, not continuous.

H e a d.—*Epicranium* black. *Eyes* black above, a dull grey mark behind, green below; *antennæ* black; *ocelli* brownish. *Postclypeus* narrow, black; *anteclypeus* very narrow, greenish, edged with black. *Labrum* greenish-blue. *Labium* and *mandibles* pale dirty brown.

T h o r a x.—*Prothorax* black, shaded with dark grey. *Meso-* and *metathorax* deep black, slightly metallic, a little bluish-grey bloom low down on the sides. *Underside* covered with bluish-grey bloom. *Legs* dull black, underside of femora greyish.

Abdomen cylindrical, 1-2 and 8-10 slightly enlarged. Colour: 1-2 dull black, bluish-grey bloom on the sides of 1 and at base of 2, genital appendages of 2 rather large; 3-7 deep metallic olive-green; 8 steel-coloured; 9 bluish-grey, with a very thin transverse black basal ring; 10 black.

Appendages.—*Superior* very small, touching at tips, pointed, black. *Inferior* minute. (See Plate xvii., fig.9*a*).

♀. Unknown.

Hab.—Redlynch and Cairns, N.Q; Townsville (1♂). January, 1905. Rare.

I took three males of this insignificant-looking insect flying over billabongs of still water or along the edges of stagnant lagoons. M. René Martin remarks that Selys has described a species, *A. australis*, from a ♀ only, and that this might possibly be the ♂ of that species, though the superior size of the present species leads him to regard this as new to science. I know of no Agrionid in which the ♂ is considerably larger than the ♀, and have no doubt that Selys' ♀ is distinct.

11. Agriocnemis argentea, n.sp.

♂. Total length, 21-24 mm.; abdomen, 16-19 mm.; wings, fore 10-11 mm., hind 9-10 mm.

Wings.—*Pterostigma* 0·5 mm., rhomboidal, brown or black. *Nodal Indicator* $\left|\begin{matrix}2 & 7\\ 2 & 5\end{matrix}\right|$ Last postnodal of forewings not continuous.

Head.—*Epicranium* deep black behind, silvery white in front. *Eyes* brown above, green beneath, a green post-ocular spot on each. *Ocelli* and *antennæ* black. *Clypeus* dull white. *Labrum* black. *Labium* and *mandibles* pale dirty brownish.

Thorax.—*Prothorax* black, dusted with chalky white. *Meso-* and *metathorax* silvery white, with a broad black dorsal band, and on each side a narrower black band. *Underside* whitish. *Legs* pale brown, femora dull white.

Abdomen very thin; cylindrical. Colour: the true ground colour is a dull black, but this is completely covered in mature specimens by a beautiful silvery white bloom, which can be rubbed off with the fingers. *Underside* dirty grey; 10 brownish.

Appendages — *Superior* very small, separated at bases, slightly divergent, cylindrical, tips blunt; colour reddish-brown. *Inferior* minute. (See Plate xviii., fig. 10*a*).

♀. Slightly larger than ♂, abdomen not quite so long.

Wings as in ♂. but larger. *Nodal Indicator* | 2 7 / 2 7 | Last postnodal of all four wings not continuous.

Head.—*Epicranium* and *clypeus* black. *Labrum* dark brown; rest as in ♂.

Thorax —*Prothorax* black. *Meso-* and *metathorax* black above, sides dull green. *Underside* dirty grey.

Abdomen cylindrical, thicker than in ♂. Colour: dirty black; 9, projecting below and ending in a small spike, pale brown, tipped with black.

Appendages separated, very short, black, somewhat pointed; just below them is a small pale brown tubercle, on segment 10. (See Plate xvii., fig. 10*b*).

Hab.—Kuranda, N.Q. January, 1905. Fairly common.

This pretty little species inhabits the banks of small running creeks, and is also often found in grassy places some distance from water. It flies with its body dangling almost vertically downwards, and has a pendulum-like motion, swaying from side to side. When flying its wings are invisible, and it appears as a bright silver streak, darting in and out of the grass. The ♀ is fond of hiding in the grass, and may be obtained by sweeping, but is more likely to be found in cop.; separate females of this species could only with difficulty be recognised distinctively, unless accompanied by the males. The ♂ is quite unlike any other of the Australian members of the genus, and comes nearest to *A. exsudans* Selys, of New Caledonia, a larger insect.

EXPLANATION OF PLATE XVII.

Fig. 1.—*Argiolestes aureus*, n.sp.
Fig. 2.—*Lestes tenuissimus*, n.sp.
Fig. 3.—*Lestes paludosus*, n.sp.
Fig. 4.—*Alloneura solitaris*, n.sp.
Fig. 5—*Alloneura coelestina*, n.sp.
Fig. 6.—*Ischnura* (?) *fragilis*, n.sp.
Fig. 7.—*Pseudagrion ignifer*, n.sp.
Fig. 8.—*Pseudagrion aureofrons*, n.sp.
Fig. 9.—*Agriocnemis pruinescens*, n.sp.
Fig. 10.—*Agriocnemis argentea*, n.sp.

a. Appendages of ♂, dorsal view.
b. Segments 9, 10, and appendages of ♀, lateral view.

DESCRIPTIONS OF NEW SPECIES OF AUSTRALIAN COLEOPTERA.

By Arthur M. Lea, F.E.S.

Part VIII.

(Plate xviii.)

Family STAPHYLINIDÆ.

Antimerus punctipennis, n.sp.

(Plate xviii., fig. 1.)

♂. Blackish-brown; head, prothorax and elytra of a metallic coppery-bronze, in places glossed with green; antennæ, tarsi, front and parts of four hind tibiæ reddish. Clothed, except on head and prothorax, with blackish hair, becoming red in places; head and prothorax with sparse hairs on sides.

Head large, transverse, with seven large punctures on each side and with some smaller ones about the base and neck; jaws long and thin. Antennæ thin, extending almost to base of prothorax, 1st joint as long as 2nd-3rd combined. *Prothorax* about as long as wide, with large marginal punctures—five on each side in front, four in each front, and two in each hind angle. *Scutellum* large and triangular, with numerous setiferous punctures. *Elytra* not much wider than head, with dense, rather large, round, clearly defined setiferous punctures, the interspaces very finely rugulose. *Abdomen* with dense setiferous punctures. *Legs* stout, middle tibiæ densely, the hind moderately densely spinose. Length to apex of elytra 9, of abdomen 15 mm.

Hab.—Gosford, N.S.W. (A. M. Lea).

I have seen this species in several collections under the name of *A. smaragdinus*, and had it so named myself, but recently received a specimen of the real *A. smaragdinus* from the Dandenong Ranges in Victoria,* and it differs from that species in its coppery colour, paler antennæ, abdomen not subcarinate along middle and very different punctures, especially of the elytra; in *A. smaragdinus* these punctures are rather small, comparatively distant, and no larger than those on the scutellum; in the present species they are much larger than those on the scutellum (these being the same size as in *A. smaragdinus*) and much closer together. The coppery parts are very finely shagreened, and the play of colours on them when wet is very beautiful.

Hyperomma pictipes, n.sp.

(Plate xviii., fig. 2).

♂. Shining. Of a rather dark brownish-red; legs flavous, coxæ, base of femora and middle of tibiæ more or less infuscate; palpi and antennæ reddish-flavous, the latter infuscate in middle. Upper surface and sides with a few scattered hairs; abdomen sparsely pubescent.

Head ovate, smooth, with a few rather large clearly defined punctures, almost absent from disc. Eyes almost on top of head. Antennæ scarcely extending to base of prothorax, 1st joint as long as 2nd-3rd combined, 2nd rather more than half the length of 3rd. Terminal joint of palpi small but distinct. *Prothorax* regularly convex, distinctly longer than wide, just perceptibly wider than head, widest near apex, all the angles rounded, with a row of about ten small setiferous punctures on each side of middle, the rows diverging in front; towards each side an irregular row of about six similar punctures. *Elytra* narrower and much shorter than prothorax, shoulders strongly rounded, apex incurved to middle; with rather large, but not sharply defined, punctures, in irregular rows, and becoming smaller posteriorly. *Abdomen* at base as wide as elytra, gradually dilating to beyond the middle, and then strongly narrowed; with rather sparse and indistinct punctures; terminated by two long styles; 5th and 6th segments

* The type was from the Victorian Mountains.

distinctly longer than the others, the 6th below with a deep almost parallel-sided incision. Front *tarsi* rather strongly inflated, the others narrow. Length to apex of elytra 3, of abdomen 7 mm.

Hab.—Hobart, Tasm. (A. M. Lea; in moss).

The almost entirely dorsal eyes, dilated front tarsi, small terminal joint of palpi and apterous body should leave no doubt but that this species belongs to *Hyperomma*. Fauvel, it is true, says of the genus "Corpus robustum," but as he describes the prothorax of *H. lacertinum* as being almost twice as long as wide, and the elytra as narrower than the prothorax, this expression cannot be taken literally.

HYPEROMMA NIGRUM, n.sp.

♀. Shining. Black; legs reddish-brown, apex of femora and the tarsi paler; antennæ reddish-brown at base, darker in middle and flavous at tip. Clothing much as in *H. pictipes.*

Head rather shorter and with larger punctures than in *H. pictipes.* Eyes, antennæ and palpi much the same. *Prothorax* slightly longer and narrower than in *H. pictipes*, with a row of about seventeen setiferous punctures on each side of middle, the rows distinctly diverging in front, each side with an irregular row of about twelve punctures, and a smaller irregular row of about six joining in with same, a few much smaller punctures scattered about. *Elytra* slightly narrower and much shorter than prothorax, shoulders strongly rounded, with moderately numerous clearly defined punctures of two sizes, some fairly large ones (as large as the seriate punctures of prothorax) forming four irregular rows, and smaller ones scattered about. *Abdomen* of the same shape above as in *H. pictipes*, but with denser and more distinct punctures. Front *tarsi* no wider than the middle pair and all narrow. Length to apex of elytra $3\frac{1}{2}$, of abdomen $7\frac{1}{4}$ mm.

Hab.—Bridgetown, W.A. (A. M. Lea).

The narrow front tarsi seem to imply that it is only in the male (as in *H. abnorme*) that these are dilated; the terminal joint of the palpi is small and distinct from some directions but invisible from others. Another species* before me also has very narrow front tarsi in the female; the terminal joint of its palpi, however, is more distinct than in either of the above species. With variable palpi and tarsi therefore it seems quite possible that it may be afterwards desirable to unite *Hyperomma* and *Suniopsis.*

At first sight very close to *H. pictipes*, but readily distinguished by its darker colour and by the punctures of prothorax, elytra and abdomen; the two are readily distinguished from *H. lacertinum* and *H. abnorme* by their much smaller size, etc.

SUNIUS.

The species of this genus hitherto described are all winged, but below will be found descriptions of two apterous species. Those known to me may be tabulated as follows :—

APTEROUS.	
Abdominal punctures in transverse series..............	*Simsoni*, n.sp.
Abdominal punctures dense and irregular.............	*favosus*, n.sp.
WINGED.	
Form very robust for the genus.†	
Base of elytra dark...	*Hackeri*, n.sp.
Base of elytra not dark..................................	*brevicollis* Lea.
Form of normal tenuity.	
Prothorax darker at sides than on disc...........	*cylindricus* Macl.
Prothorax of uniform colour.	
Elytra maculate..................................	*guttula* Fvl.
Elytra of uniform colour or almost so.......	*æqualis* Blackb.
Elytra flavous at apex	*apiciflavus* Lea.
Elytra with longitudinal markings.......... ...	*trilineatus* Lea.

SUNIUS SIMSONI, n.sp.

Of a rather pale reddish-brown; head, basal half of elytra and 5th and 6th segments of abdomen dark brown or black; legs flavous, antennæ and palpi somewhat darker. Clothed with straggling blackish hairs and with sparse greyish pubescence.

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* The largest of the genus, but my specimen is too damaged to be described.

†These two species are fully twice as robust as the common *S. guttula*, and their elytra are considerably larger.

Head longer than wide, rather strongly convex in middle, covered with shallow, honeycomb-like punctures, each of which has a small central pit. Antennæ slightly passing base of prothorax, 2nd joint more than half the length of 3rd. *Prothorax* ovate, with punctures as on head. *Elytra* as long as prothorax, but at their widest narrower than its widest; with strong, rather dense and clearly defined punctures. *Abdomen* dilated towards, but not to, apex, with rather small setiferous punctures in more or less regular transverse rows. Apterous. Length to apex of elytra 2, of abdomen 3½ mm.

Hab.—Launceston (Aug. Simson), Hobart, Huon River, Frankford, Tasm. (A. M. Lea).

The colours as given above apply only to one of the specimens before me; a second differs in having the 5th abdominal segment no darker than the 1st; a third has the whole of the upper surface pale except the base of the elytra (which is not very dark, however), and the 6th abdominal segment which (except at its tip) is almost black; the 4th has the whole of the upper surface of a dark brown, except the apex of the elytra and of the abdomen. One of the specimens was taken from moss and another from tussocks.

In general appearance rather close to *S. guttula*, but apterous, and elytra not maculate.

Sunius favosus, n.sp.

(Plate xviii., fig.3.)

Almost black; mouth-parts reddish, appendages and apex of elytra flavous. Clothed with straggling blackish hairs and with greyish pubescence.

Head longer than wide, moderately convex in middle, with a narrow plate-like expansion at sides of antennæ; with punctures as on head of preceding species. Antennæ thin, just passing base of prothorax, 2nd joint scarcely half the length of 3rd. *Prothorax* and *elytra* much as in the preceding species, except that the elytral punctures are more numerous, although fully as large. *Abdomen* slightly diminishing in width to base and apex, with dense setiferous punctures, which on the basal segments are almost coarse; the four basal segments finely corrugated at apex. Apterous. Length to apex of elytra $3\frac{1}{2}$, of abdomen 7 mm.

Hab.—Cairns, Q. (Henry Hacker).

The pale portion of the elytra covers about one-third of their surface, and is roughly triangular in shape on each, the triangles just touching the suture and sides.

This is the largest *Sunius* as yet recorded from Australia; from *S. apiciflavus*, which it closely resembles in colour (except that the markings at apex of elytra are somewhat different), it differs in being larger and elytra much narrower and with coarser punctures; it is also apterous, whilst that species is winged.

Sunius Hackeri, n.sp.

Of a rather dingy brown; legs flavous, apex of abdomen, apical two-thirds of elytra and the antennæ slightly darker. Clothed with straggling brownish hairs and with greyish pubescence.

Head slightly wider than long, diminishing in width from eyes to apex, eyes prominent; punctures as on head of two preceding species. Antennæ passing base of prothorax, 2nd joint not much shorter than 3rd, 11th briefly obpyriform. *Prothorax* briefly ovate, with punctures as on head. *Elytra* longer and wider than prothorax, conjointly almost quadrate, with numerous, fairly large, clearly defined punctures. *Abdomen* short, at base the width of elytra, almost parallel-sided to near apex, punctures distinct only on basal segments. Winged. Length to apex of elytra $2\frac{1}{4}$, of abdomen 3 mm.

Hab.—Cairns, Q. (Henry Hacker).

Of the robust form of *S. brevicollis*, but differs from that species in the dark portion of its elytra being basal and transverse, and in the punctures of the elytra and abdomen.

Typhlobledius, n.g.

Head subcylindrical; clypeal suture distinct; mandibles short and stout.* Eyes absent. Antennæ rather short and thin.

* Only the tips of the mandibles are exposed.

Labial palpi minute. Maxillary palpi small, apparently four-jointed, the third joint large and swollen, the fourth minute.* Prothorax transverse, cylindrical; prosternum produced in middle of apex, ridged along middle, stigmata concealed. Scutellum small, widely triangular.† Elytra very short. Metasternum very short Abdomen large, cylindrical, the joints briefly elliptic in outline and without visible sutures between dorsal and ventral surfaces, segments increasing in width to fifth, which is almost as large as the two preceding combined, sixth triangular. Hind coxæ contiguous, front slightly separated, middle more noticeably but still very slightly separated; femora stout; tibiæ spinose; tarsi apparently four-jointed,‡ terminal joint stout and as long as the rest combined. Body cylindrical and apterous.

The position of this genus is very doubtful, but I refer it to the neighbourhood of *Bledius*, on account of its prosternum, coxæ, palpi and mandibles. The almost entirely uniform colour of the body and appendages, with the joints closely connected and the sutures frequently indistinct, render it impossible to give as satisfactory a generic diagnosis as is desirable. No confusion, however, is likely to arise through this, as it is the only blind genus of its family recorded from Australia. On a casual glance there appear to be eyes, immediately behind the antennæ, on top of the head, but these on examination under the microscope are seen to be but slight infuscations and are double, marking the sides of a slight antennary ridge. Under a high power the surface of these infuscated spots is seen to be covered with exactly the same scale-like reticulations as the rest of the head, these spaces bearing a deceptive resemblance to facets. The

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* I cannot see this joint at all clearly, even under a high power, and what appears to be a fourth joint may really be a fascicle of hairs.

† Although fairly large in comparison with the elytra, the scutellum is very indistinct on account of the fine nature of its sutures.

‡ I cannot make out the joints of the tarsi at all clearly; in most lights they appear to be four-jointed, but they may really be composed of five.

metasternum is so short that the four hind coxæ are practically all touching.

Typhlobledius cylindricus, n.sp.

Pale reddish-brown, legs and antennæ somewhat paler, palpi of a clear lemon-yellow. Shining and (except the appendages) glabrous.

Head smooth and convex, with minute scattered punctures, and with four of larger size forming a transverse series near the base. Antennæ extending to base of prothorax, 1st joint stout, longer than 2nd, its base partly concealed, 2nd and 3rd of equal length, 4th-6th subglobular, 7th-10th gradually becoming more transverse, 11th briefly ovate. *Prothorax* moderately transverse, slightly wider than head and just perceptibly wider than elytra, with four large dorsal punctures and with small scattered punctures as on head; sides with a very narrow upturned margin. *Elytra* distinctly shorter than prothorax and with similar margins, with small scattered punctures and longitudinally and obliquely strigose. *Abdomen* more than half the total length, with minute punctures and with four small punctures on the upper surface of each, forming a row on each side of the middle, under surface with somewhat similar but much less distinct rows of punctures. Length $2\frac{3}{4}$ mm.

Hab.—Hobart, Tasm.

The outline at a glance appears to be perfectly cylindrical, but the prothorax is slightly wider than the other parts and the base of the abdomen is not quite so wide as its fifth segment. If lines were drawn so as to connect the four large prothoracic punctures, they would enclose a perfect square. Under a quarter-inch lens the entire derm appears to be divided into small scale-like areas, these being especially noticeable on the abdomen.

Unfortunately I kept no record as to the circumstances of the capture of the unique specimens before me, but it may have been taken when hunting for *Anommatus 12-striatus.*

Oxytelus.

Sec. i. Head punctate and strigose.

Oxytelus micropterus, n.sp.

(Plate xviii., fig. 4.)

♂. Moderately wide; highly polished. Deep black, elytra feebly diluted with piceous and with a slight brassy gloss; front of antennary tubercles, the mandibles and palpi red; femora piceous, the tibiæ and tarsi paler.

Head large and wide; punctate and strigose, the punctures rather small, the strigæ more apparent at the sides than on disc and frequently consisting of but several joined punctures. Clypeus greatly depressed, almost impunctate, posteriorly semicircular.* *Prothorax* strongly transverse, slightly narrower than head, much narrower at base than at apex, posterior angles strongly rounded; not very densely or strongly punctate, although the punctures are clearly defined, with a narrow median line and a shallow irregular impression on each side. *Elytra* very small, along sides almost the length of prothorax at its longest, but shorter along suture; densely and coarsely punctate throughout, but the punctures smaller towards scutellum than elsewhere. Apical segment of *abdomen* narrowly excised. Length $3\frac{1}{2}$, to apex of elytra $1\frac{2}{3}$; variation in length 3·4 mm.

♀. Differs in having the head considerably smaller and with the punctures and strigæ more distinct, the prothorax much less narrowed posteriorly and just perceptibly narrower than the head.

Hab.—Hobart, Tasm.

Very distinct from all the species known to me by the small elytra (smaller even than in *O. impennis*); the wings although present are very minute and totally useless for flight. The head of the ♀ is considerably above the average size of its sex. One

* I have not considered it necessary to describe the proportions of the joints of the antennæ in this or in any of the following species of *Oxytelus*; neither have I considered it necessary to refer to the sculpture of the upper surface of the abdomen.

of my specimens was taken from the nest of a small black sand-inhabiting ant.

OXYTELUS STRIGICEPS, n.sp.

♂. Rather wide; upper surface shining but not highly polished. Black; the elytra diluted with piceous, mandibles red, legs piceous, the knees and tarsi paler.

Head rather large and wide; feebly punctate but very distinctly and almost regularly strigose, the strigæ vanishing posteriorly and apically. Clypeus strongly (but not suddenly) depressed and almost impunctate, as is also the surface immediately behind it. *Prothorax* strongly transverse, slightly narrower than head, much narrower at base than at apex, posterior angles strongly rounded; densely, coarsely and irregularly punctate; with a moderately deep and rather wide median impression, lateral impressions indistinct. *Elytra* considerably longer but very little wider than prothorax, densely, coarsely and irregularly punctate throughout, the punctures smaller towards suture. Length 3, to apex of elytra 1½; variation in length 2-3 mm.

♀. Differs in having a smaller and narrower head, with less regular strigæ, but larger and denser punctures; the clypeus more suddenly depressed, very distinctly punctate and less shining; the prothorax is wider than the head, its base is not much wider than its apex, and its surface is less uneven although just as coarsely punctate.

Hab.—Swan River, W.A.

In appearance resembling *O. rufinodis* but abundantly distinct from that and from most other species by the strong corrugations between the eyes.

OXYTELUS TRISULCICOLLIS, n.sp.

♂. Small, depressed; moderately shining. Black, elytra scarcely diluted with piceous, mandibles and legs obscure testaceous-brown.

Head moderately large, densely punctate throughout, the sides distinctly but somewhat irregularly strigose. Clypeus not depressed, but its sutures distinct *Prothorax* strongly transverse, slightly narrower than head; densely and moderately strongly punctate; with three distinct median impressions of which the two outer are slightly curved inwards; lateral impressions large but vaguely defined. *Elytra* about once and one-half the length of prothorax and distinctly wider; very densely punctate throughout, but punctures of small size and nowhere sharply defined, becoming smaller towards suture. Length 2, to apex of elytra $1\frac{1}{4}$; variation in length $1\frac{3}{4}$-2 mm.

♀. Differs in having a smaller and narrower head with three small basal foveæ (much as in M-*elevatus* but less pronounced and not marking the terminations of longitudinal impressions), the prothorax longer, less narrowed posteriorly, and slightly but distinctly wider than the head.

Hab.—Tamworth, N.S.W.

The disc of the prothorax in the vicinity of the longitudinal impression is more shining and with smaller punctures than elsewhere. This and the two following species are not at all unlike in general appearance, but on examination they are seen to be very distinct from each other.

Sec.ii. Head punctate but not strigose.

Oxytelus V-elevatus, n.sp.

♀ (?) Small, depressed; subopaque, abdomen shining. Black, legs obscure testaceous-brown.

Head rather small; densely punctate; with a short median line towards base, on each side of which the derm is raised. Clypeus not at all depressed and with distinct sutures. *Prothorax* very flat, moderately transverse, base not much narrower than apex, which is slightly wider than head; densely and rather strongly punctate; with three median longitudinal impressions of which the lateral ones are feebly defined and the median one open in front and closed behind, the lateral impressions not traceable. *Elytra* quadrate, about once and one-half the length of prothorax but not much wider; closely covered with elongate (almost sulciform) punctures, the intervening spaces densely and minutely punctate. Apical segment of *abdomen* feebly impressed. Length $1\frac{2}{3}$, to apex of elytra 1 mm.

Hab.—Bruni Island, Tasm.

The derm on each side of the median impression is raised so as to form a narrow V, this elevation being all the more distinctly defined on account of the medio-lateral impressions; the apices of the V are slightly thickened and bent outwards. The elongate elytral punctures are rather small but are very sharply defined, and are totally different in character from those of any other species here mentioned or described.

OXYTELUS M-ELEVATUS, n.sp.

Small, depressed, subopaque, abdomen moderately shining. Black, elytra and legs dull reddish-brown, tibiæ and tarsi paler.

Head rather small; densely and finely punctate, with three small basal foveæ, of which the median one is slightly in advance of the others; clypeal sutures indistinct. *Prothorax* very flat, moderately transverse, apex slightly wider than base or than head; densely punctate, the raised spaces less noticeably so; with three median impressions, of which the median is narrowed posteriorly but continuous to base. *Elytra* lightly transverse, about once and one-half the length of prothorax and not much wider; sides and base shining and with small and rather scattered punctures, elsewhere opaque and evidently densely and closely but very indistinctly punctate. Under surface of apical segment of *abdomen* longitudinally impressed in middle. Length $1\frac{1}{3}$, to apex of elytra $\frac{2}{3}$ mm.

Hab.—Richmond River, N.S.W.

Each of the three small foveæ of the head marks the termination of a short depression, of which the median one is very indistinct. The prothoracic elevations are somewhat as in the preceding species, but differ in the sides of the median V being separated at the base and not thickened or turned round at the summit; the outer side also of each of the medio-lateral impressions is slightly raised, so that the elevated spaces form a rather distinct M, disconnected, however, as to its parts.

Oxytelus lateralis, n.sp.

♂. Moderately wide, shining. Testaceous, prothorax more or less feebly clouded with brown in the middle; head piceous, the antennary tubercles and under surface paler; antennæ infuscate, the basal joints paler; sterna and abdomen (except margins) piceous-brown, legs paler than elytra.

Head rather small; somewhat coarsely and irregularly punctate, with a very indistinct and small median fovea. Clypeus depressed and moderately punctate. *Prothorax* widely transverse, slightly wider than the head, near base very little narrower than apex but extreme base much narrower; with sharply defined but comparatively small and sparse punctures; with three feeble median impressions and a rather large but vague one on each side. *Elytra* moderately transverse, about once and one-half the length of prothorax but not much wider, sides slightly inflated posteriorly; with comparatively small scattered punctures which are smaller towards suture and base than elsewhere. Apical segment of *abdomen* with a very distinct and rather wide longitudinal impression. Length $3\frac{1}{4}$, to apex of elytra $1\frac{3}{4}$; variation in length $3\text{-}3\frac{3}{4}$ mm.

♀. Differs in having the head smaller and its punctures rather larger, especially on the clypeus; the prothorax longer, the sides more regularly rounded and with larger and denser punctures, the median impression is more clearly defined and the mediolateral ones less clearly.

Hab.—Sydney and Tamworth, N.S.W.

This species has been in my collection for a long while under the name of *O. impressifrons*, but evidently wrongly so, as only the head and abdomen (except margins) could be called "black," and even then not fairly so, whilst the prothorax is not even dark brown. The species appears to be a very common one. It is allied to *O. varius*, from which it differs in being rather larger and wider; moreover, of all the specimens of *O. varius* that I have seen not one has the margins of the abdomen paler than its disc, whilst in the specimens under examination of the above species the margins are invariably paler.

OXYTELUS TUBERCULATUS, n.sp.

♂. Moderately wide, not very highly polished. Piceous-brown, head deep black, the antennary tubercles and mandibles red. elytra and margins of abdomen paler than prothorax, legs pale testaceous, the tibiæ and tarsi slightly paler than femora.

Head large and wide; punctures small and sparse, but a moderately large one on each side near the base; with a feeble but distinct median line. Clypeus strongly and rather suddenly depressed, semicircular posteriorly and almost impunctate. *Prothorax* very widely transverse, exactly the width of head, sides rounded and diminishing rather strongly to base; punctures small and rather sparse, disc with three shallow and distinct but rather vaguely defined impressions, each side on apical half with a curved and very distinct impression. *Elytra* strongly transverse, not much longer than prothorax and at base no wider, sides inflated posteriorly; moderately closely covered with small punctures, the interspaces (except for a subtriangular space about the scutellum and part of the shoulders where the derm is shining) densely covered with microscopic punctures. Apical segment of *abdomen* lightly longitudinally impressed. Length 3, to apex of elytra $1\frac{3}{4}$; variation in length $2\frac{1}{2}$-$3\frac{1}{2}$ mm.

♀. Differs in having a very much smaller head (scarcely more than half the size of that of the male), with larger and denser punctures, the clypeus much less depressed and distinctly (although not strongly) punctate.

Hab.—Clarence and Hawkesbury Rivers, N.S.W.

In general appearance moderately close to *O. discipennis*, and the punctures of the elytra somewhat similar (except that the larger ones are very much larger) but differs in being considerably narrower, elytra not entirely black (as in *O. vulneratus*, they are paler in the vicinity of the base and suture than elsewhere), the antennary tubercles margined with red and the punctures of both head and prothorax different; from *O. vulneratus* it differs in being very much narrower (both sexes); from *O. varius* it differs in having microscopic punctures densely distributed amongst the ordinary ones.

In consequence of the very distinct outer impressions each apical corner of the prothorax appears to be supplied with a tubercle—elongate-ovate in ♂, subcircular in ♀; in *O. vulneratus* and *O. varius* these tubercles are entirely absent; in *O. discipennis* they are present but much less pronounced.

Oxytelus dispar, n.sp.

♂. Wide, highly polished. Deep black, elytra feebly or not at all diluted with piceous, front of antennary tubercles, the mandibles and palpi red, legs obscure testaceous.

Head large and wide; with very distinct although not large or dense punctures. Clypeus rather suddenly depressed and with a few small but distinct punctures. *Prothorax* strongly transverse, slightly narrower than head, base considerably narrower than apex and gently continuously rounded; densely and rather strongly punctate, the three median longitudinal impressions shallow and very irregular, although sufficiently distinct; lateral impressions wide and very vague, the anterior sides almost perfectly flat. *Elytra* moderately transverse, about once and one-third the width of prothorax and not much wider, sides gently inflated posteriorly; densely and rather coarsely punctate throughout, the punctures sharply defined except towards the apex and sides, where they become more or less confluent. Apical segment of *abdomen* lightly impressed on each side of apex. Length $4\frac{1}{4}$, to apex of elytra $2\frac{1}{4}$; variation in length $3\text{-}4\frac{1}{2}$ mm.

♀. Differs in having a very much smaller head with much denser and coarser punctures; the clypeus larger, less depressed and the punctures not much smaller than elsewhere; prothorax slightly wider than the head, sides not much wider at apex than at base, and punctures denser and slightly stronger.

Hab.—Hobart, Tasm.

Close to *O. vulneratus*, but colour different and punctures very much coarser; punctures (especially of elytra) different from those of *O. melas*.

Oxytelus inconstans, n.sp.

♂. Wide and highly polished. Deep glossy black, the mandibles red; elytra red, but the outer apical angles and the suture in the vicinity of the scutellum black; legs red, femora darker.

Head large and wide; punctures very distinct and sharply defined although not very large or dense, larger at sides than in middle; antennary tubercles unusually large. Clypeus strongly but not at all suddenly depressed, impunctate, its posterior suture invisible. *Prothorax* strongly transverse, the exact width of or very slightly narrower than head, sides much narrower at base than at apex, base gently but not continuously rounded; punctures deep but rather small and not dense; three median impressions shallow and rather vague, continuous to base but not to apex, lateral impressions short and apparently caused by punctures being massed closely together. *Elytra* rather strongly transverse, along middle not much longer than prothorax, but considerably more along sides, sides nowhere inflated, the posterior angles rather strongly rounded; along base and suture with not very dense and comparatively small punctures, the punctures elsewhere rather larger and with a more or less distinct tendency to become confluent. Apical segment of *abdomen* with a very feeble circular impression. Length $4\frac{1}{2}$, to apex of elytra $2\frac{3}{4}$; variation in length $4\frac{1}{4}$-5 mm.

♀. Differs in having the head very much smaller, the jugular constriction less apparent, and the punctures somewhat larger and denser; the clypeus wider, less depressed and with distinct punctures; the antennary tubercles are smaller, though still of rather large size; the prothorax is longer, considerably wider than the head and with somewhat larger and denser punctures, especially towards the sides.

Hab.—Vasse, W.A.

Of the *O. vulneratus* type, but (leaving out considerations of colour) differs on account of punctures, prothoracic impressions and jugular constriction. The latter in the male of *O. inconstans* forms a very decided semicircle, so that the basal lobes of the head are much larger than usual. The antennary tubercles are just perceptibly diluted with red in the middle.

A female specimen from Albury (N.S.W.) differs in having a greater portion of the outer apex of each elytron black. A male specimen from the Swan River differs in having the elytra entirely red.

OXYTELUS BRUNNEIPENNIS Macl.

This is a very distinct species, rendered so by an infuscate line extending along the middle of the abdomen (a character not mentioned in the original description). The eyes are much above the average size, but smaller than in *O. sculptus*. My specimens are from Sydney.

OXYTELUS VARIUS Fvl.

Some years ago at Forest Reefs I remember seeing many thousands of specimens of this species flying around and settling on bags containing potatoes cut ready to be planted out.

OXYTELUS SEMIRUFUS Fvl.

This species (which I have from W. Australia, N. S. Wales, and Tasmania) usually has a square black space in the middle of the clypeus; this square is invariably (sometimes but very slightly, however) darker than its surroundings.

O. SCULPTUS Grav. *Hab.*—West Australia; Tasmania.

O. APICALIS Fvl. *Hab.*—Mount Barker, W.A.

O. RUFINODIS Fvl. *Hab.*—Swan River.

O. VULNERATUS Fvl. *Hab.*—Tasmania.

O. DISCIPENNIS Fvl. *Hab.*—Windsor, Sydney, Clarence River, Armidale, and Queanbeyan, N.S.W.; Victoria.

O. SPARSUS Fvl. *Hab.*—Tamworth, Cootamundra, Forest Reefs, Windsor, Clarence and Tweed Rivers, N.S.W.

O. SUBÆNEUS Fvl. *Hab.*—Swan River and Newcastle, W.A.

O. SCABRELLUS Fvl. *Hab.*—Vasse, W.A.

O. PICEICOLLIS Fvl. *Hab.*—Sydney.

O. IMPENNIS Fvl., and O. MELAS Fvl. I have received specimens of both these species from the Rev. T. Blackburn; they are without locality labels, but agree exactly with the descriptions.

Homalium crassicorne, n.sp.

Narrow and moderately shining. Reddish-testaceous, apical third and suture of elytra and the seven terminal joints of antennæ blackish. Clothed with rather short golden pubescence which is very distinct on the elytra and abdomen.

Head moderately large; densely and rather strongly punctate, front scarcely punctate; each side of middle with a short deep sulcus extending to the neck and open posteriorly. Antennæ stout, 1st joint almost as long as 2nd and 3rd combined, 2nd slightly longer than 3rd, and 3rd than 4th, 5th and 6th slightly, the 7th-10th strongly transverse. *Prothorax* moderately transverse, very slightly wider than head, sides strongly rounded in front and greatly diminishing in width to base, densely and rather coarsely punctate, a shallow impression on each side of the median line (itself appearing as a feeble impunctate elevation continuous to base but not to apex), each side of base with a curved impression continuous to about the middle, from whence it is directed slightly inwards. *Elytra* considerably wider than long, sides parallel except at base and apex, apex almost truncate; moderately densely and coarsely punctate, the punctures becoming smaller posteriorly. *Abdomen* parallel-sided, the apical segment suddenly much narrower and triangular. Length $2\frac{1}{3}$, to apex of elytra $1\frac{1}{2}$ mm.

Hab.—Richmond River, N.S.W.

A very distinct species which in colour somewhat resembles *H. Tasmanicum*, but the two have scarcely anything else in common. The antennæ are stouter than in any other species known to me.

Homalium parallelum, n.sp.

Narrow and shining. Piceous or piceous-brown; prothorax, shoulders and abdomen somewhat paler; legs and palpi reddish-testaceous; antennæ infuscate, the basal joints paler. Clothed with short sparse whitish pubescence, sufficiently distinct on the abdomen but (except from one or two directions, although it is almost as dense) invisible on the prothorax and elytra.

Head rather large and feebly transverse; densely and coarsely punctate, the punctures smaller and sparser on clypeus than elsewhere; each side of middle of base with a deep and almost round fovea, immediately behind which is a small granule; each side of clypeus foveate, but the foveæ smaller and shallower than the basal ones. Antennæ stout, 1st joint as long as the 2nd and 3rd combined, 2nd slightly longer than 3rd, and 3rd than 4th, 3rd-5th feebly, the 6th-10th strongly transverse. *Prothorax* moderately transverse, apex considerably wider than base, and slightly wider than head; densely and rather coarsely punctate; disc with a wide longitudinal depression in which is an impunctate median line; each side with one or two almost foveate impressions. *Elytra* considerably longer than wide, sides parallel except at base and apex, apex conjointly widely rounded; densely and coarsely punctate, the punctures more or less seriate in arrangement. *Abdomen* with the four basal segments parallel-sided and with their margins elevated at a greater angle than usual. Length 2, to apex of elytra $1\frac{1}{6}$; variation in length $1\frac{4}{5}$-$2\frac{1}{6}$ mm.

Hab.—Frankford, Huon River, Bruni Island, Tasm.

A very narrow species, in appearance somewhat resembling *H. philorhinoides*, but narrower, much less coarsely punctate, the prothorax and elytra apparently (only) glabrous, the elytra more parallel and the prothoracic impressions different.

Homalium xanthorrhϾ, n.sp.

♀.(?) Narrow and shining. Reddish-brown, appendages and the apex of each of the abdominal segments paler; head piceous. Clothing as in the preceding species.

Head rather small, densely and moderately coarsely punctate, front shining and sparsely punctate; each side of middle near base with a short deep sulcus (or fovea) terminated posteriorly by a feeble granule; margin of clypeus glittering. Antennæ stout, 1st joint as long as 2nd and 3rd combined, 2nd longer than 3rd, 6th-7th feebly, the 8th-10th strongly, transverse. *Prothorax* moderately transverse, apex considerably wider than base or than head; microscopically transversely corrugated, with rather small scattered punctures, a vague impression on each side of the (wide and indistinct) median line. *Elytra* much as in the preceding species except that the punctures are very much smaller though still seriate in arrangement. Five basal segments of *abdomen* almost parallel-sided. Length 2, to apex of elytra $1\frac{1}{6}$ mm.

Hab.—Darling Ranges, W.A. (on the common "black boy" *Xanthorrhœa* sp.).

In appearance close to the preceding species but slightly wider, punctures of both prothorax and elytra considerably smaller, the antennæ of uniform colour throughout, the prothorax minutely corrugated and the abdominal margins at a very feeble angle. The apex of the clypeus causes the head to appear as if margined with a piece of highly polished metal. The transverse corrugations of the prothorax are most distinct along the median line, elsewhere they are interrupted by the punctures.

H. PHILORHINOIDES Fvl. *Hab.*—South Australia; Tasmania.

H. GAYNDAHENSE Macl. *Hab.*—Brisbane; Tweed River.

H. MORRISI Blackb. *Hab.*—Victoria; Tasmania.

H. TASMANICUM Blackb. *Hab.*—Tasmania.

LISPINUS RIVULARIS, n.sp.

Elongate, depressed, subparallel, shining. Testaceous-brown, appendages paler (but antennæ darker than legs), head piceous, elytra slightly infuscate at apex, abdomen (except the 6th segment and the apex of each of the others) darker than prothorax. Abdomen clothed with sparse yellowish hair, elsewhere the clothing very much sparser.

Head feebly transverse, with rather small scattered punctures. Clypeus feebly impressed on each side. Antennæ as in *L. Sidneensis*. *Prothorax* moderately transverse, with rather small and irregularly distributed punctures, the interspaces microscopically punctate; basal half with four shallow longitudinal impressions, the lateral ones rather deeper and wider than the median. *Elytra* slightly wider than and about once and one-half the length of prothorax, with scattered punctures of similar size to those on prothorax, sutural stria as in *L. Sidneensis*. *Abdomen* parallel-sided to near apex, each segment with two feeble transverse series of small punctures, the surface (except at about apical fourth of each) very densely and finely punctate. Length $2\frac{1}{2}$, to apex of elytra $1\frac{1}{4}$ mm.

Hab.—Tweed and Richmond Rivers, N.S.W.

Differs from *L. Sidneensis* in being smaller, comparatively wider, the head with smaller and sparser punctures, the clypeal impressions shallower, the prothorax with more irregular punctures and with a distinct impression on each side of the middle, the elytra paler, except at apex; and the abdominal segments with a greater part of their surface occupied by dense minute punctures.

L SIDNEENSIS Fvl. *Hab.*—Sydney and Galston.

DABRA TERMITOPHILA, n.sp.

Broad and feebly shining, but the abdomen polished. Reddish-testaceous, elytra and the 2nd-5th segments of abdomen stained with piceous, antennæ infuscate, the basal and apical joints paler. Clothed with extremely short greyish pubescence, the abdomen (except apical segment) glabrous on the upper surface, except for a row of setigerous punctures at the apex of each and a few hairs at the sides; prothorax with four short erect setæ across middle at apex, and two on each side (one at base and one at apex); each side of elytra with three short setæ (two at base and one at apex).

Head densely and finely punctate. Antennæ rather short and stout, increasing in width to base of terminal joint, this joint wedge-shaped and about as long as the three preceding combined. *Prothorax* about twice as wide as long, apex widely emarginate, sides rounded and increasing to base, disc convex, the sides flattened, base feebly bisinuate, the posterior angles slightly produced; densely and finely punctate. *Elytra* slightly shorter and narrower than prothorax, base and shoulders rounded, sides feebly increasing in width to apex, each feebly separately rounded at apex, but the posterior angles somewhat acutely produced; punctures very slightly stronger than on prothorax. Upper surface of *abdomen* impunctate, except at the apex of the segments. Length 3½, to apex of elytra 1⅓ mm.

Hab.—Swan River, W.A. (two specimens taken from a nest of *Coptotermes Raffrayi*).

In some respects it appears to agree with the description of *D. myrmecophila*, but the sides of prothorax not provided with "seven or eight erect setæ," having in fact only two (one at base and one at apex).

DABRA CONVEXICOLLIS, n.sp.

Moderately broad and somewhat shining, the abdomen highly polished. Brownish-testaceous, basal and apical joints of antennæ and the legs paler. Densely clothed with short golden-grey pubescence, except on upper surface of abdomen, which is almost glabrous; each side of prothorax with four long brownish hairs, of the elytra with three, each abdominal segment with from one to three hairs at the sides, and a fringe of setigerous punctures at the apex, the apical segment, however, densely pubescent.

Head densely punctate. Antennæ stout, terminal joint compressed and as long as the three preceding combined. *Prothorax* strongly transverse, convex throughout, sides strongly rounded and nowhere flattened, base bisinuate, the posterior angles produced and acute; densely and regularly punctate. *Elytra* slightly narrower and scarcely longer than prothorax (at its longest), each feebly separately rounded at apex, but the posterior angles acute and produced; punctures as on prothorax. *Abdomen* regularly diminishing in width from base to apex, upper surface (except at apex of each segment) impunctate, lower densely and finely punctate. Length 2⅓, to apex of elytra 1¼ mm.

Hab.—Forest Reefs, N.S.W. (two specimens taken from the nest of a "green" stinging ant under a stone).

Differs from the preceding and from the two previously described species by the prothorax being regularly convex throughout.

The genus *Dabra* will probably be found to be numerous in species when the nests of ants and termites have been more systematically examined than they have been up to the present.

Family PAUSSIDÆ.

MEGALOPAUSSUS, n.g.

Antennæ 11-jointed; 2nd joint very small, globular and almost contained in 1st, none of the others transverse. Scutellum small but distinct. Elytra without membranous tip. Tibiæ moderately long and compressed, but not very wide. Tarsi with 1st and 3rd joints rather small, 2nd large, 4th very small and apparently forming part of 5th, 5th almost as long as the rest combined. Palpi and other characters as in *Arthropterus*.

The species described below is the largest of its family in Australia, if not in the whole world. Its shape, whilst peculiar, is much less so than that of all others of its family of which I have seen specimens or figures; its comparatively simple antennæ and tibiæ being strongly at variance with those parts of all other *Paussidæ*. Its antennæ are suggestive of *Protopaussus*, but the second joint is not truly free as in that genus, and the prothorax is utterly different.

MEGALOPAUSSUS AMPLIPENNIS, n.sp.

(Plate xviii., fig.5.)

Dark reddish-brown. Clothed with rather short, suberect, setose pubescence of a reddish colour.

Head small, with sparse scattered punctures, vertex with two shallow and irregular impressions. Antennæ passing hind coxæ; 1st joint longer than 3rd, thick and subcylindrical, but at base very thin, with rather coarse punctures; 2nd almost concealed, 3rd-11th flat, with dense punctures more or less granular in appearance; 3rd-10th each slightly longer than wide, but gradually decreasing in width; 11th rounded at apex and the length of 9th and 10th combined. *Prothorax* slightly incurved to middle of apex; sides strongly rounded in front, suddenly constricted near base, median line traceable throughout, but distinct only in two places; with scattered punctures. *Scutellum* very small. *Elytra* very large, much wider than prothorax and more than twice as long as head and prothorax combined, almost parallel-sided to near apex, almost at apex a slight outer projection on each side; with rather small punctures. *Metasternum* behind the middle glabrous and impunctate. *Abdomen* with small punctures, from each of which arise two setæ. *Legs* moderately long; hind trochanters large and subcordate; femora curved; tibiæ flattened, moderately dilated to apex; tarsi shorter than tibiæ, three basal joints densely spongiose. Length 18mm.

Hab.—Kuranda, Q.

The medio-basal suture of the prosternum is not straight, but appears as if one part had been folded over another. Each puncture contains a seta, except on the abdomen where each contains two, and these cause it to appear to be divided off into numerous small triangles; the prothoracic punctures from some directions appear to be feebly connected by transverse strigosities, but from most directions each appears to be isolated. By measurement the prothorax is seen to be wider than long ($3\frac{1}{6} \times 3$ mm.), but to the eye it appears slightly longer than wide. The elytra are very finely wrinkled throughout, and this with the punctures gives the surface an appearance much the same as the skin of a fish from which the scales have been removed. The type and only specimen I have seen is in Mr. C. French's collection, and was taken by Mr. F. P. Dodd in January, 1905.

Family CUCUJIDÆ.

Inopeplus angulicollis, n.sp.

(Plate xviii., fig.6.).

Black, upper surface with a more or less coppery gloss, each elytron with a large, subapical, semilunar, whitish blotch; appendages reddish, the antennæ gradually becoming darker to tips.

Head large, with numerous and fairly large punctures; two foveate impressions between antennæ. Eyes small and prominent. Antennæ passing base of prothorax, joints subglobular, 3rd slightly longer than 4th and distinctly longer than 2nd. *Prothorax* transverse, sides increasing in width to middle and then suddenly diminishing to base; with or without two large shallow discal impressions; punctures much as on head. *Elytra* strongly inflated posteriorly, with feeble punctures. *Abdomen* wide, but narrower than elytra. *Legs* rather short. Length $2\frac{3}{4}$-$3\frac{1}{4}$ mm.

Hab.—Huon River, Hobart, Swansea, Tasm. (A. M. Lea); Jenolan, N.S.W. (J. C. Wiburd).

In the male the sides of the prothorax are widest and almost pointed just before the middle; between here and the base is a distinct notch, but this is not traceable from some directions. In the female the sides are not notched, and at their widest are slightly rounded. The lower surface, except of head, is more or less piceous. The semilunar markings of the elytra are not always sharply defined, and in one specimen extend to the apex. The Tasmanian specimens were taken beneath the rough bark of apple trees. The colour and the shape of its prothorax will readily distinguish it from the previously described Australian species.

Family LATHRIDIIDÆ.

Two papers in which Lathridiidæ have been recorded from Australia appear to have escaped observation by Australian entomologists. These are by Motschulsky* and Reitter.† The former first‡ recorded *Lathridius nodifer*, Westw. (p.260) from New Holland, but placed it in his genus *Aridius*; according to him, also, (p.262) *L. antipodum* White,§ is one of its synonyms. *Melanophthalma gibbosa* Herbst, (p.287) is also recorded by him from New Holland. Herr Reitter records (p.96) *Corticaria pubescens* Illiger and *Monotoma picipes* Herbst, (p 96) from Australia.

Monotoma quadricollis Aubé.

This species has been introduced to Tasmania. I sent some specimens to Mr. Champion, to whom I am indebted for the name.

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* Bull. Soc. Imp. Nat. Moscou, xxxix. Vol. ii. 1886.

† Deutsche Ent. Zeit. xxii. 1878.

‡ It was subsequently also recorded by the Rev. T. Blackburn.

§ Voy. "Erebus" and "Terror." Insects, p.18.

Lathridius dolicocephalus, n.sp.

Long, thin and greatly depressed. Pale reddish-testaceous, head and prothorax darker.

Head flat, subovate, considerably longer than wide, densely punctate, without median line. Antennæ thin, passing base of prothorax. *Prothorax* flat, obovate, scarcely longer than head and scarcely wider than across the eyes, sides narrowed to base but nowhere suddenly constricted; densely punctate; a feeble transverse impression towards base. *Elytra* elliptic; at base no wider than prothorax, but at its widest more than twice the width of that segment; suture narrowly raised throughout, 3rd and 7th interstices strongly raised and conjoined at apex, the interspaces with regular rows of large punctures. Length 1¼ mm.

Hab.—Swan River and Vasse, W.A.

A pale, narrow, depressed species with an ovate prothorax (nowhere suddenly constricted) and almost perfectly elliptic elytra. It will probably not rest in *Lathridius*.

Lathridius obsoletus, n.sp.

Moderately long and lightly convex. Dark reddish-brown, legs and antennæ (club excepted) paler.

Head densely punctate; without median line. Antennæ scarcely as long as the width across eyes. *Prothorax* not much wider than head; densely punctate; suddenly constricted near base, base not much narrower than apex; with four feeble longitudinal elevations, of which the outer ones are scarcely traceable. *Elytra* at their widest about once and one-half the width of prothorax; suture, 3rd, 5th and 7th interstices finely and not very acutely raised, the 3rd and 7th conjoined near apex, punctures large and subquadrate, but on disc from about basal third diminishing in size to near apex, when they increase in size. Length 2 mm.

Hab.—Mount Wellington, Tasm.

In build and general appearance close to *L. costatus*, but the prothorax very decidedly transverse (in *L. costatus* it is longer than wide), much more deeply constricted near base, the basal portion not much narrower than the apical portion, and the longitudinal elevations much less distinct; the elytra are less inflated posteriorly, and the interstices are much less acutely raised.

Lathridius denticollis, n.sp.

Moderately short and convex. Dark piceous-brown, appendages paler.

Head densely punctate, with a distinct median line, on each side of which is a very feeble ridge. Antennæ rather short. *Prothorax* noticeably wider than head, densely punctate; sides suddenly constricted near base, the basal portion depressed, considerably narrower than the apical, and continuously decreasing in width to base, each side at the exact middle with a small but distinct tooth; apical half with a feeble longitudinal impression; without raised lines. *Elytra* elliptic-ovate, rather strongly convex, with a feeble transverse subbasal impression; with series of large punctures becoming smaller along the middle, 5th and 7th interstices scarcely visibly raised above the others. Length $1\frac{2}{3}$ mm.

Hab.—Huon River, Tasm.

Lathridius serratus, n.sp.

Moderately long and subdepressed. Dark piceous-brown, margins and appendages paler.

Head densely punctate, with a distinct median line. Antennæ extending backwards almost to elytra. *Prothorax* considerably wider than head, sides rather strongly diminishing in width from near apex to base, but nowhere suddenly constricted; margins flattened and very finely serrated; without raised lines but with a distinct median impression, and which is interrupted at about its middle. *Elytra* ovate, shoulders rounded; alternate interstices feebly raised; punctures large, becoming smaller along middle of disc. Length 2 mm.

Hab.—Hobart and Launceston, Tasm.; Somerville, Vic.

From Forest Reefs (N.S.W.) I have about fifty specimens that I cannot structurally separate from this species, but which differ in being considerably smaller and paler; they were obtained from the rubbish at the foot of a hay-stack; the typical specimens were taken from fence tops at dusk.

L. COSTATUS Er *Hab.*—Tasmania.

L. NODIFER Westw. *Hab.*—Victoria; New South Wales; Tasmania.

L. APICALIS Blackb. *Hab.*—Tasmania.

L. COSTATIPENNIS Blackb. *Hab.*—Victoria; New South Wales; Tasmania.

L. MINOR Blackb. *Hab.*—Clarence River.

L. NIGROMACULATUS Blackb. *Hab.*—West Australia; New South Wales; Tasmania.

L. PUNCTIPENNIS Blackb. *Hab.*—West Australia.

L SATELLES Blackb. *Hab.*—New South Wales; Tasmania; West Australia.

L. SEMICOSTATUS Blackb. *Hab.*—West Australia; Tasmania.

Family SCARABÆIDÆ.

PHYCOCHUS SULCIPENNIS Lea.

Although when describing this species, and since, I repeatedly examined several specimens without finding eyes, I now find that these are present; they are very small and narrow, and each consists of about ten facets; they are invisible from above, behind, or in front, and it is only from certain oblique directions and with certain lights that they can be seen to be eyes at all. With the head partly withdrawn into the prothorax they are quite concealed.

PHYCOCHUS GRANICEPS Broun.

Of this species Capt. Broun * says: "Eyes apparently absent quite invisible." This species also I repeatedly examined to see if it had eyes, without finding any; but now I am doubtful as to whether it is really blind or not. Entirely on the lower surface of the head, in a sloping position behind the insertion of the

* Man. N.Z. Col., Part iii. p.770.

antennæ, are two small spaces, slightly darker than their surroundings, and with what (under a quarter-inch power) appear to be facets. It is quite possible, however, that these are really slight granular elevations of the derm. They cannot be seen until the head has been removed. Of this species Capt. Broun writes me: "I have made two examinations of the head from above and below, using half-inch lens in the microscope, and a good Coddington glass. There may be seen minute, rather distant, granules, which cannot be distinguished from ordinary sculpture. I possess three specimens, one mounted on its back with the head exposed; all were examined." Of his *P. lobatus* he says: "My mounted specimen shows no indication of eyes, but I cannot remove the head without spoiling the type."

Family CLERIDÆ.

Pelonium australicum, n.sp.

(Plate xviii., fig.7.)

Black; muzzle and a curvilinear triangle on lower surface of head, prothorax, legs (tips of femora, apical half of tibiæ and the tarsi excepted), basal third of antennæ, and basal joints of palpi, more or less flavous. Clothed with straggling yellowish pubescence or hair.

Head transverse, with prominent eyes, black portion (both upper and lower) densely and rather coarsely punctate. Antennæ with 1st joint stout, as long as 2nd and 3rd combined, 2nd stouter than but about as long as 3rd, 6th-8th very short, 9th-10th each strongly forked and each about as long as 2nd-8th combined, 11th slightly longer and stouter than 10th. *Prothorax* at apex slightly narrower than head across eyes, sides slightly incurved near apex, then rather strongly dilated to beyond the middle, and again diminishing to base; basal margin narrowly raised, with rather large scattered punctures, becoming dense on sides. *Scutellum* transverse. *Elytra* not much wider than prothorax, coarsely and rather densely punctate, the punctures becoming very small and less numerous posteriorly. *Mesosternum* coarsely punctate. *Legs* rather short, tarsi apparently four-jointed. Length 4½ mm.

Hab.—Sydney, N.S.W. (A. M. Lea).

This genus is abundantly represented in Tropical America, and a few species have been recorded from Burmah, &c.; but it has not hitherto been recorded from Australia. It can be readily recognised by the terminal joints of the antennæ. In the only specimen I have seen it is difficult to see the 6th-8th joints at all clearly, as they are not only very short and closely joined together, but are partly obscured by pubescence.

Family PTINIDÆ.

TRIGONOGENIUS GLOBULUS Sol.

This species occurs in houses in Tasmania and Western Australia; it was originally described from South America, and has also been taken in England. I am indebted to Mr. Champion for the name.

NIPTUS HOLOLEUCUS Feld.

This species also occurs in Tasmania, as Hobart specimens agree exactly with two sent to me under this name by Mr. Champion.

HEXAPLOCOTES, n.g.

Antennæ very stout, six-jointed, the two terminal joints forming an almost circular club. Other characters as in *Polyplocotes.*

This genus belongs to the section of the *Ptinidæ* which includes *Diplocotes*, *Polyplocotes*, *Diphobia* and *Paussoptinus*, from all of which its six-jointed antennæ will readily distinguish it. For purposes of classification it may be placed after *Polyplocotes.* The type and only specimen I have seen was taken in the nest of an ant under a stone.

HEXAPLOCOTES SULCIFRONS, n.sp.

(Plate xviii., fig.8.)

Dark reddish-brown; club, legs and abdomen somewhat paler. Clothed with a thin yellowish pubescence.

Head small, coarsely punctured; sides with several oblique impressions; front with three deep impressions, of which the median one is the narrowest. Eyes small and oblique. Antennæ very stout. four basal joints subgranulate, 1st curved, 2nd from above apparently shorter than 1st but from below noticeably longer, thick but curved, and joined to 1st at about the middle of its lower surface, 3rd slightly longer than wide, 4th almost spherical, 5th-6th combined almost circular, as wide as head and depressed at their junction; 6th slightly larger than 5th, and at its inner apex strongly impressed and with an outer ridge. *Prothorax* slightly longer than wide, rounded in front, sides incurved near base; disc and apex almost impunctate, sides coarsely punctate; base with coarse punctures turning into short longitudinal lines running from near the base to a subbasal curved impression. *Scutellum* absent. *Elytra* not much wider than prothorax, with rows of small isolated punctures, but at base with traces of striæ, each of which ends in a distinct puncture; basal margin raised and rather coarsely punctate. *Abdomen* with irregularly distributed punctures, 2nd segment slightly larger than 3rd and considerably larger than 1st, 4th very short. *Legs* rather short; front coxæ almost touching, middle rather widely, the hind pair very widely separated; femora deeply grooved for the reception of tibiæ; tarsi thin, claws feeble. Length $2\frac{1}{3}$ mm.

Hab.—Newcastle, W.A. (A. M. Lea).

In some lights the elytra, especially at the sides and apex, appear to be very finely strigose. The intercoxal process of the mesosternum is irregularly concave, as are also the four front coxæ. Seen from below the two basal joints of the antennæ appear to be widely and irregularly triangular; from the side the 5th appears to be slightly larger than the 6th.

Family CIOIDÆ.

Lyctus oblongus Oliv.

This species is destructive in Australia and Tasmania to cane furniture, &c. It has not previously been recorded from Australia. I have to thank Mr. C. O. Waterhouse for confirmation of my opinion.

Family TENEBRIONIDÆ.

Morychus heteromerus King.

Cædiomorpha australis Blackb.

I have recently examined the type of *Morychus heteromerus** King; in Masters' Catalogue appearing (number 1913) as a *Pedilophorus*;† it belongs to the *Tenebrionidæ* and is identical with *Cædiomorpha australis* Blackb.‡ As *M. heteromerus* was the prior name that must stand, but as King certainly referred it to the wrong genus, and even family, the species must remain under *Cædiomorpha*.§

Family PYROCHROIDÆ.

Lemodes splendens, n.sp.

(Plate xviii., fig.9).

Red; elytra with a broad purplish-blue fascia, mesosternum and appendages black, tip of antennæ and of palpi and parts of the tarsi of a dingy red. Length 5-5½ mm.

Hab.—Walcha, N.S.W. (W. W. Froggatt).

The shape, punctures and pubescence are much as in *L. Mastersi* and *L. coccinea*. The elytral fascia occupies rather more than one third of the surface, its hind margin is irregularly concave

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* The type is in the Australian Museum, and bears a blue label in the late Rev. R. L. King's writing.

† No authority is quoted for referring it to *Pedilophorus*.

‡ Of *Cædiomorpha australis* I have specimens which were so named by Mr. Blackburn and Mr. G. C. Champion, and which agree perfectly with Mr. Blackburn's description.

§ King's original description, 11 words, is certainly insufficient for its positive identification, but as the type is in good order, and I had the authentically named specimens of *C. australis* with me at the time (the second occasion when I examined it) of comparison, there can be no doubt as to the correctness of the synonymy.

and front trilobed, the median lobe being considerably advanced along the suture. Mr. Froggatt informs me that he captured several specimens that were crawling over a log in company with *L. coccinea.*

EXPLANATION OF PLATE.

Fig. 1.—*Antimerus punctipennis* Lea.
Fig. 2.—*Hyperomma pictipes* Lea.
Fig. 3.—*Sunius favosus* Lea.
Fig. 4.—*Oxytelus micropterus* Lea.
Fig. 5.—*Megalopaussus amplipennis* Lea.
Fig. 6.—*Inopeplus angulicollis* Lea.
Fig. 7.—*Pelonium Australicum* Lea.
Fig. 8.—*Hexaplocotes sulcifrons* Lea.
Fig. 9.—*Lemodes splendens* Lea.

PRELIMINARY NOTE ON THE GEOLOGICAL HISTORY OF THE WARRUMBUNGLE MOUNTAINS.

By H. I. Jensen, B.Sc., Linnean Macleay Fellow of the Society in Geology.

(Plate xix.)

i.—Introduction.

While carrying on geological investigations in the Warrumbungle Mountain district during October and November last, I was very forcibly struck with the vast differences in physiography between this district and that of the Glass House Mountains.

In both regions the chief rocks represented are Trias-Jura sandstones and the volcanic series ; the latter here consisting of alkaline trachytes, trachydolerites, and alkaline basalts, associated with tuffs, breccias, and diatomaceous earths.

Granite inclusions have been brought to the surface by the lavas at Tundebrine, and Carboniferous slates standing on end surround the trachytic mass known as Scabby Rock in the Pilliga Scrub. These facts show that rocks as old as Carboniferous underlie the Triassic rocks at no great depth to the north and west of the Warrumbungles; whilst to the south and east, rocks supposed to belong to the Upper Coal Measures and dipping south-west, constitute the dominant formation.

ii.—Physiography.

The Warrumbungle Mountains occupy a roughly circular area, having a diameter of about 30 miles. They must be distinguished from the Warrumbungle Range, which is merely a low ridge (averaging 2,000 feet in altitude) which forms the watershed between the Namoi and Castlereagh Rivers.

The Warrumbungle Mountain group is built up of volcanic rock. The highest points situated between the Tannabar Split Rock (Berum Buckle) and Mt. Exmouth (Wombalong) reach a height of 4,000 feet, and form the centre of the system. To an observer stationed on one of these peaks it is apparent the other mountains north, south, east and west are of a gradually lessening altitude, depending on their distance from the central bunch. In the latter all the streams of the district originate, diverging and flowing outwards in all directions till the surrounding plain country is reached. Through the mountains they flow in deep gorges which gradually widen as they reach lower parts; nevertheless they retain their youthful appearance, with steep slopes, often vertical cliffs of volcanic rock capping sandstone on either side. Such are the valleys of the Castlereagh between Mobara Rock and Coonabarabran, Jack Hall's Creek, Belar Creek, Uargon Creek, and many others.

Rock-weathering is very slow in this region, so that many of the volcanic tablelands and table-mountains have only a very thin covering of soil. Some are even quite bare, and become known as "scorched plains." The rock waste round the more conical mountains consists largely of coarse fragments of rock broken up by atmospheric agencies and fires, but only slightly, if at all, decomposed.

The central group of mountains is built up essentially of arfvedsonite trachyte and phonolitic trachytes. Surrounding them and surrounding masses of a similar nature elsewhere, also overlying tuffs and breccias of the arfvedsonite trachytes, we have the ægirine trachytes and trachydolerites. The outskirts of the Warrumbungle Mountains are basaltic, and basalts are also met with in the central group capping trachydolerites and trachytes. Mt. Exmouth has a capping of sodalite basalt about 50 feet thick overlying a bed of tuff and breccia of about the same thickness.

Evidently at the close of the volcanic period the region of the Warrumbungle Mountains formed a huge dome-shaped volcanic mass, with its apex near Berum Buckle, and consisting of trachytes, overlain by trachydolerites, which were again capped with basalt.

Surrounding the mountains we have the "plain" country through which the Castlereagh flows after leaving the mountains. The plain very gradually diminishes in altitude from 1,700 feet at Coonabarabran east of the group, to about 1,200 feet on the west side, where it merges into the great western plains. It is not a true plain or tableland, but dotted over it we meet with numerous volcanic hills and sandstone residuals, which usually obtain an elevation of 2,000 feet, the same as that of the Warrumbungle Range. The sandstone residuals are typical mesas, having steep, often precipitous, sides. The volcanic hills are usually conical, and sometimes reach 2,200 feet in height. From observations made at Shawn's Creek, at Tannabar, and around Coonabarabran, it was ascertained that the lavas rest on a *dissected peneplain* of Trias-Jura rock. The peneplain is marked by the present 2,000 feet level, the Warrumbungle Range and the sandstone mesas being relics of it. The lava flows filled up its gorges and valleys, and in places increased the average altitude by several hundred feet. Subsequent erosion has removed the bulk of the volcanic flows as well as most of the old level.

The Coonabarabran tableland is a "peneplain" (of Post-Tertiary age) bestrewn with mesas and buttes which mark two old levels, the raised "peneplain" of the present 2,000 feet level, and a later lava plain forming part of the conical lava mass of the Warrumbungle Mountains, and reaching a higher altitude than the sandstone "peneplain."

The Post-Tertiary "peneplain" has been formed under the influence of a normal cycle in Pleistocene times, modified by an "arid" cycle in recent times. It is being base-levelled, not to the general base-level of the sea, but to the level of the western plains (1,100-1,200 feet).

The Pilliga Scrub lies north of the mountain group. It has a poor sandy soil covered with a thick pine forest. Mesas and buttes like those around Coonabarabran abound in it near the mountains proper. East and south of the mountains there is also a poor sandy soil, except on the talus slopes below volcanic hills, and on alluvial river flats. The plains to the west, on the other hand, have a rich black soil, which in general character resembles that met with on alluvial flats in the mountains, where débris from various volcanic rocks and sandstone has accumulated. These black soil plains have, in fact, been formed out of the detritus and rock-waste of the Warrumbungles brought down by means of water at a time when the rainfall there was much greater than at present.

The Castlereagh River is a peculiar stream. It rises in the heart of the Warrumbungles and subsequently sweeps round the group, describing in so doing three-parts of a circle. There can be little doubt that prior to the great volcanic outbursts, the drainage was more direct, taking a "consequent" direction to the north-west. The volcanic mass blocked effectually the old course and made the waters seek a new ("insequent") course round the obstacle.

Whilst the Namoi is a running stream, the Castlereagh is quite dry in its course through the plains. It is running at Coonabarabran, but further south becomes a mere string of waterholes, and further west it is usually quite dry. On the plains it has shifted its position from time to time, giving rise to billabongs. Often both the present course and the billabongs are distinguishable only as sand ridges known as "monkeys." The river, instead of being marked by a depression, stands in relief, its bed having been filled with wind-blown sand. When floods occur the waters flow across the plain in a sheet, as the river no longer serves its purpose. The fact that proper river courses exist shows that once the rainfall in the mountains was much greater than at present.

The tributaries of the Castlereagh flow in definite watercourses, and have eroded gorges in the mountains where they are fed by springs. On reaching the plains, at any rate on the western side of the mountains, they dry up and can hardly be said to occupy any beds at all. This vanishing of the streams is also observed on the north in the Pilliga country, and may be due to their crossing the intake beds of the artesian system.

The country has been base-levelled to the level of certain depressions in the western plains, which probably were lakes in the wet period, and now form black soil plains. The wet period probably was coincident with the generally accepted Pleistocene *pluvial period* of Australian geology and glaciation on Mt. Kosciusko. At that time the detritus was deposited on the plains, alluvial fans (now black soil flats) were formed in the mountains, and gorges were carved. In the subsequent arid period the integrated drainage system, brought into existence at the end of the pluvial period, has been destroyed; the mountain valleys have been enabled to retain their youthful appearance; scorched plains devoid of soil have developed in the mountains through the aridity of the climate, and the "bad land" topography of the Coonabarabran tableland has been shaped.

In a recent paper* Ida H. Ogilvie describes a conical laccolithic mass under the new term of *conoplain.* The district studied by her has been dissected at its present altitude, with the result that the mountain peaks diminish in height from the centre outwards, alluvial fans flank the mountains, and valleys widen by the retreat of nearly vertical cliffs.

A study of the paper referred to, in conjunction with my observations in the Warrumbungles, shows a striking resemblance between the latter district and that of the Ortiz Mountains, which are taken as a type of the conoplain. There is the same group of high peaks surrounded by smaller and smaller heights, showing that all are but the remnants of a conical pile of igneous rock. We have a surrounding plain sloping gently away from the mountains, and covered with vast deposits of rock waste from them; the want of permanency of watercourses in the plain country; the deep gorges in the mountains, with steep cliffs of a youthful appearance, pointing to occasional heavy rainfalls with

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* "The High Altitude Conoplain" (The American Geologist, vol. xxxvi., No. 1, July, 1905).

long periods of dry weather, are characteristics common to both regions. The only difference is that the Ortiz Mountains are a dissected laccolite, whilst the Warrumbungles form a dissected volcanic dome—a distinction of no importance. The Warrumbungle Mountain district is, therefore, best regarded as a conoplain. Like that of the Ortiz Mountains, it has been formed by arid agencies.

Professor W. M. Davis in the "Journal of Geology," (Vol. xiii., No. 5, July-August, 1905), has described the characteristic features of arid erosion.

In a mountainous district they are exactly the topographical features met with in the Ortiz Mountains in the United States, and in the Warrumbungle and Nandhewar Mountains in this State.

I have already shown that the Coonabarabran tableland, the adjacent parts of the Pilliga Scrub, and the plain country to the south and west of the mountains also, have the features of a "desert plain," in whose degradation sand-blast action has played, and is playing, an important part. This is proved by the existence of "mesas," "buttes," and bad lands.

An elevated "desert plain," according to Professor Davis, is best regarded as having formed *in situ* by arid agencies. As no evidences to the contrary have been found, such as Tertiary marine deposits, it is best to consider the Warrumbungle Mountains and the surrounding district to be a conoplain dissected by arid agencies in Post-Tertiary and recent times.

The plains west of the Warrumbungles owe their table-like flatness to the fact that only wind erosion is going on. They have the features characterising the "old age" of the "arid cycle," whilst the Coonabarabran tableland displays those of "maturity," and the mountains themselves those of "youth." It is indeed highly probable that the peneplain, of which we have evidence in the flat-topped mesas of Coonabarabran and the even 2,000 feet skyline of the Warrumbungle Range, was developed itself by means of arid erosion.

iii.—Succession of Lavas.

The earliest volcanic eruptions gave rise to tuff cones, into which plugs of arfvedsonite trachyte were injected. The next outbursts led to flows of ægirine trachyte, which surrounded and sometimes covered over the already existing cones. Subsequent eruptions gave trachydolerites. Finally sodalite-basalts and ordinary basalts were erupted.

In the dissection of the conical mass thus formed, as soon as the streams found soft tuff and ash-beds, they worked down with great rapidity. In this way plugs of arfvedsonite trachyte like Timor Rock have been completely isolated, and stand with their precipitous sides and hoary summits in broad open valleys. Other plugs of trachydolerite have been isolated in the same way.

iv.—Geological History of the District.

1. In Permo-Carboniferous times this area lay on the coast of an old Palæozoic landmass which extended westwardly.

2. In Triassic times it was depressed, and the sandstones were formed. The subsidence of the old masses continued throughout Trias-Jura and Cretaceous times.

3. An elevatory movement in the Liverpool Range gives the new sediments the prevailing N.N.W. dip. This probably took place in Cretaceous times, and elevated much of the Trias-Jura sea to the state of dry land.

4. A plain or peneplain develops (the present two thousand feet level).

5. It is further elevated and dissected, perhaps, by arid agencies.

6. Lavas are erupted in the order already stated (Eocene-Pliocene).

7. The Pleistocene pluvial period leads to the dissection of the dome-shaped volcanic mass and the accumulation of detritus at lower levels.

8. The landscape is further modified by a superimposed arid cycle which is still prevailing.

v.—The Nandhewar Mountains.

This group, which I also had occasion to visit, resembles that of the Warrumbungles very closely. Here, too we meet with powerful evidences of *arid erosion*. Alluvial fans, mesas of Trias-Jura sandstone, and the perpendicular cliffs lining the mountain creeks are features as common here as in the Warrumbungles. The Nandhewar group, cannot, however, be classed as a conoplain.

Conclusion.

The definite knowledge that the peneplain and conoplain of the Warrumbungle Mountain District have been carved by arid agencies, raises the question whether some of the other elevated peneplains of the State have not been formed in the same way.

EXPLANATION OF PLATE XIX.

Sketch Plan of the Warrumbungle Conoplain, N.S.W.

NOTES ON THE GENUS *CARDIOTHORAX*: WITH DESCRIPTIONS OF NEW SPECIES OF AUSTRALIAN COLEOPTERA. PART II.

BY H. J. CARTER, B.A.

(Plate xx.)

The genus *Cardiothorax* has gone through considerable evolution. Starting from the type *Adelium Walckenaerii* Hope, it became successively *Thoracophorus* Hope, *Atryphodes* Pasc., and finally *Cardiothorax* Motschulsky.* The genus is widely distributed throughout the highland and coastal regions of Queensland, New South Wales and Victoria, but there is at present no evidence of its existence in the other States. The furthest western limits from which I have received specimens is (excepting one species, described below, from Victoria) Condobolin on the Lachlan. The very able revision of this genus by Mr. Bates in the Ent. Month. Mag. 1879 has made the work of his successors comparatively light, but in so variable a family of the Heteronera it is, I think, a mistake to describe a species from a single specimen, or from ♀ specimens only, the variations in size, shape, colour, and sexual distinctions being very great, *e.g.*, I have *C. grandis* Bates, varying in length from 12 mm., to 23·5 mm. with proportional variation in other respects. Again, I have a specimen of *C. cordicollis* Pasc., which is distinctly blue, the normal specimens being black. Again, the strong sexual features shown in the toothed femora, curved tibiæ of the ♂ of certain species make identification impossible when species are described from ♀ specimens only. Yet four species, *C. æneus* Bates, *C. fraternalis* Bates, *C. chalceus* Bates,

* Pascoe, Ann. Mag. Nat. Hist. 1869, p. 37. Motsch., Etudes Ent. 67, nota, Helsingfors. [I regret being denied access to Motschulsky's paper, of which apparently no copy exists in Sydney.]

and *C. distinctus* Bates, have been described from females only, while *C. valgipes* Bates, and *C. politicollis* Bates, were apparently described from a single male. In Mr. Bates' table he classifies 35 species, including *O. Behri* Germ., since referred to the genus *Otrintus*. Mr. Masters' Catalogue contains the names of 39 species, of which six are probably synonymous—*C. Kirbyi* Sol. = *C. dilaticollis* Guér. = *C. Walckenaerii* Hope; *C. licinoides* Redt. = *C. Macleayi* Pasc.; *C. simulans* H. Rut. = *C. Mastersi* Macl.; (?) *C. fraternalis* Bates = (?) *C. valgipes* Bates = *C. pithecius* Pasc. = *C. errans* Pasc.

The identity of *C. Kirbyi* with *C. dilaticollis* and *C. Walckenaerii* was pointed out by Pascoe;* the former two were consequently omitted in Bates' tabulation, but reappear in Masters' Catalogue. The synonymy of *C. simulans* and *C. Mastersi* is proposed by Bates, as also of *C. pithecius* with *C. errans*. The last name holds the prior date in each case. Of the identity of *C. licinoides* with *C. Macleayi*, proposed by Bates, with a query, there can be little doubt. Mr. Pascoe's specimens were described from insects sent by Mr. Masters, whose co-types I have examined. Redtenbacher's excellent plate of *C. licinoides* and description in the 'Reise der Novara' exactly point to the identity, but there seems some doubt as to the priority of publication. Pascoe's *C. Macleayi* appears in the Journ. of Ent. 1866, while the 'Reise der Novara' came out in parts between 1866-8. The evidence is therefore in favour of Pascoe's name. There is nothing in Bates' description of *C. fraternalis* and of *C. valgipes* that sufficiently differentiates them from *C. errans* except the spines on the inner edge of the anterior tibiæ of the latter. Bearing in mind the variations in size, etc., noted above and the fact that only a ♂ specimen was available, a slight variation in convexity noted by Bates could be well accounted for sexually.

Excluding these synonyms we have 32 species. Of these, four, as pointed out above, have been described from a single ♀, and are, as Bates says, "of doubtful specific value" until the other sexes are known. *C. politicollis*, however, is readily identified by

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* Journ. of Ent. 1866, p.37.

locality and description, and I have taken it commonly in the Newcastle district. *C. brevicollis* is figured so well in the 'Reise der Novara' that I have little doubt in identifying a black species in Mr. F. Taylor's collection from Shoalhaven as corresponding to the type, while a species from Oberon in the W. Blue Mountains differs very slightly in colour (dark bronze) and in rather more marked hind angles to prothorax.* Two specimens marked *C. brevicollis* in the Macleay Museum are of the latter type. I have two specimens from Ourimbah, N.S.W., which correspond very well with the description of *C. chalceus*. Of *C. æneus* there are specimens both in the Australian Museum and the Macleay Museum which bear the distinct bicoloration noted by Mr. Bates as well as the other features which point to its identification. These specimens are in both cases labelled Hunter R. I have lately taken four specimens of what I consider to be *C. æneus* at Bulladelah in the Upper Hunter district. I have not been able to identify the following seven species—*C. æricollis* Pasc., *C. angulatus* Bates, *C. captiosus* Bates, *C. connexus* H. Rut., *C. distinctus* Bates, *C. humeralis* Bates, *C. quadridentatus* C. O. Waterh.

C. acutangulus Bates.—This seems to be merely a slight variation of *C. Walckenaerii*. I have specimens from the Blue Mountains which correspond very well with the description. As Mr. Bates points out, *C. æricollis* Pasc., is probably only a bronze variety of the same species. The remaining twenty species I have identified with some certainty as follows:—

C. aratus Pasc.—Co-types from Pine Mountain, Q., in the Macleay Museum.

C. armipes Bates.—I have one specimen from Rockhampton which exactly corresponds to the description.

C. caperatus Pasc., is found commonly on the highlands and coast districts of New South Wales and S. Queensland. I took a large number near Glen Innes, N.S.W.

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* Redtenbacher describes it as *black,* while Bates in his tabulation says, "black, with a greenish tinge."

C. Castelnaudi Pasc., is common in the Illawarra district from Bulli to Wollongong, and the highlands adjacent. At Mittagong is found also a var. of this having equal elytral interstices. I have taken both forms in the above districts respectively.

C. cordicollis Pasc., is common in the Clarence River and Tweed River districts, as also in S.E. Queensland, whence I have received a beautiful blue variety of this species.

C. crassicornis Bates.—I have identified this in the Macleay collection from Wide Bay, Q.

C. crenulicollis Bates.—In the Australian Museum, also the Macleay Museum, from the Endeavour River, Q.

C. curvipes Bates.—After much difficulty I have, I think, identified this as a species taken by myself near Jindabyne in the Monaro district of N. S. Wales.

C. eucephalus Pasc.—Co-types in the Macleay Museum, from Rockhampton, Q.

C. egerius Pasc.—Fairly common in the "Big Scrub" of the northern rivers district of N. S. Wales.

C. errans Pasc.—In the Australian and Macleay Museums from Pine Mountain, Q.

C. femoratus Bates.—I have taken this commonly near Glen Innes, N.S.W., and have specimens from the Macleay and Richmond Rivers, though described originally from Wide Bay, Q.

C. grandis Bates, is very common on the Blue Mountains near Medlow. I have also taken a specimen at Canterbury near Sydney.

C. Haagi Bates, has been given me from the Macleay River, N.S.W., and kindly identified by Mr. Blackburn.

C. Howitti Pasc., occurs commonly in the Illawarra region, N. S. Wales, from Lilyvale to Bulli.

C. longipes Bates, is the commonest form in the Richmond River district, N. S. Wales.

C. Macleayi Pasc.—A denizen of the "Big Scrub" of the northern rivers of N. S. Wales.

C. Mastersi Macl.—Co-types in the Macleay and Australian Museums, from Gayndah, Q.

C. opacicollis Macl.— Co-types in the Macleay and Australian Museums, from Gayndah, Q.

C. Walckenaerii Hope (mis-spelt in Mr. Masters' Catalogue) is the common species found near Sydney. Its range seems to be from the Hawkesbury River to Botany and westward to the Kurrajong, where it is very plentiful.

Since the publication of Mr. Masters' Catalogue, one species only has so far been added, *C. æripennis* Blackburn, which I have taken in some numbers at Mt. Wilson, and sparingly round Blackheath (kindly identified for me by Mr. Blackburn). I have seen one specimen, captured by Mr. Taylor, from North Sydney, and there are two specimens in the Macleay Museum, from Newcastle. To these I propose to add the names of *nine* new species, described below, so that if *C. fraternalis*, *C. valgipes*, *C. acutangulus* and *C. æricollis* are to be considered as good species, we have recorded forty-three members of this genus; or if the first two of these be considered as synonyms of *C. errans*, we shall have forty-one; and there is little doubt but that more forms will come to light.

CARDIOTHORAX ANGUSTICOLLIS, n.sp. (Plate xx., fig.8).

Elongate-oval, narrow, coppery-bronze, shining. Legs and abdomen black. *Head* scarcely depressed on front; palpi large and prominent; antennæ stout and pilose; third joint about one and a half times the fourth; joints nine to thirteenth increasingly bigger, thirteenth much the largest and ovate.

Prothorax longer than wide, widest before the middle, apex scarcely emarginate, front angles widely obtuse and rounded; base sinuate, feebly emarginate, narrower than apex; hind angles obtuse without dentation. Sides slightly rounded, foliaceous margins almost obsolete and without any separating sulcus. Very narrow reflexed border, disc flat, medial channel faintly impressed at base and apex, on each side of this a strongly impressed irregularly interrupted line. *Scutellum* large, transverse, curvilinear triangular, not depressed below elytra. *Elytra* narrowly ovate, broader than prothorax; humeral angles obtusely rounded, sides slightly rounded to the greatest width (behind half their length), whence they narrow sharply towards apex; apical declivity rather steep. Strongly striate, with eight striæ on each elytron, irregularly confluent towards apex, the first two continued, without meeting the others, to the apex Interstices subequal and moderately convex, one or more striæ on sides without punctures. *Epipleuræ* very narrow on sides, abruptly expanded towards the shoulder, this widened portion with strong scattered punctures. *Legs*, especially femora, short and unarmed, tibiæ nearly straight. *Dimensions* 11 × 4 (vix) mm.

Hab.—Clarence River, N.S.W. (Mr. McGillivray).

Types in the Macleay Museum. There are three specimens in the collection, apparently one ♂ and two ♀ The ♂ is smaller, with sides of elytra narrower and more parallel, front femora much thickened towards apex, while the hind femora and tibiæ are very thin. The ♂ specimen is without a head. The small size combined with its very narrow and nearly straight pronotum and margin, pronotum without any basal dentation, its marked epipleural formation, sufficiently differentiate this species from all its congeners.

Cardiothorax aureus, n.sp. (Plate xx., fig.1).

Ovate, bronze-shining, antennæ fuscous, body beneath darker. *Head*: epistomal ridge round and prominent, with two setiferous punctures thereon. Front with circular prominence with central impression like that of cloven hoof. Antennæ long and moderately slender (7 mm.). Third joint little longer than fourth, eleventh little larger than tenth. Joints four to ten equal. *Prothorax* cordate (4 × 5 mm.), widest at middle. Disc slightly convex. Lateral foliation reflexed, with well defined margins on sides, narrower at base and apex. Anterior angles prominent, raised and subrectangular. Posterior angles sharply dentate, teeth pointing outwards. Much narrower at base (2·2 mm.) than at apex between angles (3 mm.). Sides rounded and widening to about half their length, abruptly narrowed near posterior tooth without sinuation, lateral foliation suddenly narrowing on this hinder curve and separated from disc by deep curved furrow.

Median channel deep and wide except on centre of disc, where it is narrower. Two shallow longitudinal sulci near the base. On foliaceous sides are two or more setiferous punctures near the centre. *Elytra* (9 x 5 mm.) ovate, shoulders not angular, but somewhat squarely rounded, widest at middle and narrowing to apex. Striate, with six deeply cut striæ on each elytron, excluding the two shallow striæ on epipluræ. Intervals between striæ flat and glabrous; 3rd and 5th conjoined near apex, 5th rather broader than others. *Legs* thin, femora unarmed, anterior tibiæ slightly thicker towards apex and a little curved on outer edge, median and hind tibiæ straight. What I take to be the ♂ differs only in narrower form and thinner hind tibiæ. *Dimensions* 15 x 5 mm.

Hab.—Grose Valley, Blue Mountains (H. J. Carter and E. W. Ferguson).

The brilliant brassy sheen and the curiously shaped prothorax mark this species as very distinct from any known to me. In some respects like a small *C. Howitti* Pasc., it differs from that species in its longer and more slender antennæ, its more brilliant colour, and in its distinct foliaceous prothorax, with its characteristic setæ on folia and epistoma. Apparently differs from *C. chalceus* Bates, which is described from a single ♀, in form of prothorax, which is widest before middle and whose hind angles are not produced or prominent.

CARDIOTHORAX AUSTRALIS, n.sp.

Very near preceding (*C. aureus*) in colour and general facies, so that at first I was inclined to consider it as a var. of *C. aureus*. Having lately acquired a large number of specimens, I can now confidently describe this as a distinct species. Confusion will be best avoided by the following contrasts :—

C. australis.	*C. aureus.*
Colour dark bronze, shining, varying rarely to light bronze. (Of 17 specimens before me two only are as bright as the typical *C. aureus*).	Golden bronze, shining.

Prothorax—Foliaceous margins narrower and less recurved. Sides regularly rounded. Widest in front of middle. Narrower and more convex.	Foliaceous margins wider and more recurved. Sides gradually widening to about half way, then more abruptly narrowed. Widest at, or a little behind, middle. Broader and flatter.
**In general*—Discal impression consisting of a single irregular deep fovea near base of each lobe.	Discal impression subobsolete.
Elytra—Shoulders obsolete, or very widely rounded. Narrower and more convex. All interstices equal.	Shoulders much more squarely rounded. Wider and flatter. Fifth interstice wider than the others.
Dimensions—Average of 17 specimens—13·5 mm. long. 4·5 mm. broad.	Average of 5 specimens—15·4 mm. long., 5·6 mm. broad.

Hab.—Moruya (Mr. G. Cheesman), Bombala (Mr. W. W. Froggatt), Victorian Alps (Mr. C. French), Mt. Kosciusko (H. J. Carter).

The other characters are very much as in *C. aureus.* I have called it *C. australis* from the fact of its wide distribution over the most southern habitat so far recorded for this genus.

CARDIOTHORAX BATESI, n.sp. (Plate xx., fig.2).

Elongate-ovate, dark bronze, moderately shining; underside, legs, and antennæ black.

Head with epistomal ridge convex and prominent. Usual frontal impression well marked and sometimes foveate; antennæ stout, reaching to base of prothorax, 3rd joint a little longer than the 4th, 10th larger than preceding joints, 11th much the largest and ovate. *Prothorax* nearly flat, transverse and cordate, widest before middle, foliaceous margins wide except at base, separated by sulcus, less distinct than in *C. Walckenaerii*; strongly

* This character is not a constant one. The single fovea being sometimes elongate and sometimes subobsolete.

bordered throughout; lateral margin raised with border reflected, widest at middle (where they are one-fourth the width of disc); front angles roundly acute and prominent, apical border arcuate and interrupted by medial channel; base subtruncate, hind angles subrectangular, distinct but not prominent; sides regularly rounded to near base, slightly constricted near hind angle, base narrower than apex. Disc with medial channel strongly marked throughout but widest at base; irregular basal impressions sometimes extending by faint interrupted foveæ to half-way up disc, which is otherwise smooth. *Scutellum* transverse, subcordate, rounded behind, with small triangular depression on elytra behind this region. Scutellum on the same level as elytra. *Elytra* a little wider than prothorax at widest, shoulders broadly rounded without epipleural fold, even and finely sulcated, with six sulci on each elytron, of which the inner two are continued to apex, 4th and 5th unite near apex. Interstices smooth, equal and slightly convex. Three variable striæ on sides and epipleuræ, sometimes obsolete. *Abdomen* smooth, shining; intermediate and hind tibiæ straight, fore tibiæ slightly arcuate, especially on their outer edge; femora unarmed, but in ♂ slightly thickened near apex. *Dimensions* 15 × 5 mm.

Hab.—Ourimbah and Wyong, N.S.W. (H. J. Carter).

This species has some affinity with *C. Walckenaerii* Hope. It differs in lighter colour, smaller size, less transverse prothorax, which is also more constricted and narrower at base; in its much smaller hind angles to prothorax, less flat foliaceous margins, less distinct separating sulcus, and much thinner legs. There seems to be very slight sexual differentiation in this species; the only distinction I can find is the slightly enlarged front femora of the ♂, and the wider body of the ♀. It is very common within a limited area, but so far I have not met with it outside the above localities.

Cardiothorax lachlanensis, n.sp.

Elongate, black, very shiny, subcylindrical; antennæ piceous, tarsi and fore tibiæ at apex clothed with castaneous hair beneath.

Head like that of *C. caperatus* Pasc., but wider, with frontal impression proportionately larger. ♀. *Prothorax* rather convex, rather broader than long (6 × 6·5 mm.), widest before middle, anterior angles acute and reflexed, sides scarcely rounded and narrower towards base, then rather abruptly constricted, base narrower than apex. Posterior angles acute, prominent and directed outwards; foliaceous margins narrow, marginal border thick on sides, obsolete on apex and narrow at base. Disc with medial channel not generally reaching apex, deepest at base. Between medial channel and margin two irregular sulci near base. *Scutellum* almost semicircular and smooth. *Elytra* (13·5 × 6·5 mm.) convex, somewhat cylindrical, as wide as prothorax at widest. Strongly striate, with six equal furrows on each elytron and two well marked striæ on sides, and one strongly punctured, on each epipleura. Interstices strongly convex, and equal up to the apex, the 8th (on sides) not reaching the basal border of epipleuræ. Sides subparallel till near apex, apical declivity steep, shoulders nearly square, this accented by well marked border of elytra somewhat reflexed at anterior angles. *Femora* unarmed in both sexes. *Tibiæ* nearly straight, fore tibiæ strongly dilated at apex. *Abdomen* black and shining. ♂. Smaller, narrower, with intermediate and hind tibiæ strongly compressed. *Dimensions*—♀ 22 × 6·5 mm.; ♂ 20 × 5·5 mm.

Hab.—Condobolin, N.S.W. (Mr. G. H. Halligan).

I am indebted to Mr. Gerald Halligan for this interesting addition to the genus. There is also a pair in the Macleay Museum from the same locality. It is evidently allied to *C. caperatus* Pasc., but the following differences seem sufficient for considering it as distinct, apart from its widely remote habitat, from a denizen of the northern tablelands and coastal district of N. S. Wales.

C. lachlanensis.	*C. caperatus* Pasc.
Size—20-22 mm. *Colour* very shiny black.	17-19 mm. Moderately shiny black.

Prothorax—Convex, widest before middle. Sides nearly straight, strongly contracted near base, posterior angles acute and prominent.	Flat, widest at middle, sides evenly rounded, posterior angles subrectangular and not so prominent.
Elytra—More convex, intervals at apex equal.	Less convex, intervals unequal at apex.

CARDIOTHORAX PUNCTO-STRIATUS, n.sp.

Elongate-oval, shining bronze with violet reflections, antennæ fuscous-brown, tarsi pale brown.

Head densely rugosely punctate, especially on the vertex, where the usual frontal impression is subobsolete; antennæ reaching to base of prothorax, 3rd joint thinner than but one and a half times the length of the 4th, succeeding joints successively thicker than the preceding, 11th nearly twice the length of the 10th and ovate. *Pronotum* narrow, with greatest width in front of middle; about as long as wide, narrower at base than at apex; apex slightly arcuate towards the anterior angles; these widely acute but not prominently advanced; foliaceous margin subobsolete, bordered throughout by narrow reflexed edge. Sides very slightly rounded and feebly narrowed towards base, where the angles are abruptly obtuse but scarcely dentate. Base truncate. Disc finely and regularly punctate; medial furrow deep and uniformly channelled throughout; on each lobe of disc is a deep longitudinal impression, formed by two long and deep foveæ which are nearly continuous. Of these the more forward one extends nearly to the anterior angles; the hinder one is curved inwards so as to nearly meet the medial channel. *Scutellum* small, smooth, and curvilinear triangular. *Elytra* oval, moderately convex, shoulders narrowly rounded, but rendered more prominent by the almost rectangular reflexed epipleuræ, gradually widening towards apical two-thirds, then sharply narrowing to a somewhat pointed apex; finely regularly punctate-striate, with ten striæ on each elytron, alternate pairs meeting at apex. Intervals smooth, narrow and convex (especially towards apex); the punctures in the striæ regular and close, giving a finely crenate appearance to the interstices. *Femora* unarmed in both specimens, front tibiæ slightly curved inwards, middle and hind tibiæ straight. *Abdomen* shiny bronze-black. *Dimensions*—♂ 14 × 4 mm.; ♀ 14 × 4·5 mm.

Hab.—Ourimbah, N.S.W. (Mr. R. Helms).

This beautiful species was discovered by Mr. Helms, to whose courtesy I am indebted for the specimen which I believe to be the ♀. The ♂ type specimen has been returned to Mr. Helms. The apparent ♀ is wider, stouter, with wider femora and slightly less convex than the ♂, while the latter has more finely attenuated hind tibiæ.

This species is easily distinguished from any other Cardiothorax by the unique sculpture of the elytra, being the only member of that genus having distinctly punctate striæ; while from the other Cardiothorax with narrow margins to the pronotum (*C. politicollis* Bates, *C. errans* Pasc.) it also differs in having less convex pronotum, combined with brilliant violet-bronze colouring, crinkled disc, and narrowed and little curved sides.

Cardiothorax pygmæus, n.sp. (Plate xx., fig.9).

Elongate-oval, flat; pale bronze; under side and legs darker; very nitid above and beneath.

Head of conventional form, smooth, frontal impression subobsolete. Antennæ short, fine, joints 4-13 of same thickness, 1st joint much stouter than the rest, 3rd a little longer than 4th. *Prothorax* subcordate, nearly as long as wide, widest at middle. Apex deeply emarginate, front angles acute. Sides moderately foliaceous and evenly rounded, with narrow reflexed border; base almost straight, narrower than apex, hind angles strongly dentate; tooth pointing outwards and downwards. This dentation accentuated by a large and deep triangular discal impression at base, the base of which is the space between tooth and median line. Shallow sulcus at middle between foliaceous sides and disc; shallow depression on centre of each lobe of disc; medial channel deep, especially at base. *Scutellum* on same level as elytra, curvilinear triangular, smooth. *Elytra* : shoulders rounded but definite, deeply striated, with six striæ on each elytron, all except the sixth well marked to the apex and not confluent. Interstices convex, straight and equal. On sides and epipleuræ are three lines of punctures. Two punctures much larger than the rest on side, about equal distances apart, and the same distance respectively from the base and apex. *Legs* thin, tarsi nearly straight, femora unarmed. *Dimensions* 10 × 3·5 mm.

Hab.—Clyde River, N.S.W. (Mr. Masters).

Through the courtesy of Mr. Masters I am able to describe this species, of which the two type specimens are in the Macleay collection, captured by Mr. Masters himself. I am unable to speak definitely as to the sexes of these, the abdomen of one specimen being absent, nor are there any marked sexual characters in the tibiæ and femora. The small size, light colour, the triangular depression on prothorax, and the two large punctures on sides of elytra are sufficient to point out the identity of this species.

CARDIOTHORAX RUGOSUS, n.sp.

Elongate-ovate, black, opaque. Legs, abdomen, and basal half of antennæ shining black.

Head: epistoma rather flat and longitudinally rugose; frontal impression large with front and sides rectangular, base rounded; with two large shallow foveæ on its centre. Antennæ about the length of head and prothorax combined, rather slender at base, thickening towards apex. Joints 1-7 shining, 8-11 dull black, 3rd joint much longer than 4th. *Prothorax* very little convex, transverse, widest at middle, finely bordered throughout, apex emarginate, front angles wide, obtusely pointed, reaching nearly to the eyes; foliaceous margins wide, flat and of nearly equal width to the base, separated from disc by a broad and deep sulcus; sides gently rounded anteriorly, more abruptly posteriorly, where they are suddenly constricted towards the wide, subrectangular, dentate hind angle; this angle sometimes more acutely produced outwards by the thickened border. Base much narrower than apex and widely angular. Disc with medial channel evenly and strongly marked throughout, but not interrupting front or hind border. On each side of this, about the middle of each lobe, is a strongly marked interrupted line, sometimes only indicated by long shallow foveæ. The disc is faintly, the hind part of margin more strongly, rugose; the former generally longitudinal, the latter transverse. *Scutellum* very large, oval, channelled or impressed in the middle; on the same level as elytra; sometimes with small, wide triangular depression behind this region. *Elytra* roughly and unevenly crenulate-striate, with eight striæ on elytra, and three equally or more strongly marked striæ on the sides and epipluræ, these last strongly punctate, the punctures large and widely separated. The 1st, 3rd, and 5th interstices form rounded ridges crenulated on the sides, the 2nd, 4th and 6th smaller. Humeral angles strongly reflexed by epipleural fold and widely rounded, increasing in width rather suddenly behind the shoulders, then gradually widening to near the apex, where they are rather abruptly narrowed and broadly curved at the apex. The surface of elytra is unevenly convex, with a distinct depression about midway between the sulci and the sides, so that the sides, viewed from behind, appear raised. Front and intermediate tibiæ slightly curved, hind tibiæ straight; all the tibiæ somewhat serrated on their inner edge; femora unarmed in both sexes. *Dimensions*—♂ 16 × 5·5 mm.; ♀ 16·5 × 6·5 mm.

Hab.—Terrigal and Wyong, N.S.W. (Mr. Cox).

Mr. Cox, who discovered this species, has kindly given me three specimens (one ♂, two ♀). It is strongly differentiated from all the other opaque species known to me by the sculpture of the elytra, in which it is nearest to *C. aratus* Pasc., from which it differs widely in the shape of its prothorax *inter alia.*

The sexual differences I note are the following :—

♂. Narrower form, humeral angles of elytra more prominent, narrower and more reflexed, femora stouter, hind tibiæ thinner.

♀. More robust, elytra flatter (with the uneven surface, as above described, less marked), shoulders of elytra more rounded and less reflexed. Hind angles of prothorax more produced outwards and acute.

CARDIOTHORAX CŒRULEO-NIGER, n.sp.

Elongate-ovate, upper surface shining metallic blue-black, beneath black; antennæ and tarsi brown.

Head with frontal impression deeply marked and having thereon a cluster of foveæ, varying in number from two to six, between the eyes. Antennæ stout and long, *i.e.*, extending beyond the base of prothorax when set back. *Prothorax* convex, apex feebly emarginate, front angles short and obtuse, sides gently rounded anteriorly, more abruptly posteriorly, with regular reflexed border; foliaceous sides narrow, obsolete behind, and bearing two or more setæ. Disc smooth, median line strongly impressed throughout; base much narrower than apex, nearly truncate at base and apex; hind angles small but distinct and directed outwards. *Scutellum* triangular, smooth and on same level as elytra. *Elytra* not depressed behind scutellum; shoulders narrow, very obliquely rounded; on each elytron are six narrow sulci, which tend to become obsolete towards the sides and apex. Intervals flat and equal. *Femora* unarmed in both sexes; front tibiæ strongly thickened towards apex; intermediate tibiæ of ♀ slightly bowed, in ♂ straight; hind tibiæ straight in both sexes. *Dimensions* 13-15 × 4-5 mm.

Loc.—Buladelah, N.S.W. (brush country inland from Port Stephens; H. J. Carter).

This species is readily distinguished from all other Cardiothorax by its glossy blue-black colour combined with its *smooth prothorax.** In structure it is somewhat allied to *C. æneus* Bates, and *C. politicollis* Bates, but differs from both in its more explanate margin of *pronotum.*

In the ♂ the elytra are about of the same width as the prothorax at widest; in the ♀ the elytra are rather broader than the prothorax.

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* Only the very faintest impressions of any discal foveæ are to be discerned on some specimens, near the base.

TRACHYSCELIS NIGRA, n.sp. (Plate xx., fig.11).

Short, ovate, convex, very shiny, black, the antennæ and legs testaceous, a lighter-coloured border at the under edge of elytra and epipleuræ; the marginal cilia dense. *Head* and prothorax impunctate, the latter without medial channel.

Elytra scarcely rounded at sides, widest behind the middle, punctate-striate, the three inner striæ well marked and deeply impressed towards the base; the punctures fine and close, becoming finer laterally; the interstices impunctate, two nearest the medial channel somewhat convex, especially towards the apex, flat at the sides. Femora, front tibiæ and abdomen densely punctate. Length $3\frac{1}{4}$ to $3\frac{1}{2}$ mm.

Hab.—Sydney; found on sandy beaches from Gosford to Stanwell Park, at the roots of grass, or under seaweed.

Allied to *T. ciliaris* Champ., but differs from that species in the following details, *inter alia* :—

T. ciliaris.	*T. nigra.*
* *Colour* castaneous.	Black.
Prothorax obsoletely canaliculate.	Without canaliculation.
Elytra almost rounded at sides, widest at middle. Striæ faint except on disc.	Scarcely rounded at sides, widest behind middle. Striæ more deeply impressed.
Venter testaceous.	Black.

ACTHOSUS BRUNNEUS, n.sp.

I have before me eight specimens of an Acthosus (seven from the Blue Mountains and one from North Sydney) that is perhaps best described by comparison with the well-known *A. laticornis* Pasc.

Colour castaneous, in shape flatter, in size smaller. *Head* less deeply concave in front, punctures much finer. *Prothorax* less

* Occasional castaneous specimens are found, but they are probably immature specimens.

convex, punctures finer and closer; two only of the eight specimens have a slight indent at the apex, three have a small fovea at the middle of the base, but *all* have a considerable depression near the anterior angles, not present in *A. laticornis*. *Elytra* are more faintly striate-punctate, the punctures smaller, the striæ finer, and the intervals much flatter; the scutellum is less transverse. *Legs* of a lighter colour; anterior tibiæ less thickened at apex, with much finer seriation on outside edge. Beneath, entirely castaneous (in *A. laticornis* it is black) with a different structure to the prosternum; that of *A. laticornis* has a narrow arched keel, the flanks on each side being hollowed out. In *A. brunneus* this keel is widened out anteriorly, while the flanks are very slightly concave. The longitudinal rugosity on the first two segments of the abdomen is much finer and closer. *Dimensions* 8 × 3 mm.

Hab.—Blue Mountains and Sydney (H. J. Carter).

I do not think that the colour is due to immaturity, having taken this insect persistently of the same colour, at widely different seasons of the year, in the Blue Mountains, both at Kurrajong and Medlow.

Acthosus minutus, n.sp.

Oblong-ovate, parallel, dark copper-brown, shining. Legs and antennæ light castaneous.

Head small, finely punctate and imbedded in the thorax up to the eyes, which are large. Antennæ broad, especially the four last joints. *Prothorax* convex, densely punctate, base and apex truncate, rather sinuate anteriorly, closely fitting the elytra at base. *Elytra* punctate-striate, punctures very minute, intervals quite flat. *Abdomen* black, shiny and punctate. *Femora* and tibiæ wide, hind tibiæ curved. *Dimensions* 2·8 mm. long.

Hab.—Booyong, Richmond River (Mr. R. Helms).

I am indebted to Mr. Helms for the possession of four specimens of this insect, whose minute size alone distinguishes it from any of its allies. I can see few structural differences between this and *A. laticornis* Pasc., but all four specimens are without any depression on the pronotum.

OTRINTUS STRIATUS, n.sp. (Plate xx., fig.4).

Elongate-elliptical, slightly convex. Opaque brownish-black except palpi, knees which are castaneous, and antennæ which are piceous. Tarsi and tibiæ clothed beneath with castaneous tomentum.

Head wider than long, densely and coarsely punctate above and beneath, epistoma convex with apex semicircular, labrum prominent. Shallow lunate frontal impression. Antennal orbits forming round shining knobs of lighter colour. Eyes large, widely separated and oblique. Antennæ long, gradually thickening to apex; 1st and 2nd joints short, castaneous and shining; 3rd joint about one and a half times the length of the 4th, 7th to 11th becoming more spherical, 11th much the largest. *Prothorax:* ♀ flat, ♂ more convex and narrow, wider than long, widest at front, much narrower at base; apex with narrow reflexed border, and subtruncate except for slight sinuation formed by the widely acute front angles, and at the middle by the increased convexity of disc. Anterior angles slightly advanced, sides gently rounded and narrowing towards base, then shortly sinuate so that the posterior angles are subrectangular; base truncate. Disc densely and finely rugose, this rugosity transverse on sides and base. Median channel distinct throughout, deepest in front, wider towards base; on each side of this a shallow longitudinal depression. *Scutellum* almost circular and finely punctate. *Elytra* slightly convex in ♀, narrower and more convex in ♂; wider than prothorax at base, widest behind middle. Shoulders sharply rounded and made prominent by reflexed border. This border extends the whole way round, becoming more prominent again at apex, which is acuminate. Striate, with nine deep striæ on each elytron. Interstices sharply ridged, the 5th and 7th extending beyond the rest front and behind. Sternum and epipleuræ very minutely and lightly punctate. *Abdomen* black, shining and glabrous. *Legs* black except at joints, which are castaneous.

Tibiæ straight, hind tarsi with 1st joint much longer than the 4th. *Dimensions*—♂ 12 × 3·5 mm.; ♀ 14 × 4 mm.

Hab.—Byron Bay, N.S.W.

The ♂ is smaller, narrower, and more convex, especially as to the pronotum. Antennæ are relatively longer, hind tarsi shorter. I have examined three specimens of this insect (one ♂, two ♀). In colour and shape it is most like *O. Jacksoni* (mihi), from which it may be easily distinguished by size, shape of prothorax (much more cordate than in *O. Jacksoni*) and by the widely different sculpture of the elytra, *e.g.*, the sharp edge of the interstices, the number of striæ *inter alia.* The ♂ and one ♀ have been returned to Mr. R. Helms, to whom I am indebted for the third specimen, and who called my attention to this species.

Possibly a new genus may hereafter be required for this insect. The complete absence of any foliaceous margin to prothorax prevents its inclusion in Cardiothorax, while it differs structurally from the typical *O. Behri* Germ., in its truncate base to pronotum and in its less elevated mesosternum.

Daedrosis hirsuta, n.sp. (Plate xx., fig. 14).

Elongate-ovate, hirsute; head, pronotum, elytra and legs dark bronze; tarsi and antennæ dark castaneous; underside bronze-black.

Head very similar to that of *D. crenato-striata* Bates, but the division between front and epistoma more strongly marked; in other words, the irregular frontal depression is deeper, and the punctures thereon are deeper and more widely separated. *Prothorax* more widely rounded than in *D. crenato-striata*, as wide as long, widest about the middle and nearly equally obtusely rounded before and behind, the angles in both cases obsolete. The disc is even more deeply punctate, the punctures with less tendency to coalesce (to become rugose) than in the above. Medial line indicated by a slight depression, with fewer punctures than the rest of disc, widest towards base. On the disc, which is more convex than *D. crenato-striata*, are two irregular depressions on each lobe, the larger about the centre, the smaller one directly in front of this. *Elytra* punctate-striate, striæ shallow and somewhat irregular, these becoming obsolete towards the apex. The punctures in the striæ are deep and close, the intervals almost flat and varying in width, with little, if any, crenulation; 1st, 3rd and 5th having large punctures irregularly placed at some distance apart. Towards the epipleural region the striæ are obsolete, but punctures are dense. The whole upper surface of the body, and femora, clothed with black upright hairs, thickest on the head and pronotum. *Tibiæ* and *tarsi* clothed, especially beneath, with light castaneous hair, front tarsi very transverse and much larger than in *D. crenato-striata*, while the mesosternum is rounder and less declivous, abdomen less concave; the whole underneath part of the body is less shining and of a darker colour. *Dimensions*—♂ 8 × 2·5 mm.; ♀ 10·5 × 3·5 mm.

Hab.—Mount Kosciusko; 13 specimens (H. J. Carter).

This species differs from its other allies (except *D. pygmæa*) in its having clothing. I have above shown its distinction from *D. crenato-striata*; from *D. pygmæa* it differs in size, elytral sculpture, etc.; from *D. victoriæ* Blackb., in its darker legs and antennæ, hirsute covering, small abdominal cavity, &c.

Adelium cœruleum, n.sp.

Antennæ, legs and abdomen black. Head and prothorax dark blue; elytra greenish-blue, metallic shining.

Head: frontal impression as usual in *Adelium*; upper surface of head coarsely and densely punctate, with a row of large shallow punctures beneath the eyes; lightly clothed with short upright hairs, especially round the eyes. Antennæ (6 mm. long), 3rd joint the length of 4th and 5th combined, 11th slightly longer but not wider than the 10th, finely pilose. *Prothorax* (4 × 5 mm.) convex, widest near, not at, base; sides widely rounded and abruptly sinuate at base, apex emarginate; anterior angles sub-rectangular and prominent, width between anterior angles and of base equal (3·5 mm.). Posterior angles short and rectangular, base truncate. Whole surface rugosely punctate, without distinct separation of disc and margin. *Scutellum* transverse-elliptical; elytral suture wide in this region. *Elytra* (8 × 5·8 mm.)

punctate-striate, striæ consisting of ten rows of broad deep furrows, 9th and 10th on sides wider than the rest. The punctures in the striæ large and sometimes coalescing, especially in striæ nearest the suture. Intervals acutely ridged and irregularly interrupted near apex; subovate, convex, widest behind middle; shoulders round, sides slightly widening towards apex. Epipleural fold with lines of coarse punctures, of which there are five rows on anterior part. *Abdomen* finely punctate on last two segments. *Legs* thin, tibiæ straight, tarsi long and slightly pilose. *Dimensions* 13·5 × 5·8 mm.

Hab.—Cairns, N.Q. (Mr. H. Hacker).

I am indebted to Mr. Hacker for this beautiful Helopid. Its striking feature is its colour and metallic sheen, so that in the sunlight its faceted pronotum and metallic elytra scintillate like those of the most beautiful Chrysomelidæ or Buprestidæ. It is entirely distinct from any other Adelium in this respect.

Adelium nitidum, n.sp.

Bright copper colour, shining; legs and abdomen darker; antennæ dark brown.

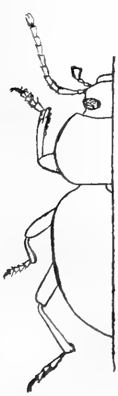
Fig.1.—*Adelium nitidum.*

Head rather narrow, closely and regularly punctate. Usual frontal impression definite. Antennæ long, reaching to base of pronotum, 3rd joint shorter than 4th and 5th combined, 11th much larger than 10th. *Prothorax* (2·5 × 4 mm.) widest at middle. Sides regularly rounded and deflexed; scarcely or obtusely angulate anteriorly and posteriorly; lightly rounded at apex, truncate at base; strongly convex, closely and minutely punctate, with a few larger punctures on disc, and shallow longitudinal sulci near the lateral slopes. *Elytra* (5·5 × 4 mm.) convex, ovate. Shoulders rounded and widely separated from the pronotum. Feebly striate-punctate, striæ consisting of lines of long shallow punctures, irregular in size and continuity; scarcely perceptible at apex and sides. Intervals flat and minutely punctate. *Abdomen* and *epipleuræ* glabrous. Anterior tibiæ very slightly curved. *Dimensions* 9-11 × 4-4·7 mm.

Hab.—Tenterfield, N.S.W. (H. J. Carter).

This insect has its closest congener in *A. ellipticum* Blackb., in general appearance. It differs from that sp. in smaller size and pronounced sculpture of elytra. Its prothorax is more circular, and the colour of antennæ and legs is much darker than in *A. ellipticum.*

ADELIUM PUNCTUM, n.sp. (Plate xx., fig.3).

Dark copper colour, moderately shining. Tarsi with light brown pubescence.

Head densely and coarsely punctate on clypeus; punctures more widely scattered on front. Frontal impression slight, well marked punctate fovea on forehead. Antennæ stout, 3rd joint the length of 4th and 5th combined. *Prothorax* (3 × 4·1 mm.) widest behind the middle, sides strongly rounded and sinuous posteriorly. Anterior angles prominent and acute; posterior angles rectangular and definite. Moderately convex, the disc covered with unequal punctures; sides transversely rugose, medial line evident. *Scutellum* curvilinear triangular, minutely punctate. *Elytra* (8·5 × 5 mm.) very slightly convex. Shoulders strongly rounded, sides subparallel to near apex; striate-punctate, ten lines of long and widely separated punctures on each elytron, the 10th on lateral border. Interstices flat and without punctures. *Epipleuræ* punctate. *Abdomen* shining, glabrous and slightly crinkled on sides. Tibiæ curved. *Legs* beneath minutely punctate. *Dimensions* 12 × 5 mm.

Hab.—Richmond and Bellinger Rivers, and Tenterfield (Mr. Jackson).

A rather flat insect whose nearest congeners are *A. scutellare* Pasc., and *A. reticulatum* Carter. From the former it differs in smaller size, more rectangular form, flatter elytral interstices, &c. From *A. reticulatum* it is easily distinguished by absence of punctures on the elytral interstices while the pronotum is very different, the sides of reticulation being reflexed, while those of *A. punctum* are nearly flat, while its disc is much less densely punctured.

BRYCOPIA TAYLORI, n.sp. (Plate xx., fig.6).

Shortly ovate, very convex. The whole a shining metallic black except the antennæ, which are a dull brown, and the underside of tarsi and joints of legs, which are slightly castaneous.

This insect is very closely allied to *B. globulosa* Carter,* from which it differs markedly in colour and in the following particulars :—

Head wider, front more convex and widely rounded at the sides, more constricted towards base, with lateral foveæ larger and longitudinally prolonged, not quite meeting a second shallower fovea near hind angles. *Elytra* with shoulders more strongly indicated; the striæ are deeper and somewhat crenulate, the punctures therein are much smaller and closer, while the intervals are much less flat, 3rd and 5th wider than the rest. *Legs*, especially femora, much stouter, and tarsi much more transverse. *Abdomen* black, shining, sternum and abdomen densely punctate. *Dimensions* 6 × 3 mm.

Hab.—Oberon, N.S.W. (F. Taylor).

I am indebted to Mr. Taylor for this species, of which four specimens are before me, and in which I cannot detect any sexual differences. I have dedicated it to Mr. Taylor, senr. In general facies is very similar to *B. globulosa*; but whereas that species is of a brilliant copper with paler legs and antennæ, and yellow tarsi, *B. Taylori* is a nitid black, with legs and tarsi dark brown. It is altogether a more stoutly built insect, with width a shade over 3 mm., while *B. globulosa* is slightly under 3 mm.

LEPISPILUS STYGIANUS Pasc.

As there seems some doubt as to the distinction between this insect and *Lepispilus sulcicollis* Boisd., a doubt which is emphasised by Mr. Champion,† I should like to note that on Mt. Kosciusko, Jan. 1906, I took six specimens (3♂, 3♀), of a *Lepispilus* that corresponds with Mr. Pascoe's description. Mr. Lea also has one

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* These Proceedings, 1905, p.184.

† Trans. Ent. Soc. Lond. 1894, p.393.

specimen, and his description* holds true of mine. The specimens were quite fresh when captured, and show no signs of abrasion. The whole insect is a nitid black, without any pubescence, except on the prosternum. The puncturation of the elytra is entirely different from that of *L. sulcicollis*, being finer and without the large reticulated foveæ. It is apparently not rare in this district, which again corresponds to that of Mr. Pascoe's insect (Mts. of Vic.). I have had the same insect sent to me for identification by Mr. C. French.

Adelium minor Carter, *A. globulosum* Carter.—Having lately drawn these insects under a dissecting lens, the rounded eyes were brought prominently under my notice. This fact brings them into the genus *Brycopia*. Having examined *A. minutum* Lea, the same is true of that species. All three should therefore be classified as *Brycopia*.

STIGMODERA HELMSI, n.sp. (Plate xx., fig.10).

Elongate-oblong, rather narrow and flat. Head and pronotum dark bronze-green, except clypeus which is blue, with sides, sternum, legs and antennæ dark blue. Abdomen with first two segments metallic peacock-green, shading into blue on the apical segments. Elytra blue with three interrupted fasciæ red.

Head slightly excavate in front, densely punctate; width 2mm. between eyes. *Pronotum* (3·5 × 4·5 mm.) strongly narrowed anteriorly, at base meeting elytra without constriction. *Scutellum* large, triangular, blue, minutely punctate. *Elytra* (12 × 6 mm.) deeply striate, 3rd and 5th intervals costate towards base; dark blue ground with irregular bands interrupted widely at suture. On each elytron an oblique shoulder band extending from second striæ to the humeral angle; a second about midway roughly parallel to the former and joining it on the sides, also reaching from the second striæ to sides. A third band nearly straight nearer apex. The whole apical fourth part of elytra blue. Body slightly wider than thorax, widest about half way, then strongly narrowed towards apex, which is shortly spinose, the teeth

* Proc. Linn. Soc. N.S.W. 1896, p.293.

separated by a small circular excision. *Abdomen* covered with shallow punctures. *Dimensions* 14-16 × 4·5-6 mm.

Hab.—Mount Kosciusko, 6000 ft., on flowers of *Eucalyptus coriacea*; collected by Mr. R. Helms and H. J. Carter.

I have dedicated this species to Mr. R. Helms, whose scientific work on Mount Kosciusko and in entomology needs no feeble recognition of mine, and by whom this species was first discovered. I took five specimens of it myself in Jan. 1906. It is quite distinct from any *Stigmodera* known to me, nor can I find its description among Mr. Kerreman's papers. Its nearest allies amongst those known to me are *S. colorata* Kerr. (*nec* Hope), and *S. Thomsoni* Saund., from both of which it differs in shape, colour arrangement, and in elytral apical structure *inter alia*.

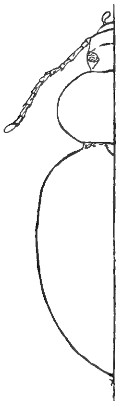

Fig.2.—*Adelium Helmsi.*

The figures marked with an asterisk in the subjoined list, as well as text fig.2, illustrate species described in my previous paper (these Proceedings, 1905, p.177).

EXPLANATION OF PLATE XX.

Fig. 1.—*Cardiothorax aureus.*
Fig. 2.—*Cardiothorax Batesi.*
Fig. 3.—*Adelium punctum.*
Fig. 4.—*Otrintus striatus.*
*Fig. 5.—*Brycopia minor.*
Fig. 6.—*Brycopia Taylori.*
*Fig. 7.—*Brycopia globulosa.*
Fig. 8.—*Cardiothorax angusticollis.*
Fig. 9.—*Cardiothorax pygmæus.*
Fig. 10.—*Stigmodera Helmsi.*
Fig. 11.—*Trachyscelis nigra; a.*insect: *b.*antennæ; *c.*fore leg; *d.*intermediate leg; *e.*hind leg.
Fig. 12.—*Egestria albilineata.*
*Fig. 13.—*Coripera Morleyana.*
Fig. 14.—*Dædrosis hirsuta.*
*Fig. 15.—*Adelium reticulatum.*
*Fig. 16.—*Coripera distincta.*

NOTES AND EXHIBITS.

Mr. Tillyard exhibited the type specimens of the new Australian species of Agrionidæ described in his paper.

Mr. Froggatt showed a series of specimens of the gregarious phasmids *Podacanthus wilkinsoni* Macleay, showing remarkable colouration varying from deep green to bright red. There were hundreds of thousands of these stick insects crawling over the scrub about 20 miles east of Glen Innes, where these were taken in the middle of March.

Mr. R. T. Baker exhibited a sample of a vegetable fibre which appeared like teased out cocoa-nut fibre. This material is found at Tickera, 15 miles north of Wallaroo, South Australia, and runs in a straight line from the beach inland in a general easterly direction for some distance. At the beach it is 15 feet wide, and at the eastern end tapers out to a mere trace. The origin of this remarkable deposit is so far unknown, and a microscopical investigation determined it to be vegetable, consisting of cellulose and lignin. Locally it is regarded as Kelp, but that is incorrect, as seaweeds do not contain vascular bundles. However, the find is interesting from a technological point of view, for an English firm having severely tested the fibre, has declared that it is the best of its kind yet discovered, and intends to utilise it for making a valuable paper, as well as ropes, cords, matting and similar goods. The specimen exhibited was received from Mr. W. J. Garland, Wagga District School.

Mr. David G. Stead exhibited examples of the common "Freshwater Perch" of the eastern rivers of New South Wales, which though so common and so widely known as a valuable game-fish, he considered to be new to science. On account of its purely fluviatile habitat, Mr. Stead proposed for it the name of *Percalates fluviatilis.* The structural features at present chiefly relied upon for the differentiation of this form from its ally *P. colonorum*

(Estuary Perch) are as follows:—(*a*) The far more elongate habit. (*b*) The non-excavate character of the upper profile of the head (which in *P. colonorum* is invariably concave—often highly so). (*c*) The relatively greater general thickness as compared with body-height. (*d*) The shorter head. (*e*) The much more ctenoid character of certain body scales in all but older specimens. It was also pointed out that the habits of *P. fluviatilis* were different from those of *P. colonorum.* Mr. Stead stated that he considered that none of the names now taken as synonyms of *P. colonorum* were applicable to this form. Specimens of *P. colonorum* for comparison with those of the new species were also exhibited.

Mr. John Mitchell exhibited specimens of some fossil shells which are either rare or have not been previously recorded from this State. *Gypidula galeata* was collected at Hatton's Corner, Yass River, and from the junction of Limestone Creek and Jones Creek, Silverdale. A species of *Nucula* occurs in the Upper Trilobite Bed of the Bowning Series, and was found at Bowning, in the small creek that runs through the village, associated with the trilobites, *Odontopleura Rattei* and *Phacops Crossleii* Eth. fil. and Mit. A *Conocardium* was collected from the Lower Limestone Bed of the Bowning Series at Limestone Creek, Silverdale. The specimen is small, not more than half-an-inch along the hinge line. Associated with it were *Atrypa reticularis* Linn., *Sphærexochus mirus* Beyr., etc. Two valves of a specimen belonging to the genus *Beyrichia* were taken from an impure limestone on the Glen William Road, three miles from Clarence Town. The range of this genus in Europe is Silurian to Carboniferous, and its occurrence in the Clarence Town beds is interesting. In the same rocks were fragments of *Griffithidia* or *Phillipsia*, Spirifers, *Ariculopecten, Orthothetes, Conocardium,* etc. A *Bronteus* near to *B. Jenkinsi* was collected near Molong. It was associated with species of *Athyris* and *Meristella,* apparently identical with those with which *B. Jenkinsi* occurs in the Hume Beds and Bowning Series. From the same limestone, near to the hospital, were collected specimens of *Pentamerus Knighti*, the association indicating that the Molong and Yass-Bowning Beds are of the same geological age and belong to the Silurian system. A species of the genus *Rafinesquina* from Hatton's Corner and a *Pentamerus linguifer*(?) from Molong were shown; as well as a remarkable slickensided piece of dolerite from a dyke, met with in the workings of one of the Newcastle coal mines.

WEDNESDAY, JUNE 27TH, 1906.

The Ordinary Monthly Meeting of the Society was held in the Linnean Hall, Ithaca Road, Elizabeth Bay, on Wednesday evening, June 27th, 1906.

Mr. Thos. Steel, F.C.S , F.L.S., President, in the Chair.

The Donations and Exchanges received since the previous Monthly Meeting, amounting to 8 Vols., 81 Parts or Nos., 32 Bulletins, 1 Report, and 12 Pamphlets, received from 54 Societies, &c., and 2 Individuals, were laid upon the table.

THE FORMATION OF SLIME OR GUM BY *RHIZOBIUM LEGUMINOSARUM.*

By R. Greig-Smith, D.Sc., Macleay Bacteriologist to the Society.

The production of slime by *Rhizobium leguminosarum* under certain conditions of cultivation has been noted by many investigators as a character of the composite microbe. In a paper which was published in these Proceedings (1899, 653) a few references are made to these. Thus Frank saw zooglœa forms and mucilaginous colonies, Kirchner described the colonies of the Soja-Bean race as being like drops of paraffin, and Laurent said that old gelatin colonies are slimy. With my experience of slime-forming bacteria, I can now recognise the evidence of slime that I then obtained upon nutrient glycerin-agar.

The present research had its origin in the occurrence of *Rhizobium* in the gum that exuded from a *Macrozamia spiralis*. The *Rhizobium* was induced to produce its slime and from that a gum was obtained, but as this was totally different from the natural gum of the plant, it was evident that the organism had been present accidentally. The importance of the gum-production, however, had by this time impressed itself upon my attention, and work was begun not only with this particular race but with others obtained from Kral of Prague and from locally grown leguminous plants. The investigation extended over a considerable time, and many of the results had to be rejected on account of the relatively small yield of slime under certain conditions of nutrition and physiological activity.

It is accepted that the nodule-former has some relation with the fixation of nitrogen by the members of the *Leguminosæ*, and many investigators have endeavoured to obtain a proof of this fixation by the micro-organisms in artificial culture. With, I think, two exceptions, viz., Mazé* and Moore,† the experiments have been negative.‡ There is, therefore, reason to believe that the direct fixation of nitrogen may not be the function of *Rhizobium*. Since, however, nitrogen is fixed by the plant, the questions arise, How is the fixation made? and How does the microbe assist in the process? I fear that the first question is for future biochemists to determine, but in this paper I shall indicate a probable answer to the second.

In a paper that is published simultaneously with this I show that *Rhizobium leguminosarum*, otherwise known as *Bacillus radicicola*, is a coccoid bacterium contained within a rod-shaped or branching capsule. The so-called bacteroidal or irregular forms are produced by vagaries in the growth of the capsule. There is no reason to connect the fixation of nitrogen with the formation of these branching forms. It would be well to bear in mind that *Vibrio* or *Mycobacterium denitrificans* furnishes the same branching forms,§ and instead of converting free into combined nitrogen, it does the reverse and converts the combined nitrogen of nitrate into free nitrogen gas. I shall show in the course of the research that the gums of *Rhizobium* and of *Vibrio denitrificans* are identical, and if, as there is reason to believe, the bacterial capsule is the "non-diffuse" slime it will be apparent that the branching is entirely due to the nature of the condensed slime of which the capsule is composed. A knowledge of the nature of the gum, the principal constituent of the slime, is thus of some moment.

But when we consider the matter, the importance of an investigation of the slime becomes more apparent. In the nodule, we can see the "infection threads" of Frank passing from cell to cell, and it has been demonstrated that these threads consist of

* Ann. de l'Inst. Past. xii.1, 128.

† Bull. No.71, Bureau of Plant Industry, Washington, U.S.A.

‡ In my former paper, I have shown that I could not detect a gain of nitrogen either in pure or in mixed culture. In the present research, it will be seen (p.281) that the formation of slime is proportional to the nitrogen supplied.

§ These Proceedings, 1901, 118.

coils or chains of bacteria contained within a mucilaginous tube. The presence of slime in the nodule is a fact, and therefore a visible function of the organism within the nodule is the formation of slime. It may have other functions, but of these we are in doubt.

One of the beliefs which is held at the present time is that after a suppositious fixation of free nitrogen and simultaneous growth of bacteroids, the latter are dissolved in some way and the products of solution are then diffused throughout the plant. In their senescence the nodules certainly atrophy and the nodule tissue must be utilised in the plant economy. But the fixation of nitrogen is manifest before the nodules arrive at this stage. In the growing plant, one would expect the solution of the albuminous matter of the bacteroids to be actively in progress, much more so than at a later period, but such does not appear to be the case. This was shown in the following experiment. A growing Lupin plant, 12 inches high, had three large nodules on the tap-root. One of these was sterilised and crushed up in a 0·2% solution of potassium chloride. A loop of the suspension was smeared over a cover-glass and stained. The bacteria and bacteroids stained deeply and there were no cells showing a faint staining. The bacterial chromatin was therefore intact, and there was no evidence of the solution of the albuminoids. The film contained approximately 3,000,000 bacteria and bacteroids. A similar loop of the same suspension was smeared over the surface of a plate of maltose-meat-agar and 25 colonies developed. A small nodule growing on one of the lateral rootlets of another plant, 24 inches high, was crushed up in potassium chloride. A small loop of the suspension contained 104,000 deeply staining bacteroidal and bacterial forms. Plates of various saccharine media were smeared with similar loops, and the greatest number of colonies that developed upon a plate was 185. It is clear from this that the great majority of bacteria in these nodules were dead, and yet the staining reaction showed that the albuminoids were not in process of solution. That the microbes fix the ambient nitrogen to build up their albuminoids, which are then dissolved by the plant, is a hypothesis which is therefore untenable.

Although the composite bacteria are found in great numbers in the nodules, they are not limited to these places. Moore found several instances of luxuriant vegetable growth without nodule formation, and upon microscopical examination detected rhizobial forms within the tissues of the root. I have isolated and grown them from the stems of the lupins quoted above. As they apparently occur throughout the tissues of the plant, one may ask, What is the significance of the nodule? This will be indicated in the research.

When taken directly from the nodule the bacterium may or may not produce a visibly slimy colony. This is notably the case when glucose-gelatine plates are used. As a soluble carbohydrate is essential, slimy colonies are not to be expected upon media containing no sugar. But even with a suitable medium, such as saccharose-potato-agar,* saccharose-bean agar,† or maltose-meat-agar,‡ I have found that the bacteria from some plants produce a relatively luxuriant slimy growth, while from other plants the microbes grow as a rather dry, loose film. It is possible in some cases, by subcultivating every two or three days, to cause the latter races to increase their slime-production, but in other cases such a recovery of power did not occur. Evidently some races are capable of producing slime abundantly and others are not.

As a rule, one can tell from the luxuriance of the original colonies whether or not the bacterium can be classed as a good slime-former. The races that formed slime to some extent were retained after isolation, for they gave material to work upon and products which could be measured under varying conditions of nutrition. The races from Kral did not produce slime at first, but they were induced to do so by frequent subcultivation for about a month upon saccharine media.

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* Saccharose 20, glycerin 10, potato juice 250, agar 20, tap-water to 1000.

† Saccharose 20, bean extract 400 (250 grm. chopped French Beans, boiled for an hour in 1000 c.c. of tap-water, strained, squeezed, filtered and made up to a litre), agar 20, water to 1000.

‡ Maltose 20, agar 20, meat extract 500, water to 1000.

The medium which I have used for growing large quantities of the slime has been saccharose-potato-agar, but saccharose-bean-agar is quite as good and it is easier to prepare. Saccharose, maltose, dextrose or levulose are the most suitable sugars, but the races vary with regard to their power of producing slime from each of these. The chief fault of the saccharose is that it always contains the very resistant spores of the slime-forming *Bac. levaniformans*, and during the sterilisation of the media some of the sugar may become inverted. It is only by careful intermittent sterilisation that the inversion can be avoided. In some cases, *e.g.*, the Kral races, the presence of small quantities of the hexoses produces a considerable reduction in the yield of slime.

Infection of the media is accomplished by smearing the moist surfaces of recently prepared large plates with an actively growing slimy culture of the bacterium. The plates are incubated at the optimum temperature, which is generally 22°C., for a week and the slime is then carefully removed.

The crude slime is principally a solution of gum, but contains in suspension the bacterial cells and in solution small quantities of nutrient matter derived from the medium, and possibly also diffusible albuminoids from the bacteria. The process of partial purification consists in eliminating the bulk of the saccharine impurity by coagulating the slime with alcohol, then in heating the emulsified coagulum in the autoclave (for 15 minutes at three atmospheres) which treatment brings about a separation of the slime into a solution of a gum and into a curdy precipitate, presumably of albuminoids and bacterial cells. The gum is purified by repeated precipitation from aqueous solution by alcohol, the tendency to "milk" or emulsify being counteracted by the addition of small quantities of a solution of 10 % potassium chloride. All bacterial gums after this method of treatment retain a small quantity of nitrogenous matter which may have been originally dissolved in the slime, or which may have been produced from the action of the acid in the slime upon the bacterial cells during the treatment in the autoclave. The slimes grown upon media with a plant basis are acid as a rule, but if they are not distinctly so to litmus paper, it is advisable to add a drop or two of dilute sulphuric acid before they are heated in the autoclave in order to ensure the complete formation of gum-acids.

The gums, which are really gum-acids, were obtained from the slimes of a number of races of *Rhizobium* and were tested in the usual manner, that is, by adding a drop of reagent to a drop of the thick gum mucilage. The following results were obtained:—

REACTION OF THE GUMS OF VARIOUS RACES OF *RHIZOBIUM*, ETC.

	Macro-zamia	Lupin (Kral)	Pea (Kral)	Bean (Kral)	*Vibrio denitrificans*
Alcohol	†	†	†	†	†
Basic lead acetate ...	†	†	†	†	†
Ammoniacal lead acetate	†	†	†	†	†
Neutral lead acetate ..	†	×	†	†	×
Barium hydrate ...	*	*	†	†	*
Ferric chloride	†	†	†	†	×
Copper sulphate ...	0	0	0	0	0
$CuSO_4$ (dil.) followed by KOH	†	†	†	†	†
Phosphotungstic acid ...	†	†	†	†	†
Fehling's solution ...	0	0	0	0	0
Ammoniocupric hydrate	0	0	0	0	0
Milk of lime	0	0	0	0	0
Silver nitrate	0	0	0	0	0
Iodine	0	0	0	0	0
Tannic acid	?	?	?	?	?
Sulphuric acid	—	—	×	†	—

†, a clot or coagulation; ×, thickened; *, a slight precipitate; ?, an opalescence; 0, no reaction; —, not tested.

The race "Macrozamia," as I have mentioned, was obtained from the gum of a *Macrozamia spiralis* that grew on the margin of a plot of ground which bears a crop of Blue Lupins every year. The races "Lupin (*L. luteus*), Pea (*P. sativum*), and Bean (*Vicia faba*)" were obtained from Kral of Prague, while *Vibrio denitrificans* was originally isolated from the Sydney water supply. Bearing in mind that in these tests a thickening is really an incipient coagulation and that a precipitate is a partial clot, one can see that these gums have virtually the same reactions.

In testing the gum of the Pea and especially of the Bean race, it was noted that dilute sulphuric acid thickened or clotted the mucilages. These were not so gelatinous as the gum* from the Macrozamia organism, but the slime of that gum had been acidified with dilute acid before being heated in the autoclave, and the acidification probably accounted for the very gelatinous nature of the solution. The Bean gum was tested with a few acids to see if the kind of acid had an influence in producing the insolubility. A drop of acid was stirred into a drop of the gum and the effect noted. Clotting was obtained with sulphuric acid (1-6), hydrochloric acid (1-4), nitric acid (1-4), phosphoric acid (glacial), acetic acid (glacial), and oxalic acid (saturated solution). A thickening was produced with lactic acid (concentrated). No effect was obtained with acetic acid (1-9) or with saturated solutions of citric, tartaric and succinic acids. During the hydrolysis of these gums, it was noted that they were insoluble in cold 5 % sulphuric acid even when in contact with it for a day, but they readily dissolved on boiling. The insolubility of the gum in dilute acid is probably a factor in causing the formation of the long filaments which are seen stretching from cell to cell in the nodules of the roots of the *Leguminosæ*. From these experiments with acids, one might be justified in inferring that the acidity of the juice of the nodules is due, in part at least, to oxalic or to mineral acids which are possibly liberated from manurial salts through the withdrawal of the base necessary for the formation of tissue.

The gum of the Macrozamia race was more fully examined than the gums of the other races, partly because the slime was produced in greater abundance and partly because the gum remained transparent during the various coagulations with alcohol. It was easily hydrolysed with 5 % sulphuric acid, and during the hydrolysis, furfural was detected in the aerial condenser. Two osazones were obtained; one, present in relatively much greater

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* A solution containing 1·6 % of the crude gum gave a jelly of the same consistency as a 1 % solution of gelatine.

amount, melted at 205° and was a glucosazone; the other, present in very small amount, was galactosazone, and melted at 193°. As the glucose might either be dextrose or levulose, the optical activity was determined. The rotation of a solution of the hydrolysed gum in a 200 mm. tube was +0·9°. The sugar in 5 c.c. of this solution, when boiled with Fehling's solution, yielded 0 0862 grm. of copper, which is equivalent to 0·044 grm. or 0·88 % of dextrose by Allihn's table. From these data the specific rotation was $[a]_D = +51{\cdot}14°$. This closely agrees with the specific rotation of dextrose, $[a]_D = +51{\cdot}78°$. As the relatively small proportion of galactose present would have lowered the copper-equivalent and therefore increased the specific rotation, it is probable that the glucose was entirely dextrose.

The optical activity of the gum was examined and was found to be lævorotatory. The observed angle of rotation was −0·98° at 15° C., and as the solution contained 1·6875 % of total solids, 0·0710% of ash, and 0·0118% of nitrogen equal to 0·0737% of albuminoids, the specific rotation was $-\frac{0{\cdot}98\% \times 100}{1{\cdot}543 \times 2}$ or $[a]_D = -31{\cdot}75°$. A portion of the gum-jelly was hydrolysed by boiling with 5 % sulphuric acid for five hours and made up to the original volume. The acid solution gave a reading of +1·72° in a 200 mm. tube. Upon the assumption that the formula of the gum is $C_6H_{10}O_5$ and that it becomes entirely converted into sugars of the dextrose formula, $C_6H_{12}O_6$, there should have been in the solution $1{\cdot}543 \times \frac{180}{162}$ or 1·714 % of the hexoses. Calculating upon this, the observed rotation was $[a]_D = +50{\cdot}17$, which shows that the hydrolysis was complete and at the same time confirms the former determination.

A solution of the gum of the Lupin race contained 0·922 % of total solids and gave a rotation in a 200 mm. tube of +0·5°; after inversion with sulphuric acid and reduction to volume the rotation was +0·9°. The direction of rotation of the gum thus differed from the Macrozamia gum. On the assumption that the gum contained 8·6 % of impurity (albuminoids and ash) as in the former case, the specific rotation of the gum works out to $[a]_D = +29{\cdot}7°$ and the sugar derived therefrom to $[a]_D = +48°$.

During the hydrolysis of the gum, furfural was detected, and the osazones obtained from the neutralised solution consisted of a mixture of glucosazone and galactosazone. From the calculated rotation and the relatively greater quantity of glucosazone in the mixture, the glucose was chiefly, if not entirely, dextrose as in the previous case.

The gum of the Pea race was dextrorotatory, the specific rotation being $[\alpha]_D = +31{\cdot}7^\circ$. During hydrolysis, furfural was detected. The hydrolytic products contained galactose and a glucose.

The gum of the Bean race was dextrorotatory and yielded dextrorotatory products upon hydrolysis, during which furfural was detected. The sugars consisted of galactose and a glucose.

The gum of *Vibrio denitrificans* was rather difficult to clarify, but the solution permitted enough light to pass to show that it was dextrorotatory like the product of its hydrolysis. During the hydrolysis furfural was given off and the neutralised solution yielded, after treatment with phenylhydrazine solution, a mixture of glucosazone and galactosazone.

With the exception of a difference in the direction of rotation of the gum of the Macrozamia race, the gums were all more or less alike.

It has been shown that *Rhizobium leguminosarum* and *Vibrio denitrificans*, the former of which is supposed to fix ambient nitrogen, the latter is capable of doing exactly the reverse, can assume a similar morphological structure and produce slimes of a similar chemical nature. According to Marshall Ward, the slime is simply the capsule of the micro-organism which has become swollen, the "diffuse-sheath" as he calls it. It is evident then that the formation of bacteroids depends entirely upon the chemical nature of the capsules of the bacteria, and that there is no reason to connect the formation with any fixation of nitrogen that may occur within the plant.

The slime which *Rhizobium* produces has thus as its typical constituent a gum which hydrolyses to a mixture of dextrose and galactose. This peculiar gum may be of great importance to the plant if the carbohydrate which is contained in the nucleoproteid molecule of the plant cells is of the same or an allied nature. According to Kossel, the carbohydrate of certain nucleoproteids can be hydrolysed to a glucose and a pentose.* Galactose, although it is not a pentose, might be mistaken for one if incompletely investigated, and I have obtained, from *Dematium pullulans*, a carbohydrate which was derived from the nucleoproteid of the mould and which hydrolysed to galactose and a glucose. The observation that the slime and the cells of *Rhizobium* stain much more deeply when phosphates are contained in the medium upon which the slime is produced than when they are absent may have some bearing upon this question in view of the fact that phosphoric acid is a typical constituent of the nucleoproteid molecule. There is the probability that the plant is capable of utilising the bacterial slime to build up its nucleoprotein for which it appears to be peculiarly adapted. If such be the case the cells of the root in the proximity of the bacteria will be better nourished than the cells of the localities to which the slime may be transported, and there will be a greater formation of nucleoproteid, protoplasm and tissue generally. Thus will the nodule be formed, not because of the irritation by a parasitic bacterium as some authors consider, but because of the assistance given to the synthetic elaboration of at least one important constituent by a symbiont. We thus return to the older and original idea that there is a symbiosis between host and bacterium, but the symbiosis relates to the alteration of carbohydrate instead of to the fixation of nitrogen.

While the races of *Rhizobium* obtained from the nodules of the Lupin were capable of producing a luxuriant growth of slime immediately after isolation, the bacteria isolated from the stems of the same plants produced none. The location of the micro-organisms in the plant is clearly of considerable importance so far as the production of slime is concerned. In the feebly acid nodule the bacterium can form slime, a thing which it cannot do

* Wohlgemuth obtained xylose and no other sugar from liver nucleoproteid (Biochem. Centrlb. i. 464).

in the more strongly acid stem. Furthermore, the location or the sap of the localities of the plant in which the bacteria occur appear to impart a temporary or permanent physiological character to the microbe in making it unable to produce slime *

The nutrition of the micro-organism.—Besides the examination of the essential constituents of the slime, experiments were made to determine the influence of various factors upon its production and upon the relative physiological activity of the races. The method of determination consisted in preparing media of varying composition and in growing the races† upon plates of the medium contained in Petri-dishes. The volume of medium used in each test was 20 c.c., and the slime that formed upon each of the plates in seven days at 22° was carefully scraped off and weighed; the plates were generally reinfected and any slime that formed was scraped off upon the fourteenth day. The result was multiplied by five to give the quantity that would be obtained under similar circumstances from 100 c.c. of medium, and the calculation was made to the nearest whole number. These numbers are given in the tables.

The vitality of the bacterium at the time of making the experiment has so great an influence upon the result that one experiment can only be compared with another in a general or relative manner. It is for this reason that I have numbered the experiments when more than one are, to economise space, grouped into one table. Each experiment stands upon its own merits, for the experimental conditions were the same. The variation of a week or a month in making the experiment while making very little relative difference in the results as a rule, made some difference in the absolute weights of slime obtained. Even when experiments are made at the same time, the experimental error

* A somewhat similar alteration of function has been noted in the case of *Bact. acaciæ* which in the Peach is altered to the metarabin-forming variety, *Bact. metarabinum* (these Proceedings, 1904, 249).

† The races were subcultivated upon saccharose-potato-agar or saccharose-bean-agar, transfers being made twice a week, and the experimental plates were infected with portions of these growths.

is comparatively great, and the numbers must therefore not be accepted too rigidly. A difference of two units is sometimes, of one unit frequently obtained. As a rule, the media contained a sugar (2 %), a salt (0·2 %), asparagin (0·04-0·06 %), and agar (2 %), excepting when a nutrient was under examination.

With one exception, all the races isolated from nodules which produced a slime upon potato- or bean-agar, also formed it upon the synthetic media. The exception was a race isolated from the Blue Lupin which, while forming slime luxuriantly upon the plant media, could not be induced to form it from any of the combinations of nutrients hereinafter described.

The presence of a carbohydrate capable of being converted into gum is necessary for the growth of all slime-forming bacteria. Saccharose and maltose are generally the most easily changed, and other sugars and carbonaceous substances may or may not be capable of being utilised by the bacterium. For the sake of comparison, I have in the following table adopted the yield from

The Influence of Sugars upon Slime-Formation.

	With citrate of potash.				With phosphate of soda.					
	Expt. 1. 9/7/04.	Expt. 2. 1/11/04.			Expt. 3. 14/3/06.					
	Macro-zamia	Lupin (Kral)	Pea (Kral)	Bean (Kral)	Lupin (Kral)	Pea (Kral)	Pea (March)	French Bean	Robinia	Macro-zamia
Dextrose	10	10	10	10	10	10	10	10	10	10
Levulose	8	10	10	13	28	3	3	3	10	10
Maltose	13	90	83	76	11	7	8	5	11	10
Saccharose	9	50	43	26	15	5	6	5	12	10
Mannit	10	43	36	23	8	8	6	6	12	10
Glycerin	10	13	13	13	18	8	2	3	10	2
Lactose	1	—	—	—	0	0	5	2	0	1
Dextrose actual %...	20	3	3	3	3	4	11	8	14	10

dextrose as a standard (= 10), but the actual weight of slime calculated as being obtained from 100 c.c. of the dextrose medium is also given, and from these the actual weights from all the other sugars may be calculated.

Experiment 2 with citrate is an example of the identical behaviour of the three Kral races when citrates, succinates or tartrates were employed in the construction of the medium. We shall see a few other examples, but it may be mentioned that with these races some fifteen experiments were made with various nutrients, and it was found that so long as an organic salt was present the behaviour of the three races was precisely similar.

The Kral races gave a very small yield with dextrose, so that by using dextrose as a standard the numbers for maltose, saccharose and mannit in presence of citrate are very high. According to the phosphate experiment, the races* fall into three groups, consisting of—(1) the Lupin race, (2) the Pea and Bean races, and (3) the Robinia and Macrozamia races. In the presence of phosphate, the members of the first group form most slime from levulose, the second from dextrose, while the third are indifferent to five of the nutrients.

The percentage of dry matter was determined in the Lupin-citrate slimes. It varied from 2·1 % (saccharose) to 4·5 % (dextrose). The maltose and mannit slimes contained 2·5 %, levulose 3·7 %, and glycerin 2·2 %. With the exception of glycerin, the slimes with the smallest yield contained the most solid matter, but this did not influence the relative effects of the nutrients to any appreciable extent.

Until the experiments with phosphate were made, the behaviour of the Lupin (Kral) race in producing a luxuriant slime upon a levulose or glycerin medium containing an extract of either meat, yeast, turnip or potato, could not be explained. It afterwards became clear that the high yield of slime with levulose

* With regard to the origin of these races, the Macrozamia race, as already mentioned, occurred in the gum exuding from *Macrozamia spiralis*, the Kral races, sometimes indicated by "(K)", came from Kral of Prague. Pea (March) and the French Bean races were isolated from the nodules of *Pisum sativum* and *Phaseolus vulgaris*, forwarded from the Hawkesbury Agricultural College by Mr. H. W. Potts in March, 1905. The Robinia races were obtained from nodules of *Robinia pseudacacia* sent from the same place in May, and the Pea (Oct.) and Black Tare from *Pisum sativum* and *Vicia sativa* sent in October.

or glycerin and the low product from dextrose was caused by phosphate in the vegetable or other extract. The experiment is the following:—

The Lupin (Kral) Race with Various Extracts and Carbonaceous Nutrients.

Nature and strength of extract in medium.	Dextrose 2%	Levulose 2%	Glycerin 2%
Meat, 12·5 grams % ...	4	13	22
Yeast, 10 ,, ,, ...	5	18	21
Lupin, 25 ,, ,, ...	5	11	6
Turnip, 25 ,, ,, ...	4	5	3
Potato, 25 ,, ,, ...	3	26	25

In the course of the investigation, with the Kral races, it was noted that very small yields were sometimes obtained from saccharose. This was traced to the partial inversion of the saccharose during sterilisation. It was then considered possible that the action of dextrose or levulose in combination with saccharose might give some information regarding the affinities of the races, and accordingly experiments were made with this object in view.

The Influence of Dextrose and Levulose upon Saccharose.

Saccharose 2%, Asparagin 0·05% Salt 0·2%, Agar 2% with 2% of	With Citrate of Potash.					With Phosphate of Soda.				
	Expt. 1. 2/12/'04	Expt. 2, 12/12/'04.				Expt. 3, 9/3/'06.				
	Lupin (Kral)	French Bean	Pea (March)	Pea (Oct.)	Robinia	Lupin (Kral)	French Bean	Pea (March)	Pea (Oct.)	Robinia
Saccharose, = 10	10	10	10	10	10	10	10	10	10	10
Dextrose ...	2	8	12	11	12	3	13	9	7	9
Levulose ...	2	2	0	3	12	17	6	2	2	12
Saccharose, actual %	13	12	9	4	11	6	7	6	6	14

The experiments were repeated, and in No. 2, which follows, the reaction of the medium after the slime had been scraped off was tested.

THE INFLUENCE OF DEXTROSE AND LEVULOSE UPON SACCHAROSE.

Medium as in previous experiment with 2% of	Expt. 1, 19/3/'06.		Expt. 2, 9/4/'06.							
	Lupin (Kral)		Pea (Kral)		Pea (March)		Fr'nch Bean		Macrozamia	
	Phosphate.	Citrate.	Phos.	Citr.	Phos.	Citr.	Phos.	Citr.	Phos.	Citr.
Saccharose, =10	10	10	10†	10*	10†	10*	10†	10*	10†	10*
Dextrose,	6	2	14†	9†	12†	23*	10†	14*	10†	13*
Levulose,	23	5	5†	2†	1†	0†	1†	1†	11‡	11*
Saccharose, actual %	3	16	3	15	11	5	7	14	10	8

†, means an acid reaction of the medium after removal of the slime.
*, an alkaline, and ‡, a neutral reaction.

So far as the identity or otherwise of the races is concerned, these results indicate the same thing that was found with the individual sugars, viz., that the races fall into three groups,—(1) Lupin, (2) Peas and Bean, and (3) Macrozamia and Robinia. But they also show that the Pea (Kral) race differs from the Australian race with respect to the action of phosphate or citrate in reducing the actual yield.

The reaction of the medium at the end of the experiment, when considered with the comparative yields of slime, shows that levulose probably produces an acid which is injurious to the composite bacterium, and this is in all likelihood the reason for the poor yield of slime. Could the acid be neutralised as it is produced the slime might be much greater. This was tested by repeating the experiment with some of the races, the medium being mixed with 1 % of chalk and the phosphate being added at the time of preparing the plates.

THE INFLUENCE OF DEXTROSE AND LEVULOSE UPON SACCHAROSE IN PRESENCE OF CALCIUM CARBONATE AND SODIUM PHOSPHATE.

	Pea (Kral)	Bean (Kral)	French Bean	Pea (March)
Saccharose = 10 ...	10‡	10†	10‡	10‡
Dextrose	13†	21†	18‡	8†
Levulose	16†	19†	7†	9†
Saccharose actual yield	3	2	6	4

Although the experiment bears out the idea that the low yields with levulose were due to the formation of acid, they are, however, subject to some discount, for at the end of the experiment the surfaces of the plates were acid to litmus in spite of the fact that the medium was white from the presence of calcium carbonate.

The action of dextrose upon saccharose in the case of the Lupin race from Kral was very marked, and in the following experiment it will be seen that even very small amounts of dextrose have a considerable depressing effect upon this race.

THE DEPRESSING INFLUENCE OF SMALL QUANTITIES OF DEXTROSE UPON SACCHAROSE.

Dextrose added to the 2% saccharose-citrate medium.	None	0·01	0·05	0·1	0·2	0·6	1·0	2	2·5	4%
Lupin (Kral) ..	23	22	13	9	2	1	1	2	2	3

In testing the influence of several nitrogenous nutrients, amounts of substances containing equivalent quantities of nitrogen corresponding to 0·06 % of asparagin were employed.

THE INFLUENCE OF VARIOUS FORMS OF NITROGEN.

	Expt. 1. Saccharose and citrate.			Expt. 2. Saccharose and phosphate.							Expt. 3. Dextrose and phosphate.					
	Lupin (Kral)	Pea (Kral)	Bean (Kral)	Lupin (Kral)	Pea (Kral)	Bean (Kral)	Pea (Oct.)	French Bean	Macrozamia	Robinia (26°)	Lupin (Kral)	Bean (Kral)	Pea (March)	Pea (Oct.)	French Bean	Robinia (26°)
Asparagin	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Urea ...	9	8	9	9	4	10	8	6	9	10	4	4	11	8	3	8
Peptone ...	3	5	3	9	6	8	11	10	4	11	5	5	11	8	4	4
Potassium nitrate ...	11	10	11	12	5	17	11	6	16	15	6	6	13	10	3	9
Ammonium sulphate..	9	7	8	8	1	—	5	3	4	2	3	4	3	3	6	—
Ammonium phosphate	—	—	—	4	3	7	6	6	6	—	3	4	—	—	7	5
Asparagin actual %	17	17	17	3	4	7	8	4	10	17	3	3	10	13	11	20

The experiments show that either asparagin or potassium nitrate can be accepted as being the most suitable nutrient for feeding the micro-organism in order to obtain a maximum of slime. After these come peptone, then urea, and finally ammonia. It must be remembered that equivalent quantities of these were present; while the asparagin tests contained 0·06 %, the urea media contained 0·024 %. It will be noted that in some cases ammonium phosphate was used, and the yields show that the low results with ammonium sulphate were chiefly due to the ammonium and not to the presence of free sulphuric acid in the media as growth proceeded. The plates with the ammonium salt were always more acid than the others at the end of the experiment, but this is only what may be expected in the case of a salt, the base of which is utilised by the micro-organism. The addition of small quantities of alkali as suggested by the "influence of reaction" experiment which follows later had but little effect in reducing the final acidity or in increasing the yield in the ammonium salt tests.

The results indicate that the Kral races of the Lupin and the Bean are the same, and that all the other races differ one from the other. Dextrose shows a difference even between the March and October races of the Pea.

THE OPTIMUM PERCENTAGE OF NITROGENOUS NUTRIENT.

Percentage of nutrient added.	Expt. 1. Macrozamia with citrate and asparagin (9 days).	Expt. 2. Macrozamia with phosphate and asparagin (14 days).	Expt. 3. Macrozamia with citrate and ammonium sulphate (14 days).	Expt. 4. Dextrose, phosphate and asparagin. (7 days).		
				Robinia at 26°.	Pea (March).	French Bean.
None	1	1	—	5	2	1
0·01	3	4	—	9	6	3
0·02	—	6	—	12	9	5
0·025	11	—	18	—	—	—
0·03	—	7	—	14	13	6
0·04	—	8	—	16	16	8
0·05	15	10	25	18	—	10
0·06	—	11	—	21	19	11
0·075	17	—	—	—	—	—
0·08	—	12	—	23	17	13
0·10	15	11	24	27	17	6
0·12	—	11	—	28	15	8
0·15	14	—	19	—	—	—
0·20	—	—	15	—	—	—
0·25	14	—	15	—	—	—

The races differ with regard to the influence of increasing quantities of nutrient in the medium. The Robinia race responds steadily to the gradual addition of asparagin, while the other races show an optimum between 0·04 and 0·08 %. Thus the Robinia race shows a marked difference from the other races.

The steady rise of slime with increasing quantities of nitrogenous nutrient points to there being no gain or fixation of nitrogen from the atmosphere. The Robinia race is a good slime-former, and this fact may account for the comparatively high yield in the test in which no nitrogen was added. There is, however, the possibility that there might have been a slight gain of nitrogen with this race. An observation upon this point appears in the addendum.

The influence of various salts was tested, and, for the sake of uniformity, I have, in the table, calculated the results upon a no-salt standard of 10. The blank tests varied from 6 to 11. Salts other than these tabulated were tried in some cases, but as they did not promise to differentiate between the races they are not recorded. Sodium-potassium tartrate and potassium lactate gave very good yields of slime.

THE INFLUENCE OF SALTS UPON SLIME-PRODUCTION.

Taking no salt as a standard = 10.

	0·5% of salt in medium.		0·2% of salt in medium.				
	Lupin (Kral)	Pea (Kral)	Robinia	Black Tare	Pea (Oct.)	French Bean	Pea (March)
No salt (= 10)	10	10	10	10	10	10	10
Potas. citrate	6	6	12	9	9	14	11
Potas. phosphate ...	1	1	13	9	18	12	11
Sodium phosphate ...	4	4	13	12	20	11	12
Potas. oxalate	0	1	6	2	2	9	3
Calcium lactate ...	8	—	7	9	8	5	9
Potas. sulphate... ..	9	9	10	9	9	9	9
Magnesium sulphate ...	8	8	9	9	8	8	6
Manganese sulphate ...	—	—	3	4	3	2	6
Sodium succinate ..	9	11	5	6	6	7	6

THE INFLUENCE OF QUANTITY OF SALT UPON SLIME-PRODUCTION.

Percentage of sodium-potassium tartrate ...	None.	0·1	0·2	0·3	0·4	0·6	0·8	1·0	2·0
Saccharose 2·5%, Asparagin 0·04% ...	18	17	16	15	15	12	12	10	—
Maltose 2%, Ammon. sulph. 0·05%	—	9	13	—	12	8	5	5	5

In this experiment with the Lupin (Kral) race, it is evident that the addition of even small percentages of salt may diminish the yield. There are, of course, traces of saline matter in the agar and tap-water which may be sufficient to nourish the bacterium. A small quantity of salt is, however, in some cases preferable, and in all cases the addition of say 0·2 % of a salt will not diminish the slime to any considerable extent.

One generally looks upon 0·5 % as being the usual amount of salt that should be in the great majority of bacteriological media, chiefly because it is employed in the cultivation of bacteria pathogenic to animals. There is no reason why that percentage should be employed in growing all bacteria. It is only from experiments such as this, in which the influence of the salt can be definitely determined by the weight of the product, that the optimum quantity of salt can be really ascertained.

We have seen that for the production of slime, the optimum quantity of nitrogen lay between 0·011 % and 0·015 %, equivalent to 0·06 % and 0·08 % of asparagin, and also that the most suitable amount of salt lay between zero and 0·2 %. It is interesting to note that this is not far removed from the amount of these constituents in soil water. With regard to the nitrogen, the nearest approach that we can get to the composition of actual soil water is found in the analyses of drainage waters which consist of soil water diluted with rain, and in these the nitrogen varies from 0·0015 % to 0·005 %. According to Nobbe and others, plants grow in fluids containing from 0·05 % to 0·2 % of saline matter, the growth being most luxuriant with 0·1 %. This is slightly stronger than the drainage water of fields which contains about 0·05% of dissolved mineral and organic matter. These percentages are, however, so close to that experimentally found for the optimum slime-production, that it may be accepted that so far as nitrogen and saline matter are concerned, the water of the soil maintains the slime-forming faculty of this bacterium in an active condition

Since the saline and nitrogenous matters of the soil suffice for the wants of the micro-organism, the carbohydrates of the root sap must be the substances that induce it to enter the root hairs.

An incubation temperature of 22° was used in these experiments, chiefly for the sake of convenience. This might, however, not be the optimum. Experiments were tried with several races with the following results :—

THE INFLUENCE OF TEMPERATURE.

	Experiment 1 (saccharose and citrate).			Experiment 2 (saccharose and phosphate).				Experiment 3 (dextrose and phosphate).			
	22°	28°	37°	16°	22°	26°	30°	16°	22°	26°	30°
Robinia	13	21	0	8	16	17	15	—	—	—	—
French Bean ...	6	1	1	5	4	3	0	3	4	2	0
Black Tare ...	2	2	0	1	3	1	0	—	—	—	—
Pea (Oct.)	4	2	0	—	—	—	—	—	—	—	—
Pea (March) ...	3	2	1	3	12	5	1	2	5	1	1
Lupin (K)	—	—	—	5	3	1	0	2	5	2	0
Pea (K)	—	—	—	2	2	2	0	2	3	2	1
Macrozamia ...	—	—	—	6	10	8	0	—	—	—	—

The optimum temperature for the majority of the races lies about 22° while the Robinia race grows best at about 26°C.

The slimes were generally alkaline in the presence of citrate and acid when phosphate had been used in the medium. The influence of the reaction of the medium was tested upon two occasions. On the first of these, two Kral races were grown upon media containing saccharose, asparagin and tartrate, to which varying quantities of normal sulphuric acid and sodium carbonate had been added. On the second occasion, four New South Wales races were grown upon media containing dextrose and phosphate, to which different amounts of normal phosphoric acid and sodium carbonate were added before pouring the plates.

INFLUENCE OF REACTION OF THE MEDIUM.

100 c.c. of medium with the addition of – c.c.N/1.		Experiment 1, Sulphuric Acid.		Experiment 2, Phosphoric Acid.			
Acid.	Sodium Carbonate.	Pea (K)	Lupin (K)	Robinia (27°)	French Bean	Pea (March)	Macrozamia
1·5	—	—	—	11	0	0	0
1·0	—	—	—	12	5	5	4
0·6	—	0	0	—	—	—	—
0·5	—	—	—	14	7	4	7
0·4	—	1	2	—	—	—	—
0·25	—	—	—	16	6	4	9
0·2	—	8	10	—	—	—	-
0·1	—	11	11	—	—	—	—
0·0	0·0	14	15	16	8	9	10
—	0·1	14	15	—	—	—	—
—	0·2	13	15	—	—	—	—
—	0·25	—	—	19	8	—	10
—	0·4	13	15	—	-	—	—
—	0·5	—	—	20	9	14	10
—	0·6	11	14	—	—	—	—
—	1·0	—	—	17	8	15	10
—	1·5	—	—	12	8	13	10

Although the quantities of acid and alkali in the table are expressed in terms of 100 c.c. of medium, the actual amounts put into the 20 c.c. tests varied from 0·01 to 0·3 c.c. The results show that phosphoric acid is less injurious than sulphuric, and also that the addition of an alkali, by conditioning an alkaline and then faintly acid state of the medium, assists in the formation of slime. The optimum quantity to add appears to be 0·5 c.c. of normal sodium carbonate to 100 c.c. of medium. It is interesting to note that this amount is approximately what is required to convert the phosphate into the tri-sodic salt. In experiment 2, the reactions of the carbonated plates at the end of the test were observed, and it was found that, with the exception of the Macrozamia race, which was neutral with

0·25 c.c., a permanent alkalinity was only obtained when 1 c.c of alkali per 100 c.c. had been added. The normal acidity of the medium is so weak (100 c.c. = 0·05 c.c. N/1) that it need not be taken into account.

The increased yield obtained by the addition of small quantities of alkali indicate that the faint alkalinity of the soil would not diminish the slime-forming faculty of the bacterium.

In connection with the possible physiological variation of races found in the nodules of different species of plants, it is essential to know whether or not the bacteria obtained from one and the same plant vary from one another. This point was investigated with microbes from the nodules of a *Robinia pseudacacia* with the result that the bacteria were found to be of one race. The experiments illustrating this are the following:—

ROBINIA RHIZOBIA WITH VARIOUS FORMS OF NITROGEN.

Sacch 2%, sod. succinate 0·2%, agar 2%, and	R1	R2	R3	R4	R5	R6
Ammonium sulphate, 0·04%	5	5	5	5	5	5
Asparagin, 0·035%	10	9	9	9	9	11
Potassium nitrate, 0·054%	10	9	10	9	8	9

ROBINIA RHIZOBIA WITH VARIOUS SUGARS.

Asparagin 0·04%, sod. succ. 0·2%, agar 2%, and	R2	R3	R4	R5	R6
Maltose	16	22	14	22	19
Saccharose	8	8	6	9	9
Dextrose	16	16	13	10	16
Galactose	7	6	6	6	6

This was also found to be the case with two bacteria obtained from nodules of different plants of *Pisum sativum* in March. When tested together, the activities were similar. But on the other hand, I have obtained races from a single nodule of the Blue Lupin which differed from one another morphologically and in their staining properties.

The differences led me to examine them further to see if they were physiologically different. Morphologically the races were as follows:—

Nodule race (a), short vacuolated cells staining deeply.
" " (b), " " " " feebly.
" " (c), long vacuolated rods.
" " (d), short and long forms with very many bacteroids.
Stem race, short vacuolated cells.

In testing the influence of the various forms of combined carbon, the media contained 0·06% asparagin, 0·2% sodium phosphate, 2% of sugars, etc., and just before pouring the plates 0·1 c.c. of 2N/1 sodium carbonate was added to each tube of molten agar (20 c.c.). In this and the succeeding experiment, the slimes were scraped off upon the sixth day; the plates were reinfected and again scraped on the fourteenth day.

LUPIN RACES WITH DIFFERENT FORMS OF CARBONACEOUS NUTRIENT.

	(a)	(b)	(c)	(d)	Stem	(d) neutral
Dextrose	4	3	18	1	2	23
Levulose	6	6	5	2	1	23
Maltose	13	11	14	1	2	11
Saccharose	8	10	8	6	1	1
Mannit	18	22	20	1	1	22
Glycerin	10	7	10	3	2	12
Lactose	2	2	6	2	2	18

LUPIN RACES WITH DIFFERENT FORMS OF NITROGENOUS NUTRIENT.

Dextrose, sodium phosphate, and	(a)	(b)	(c)	(d)	Stem	(d) neutral
Asparagin (=10)	10	10	10	10	10	10
Urea	6	6	1	5	10	8
Peptone	16	16	6	18	13	6
Potassium nitrate	6	6	2	9	14	7
Ammonium phosphate ...	6	6	1	46	18	9
Asparagin, actual %... ..	3	3	16	3	2	—
The same without alkali (7 days) ...	2	2	9	18	1	21

It is evident that races "a" and "b" are the same and that "c" and "d" are different. Race "c" differs from "a" and "b" chiefly in being able to form a considerable amount of slime from dextrose and asparagin. Race "d," which produces bacteroidal forms freely, differs from all other races that I have examined in being injuriously affected by the presence of alkalies. Without the addition of alkali, in the experiment with different forms of nitrogen, it produced 18 % of slime in a week, while with the alkali only 3 % was formed in a fortnight. The favourable influence of acidity explains the high yield with ammonium phosphate, which soon produces an acid condition of the medium. It also accounts for the low yields with the different sugars. The two experiments were repeated with "d," but sodium carbonate was not added before pouring the plates; the results are included in the tables under the heading (d, neutral). The stem race produced no slime during the first week at 22°, but during the second week while growing at 26°, a decided although small quantity of slime appeared on the plates.

The discovery of a race capable of producing a maximum amount of slime on an acid medium is of considerable importance, for such a race would form slime much more readily in the faintly acid nodular tissue than other races which thrive best in slightly alkaline media. It was previously deduced that the acidity of the nodular sap occasioned the formation of the "infection threads" which stretch from cell to cell, and it occurred to me that this was an excellent race with which to test the point. Accordingly flasks containing 50 c.c. portions of a medium containing dextrose 2 %, asparagin 0·06 %, and sodium phosphate 0·2 % were treated with increasing quantities of phosphoric and citric acids, and seeded with this acidophile race. Growth occurred in the flasks containing 0·033 % phosphoric and 0·14 % citric acids and in those containing smaller quantities. No growth took place in the flasks with larger percentages. At the end of a week, infection threads were found in the cultures and especially in that containing 0·0165 % of phosphoric acid. All the cultures contained bacteroids in considerable quantity, but they were most numerous with the limiting amounts of acid. The infection threads were noted upon examination at the end of seven days, and upon a second examination, at the end of a fortnight, it was found that the threads had given place to coils or threads of felted bacteroids. The cells in growing had apparently pushed through the wall of the thread, the slime of which had possibly dissolved, but more probably had swollen and kept the bacteroidal cells together. Cultures on solid media ("d neutral") contained short swollen vacuolated cells and few bacteroidal branching forms, a condition which was in sharp contrast with the acid fluid cultures.

From finding most "infection threads" in the flasks containing limiting amounts of acid, one would infer that the micro-organism protects itself from the action of the acid by forming a denser slime-capsule until it becomes accustomed to the acidity. While this tolerance is developing, growth proceeds actively and at the same time the capsular thread becomes diffuse and the bacteroids spread out in all directions. At the same time it must not be forgotten that acid makes the slime less soluble, that is less diffusible. But it does not matter much whether the acid affects the bacterium in the first place or the slime; the formation of an infection thread is the result of the acidity. There is one interesting point, infection threads are rarely found in the nodules of the Lupin, and this race was obtained from such a nodule.

It would appear that there is a relation between the acidity, the bacteroids and the number of dead forms in the nodule. The acidity brings about the bacteroidal condition, but an increase in the amount is enough to kill the bacteria. Since, however, some of the bacteria are alive, it is probable that the acidity varies in different parts of the nodule, and it is only in the less acid cells or vessels that the living Rhizobia may be found. There is, on the other hand, the possibility that the cells which have remained alive have been better protected by their slime capsules than those which have perished.

I believe it is assumed that a race obtained from one species of plant is typical of that species. To obtain a culture for infecting sterile soils or for the preparation of so-called "Nitragin," one need only isolate a bacterium from the nodules of, say, growing Blue Lupins, in order to be able to infect other Blue Lupins.

While this may be true generally, it cannot be relied upon, as is shown by the isolation of three distinct races from a single nodule of the Blue Lupin. We cannot say with certainty which of these races is typical for the species or for the individual plant in the nodule of which they occurred. Race (a) or (b) was more numerous, but that may not be a criterion. Upon theoretical grounds, I should rather trust to the acidophile race (d). The isolation of at least three races in one nodule raises the questions, Which of these is most akin to the original microbe that entered the root-hair? and, If such an alteration can occur in the nodule, is there a microbe specific for any species or genus of plant? Remembering the case of *Bact. acaciæ* and its variety *Bact. metarabinum*, I am of the opinion that the differences which are found among the races after isolation are largely the result of the sojourn of the microbe in the sap of the host-plant.

The plant is probably able to modify the faculties of a *Rhizobium* derived from any other plant to its individual requirements, once the bacterium has obtained access to the tissues of the root. But if the micro-organism cannot form slime from a particular sugar and only that sugar chances to be in the sap of the plant, there can be no inducement offered to the microbe to enter the root-hair. Bacteria from one plant are therefore best adapted for entering into symbiotic relationship with members of the same genus, as it is only upon plants of the same kind that we can rely for containing the sugars to which the microbe has been accustomed.

Conclusions.

It has been shown that slime is formed by the majority of the races of the nodule-former upon solid media and that as a rule the media need only contain a sugar and a source of nitrogen, the traces of salts such as occur in the infecting material, the nutrients and the tap-water being enough for their requirements. In such media, growth could not be maintained for any length of time, but this could not be expected.

The quantity of slime that may be produced depends largely upon the combination of nutrients, and especially upon the nature of the salt. Organic salts such as citrates, tartrates or succinates enable a luxuriant slime to be formed, but they do not enable differences to be exhibited between the races. Phosphates, although they do not as a rule assist the formation of so luxuriant a slime, yet bring out certain racial peculiarities in response to the nutrients. With certain races, small quantities of dextrose in the presence of citrate nearly prohibit the formation of slime from saccharose. With other races, and in the presence of phosphate, the addition of dextrose to saccharose increases the yield. The action of levulose is peculiar. Some races produce slime from it while others do not. Lupin (Kral) race makes slime from this sugar in the presence of phosphate, but not of citrate or other organic salt. The general inability of the races to form slime from levulose appears to depend more upon the individual acid which is also produced than upon the acidity.

The most suitable sources of nitrogen are asparagin and nitrate; ammonium salts are bad, while peptone and urea are variable. As a rule the optimum percentage of asparagin in the medium varies from 0·04 to 0·08, but in the case of Robinia the yield of slime was proportional to the asparagin added.

The quantity of saline matter required in the formation of slime is small, from 0·1 % to 0·2 % is enough, and like the optimum quantity of nitrogen, this approximates to what is found in soil water.

As a rule the optimum temperature is 22°C. An exception is the race obtained from *Robinia pseudacacia*, which has an optimum of 26°.

The most favourable reaction for the medium depends upon the kind of salt which may be present; a neutral reaction is best with organic salts and an alkaline with phosphates. An exception was found in an acidophile race which was obtained from the Blue Lupin.

The experiments upon the physiological activities of the various races of the micro-organism show that, after their isolation from the nodules, they are all different. How they may have behaved before they had been subjected to the individual juices of the various plants, we cannot tell, but they undoubtedly differ after their isolation. Some form slime upon nutritive media and others do not; some of the former produce slime upon composite media and not upon synthetic media, while the majority form it upon both. The bacteria from the nodules of the same plant may or may not be similar physiologically. From the same kind of plant isolated at different times of the year, they may be closely related, and show fewer differences than bacteria from different kinds of plants. The race from *Robinia pseudacacia* is quite distinct from Kral's race from *Lupinus luteus*, and both of these clearly differ from races obtained from *Pisum sativum* (Kral's as well as Australian races) and *Phaseolus vulgaris* (Australian). The latter race approximates to those from *Pisum*, and that from *Vicia faba* (Kral) approximates to the race *Lupinus luteus* (Kral). But that there can be no rule in the matter is shown by the isolation of three physiologically different races from a single nodule of the Blue Lupin.

With regard to the function of the micro-organism in the nodule, there is strong evidence that it is to produce slime which may be closely related to the carbohydrate of the nucleoproteid molecule. The slime, in all likelihood, is partly utilised *in situ*, and the formation of the nodule is the result. Thus there is, probably, a true symbiosis so far as the nodule is concerned. The slime may be transported to other parts where it is utilised. There is no evidence to show that the albuminoids of the micro-organism are utilised by the growing plant, for, although the majority of the bacteroids of the nodule are dead, they still retain their chromatin. Living Rhizobia are found in other parts of the plant, *e.g.*, the stem, but in these places they are unable to form slime, and are probably of no use to the host-plant. The formation of slime is proportional to the nitrogen supplied, and there appears to be no fixation of nitrogen in pure culture. The formation of bacteroids depends upon the nature of the carbohydrate, which is the principal constituent of the slime. *Vibrio denitrificans*, which converts combined nitrogen, *e.g.*, nitrate, into free nitrogen gas, produces the same slime and gives the same bacteroidal formation. Much, however, depends upon the acidity of the sap of the nodule, which, by making the capsule of the micro-organism more insoluble, brings about the branching condition. The acidity also conduces to the formation of the "infection threads" of the nodule.

The inconsistency of the results hitherto obtained in the inoculation* of the leguminous crops with bacterial cultures are, probably, in part, at least, due to the fact that the slime-forming function of the micro-organism has not been recognised, and races incapable of forming slime have been taken. Furthermore, the infective material may have, to a great extent or entirely, lost this typical property. But even among those races which form slime luxuriantly, and which are probably the better able to assist the plant, there are to be found differences of character which may be of such a nature as to determine whether the micro-organism is a nodule-former or not. A notable example is the acidophile slime-forming race isolated from the Blue Lupin. Such a race appears to be one which, among all others, is most suitable for producing slime in the nodules of the plant. Races with similar acidophile, slime-forming characters, promise to be most efficient agents to use in the preparation of commercial cultures of the micro-organism.

Addendum.—When isolating *Rhizobium leguminosarum* from the Blue Lupin, I found a colony which produced a luxuriant slime upon saccharine media. It consisted of a mixture of three bacteria, viz., *Bact. radiobacter*, *Azotobacter chroococcum* and *Bac. levaniformans*. In a synthetic, nitrogen-free medium, the mixture of the bacteria gave 10 % of slime, and a determination of the

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* An experiment upon a small scale was made by Mr. H. W. Potts, Principal of the Hawkesbury Agricultural College, at my request, to test the effect of the infection of Cow Peas with slime-forming bacteria isolated from the Field Pea and Black Tare. The results were negative, but this might be explained by the abnormally dry season, by the unsuitability of the bacteria of one crop for another, or by the presence of a sufficient number of slime-forming bacteria already present in the experimental soil. Probably the last of these conditions prevailed.

nitrogen showed a gain equal to 0·01 % of asparagin. If the ubiquitous and multifarious *Bac. levaniformans* is the same bacterium as Beijerinck's *Granulobacter*, then he experimented with the same three bacteria and found that the gain was due to *Azotobacter*. My experiments, which are in progress, indicate that *Bact. radiobacter*, and not *Azotobacter*, is the active nitrogen-gainer. An extension of the experiments has shown that some races of *Rhizobium leguminosarum*, *e.g.*, Robinia, are capable of forming a comparatively luxuriant slime on nitrogen-free, dextrose media in combination with *Bac. levaniformans*, which does not form slime (levan) from that sugar. The quantity of slime indicates that there may be a gain of nitrogen. The matter is, however, under investigation.—*July 19th, 1906.*

THE STRUCTURE OF *RHIZOBIUM LEGUMINOSARUM.*

By R. Greig-Smith, D.Sc., Macleay Bacteriologist to the Society.

(Plates xxi.-xxii.)

From the appearances presented by *Rhizobium leguminosarum* when grown in a peptone-glucose fluid medium, I concluded in a former paper* that it was a yeast, chiefly because vacuoles and budding forms were the prominent features. I have not, however, been able to confirm this view, for although vacuolation and small terminal cocci are undoubtedly present, we can interpret these characters otherwise when we take into consideration other phenomena that are manifest upon growing and staining the cells under more favourable conditions.

During the investigation of the production of slime by *Rhizobium*, recorded in the preceding paper, cover-glass preparations were made from time to time to determine the influence of nutrients, &c., upon the formation of bacteroids, *i.e.*, branching forms of the micro-organism, and in some cases special experiments were made to discover the action of certain methods of nutrition.

Süchting† in a critical study of the nodule bacteria reviews the work of numerous investigators, some of whom, *e.g.*, Beijerinck, Laurent, Stutzer and Hiltner, found that bacteroids could be obtained on solid media, while others, *e.g.*, Prazmowski, Neumann and Süchting himself, found that they could not.

I have grown the cells upon solid media and have undoubtedly obtained bacteroidal forms, as can be seen from the plates which accompany this paper. But at the same time I have found a

* These Proceedings, 1899, 653.
† Centr. für Bakt. 2te. Abt. xi. (1903) 381.

much larger percentage of these irregular forms in suitable (acidified) fluid media. This was the case with the acidophile race obtained from the Blue Lupin (p.287). When recently isolated it produced an abundance of bacteroidal forms, but as time went on the cells became more and more rod-shaped, until at the time of making the fluid cultures few bacteroids were obtained upon saccharose-bean-agar. The acidified fluid cultures, when examined at the end of a fortnight, contained few rod-shaped cells, the rest were well-defined bacteroids.

Upon a maltose-citrate medium (p.275) the cells imbedded in the slime were of comparatively large size, measuring $0{\cdot}9 : 3{\cdot}4\,\mu.$, and among the mass of rod-shaped organisms were many γ and Y forms. The cells were not readily coloured with the ordinary stains; in the majority of cases they appeared in silhouette, the matrix or slime around the cells being stained while the cell itself was colourless.

It was noted that the kind of nitrogenous nutrient had no influence upon the formation of the branching forms, but this could not be said with regard to the influence of salts, for some acid radicles, *e.g.*, citrate and phosphate, did seem to favour their production. Much, however, depended upon the individual bacterium. Differences occurred among the varieties of the races, if such an expression may be used, even when these varieties were isolated from the same nodule. This was very clearly shown in the case of several cultures obtained from colonies derived from a single nodule of the Blue Lupin. Some consisted of short cells, others were long; some stained deeply, others feebly; the irregular forms were few, with the exception of the acidophile race, in which they were numerous.

The percentage of salt (citrate) in the medium did not have much effect upon the irregularity of the cells. In the absence of saline matter the cells stained feebly; with 1% they stained deeply and irregularly. In experiments with acid and alkaline media (p.285) the reaction had little influence.

For the production of a slime containing large stout cells with many bacteroids, no medium appeared to be so suitable as one containing maltose 2%, ammonium sulphate 0·04-0·06%,*, potassium citrate 0·5% and agar 2%. Phosphate (0·5%) gives rise either to short cocco-bacteria or to short rods, while citrate produces long rods.

It is obvious that with an organism which varies so much, and which has baffled so many investigators, one must endeavour to obtain large cells in order to see the inner structure. So far as I know, this has not hitherto been done; but during this research, as has been already mentioned, large forms were obtained when maltose, citrate and ammonium sulphate were contained in the agar medium. But the difficulties connected with a clear and sharp staining of the cells were not overcome by growing a large-sized microbe. There is always some slime produced, sometimes in quantities so small as to be inappreciable except when one endeavours to determine the structure of the cells. The slime is a disturbing element, for it is in most cases stained as deeply as the chromatin. This applies to the slime without the cells. If there be slime within the cells, there is little wonder that the recognition of the structure has been so difficult. An examination of over thirty anilin dyes showed that the slime in bulk was coagulated and coloured by all except eosin and methyl-green (Grubler). But having previously obtained a good staining with an old solution of carbol-fuchsin, I made experiments and found that the best results were obtained with a weak stain containing the following:—Fuchsin (Grubler) 0·1 grm., alcohol 10 c.c., 1% phenol 90 c.c. The method consisted in adding a large loopful (5 mm. diam.) of the slime to 4 c.c. of distilled water contained in a test-tube, and inserting the tube into a beaker of water at 80°. The slime is, as a rule, speedily distributed in the water and a uniform suspension of the cells obtained. Two c.c. of the stain (at 80°) are added and the tube replaced in the water and kept at 80° for from 4 to 8 hours. By this treatment the solution does not gelatinise upon cooling, and the cells remain uniformly

* We have already seen that this salt produces an acid reaction of the medium (p.280).

distributed. A large loop or a small drop of the suspension is spread over a cover-glass. The film is allowed to dry in the air, it is then passed through the flame and decolourised with 0·5 % acetic acid (0·5 c.c. of the glacial acid in 100 c.c. of water), after which it is dried between sheets of blotting-paper and imbedded in balsam.

The method is simple, but the result depends largely upon the time that the stain is in contact with the cells. Six hours is generally correct. With less than this the contents of the cells are not sufficiently stained, while with more they become overstained and the structure cannot be seen. Stronger acetic acid than that advised does not remove the excess of stain and only produces a grey colour. Every culture will not give good films; much appears to depend upon the amount of slime. It was only from cultures giving over 8 % of slime that good films were obtained. The cells then appear to be very diffuse or swollen, and the contents are readily stained and observed. It is not advisable to have too much of the culture in the dilute stain as the slime forms a coagulum with the fuchsin.

Instructive films were obtained from cultures of Robinia and Bean races which produced over 8 % of slime upon plates of maltose-citrate-ammonium sulphate-agar. Overstained cells appeared to contain one or two spongy portions (fig.1), but when properly stained the rods were seen to consist of a number of bipolar staining spherules or coccoid structures (fig.7). Once these bodies are recognised it is not an easy matter to find cells which suggest any other form of structure. Here and there in the films were deeply-staining free cocci (fig.2). These were also frequently seen within rod-shaped cells or capsules (fig.3), sometimes singly and central, but generally paired and terminal. There may be two or more (figs.3,4). The occurrence of the large diffusely-staining spherules and the deeply-staining cocci in the same capsule enables the latter to be recognised as a condensation of the former, and this is made manifest by the diplococcoid structure of the larger deeply-staining units (figs.5,6). The poles of the large spherules are frequently absent and a uniform outline is seen (figs.8,10). Occasionally a single pole is noted (fig.12). The spherules are sometimes flattened and present the appearance of a bipolar rod or bacillus (shown double in fig.9).* Since the *Rhizobium* cell is a tubular capsule containing spherules, it is easy to understand that by an increase in the number of these spherules the cell may become misshapen, and irregular forms be produced. The beginning of a T shape is depicted, and also an exclamation mark, "!" (fig. 10). The displacement of the spherules from internal pressure is often seen (fig.11). The poles have no definite inclination to the direction of the rod-shaped capsule; sometimes they are parallel, at others they are at right angles, while, again, they may be at a smaller angle (fig.7). Since the poles of the spherules have inclinations at different angles to the length of the tubular rod, they will, upon dividing, grow in different directions. Should the growth proceed at a pronounced angle to the rod, an irregular form or bacteroid will result. The same will occur if the spherules within the rods increase in size at different rates as in fig. 6. A flattened terminal structure may be seen at an angle to the rod (fig.13).

Such are the most instructive forms that were seen in a culture of a Robinia race. Those shown in figs. 7 and 12 were by far the most numerous; occasionally long and much branched forms were seen, the whole contents consisting of the swollen spherules.

A Bean race which was also examined showed a similar structure (Plate xxi.) of the cells, but as they chanced to be much more swollen and more branched forms were present, the films were very instructive. Probably on account of the very swollen condition of the spherules, the bipolar staining was not so much in evidence. Although the majority of the cells were rod-shaped, as in the Robinia slime, the odd forms showed points of interest. A curious, but not uncommon, massing of the spherules is shown in fig. 3, in which the alteration of shape due to pressure is seen.

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* The bipolar rod-shape recalls the form of the bipolar staining bacteria such as *Bact. pestis*, which, under some conditions, exhibits a branching formation.

A similar distortion occurs in figs. 4, 5, 6 and 12. Most of the other cells figured in the plate show the method of formation of the bacteroids; the multiplication of the spherules within the capsule causes a pressure which is laterally applied, probably through the division of the spherule at right angles to the direction of the rod. Without the pressure, the dividing spherule would arrange itself along the capsule. In this particular set of Bean race films the condensed forms of the spherules were rarely seen, but one with a lateral outgrowth is shown in fig. 17. When the cells are overstained and decolourised with alcohol, the denser crescentic portions of the spherules alone retain the stain, and forms like figs. 18, 19 are seen.

Although a maltose medium was used for growing the slimes in these two cases, other sugars gave similar results. With saccharose there was rather more condensation of the spherules, and especially of the terminal units. These were at some distance from the central spherules, and gave the appearance of terminal buds, which is so common a feature of the cells grown in or on ordinary media.

The coccoid* structure of *Rhizobium* has been advanced by other observers, and this could only be expected in view of the frequent occurrence of the condensed terminal cocci. In a critical review Vogel† mentions Paratore, who saw small cocci in the plasma of the branched forms. That the bacteroids are sporangia was brought forward by Brunchorst and Moeller, and confirmed by Hiltner and by Hartleb. Süchting considered that the proof of the sporangium nature of the bacteroids was not convincing enough, as it was possible that the contents of the sporangia were either artificial products or they were the Babes-Ernst granules which are met with in other bacteria, *e.g.*, *Bac. diphtheriæ.*

With regard to these granules, Marx and Woithe ‡ consider that they are the products of the maximum condensation and of a typical localisation of the chromatin of the bacterial cell.

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* Mazé (Ann. de l'Inst Past. xii.) figures cocco-bacteria.
† Cent. für Bakt. 2te. Abt. xv. 185.
‡ Cent. für Bakt. 1te. Abt. xxviii. 100.

As these granules become more or less reddish when coloured by some blue stains, *e.g.*, polychrome methylene blue, they are said to be metachromatic. Granules staining similarly are met with generally in the bacteria, yeasts, moulds, algæ, &c., but they appear to be of the nature of a reserve material which has been called "volutin" by Arthur Meyer. On account of the metachromatic character of the Babes-Ernst bodies, Guilliermond* assumes that they consist of volutin.

Although the round granules of *Rhizobium* may simulate volutin granules in their staining properties, yet in view of these observations regarding the structure of the nodule-former, it is clear that they are not reserve material. *Rhizobium leguminosarum* is a compound micro-organism and consists of cocci, micrococci or diplococci, the chromatin of which may be swollen or condensed, within a tubular, straight or branching rod or capsule.†

There are some points of resemblance between *Rhizobium leguminosarum*, *Bac. diphtheriæ* and *Bac. tuberculosis.* Under certain conditions they exhibit branching forms and the cells contain granules of dense chromatin. The granules of *Rhizobium*, which I have shown to be condensed coccoid structures, are stained reddish (purple) by Leishman's modification of the Romanowsky stain, and in this respect appear to be identical with the Babes-Ernst granules of the diphtheria bacillus. *Bac. tuberculosis*, under certain conditions, shows an irregular staining and has a vacuolated appearance, supposed to be caused by a plasmolysis of the bacterial protoplasm, and even terminal coccoid structures (so-called spores) may be observed.‡ It is true that the free coccoid forms have not been observed with these bacteria, but this may be a question of medium and of the nature of the capsule. The so-called spores are most clearly seen when the bacteria are grown upon media with a vegetable basis, and it is upon such

* Bull. de l'Inst. Past. iv. (1906) 145.

† A name is required for the capsular rod. That of sporangium raises the inference that the contents are spores, and as they are clearly micrococci or diplococci, the name is misleading.

‡ Meier, Cent. für Bakt. Ref. xxxvi. (1905) 606.

media that a certain amount of slime would be formed. Much might be learnt regarding the true inner structure of the cells by training them to increase their zooglœa slime as I have done with the nodule-former.

Rhizobium leguminosarum is not the only bacterium which has a composite structure. I have mentioned some pathogenic bacteria, and in view of the similar morphology and chemical nature of the slime (capsule) of *Vibrio denitrificans*, there can be little doubt that it has the same structure. The rosette-forming *Bacterium radiobacter* produces a slime under certain conditions, and when stained in the manner that I have recommended, it is seen to have a vacuolated appearance. The chromatin appears in transverse bands in the majority of cases, but frequently these are divided, and just as often a large terminal coccus can be seen. The division of the band is sometimes pronounced and the halves are rounded, in short, they are cocci. Frequently the large coccus shows a transverse clear space or line. It is probable that the bands are cocci pressed out of shape by a non-staining cell plasma, and that the true coccoid shape results when the surface pressure is reduced.

We thus see that *Bact. radiobacter* has some structural affinity with *Rhizobium leguminosarum*, and probably many more bacteria may be similarly constructed.

ON TWO SPECIES OF EUCALYPTUS, UNDESCRIBED OR IMPERFECTLY KNOWN, FROM EASTERN AUSTRALIA.

By R. T. Baker, F.L.S., Curator, Technological Museum, Sydney.

(Plates xxiii.-xxiv.)

Eucalyptus carnea, sp.nov. (Syn. *E. umbra* R. T. Baker, partim).

(Plate xxiii.)

A tall tree, attaining sometimes a height of 100 feet, with a dark-coloured "stringy bark" which runs right out to the branchlets. Abnormal leaves opposite, sessile, cordate, ovate, acuminate, thin, pale-coloured on the underside where the venation is more pronounced, upper surface shining, over 3 inches broad, and sometimes 6 inches long. Normal leaves lanceolate-falcate, varying in length up to 8 or 9 inches, and in breadth from under 1 inch up to nearly 3 inches, and often very oblique at the base, the larger leaves especially so, coriaceous, pale-coloured on both sides. Venation well pronounced in the abnormal, but not quite so distinct in the normal leaves; the intramarginal vein is well removed from the edge, and the lateral ones are distinct, oblique and spreading.

Inflorescence occurs mostly in terminal panicles, but occasionally in axilliary peduncles. Calyx turbinate, gradually tapering into the flattened pedicel. Operculum hemispherical, shortly acuminate.

Fruits hemispherical, about 3 lines in diameter, rim thin, valves sunken.

Technology.

From a technological point of view its greatest interest lies in its oil content, although the timber and bark are of some marketable value.

Timber.—Commercially, the timber of this species is very little known, but the experiments so far carried out with the specimens available show it to be one of the best of the Stringybarks. It is closely textured and not easily dressed, being fairly interlocked, and more so than its congeners; it is pink or flesh-coloured, and is no doubt a good timber for building purposes, fences, &c. Two pieces 2 feet by 2 inches by 2 inches each were tested for bending stress, (a) broke at 4,400 lbs.; (b) broke at 4,200 lbs.

Oil.—The yield of oil is small, amounting to 0·155 per cent. It consists largely of a dextro-rotary pinene, and a small percentage of eucalyptol, about 5 per cent.; whilst no phellandrene could be detected. The oil is thus of no immediate commercial value, but is of scientific interest, in that it contains an acetic acid ester, a partial analysis of which is published in "Research on Eucalypts and their Essential Oils" (Baker and Smith), and a full determination is now in progress, and the results will be published at a later date by Mr. H. G. Smith of this Museum.

Hab.—Wardell; Dunoon, Richmond River; Lismore (W. Bäuerlen).

This species was originally confounded by me with *E. umbra* when describing that species in the Society's Proceedings (1901, p.687). Since publishing that original description, facts have come to light which show that the abnormal leaves and "early fruit" there described and figured under *E. umbra* are those of this species, otherwise the botanical description and figure of *E. umbra* (l.c.) are correct, and apply well to the "Coast Bastard White Mahogany." In the work "Eucalypts and their Essential Oils" (Baker and Smith), p.36, these errors are repeated. The "early fruits" were thought at the time to be immature specimens of *E. umbra.* In general appearance, especially so in bark characters, *E. carnea* resembles *E. nigra*, along with which it is found growing (W. Bäuerlen), the timber is, however, tinged with pink, giving it a flesh colour, and this feature can be used in Museum specimens to distinguish the timber from other species of Stringybarks.

It is fairly plentiful in the Lismore district, being gregarious with *E. nigra* R. T. Baker, and *E. microcorys* F.v.M., but is more restricted to the open forest than those trees, both of which also occur in the rich dense scrub, in fact, it is there that these attain their greatest perfection (W. Bäuerlen).

The bark is persistent right out to the smallest branchlets, and is used for roofing and other purposes by the settlers (W. Bäuerlen). The abnormal leaves, venation and texture differ in shape from those of *E. umbra*, the species with which it was previously confounded by me. The fruits, however, can scarcely on a first inspection, if at all, be distinguished from those of *E. acmenioides*, a species otherwise having quite a different timber, oil and foliage. In *E. acmenioides* it will be found that the valves and inner rim are always deeper sunk than in *E. carnea.* The leaves of these two trees, though having much the same venation, are decidedly different, especially in their texture, shape and colour. Those of *E. acmenioides* are thin, whilst those of *E. carnea* are thick; and the abnormal leaves of each are quite different and sharply divide the species. Its nearest congener is *E. nigra* in a ligneous classification, otherwise it differs from it in the shape of its fruits, leaves and oil contents.

The specific characters which differentiate it from the other Stringybarks, such as *E. Wilkinsoniana*, *E. lævopinea*, *E. dextropinea*, *E. eugenioides*, *E. fastigata*, *E. capitellata*, *E. macrorhyncha*, are too obvious to be enumerated here.

In a systematic series it might be placed between *E. acmenioides* and *E. nigra.*

EUCALYPTUS THOZETIANA F.v.M., ined. "Lignum-vitæ."
(Plate xxiv.)

An erect, graceful tree, rarely attaining a height of over 70 feet, with a smooth, compact, whitish bark, decorticating in hard, short flakes at the base, which, according to Mueller's MS., is deeply furrowed, but is not so described by my correspondent, Mr. C. W. Chapman (to whom I am indebted for the full material). Branchlets angular, but soon terete, reddish-coloured.

Leaves mostly alternate, from linear or narrow lanceolate in the adventitious shoots, and from lanceolate to oblong lanceolate in the normal form; under 6 inches long and half an inch wide; occasionally shining. Venation rather obscured in the thick epidermis; lateral veins sparse, oblique, distant; intramarginal vein removed from the edge. Oil glands numerous, but exceedingly small.

Flowers small on axillary peduncles or terminal panicles. Calyx turbinate, angled, gradually tapering into a short pedicel. Operculum conical, blunt.

Fruits small, oval-urnshaped, angled, under 3 lines long, and under $1\frac{1}{2}$ lines in diameter, valves depressed.

TECHNOLOGY.

Timber.—The timber of this tree is harder than that of any Eucalyptus tree known to me. It is very heavy, close-grained and interlocked, has a chocolate colour, and much resembles, in texture, colour and hardness, Lignum-vitæ, *Guaiacum officinale* Linn., of Central America. In fact, it is more deserving the title of Australian "Lignum-vitæ" than other trees of the Continent passing under that name, and I have so named it in Museum specimens. It is no doubt very durable and suitable for sleepers, posts, rails, bridges, cogs, mallets, &c., &c.

Oil.—Through the kindness of Mr. C. W. Chapman of Tandawanna Estate, leaves were received from that locality, but the result of the distillation was disappointing, as the amount of oil was very small, not more than a large teaspoonful of oil being obtained from 88 lbs. of leaves and terminal branchlets.

The oil is reddish in colour and very mobile, evidently consisting largely of esters.

The refractive index at 16°C. is high, –1·5026; Specific Gravity at 16°C. 0·9257 (H. G. Smith).

Hab.—Queensland, Tandawanna (C. W. Chapman), Newinga, Goondiwindi (C. W. Chapman), Cometville and Emerald (rare; P. A. O'Shanesy, in Herb. Melb.); Expedition Range (Thozet, in Herb. Melb.).

Baron von Mueller refers to this tree in his 'Eucalyptographia' under *E. gracilis*, in these words :—"Either as a variety or perhaps, even as a species, can be distinguished from *E. gracilis*, an Eucalyptus gathered by the lamented late Monsieur Thozet in his last botanical journey to Expedition Range, during which he became a victim of the paludal fever, to which this excellent man so sadly succumbed. This Eucalyptus, which should bear his name, can be distinguished by its longer leaves, narrow-ellipsoid flowerbuds, smaller, more or less conspicuously angular calyces, and also smaller and particularly narrower fruit, irrespective of the size of the tree, which rises to a height of 60 feet, according to Mr. E. Bowman, and Mr. P. O'Shanesy who noticed it near the Mackenzie and Comet Rivers."

Maiden in his "Critical Rivision of Eucalypts" (Part iii. p.82) also places it as a doubtful variety under *E. calycogona* Turc., var. *gracilis* F.v.M., var. *Thozetiana*, and states, *inter alia*, "While these specimens (from Expedition Range, Q.; Mackenzie River, Q.; Warrego and Flinders Rivers, Q) probably belong to *E. calycogona*, in my opinion these Queensland trees appear to show transit to the narrow-leaved forms of *E. odorata*. Additional material, including ripe fruits, and further particulars as to habit, bark, timber, &c., are necessary before the position of this tree can be stated without doubt."

This Eucalyptus occurs in the interior of Queensland, "mostly on the dry ridges bordering on the brigalow scrubs, and sometimes extending to them" (O'Shanesy), a location endorsed by the observations of Mr. C. W. Chapman, from whom all the material described in this paper was obtained.

Leaf- and budding specimens of this Eucalyptus were sent to this Museum as far back as 1898, but it was only recently that complete material had been obtained, after much trouble and expense incurred by Mr. C. W. Chapman in defraying the expense of carting the material to the coast from so far an inland town as Goondiwindi, and thence to Sydney.

The fruit, timber and oil constituents at once showed that it was distinct from any recorded species of Eucalyptus, the timber especially so.

It differs from *E. gracilis*, under which it has been placed, in (1) That it attains tree form, whilst *E. gracilis* is invariably a "Mallee" in Eastern Australia. (2) The shape of the abnormal leaves. (3) The shape of the normal leaves. (4) Texture of leaves. (5) Shape of the buds. (6) Shape of the fruits. (7) Nature of the timber. (8) Oil constituents.

Morphologically the leaves resemble those of *E. polybractea* R. T. Baker, and some forms of other Mallees such as *E. viridis* R. T. Baker, &c.

The bark and colour of timber show some analogy to those of *E. tesselaris*, but the latter has bark of a coarser nature with larger tesselations, and a timber much less durable and softer than that of *E. Thozetiana.*

E. loxophleba Benth., the "York Gum" of Western Australia has the reputation of being the hardest of Australian timbers, but *E. Thozetiana* far exceeds this species in this particular quality.

Systematically the species might be placed next to *E. tesselaris* F.v.M.

At Tandawanna, Goondiwindi, it is called "Yappunyah," a name applied also to *E. ochrophloia* F.v.M., a far western species.

EXPLANATION OF PLATES.

Eucalyptus carnea R. T. Baker.

Plate xxiii.

1.—Abnormal leaves.
2.—Panicle of buds.
3.—Flowering spray with normal leaves.
4.—Fruits.

[All natural size].

Eucalyptus Thozetiana F.v.M.

Plate xxiv.

1.—Abnormal leaves.
2.—Twig with bud and leaves.
3.—Fruiting spray.

[All natural size].

REVISION OF THE CICINDELIDÆ OF AUSTRALIA.

By Thomas G. Sloane.

Plates xxv.-xxxi., from drawings by Arthur M. Lea and H. J. Hillier (Plate xxxi.).

This paper had its origin in an offer by Mr. A. M. Lea to prepare some illustrations of the Cicindelidæ of Australia if I would supply the letterpress. Students of the Cicindelidæ owe a debt of gratitude to Mr. Lea for applying to this family his skill and knowledge of anatomical draughtsmanship gained by long study and careful descriptive work in the order Coleoptera, more especially as his action was prompted solely by his enthusiasm as a coleopterist.

After considerable progress had been made with this Revision Dr. Walther Horn sent me his "Systematischer Index der Cicindeliden" (Berlin 1905), and invited me to correspond with him; he kindly read the first drafts of my species-tables, and offered some opinions thereon; it is therefore with much pleasure that I record my thanks to him for the assistance he has given, which has enabled me to make my work of fuller value and more modern tone than could otherwise have been the case. My thanks are also especially due to Mr. C. French, of Melbourne, for valuable assistance by the gift and loan of specimens, including the three new species recorded in this Revision.

Taxonomy.

Darwin's views on classification should never be lost sight of by the systematist, and I would direct particular attention to the following, namely (1) the falsity of the idea that those parts of the structure which determined the habits of life, &c., of each animal would be of very high importance in classification; (2) the importance of an aggregate of characters even of trifling value; (3) the invariable failure of classifications founded on any single character; (4) the quotation from Linnæus "that the characters do not give the genus, but the genus gives the characters."*

The Darwinian dictum that a classification founded on a single character has always failed, and the Linnean aphorism that the genus gives the characters not the characters the genus, form the true foundations of taxonomy, yet it is to be noticed that these basic principles are often utterly neglected by systematists in entomology. The following two hypotheses (not new) are also deserving of careful consideration. (1) Any character with a tendency to vary is likely to vary greatly, so that it may become exaggerated, rudimentary, or may be quite lost in different allied families, tribes, genera, or even in groups of species in large genera. (2) Characters once lost are extremely unlikely to be reacquired.

The first of these hypotheses will justify us sometimes in treating an organism which varies greatly from its nearest known allies in some particular character as possibly an exceptional case; *e.g.*, the absence of pubescence on the body generally in *Cicindela tetragramma* (and allied species) may not necessarily indicate descent from a stem in which such pubescence was wanting. The second hypothesis results from the belief that any character which becomes lost does so from such fundamental inherent tendencies of the organism that its reacquirement, at any rate in such a highly developed order as the Coleoptera, would imply an absence of continuity in the laws of development which seems at variance with the orderly trend of such laws

Till the year 1898 the classification of the Cicindelidæ adopted by Lacordaire in his "Genera" (1854) was that generally recognised; but in 1898 Dr. Walther Horn formulated a new and quite original system of classification. It will be useful to set out these two systems.

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* *Cf.* 'Origin of Species' (6th ed. Lond. 1878) pp.365-367.

Lacordaire's System (1854).

i. Maxillæ terminated by an articulated hook.
  A. Third joint of the maxillary palpi longer than the fourth.*
    First joint of the labial palpi extending feebly beyond the bottom of the sinus of the mentum.......... ... .MANTICORIDES.
    First joint of the labial palpi extending strongly beyond this sinus.................. ................................MEGACEPHALIDES.
  B. Third joint of maxillary palpi shorter than the fourth
    Fourth joint of the tarsi entire............. ... .CICINDELIDES.
    Fourth joint of tarsi cordiform, at least the anterior.....COLLYRIDES.
ii. Maxillæ without an articulated hook....... . ... CTENOSTOMIDES.

Horn's System (1898).

(Abbreviated to show Australian tribes.)

i. Episterna of metathorax small, narrow, furrowed from the front.
  CICINDELIDÆ ALACOSTERNALIÆ...... .. .. { i. *Ctenostomidæ* Lacordaire. / ii. *Collyridæ* Chaudoir.
ii. Episterna of metathorax wide, not furrowed from the front...... ....CICINDELIDÆ PLATYSTERNALIÆ.
  Prosternal sulcus the continuation of pronotal sulcus.
    Outer lobe of maxillæ rudimentary, &c.....................iii. *Theratidæ.*
    Outer lobe of maxillæ long, biarticulate. Fourth joint of tarsi not widely cordiform. Orbital plane seldom sharply defined. Body frequently setose. Basal furrow variable.... iv. *Cicindelidæ* Lacordaire.
  Prosternal sulcus not the continuation of pronotal sulcus. Orbital plane not defined.
    Shoulders extending above hind angle of pronotum. Prosternum between coxæ raised in a curve.
      Pronotal and proepisternal sulci permanently separated.
        Tibiæ not densely uniformly setose. Basal furrow variable.
          First joint of labial palpi extending far beyond the tooth of the mentum, second generally much smaller than first. Number and size of the visible abdominal segments often variable, &c.. ....v. *Megacephalidæ.*

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* Lacordaire speaks of the labial palps as 4-jointed, though he described them thus :—" Palpes de quatre articles : le premier formé par leur support qui s'est agrandi et est devenu libre." (Genera, p.1). Horn in the table given below also refers to the basal piece of the palp as its first joint. Ganglbauer describes the labial palps accurately as 3-jointed, but appearing 4-jointed owing to the palpigerous piece of the labium becoming free and showing in the sinus of the mentum like the basal joint of the palp (Die Käfe von Mitteleuropa, 1892, p.6).

Then follow—vi. *Neomantichoridæ*, vii. *Paleomantichoridæ*, and viii. *Platychilidæ*, which are together equivalent to the MANTICHORIDES of Lacordaire, but are not represented in our fauna.

Lacordaire's classification is very artificial, the variations of the labial and maxillary palpi being quite inadequate for the purpose of differentiating tribes amongst the Geodephaga. All our Cicindelidæ belong to the *Cicindelidæ platysternaliæ* of Horn; and our only tribes, the Megacephalini and Cicindelini are the same in the systems of Lacordaire and Horn.

Note on the prothorax.—Dr. Horn divides the *Cicindelidæ platysternaliæ* into two chief divisions according as the prosternal sulcus is continuous with the apical pronotal sulcus or not. This division is a most excellent one, but Dr. Horn's way of expressing the difference between the Megacephalini and the Cicindelini, though terse and readily understood, and therefore eminently suitable for tabulation purposes, does not convey my idea of what really constitutes the divergent character between the prothorax of a *Megacephala* and that of a *Cicindela*. The difference in the continuity of the anterior sulci of the upper and lower sides of the prothorax is, in my conception of the matter, a secondary thing, resulting from the dissimilarity in the union of the pronotum and prosternum in front to inclose the pro-episterna. If the underside of the prothorax of a Cicindelid be examined it will be noticed that the pronotum and the prosternum meet in front on each side and inclose the pro-episterna. In a species of the tribe Cicindelini the prosternum extends as far forward as the pronotum, so that the prothorax is truncate in front; and the pronotum and prosternum are so closely connected as to appear fused together, with hardly a trace of a suture. But in a species of *Megacephala* the pronotum projects forward beyond the prosternum; and, although these two pieces meet and inclose the pro-episterna in front, yet their point of contact is very small and their union in no way amounts to a fusion of the parts. No exception to the characteristic formation of these parts occurs in any Australian species of the tribes Megacephalini and Cicindelini.

Coxæ.—In the Cicindelidæ the anterior coxæ project strongly beyond the intercoxal piece of the prosternum, and have on their inner side a small tubercle which is received into a sinuosity of the coxal cavities (figs.39, 40). In the Carabidæ the coxæ do not so project above the intercoxal part of the prosternum, and are without the tubercle of the inner side.

*Tactile setæ.**— Among the Carabidæ and Cicindelidæ certain hairs are found which rise singly from pores in the chitinous skeleton. Considerable importance, for the purposes of classification, has been attributed to many of these setæ in the Carabidæ; but I have not met with any notice of their use in the Cicindelidæ.

In the Australian Cicindelidæ the following setæ at least have some taxonomic value—(1)The supraorbital setæ of the head (one seta above the eye in *Rhysopleura*, *Distypsidera*, and *Nickerlea*; two in *Megacephala* and *Cicindela.* (2)The juxta-antennal seta on each side of the clypeus (wanting in the genus *Cicindela* alone in our fauna). (3)The setæ of the labrum (*marginal* in *Rhysopleura*, *Distypsidera*, and *Nickerlea*; *submarginal* in *Megacephala* and *Cicindela*†). (4)The coxal tactile setæ (present *always* throughout the Australian Cicindelidæ on all the coxæ except in the genus *Megacephala* in which the *anterior coxæ are without setæ*). (5)The seta on each of the four anterior trochanters, which are wanting in the genus *Megacephala* alone in our fauna‡ (the posterior trochanters are always without setæ).

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* These tactile setæ have nothing to do with the pubescence or bristles always to be found on some part of the body or coxæ throughout the genus *Cicindela.* For their use in the classification of the Carabidæ, *cf.* Horn, Trans. Amer. Ent. Soc. 1881, ix.; Sharp, Fauna Hawaiiensis, Col. Carab iii. Pt. 3, p.182(1903); Sloane, these Proceedings, 1904, xxix. p.106.

† The New Caledonian genus *Caledonica* has the large Distypsidera-like form of the labrum, but with only four setæ, the anterior pair of which are submarginal. This character, with the presence of two fully developed supraorbital setæ, seems to indicate that the phylogenetic position of *Caledonica* is between *Distypsidera* and the *Cicindelæ spuriæ.*

‡ I have noticed that in the Papuan *funerata*-group of the genus *Cicindela* *none* of the trochanters have a tactile seta.

I believe the presence or absence of these setæ to be constant in every species; therefore, they may be useful in helping to determine affinities. Often the seta is rubbed off, but then the puncture from which it rises may be seen by a careful examination These setæ must have an important functional utility to the insect, but this is a subject on which I know nothing. The objection to the use of these tactile setæ in taxonomy is that too much stress may be laid upon the mere absence of one or more of them in a species. Negative evidence is always to be taken cautiously, as of less value than positive evidence; and it may be expected that any of these setæ may be lost in a species, all the congeners of which show such a seta; therefore, only when the absence of any tactile seta or setæ occurs throughout a group of species or a whole genus, and is supported by other characters of taxonomic value, can one feel confident that such loss of a seta or setæ is of more than merely negative importance. Occasionally, in species which have lost a seta, specimens may be found in which such seta is present; *e.g.*, a single specimen of *Megacephala crucigera* in my collection has the seta of the intermediate trochanters present, though in no other case have I found a *Megacephala* with a seta on any of the trochanters; this is evidently a case of atavistic reversion, and of interest as showing that the ancestral form from which *Megacephala* is descended had tactile setæ on the trochanters.

Some primitive characters.—Some characters may be noticed which, being found in the Megacephalini and Cicindelini, are evidently of ancient origin. Such are—(1)The pubescence of the outer side towards the apex of the intermediate tibiæ in the male; this is not found in the genus *Distypsidera*, nor in the *Cicindelæ spuriæ* of this paper. (2)Last ventral segment emarginate at apex in the male;* the notch is sometimes lost in the genus *Megacephala*. (3)A subsutural row of foveæ on the elytra.

* The old authors described the Cicindelidæ as having seven ventral segments in the male and six in the female. The modern view is that the so-called seventh segment of the male is only part of the genital armature.

(4)The humeral depression of the elytra; on each side of the base of the elytra, just behind the basal angles of the prothorax, there is usually a more or less developed longitudinal depression, often punctate; it is very deep in *Therates.* In our fauna the humeral depression varies considerably; in all the species of *Megacephala* with the basal part of the elytra unicolorous it is obsolete; but it is present in the species with the lateral margins brownish or testaceous (most feeble in *M. crucigera*); in *Distypsidera* it is strongly developed; it is present in *Rhysopleura*; in *Cicindela* it varies, being well developed in the *iosceles*- and *doddi*-groups which come nearest *Distypsidera.* It is probably a secondary sexual character originally pertaining to the female, correlative with the deeply concave mesepisterna in many species of *Cicindela,* and the protuberant posterior angles so strongly developed in *C. aurita.*

Phylogeny.

Dr. Walther Horn, in his "Index," has some notes on the phylogeny of the Cicindelidæ, from which I take the following interesting hypotheses—(1)The earliest Cicindelid-like form appeared in the Tropics of the Ethiopian region, branching from a Carabid-stem. (2)The Paleomantichorini, &c., followed by the Megacephalini, &c., leading on to the Cicindelini (geologically the most recent Cicindelid-form) may be taken as the general line of descent.

Dr. Horn believes that the original Cicindelid-forms were wingless, but there appear to be such strong objections to this idea that I cannot follow him on this point. I do not propose to elaborate arguments against the descent of strong-flying species from wingless ancestors amongst the Coleoptera; but I believe it will be impossible for anyone to accept the conclusion that the earliest Cicindelid-forms were wingless, who holds with me the following opinions—(1)That the Coleoptera are descended from insects with four free wings. (2)That the earliest Coleoptera were winged. (3)That the loss of the underwings indicates a degradational form among the Coleoptera. And (4)that characters once lost are extremely unlikely to be re-acquired in such a highly specialised order as the Coleoptera.

It has been impossible for me to formulate any theories on the phylogeny of our Megacephalini, therefore only the tribe Cicindelini is here dealt with. Taking the genera, I believe the order to be *Rhysopleura*, *Distypsidera*, *Nickerlea*, *Cicindela*. In his "Index" (p.39) Dr. Horn gives his views on the phylogeny of the species of the genus *Cicindela* which are found in the Australian region as a whole. These he divides into four branches, all of which occur in Australia. (1) With two Australian groups (viz., the *tetragramma-* and the *ypsilon*-groups) descended from the "*longipes-biramosa-limosa*"-stem. (2) The *sætigera*-group of Antarctic origin. (3) The *mastersi-* and *semicincta*-groups, forming part of the great Papuan "*funerata*-group," and (4) The "*nigrina-iosceles*"-group descended from a *Euryoda*-stem. It is evident that Dr. Horn considered the *C. nigrina* and *C. iosceles* types as our most ancient forms. But *C. sloanei* Lea, *C. tenuicollis* Macl., and *C. oblongicollis* Macl., were unknown to him in nature, so that they are placed by him without exact knowledge; therefore their positions in his system of groups must be somewhat in the nature of a guess.

For me *C. sloanei** is our oldest Cicindela, followed in order by the *crassicornis-iosceles-*, *doddi-*, and *tenuicollis*-groups, which seem to me more inter-related amongst themselves than any of them is to the next succeeding group, viz., the *nigrina*-group. I am not prepared to offer any views on the lines of descent or relationships between the *tetragramma-*, *ypsilon-*, *igneicollis-*, and *semicincta*-groups, beyond indicating that in my opinion *C. frenchi* is, perhaps, not very closely allied to the other species of the *ypsilon*-group, and that *C. rafflesia* is probably the oldest Australian species of this group.

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* I have referred *C. sloanei* Lea, to the genus *Nickerlea* on account of its glabrous undersurface and the form of the mentum and labial palps, but I do not think it can be at all closely allied to *N. distypsideroides* Horn, the type species of that genus.

The only Australian Cicindelid larva which I have seen is that of *Megacephala australis* Chaud.; this corresponds thoroughly with the general description given by Leconte.*

The two tribes found in Australia may be differentiated thus:—

Prothorax with pronotum projecting forward beyond prosternum at sides.
Prosternal sulcus not continuous with apical pronotal sulcus. Scutellum on peduncle, hidden by prothorax, not dividing elytra at base........... ....MEGACEPHALINI.

Prothorax truncate at apex.
Prosternal sulcus continuous with the apical pronotal sulcus. Scutellum large, not hidden by prothorax, dividing elytra at base... .CICINDELINI.

Tribe **Megacephalini**.

Genus MEGACEPHALA.

I follow Horn in placing all the Australian species of Megacephalini in one genus; but I have not tried to arrive at reasons why former writers called one species a Megacephala and another a Tetracha; nor why M. Fleutiaux saw such decided differences in *M. cylindrica* Macl., that he suggested a distinct genus, *Pseudotetracha*, for it. M. Fleutiaux seems to have missed the most decided character isolating *M. cylindrica* and *M. frenchi* Sl., namely, the short basal stalk of the labial palpi (see figs.11 and 12). In any case *M. spenceri* Sl., and *M. greyana* Sl., together with *M. howitti* Cast., seem to greatly reduce the value of the differences sought to be established in the tables given in his "Troisième Note sur les Megacephalidæ d'Australie"† In *M. spenceri* the posterior femora do not reach the apex of the abdomen; in *M. greyana* these femora do not extend beyond the apex of the abdomen in the female, but do so slightly in the male; in *M. howitti* (♀) they extend beyond the apex of the abdomen; these species are all wingless, and to my mind congeneric.

* Classification of the Coleoptera of North America, p.4 (Washington, 1883).
† Revue d'Entomologie, 1899, p.46.

There are some variable minor characters of merely specific value which seem worth attention and study in the genus *Megacephala*, but for this work my material is insufficient. Such are—(1)The teeth of the mandibles. (2)The underwings present, or not. I regard the underwings as present in the described Australian species except *M. cylindrica*, *M. frenchi*, *M. spenceri*, *M. greyana*, and *M. cylindrica*, but their absolute absence in these species requires confirmation; and their presence and development in the other species also require attention. In this connection it is to be noted that in the species with unicolorous elytra those which are winged have the elytra less convex and cylindrical, and much more strongly ampliate at the base on each side of the peduncle than those which are without wings. This difference in the amplitude of the elytra between the winged and the wingless species is noticed less along the lateral border than above the border, a result evidently caused by the necessity for a greater dilatation to cover the bases of the wings in the winged forms. Though this is apparently a feature of high importance, and readily noticeable, it has not appeared to me very suitable for tabulation purposes, the differences being merely of degree; and differences which are not trenchant are generally unsatisfactory in tables, as liable to misinterpretation. (3)The relative length of the posterior femora as compared with the abdomen seems to me merely of specific value, there being all degrees of length; in the species with short posterior femora the posterior trochanters do not extend behind the posterior margin of the third ventral segment. (4)The form of the two basal ventral segments varies; the first segment is triangular in *M. cylindrica*, and with inner part much narrower and more extended in *M. crucigera*; there seem all degrees of difference between these forms; the second segment is much longer, especially behind the posterior coxal cavities, in *M. cylindrica* than in the wider-bodied winged species. (5)The distance between the intermediate and posterior coxæ varies; it is shortest in *M. howitti*, *M. greyana* coming next; it is merely a specific difference.

Table of Species.

A. Elytra green or violaceous, with never more than an apical testaceous mark on each elytron.

B. Labial palpi with basal stalk short, not projecting beyond apex of lobes of mentum. (Wingless. Posterior femora not extending beyond apex of abdomen. Elytra unicolorous).

c. Pronotum with sides obtusely rounded vertically and without trace of a lateral carina even near anterior angles. Legs and apex of abdomen testaceous.......... .... *M. cylindrica* Macl.

cc. Pronotum with sides sharply subcarinate near anterior angles. Legs and apex of abdomen black.......... ....*M. frenchi* Sl.

BB. Labial palpi with basal stalk long, projecting beyond lobes of mentum.

D. Species with elytra unicolorous (except a very narrow apical margin in *M. castelnaui*).

E. Species without wings. Elytra convex, or cylindrical, lightly ampliate on each side of peduncle; puncturation obsolete towards apex.

f. Elytra parallel, cylindrical. Posterior femora in ♀ not reaching beyond apex of abdomen. Metasternum wider between intermediate and posterior coxæ than mesepimera and basal border of metepisterna together.

g. Elytra smooth and finely punctate near shoulders. Posterior femora (♀) not reaching apex of abdomen... ... .*M. spenceri* Sl.

gg. Elytra rough and coarsely punctate near shoulders. Posterior femora (♀) attaining apex of abdomen (in ♂ extending a little beyond apex)...................... *M. greyana* Sl.

ff. Elytra short, oval; disc convex longitudinally as well as transversely. Posterior femora (♀) extending beyond apex of abdomen. Metasternum very narrow between intermediate and posterior coxæ, not wider than mesepimera and border of metepisterna together................*M. howitti* Cast.

EE. Species with wings. Elytra subdepressed, strongly ampliate on each side of peduncle; puncturation extending to apex, or not.

h. Elytra with punctures extending to apex.

i. Ventral segments punctate. Prothorax with lateral carina obsolete behind anterior transverse impression.

j. Elytra unicolorous... .... *M. pulchra* Brown.

jj. Elytra with narrow testaceous apical margin............... ....*M. castelnaui* Sl.

ii. Ventral segments impunctate. Prothorax with lateral carina extending backward almost to base.. *M. blackburni* Fleut.

hh. Elytra punctate on basal half, puncturation obsolete towards apex. (Prothorax with lateral carina extending backwards to posterior transverse impression)...... *M. murchisoni* Fleut.

DD. Species with apex of elytra widely testaceous.. { *M. australis* Chaud. / *M. helmsi* Blackb.*

AA. Elytra with sides of a more or less clear testaceous or brownish colour. Elytra punctate or wavy-rugose-punctate. (Winged species).

k. Prothorax with lateral carina not extending backwards to posterior transverse impression.

l. Abdomen with all the segments testaceous on sides. Male with left mandible bifurcate at apex.............................*M. crucigera* Macl.

ll. Abdomen with two basal segments metallic laterally. Male with left mandible of normal form, 3-dentate.

m. Prothorax with posterior transverse sulcus decidedly terminated at place of lateral carina, not reaching sulcus of pro-episterna. Antennæ with basal joints clear testaceous.......*M. intermedia* Sl.

mm. Prothorax with posterior transverse sulcus continued in a more or less distinct course laterally to the extreme border of the pronotum opposite the sulcus of the pro-episterna. Antennæ with four basal joints fusco-maculate.

n. Metepisterna lightly and widely obliquely concave. Elytra with inflexed border not excised opposite third ventral segment.. *M. basalis* Macl.

nn. Metepisterna with a deep concavity. Elytra with inflexed border decidedly excised opposite third ventral segment..*M. bostocki* Cast.

kk. Prothorax with a strong lateral carina extending from anterior angle backwards past posterior transverse impression. Elytra with wavy-rugose-punctate sculpture.

o. Elytra with clear subtestaceous margin dilated inwards at about basal third...*M. australasiæ* Hope.

oo. Elytra green with narrow obscure brownish lateral margin..*M. scapularis* Macl.

Megacephala pulchra Brown.

Dr. W. Horn, of Berlin, kindly sent me a specimen (♀) of *Tetracha pulchra* Brown, "identical with type." The following

* *M. helmsi* is the only species I have not seen.

features, not noticed in the original description, or inaccurately stated, require recording. The puncturation of the elytra, though becoming very fine at the apex, is not actually "obsolete." The prothorax has the lateral carina strongly developed just behind the anterior angles, but quite obsolete behind the anterior transverse impression; the sides are hardly incurved laterally. The ventral segments 3-6 are finely punctate behind the posterior coxæ.

♂. (From a specimen in the collection of the National Museum, Melbourne), with apical (sixth) ventral segment more strongly punctate than female, and with the usual median notch so reduced as to be with difficulty perceived; in fact it may be called *obsolete.*

I have detected the presence of wings in *M. pulchra.*

Megacephala castelnaui, n.sp.

Green; head between eyes dark in middle with golden tints on each side; prothorax with middle of disc bluish-black; elytra with a golden tint on disc in some lights, apex with narrow testaceous margin. Mandibles (apex black), labrum, antennæ, palpi, and legs testaceous (tibiæ, palpi, antennæ, except basal joint, paler). Underside of prothorax, sides of body, and anterior ventral segments green; two penultimate ventral segments brown in middle, becoming lighter-coloured towards sides; apical segments subtestaceous.

Prothorax with a lateral carina on anterior fourth. Elytra strongly punctate, puncturation strong on basal half, becoming finer posteriorly, continuing to apex; the derm smooth between the punctures (though slightly undulate on lateral parts of basal half of disc). Ventral segments longitudinally rugulose towards sides, segments 3-6 finely punctate backwards from posterior coxal cavities. Length 18, breadth 7 mm.

Hab.—S.W.Aust.: Norseman District (*fide* French; Coll. French; unique).

Having the puncturation of the elytra extending to the apex, this species requires comparison only with *M. pulchra* Brown, and *M. blackburni* Fleut. It is closely allied to *M. pulchra*, having the same small round separate punctures impressed in the derm of the elytra, and the abdomen similarly punctate (the punctate ventral segments differentiate *M. pulchra* and *M. castelnaui* from all the other described species of Australia). *M. castelnaui* differs from *M. pulchra* by the testaceous apical margin of the elytra (this testaceous margin is less than 1 mm. in width); the sides of the prothorax behind the anterior impression less rounded vertically, and with obsolete traces of a carina, of which no trace is found in *M. pulchra*; the lateral margin of the prothorax decidedly incurved outside the position of the lateral carina (hardly incurved but simply rounded in *M. pulchra*); the transverse impressions of the pronotum more strongly impressed. From *M. blackburni* it differs (from Fleutiaux's description) by elytra with apex testaceous, and not so strongly punctate posteriorly; prothorax with lateral carina not strongly developed behind anterior transverse impression; abdomen punctate (impunctate in *M. blackburni*).

The type specimen is in a crushed and damaged state.

Megacephala blackburni Fleutiaux.

A specimen (♂) which it seems necessary to place under *M. blackburni* Fleut., has been sent to me by the Rev. Thomas Blackburn. It resembles *M. pulchra* Brown, in colour, except that it has a black sutural patch on the basal half of the elytra, this patch being bounded laterally by the subsutural row of foveæ. It differs decidedly from *M. pulchra* by ventral segments impunctate, lateral carina of prothorax extending strongly backwards behind the anterior transverse impression, the apical puncturation of the elytra much stronger. My specimen also differs from *M. pulchra* (♂) by the apical ventral segment strongly notched. It only differs, as far as I can see, from the description of *M. blackburni* (the sex not given) by the lateral carina of the prothorax ending a little before the base; it attains the base in *M. blackburni* according to Fleutiaux.*

I have found no variation in the lateral carina of the prothorax in any Australian species of which I have seen more than one specimen, but Dr. Horn has informed me that this character varies in African species of *Megacephala*; possibly it does so in *M. blackburni*.

Megacephala intermedia, n.sp.

♂. Allied to *M. basalis* Macl. (in general appearance intermediate between *M. basalis* and *M. crucigera* Macl.). Head, prothorax, sides of mesosternum, metasternum, and basal ventral segments green; elytra with wide testaceous margin and a discal viridescent anchor-shaped mark (posterior part of this mark wide and nigro-viridescent). Elytra with apical edge minutely serrulate. Length 13·5, breadth 6 mm.

Hab.—N.W. Aust.: King's Sound (Macleay Museum), Carnot Bay (*fide* French). Colls. Macleay Museum, French, Lea, Sloane.

This species is in the Macleay Museum under the name of *Tetracha australasiæ* Hope, a species which European coleopterists consider conspecific with the species known in Australian collections as *T. humeralis* Macl.

M. intermedia (♂) differs from *M. basalis* (♂) by left mandible with apical tooth very long, narrow, and extending greatly beyond the penultimate tooth, the third tooth (counting apex) as large and as prominent as the penultimate tooth; labrum with four triangular pointed teeth of nearly equal size in middle (in *M. basalis* ♂ these teeth are represented by inconspicuous obtuse prominences); antennæ without black maculæ on basal joints. The prothorax is generally similar, but not so strongly constricted opposite the posterior transverse impression; this impression not reaching the sides of the pronotum to join the basal furrow of

* I subsequently sent this specimen to Dr. W. Horn, who wrote under date of 12th April, 1906, "To-day I got Fleutiaux's type of *Tetracha blackburni*; the specimen you gave me is without doubt the same species. . . . The carina of the pronotum, the posterior sulcus, the formation of the posterior lateral angles, the sculpture of the elytra, etc., are identical."

the prosternum as in *M. basalis*; lateral carina longer. The elytra have a similar pattern. Its general appearance and facies is that of *M. crucigera* Macl., which sometimes has the anchor-shaped mark of the elytra equally large, but it differs by the abdomen not testaceous along sides to the posterior coxæ, piceous-black in the middle to and including the fourth segment; left mandible in ♂ not bifurcated towards apex, &c. The metepisterna resemble those of *M. crucigera*, being flat and rugulose, hardly widely and feebly concave posteriorly [in *M. basalis* the metepisterna are decidedly concave posteriorly; in *M. bostocki* Cast., (?= *M. excisilatera* Sl.) they have a deep pit or concavity]. In *M. intermedia* the antennæ are wholly testaceous as in *M. crucigera*, not with basal joints fusco-maculate as in *M. basalis* and *M. bostocki*. This species has also a slight emargination of the inflexed margin of the elytra opposite the third ventral segment, a feature which becomes conspicuous in *M. bostocki* but is wanting in *M. basalis*. The apical border of the elytra is minutely serrulate, a character I have only noticed in *M. humeralis* Macl., and *M. scapularis* Macl., among our species.

MEGACEPHALA BOSTOCKI Castlenau.

In his "Index" Dr. Horn follows M Fleutiaux (whose idea of *M.* (*Tetracha*) *basalis* Macl., included *M.* (*Tetracha*) *excisilatera* Sl., in considering *M.* (*Tetracha*) *bostocki* Cast., as synonymous with *M. basalis* Macl.; but, for reasons given below, I cannot concur in this synonymy, and therefore regard *M. bostocki* Cast., as a good species under which I believe *Tetracha excisilatera* Sl., must be placed. The Rev. Thomas Blackburn has informed me that he had considered as *M.* (*Tetracha*) *bostocki* Cast., the species which I described under the name *T. excisilatera;* and subsequent consideration of the original description of *T. bostocki* inclines me so strongly to accept Mr. Blackburn's opinion that I now adopt it, though it is a question that cannot be absolutely settled, except by examination of Castlenau's type of *T. bostocki*, or by collecting at Nickol Bay. Castlenau's description of *T. bostocki*, poor as it is, contains two points that seem to compel the recognition of his species as that which I subsequently named *T. excisilatera;* these are (1) elytra "black," &c., (2) anterior angles of prothorax "much more rounded" than in *M. humeralis* Macl. Among the species known to me, only *T. excisilatera* Sl., has elytra that could be called *black*, and the prothorax with anterior angles *more rounded* than in *M. humeralis* Macl. When I described *T. excisilatera* I relied on Fleutiaux's synonymy of *M. basalis* Macl.

Hab.—Tropical Australia: Nickol Bay (*fide* Castelnau): Barrow Creek (*fide* French). Colls. French, Blackburn, Sloane, Macleay Museum.

MEGACEPHALA AUSTRALASIÆ Hope.

Dr. W. Horn formerly expressed the opinion* that *Tetracha scapularis* Macl., (evidently following Fleutiaux he included *T. hopei* Cast., under *T. scapularis*), and *T. humeralis* Macl., were varieties of *Megacephala australasiæ* Hope (he says the dark elytral marking becomes enlarged towards the end, and forms a cross in *M. australasiæ* Hope). Subsequently having visited London, Tring, and Oxford, and having seen the collections in those places, he reversed his views about *T. scapularis* after seeing the type-specimen of *T. hopei* Cast., in the British Museum, and recognised it as a good species.†

In his "Index" (1905), *M. humeralis* Macl., (which Dr. Horn has informed me is known to him), is placed as a variety of *M. australasiæ* Hope. No doubt this is the opinion of Dr. Horn after seeing types of *M. australasiæ;* and, therefore, it must be accepted as a correct view. Seeing that *M. humeralis* has a very wide range (I have species from Queensland, Port Darwin and Carnot Bay), while any form with the discal pattern forming a cross is unknown in Australian collections, it looks as if this were the dominant form, *M. australasiæ* Hope, being merely a local race. Be that as it may, it appears to me that, as far as Australian collections are concerned, the name *M. humeralis* Macl., may

* Deutsche Ent. Zeit. 1896, p. 353.
† *Op. cit.* 1898, p. 194.

well be recognised, at least till we become acquainted with Hope's typical form. The variety *M. nickerli* Srnka, from Cooktown, is of a wholly testaceous colour.

Habits.—Never having taken a species of *Megacephala*, I have no personal knowledge of their habits; but I am able to give a few notes from the observations of others.

Mr. Masters informed me that he found *M. crucigera* Macl., coming out from its diurnal hiding places in the evening, on sand banks along the river Burnett at Gayndah in Queensland.

The types of *M. humeralis* Macl., were found by Mr. Masters "in considerable numbers under rubbish in the dry sandy bed of the river Don," near Port Denison;* and Mr. F. P. Dodd wrote to me that he found this species "along salt pans near Townsville."

Mr. C. French writes to me that he has found "*Tetracha* [*australis* Chaud.] running about on the margins of salt lakes [in the Mallee District, N.W. Victoria], and that he has been informed that "*M. murchisoni* Fleut., and other species from Western Australia are found in similar haunts." Mr. C. French, junr., wrote to me that he found *M. australis* "on the sandhills in the mallee in the hottest part of the day, and under logs on the margins of swamps at Benjeroop near Kerang" [Victoria]; and that he also obtained "two specimens one evening on the edge of Lake Albacutya at a lighted candle placed in the middle of a sheet spread out on the ground, evidently attracted by the light." Mr. H. J. Hillier, when sending a specimen of the larva of *M. australis*, and the drawings of the larva for Plate xxxi., wrote to Mr. Lea, "I had often noticed small holes a good $\frac{1}{8}$-inch in diameter in places around the beds of (dry) lakes on Cooper's Creek (where I lived for several years); and so I dug down, following some of the holes, and then I found the larva always head upwards in the hole as I have drawn it. The holes were about $2\frac{1}{2}$-3 feet deep. I do not know whether they would go deeper, but these holes were almost down to the level of the

* *Cf.* Macleay, Trans. Ent. Soc. N.S. Wales, i. p. 9.

soakage water—within about six inches. The blacks have no real name especially for these larvæ, but call them 'Kintala,' which name they also use for another larva, and also for a dog, so that they do not know much about these particular larvæ. Kintala is a word of the Diara tribe which inhabits the Killalpaninna district."

Recently Mr. Lea sent me a note on the larva of *M. crucigera* which he received from Mr. J. A. Anderson, of Cairns, Queensland. Mr. Anderson when sending the larvæ wrote under date of 10th April, 1906—"I got some larvæ of *Tetracha crucigera* this afternoon. There are scores of these in my yard, but as I had not much time, I could only get a few; they are rather difficult to get out of the earth, as they go down about a foot or eighteen inches. I got these by putting a straw two or three inches from the top, when they came up to push it out, and I then dug them up with a spade before they could go down again. I could not get any adults in the ground, nor have I seen any for the past month or two."

Tribe **Cicindelini.**

The component parts of the tribe Cicindelini, as represented in Australia, are variable; in this showing a marked difference from the closely allied types (all of the genus *Cicindela*) found in the Palæarctic and Nearctic regions of the globe. Before tabulating the genera I propose to notice briefly some characters of high taxonomic importance, but of which the full value can only be estimated by someone with a knowledge of the Cicindelini of the whole world.

Labrum.—Lacordaire says the labrum varies greatly in respect of form and particularly of size; and it is a constant rule that, in every case in which it is dentate in front, the teeth are more pronounced in the female than in the male (Genera, p. 2). The shape of the labrum varies very little in some genera, *e.g.*, *Megacephala* and *Distypsidera*; but in the genus *Cicindela* (especially if the division I have called *Cicindelæ spuriæ* be retained in the genus) it is very variable, although, as far as my observations go, constant in each species, except that often it differs in the sexes, such sexual differences being constant. In the genus *Cicindela*, *sensu lato*, as represented in Australia, there are two quite different forms of the labrum. (1) The Distypsidera-like form, which, though showing considerable variation, is always large, convex, 7-dentate, the posterior tooth being a lateral one (in *C. iosceles* Hope, the two teeth behind the one at the extreme apex are bidenticulate, so that the labrum appears 11-dentate). In the Distypsidera-like form the setæ are marginal, a seta being found in every notch between the teeth. (2) The true Cicindela-form, which is shorter (and never of the 7-dentate form with lateral outer teeth) has the setæ placed a little behind the anterior margin (submarginal).

Mentum.—This varies greatly. In the typical species of the genus *Cicindela* the median tooth is very long, while in *Distypsidera* and *Nickerlea* it is reduced to a mere obtuse prominence at the bottom of the sinus (figs. 13, 14). In the genus *Cicindela,* as used in this paper, it varies greatly, for in *C. semicincta* Brullé, and all allied species, the median tooth is longer and more acute than in *C. ypsilon* Dej.; while in *C. doddi* Sl., (tooth small, but sharp and triangular), *C. iosceles* Hope (tooth similar to that of *C. doddi*, but a little less developed), and *C. leai* Sl., (a little more reduced, but still distinct and triangular), it is very much smaller than in *C. ypsilon.*

Labial palpi.—All those species which have the median tooth of the mentum greatly reduced in size have the basal piece and two basal joints of the labial palpi stout, and the apical joint small; the true Cicindela-form is to have the penultimate joint of the palpi long and slender.

Colour.—Dr. W. Horn has informed me that, in the Cicindelidæ, the dark portion of the elytra must be taken to be the ground-colour, the whitish marks so frequently found on the elytra being the secondary part of the pattern; a proper appreciation of this fact is important. Leng in his "Revision" has the following:—"In the maculate species the punctures cease, or nearly cease, within the maculation, which is visible on the other side of the elytron when it is detached from the beetle."* This refers to the genus *Cicindela;* in *Distypsidera* and *Rhysopleura* the puncturation does not cease within the maculation. Dr. Horn has expressed the opinion, in a letter to me, that the pattern of the elytra in species is so variable that it should be used as sparingly as possible in tabulating them; in fact, he would prefer never to use it in synoptic tables. This opinion (with which I concur) has considerably influenced my tabulation of the genus *Cicindela;* but in the genus *Distypsidera* I have been unable to dispense with colour-differences between the species, though I do not feel confident as to their being very reliable. Notwithstanding the view expressed above on the objection to colour-differences in synoptic tables, colour has an importance in the Cicindelidæ that cannot be overlooked, *e.g.*, (1) the testaceous elytral margin in many species of *Megacephala;* (2) the median transverse maculæ in *Distypsidera;* and (3) the colour of the under surface, *e.g.* (*a*) ferruginous in *Cicindela sloanei* Lea; (*b*) æneous in *C. ypsilon*, *C. tetragramma*, &c.; (*c*) chalybeous in *C. plebeia*, *C. doddi*, &c.†

Puncturation.—This character is important. In the genus *Cicindela*, Leng notes four types of elytral puncturation:—(1) "impunctate" (applied to North American species of the *C. scutellaris*-group); (2) "simply punctate" when "without elevated granules beside each puncture"; (3) "granulate-punctate" when "the surface is roughened with raised points as well as with depressed punctures"; (4) "semipunctate" when "merely the anterior half is punctate."‡ I have not used these terms, but would draw attention to the great difference in the puncturation in *C. semicincta*, *C. nigrina*, and *C. aurita*.

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* Trans. Amer. Ent. Soc. xxviii. p. 114, 1902.

† Having brought this opinion under the notice of Dr. Horn, he wrote in reply:—"I agree completely with you; in my first paper (Monographie der palaarktischen Cicindelen, p.3) I expressed this opinion. Only as a character for species I do not think much of it."

‡ *Op. cit.* p. 112.

Table of Australian Genera of the Tribe Cicindelini.

Labial palpi with basal stalk long; (penultimate joint long, slender. Proepisterna rugulose. Elytra simply punctate. Head with one supraorbital seta. Under surface glabrous)......... ....*Rhysopleura.*

Labial palpi with basal piece short.

Elytra with intricate punctate-undulate sculpture. (Head with one fully developed supraorbital seta.† Under surface and all coxæ glabrous. Metepisterna with a deep horse-shoe-shaped impression posteriorly)...................................... ....*Distypsidera.*

Elytra not with punctate-undulate sculpture.

Body, including all sternal side-pieces and coxæ, glabrous. Head with one fully developed supraorbital puncture. Clypeus with a juxta-antennal seta on each side............................ *Nickerlea.**

Body normally with at least some bristles or pubescence on one or more of the sternal sidepieces and coxæ (in *tetragramma*-group body and posterior coxæ glabrous). Head with two fully developed supraorbital punctures. Clypeus without juxta-antennal setæ ....*Cicindela.*

RHYSOPLEURA, n.g.

Head with one supraorbital setigerous puncture; clypeus bisetigerous. *Mentum* with a distinct pointed median tooth; lobes pointed at apex. *Maxillæ* with outer lobe two-jointed;

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* The characters attributed to *Nickerlea* here are those of *Cicindela sloanei* Lea; *N. distypsideroides* Horn, the type of the genus, is unknown to me in nature, but I believe it will show the setæ of the head and clypeus as in *C. sloanei*, which I place in *Nickerlea* with considerable hesitation.

† While this paper has been passing through the press, I have been informed by Dr. Horn that, in the genus *Distypsidera*, there is a small fine anterior intraorbital seta placed as in the genus *Cicindela*. Dr. Horn reports this seta in *D. undulata*, *D. gruti*, and *D. flavipes*; and I have since found it in *D. parva*. I had failed to detect this little seta, the pore from which it rises being so minute that, if the seta is rubbed off (as it usually is, judging from my specimens of *Distypsidera*) its presence would not be suspected. I have not thought the discovery of this greatly reduced anterior seta invalidates entirely the distinction I have sought to establish between the genera *Distypsidera* and *Cicindela* by the use of the supraorbital setæ; but for the sake of accuracy, and to prevent misunderstanding, I now refer to the *fully developed* supraorbital setæ. In *Distypsidera* the posterior seta is placed much more forward than in *Cicindela*.

inner lobe with an articulated hook. *Palpi*: *labial* slender, longer than maxillary; basal stalk long; first joint very short; second (*penultimate*) joint narrow, very long, reaching to anterior coxæ, plurisetose on lower side; *maxillary* slender, apical joint longer than penultimate. *Labrum* (♀) large, covering mandibles; apex wide, obtuse; a rather strong tooth followed by a very small second tooth on each side behind apex; margin 6-setose; four closely placed setæ on the obtuse apex, and one on each side in the notch before posterior lateral tooth. *Pronotum* orbiculate (disc tumid and almost hemispherical), rugulose. *Scutellum* dividing elytra at base. *Elytra* with derm closely punctate; puncturation rather strong towards base, very fine towards apex, strongly punctate basal part with obscure ferruginous marks, more finely punctate part sericeous. *Under surface* (including coxæ) glabrous; pro-episterna convex, rugulose; metepisterna longer than broad, lightly longitudinally concave and transversely rugulose. *Legs* very long and slender; posterior femora slightly bent opposite sides of elytra as in *Distypsidera*; intermediate tibiæ in male not pubescent on inner side near apex; tarsi long, first joint almost as long as second and third together, third much shorter than second, fourth shorter than third, elongate-triangular, not emarginate at apex; male with joints 1-3 squamulose beneath, 4th widely dilatate.

Type *Distypsidera orbicollis* Sloane.

Rhysopleura orbicollis Sloane.

Distypsidera orbicollis requires a new genus, which, notwithstanding its very different labial palpi, is nearer *Distypsidera* than to any other Australian genus. It is, however, extremely isolated, and I do not know its natural position in the tribe Cicindelini.

Mr. F. P. Dodd has informed me that *R. orbicollis* "is found on mossy trunks of scrub-trees."

Genus Distypsidera.

The genus *Distypsidera* is at once isolated and characterised by the undulate-plicate-punctate sculpture of the elytra. The body is always quite glabrous; the head has one fully developed supraorbital setigerous puncture placed in a position almost intermediate between the positions of the two supraorbital setæ found in *Cicindela*, and a very small fine setule at the usual position of the anterior seta; the labrum is large, convex, and covers the mandibles in repose, it is 7-dentate with six fine *marginal* setæ placed in the notches dividing the teeth. The clypeus is bisetigerous. The palpi in the male are pale testaceous, with sometimes the apical joint merely a little infuscate towards apex, sometimes piceous-black; in the female the apical joint of the labial, and the two apical joints of the maxillary are piceous; a similar sexual character is found in *Cicindela iosceles* Hope, indicating an ancient origin and great persistence for this apparently unimportant feature. The male has the outer side of the intermediate tibiæ not densely setose towards the apex as in *Megacephala* and the *Cicindelæ veræ.*

I have been unable to tabulate the species except by using the pattern of the elytra, which it seems certain is insufficient for differentiating species. I have therefore given notes on some of the species after the table.

Table of Species.

A. Elytra with apical maculæ.

Basal maculæ only present at humeral angles; apical maculæ triangular and not reaching suture { *D. undulata* Westw. / *D. volitans* Macl.

Basal maculæ extending inwards behind scutellum; apical maculæ reaching suture and forming a continuous transverse apical fascia when elytra are closed.

Basal and median maculæ narrowly separated on sides. Prothorax not strongly rounded in middle of sides.... { *D. flavicans* Chaud. / *D. mastersi* Macl.

Basal and median maculæ widely separated on sides. Prothorax smooth, strongly rounded on sides.............. .. *D. flavipes* Macl.

AA. Elytra without apical maculæ.

♂. Labrum black with pale median stripe. Mandibles with lower side and apex black. Palpi with apical joints black. Length 13·5-16 mm.. ....*D. gruti* Pasc.

♂. Labrum testaceous with narrow piceous margin. Mandibles testaceous with apex piceous. Palpi pale testaceous. Length 10 mm.. ... .*D. parva* Macl.

D. volitans Macl., is very closely allied to *D. undulata*, but has the sculpture everywhere finer. It makes its appearance further to the north than *D. undulata* (Port Denison and Townsville). I do not know the limits of the range of *D. undulata* northward, but it seems to me probable that, if the ranges of *D. undulata* and *D. volitans* meet or overlap, there may be great difficulty in differentiating these species where they are found together. Dr. W. Horn has informed me recently that, from material obtained since he described *D. lævisculpta*, he now considers that name must become a synonym of *D. volitans*. A specimen (♂) in the National Museum, Melbourne, ticketed Queensland, has the humeral macula reduced to merely a little dot, so that the elytra before the median fascia appear at a casual glance quite black.

D. flavicans Chaudoir (= *D. cursitans* Macl. = *D. strangei* Cast.) is a much smaller species than *D. undulata* and *D. volitans*, and has the sculpture finer, especially near the base. Its most distinctive character is to have the posterior lateral tooth of the labrum placed much further forward than in the other species of the genus. It has the labrum with the central testaceous part very wide; elytra with base testaceous; palpi in male pale testaceous with the apical joint merely infuscate at apex. With the material before me I am not prepared to separate *D. mastersi* Macl., from *D. flavicans* Chaud., yet I would not declare definitely that these names are synonymous.

D. gruti Pasc.*(= *D. plustchevskyi* Dokht., = *D. interrupta* Dokht., and *D. pascoei* Macl.). I place under *D. gruti* Pasc., all the forms that I have seen without any apical maculæ (excepting the distinct species *D. parva* Macl.). The typical form has the elytra dark cyaneous black, each elytron 5-maculate, as shown in fig.69 (but with inner basal macula larger, as in fig.68). Pascoe's description is founded on the female, as is shown by his describing the palpi as "black, second and third joints of the

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* *D. papuana* Gestro, is allied to *D. gruti* Pasc.; *cf.* Horn, Deutsche Ent. Zeit. 1893, p.331. It is the only extra-Australian species known.

labial yellowish-white." The male has only the apical joint of both labial and maxillary palpi black. Specimens from Cairns vary from 13·5 (♂) to 16 (♀) mm. in length; they also vary in pattern of the elytra (as shown in figs. 68, 69 and 70). Other specimens received from Mr. French, as from North Queensland, are equally large but have the posthumeral and humeral maculæ united. The legs vary in colour from all black (except trochanters and an apical spot on four anterior femora) in a specimen (♀) from Mr. French, ticketed "Endeavour River," to femora ferruginous (except upper side, more particularly towards apex, piceous-black); tibiæ ferruginous with outer side infuscate in a specimen (♂) from Cairns. The colour of the legs is evidently of slight importance in *D. gruti*.

Var.? A. There remains a small form from Cairns in which the colour of the upper surface is darker, the elytra without an inner basal macula on each side of the scutellum, and with the humeral macula extending backwards in a slender stripe (figs. 66, 67). Length 13·5 mm ♀. Possibly this may represent a distinct species, but more data than I possess would be required to form a decided opinion on this point. It may be noted that var. A so closely resembles *D. volitans* Macl., that it seems impossible to separate these species except by the presence of the apical maculæ in *D. volitans*.

D. parva Macleay, has more affinity to *D. flavicans* Chaud., than to any other species. Labrum testaceous with a narrow lateral margin; metasternum in male testaceous, in female piceous in middle with sides testaceous; palpi pallid, apical joints in female piceous, in male hardly infuscate just at apex.

Genus NICKERLEA.

NICKERLEA DISTYPSIDEROIDES Horn.

From Dr. Horn's Latin diagnosis of this species I take the following excerpts :—

"Differt a *Distypsidera flavicante* Chaud., labro paullo breviore, antice latius truncato et in parte centrali antica dentibus 3 (non dente una) perparvis (vix percipiendis) ornato: dentibus 2 majoribus in utroque latere fere ut in illa specie, toto unicolori obscure metallico . . . . thorace breviore antice magis dilatato marginibusque lateralibus magis arcuatis; elytris . . . . serie punctorum majorum rarorum juxta-suturali evidente; . . signatura alba: maculis 3 sat magnis marginalibus, prima humerali vix marginem s-quente, secunda media, tertia ante-apicali . . . . . . subtus cyaneo-nigricante; . . . . . . pedibus testaceo-rufis. Long. 10½ mm. (sine labro). 1 ♀ (?) Australia bor. (Odewahn)."

In the short generic diagnosis we find "*Corpus* (*cum coxis posticis*) *glabrum*." It is, from the above notes, allied to *C. sloanei* Lea, but differs at once by colour of under surface "*cyaneo-nigricante*" (not reddish-testaceous; the colour of the under surface is an important character in the genus *Cicindela; C. sloanei* Lea, is the only Austral ian species known with the under surface ferruginous); elytra with three lateral white maculæ. The antennæ were wanting in the type of *N. distypsideroides*, therefore its true relationship towards *C. crassicornis* Macl., cannot be accurately known. It seems to have some resemblance to *C. crassicornis*, but that species has the labrum "white" and the metepisterna and posterior coxæ hirsute.

Nickerlea sloanei Lea.

Cicindela sloanei Lea, may not be congeneric with *Nickerlea distypsideroides* Horn; but, be that as it may, it seems best to consider it so till these two species can be compared. The following characters not alluded to in Mr. Lea's description require notice:—♂. Labrum large, convex, outline rotundate, 7-dentate (the teeth as in *Distypsidera*, but smaller, viz., three on the obtuse apex and two on each side, see fig. 21). Labial palpi short, resembling those of *Distypsidera*, but penultimate joint shorter and still more inflated, with a few short setæ on each side; apical joint very small. Antennæ slender, resembling those of *Distypsidera*. Clypeus with a setigerous puncture on each side near antenna. Prothorax broader than long (1·5 mm × 1·7 mm.). Under surface glabrous, including all the coxæ.

I may here note that *N. sloanei* seems an ancient form descended from a stem in which the pubescence of the body had never been acquired, and thereby differing from the *tetragramma*-group of the genus Cicindela in which I believe the pubescence to have been lost.

Mr. Lea's description is wrong in saying "prothorax slightly longer than broad." I have the type before me (kindly lent by Mr. Lea), and find its thorax broader than long, the measurements being as given above. Also, by a slip, the word "clypeus" has been printed instead of *labrum* in the original description. The labrum in the male is dark with a median testaceous stripe, in the female of a uniform dark colour. It was found by Mr. Lea running actively on the sandy bed of a dry creek at Mullewa, W.A.

Genus CICINDELA.

Table of Species Groups.

i. Labrum large, convex, 7-dentate, posterior tooth on each side lateral; setæ marginal.* Mentum with median tooth small or obsolescent. Labial palpi stout, apical joint small.....................CICINDELÆ SPURIÆ.

A. Antennæ with joints 5-11 swollen. (Elytra with subsutural row of foveæ) ....*iosceles*-group.

AA. Antennæ slender.

B. Pronotum not strongly transversely impressed. Elytra opaque, subsericeous, not strongly punctate; a subsutural row of lightly impressed foveæ... ...*doddi*-group.

BB. Prothorax encircled by a strong impression anteriorly and posteriorly. Elytra convex, nitid, covered with a strong and dense puncturation...............................*tenuicollis*-group.

ii. Labrum short, never with lateral teeth, setæ submarginal. Mentum with median tooth long, pointed. Labial palpi slender, apical joint elongate ....CICINDELÆ VERÆ.

C. Prothorax encircled by a deep anterior impression; pronotum convex, glabrous. Elytra convex, covered ~~with~~ a strong puncturation, dark green, not opaque (each elytron 3-maculate). ♀. With proepisterna sparsely setose near coxæ; mes- and metepisterna glabrous; apex of each elytron deeply excised and with a long apical sutural spine...... ....*nigrina*-group.

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* Sometimes the labrum has more than seven teeth, *e.g.*, *C. iosceles* Hope, ♀, and *C. doddi* Sl., ♀, but the extra teeth in these cases are small and seem merely a modification of the normal 7-dentate form.

CC. Prothorax and elytra subdepressed. [Pronotum (a) glabrous, (b) covered with setæ, or (c) setose along lateral margins. Elytra glabrous or setose near shoulders. Under surface normally with all sternal side-pieces and posterior coxæ setose (glabrous only in the *tetragramma*-group). Head glabrous or setose].

D. Body glabrous (except four anterior coxæ). Pronotum, at least in ♀, with prominent posterior angles...............*tetragramma*-group.

DD. Various parts of body setose, including always all sternal side-pieces and posterior coxæ. Pronotum never with prominent posterior angles.

E. Elytra with dark parts of pattern metallic (brassy or bronzy) and with a large lateral and apical area white.

F. Pronotum and elytra glabrous........................*ypsilon*-group.

FF. Pronotum (including disc) and elytra near base setose..*igneicollis*-group.

EE. Elytra with groundcolour dark, opaque, some whitish markings, either narrow and lateral, or maculiform on posterior half of disc. Pronotum setose along lateral margins only. ♀. With a small nitid or subnitid dark spot on disc of elytra a little before middle.....................................*semicincta*-group.

Cicindelæ spuriæ.*

The division of the genus *Cicindela* (*sensu lato*) for which I use the name *Cicindelæ spuriæ* includes Dokhtouroff's genus *Antennaria*, founded on *C. iosceles* Hope. I regard the generic name *Antennaria* as preoccupied by the previous use of *Antennarius*; and also I doubt whether the swollen antennæ are in themselves a character of sufficient importance to justify the formation of a genus, considering the existence of the somewhat allied species, *C. doddi*, with slender antennæ. *C. tenuicollis* Macl., does not seem to have any close affinity to *C. iosceles* or *C. doddi*; but it can be grouped with these species by some features of importance, as given in the table above, which also

* Dr. Walther Horn had formerly applied the name *Euryodæ spuriæ*, and latterly *aberrant forms of Cicindela* to the species I have called *Cicindelæ spuriæ*; I was unaware of this when I proposed to divide the Australian species of *Cicindela* into *Cicindelæ spuriæ* and *Cicindelæ veræ*.

serve to separate it most decidedly from the typical species of *Cicindela.* It is, I believe, the intention of Dr. Horn to review the great genus *Cicindela* as a whole, and arrange the species in groups; should he carry out this project he will doubtless fix the position and value of my *Cicindelæ spuriæ* authoritatively

Iosceles-Group.

Two species of this group are known, namely, *C. crassicornis* Macl., and *C. iosceles* Hope. I have examined the type of *C. crassicornis,* in the Macleay Museum, in comparison with a specimen of *C. iosceles,* and separated them thus:—

Pro- and mesepisterna glabrous; metepisterna and posterior coxæ setose...... .... *C. crassicornis* Macleay.
Pro-, mes- and metepisterna setose.................................*C. iosceles* Hope.

The shape of the prothorax is also very different, but I did not record the differences; speaking from memory, I may note that in *C. crassicornis* it is shorter and more rounded on the sides than in *C. iosceles.*

Cicindela iosceles Hope.

Dr. Walther Horn has sent me a cotype of *C. platycera* Gestro, which he has noted as synonymous with *C. iosceles* Hope, from examination of Hope's types; this specimen of *C. platycera* is identical with my *C. hackeri.* It may be noted that in *C. iosceles* the male has the labial palpi with the apical joint green, the other joints testaceous; the female has the whole of the labial palpi dark greenish.

Range.—Cooktown (Hacker) to Port Essington (*fide* Hope).

Doddi-Group.

Cicindela doddi Sloane.

In the description of *C. doddi* I have omitted to record that the type (♂) has the proepisterna with a few white setæ above the coxæ, and the posterior coxæ setose near the anterior external angle.

♀. Mr. F. P. Dodd recently sent me the female from Kuranda; it differs from the male by size larger (length 9 mm.), pro- and mesepisterna glabrous; labrum larger and longer, teeth far more prominent (median tooth prominent, triangular, flanked on each side by a subdentiform prominence; on each side of this wide tridentate median prominence a deep setigerous notch, and behind this setigerous notch two strong triangular teeth, side of labrum roundly dilatate some distance behind the outer of these teeth, a marginal seta just before this lateral dilatation). The description above applies to the labrum from the apex; taking it from the base it is wide, strongly sinuately narrowed at about half the length, 7-dentate before this lateral sinuosity of each side. I regard this as only a modification of the 7-dentate form of the labrum, in which the posterior lateral tooth has become reduced to a mere rounded prominence, and the second tooth from the base has become duplicated.

Tenuicollis-Group.

C. oblongicollis Macl., is closely allied to *C. tenuicollis* Macl. When examining the types of these species in the Macleay Museum, I could not fix on any point of difference between them, except the dark obscure colour of *C. oblongicollis.*

C. tenuicollis Macl., is characterised by its prothorax with a very deep encircling groove anteriorly and posteriorly, the intervening space being roundly convex.

C. leai Sl., is the same colour as *C. tenuicollis* Macl., but with prothorax wider (1·3 × 1·3; *C. tenuicollis* 1 25 × 1·1 mm.); pronotum with apical and basal sulci much shallower, sides and disc far less strongly rounded between these sulci. In fresh specimens a few scattered setæ may be noticed rising from the punctures towards the base of the elytra; doubtless similar setæ are present in fresh specimens of the other two species of this group.

Cicindelæ veræ.

Nigrina-Group.

This group has only one species (*C. nigrina* Macl.), an ancient and isolated form remarkable for the shape of the apex of the elytra in the female (fig.51). Fresh specimens show a few scattered setæ rising from punctures near the base of the elytra.

Tetragramma-Group.

Dr. Horn has informed me that, in the great genus *Cicindela*, with nearly 600 species, he knows of only one extra-Australian species (viz., the African *C. intricata* Dej.), with all the sternal side-pieces and the posterior coxæ glabrous. In Australia, among the sixteen known species of the *Cicindelæ veræ*, there is the *tetragramma*-group of three species with a similar want of pubescence. Dr. Horn also expressed in his letter the opinion that the *tetragramma*-group is a primitive one; and from this I see no reason to dissent, though I believe the *tetragramma*- and *ypsilon*-groups have branched from the same stem. In the case of the *tetragramma*-group I believe the pubescence of the sternal side-pieces and posterior coxæ has been lost (probably because, for some reason, they became of no vital importance to the species).

Table of Species.

Elytra with dark groundcolour compact, without a longitudinal discal white band extending backward from middle of base. (Prothorax with prominent posterior angles in both sexes)........................... *C. aurita* Sl.

Elytra with dark groundcolour intricate, a longitudinal white band extending backwards from middle of base.

- Prothorax (♀) with posterior angles prominent, triangular. Elytra with sutural white vitta extending forward almost to base.. *C. tetragramma* Boisd.
- Prothorax (♀) with posterior angles subprominent, obtuse (in ♂ not prominent). Elytra with sutural white vitta on apical half—extending forward hardly beyond half the length of the elytra... *C. albolineata* Macl.

CICINDELA TETRAGRAMMA Boisduval.

Dr. Walther Horn has written to me that, from data I supplied to him, he is of opinion that *C. trivittata* Macl., is a form of *C. tetragramma* Boisd.; I believe there is but little doubt of the correctness of this view, so I place *C. trivittata* as a variety of *C. tetragramma*. It may be noted that Dr. Horn has drawn attention to the deep excavation of the mesepisterna in *C. tetragramma*, female, which is not found in the male.* *C. tetragramma* is unknown to me in nature, but the allied species *C. aurita* Sl., has the mesepisterna lightly concave outward from the middle coxæ in the male, and far more deeply concave in the female, but in *C. ypsilon* Dej., *C. albicans* Chaud., and *C. rafflesia* the mesepisterna are somewhat similar in form, the sexual difference being sufficiently marked to enable the sexes to be determined by the greater (♀) or less (♂) concavity of the mesepisterna.

Ypsilon-Group.

I look upon *C. rafflesia* Chaud., as probably the most ancient form of this group in Australia; the emargination of the apex of the elytra in the female (found also in *C. nigrina* Macl., a species not closely allied to *C. rafflesia*) seems a primitive character. The small second tooth of the mandibles (counting from apex) is characteristic of this group.

Table of Species.

Labrum (at least in ♀) not unidentate. (Elytra with base of metallic groundcolour compact; apex of each elytron rounded)...*C. frenchi* Sloane.
Labrum in ♀ unidentate in middle.
- ♀. With each elytron deeply excised at apex and armed at inner angle with a very long spiniform mucro. (Apex of each elytron in ♂ rounded and with a short sutural mucro)......*C. rafflesia* Chaudoir.
- ♀. With each elytron rounded at apex and with a short sutural mucro.
  - ♂. Without mucro at sutural apex of each elytron and with apical curve hardly serrulate..................................*C. ypsilon* Dej.
  - ♂. With a short mucro at sutural apex of each elytron, apical curve strongly serrate.....................................*C. albicans* Chaud.

Cicindela frenchi Sloane.

The type (♀) is in the possession of Mr. French. I have not had it before me when writing this Revision, but have separated it from the rest of the *C. ypsilon*-group by the form of the labrum, as figured by Mr. Lea (fig.25).

* Deutsche Ent. Zeit. 1904, p.88.

Cicindela ypsilon Dejean.

I regard the form found about Sydney as the typical form. It has the elytral pattern as in fig.84, the male being without any mucro at the sutural apex. It is hard to tabulate the differences between *C. ypsilon* and *C. albicans* Chaud., but, in all the specimens of the latter which I have seen, the apex of the suture of the elytra was mucronate in the male as well as in the female. The albescent form shown in fig.83 has, from a specimen in the National Museum, Melbourne, the sutural apex mucronate. This character and the form of the mandibles require careful attention with a large series of specimens from many localities before one.

Igneicollis-Group.

It appears to me that *C. blackburni* Sl., which is evidently closely allied to *C. sætigera* Horn, yet has head and basal joint of antenna glabrous, is a species which helps to show that too much reliance must not be placed on the pubescence of parts of the body for arranging species in groups.

Table of Species.

Front and clypeus (also head beneath eyes) glabrous.........*C. blackburni* Sl.
Front and clypeus setose.
- Elytra with a common metallic sutural patch giving off posteriorly a spatulate process on each elytron..............................*C. sætigera* Horn.
- Elytra with a common metallic sutural patch giving off posteriorly a narrow longitudinal subsutural stripe on each elytron, also outside the subsutural vitta two small metallic marks .....*C. igneicollis* Bates.

Cicindela blackburni, n.sp.

♀. Oval; prothorax (including pronotum), base of elytra and lateral parts of under surface beset with white hairs. Cupreous, elytra widely margined with white; the white margin extending from humeral angles to apex, indenting the cupreous discal area widely and lightly at basal fourth, very deeply at half the length, very lightly at apical third, and deeply and narrowly at apex near suture(fig.86).

Head rugulose-striolate, deeply channelled between eyes; front, clypeus and sides beneath eyes glabrous. Antennæ as in *C. ypsilon* Dej. (*i.e.*, four basal joints metallic, other joints blackish, stout). Prothorax broader than long (1·8 × 2·3 mm.), lightly rounded on sides; pronotum sparsely covered with white hairs over the whole surface; anterior and posterior transverse impressions not deep. Elytra oval (7 × 4·7 mm.); base with some white hairs on each side of scutellum; apex roundly emarginate with a short conspicuous spine at sutural apex of each elytron (at apex of apical emargination). Under surface, except middle of abdomen and metasternum, beset with white hairs. Legs albido-pilose. Length 11·5, breadth 4·7 mm.

Hab.—S. W. Australia: Colls. French, Sloane (received by Mr. C. French as from the Norseman District, Norseman being 120 miles north of Esperance; approximate position lat. 32° S., long. 122° E.).

It comes nearest *C. sætigera* Horn, among described Australian species. Only the male of *C. sætigera* is known to me, from which *C. blackburni* presents the following nonsexual differences: antennæ with basal joint glabrous (only one long white seta), clypeus, front and head beneath eyes without any white hair; cupreous groundcolour of elytra overspreading far more of the surface (extending to within 1 mm. of apex); the white margin is narrow at the humeral angles and has a width of 0·5 mm. just before and 0·7 mm. just after its median branch; this branch is 0·7 mm. in width and extends inward to within 0 8 mm. of the suture. Mr. French obtained two specimens (♀), one of which he kindly gave to me.

CICINDELA SÆTIGERA Horn.

In his "Index" (1905) Dr. W. Horn places *C. jungi* Blackb., as a synonym of *C. sætigera* Horn; and he has informed me by letter that, after seeing Rainbow's figure of *C. jungi*, he has no doubt of its identity with *C. sætigera* Horn. I may add that one has only to compare Horn's figure with Rainbow's to be convinced that they represent the same species.

Horn described the elytra of *C. sætigera* as "hinc inde hirsutis"; whereas the specimens of *C. sætigera* which I have seen (all collected by Mr. George Masters many years ago at Wallaroo, on the shores of Spencer's Gulf) have the elytra only setose along the base on each side of the scutellum. I wrote to Dr. Horn on this point, and he courteously answered: "My type of *C. sætigera* has, as it is now, only bristles on the shoulders, but I remember very well, as I saw it first, the specimen had also *a few* bristles on the other part of the elytra; when I got it the second time the bristles had disappeared, but my friend wrote to me, 'I have cleaned the specimen and brushed it.' I think fresh specimens in good condition will show a few bristles elsewhere and not only on the shoulders." I do not expect *C. sætigera* to show any setæ on the elytra except near the base; perhaps the explanation of the matter may be that some foreign whitish hairs had become attached to the specimen Dr. Horn described, as he first saw it, which were removed by the subsequent cleaning.

Hab.—Yorke's Peninsula, S.A. (Dr. Horn suggests that doubtless his locality, "Cape York," was given to him erroneously for Yorke's Peninsula).

CICINDELA IGNEICOLLIS Bates.

Dr. W. Horn has kindly sent me a sketch of the elytral pattern in *C. igneicollis*, made from the type, which he has examined; by the aid of this sketch I have worked it into the table given above. Bates' description says, "forehead and base of labrum with a dense patch of white laid hairs," and also notes the setæ of the pronotum, base of elytra, and sides of body. It evidently comes nearest *C. sætigera* Horn.

Semicincta-Group.

This group seems to have spread into Australia from Malasia; as represented in Australia it is readily divisible into two subgroups, namely, the *C. semicincta*-subgroup and the *C. mastersi*-subgroup. I believe all the species of the *semicincta*-group have the pronotum with setæ along the sides. These setæ are a conspicuous feature in the *semicincta*-subgroup, but are not always easily seen in the *mastersi*-subgroup, though I consider they would always be found in fresh specimens. The elytra in the female have invariably a nitid, or subnitid round dark discal spot on the basal half of each elytron; in *C. semicincta* and *C. mastersi* these nitid spots are very inconspicuous, though their presence can be detected. The species of this group have the labrum normally 3-dentate, the median tooth more strongly developed in the male than in the female; also four widely placed submarginal setæ, except in *C. discreta* var. *froggatti*, which has the lateral setæ as in the other species, but in the middle a transverse row of six setigerous punctures (probably the number of these intermediate punctures is not constant).

Table of Species.

Head setose beneath eyes. Pronotum subrugose, lateral setæ readily discernible.
- Elytra without whitish discal spots........................*C. semicincta* Brullé.
- Each elytron with a whitish discal spot on posterior half.. { *C. discreta* Schaum, var. *froggatti* Macl.

Head glabrous, including sides beneath eyes. Pronotum rugose, lateral setæ small and inconspicuous.
- Prothorax subparallel (hardly rounded) on sides. Labrum with a large infuscate apical area; in ♀ with median tooth long, very prominent, the tooth on each side obsolescent..............................*C. plebeia* Sl.
- Prothorax rounded on sides. Labrum with edge only infuscate, the tooth on each side of the median one triangular.
  - Elytra without lateral pale marks, except a small median fascia. Upper surface of a dark copper colour.....................*C. catoptriola* Horn.
  - Elytra with lateral pale marks, including a humeral lunule, median fascia, and apical lunule. Upper surface of a greenish or bronzy colour..*C. mastersi* Cast.

Semicincta-Subgroup.

C. SEMICINCTA Brullé.

Following Fauvel in his "Faune Analytique des Coléoptères de la Nouvelle Caledonie" (1903), I have, in my description of *C. plebeia*, referred to *C. semicincta* Brullé, under the name of *C. interrupta* Fabr. It appears, however, from Fleutiaux's "Catalogue" and Horn's "Index," that the name *C. interrupta*

Fabr., with which *C. semicincta* Brullé, has been confused, must be restricted to an African species from Senegal. *C. semicincta* is remarkable for the long prominent white hairs on the upper side of the fifth joint of the tarsi; these are present, but far less developed, in other species of the group There are two forms of *C. semicincta* in Australia, namely, one with the elytra greenish (♂, ♀) and with a white marginal stripe from shoulder to apex (fig. 89); the other (I have only the ♀) with two decidedly divided white marginal marks, one apical, the other lateral and extending forward beyond the triangular dilatation that is always found at about one-half the length of the elytra (fig.88). Mr. F. P. Dodd has sent me both these forms from Kuranda, Queensland; but I have not sufficient material to be able to give any opinion on the value of the differences between the two forms.

Range in Australia.—Sydney to Nickol Bay. It is also found in New Caledonia, New Hebrides, New Guinea, and Java.

C. DISCRETA Schaum, var. FROGGATTI Macl.

C. discreta Schaum, seems to range over the whole of the Malay Archipelago, and to be differentiated into several subspecies or varieties. Dr. W. Horn, to whom I sent specimens (from the collection of the late Sir William Macleay) of *C. froggatti* Macl., identified these as a form of *C. discreta* Schaum, for which he had also proposed a separate name, var. *subfasciata.** I would index the Australian species as *C. discreta* Schaum, var. *froggatti* Macl. (= var. *subfasciata* Horn).

C. mastersi-Subgroup.

I do not know the extra-Australian affinities of the *mastersi*-subgroup. It is not easy to tabulate the three closely allied species which I recognise as composing this subgroup.

C. plebeia Sl., is differentiated from *C. mastersi* Cast., and *C. catoptriola* Horn, by prothorax less rounded on sides; prosternal episterna blue, almost smooth; elytra of a much blacker

* This variety was described from specimens from Sumatra.

colour, less strongly shagreened and more distinctly punctured; labrum with a large apical infuscate patch, median tooth in the female much stronger, &c.

C. mastersi and *C. catoptriola* have the prothorax decidedly rounded on the sides; the prosternal episterna æneous and finely rugulose; labrum with edge only infuscate. *C. catoptriola* Horn (= *C. curvicollis* Sl.), may be readily separated from *C. mastersi* by the uniform bronzy colour of the upper surface, the lateral transverse mark of the elytra very small or obsolete, the posterior discal spot very small and inconspicuous, the apical and humeral marginal spots wanting. Dr. W. Horn, to whom I sent specimens of my *C. curvicollis*, has informed me that it is synonymous with his *C. catoptriola*, which he now looks upon as merely a race of *C. mastersi*; to me it looks sufficiently distinct to require a separate name.

Habits.—Rhysopleura orbicollis Sl., is found on the mossy trunks of scrub-trees at Kuranda, Queensland. All the species of *Distypsidera* are found on the trunks of trees. The *Cicindelæ spuriæ* are terrestrial in their habits; Mr. Lea found *C. sloanei* Lea, in the sandy bed of a dry creek at Mullewa, inland from Champion Bay. Mr. Hacker found *C. iosceles* Hope, and *C. leai* Sl., beside the railway line near Cooktown; and Mr. Froggatt obtained *C. tenuicollis* Macl., and *C. oblongicollis* Macl., 100 miles inland from King's Sound. *C. nigrina* Macl., and the species of the *tetragramma*- and *ypsilon*-groups frequent sea beaches, as also does, I believe, *C. sætigera* Horn. I have taken *C. mastersi* in different places in New South Wales in open forest country—on the margin of swamps near Urana, and on the margin of Lake Cudgellico, near the Lachlan River; doubtless all the species of the *semicincta*-group have similar habits.

Geographical Distribution.

The publication of Dr. Walther Horn's "Systematischer Index der Cicindeliden" furnishes data for reviewing the geographical distribution of the Cicindelidæ, and has enabled me to offer the following notes on the distribution of the tribes found on the Australian Continent.

Dr. Horn has catalogued the Cicindelidæ of the globe under 8 tribes, including 38 genera and 1184 species. Of these 8 tribes only one, viz., the Cicindelini, is truly cosmopolitan. The Megacephalini is the next most universally distributed tribe, being found in all the great zoogeographical regions of the earth, though the Palæarctic and Oriental Regions have only one species, while not one has been reported from New Guinea or the East Indian Archipelago. The other tribes have restricted ranges as under—Ctenostomini, Neotropical Region and Madagascar; Collyrini and Theratini, Oriental, but spreading to New Guinea; Neomantichorini, Neotropical and Nearctic; Paleomantichorini and Platychilini, Ethiopian.

Table of Distribution.

Region.	Tribes.	Genera.	Species.*
Palæarctic	2	2	68
Nearctic	3	4	111
Neotropical	4	19	263
Ethiopian	5	10	285
Oriental	4	7	361
Australian	4	11	96

In the enumeration of the tribes, genera, and species given above, the Palæarctic and Oriental Regions receive the benefit of one tribe and genus by the presence of *Megacephala euphratica* Latr., which seems merely a straggler from the Ethiopian Region; while, in regard to the Nearctic Region, probably the tribe Megacephalini (as there represented by four species in the south) is merely an invader from the Neotropical Region. If we divide the globe into two parts, one to include Eur-Asia and all North America north of Mexico and the other the rest of the globe, we find (excluding *Megacephala* from the first division as a southern

* The number of species is approximate ; the numbers given total 1184, the number catalogued by Horn ; any species that occurs in more than one region has been counted only as belonging to a single region.

invader) only eight genera against thirty genera in the second division, *i.e.*, the southern land areas of the globe; this seems to indicate that the Cicindelidæ are not of northern origin.

From the Australian region, as here intended, the Oriental tribe *Collyrini* might well be excluded; it is represented by *Collyris celebensis* Chaud., in the Aru Islands, and *Tricondyla aptera* Oliv., in New Guinea.* I would go further and also exclude, as Oriental, the Theratini, represented by four species of *Therates*. This would reduce the Cicindelidæ of the Australian region to two tribes, nine genera, and ninety species, but would still leave the Australian Cicindelid fauna, by the variety of its component parts, of greater importance than the Cicindelid faunas of the Oriental, Palæarctic, or Nearctic region, though not equal to those of the Ethiopian or Neotropical region.

Turning now to the Australian Continent, we find represented there two tribes and five genera. The species of Australia are, so far as is known at present, endemic, except the widely-spread *C. semicincta* Brullé, and *C. discreta* Schaum, var. *froggatti* Macl.

Tribe Megacephalini.—The distribution of the Megacephalini shows:—South America, five genera and sixty-four species; North America, the genus *Megacephala* with four species; Europe and Asia, *Megacephala euphratica* Latr., only; Africa, the genus *Megacephala* with ten species; Australia, the genus *Megacephala* with seventeen species. The great development of this tribe in the Neotropical region, and its almost complete absence from the Nearctic, Palæarctic, and Oriental regions, together with the strong representation of the genus *Megacephala* in the three great southern land-areas of the globe, seem the important points in connection with the distribution of the Megacephalini; and here we see a striking instance of that obscure zoological problem, namely, the relationships which exist in some groups between the faunas of South America, Africa and Australia. My data are not sufficient to enable me to

* *Postscript.*—*Tricondyla aptera* has recently been found at Coen, North Queensland, by Mr. Henry Hacker.—T.G.S., 6-viii.-06.

deal with the distribution of the genus *Megacephala* in Australia; its absence from South-Eastern Australia, and its great development in the tropical parts of the continent are evident and striking points in this connection.

Tribe Cicindelini.—The four genera represented in Australia are *Cicindela*, universal (but not in Tasmania); *Nickerlea* from North Australia; *Distypsidera*, eastern coastal districts northward from the Clarence River (one species has been reported from New Guinea); *Rhysopleura*, an isolated form from the Cairns district of Queensland.

The broad facts of the distribution of the Cicindelidæ in Australia support the importance of Spencer's Torresian and Bassian Subregions; but the Cicindelidæ of the Eyrean Subregion are too little known for any conclusions to be drawn from the distribution of the family in that subregion. The two evident points are (1) their great scarcity in South-Eastern Australia, and complete absence in Tasmania (=the Bassian Subregion of Spencer); (2) their great development in the Torresian Subregion. In that part of South-Eastern Australia which I have named the north and middle Bassian districts* (=the mainland portion of Spencer's Bassian Subregion) only four Cicindelids have yet been found, namely, *C. semicincta* Brullé, and *C. mastersi* Cast., (evidently invaders from the north), with *C. ypsilon* Dej., and and *C. albicans* Chaud. The Torresian Subregion, on the other hand, is rich in genera and species, all the genera of the Australian Continent, including thirty-four species, being found therein. It seems that there is some check to the development of Cicindelidæ in Southern Australia, but whether this is (*a*) some climatic influence, (*b*) scarcity of food at the proper time of the year for the larvæ, (*c*) or the presence of some insect or other enemy, I do not know; but it is evident that the southern spread of the Cicindelidæ in Australia is arrested by conditions of an adverse character.

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* *Cf.* Check-list of the Australian Carabidæ, Pt. i. p.3, being Supplement to Proc. Linn. Soc. N. S. Wales, 1905.

EXPLANATION OF PLATES.

Plate xxv.

Fig. 1.—*Megacephala cylindrica* Macl. (♀)
Fig. 2.—*Distypsidera flavipes* Macl. (♀)
Fig. 3.—*Ryssopleura orbicollis* Sl. (type, ♀).
Fig. 4.— ,, ,, side view.

Plate xxvi.

Fig. 5.—*Megacephala crucigera* Macl.
Fig. 6.—*Cicindela iosceles* Hope (from a Cooktown specimen).
Fig. 7.— ,, *doddi* Sl. (type). (♂)
Fig. 8.— ,, *sloanei* Lea (type). (♂)

Plate xxvii.

Fig. 9.—*C. aurita* Sl.
Fig. 10.—*Megacephala australis* Chaud.; side view of larva.
Fig. 11.— ,, *cylindrica*; mentum and labial palps.
Fig. 12.— ,, *humeralis* Macl.; mentum and labial palps.
Fig. 13.—*Distypsidera undulata* Westw.; ,, ,, ,, ,,
Fig. 14.—*Cicindela ypsilon* Dej.; ,, ,, ,, ,,
Fig. 15.—*Megacephala cylindrica*; maxilla and palp.
Fig. 16.—*Cicindela ypsilon*; ,, ,, ,,

Plate xxviii.

Fig. 17.—*Megacephala cylindrica*; labrum (♀).
Fig. 18.— ,, *humeralis*; ,,
Fig. 19.—*Distypsidera undulata*; ,,
Fig. 20.—*Cicindela doddi* Sl; ,, (♂)
Fig. 21.— ,, *sloanei* Lea; ,, (♂)
Fig. 22.— ,, *leai* Sl.; ,,
Fig. 23.— ,, *tenuicollis* Macl.; ,,
Fig. 24.— ,, *aurita*; ,, (♂)
Fig. 25.— ,, *frenchi* Sl.; ,, (♀)
Fig. 26.— ,, *ypsilon*; ,, (♀)
Fig. 27.— ,, *blackburni* Sl.; ,, (♀)
Fig. 28.— ,, *sœtigera* Horn; ,, (♂)
Fig. 29.— ,, *discreta* Schaum, var. *froggatti* Macl.; labrum (♂).
Fig. 30.—*Cicindela plebeia* Sl.; labrum (♀).*
Fig. 31.— ,, ,, ,, ,, (♂).

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* Fig. 30 shows the appearance of the labrum in the type specimen (♀). A second specimen in the possession of Mr. C. French has a small tooth on each side of the central one. Fig. 31 shows the labrum of the male as too truncate on each side; it should slope forward from the external angles more as shown in fig. 30.—T.G.S.

Fig.32.—*Cicindela catoptriola* Horn; labrum (♀).
Fig.33.— ,, ,, ,, ,, (♂).
Fig.34.— ,, *mastersi* Cast.; ,, (♂).
Fig.35.— ,, *sloanei*; apices of elytra.
Fig.36.— ,, *nigrina* Macl.; apices of elytra.
Fig.37.— ,, *ypsilon*; ,, ,, ,,
Fig.38.— ,, *semicincta* Brullé; ,, ,, ,,
Fig.39.—*Megacephala cylindrica*; anterior coxal cavity.
Fig.40.— ,, ,, ; anterior coxa.
Fig.41.—*Cicindela ypsilon*; apical ventral segment (♂).
Fig.42.—*Megacephala greyana* Sl.; maxillary palp.
Fig.43.— ,, *humeralis*; ,, ,,
Fig.44.— ,, *crucigera* Macl.; mandibles and labrum (♀).
Fig.45.— ,, ,, ,, ,, ,, (♂).
Fig.46.— ,, *cylindrica*; right mandible (♀).
Fig.47.— ,, *humeralis*; left ,,
Fig.48.— ,, ,, right ,,
Fig.49.—*Cicindela nigrina*; ,, ,,
Fig.50.— ,, *ypsilon*; ,, ,,
Fig.51.— ,, *nigrina*; left elytron viewed from side (♀).
Fig.52.—*Megacephala bostocki* Cast.; left elytron viewed from side*(♀).

Plate xxix.

Fig.53.—*Megacephala australis* Chaud.; right elytron (pattern).
Fig.54.— ,, *basalis* Macl.; ,, ,, ,,
Fig.55.— ,, *intermedia* Sl.; ,, ,, ,,
Fig.56.— ,, *bostocki*; ,, ,, ,,†
Fig.57.— ,, *crucigera*; ,, ,, ,,
Fig.58.— ,, *humeralis*; ,, ,, ,,
Fig.59.—*Distypsidera undulata*; ,, ,, ,,
Fig.60.— ,, ,, ,, ,, ,,
Fig.61.— ,, *volitans* Macl.; ,, ,, ,,
Fig.62.— ,, ,, ,, ,, ,, ,,
Fig.63.— ,, *flavicans* Chaud. ,, ,, ,,
Fig.64.— ,, *flavipes*; ,, ,, ,,
Fig.65.— ,, ,, ,, ,, ,,
Fig.66.— ,, *gruti* Pascoe, var. ? ,, ,, ,,
Fig.67.— ,, ,, ,, ,, ,, ,, ,,

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* Figs.52 and 56 are drawn from the type specimen of *Tetracha excisilatera* Sl.

Fig.68.—	*Distypsidera*	*gruti* Pascoe, var. ? ;	right	elytron	(pattern).	
Fig.69.—	,,	,, ,,	,,	,,	,,	
Fig.70.—	,,	,, ,,	,,	,,	,,	
Fig.71.—	,,	*parva* Macl.;	,,	,,	,,	
Fig.72.—	*Cicindela*	*doddi*;	,,	,,	,,	(♂).
Fig.73.—	,,	*sloanei*;	,,	,,	,,	(♂).
Fig.74.—	,,	*leai*;	,,	,,	,,	
Fig.75.—	,,	*tenuicollis*;	,,	,,	,,	
Fig.76.—	,,	*nigrina*;	,,	,,	,,	(♂).
Fig.77.—	,,	*rafflesia* Chaud.;	,,	,,	,,	(♂).
Fig.78.—	,,	,, ,,	,,	,,	,,	(♀).
Fig.79.—	,,	*frenchi* ,,	,,	,,	,,	(♀).
Fig.80.—	,,	*albicans* ,,	,,	,,	,,	(♂).
Fig.81.—	,,	,, ,,	,,	,,	,,	(♀).
Fig.82.—	,,	*ypsilon*;	,,	,,	,,	(♂).
Fig.83.—	,,	,,	,,	,,	,,	
Fig.84.—	,,	,,	,,	,,	,,	
Fig.85.—	,,	,,	,,	,,	,,	
Fig.86.—	,,	*blackburni*;	,,	,,	,,	(♀).
Fig.87.—	,,	*sætigera*;	,,	,,	,,	(♂).
Fig.88.—	,,	*semicincta*;	,,	,,	,,	
Fig.89.—	,,	,,	,,	,,	,,	
Fig.90.—	,,	*discreta* var. *froggatti*;	,,	,,	,,	(♂).
Fig.91.—	,,	*plebeia*;	,,	,,	,,	(♀).
Fig.92.—	,,	*catoptriola*;	,,	,,	,,	(♂).
Fig.93.—	,,	,,	,,	,,	,,	
Fig.94.—	,,	*mastersi*;	,,	,,	,,	

Plate xxx.

Fig. 95.—	*Cicindela*	*trivittata* Macl.;	right elytron;	from	type	(♀).	
Fig. 96.—	,,	*albolineata* Macl.;	,,	,,	,,	,,	(♀).
Fig. 97.—	,,	*crassicornis* Macl.;	,,	,,	,,	,,	(♀).
Fig. 98.—	*Nickerlea* (?)	*sloanei* Lea;	mentum and labial palps;	from type(♂)*			
Fig. 99.—	*Cicindela*	*iosceles* Hope;	,,	,,	,,	,, †	
Fig. 100.—	,,	*tenuicollis* Macl.;	maxilla and palp.				

* This sketch was made from the parts without removal from the head, in consequence of which the base of the palps could not be seen very clearly, nor could the hairs thereon be drawn (the hair of the palps is sparse).—A.M.L.

† This sketch having been drawn from the parts *in situ*, the bases of the palps, &c., could not be seen sufficiently clearly to be drawn with absolute accuracy.—A.M.L.

Fig. 101.—*Cicindela albolineata* Macl.; prothorax; from type (♀).
Fig. 102.— ,, *trivittata* Macl.; ,, ,, ,, (♀).
Fig. 103.— ,, *iosceles* Hope; labrum (♂).
Fig. 104.— ,, ,, ,, ,, (♀).*
Fig. 105.— ,, *tenuicollis* Macl.; labrum showing marginal setæ.
Fig. 106.— ,, *crassicornis* Macl.; labrum; from type (♀).
Fig. 107.— ,, *tenuicollis* Macl.; labial palp.
Fig. 108.— ,, *semicincta* Brullé; anterior coxa, showing tactile seta.
Fig. 109.— ,, ,, ,, intermediate ,, ,, ,, ,,
Fig. 110.— ,, ,, ,, posterior ,, ,, ,, ,,
Fig. 111.— ,, ,, ,, anterior trochanter ,, ,, ,,
Fig. 112.— ,, ,, ,, intermediate ,, ,, ,, ,,
Fig. 113.— ,, ,, ,, posterior ,, ,, ,, ,,

Plate xxxi.

Fig. 114.—Larva of *Megacephala australis* Chaud.; in its burrow, viewed from the side.
Fig. 115.—Larva of *Megacephala australis* Chaud.; viewed from above.
Fig. 116.— ,, ,, ,, ,, ,, viewed from below.
All natural size. From drawings by Mr. H. J. Hillier (see p. 326).

CATALOGUE OF THE DESCRIBED CICINDELIDÆ OF AUSTRALIA.†

Tribe MEGACEPHALINI.

Genus MEGACEPHALA Latreille, Gen. Crust. et Ins. i. 1806, p. 175.

Tetracha Hope, Col. Man. ii. 1838, p. 7.

Pseudotetracha Fleutiaux, Rev. Ent. 1894.

AUSTRALASIÆ Hope, Proc. Ent. Soc. 1841, p. 45; Ann. Nat. Hist. 1842, ix. p. 425; Thomson, Monogr. p. 49; Fleutiaux, Rev. Ent. 1894; Horn, Deutsche Ent. Zeit. 1896, p. 353. *Hab.*—Port Essington.

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* In my female specimen of *C. iosceles* there is a small tooth, or serration, in the shallow emargination shown in Mr. Lea's figure on the outer side of each deep anterior excision, so that the labrum is 11-dentate (not 9-dentate as in fig. 104); therefore corresponding, in the number of its serrations, with the labrum of *C. crassicornis*, ♀ (fig. 106).—T.G.S.

† This Catalogue is published free from any charge on the funds of the Society.—Ed.

Var. HUMERALIS Macl., (*Tetracha* id.) Trans. Ent. Soc. N. S. Wales, i. p.9, 1863; Fleutiaux, Rev. Ent. 1894; Horn, Deutsche Ent. Zeit. 1896, p.353; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.325. *Range*—Townsville to Nickol Bay.

Var. NICKERLI Srnka, (*Tetracha* id.) Deutsche Ent. Zeit. 1895, p.269; Horn, *op. cit.* 1896, p.353. *Hab.*—Cooktown.

AUSTRALIS Chaudoir, (*Tetracha* id.) Cat. Coll. Cicin. 1865, p 6 ; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.320.

waterhousei Castelnau, (*Tetracha* id) Trans. Roy. Soc. Vict. viii. p.32, 1867.

Hab.—Central Australia (Waterhouse), Cooper's Creek (Hillier), North-west Victoria (French).

BASALIS Macleay, (*Tetracha* id.) Trans. Ent. Soc N. S. Wales, i. p.lviii., 1866; Fleutiaux, Rev. Ent. 1894; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, p.320.

Var. PHÆOXANTHA Horn, Deutsche Ent. Zeit. 1894, p.110.

Range—Townsville to King's Sound.

BLACKBURNI Fleutiaux (*Tetracha* id.) Bull. Soc. Ent. Fr. 1895 p.245; Rev. Ent 1899, p.46; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.322. *Hab.*—S.W. Australia.

BOSTOCKI Castelnau, (*Tetracha* id.) Trans. Roy. Soc. Vict. viii. 1867, p.36; Sloane, Proc Linn. Soc. N. S. Wales, 1906, xxxi. p.324.

? *excisilatera* Sloane, (*Tetracha* id.) *op. cit.* 1897, xxii. p.34.

Hab.—W.A.: Nickol Bay (*fide* Castelnau)—Northern Territory: Barrow Creek (*fide* French).

CASTELNAUI Sloane, *op. cit.* 1906; xxxi. p.321. *Hab.*—W.A.: Norseman District (*fide* French).

CRUCIGERA Macleay, (*Tetracha* id.) Trans. Ent. Soc. N. S. Wales, i. 1863, p.10; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.320. *Range*—Gayndah to Gulf of Carpentaria.

CYLINDRICA Macleay, Trans. Ent. Soc. N. S. Wales, i 1863, p.11; Fleutiaux, Rev. Ent. 1894; *op. cit.* 1899, p.46; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.319. *Hab.*—N.S.W.: Darling River—Q.: Peak Downs, etc.—C.A.: Katherine River (*fide* French).

FRENCHI Sloane, Proc. Linn. Soc. N. S. Wales (2) viii. 1893, p.25; *op. cit.* 1906 xxxi. p.319 ; Fleutiaux, Rev. Ent. 1899, p.45.

cylindrica Chaudoir & Dokhtouroff (not Macleay), Horn, Deutsche Ent. Zeit. 1904, p.94.

howitti Fleutiaux (not Castelnau), Bull. Ent. Soc. Fr. 1895, p.204; Rev. Ent. 1896, p.285.

Hab.—Q.: Cloncurry (*fide* French—W.A.: Inland from Roeburn (*fide* French).

GREYANA Sloane, (*Tetracha* id.) Proc. Linn. Soc. N.S. Wales, 1900, xxv. p.632; *op. cit.* 1906, xxxi. p.319. *Hab.*—W.A.: Carnarvon District (Sharks Bay; *fide* French).

HELMSI Blackburn, (*Tetracha* id.) Trans. Roy. Soc. S. Aust., 1892, xvi. p.16. *Hab.*—W.A.: Murchison District (Helms).

HOWITTI Castelnau, Trans. Roy. Soc. Vict. viii. 1867, p.31; Sloane, Proc. Linn. Soc. N. S. Wales (2) viii. 1893, p.483; *op. cit.* 1900, xxv. p.634; *op. cit.* 1906, xxxi. p.319: Fleutiaux, Rev. Ent. 1899, p.46. *Hab.* –Q.: Cooper's Creek (W. A. Howitt) —S.A.: Lake Callabonna (Zietz).

INTERMEDIA Sloane, Proc. Linn. Soc. N. S. Wales, 1896, xxxi. p.323. *Hab.*—W.A.: King's Sound (Froggatt), Carnot Bay (*fide* French).

MURCHISONI Fleutiaux, (*Tetracha* id.) Rev. Ent. 1896, p.285; *op. cit.* 1899, p.46 : Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.320. *Hab.*—W.A.: Murchison District.

PULCHRA Brown (*Tetracha* id.) Trans. Ent. Soc. 1869, p.352; Fleutiaux, Rev. Ent. 1894; *op. cit.* 1899 p.46 : Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.320. *Hab.*—West Australia.

SCAPULARIS Macleay, (*Tetracha* id.) Trans. Ent. Soc. N. S. Wales, i. 1863, p.10; Fleutiaux, Rev. Ent. 1894; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.320.

hopei Castelnau, (*Tetracha* id.) Trans. Roy. Soc. Vict. iii. 1867, p.37; Fleutiaux, Rev. Ent. 1894; Horn, Deutsche Ent. Zeit. 1898, p.194.

Range—Port Denison to Nickol Bay.

SPENCERI Sloane, Proc. Linn. Soc. N. S. Wales, 1897, xxii. p.33. *Hab.*—W.A.: Murchison River (*fide* French).

Tribe CICINDELINI.

Genus Rhysopleura Sloane, Proc. Linn. Soc. N. S. Wales, 1906, p.330.

ORBICOLLIS Sloane, (*Distypsidera* id) Proc. Linn. Soc. N.S.Wales, 1904, xxix. p.529; *op. cit.* 1906, xxxi. p.331. *Hab.*—Q.: Kuranda (Dodd).

Genus Distypsidera Westwood, Mag. Zool. Bot. i. 1837, p.251.

FLAVICANS Chaudoir, Bull. Soc. Imp. Nat. Mosc. i. 1854, p.125; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.333.
cursitans Macleay, Trans. Ent. Soc. N. S. Wales, i. 1863, p.12.
strangei Castelnau, Trans. Roy. Soc. Vict. viii. 1867, p.33.
Hab.—Coastal districts of Northern New South Wales and Southern Queensland.

FLAVIPES Macleay, Proc. Linn. Soc. N. S. Wales (2) ii. 1887, p.214. *Hab.*—Q.: Cairns.

GRUTI Pascoe, Ann. Mag. Nat. Hist. (3) 1862, ix. p.462; Horn, Deutsche Ent. Zeit. 1892, p.93; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.333.
plustchevskyi Dokhtouroff, Rev. Mens. Ent. i. 1883, p.7.
var. *interrupta* Dokhtouroff, *l.c.* p.7 = *pascoei* Macleay, Proc. Linn. Soc. N. S. Wales, (2) ii. 1887, p.214.
Hab.—Q.: Lizard Island, Cairns.

? MASTERSI Macleay, Trans. Ent. Soc. N. S. Wales, ii. 1871, p.80; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.333. *Hab.*—Gayndah.

PARVA Macleay, Proc. Linn. Soc. N. S. Wales, (2) ii. 1887, p.215; Sloane, *op. cit.* 1906, xxxi. p.334. *Hab.*—Q.: Cairns.

UNDULATA Westwood, Mag. Zool. Bot. i. 1837, p.252; Sloane, Proc. Linn Soc. N. S. Wales, 1906, xxxi. p.333. *Hab.*—Coastal districts of Northern New South Wales and Southern Queensland.

VOLITANS Macleay, Trans. Ent. Soc. N. S. Wales, i. 1863, p.11; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.333.

fasciata Motschulsky, Bull. Soc. Imp. Nat. Mosc. 1864, iii. p.174; Horn, Deutsche Ent. Zeit. 1892, p.93.
lævisculpta Horn, *op. cit.* 1894, p.222.
Hab.—Q.: Port Denison, Townsville.

Genus NICKERLEA Horn, Deutsche Ent. Zeit. 1899, p.135.

DISTYPSIDEROIDES Horn, *l.c.* p.136. *Hab.*—Northern Australia.

SLOANEI Lea, (*Cicindela* id.) Proc. Linn. Soc. N. S. Wales, 1897, xxii. p.584. *Hab.*—W.A.: Mullewa (Lea).

Genus CICINDELA Linné, Syst. Nat. ii. 1735, p.657.

ALBICANS Chaudoir, Bull. Soc. Imp. Nat. Mosc. 1854, i. p.117.
wilcoxi Castelnau, Trans. Roy. Soc. Vict. viii. 1867, p.34.
Hab.—Eastern Australia (Clarence River, N.S.W., to Fitzroy River, Q.).

ALBOLINEATA Macleay, Proc. Linn. Soc. N. S. Wales, (2) iii. 1888, p.444. *Hab.*—King's Sound.

AURITA Sloane, *op. cit.* 1904, xxix. p.528. *Hab.*—Q.: Cooktown.

BLACKBURNI Sloane, *op. cit.* 1906, xxxi. p.342. *Hab.*—W.A.: Norseman District.

CRASSICORNIS Macleay, *op. cit.* (2) iii. 1888, p.445. *Hab.*—King's Sound.

CATOPTRIOLA Horn, Deutsche Ent. Zeit. 1901, p.355.
curvicollis Sloane, Proc. Linn. Soc. N. S. Wales, 1905, xxx. p.233. *Hab.*—N.W. Australia.

[DISCRETA Schaum, Journ. Ent. 1863, p.59.]
var. *froggatti* Macleay, Proc. Linn. Soc. N. S. Wales, (2) iii. 1887, p.213; Sloane, *op. cit.* 1906, xxxi. p.346.
= var. *subfasciata* Horn, Deutsche Ent. Zeit. 1892, p.370.
Hab.—Q.: Cairns District (also New Guinea, &c.).

DODDI Sloane, Proc. Linn. Soc. N. S. Wales, 1905, xxx. p.230; *op. cit.* 1906, xxxi. p.338. *Hab.*—Q.: Cairns.

FRENCHI Sloane, *op. cit.* 1904, xxix. p.527; *op. cit.* 1906, xxxi. p.341. *Hab.*—N.W. Australia (Carnot Bay).

IGNEICOLLIS Bates, Ent. Mo. Mag. 1874, x. p.262; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.344. *Hab.*—Nickol Bay.

IOSCELES Hope, Proc. Ent. Soc. 1841, p.45; Ann. Mag. Nat. Hist. 1842, ix. p.425: Horn, Deutsche Ent. Zeit. 1898, p.193: Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.338.

hackeri Sloane, *op. cit.* 1905, xxx. p.229.

platycera Gestro, Ann. Mus. Civ. Genov. 1879, xiv. p.553.

Range—Cooktown to Port Essington.

LEAI Sloane, Proc. Linn. Soc. N. S. Wales, 1905, xxx., p.234; *op. cit.* 1906, xxxi. p.339. *Hab.*—Q.: Cooktown.

MASTERSI Castelnau, Trans. Roy. Soc. Victoria. viii. 1867, p.33. *Hab.*—N.S.W.: Mulwala, Urana, Lake Cudgellico and Parramatta (Sloane), Queanbeyan (Lea), Rope's Creek (Masters).

NIGRINA Macleay, Trans. Ent. Soc. N. S. Wales, i. 1864, p.107; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.339. *Hab.*—Q.: Port Denison (Masters), Townsville (Dodd).

PLEBEIA Sloane, *op. cit.* 1905, xxx. p.232. *Hab.*—Q: Kuranda (Dodd).

OBLONGICOLLIS Macleay, *op. cit.* (2) iii. 1888, p.445. *Hab.*—N.W. Australia, 100 miles inland from Derby (Froggatt).

RAFFLESIA Chaudoir, Bull. Soc. Imp. Nat. Mosc. 1852, i. p.13.

montraveli Blanchard, Voy. Pôle Sud, iv. 1852, p.8, Pl.i. fig.6.

Hab.—Cape York; Raffles Bay.

SEMICINCTA Brullé, Silb. Rev. Ent. ii. 1834, p.100; Horn, Deutsche Ent Zeit. 1893, p.336; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.344.

circumcincta Castelnau, Trans. Roy. Soc. Vict. viii. 1867, p.34.

hemicycla Montrouzier, Ann. Soc. Linn. Lyon, vii. 1857, p.7.

interrupta Fabr., Syst. El. i. 1801, p.243.

menetriesi Gistl, Syst. Ins. p.25.

Range—Australia; New Caledonia; New Hebrides; New Guinea; Java.

SÆTIGERA Horn, Deutsche Ent. Zeit. 1893, p.198; Sloane, Proc. Linn. Soc. N. S. Wales, 1906, xxxi. p.343.

jungi Blackburn, Trans. Roy. Soc. S. Aust. 1901, p.15; Rainbow, Rec. Aust. Mus. 1904, v. p.245, (fig.).

Hab.—S.A.: Yorke's Peninsula.

TENUICOLLIS Macleay, Proc. Linn. Soc. N. S. Wales, (2) iii. 1888, p.446; Sloane, *op. cit.* 1905, xxx. p.234; *op. cit.* 1906, xxxi. p.339. *Hab.*—N.W. Aust.; 100 miles inland from Derby (Froggatt).

TETRAGRAMMA Boisduval, Voy. Astrol. ii. p.6 : Horn, Deutsche Ent. Zeit. 1893, p.335; *op. cit.* 1899, p.41; *op. cit.* 1904, p.88; *op. cit.* (Index) 1905, p.39.

macleayi Castelnau, Trans. Roy. Soc. Vict. viii. 1867, p.37.

? var. *trivittata* Macleay, Proc. Linn. Soc. N. S. Wales, (2) iii. 1888, p.444; Sloane, *op. cit.* 1906, xxxi. p.340.

Hab.—N.W. Australia.

YPSILON Dejean, Spec. i. p.126; Boisduval, Voy. Astrol. ii. p.8. *Range*—Lakes Entrance, Victoria to Sydney (on sea beaches).

ADDENDA.

The following references were overlooked in their proper places :—

p.354, M. AUSTRALASIÆ Hope—White, Stokes Voy., Append. Ins. Pl.i., fig.1.

p.356, M. FRENCHI Sloane—*op. cit.* 1900, xxv. p.634.

NOTES AND EXHIBITS.

Mr. R. T. Baker brought forward herbarium specimens of the leaves and fruits and economic specimens of the timbers of the two species of Eucalypts in illustration of his paper.

Dr. Greig-Smith exhibited a specimen of the dry gum of *Rhizobium leguminosarum* and a solution to show its gelatinous nature. Stained preparations under the microscope showed the coccoid nature of the composite bacterium.

Mr. T. Griffith Taylor exhibited numerous slabs and thin microscopic sections of limestone containing fossil corals. The points connected with the structure of these were explained by means of lantern slides. The fossils were collected during a visit to South Australia last February. The *Archeocyathinæ* occur in a limestone belt extending four hundred miles in a northerly direction from Port Victor to Lake Eyre. The best localities appear to be at Sellick's Hill (30 miles south of Adelaide) and the Ajax Mine, Beltana, about 350 miles north, near Lake Torrens. From each of these places some two hundred specimens were obtained, many slabs being from six to fourteen inches across. The Archeocyathinæ reef is probably the largest deposit of Cambrian fauna in the world. Huge outcrops occur along the line of strike, as at Normanville, Ardrossan, Wilson, Parachilna, Beltana, &c. The fossils vary in size from a diameter of 5 or 6 inches to small (or young) forms hardly discernible to the naked eye. They are marvellously preserved, and the Beltana specimens have undergone silicification to a great extent. This enables one to etch them with wonderful results, each pore of the perforate walls standing out as a white structure on the brown limestone. Investigations during the past eight months lead one to the belief that they possibly represent a link connecting the Cœlenterata and Porifera. The numerous specimens of etched material and serial sections for the microscope throw much light on their morphology. Of especial interest are the methods of attachment and reproduction (so far not recorded), the determination of which is of great value in connection with the affinities of the *Archeocyathinæ.* Many slabs are crowded with minute calices showing varying degrees of complexity in their septation.

Mr. Griffith Taylor also exhibited, in the absence of Mr. H. I. Jensen, specimens of diatomaceous earth from Bugaldie, north of the Warrumbungle Mountains. The deposit occurs near the summit of a basaltic mountain, Mt. Chalker or Chalk Mountain, at an elevation of about 2,260 feet. It apparently represents a deposit formed in a geyser or crater lake and afterwards covered with a lava flow.

Mr. H. J. Carter exhibited the type specimens of *Cardiothorax* described in his paper which was read at the preceding meeting.

Dr. E. S. Stokes showed drawings and microscopic preparations illustrating the structure of *Fredericella sultana*, var., *Anabæna* sp. and *Peridinium* sp., all taken from the upper reaches of the Sydney Water Supply. The effect of the growth of these upon the quality of the water was described.

Mr. A. G. Hamilton exhibited a ball of vegetable fibre similar to that exhibited at the last meeting by Mr. R. T. Baker. It was picked up on a beach near Albany, W.A., where there was an area of 3 or 4 acres covered with balls and cylinders rolled by the action of the waves. The bay was shallow and the bottom covered with a thick growth of some grass-leaved plant like *Zostera*, and it was from the decayed leaves that the fibre was derived. As there were no flowers or fruits it was impossible to determine the plant.

Dr Chapman drew the attention of members to a variation in the reaction between *Hyla aurea* and strychnine. He pointed out that frogs obtained in the neighbourhood of Sydney rarely showed typical convulsant action, but a paralysis of peripheral nerve endings. Further research was being carried out to determine the cause of this variation.

WEDNESDAY, JULY 25TH, 1906.

The Ordinary Monthly Meeting of the Society was held in the Linnean Hall, Ithaca Road, Elizabeth Bay, on Wednesday evening, July 25th, 1906.

Mr. Thomas Steel, F.C.S., F.L.S., President, in the Chair.

On behalf the Council and the Members of the Society, the President said that he had great pleasure in tendering to Dr. J. P. Hill, who was present, hearty congratulations on his appointment to the important position of Professor of Zoology in University College, London, with best wishes for his future success. While rejoicing at this well-deserved recognition of Dr. Hill's eminent services to science, his departure from Sydney was to be regretted, for science in Australia could ill spare workers of the zeal and ability of Dr. Hill.

The President also said that since last Meeting the Members had learned, with the deepest regret, of the death of the Hon. James Norton, LL.D., M.L.C., in the 82nd year of his age. The Society was under great obligations to Dr. Norton for his active aid in the management of its affairs during the long period of his official connection with it, he having held office as a Member of Council in 1878, 1879, and from 1881 to the time of his decease; as Honorary Treasurer from 1882 to 1897; and as President in the years 1899 and 1900. Dr. Norton's claim upon the respect and affectionate regard of Members rested, however, upon a wider basis than this, for he was the "father" of the Society, inasmuch as not only was he one of its founders, his name being eighteenth on the first list of effective Members, but he had outlived all those whose names preceded his own on the list. During the entire history of the Society Dr. Norton's active interest in its work and welfare never wavered; and those who had served with him on the Council knew well how helpful had been his advice, especially where legal points were concerned. It was only quite recently that his familiar presence had begun to be missed at the Council and Monthly Meetings on account of failing health. He had gone to his rest, honoured and respected, and his name must always remain enshrined as one of the early benefactors of the Society which he loved so well.

On the motion of Dr. T. Storie Dixson, Vice-President, seconded by Mr. Henry Deane, M.A., Vice-President, it was resolved :—

1. That the Members of this Society desire to give expression to the profound regret evoked by the decease of Dr. Norton; and to place on record their warm appreciation of his inestimable services in official capacities (Member of Council, Hon. Treasurer, and President), with special recognition of his unflagging, active nterest in the Society's welfare and progress throughout the entire period of its existence (nearly thirty-two years).

2. That a copy of the resolution be forwarded to Mrs. Norton and family, with an expression of the Society's deep sympathy in their bereavement.

The Donations and Exchanges received since the previous Monthly Meeting, amounting to 9 Vols., 64 Parts or Nos., 13 Bulletins, 3 Reports, 1 Pamphlet, 1 Map, and 2 Miscellanea, received from 57 Societies, &c., and 1 Individual, were laid upon the table.

BOTANY OF NORTH-EASTERN NEW SOUTH WALES

By Fred. Turner, F.L.S., F.R.H.S., etc.

Introduction.

North-Eastern New South Wales, considered from a botanical point of view, is one of the most fertile and interesting sections of country on this continent. It comprises the region lying between the Macpherson Range, the boundary of this State and Queensland, and the parallel 32° South. The western boundary is the meridian 152° 20′ East as far south as the parallel 31° South, thence it is the meridian 151° East. It is bounded on the east by the South Pacific Ocean, the coast line being approximately 350 miles long. It has an area of about 18,750 square miles. The physical features of the western portion of this region consist of rugged mountain ranges, principally spurs from the Great Dividing Range, with deep ravines and several prominent peaks, a series of plateaux, very steeply and gently undulating country, and some fairly level land. The eastern division consists for the most part of low ranges and isolated hills, steeply and gently undulating country, also considerable tracts of comparatively level land. The principal soils of the North-East are volcanic, alluvial, clayey and sandy. Over a great part of this area the soil is of great depth and very fertile; abundant crops of excellent produce of a semi-tropical character are annually raised on cultivated areas. The pasturage, which is composed of indigenous and acclimatised grasses and herbage, provides rich feed for large herds of cattle and other domestic herbivora.

Climate.

Temperature of Grafton.

Mean temperature	68·5° F.
Mean Summer temperature	77·1°
Mean Winter temperature	58·1°
Highest temperature (shade)	118·0°
Lowest temperature (shade)	20·9°

The temperature will range from a few degrees higher in the extreme north to a few degrees lower in the extreme south, but those mentioned will give a good idea of the climate of North-Eastern New South Wales.

Rainfall.

The average annual rainfall at Grafton is 53¾ inches, but it ranges from 73¾ inches in the extreme north to 58¼ inches in the extreme south. That is the highest average annual rainfall in any part of New South Wales.

Water.

In addition to its abundant rainfall the North-East is watered by the following rivers, some of which are navigable for a considerable distance from their estuaries:—Tweed, Richmond Clarence, Bellinger, Nambucca, Macleay, Hastings and Manning There are several smaller rivers and numerous creeks, also a number of small lakes and swamps containing large quantities of permanent water.

The Flora.

Immediately after my arrival in Australia in 1874, the Government of Queensland sent me on a botanical excursion into the southern part of that State, and it was at Point Danger, near the entrance to the Tweed River, that I first saw *Pandanus pedunculatus* R.Br., and *Ischœmum triticeum* R.Br., growing in New South Wales. Although it is so long ago I have a vivid recollection of them. The former was growing on the sea-ward side of a grassy knoll and the latter on the shelving sides of the rocky prominence. There were, of course, many other plants in the immediate neighbourhood, but those two species first attracted my attention. During rough weather sea spray must have often drenched them, but they seemed to luxuriate in the position. Since I settled in New South Wales I have travelled much and botanised largely in the North-East, and have written many special reports on the economic value of the indigenous and acclimatised flora growing there. Many of the plants in this region have been figured and described, as to their economic value, by me, under instructions from the Government of New South Wales. The vegetation of the North-East may be described as semi-tropical, and more indigenous species of plants are found there than on any other area of similar size in New South Wales. In the most favoured places the growth is very dense and luxuriant, and in many of the scrubs or brushes it is not possible to see many yards in any direction. Much of the arboreal vegetation is festooned with immense, and often beautiful flowering climbing plants, and on the trunks and larger branches of the trees many epiphytal orchids and ferns may be seen growing, while the ground is literally carpeted with a great variety of terrestrial ferns. On one gigantic fig tree, *Ficus macrophylla* Desf., I counted more than two hundred epiphytes, consisting of *Dendrobium æmulum* R.Br., *D. gracilicaule* F.v.M., *D. speciosum* Sm., *D. s.*, var. *hillii*, *D. teretifolium* R.Br., *D. tetragonum* A. Cunn., *Sarcochilus divitiflorus* F.v.M., *S. hillii* F.v.M., *Cymbidium suave* R.Br., *Saccolabium hillii* F.v.M., *Asplenium falcatum* Lam., *A. nidus* Linn., *Aspidium cordifolium* Swartz, *Davallia pyxidata* Cav., *Ophioglossum pendulum* Linn., *Platycerium alcicorne* Desv., *P. grande* J.Sm., and *Vittaria elongata* Swartz. The trunks of some trees are almost enveloped by climbing ferns, which have a singular but pleasing effect in the almost impenetrable forest. Fern trees grow abundantly in many places, and some of the species attain considerable height. Their large graceful fronds are a charming sight amongst the sub-arboreal vegetation. The palms, although they only number a few species, sometimes grow into miniature forests, giving a decidedly tropical aspect to the surroundings. The tallest I have seen in the North-East were on the Tweed River, but many noble specimens may be seen dotted over a great part of this region. In different parts of this area there are magnificent forests of various kinds of trees producing timber of great industrial value; the Eucalypts being extensively employed where strength and durability are required, and the more easily worked, softer timbers being largely used for the finer classes of carpentry work. There are many trees producing valuable, and in some instances, highly ornamental timber, which only require to be better known to commerce to be used for many industrial purposes. The largest soft-wood tree producing the most valuable and beautifully marked timber is the "Red Cedar," *Cedrela toona* Roxb., and it is so eagerly sought by timber-getters that very fine specimens are only to be seen growing in comparatively inaccessible places. In different parts of this region there are heaths covered with dwarf vegetation. The first heath over which I botanised is between Broadwater and Woodburn on the Richmond River, where I was agreeably surprised to find many species of plants that grow in the neighbourhood of Sydney. It was on the borders of this heath, under the partial shade of some species of *Eucalyptus* and *Angophora*, that I found the tallest and most floriferous specimens of *Hovea longifolia* R.Br., and *H. linearis* R.Br., that I ever set eyes on in any part of Australia.

Following is a brief description of some of the noteworthy Orders, genera, species and varieties found in the North-East:—

Ranunculaceæ are not largely represented, but include three species and a few varieties of *Clematis* which climb trees and shrubs and sometimes cover rocks on the mountain sides. In the early spring they produce a profusion of white or cream-coloured flowers, which are very effective amongst the surrounding vegetation. Amongst the four indigenous species of *Ranunculus* one, *R. lappaceus* Sm., has a rather rare variety which produces semi-double and double flowers of a rich yellow colour. With one exception, *Dilleniaceæ* consist of eleven species and two varieties of *Hibbertia*, the most showy flowering one being *H. volubilis* Andr. On one occasion I saw this climbing plant growing over a shrub several feet high, and literally covered with large, yellow flowers. The "custard apple" family, *Anonaceæ*, includes trees, shrubs, and climbing plants, some of which produce sweetly scented flowers and edible fruit. *Menispermaceæ* are represented by five genera and species. All are climbing plants and some regarded as poisonous. *Nymphæaceæ*, consisting of only two genera and species, sometimes cover the surface of lakes with their large leaves and beautiful flowers. I have seen waterlilies growing in many parts of the world, but never any that presented a more beautiful sight than *Nymphæa gigantea* Hook., on a lake a few miles west of Grafton. Many of the leaves were eighteen inches in diameter, and the lovely blue flowers a foot across. Hundreds of such blooms in the bright sunlight are a sight not easily forgotten. Under *Capparideæ* there are a few interesting species, including *Capparis nobilis* F.v.M., which grows into a fair sized tree with evergreen shining leaves, white flowers, and globular or ovoid fruits. I have grown this species in the neighbourhood of Sydney, where it has produced flowers for the last few years Some of the several trees and shrubs of *Pittosporeæ* have sweetly perfumed flowers. *Hymenosporum flavum* F.v.M., is one of the most handsome evergreen and floriferous trees of this Order. When in bloom its terminal corymbose panicles of large, yellow flowers never fail to attract the attention of the most unobservant person. The allied "Orange-thorns," *Citriobatus multiflorus* A. Cunn., and *C. pauciflorus* A. Cunn., produce numerous yellow fruits like very small oranges. Those of the former being sometimes nearly half an inch in diameter, while those of the latter are often four and a half inches in circumference. Many species of the seven indigenous genera of *Malvaceæ* are found over a great part of this region Amongst the shrubby kinds none have such large and varied coloured flowers as the different species of *Hibiscus*. Those producing the most showy flowers are *H. rhodopetalus* F.v.M., with red flowers from three to four or more inches in diameter, *H. divaricatus* Grah., with yellow flowers with a crimson eye, from four to five inches in diameter, and *H. splendens*

Fraser, with rose-coloured flowers about six inches in diameter. The small trees, *Hibiscus heterophyllus* Vent., and *H. tiliaceus* Linn., respectively, have white flowers with a purple centre, about six inches in diameter, and yellow flowers with a dark crimson centre, from four to six inches in diameter. The closely allied tree, *Lagunaria patersoni* Don, produces a profusion of pink flowers. *Sterculiaceæ* include several highly ornamental trees and shrubs. The most conspicuous flowering species of this Order is *Sterculia acerifolia* A. Cunn. In the month of December this fine tree usually produces numerous auxiliary panicles of rich red flowers, which can be seen from long distances, and have a charming effect amongst the surrounding vegetation. The bark of some allied trees and shrubs yields a strong fibre, which the aborigines used for many purposes. Although *Tiliaceæ* are not numerous in the North-East, the Order is represented by some interesting species of arboreal and shrubby growth. One of the most admired trees when in bloom is *Elæocarpus cyaneus* Ait. Its flowers are borne in great profusion, being usually white, but occasionally rose-coloured, and they are succeeded by globular or ovoid, blue fruits. *E. grandis* F.v.M., yields the northern "Quandong." The globular, blue fruits of this species, about one inch in diameter, have a hard rugose putamen, and are often used for making bracelets, &c.

Rutaceæ are well represented in the flora of the North-East, and some of the dwarf shrubby kinds, especially species of the genera *Boronia*, *Correa*, *Crowea*, and *Eriostemon*, are greatly admired for their charming flowers. *Boronia pinnata* Sm., is a very variable plant as regards stature and the colour of its flowers, which ranges from almost pure white to deep pink. There is a beautiful white-flowering variety of *Eriostemon salicifolius* Sm., but it appears to be rare. Species of this genus sometimes produce double flowers. A number of trees of commercial importance are included in this Order. The wood is generally of a light or deep yellow colour, close in the grain, and durable; *Zanthoxylum brachyacanthum* F.v.M., yields a beautiful glossy timber, known locally as "Satinwood" and "Thorny Yellow

Wood." Two species of *Citrus*, *C. australis* Planch., and *C. australasica* F.v.M., produce acid fruits which are used for making into preserves. The former has a globular fruit from three to seven or more inches in circumference, and the latter an oblong or almost cylindrical one from three to four inches long. From an arboriculturist's point of view the Order *Meliaceæ* is very important, as it includes some of the most ornamental and useful timber trees in New South Wales. Reference has already been made to the "Red Cedar," *Cedrela toona* Roxb. "White Cedar" is the timber of *Melia composita* Willd , an elegant tree with compound leaves, large panicles of lavender-coloured flowers, and ovoid drupes. Species of *Dysoxylon* furnish the well-known "Rosewood," "Red Bean," &c., and those of *Flindersia* the "Yellow Wood." The curious, hard, muricate fruits of the latter are sometimes called wooden rasps. *Celastrineæ* are not numerous in this region, but consist of some ornamental trees, shrubs, and vigorous-growing climbing plants. *Elæodendron australe* Vent., is an exceedingly pretty tree when in fruit. The drupes are ovoid or globular, and of a bright red colour when ripe. Many species of *Vitis* of the *Ampelideæ* are tall, woody climbing plants, and are fairly common in some of the brushes. They often climb to the tops of the highest trees, some of them producing fruit in small grape-like bunches, which is edible when ripe, and is sometimes made into preserves. From the stems of some species I have obtained good drinking water. The important Order *Sapindaceæ* is well represented by a number of ornamental trees, some of which produce timber of great economic value. *Harpullia pendula* Planch., yields the beautifully figured "Tulip-wood." The succulent arillus wholly or partly surrounding the seeds of some species is edible, and often acceptable to those who camp in the bush. There are only two genera and species of *Anacardiaceæ*, *Rhus rhodanthema* F.v.M., being an ornamental, umbrageous tree, which grows into fair dimensions in some situations. Its panicles of small red flowers are usually produced in great profusion, and have a pretty effect when in bloom. It produces the "Yellow Cedar," a finely grained, beautiful timber.

Leguminosæ are widely distributed, and are a conspicuous feature in the vegetation in many parts of this region. They are found on all classes of soil, and in rocky situations. The Suborder *Papilionaceæ* includes some very beautiful flowering trees, shrubs and climbing plants. Amongst the trees *Barklya syringifolia* F.v.M., with bright yellow flowers, *Castanospermum australe* A. Cunn., with deep orange-coloured flowers, *Daviesia arborea* W. Hill, with bright yellow flowers, and *Erythrina indica* Lam., with scarlet flowers, are a charming sight when in bloom. The two last-named are not nearly as common as the others, and as far as my observations go, only occur in the extreme north. The shrubby species are numerous, and some of the most beautiful and profusely flowering ones belong to the genera *Aotus*, *Daviesia*, *Dillwynia*, *Gompholobium*, *Hovea*, *Indigofera*, *Jacksonia*, *Oxylobium*, and *Pultenæa*. One of the most beautiful flowering climbing plants is the "Native Wistaria," *Millettia megasperma* F.v.M., which I have seen hanging down in most graceful festoons from trees more than fifty feet high, thus showing its large racemes of purple flowers to the greatest advantage. *Lonchocarpus blackii* Benth., is another singularly effective, tall, woody climbing plant with dark purple flowers borne in large, terminal panicles. *Mucuna gigantea* DC., is a large twiner with pale greenish-yellow flowers in short, loose corymbs on rather long, pendulous peduncles. There are quite a number of smaller climbing or twining plants producing flowers of various hues which when in bloom have a pleasing effect. The only species of the Suborder *Cæsalpinieæ* which attains arboreal dimensions in the North-East is *Cassia brewsteri* F.v.M. (the other members of this group being either shrubs or climbers) It is an exceedingly ornamental evergreen tree, of which there are two or three well-marked varieties In the dense forests the trunks grow straight with only a few branches near the apex, but in more open country the tree forms a beautiful umbrageous head. In the Suborder *Mimoseæ* species of the genus *Acacia* largely predominate; the *Phyllodineæ* being much more numerous than the *Bipinnatæ*. Many of the former are of shrubby habit, but several grow into fair-sized trees and produce timber of great industrial value. One of the most important in this respect is *A. melanoxylon* R.Br., which furnishes the "Blackwood" and "Lightwood" of timber-getters. The *Bipinnatæ* include some of the most beautiful flowering species of *Acacia* in Australia, and one, *A. decurrens* Willd., yields the best tanning bark in the State. Of the four species of *Pithecolobium*, one, *P. pruinosum* Benth., has long been under cultivation, and the others deserve similar attention. The stamens of *P. grandiflorum* Benth., are long and of a rich crimson colour. The most useful fruit-producing plants of *Rosaceæ* are the four indigenous species of *Rubus*. They are common in places, and their ripe fruit is often eaten fresh, and sometimes made into preserves. *Saxifrageæ* are fairly well represented over a great part of this region. They consist of trees and shrubs, some of which are of a highly ornamental character, one of the rarest being *Davidsonia pruriens* F.v.M., var. *jerseyana*. The Order *Myrtaceæ*, either in an arboreal, sub arboreal or shrubby state is common. Some of the immense forests are largely composed of Myrtaceous trees, of which the most important are species of *Eucalyptus*. No less than twenty-five species, besides several well-marked varieties, of this genus occur, and these furnish some of the best hardwood in Australia. Very valuable timber trees are included in other allied genera, notably *Tristania* and *Syncarpia*. The shrubs of this Order are fairly numerous, some of them producing showy flowers of various hues. Different species of *Eugenia*, when in fruit, have a pretty effect in some of the brushes. The indigenous *Passifloreæ* consist of only two species but two exotics have become acclimatised, one, *Passiflora edulis* Sims, producing quantities of good edible fruit. *Cucurbitaceæ* include several interesting prostrate or climbing plants, one of which, *Trichosanthes palmata* Roxb., climbs to the tops of the tallest trees in the forests and has a nearly globular fruit about nine inches in circumference. The *Umbelliferæ* are rather numerous as regards species and are widely distributed. The most popular species of this Order from a horticultural point of view is *Actinotus helianthi* Labill. It is common in some of the mountainous country, where it is known as the "Australian edelweiss" or "flannel flower," and some forms produce very large involucres. This species is variable in habit in different situations, and specimens with fasciated stems may occasionally be seen. The allied Order *Araliaceæ* includes some highly ornamental trees and shrubs. The three species of *Astrotricha*, which are fairly abundant in many places, are remarkable for the stellate tomentum covering the upper part of their branches, inflorescence and underside of the leaves. *Panax murrayi* F.v.M., and *P. elegans* F.v.M., are two handsome trees with very large, pinnate leaves, often several feet long. The other two species of *Panax* are of shrubby habit with elegantly divided leaves. There is only one genus and species (*Marlea vitiensis* Benth.) of *Cornaceæ* known in Australia, and this is found in the North-East as well as in Queensland. This large tree has leaves from three to five inches long, and flowers arranged in short, axillary cymes. Its fruit is ovoid and about half an inch long. It yields a very good timber, which is known locally as "Muskwood."

The Order *Loranthaceæ* includes three genera, fourteen species and one variety. These parasitical plants are found on many species of trees and shrubs *Rubiaceæ* consist of a number of interesting small trees, shrubs, climbers, and herbs, and are fairly well distributed. Some species produce highly fragrant flowers, and when in bloom give a delicious perfume to the surrounding air. The fruit of *Gardenia chartacea* F.v.M., is oval, about the size of a small plum, and red when ripe. Its seeds are enveloped in a pulp pleasant to the taste. An allied shrub or small tree, *Randia densiflora* Benth., bears a globular or ovoid, scarlet fruit which forms a pleasing contrast to its shining green foliage. One of the most floriferous climbers is *Cœlospermum paniculatum* F.v.M. Its white flowers are borne in cymes forming a dense, oblong, terminal panicle, and the globular fruit is of a purplish colour when ripe. Although *Compositæ* are well represented both as regards genera and species, they do not grow nearly as densely as on the western plains, where thousands of acres may be seen covered with similar vegetation. The majority in the North-East are found in mountainous and broken country, where some of the showy flowering species display such a wealth of bloom in early summer as would rival many a well cultivated garden. Several exotics, some of an undesirable character, have become acclimatised and spread much during recent years. One of the worst pests is the South American *Tagetes glandulifera* Schranck. The whole plant is pulicifugous. The species of *Velleia* and *Goodenia* of the *Goodenovieæ* generally have yellow flowers, but *Scævola* and *Dampiera* have mostly blue or purple ones. These occur on both high and low land, often on alluvial flats and in damp situations. *Scævola suaveolens* R.Br., is found near the sea, and has sweetly perfumed flowers. The shrubby *Dampiera brownii* F v.M., is one of the tallest species of the Order. Amongst the *Campanulaceæ* are several interesting, dwarf, annual or perennial flowering plants, none having a prettier effect when in bloom than some species of *Lobelia*. The larger, blue-flowering kinds sometimes produce albinos, and are deserving of garden culture. *Epacrideæ* have many species which are admired for their singularly showy flowers. They are rarely cultivated, however, in Australian gardens, but I have seen several growing in the plant houses of Europe. Both the tribes, (1) those with drupaceous fruit and (2) those having dehiscent capsules, occur in the North-East, the former being much more numerous than the latter. They consist of small trees and shrubs, many of them growing on poor sandstone country or on sandy heaths. Occasionally one comes across a white-flowering variety of *Epacris longiflora* Cav., and a double flowering variety of *E microphylla* R Br., and both of these are charming plants. There are only four genera and five species of the *Myrsineæ*, but they are fairly common in places. *Samara australiana* F.v.M., is a tall woody climber, sometimes reaching to the tops of the highest trees. Its small flowers are succeeded by globular, red fruits about a quarter of an inch in diameter. *Myrsine variabilis* R.Br., is a tree about forty feet high, remarkable for its variable foliage. The "River Mangrove," *Ægiceras majus* Gærtn., is common in many of the marshes on the sea coast and on some of the low banks of the principal rivers. Generally it is of shrubby habit, but sometimes attains the dimensions of a small tree. It has sweetly scented, white flowers and a curious, curved, horn-like fruit. Several species of *Sapotaceæ* produce plum-like fruits which are eaten by the aborigines, but not esteemed by the settlers. *Achras australis* Benth., is a beautiful evergreen tree. Its almost globose, plum-coloured, large, fleshy fruits when ripe are a very tempting sight, but are insipid to the taste. There are only one genus, two species, and one variety of the Order *Styracaceæ* known in the North-East, and they are not common. *Symplocos thwaitesii* F.v.M., the more floriferous, may often be seen flowering as a dwarf shrub, though it finally attains the dimensions of a fair-sized tree. In addition to the three species of *Jasminum* and three of *Notelæa*, *Jasmineæ* include a true olive, *Olea paniculata* R.Br., which grows into a moderate-sized tree with ovoid drupes, resembling those of the common olive, and may eventually prove of some commercial value. *Apocyneæ* are represented by trees, shrubs and climbers, which are found over a great part of this region. Of the seventeen known species no less than eleven are climbers, and the vigorous-growing ones partly clothe the trunks and larger branches of trees with their stems and large leaves. *Carissa ovata* R.Br., is a dwarf shrub sometimes producing a quantity of ovoid fruits which are eaten by the aborigines, whilst one of the most ornamental shrubs of this Order is *Alyxia ruscifolia* R.Br. I have grown it successfully in Sydney, and in some seasons it produces a profusion of small, orange-coloured fruits which make it an attractive object in a shrubbery. The two species of *Ochrosia*, *O. elliptica* Labill., and *O. moorei* F.v.M., are handsome, slender trees, the former occurring on the coast and the latter generally in the dense brushes further inland. Their large, scarlet fruits are very conspicuous and form a pleasing contrast with their vivid green foliage. Several interesting twining plants are included under *Asclepiadeæ*, some of them having large, tuberous roots. *Hoya australis* R.Br., may often be seen cultivated in verandahs and in bush houses for the sake of its waxy flowers which are produced very freely during the summer months. Several exotic species of this Order have become acclimatised in different parts of this area, but they do not appear to be spreading much. *Logania floribunda* R.Br., is the only shrubby species of *Loganiaceæ* in the North-East, and in early spring produces a profusion of small, white flowers. The other representatives of this Order are dwarf herbs with white flowers. *Gentianeæ* are not numerous in species, but grow over an extensive area. One species of *Villarsia* and three of *Limnanthemum* are aquatic or marsh plants with yellow or white flowers. The other two species of *Sebæa* and *Erythræa* are used for stomachic and allied complaints by the settlers. With one exception *Boragineæ* consist of herbs or undershrubs widely distributed, but nowhere plentifully. *Ehretia acuminata* R.Br., attains sometimes a height of thirty or more feet, and is one of the few Australian deciduous trees. There are two forms, the difference being principally in the leaves and flowers. In the typical form the leaves are serrate with callous teeth, the small white flowers crowded in terminal panicles, and the globular fruit usually containing four seeds. The most showy flowering plants of the *Convolvulaceæ* are the different species of *Ipomœa*. *I. palmata* Forsk., *I. hederacea* Jacq., and *I. peltata* Choisy, are tall twiners, and often ascend to the tops of trees. When in bloom they are a charming sight, the colour of the flowers being white, pink, purple, or blue. At Byron Bay I saw *I. pes-capræ* Roth., covering large areas of sand with its prostrate trailing stems. It produces rather large, pink flowers, and the roots, after being cooked, are eaten by the aborigines. Four exotic species have become acclimatised, and when in flower add considerably to the display of the floral wealth of this region. *Solaneæ* are well represented, and quite a number of exotic species have established themselves on this area. Some of these are of an undesirable, and others of a poisonous nature. Amongst the indigenous species, *Solanum* *aviculare* Forst., is fairly common on the rich lands, and its rather large fruits are eaten under the name of "kangaroo apples" The native and introduced species of *Physalis* produce quantities of fruit, eaten when ripe or made into preserves. Many species of *Scrophularineæ* are admired for their pretty flowers, especially those of *Artanema*, *Euphrasia*, and *Veronica*, and some are esteemed for their medicinal properties. *Duboisia myoporoides* R.Br., is popularly known as "Corkwood," and is common in some of the brushes. The late Dr. Joseph Bancroft discovered the medicinal value of this tree, and first used an extract from its leaves in ophthalmic surgery, and I had the privilege of witnessing many of the operations. When Curator of the Queensland Acclimatisation Society's Gardens, Bowen Park, Brisbane, I raised thousands of seedlings of *Duboisia* for Dr. Bancroft, who made a plantation of some of them at Kelvin Grove, near Brisbane, from which he gathered immense quantities of the leaves for making the extract. This drug is still largely used in this country and Europe. The six species of *Utricularia* of the *Lentibularieæ* are either aquatic or grow in marshes or wet places. They are all most interesting plants, and two of them, *U. flexuosa* Vahl, and *U. exoleta* R.Br., are carnivorous. There is a white-flowering variety of *U. cyanea* R.Br., which is a very pretty plant when in bloom, and fairly common in some wet places near the sea. Of the *Bignoniaceæ* there are two known species and three varieties (described as species by one or two authorities) of *Tecoma*, which occur in many places. They are large climbing plants, and when in bloom make an effective display as they hang in graceful festoons from the branches of the trees. *Acanthaceæ* include several species of horticultural interest, bearing white, yellow, purple, blue or pink flowers. *Eranthemum variabile* R. Br., may occasionally be seen cultivated in bush houses. Nine genera, thirteen species, and a few varieties comprise the indigenous *Verbenaceæ* of the North-East. *Gmelina leichhardtii* F.v.M., and *Vitex lignum-vitæ* A. Cunn., producing timber of economic value, represent the trees, and species of *Clerodendron* the beautiful flowering shrubs of this

Order. Small, red, succulent drupes are sometimes produced in abundance on the almost leafless branches of *Spartothamnus junceus* A. Cunn. *Avicennia officinalis* Linn., is a small tree common on the coast, and popularly known as "White Mangrove." *Labiatæ* are well represented by species, most of them widely distributed. Many species are remarkable for their powerfully scented leaves studded with resinous glands, and some of them have yielded, by distillation, valuable oils. Most of the species are perennial herbs, but some of shrubby habit, the tallest being *Prostanthera lasianthos* Labill., which attains sometimes a height of twenty-five to thirty feet. *Prostanthera* is more largely represented by species than any other genus of this Order, and most of them are very floriferous. The flowers generally are different shades of white, blue, and purple. Quite a number of exotic *Labiatæ* have become acclimatised, a few of them having spread very much during recent years.

There are only two indigenous genera and species of *Phytolaccaceæ* in this region, and neither is plentiful. One is a straggling shrub, but the other, *Codonocarpus australis* A. Cunn., grows thirty or more feet high. Its curious, almost campanulate fruit, which is suspended on a long pedicel, is composed of forty or fifty carpels which when ripe have prominent ribs on their dorsal edges. I have noticed a beautifully variegated form of the introduced *Phytolacca octandra* Linn., but it is not common. *Chenopodiaceæ* include several excellent fodder plants, but are not nearly as numerous as on the western plains. Indeed, several genera are not represented by a single species in the North-East. Although the species of *Amarantaceæ* and *Polygonaceæ* occur in greater or less profusion over a great part of this area, some of them may be regarded as weeds of an undesirable character. There are only three species of *Nyctagineæ*, and two of them, *Pisonia aculeata* Linn., and *P. brunoniana* Endl., are rather uncommon. The former is a tall climber when growing in dense forests, but in more open country it assumes the habit of a low straggling shrub, while the latter is a large tree. *Monimiaceæ* consist of trees, shrubs and climbers.

Doryphora sassafras Endl., generally found in rich scrub land, and *Atherosperma moschata* Labill., growing in mountainous country, are highly aromatic and of some medicinal value. Several trees of this Order yield timber of some industrial importance. The eight genera, twenty-two species and several varieties of *Laurineæ* include trees, shrubs and leafless parasitical twiners. With one exception, they are fairly well distributed both on high and low land. The leaves of most of the trees and shrubs are more or less aromatic, and the timber of the former is of great industrial value. The rarest tree and one of the most remarkable when in fruit is *Hernandia bivalvis* Benth. The red, almost fleshy involucel enclosing the ripe fruit is called "Parrot's beak," from its fancied resemblance to the beak of a parrot. All the species of *Cassytha* are leafless, parasitical twiners with delicate or wiry stems. They attach themselves to their hosts, usually small trees and shrubs, by means of numerous, small haustoria (suckers) through which they obtain sustenance. Most species produce quantities of small, succulent drupes, pleasant to the taste and often eaten by whites and blacks. The Order *Proteaceæ*, considered either from an economic or an ornamental point of view, is most important. It includes several valuable timber trees, and some of the most interesting, flowering, arboreal and shrubby vegetation to be found in New South Wales. Both the Suborders *Nucamentaceæ* and *Folliculares* are well represented and fairly widely distributed; the former by four genera, sixteen species and several varieties, the latter by ten genera, thirty species and a few varieties. The most important edible nut-bearing tree is *Macadamia ternifolia* F.v.M. This moderate-sized tree was figured and described, as to its economic value, by me under instructions from the Government of New South Wales.* *Xylomelum pyriforme* Knight, produces the famous wooden pears. This fair-sized tree, generally growing on poor sandstone or sandy country, is a remarkable object when in fruit. The most conspicuous flowering tree is *Stenocarpus sinuatus* Endl.

* See 'Agricultural Gazette,' Vol. iv. p.3.

Its bright red flowers are sometimes produced in great profusion and form a charming contrast to the vivid green foliage. It is popularly known as "Tulip-flower" or "Chandelier-flower." The latter name was given to it through a fancied resemblance the arrangement of the flowers has to a chandelier. Of the five species of *Banksia* only one, *B. integrifolia* Linn. f., attains the dimensions of a large tree. The remainder are small trees or tall or dwarf shrubs. All these species are popularly known as "Honeysuckles," and generally grow on the poorer classes of country. *Thymeleæ* are fairly common, and a few members are widely distributed. Several species of *Pimelea* are pretty flowering shrubs, but a few are suspected poisonous plants. One of the tallest and most floriferous is *P. ligustrina* Labill., var. *hypericina.* I have grown this variety for several years, and it is a most attractive plant in a shrubbery. *Wikstrœmia indica* C. A. Mey. is a very conspicuous shrub when in fruit, as its red drupes are often produced in great abundance. From the bark of both these plants, and several allied ones, very tough fibre can be obtained which was formerly largely employed by the aborigines for various purposes, and is still used by many white settlers. The bark of most species is more or less acrid, and may eventually prove of some medicinal value. No less than twenty-seven genera, forty-nine species, and several varieties are included under *Euphorbiaceæ.* They consist of trees, shrubs and herbs, and occur in greater or less abundance over nearly the whole of this area. The bark of several species possesses medicinal properties and the milky juice of others is acrid and poisonous. Landowners suspect many of the shrubs and herbs of poisoning stock, and some species I have received for identification are said to cause "Red-water" in cattle. Owing to their inconspicuous flowers, none of the species are regarded as interesting from a horticultural point of view, although several of them have handsome foliage. In this category may be included *Carumbium populifolium* Reinw., of which I have seen a beautiful variegated form which would be an ornament to any garden. The older leaves in the typical form often assume various shades of red and have a charming effect. Although *Urticeæ* are not a large Order they comprise some colossal and slender trees, shrubs and herbs which are widely distributed. The genus *Ficus* is represented by seven species, the largest being *F. macrophylla* Desf. This very tall tree has an enormous branching head, and at its base there are large angles formed by the extraordinary development of the roots. In old trees these angles are large enough to form a comfortable temporary dwelling when a piece of calico has been stretched over the top to keep out the rain. Reference has already been made to the epiphytes that grow on this tree. I have made a good yellow dye from *Cudrania javanensis* Trecul, which may eventually prove of some commercial importance. There is a beautiful variegated form of this species, but it appears to be rare. The two species of *Laportea*, *L. gigas* Wedd., and *L. photiniphylla* Wedd., are gigantic trees with very large leaves, popularly known as "Stinging-trees." I have seen men suffering agony from being stung by the leaves of these trees, but relief can be obtained by rubbing the affected part with a bruised stem of the "Cunjevoi" (*Colocasia macrorrhiza* Schott). Seven widely distributed species and one variety of *Casuarina* comprise the *Casuarineæ* of this area. With the exception of one species, *C. distyla* Vent., which is generally of shrubby habit, they are trees, some of considerable size and yielding timber of great industrial value. The branchlets of some species are relished by cattle and sheep and sometimes lopped and fed to pasture animals when other food is scarce. Two species are figured and described in my indigenous "Forage Plants of Australia" (non grasses). The Order *Piperaceæ* includes, amongst others, one species, *Piper novæ-hollandiæ* Miq., allied to the pepper plant of commerce. It is a tall climber, often clothing the trunks of trees in the dense forests with its large, seven-nerved leaves. It may eventually prove of some commercial or medicinal value. *Fagus moorei* F.v.M., of the *Cupuliferæ*, is, as far as is at present known, the only true "Beech" indigenous to New South Wales. This noble tree is found in the mountainous parts of the western portion of this region. It has a wider range of growth than is generally supposed, extending from near the parallel of 32° South into Queensland. *Santalaceæ* have a few interesting species but of no great industrial value up to the present time. *Leptomeria acida* R.Br., yields the "Native Currant," and *Exocarpus cupressiformis* Labill., the "Native Cherry." Both these species are fairly common on poor country.

The *Gymnospermæ* are not numerous as regards species, but are abundant and include some valuable timber trees and ornamental Cycadaceous plants. The tallest and most important timber tree, from a commercial point of view, is *Araucaria cunninghamii* Ait., and I have seen several specimens upwards of two hundred feet high and each containing about ten thousand feet of good timber. This, with some other species of *Coniferæ* and the Cycadaceous plants, have long been cultivated as ornamental features in Australian gardens.

Monocotyledonæ are a most important feature of the flora, and occur in more or less abundance over the whole of the North-East. The species include tall graceful palms, large and small climbers, beautiful flowering epiphytes, dwarf terrestrial and aquatic plants in great variety. *Hydrocharideæ* are aquatic herbs which are found in many lagoons and still waters, one of the most interesting being *Hydrocharis morsus-ranæ* Linn. Although indigenous to Australia it is common in Europe and temperate Asia, where it is popularly known as "Frog-bit." It is diœcious, and its orbicular leaves and white flowers may be observed on several lagoons in the northern part of this region. *Alpinia cærulea* Benth., is the only member of the *Scitamineæ* found there, and generally occurs in the dense brushes. When in flower or fruit it is an exceedingly ornamental plant. *Orchideæ* either as epiphytes, saprophytes, or terrestrial plants, are fairly numerous over nearly the whole of this area. Although their flowers cannot compare in size, except in a few instances, with those of the exotics so mnch esteemed and largely cultivated by horticulturists, yet most are very beautiful, and many sweetly scented. The late Mr. R. D. Fitzgerald, F.L.S. collected many species in this region and figured them in his monumental work on Australian orchids. Two of the most remarkable and largest Australian species are *Galeola cassythoides* Reichb., and *G. foliata* F.v.M., which may be regarded as saprophytes. Both are of climbing habit, the latter being much more robust, with stems often ascending for a considerable distance the tallest trees. Its panicles are much longer and its flowers much larger than those of the former species. *G. foliata* F.v.M., has capsules seven to eight inches long, and on that account is popularly called "Native Vanilla." Of the epiphytes, several species of *Dendrobium* and *Sarcochilus* are cultivated in many bush-houses in the neighbourhood of Sydney. Most admirers of terrestrial orchids grow the popular *Phaius grandifolius* Lour., and *Calanthe veratrifolia* R.Br. There are two varieties of the former species which are also well worth cultivating. On the sides of several of the mountain ranges and in some of the valleys, many of the dwarf terrestrial species are common, and at their flowering period are a charming sight. There is a white-flowering variety of *Dipodium punctatum* R.Br., which, as far as I have observed, is rare. The flowers of several orchids vary considerably both in size and colour in the same species. *Doryanthes excelsa* Correa, is the tallest of the indigenous *Amaryllideæ*, its stem being often twenty feet high, and in the typical form surmounted by a dense globular head of large, red flowers. Mr. Walter Hill, late Colonial Botanist of Queensland, discovered a white-flowering variety on Mount Lindsay, but it appears to be rare, as no subsequent botanist or botanical collector has since found it there. *Crinum pedunculatum* R.Br., fairly common on the banks of rivers and creeks and in swampy situations, is very conspicuous when in bloom, having numerous large white flowers with a delicate perfume. One of the rarest and most beautiful flowering plants of this Order is *Eurycles cunninghamii* Ait. It has large, ovate leaves on long petioles, and a scape about one foot high, bearing an umbel of from six to ten rather large, white flowers. *Dioscorideæ* have two genera and species, one, *Dioscorea transversa* R.Br., is a twining plant producing large tubers, which are excellent eating when properly cooked. It is fairly common on the borders of many of the brushes, and its small flowers are strongly but agreeably scented. *Liliaceæ* are well represented by genera and species, many being widely distributed. They are found in dense brushes, in open forest country, on mountain ranges, in damp situations, and on sandy tracts, both on the coast and farther inland. The species consist of stout and slender climbing and twining plants, shrubs, and perennial herbs, the last largely predominating. Some are amongst the most interesting flowering plants of this region, and not a few have sweetly perfumed flowers. Occasionally a few species may be found producing double flowers. There are no indigenous *Pontederaceæ*, but two exotic species have become acclimatised, one of them, *Eichhornia speciosa* Kunth, which has spread very much during recent years, is proving a pest in some of the water-courses. Included under *Juncaceæ* are the curious "Grass-trees" (*Xanthorrhœa* spp.) of which there are four species, generally growing on poor sandy country. There are five species of *Xerotes* and ten of *Juncus*, many of the latter being found in or near coastal swamps and in damp situations farther inland. The four genera and species of *Palmæ* are abundant in many parts, and give quite a tropical appearance to the vegetation. *Calamus muelleri* Wendl. et Drude, the only known climbing palm in this region, often ascends trees in the dense forests to a considerable height. A person once entangled in the straight and recurved prickles with which it is armed never wishes to repeat the experience. *Kentia monostachya* F.v.M., forming in some parts miniature forests, is known to the ruralists as the "Walking-stick" palm, seeing that it is largely used for that purpose. *Ptychosperma cunninghamii* Wendl., and *Livistona australis* Mart., are very tall handsome palms, the former being the well-known "Bangalow," and the latter the "Cabbage-tree Palm." I have eaten the soft portion, immediately below the crown of leaves, of the "Bangalow," and found it, when properly cooked, a good substitute for ordinary garden vegetables. The leaves of *Livistona australis* Mart., were formerly employed for making hats, hence its common name. *Pandanus pedunculatus* R.Br., of the *Pandaneæ* is not uncommon on the coast from the Hastings to the Tweed River. It is arborescent, attaining sometimes a height of from twenty-five to thirty feet. Its large, almost globular heads of drupes are popularly called " Bread-fruit," because the aborigines used to eat the seeds. At the Botanic Gardens, Brisbane, Queensland, I prepared some good fibre from the aërial roots of this species. The *Aroideæ*, which include some rather ornamental plants, usually found in, or on the borders of dense brushes, are not numerous as regards species. The stout stems of *Colocasia macrorrhiza* Schott, although containing an acrid poison, were, after preparation, used by the aborigines as an article of food. Its leaves, sometimes three feet long, and eighteen inches broad, make the plant conspicuous. *Pothos loureiri* Hook. et Arn., is a large climbing plant, often clothing the trunks of trees with its stems and exceedingly variable leaves, which have singular phyllodineous petioles. Its red, oblong or ovoid berries, about half-an-inch long, have a pretty effect. Species of *Naiadeæ* are rather numerous in or near water, and although of no great beauty from a horticultural point of view, they are of interest to the botanist. The few species of *Alismaceæ*, which are widely distributed, are aquatic or marsh plants with flowers disposed in terminal panicles or spikes.

Cyperaceæ are well represented by numerous genera and species, occurring on high and low land and on all classes of soil from the littoral sands to the tops of the highest ranges. Many species grow in marshy country, and some are aquatic. When in flower or fruit the majority have a decidedly ornamental appearance. Several species have flexible stems which are put to various uses by settlers. Amongst the tallest plants of this Order are the species of *Lepidosperma*, *Cladium* and *Gahnia*, some attaining a height of from six to nine or more feet, and growing in dense masses. *Gahnia melanocarpa* R.Br., has panicles more than one foot long, and produces numerous spikelets and nearly ovoid, shiny black fruits. The panicles of *G. psittacorum* Labill., are often two or more feet long and very black. Its ripe fruits are ovoid, shiny, and of a bright red colour. In both species the ripe fruits are often suspended from the spikelets by rather long filaments, which have a singular appearance. The long leaves of these plants have involute, scabrous margins ending in long, subulate points. On two occasions I rode through tracts of country nearly covered with these plants, and was much cut about the face and hands with the fine, saw-like edges of their leaves. The Order *Gramineæ* is a most important one, and its numerous indigenous species are well distributed all over the North-East. Most of the principal grasses, from a stock-owner's point of view, have been figured and described, as to their economic value, by me under instructions from the Government of New South Wales. Several of the exotic species, which have become acclimatised in this region, have a high feeding value, and a few of them are largely cultivated with much success in the dairying districts. The main area devoted to pasture, however, is composed of the valuable indigenous grasses, many of which have a high reputation amongst stock-owners for their feeding qualities. There are also several species which are very useful for binding the littoral sands or preventing erosion of the banks of tidal and other rivers and creeks. In the former category may be included *Imperata arundinacea* Cyr., *Schedonorus littoralis* Beauv., *Spinifex hirsutus* Labill., and *Zoysia pungens* Willd., and in the latter *Phragmites communis* Trin., the "Common Reed." This stout, perennial grass, sometimes only five feet high, at others attaining an altitude of twelve feet, grows equally well on the margins of tidal and non-tidal streams, and if judiciously planted where the banks are liable to erosion by floods and the wash of passing steamers, it would protect them and prevent the rivers silting up.

Acotyledoneæ, as regards vascular *Cryptogams*, and this Paper does not deal with cellular *Cryptogams*, are well represented, both by genera and species, and occur in more or less abundance over a great part of this region. *Lycopodiaceæ* include several interesting and ornamental plants. Two of the four species of *Lycopodium*, viz :—*L. cernuum* Linn., and *L. densum* Labill., when growing in favourable situations, sometimes attain a height of six and four feet respectively. The latter elegant species was once described to me as a miniature conifer, and I agreed with this apt description. *Psilotum triquetrum* Swartz, grows on trees and in the crevices of rocks, and has erect or pendulous, repeatedly dichotomous stems and minute, scale-like leaves. *Marsileaceæ* have two species, *Marsilea quadrifolia* Linn., an aquatic, and *M. hirsuta* R.Br., a terrestrial plant.

The *Filices* comprise some of the most beautiful ferns to be found in Australia. Indeed, so far as New South Wales is concerned, the North-East owing to its high temperature and abundant rainfall may be considered best suited for their development. *Ophioglossum pendulum* Linn., an epiphyte growing on other epiphytal ferns is not common. Occasionally I have seen its ribbon-like pendulous fronds nearly nine feet long, and one seeing this plant for the first time would hardly believe that it was a true fern. *Lygodium scandens* Swartz, an elegant twiner or climber usually growing in swamps or damp places, forms dense masses very difficult to penetrate. The three species of *Schizæa* are curious and pretty ferns, two of them fairly common in sandy country, but the other, *S. forsteri* Spreng., I have rarely seen except about the surface roots of palms and fern trees. *Gleichenia* has four species found on wet rocks, in damp ravines, near swamps and on the borders of dense brushes. Two conspicuous species are :—*G. flabellata* R.Br., a very beautiful fern with fronds sometimes seven or more feet high, and *G. dichotoma* Hook., the largest species of the genus, a very attractive plant often growing ten or more feet high. *Todea barbara* T. Moore, occasionally develops an enormous but short trunk with fronds nine or more feet long, and usually grows in deep ravines in, or near, water. Some of the species of *Trichomanes* and *Hymenophyllum*, found on the trunks of trees, logs and rocks in damp, shady situations, are fairly abundant. Arborescent ferns are included in the genera *Cyathea*, *Alsophila* and *Dicksonia*, and several are common in many parts of this area. Some of the tallest are between thirty and forty or even more feet high, and their large, graceful fronds have a charming effect amongst the surrounding vegetation. The genus *Adiantum* is represented by five species which are in cultivation and greatly admired for their elegant fronds. The eight species and one variety of the genus *Pteris* are, with few exceptions, very common both on the high and low lands. The geranium-leaved *Pteris*, *P. geraniifolia* Raddi, a pretty fern which often grows on little mounds formed by tufts of grass or sedge in swamps, is the smallest member of the genus. On the other hand *P. aquilina* Linn., var. *esculenta*, the "Edible Bracken," is the tallest, with fronds ten or more feet high, but generally smaller. *Lomaria* has three species, usually found in or near water. *L. capensis* Willd., common in some of the swampy places, is, owing to the reddish appearance of its young fronds, popularly known as the "Red Cabbage Fern." Its trunk is sometimes a few feet high and its pinnate fronds three or four or more feet long. The other two species, *L. patersoni* Spreng., and *L. discolor* Willd., may often be seen in cultivation. Several very beautiful species are included in the genus *Asplenium*. A few of them, such as the well-known "Bird's Nest Fern," *A. nidus* Linn., and *A. falcatum* Lam.. are epiphytes. The latter, one of the most graceful ferns that adorn trees in the dense forests, has drooping, elegant, dark green fronds sometimes four or more feet long. *A. maximum* Don, usually grows in swampy places where it forms a trunk a few feet high and produces bipinnate fronds several feet long and about three feet broad. *Aspidium* has eleven species and a few varieties which grow under widely different conditions. *A. cordifolium* Swartz, is a beautiful epiphyte usually found on other epiphytal ferns. Sometimes it grows in immense masses several feet in circumference. *A. ramosum* Beauv., climbs trees by adventitious rootlets, completely enveloping the trunks for a considerable distance with its graceful pinnate fronds. The rhizomes of one of the swamp ferns, *A. unitum* Swartz, often creep beneath the surface of the water, and its fronds are from one to two or more feet long with stipes nearly as long. All the species of *Polypodium* have creeping rhizomes. Some climb trees by adventitious rootlets, enveloping the trunks with their beautiful and very distinct fronds, and others grow in large masses on rocks. Amongst the latter is *P. rigidulum* Swartz, with dimorphous fronds, the fertile ones being pinnate, from two to four feet long, while the barren ones, from six to twelve inches long, and three to four inches broad, are lobed and very prominently veined. There are two distinct forms of this curious fern, which is common in many places. *P. irioides* Poir., the "Iris-leaved Fern," grows on the margins of some creeks and swamps in the northern part of this area. *Acrostichum aureum* Linn., popularly known as the "Golden Swamp-Fern," is fairly abundant in some of the saltwater marshes on the coast, and is very striking when growing in masses. Its fronds sometimes attain a length of six or more feet. The two species of *Platycerium* are epiphytes and common on trees in the dense brushes and open forest country. Although they vary in form according to situation, they cannot be regarded as distinct varieties. Quite a number of ferns in different genera have crested or bi- or multi-lobed fronds which are variations from the typical form. They are well worth cultivating for their singular appearance, as they would be an acquisition to any collection. Many years ago Mr. Latham, Curator, Botanic Gardens, Birmingham, England, a great authority on ferns, informed me that the crested and lobed varieties or forms of ferns would reproduce themselves true to the parent from spores.

The southern portion of North-eastern New South Wales was traversed in 1818 by the early explorers Oxley, Evans and Fraser, the last-named being the botanist of the expedition. It was on that journey from the Liverpool Plains to the sea that Oxley discovered and named the Hastings River. In 1827 Allan Cunningham crossed Oxley's tracks to Port Macquarie and botanised en route. Since those early exploring days the following botanists have made the largest collections of plants, prior to my own, in different parts of this region:—James Backhouse, Dr. H. Beckler, Charles Moore, F.L.S., late Government Botanist of New South Wales, and W. R. Guilfoyle, F.L.S., Director, Botanic Gardens, Melbourne, Victoria. Collections of plants have also been made by Messrs. Wilcox, Tozer, Fawcett and Bäuerlen.

My thanks are due to a number of landowners and others for forwarding me botanical specimens for identification during the last twenty-one years.

This, the first botanical survey of the North-East has added to the indigenous plants not hitherto recorded for New South Wales eight genera, fifty-five species and many new varieties. This does not take into account the large number of species indigenous to this State which had not been hitherto recorded from that region. The number of indigenous species for New South Wales now amounts to 3314.

Genera not hitherto recorded for New South Wales.

DICOTYLEDONS: *Anisomeles, Dissiliaria, Hermandia, Hygrophila, Melodinus* and *Tetranthera.* MONOCOTYLEDONS: *Geodorum.* ACOTYLEDONS: *Ceratopteris.*

The Census of the plants of North-Eastern New South Wales will be embodied in my paper on the Botany of South-Eastern New South Wales, when the vegetation of this important section of the State will be brought under critical review.

The accompanying table shows the percentage of the indigenous *Phanerogamia* and the vascular *Cryptogamia* of the North-East compared with the similar flora of New South Wales.

NEW SOUTH WALES.		NORTH-EASTERN NEW SOUTH WALES.		PERCENTAGES.	
Dicotyledoneæ.		*Dicotyledoneæ.*			
Genera ...	671	Genera ...	523	Genera ...	77·94
Species ...	2461	Species ...	1199	Species ...	48·72
Monocotyledoneæ.		*Monocotyledoneæ.*			
Genera ...	214	Genera ...	176	Genera ...	82·24
Species ...	701	Species ...	452	Species ...	64·47
Acotyledoneæ.		*Acotyledoneæ.*			
Genera ...	41	Genera ...	35	Genera ...	85·36
Species ...	152	Species ...	116	Species ...	76·31
Total Genera	926	Total Genera	734	Genera ...	79·26
Total Species	3314	Total Species	1767	Species ...	53·31

All the indigenous plants referred to in this paper that I did not know at sight I have worked out by the diagnosis given in Bentham's 'Flora Australiensis,' Bailey's 'Queensland Flora,' and Baron von Mueller's 'Fragmenta Phytographia Australiæ,' and I have followed the same classification and nomenclature as have been adopted in the first indispensable reference work.

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A REVIEW OF THE NEW SOUTH WALES SPECIES OF HALORRHAGACEÆ AS DESCRIBED IN PROF. A. K. SCHINDLER'S MONOGRAPH (1905); WITH THE DESCRIPTION OF A NEW SPECIES.

By J. H. Maiden and E. Betche.

In Prof. Anton K. Schindler's Monograph of *Halorrhagaceæ*, written for Engler's 'Pflanzenreich,' 23 Heft (iv. 225), December, 1905, the following new species are described for New South Wales :—

Halorrhagis tenuis Schindler, *l.c.* p.27. Quirindi, William Macdonald, November, 1903. Nearest allied to *H. elata* A. Cunn., and chiefly distinguished from it by the glabrous ovarium. In habit it is a more slender and more branched plant, with thin branches and sparse narrow leaves, almost entire, or the lower ones with a few short teeth.

Halorrhagis villosa Schindler, *l.c.* p.31. Jenolan Caves, W. F. Blakely, January, 1900. This species is, in appearance, very much like a straggling form of *H. serra* Brongn., with villous branches, but in affinity it is nearest to *H. tetragyna* (Labill.) Hook. f. It belongs to Prof. Schindler's section Monanthus (a single flower in the axils of the floral-leaves or bracts), while *H. serra* belongs to the second section Pleianthus (several flowers in the axils of the bracts). From *H. tetragyna* it is easily distinguished by the tall straggling habit and by the hairy calyx.

Halorrhagis longifolia Schindler, *l.c.* p.35. N. S. Wales, on steep hills of Leuwin's Land* (Bauer); Port Jackson (Anderson†);

---

* Leuwin's Land" is not in New South Wales, but in the extreme sonth-west of Western Australia.

† Probably James Anderson, Botanic Gardens, Sydney, circa 1830-40.

no habitat (Caley*). This belongs to section Monanthus, subsection Leptocalyx (calyx-lobes with basal callosities). Its affinity is with *H. teucrioides* P.DC., from which it is most readily distinguished by the linear-lanceolate acute leaves, which are at least three times as long as broad.

Halorrhagis veronicifolia Schindler, *l.c.* p.35. N.S. Wales, without habitat (Ferd. Bauer). This belongs to section Monanthus, subsection Trachycalyx (calyx-lobes without basal callosities, the tube verrucose). Its affinity is with *H. teucrioides* and *longifolia*; it is the only species of the subsection, and therefore best recognised by the calyx.

Halorrhagis pedicellata Schindler, *l.c.* p.51. Blue Mountains (Lessow†). This belongs to section Pleianthus. It is easily distinguished from the allied *H. exalata* F.v.M., by the long pedicellate flowers.

Halorrhagis coronopifolia Schindler, *l.c.* p.56. Girilambone, E. Betche; October, 1886. Closely allied to *H. odontocarpa* F.v.M., of section Pleianthus. It is in habit and appearance exactly like this species, and only distinguished from it by the absence of the protuberances of the wings of the fruits. A rather doubtful species, requiring investigation from more material; we took it to be an abnormal form of *H. odontocarpa*.

This species, as well as *H. tenuis* and *H. villosa*, were described by Prof. Schindler from specimens communicated to him from the National Herbarium, Sydney, in response to his request to send material for his Monograph; the other new species are unknown to us.

Myriophyllum longibracteolatum Schindler, *l.c.* p. 84. Mt. Wilson, J. Gregson; December, 1901, and February, 1902.

This is the same plant we published in these Proceedings (1902, p.59) as a floating form of *M. pedunculatum* Hook. f.

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* George Caley, 1800-10. Perhaps Port Jackson, but not certainly.

† Should be A. Lesson, who was a naturalist of the French exploring ship "Astrolabe." He collected near Port Jackson in 1827, and Fraser, Superintendent Botanic Gardens, Sydney, gave him many specimens.

M. pedunculatum grows generally in mud and has short leaves, and we took the view that the longer leaves and other differences were due to the aquatic habit.

Prof. Schindler's Monograph shows how very much the Australian Halorrhagaceæ have been neglected and misunderstood by Australian botanists. Out of the fifteen Australian species described by him, only the smaller part are recent discoveries; the greater number are plants long known, but mixed up in various herbaria with other species; three of these species are Victorian, apparently common plants, to judge from the number of localities and herbaria quoted, but unrecognised even by Baron von Mueller, the leading Australian botanist for the latter half of the last century. A careful comparison of Prof. Schindler's key to the species of Halorrhagis with Bentham's key in the "Flora Australiensis" is very instructive, and explains why so many species were not recognised. Bentham based the main divisions of his Key on the opposite or alternate position of leaves and flowers, and entirely neglected or under-estimated the systematic value of some characters, for instance the bracteoles; while Prof. Schindler's system is principally based on the characters of the reproductive organs, and the position of the leaves is utilised only in smaller subdivisions. Of course we must not accept all Prof. Schindler's species uncritically; his descriptions are probably occasionally based on scanty material, but we live in the midst of abundance of fresh material and should continue the work on the lines laid down for us in the Monograph.

Besides the description of new species Prof. Schindler has made several changes in nomenclature which will be seen in the following Census of New South Wales Halorrhagaceæ :—

1. Loudonia Lindl.
   Behrii Schlecht. in Linnæa, xx. (1847) 648.

2. Halorrhagis Forst.

Section i.—**Monanthus.**

elata A. Cunn., ex Fenzl, in Hueg. Enum. (1837) 45.
tenuis Schindler, n.sp.

HALORRHAGIS.

villosa Schindler, n.sp.

tetragyna Labill., Hook. f., Fl. Tasm. i. (1860) 120.

teucrioides P.DC., ex Schlecht. in Linnæa xx. (1847) 648.

longifolia Schindler, n.sp.

veronicifolia Schindler, n.sp.

salsoloides (Reichb.) Benth., Fl. Austr. ii. (1864) 485.

micrantha (Thunb.) R.Br. ex Sieb. et Zucc. Fl. Jap. Fam. Nat. i. (1843) 25.

depressa (A. Cunn.) Walp. Rep. ii. (1843) 99.

Section ii.—**Pleianthus.**

glauca Lindl., in Mitchell's Journ. Trop. Austral. (1838) 191.

heterophylla Brongn., in Duperrey, Voy. (1829) t. 68A (including *H. pinnatifida* A. Gray, *H. ceratophylla* Endl., *H. aspera* Lindl.).

exalata F.v.M., in Trans. et Proc. Roy. Soc. Vict. xxiv. (July, 1888) 133.

pedicellata Schindler, n.sp.

digyna Labill., Nov. Holl. pl. spec. i. (1804) 101, t. 129 (*H. mucronata* Benth.)

serra Brongn., in Duperrey, Voy. Coquille, Bot. (1829) t. 69.

Brownii (Hook. f.) Schindler (*Meionectes Brownii* Hook. f.).

coronopifolia Schindler, n sp.

odontocarpa F.v.M., Fragm. i. (1859) 108.

monosperma F.v M., in Proc. Linn. Soc. N. S. Wales x. (1885) 197.

racemosa Labill., Nov. Holl. pl. sp. i. (1804) 100 t. 121, var. *Bäuerleni* (F.v.M.) Schindler, (*H. Bäuerlenii* F.v.M.).

3. MYRIOPHYLLUM Linn.

gracile Benth., Fl. Austr. ii. (1864) 489.

trachycarpum F.v.M., Fragm. ii. (1860), 87. New for New South Wales. Centennial Park, Sydney; W. Forsyth, December, 1896. Previously recorded only from North Australia, Gulf of Carpentaria and Macadam Range.

longibracteolatum Schindler, n.sp.

MYRIOPHYLLUM.

pedunculatum Hook. f., in Hook., Lond. Journ. Bot. vi. (1847) 474.

propinquum A. Cunn., in Ann. Nat. Hist. (1) iii. (1839) 30 (*M. variæfolium* Hook. f.).

verrucosum Lindl., in Mitchell's Trop. Austr. (1848) 384.

elatinoides Gaudich., Ann. Sc. Nat. v. (1825) 105.

latifolium F.v.M., Fragm. ii. (1860) 87.

integrifolium Hook. f., Fl. Tasm. i. (1860) 129 t. 23A.

The genus *Callitriche*, which Bentham includes in this Order, is omitted by Prof. Schindler; in the system used in Engler's 'Pflanzenreich' it is placed in a separate Order, Callitrichaceæ.

After revising the material in the National Herbarium from Prof. Schindler's Monograph, we requested Mr. R. T. Baker to send us all his Halorrhagaceæ for revision, to which he kindly responded, and we have to thank him for his permission to describe the following new species we found amongst his material.

HALORRHAGIS VERRUCOSA, n sp.

Woodburn, Richmond River; W. Bäuerlen; December, 1894.

A perfectly glabrous annual about 1 to $1\frac{1}{2}$ feet high, branched from the base, with slender 4-angled and slightly winged stems and branches. Stem-leaves opposite, very shortly petiolate or almost sessile, distant, in all specimens seen from $1\frac{1}{2}$ to above 3 inches apart, lanceolate, $\frac{3}{5}$ to $\frac{9}{10}$ of an inch long, and at the most $\frac{1}{5}$ of an inch broad, acute, remotely serrate, with the whitish recurved margins so frequent in the genus; floral-leaves reduced to very small alternate bracts, quite minute under the uppermost flowers. Racemes filiform in a terminal panicle, the flowers solitary and very shortly pedicellate within the bracts. Bracteoles very minute or absent. Calyx-tube ovate, submembranous, glabrous, faintly 8-ribbed and densely covered with whitish callosities, about 10 between the ribs; the lobes triangular, shorter than the tube, without any distinct basal callosities, and not cordate. Stamens 8. Fruits mostly 1-celled.

According to Bentham's classification of the genus this new species is nearest allied to *H. micrantha* R.Br., from which it is sharply distinguished by the fruits, the narrow leaves, and by the taller growth. In Prof. Schindler's classification it belongs to subgenus *Euhalorrhagis* (andrœcium 2-cyclicum, discus non papillosus), section *Monanthus* (inflorescentiæ spicatæ vel paniculatæ floribus in bractearum axilliis singulis; fructus membranaceus vel submembranaceus non nucamentaceus, columella persistente 1-locularis; flores octandri), subsection *Rhagocalyx* (tubus ovarii verrucis prosilientibus interruptus), and is nearest allied to *H. tenuis* Schindler, from which it is distinguished by the habit and the opposite stem-leaves. The specific name is derived from the fruit, which is more verrucose than in any other species we know.

NOTES ON THE HYMENOPTEROUS GENUS *MEGALYRA* WESTW., WITH DESCRIPTIONS OF NEW SPECIES.

By Walter W. Froggatt.

The genus was formed by Westwood to contain a remarkable parasitic wasp which he called *Megalyra fasciipennis*; this is figured, with very slight description, in Griffith's 'Animal Kingdom,' 1832. Some years later he obtained a male, which he described, at the same time defining the genus. Erichson, about the same time (1841), described a species under the name of *M. rufipes*, from Tasmania, which Westwood found to be identical with his species. In 1851, Westwood added two more species; thereafter nothing more was done at the group until 1889, when Schletterer described two species. In 1902 Szepligeti wrote an important paper on these insects, adding three new species—one from Australia, one from New Guinea, and a third from Ceram; and at the same time he tabulated all the known species. Last year, 1905, Bradley translated Szepligeti's table of species, and added a seventh species to the genus.

The members of this genus, with the exception of the species from New Guinea and Ceram, are peculiar to Australia; and are chiefly confined to open forest country. They are very distinctive-looking insects, usually all black, with the antennæ and legs sometimes more or less reddish-brown; the head and thorax are coarsely punctured, and elongate in general form. The globular head is provided with short stout mandibles, pointed at the tips, with two blunt teeth below; the maxillary palpi are composed of five irregular joints, and the labial palpi of three regular ones; the antennæ, situated in front of the head, consist of thirteen irregular slender joints, with a stout short basal one; the finely faceted eyes are large and circular, and project slightly on the sides of the head; and on the summit between them are three ocelli forming a small triangle. The broad truncate thorax fits close behind the head, bearing a short blunt spine on either side behind the eyes; it is of a uniform thickness, slightly sloping behind to the truncate hindmargin where it is attached to the oblong-oval sessile abdomen which, in the male, is furnished with a short pair of reddish claspers at the anal extremity. In the larger females the abdomen is broadly rounded to the apex, and is provided with a curious slender ovipositing apparatus; this, when closed, looks like a stout black horse-hair several times the length of the whole insect, but it is usually opened out into three distinct parts, namely, two slender hair-like setæ, and the reddish thickened tubular ovipositor. The wings are either deeply clouded or barred with fuscous, and contain few cross-veins. The legs are moderate, with thickened thighs. The whole insect is often more or less clothed with short grey hairs.

The species can be divided into two groups—those with clouded wings, and those with forewings distinctly barred in the centre. The situation of the ocelli, the general sculpture of the head and thorax, together with the markings on the dorsal surface of the abdominal segments, are constant specific characters. The size of the insects, and the length of the ovipositor, are very variable in the same species; and the reddish tints noted by some describers are not always specific, but due to the maturity or otherwise of the specimen when captured. The forms with clouded wings seldom or never have red legs or variegated antennæ.

In Dalla Torre's 'Catalogue of the Hymenoptera of the World,' this group is raised to the rank of a family (Megalyridæ) containing the genera *Megalyra* and *Iseura*, the latter represented by a single species from Brazil.

Nothing has been recorded about the habits of these remarkable insects; but they deposit their eggs in the larvæ of the longicorn beetles which live beneath the bark in the sap-wood of Wattles and Eucalypts.

Through the kindness of Messrs. French, Lea, Kershaw, and Tepper, who have lent me the specimens in their collections, and from the examination of the series in the Macleay Museum, and in my own private collection, I have had under examination the largest collection of these curious parasitic wasps ever brought together.

Megalyra shuckardi Westw.

Trans. Ent. Soc. London, p.223, tab.7, f.1, 1851.

The only specimen of this species I have seen came from South Australia among specimens from the Adelaide Museum. It is somewhat larger than *M. mutilis*, the body measuring 12 lines, and the ovipositor 44.

All black, thickly clothed with white hairs upon the front and back of the head, abdominal segment fringed on the sides with short tufts forming irregular bars of silvery white; posterior ocelli nearer to each other than to the edges of the compound eyes; forewings with a dull light spot or blotch towards the apical part of the centre.

Hab.—Adelaide, S.A. (J. G. O. Tepper), South Australia (Macleay Museum). Two specimens (♀).

Megalyra mutilis Westw.

Trans. Ent. Soc. London, (2nd Ser.) 1851, p.226.

This large black species has uniformly clouded pitch-brown, rounded wings which are very small in comparison with the body. The head and thorax are roughened, the abdomen elongate-oval, shining, impressed on the sides with fine punctures. Length of body 11 lines; wings 8 lines.

The very small almost black wings are quite different from those of any species I have ever seen, and would almost lead one to think it was an undeveloped specimen.

Hab.—Adelaide, S.A (Westwood).

Megalyra melanoptera Schl.

Berlin. Entom. Zeitschr. xxxiii p.244, 1889 (♀).

This appears to be the common large black-winged species which is generally to be found in our collections ticketed *M. shuckardi*, from which it differs in having the wings of a uniform black or pitch-brown tint, without a hyaline spot on the fore pair, and the basal segments of the abdomen smooth and shining, with the others finely shagreened. The male is unknown. The female measures 9 lines in length, and the ovipositor 28 lines.

Mr. H. W. Cox informs me that he has bred a specimen of this parasitic wasp from the pupa of a longicorn beetle (*Rhytiphora polymita*) enclosed in a stout stem of *Acacia decurrens* which was cut out of a tree growing near Sydney.

Hab.—Oakleigh and Brighton, Vic. (Kershaw); South Australia (G. Masters); Sydney and Shoalhaven, N.S.W. (W.W. Froggatt).

Megalyra mastersi, n.sp.

♀. Black, with wings uniform pitch-brown, paler on hind margins. Head coarsely punctured; anterior ocelli nearer to each other than to the eyes. Thorax coarsely punctured; frontal spines on prothorax small but projecting. Dorsal surface of abdomen with the first segment smooth and shining, the rest finely shagreened, not shining; with scattered grey hairs on the dorsal surface and sides of abdomen. Length of body ½ inch; of ovipositor 2 inches.

Hab.—New South Wales (G. Masters). One specimen; type in Macleay Museum.

Megalyra fasciipennis Westw.

Trans. Ent. Soc. London, Vol.iii. p.270, pl.xv. f.3, ♂., 1841-43; Griffiths' Anim. Kingdom, Ins., Vol.ii. p.419, pl.66, f.4, ♀., 1832; *M. rufipes* Erichson, Beitrag zur Insecten-Fauna von Vandiemensland, p.258, 1842.

This is the common species, with the hyaline or semitransparent forewings blotched across the centre and lightly clothed at the tips. General colour black; legs red; clothed with fine grey hairs upon the face, legs, and sides of the abdominal segments. Head broadly rounded; anterior ocelli nearer to the eyes than to each other. Abdomen elongate-oval, tapering to the extremity, pointed in the male, with the genitalia reddish-brown; first segment and apical half of second smooth and shining, the rest finely shagreened. ♀. Length of body ½ to ¾ inch; of ovipositor 2 inches.

Hab.—Melville Island, Tasmania, and Australia (Westwood); Melbourne, Vic., Tasmania, Sydney, N.S.W.(Froggatt).

This species lays her eggs in the larvæ of several species of longicorn beetles of the genus *Phoracantha*, which usually in the earlier stages of their existence feed between the bark and sap-wood of different species of Eucalypts when these are dead or dying, and finally burrow into the more solid wood where they pupate. Probably the Megalyra finds them out when feeding just beneath the bark, through which she passes her stout ovipositor when inserting her egg. I have a fine series of both sexes taken by Mr. L. Gallard at Kenthurst, obtained when splitting up dead timber that was infested by the longicorn larvæ; the wasps were taken in the burrows of the beetle larvæ, fully developed and ready to emerge.

Megalyra rufiventris Schl.

Berlin. Entom. Zeitschr. xxxiii. p.224, ♀., 1889.

This species has the base of the antennæ, legs beyond the femora, and the whole of the abdomen red; very lightly clothed with hairs, those upon the abdomen not forming distinct patches.

Hab.—Australia.

Megalyra szepligetii Bradley.

Trans. Ent. Soc. London, 1905, p.396.

♀. Entirely black; wings hyaline, barred with brown near the centre, and a spot at the extremity; lateral ocelli about the same distance from each other as they are from the eyes; scutellum coarsely punctured; the dorsal surface of the abdomen with the first segment and a narrow band at the second and third smooth and shining, the rest shagreened. Length 12 mm.; of ovipositor 34 mm.

Hab.—South Australia.

MEGALYRA CAUDATA Szepligeti.

Termes. Füzetek, xxv. p.527, 1902.

Dark brown with reddish areas; front legs beyond femora and hind legs beyond tibiæ reddish-brown; scutellum longitudinally wrinkled. Abdomen not sculptured like *M. szepligetii.*

MEGALYRA VARIEGATA, n.sp.

♂. Black, with 2nd-6th antennal joints and legs reddish-brown; wings semiopaque, clouded across the centre with fuscous, and smoky at the tips of the fore pair. Head broad; the hind ocelli closer to eyes than to each other; dorsal surface very regularly punctured; thorax more rugose than head; abdomen elongate-oval, very lightly clothed with rows of grey hairs on the sides; dorsal surface with the first and second segments smooth and shining, third to seventh finely shagreened. Length 5 lines.

♀. Similar to male in colouration, except that the second joint of the antennæ is black. Length of body 8 lines; of ovipositor $2\frac{3}{4}$ inches

Hab.—Melbourne (♂; J. A. Kershaw); Ballarat, Vic. (♀; C. French). Two specimens; type in Coll. National Museum.

MEGALYRA KALGOORLIENSIS, n.sp.

♀. Black, with the sides of the abdominal segments lightly marked with dull reddish-brown; legs and tarsi light reddish-brown; forewings semiopaque, broadly clouded in the centre. Head globular, finely punctured; hind ocelli closer to eyes than to each other. Thorax closely punctured, slightly marked behind with dull reddish-brown. Abdomen short, first segment shining, second to seventh finely but distinctly punctured, none of the punctures confluent. Length of body 6 lines; of ovipositor $1\frac{3}{4}$ inches.

Hab —Kalgoorlie, W.A. (G. W. Froggatt). One specimen; type in Coll. Froggatt.

MEGALYRA PUNCTATA, n.sp.

♀. Black; legs reddish-brown, femora of the hind pair blotched with black; wings almost hyaline, marked with fuscous in the centre, and lightly clouded at the tips in the fore pair. Head broad, hind ocelli closer to eyes than to each other. Dorsal surface of thorax uniformly rugose, somewhat confluent towards the apical portion. Abdomen short, cylindrical, rounded at extremities, with the sides of each segment ornamented with a patch of silvery hairs; first segment smooth, shining, second to seventh thickly but finely punctured, forming confluent rows on the anal ones. Length of body 6 lines; of ovipositor varying from $1\frac{1}{4}$ to $1\frac{3}{4}$ inches.

Hab.—Kalgoorlie, W.A. (G. W. Froggatt); Stannery Hills, N.Q (Horace Brown). Two specimens; type in Coll. Froggatt.

Megalyra viridescens, n.sp.

♀. Black, with the legs dark reddish-brown; tarsi darker and clothed with very fine pubescence; wings hyaline, with the fore pair broadly barred with a fuscous blotch, and the tips faintly clouded. Head broad, hind ocelli about an equal distance from each other and the eyes. Thorax coarsely punctured. Abdomen short, elongate-oval, thickly tufted on the sides of the apical segments with silvery hairs; first and second segments perfectly smooth and shining, third finely shagreened only on the outer edges, fourth very finely shagreened, fifth more coarsely shagreened, sixth to seventh finely punctured. Length of body 6 lines; of ovipositor $2\frac{1}{4}$ inches.

Hab.—Albert Park, Melbourne, Vic.(A. Lording). One specimen; type in the National Museum.

Megalyra frenchi, n.sp.

♂. Black, first five and the base of the sixth joint of the antennæ reddish, the rest fuscous to black; forewings semitransparent, barred with fuscous. The whole insect lightly clothed with fine hairs. Head broad, finely punctured; hind ocelli as near to each other as to eyes. Thorax furnished in front with a very fine pointed spine on either side, the whole deeply and finely punctured. Abdomen small, pointed to the apex, first segment smooth, shining, second shagreened, third to fourth coarsely shagreened, almost punctate, fifth to seventh more finely shagreened.

Hab.—Melbourne, Vic.(C. French). Three specimens; type in Coll. French.

MEGALYRA LYELLI, n.sp.

♀. Black, with the legs light reddish-brown; wings almost hyaline with a well defined fuscous blotch across the centre in the fore pair. Head broadly rounded, hind ocelli closer to each other than to eyes. Dorsal surface coarsely punctate, confluent on the metathorax. Abdomen somewhat oval and pointed at the extremity; first segment smooth, shining; second shining, faintly shagreened, third to seventh strongly but delicately shagreened. The whole insect clothed with scattered long grey hairs, thickest on the sides of the head, legs and apex of thorax. Length of body 5 lines; of ovipositor $1\frac{3}{4}$ inches.

Hab.—Gisborne, Vic.(G. Lyell). Two specimens; type in Coll. Froggatt.

MEGALYRA HIRSUTA, n.sp.

♀. Head, thorax and antennæ, except second joint, black; second joint of antennæ, legs, and abdomen dull red; forewings semiopaque, lightly clouded with brown across the middle. Head slightly depressed on the summit, eyes very prominent; hind ocelli closer to each other than to eyes; the whole finely and closely punctured. Thorax thickly and more irregularly punctured. Abdomen elongate-oval, first and apical half of second segments smooth and shining, base of second and rest of the segments very finely punctured. The whole insect clothed with scattered grey hairs forming a fine down on dorsal surface of head and thorax, and silvery bands on undersurface of abdomen.

Hab.—Tweed River, N.S.W.(A. M. Lea). One specimen; type in Coll. Froggatt.

MEGALYRA MINUTA, n.sp.

♀. Black, legs reddish-brown; wings hyaline, with a very slight fuscous blotch across the centre of forewings. [Head wanting.]

Thorax very rugose, very truncate in front, with the lateral spines very prominent. Abdomen oval, shining, first segment smooth, second to seventh finely punctured. Length of body 2 lines, of ovipositor 16 lines.

Hab.—Melbourne, Vic.(C. French). One specimen (damaged); type in Coll. French.

Though this unique specimen has no head, from its small size and excessively long ovipositor it is so distinct from any other known species that I have the presumption to give it a name.

DESCRIPTION OF A NEW TICK BELONGING TO THE FAMILY *ARGASIDÆ*.

By Walter W. Froggatt, F.L.S., Government Entomologist.

The members of this family are few in number, but they are widely spread over the warmer portions of the globe, where they are very destructive pests to domestic poultry. The three commonest, closely allied forms, *Argas americanus*, *A. persicus*, and *A. reflexus*, have a wide range over America, Africa, Southern Asia, and Australia, and are popularly known as "fowl ticks." One of these, *A. americanus*, was introduced into Australia over twenty years ago. The discovery of an indigenous species is an interesting matter.

Argas lagenoplastis, n.sp.

Length $2\frac{1}{4}$ lines. Reddish-brown, with the dorsal surface mottled with light yellow; undersurface dull yellow, with the legs very pale yellow to almost white. Broadly oval, flattened on the dorsal surface, with the integument finely rugose and marked with irregular depressions.

Hab.—Merriwa and Narromine, N.S.W.

This tick is common in the clay nests of the Fairy Martin or "Bottle-nest Swallow," *Petrochelidon* (*Lagenoplastes*) *ariel*, and is usually to be found under the lining of feathers and grass resting against the clay in the nests containing young birds, and for some time after the nestlings have flown. The tick probably has as wide a range as the host, which nests over the greater part of the southern and eastern coast, north to Port Denison; and far out in the interior. Mr. Masters showed me specimens in the Macleay Museum which he collected in Queensland about forty years ago.

LIFE-HISTORY OF *LESTES LEDA* SELYS.

By R. J. Tillyard, B.A.

(Plates xxxii -xxxiii.)

This paper embodies the results of observations carried out during the past two years. So far, the work done on the *Odonata* of Australia has been limited to the description of species; not a single life-history has yet been attempted. The group, as far as Australia is concerned, has been singularly neglected. The descriptions of known species we owe mostly to European entomologists, who have never studied the insects on the spot, but have received them from collectors here. Hence very little is known of their habits and their life-histories. This paper then marks a new departure in the study of Australian *Odonata.*

The difficulties in the way of studying insects such as these, whose early days are aquatic, are great. It has taken me two years to complete the history of this common species. Many points of dispute, notably as to the method of oviposition, can only be cleared up by spending a great deal of time in careful observation. Even so, there will generally remain points which are still open to discussion. I have attempted here to put down accurately all the observations I have made, and to draw the correct conclusions from them.

In breeding this species in captivity I used a large glass aquarium, about 1 ft. 6 in. by 1 ft., and 1 ft. high. Besides this, half-a-dozen glass jars were required for the observation of isolated specimens. At my first attempt I tried a bottom of clear sand, but the larvæ did not do very well. After trying various methods, I found that the best plan was simply to provide them with fresh water and plenty of water-weed from their native ponds. They appeared to thrive better on the tiny animalcula so introduced than on any supplies of "water-fleas" or other small aquatic creatures that I procured for them. There was always a large mortality amongst them, especially whenever the water was changed. In the end, I found it best to leave the water stagnant and not to change it at all, only supplying sufficient to make up for loss by evaporation, and cleaning the sides of the aquarium from aquatic growths just sufficiently to enable observations to be carried on. In this stagnant water the larvæ throve excellently, so that during the second year of my observations I obtained much better results with them.

Distribution.—*Lestes leda* Selys, a pretty little blue Agrionid, is certainly the commonest dragonfly of the Sydney district, though perhaps not the most noticeable. As regards distribution, it appears to be fairly common all over New South Wales, and especially along the coastal districts. It seldom occurs, however, on the rapid creeks of the mountain districts, where its place is taken by *Lestes cingulatus*. Thus, for example, on the Blue Mountains, *Lestes leda* is practically absent, being confined to a few swamps and water-holes; and in the Monaro district I found it only high up on the Kosciusko range at an altitude of 4,000-5,000 feet, whilst *L. cingulatus* was abundant everywhere. The species is also met with all over Victoria, where its congener *L. analis* is far more abundant; in South Australia, sparingly about Adelaide and the Murray River, being replaced by *L. analis* and *L. annulosus*, both of which are commoner. Going northwards along the coast from Sydney, it soon begins to become rarer; and at Byron Bay a smaller species *L. psyche* is probably equally common with it. In Southern Queensland it occurs in widely scattered localities about Brisbane and also all over the Darling Downs. Further north it becomes rare and I doubt if it can be indicated as extending beyond Rockhampton or Mackay. In collecting in the Townsville and Cairns districts I never met with it.

It is evident that the larvæ will not live in swiftly running creeks and rivers. Hence it is essentially an insect of the plains or low hill country. It will always be found in the greatest abundance around isolated water-holes of stagnant water, these being its favourite haunts. Next in point of favour come the swamps, where in company with *Diplacodes bipunctata* it is often found in profusion. It also inhabits slowly running streams, but not so abundantly, the larvæ only congregating in certain suitable spots, and probably often suffering destruction from freshets, and also from small fishes and other aquatic creatures.

Time of Appearance—It is probable that this species is double-brooded; though I have only reared the spring brood, which is more abundant. As is usual with the *Odonata*, the females appear before the males. The latter are found throughout the summer more abundantly than the females in a proportion of about 2 to 1, and at the end of autumn are still more proportionately abundant. The following dates of the first and last emergences of the imago from my aquarium are of interest :—

Date.	First emergence.		Last emergence.	
	♂	♀	♂	♀
1904	Aug. 27th	Aug. 8th	Sept. 7th	Sept. 7th
1905	Sept. 21st	Sept. 3rd	Oct. 9th	Oct. 4th

To account for the difference in the dates of appearance in 1904 and 1905, it must be remembered that in the latter year June and July were exceedingly dry months, nearly all the water-holes around Sydney being dried up, thus retarding the growth of the larvæ. Moreover in August and September the cold weather continued much longer than in 1904, so that the above result was only to be expected.

Throughout September and October the spring brood appears in great numbers around Sydney; and the perfect insect swarms on all the creeks and water-holes right up to December. There then appears to be a decided falling off in numbers. Probably many of the spring brood perish early in summer. Certainly during January and February the species, though still common, is much less abundant. Later on, in March, freshly emerged specimens are freely met with, and the species becomes again abundant up to about the middle of May. This may be called the autumn brood, though it is by no means as prolific as the spring brood. From the end of May to midwinter their numbers rapidly decrease; the advent of the cold westerly marking the demise of the species. In 1904 my last recorded capture of the species was on June 5th (2 ♂s and 1 ♀); in 1905, the species was over before the beginning of June; but I took an isolated male right in the bush away from any water on a sunny day about the middle of July. This year (1906) the warm weather has lasted long, and at the time of writing (July 2nd) it is still possible to capture half a dozen or so round any of the big water-holes by careful searching. Hence it will be seen that this species is recorded from Sydney for every month of the year; though as a rule it is exceedingly hard to find a specimen during July and the first half of August.

Method of Oviposition.—The best time to observe the oviposition of this species is in the morning of a bright calm day in early October or April; though at any time during such a day from the end of September to the end of June one may reasonably expect to find several pairs on the wing. The female *never* oviposits without the help of the male, as is the case with many of the *Agrionidæ*, notably *Ischnura delicata*. The male seizes the female round the neck with his superior appendages, which are conveniently forcipate, and the pair fly off together to some sheltered bush or bank of reeds. Returning to the water they at once set about the process of laying eggs. The male seizes on some small reed or leaf just standing out of the water, and, holding on tightly, arches his abdomen, dragging the female up behind him. The female then reaches out with her abdomen, feeling for the surface of the water. If they are not low enough down, they creep gradually down the surface of the stem. Often they are interrupted by other dragonflies, particularly the large hawk-like *Hemicordulia tau*, which will hover over them and every now and again swoop down and try to knock them into the water. At other times males of their own species will come and attack them viciously, and sometimes this will lead to a tussle between the two males for the possession of the female. If uninterrupted, and settled into a satisfactory position, the pair will remain motionless for a short time; then the female also arches her abdomen, dipping just the tip of it into the water and pressing it against the stem on which they are resting. In this way the ova are laid. On dissecting a fertile female I found that the ova lie longitudinally along the ventral portion of the abdomen, often reaching as high up as the third or fourth segment. They appear to be exuded only one at a time. In coming into contact with the water, the sticky substance which holds them together dissolves immediately and they fall down into the water. I am forced to this conclusion, although from the action of the female in pressing her abdomen against the stem or stalk, one would naturally suppose that the ova were deposited either *on* the stem or possibly inside it. Several times I spent many hours in collecting the leaves and stems of reeds and water-plants on which I had plainly seen *Lestes leda* ovipositing the moment before, but never once did I find any ova. Sometimes the stem would be hollow, and in this case I fancied the ova might have been inserted into it, especially from their shape, and because the female has a habit of working *down* a stem a short distance at a time, apparently placing her eggs in order. But the inside of these hollow stems never revealed any ova; besides which the ovipositor in *Lestes* is not particularly sharp, as it is in some other genera, such as *Argiolestes*. From experiments I have made with the larger species of other families of the Odonata, it appears that the gum which holds together their egg-clusters is immediately soluble in water if it does not come into contact with the air first. That this is also the case with *Lestes leda* there can be little doubt; and if so, the ova must fall at once to the bottom of the pool, the female only using the stem for pressure.

It has been stated that the species of the genus *Lestes* often oviposit on the branches of trees overhanging the water. I have attempted to verify this statement. One day I was fortunate enough to find a pair of *L. leda* sitting on the thick stalk of a water-plant (*Polygonum*) about a yard above the surface of the water, and apparently ovipositing in the same way as they do *in* water I watched this pair for ten minutes, and the female appeared to lay half-a-dozen eggs. I then captured the pair and plucked the stalk carefully. Examination with a pocket lens failed to disclose any ova. Moreover the female when dissected proved to be an old one with but few ova left inside her, and these few were far removed from the extremity of the abdomen. In this case it appears reasonable to suppose that the action of the female was only a muscular one designed to force the few remaining ova down to the end of her abdomen. This is the only occasion on which I have ever seen *L. leda* apparently ovipositing out of the water. On the other hand, I have watched many hundreds of pairs ovipositing in the water, so that it can safely be accepted that that is their usual habit.

Ovum.—The ovum itself is transparent and practically colourless; in shape like a torpedo (Plate xxxii., fig. 1), and without any sculpture or markings. Length 0·8 mm.; breadth across middle 0·2 mm.

Some ova deposited by a captured female were kept by me in water for some weeks. After a short time they darkened slightly in colour; but afterwards, though I watched them every day, I could not detect the slightest change in them, and after some weeks a mouldy growth formed round them. They were probably unfertile. I have never actually succeeded in hatching out the young larvæ of this or any other species of Odonata.

Larva-Nymph:—The young larva is transparent and almost colourless. As it grows, its colour gradually deepens, first to a pale straw-colour and later on to a pale green. The half-grown larva is generally a pale transparent green, with only a slight trace of any markings. It is not very active, spending most of its time clinging to the stems and leaves of water-plants and feeding on the tiny animalcula that come within the reach of its labial mask. Unlike the larvæ of the Libellulidæ, it never buries itself in mud or sand; nor does it often even rest on the bottom, as do the Aeschnidæ, preferring rather the dense floating tangles of water-weed. In using the water-net I found invariably that dragging amongst the water-weeds in mid-water yielded me *L. leda* abundantly, but that other Agrionidæ such as *Ischnura heterosticta*, *I. delicata*, and *Pseudagrion cyane* were obtained in company with Aeschnine larvæ from the bottom of the ponds. It would appear then that the larva-nymph of *L. leda* is a cleaner living creature and avoids the mud and sediment at the bottom of the pools. In captivity also they thrive better in clear water, whereas the other species preferred the mud.

When the larva-nymph wishes to change its position it generally starts to crawl laboriously up or down the stems of the water-weed. If this does not suit it will let go and begin to fall down. Then suddenly it will project itself forward by expelling the water from its body anally, using its caudal gill-plates much as a swimmer uses his legs, opening and shutting them quickly with each propulsion. By this means it generally rises to near the surface, and having selected the spot on which it would settle, it will turn head downwards, spread out its legs and open its gill-plates to form a sort of combined parachute and rudder to guide and help it in its descent. In propelling itself it does not wriggle violently from side to side like the larvæ of *Ischnura*, but rather travels by a series of by no means ungraceful half-twists, taken at intervals of about two seconds apart. It probably subsists almost entirely on tiny animalcula, for I have found it thrive excellently in water unsupplied with anything but plenty of water-weed.

The full-grown nymph is a beautiful object, being both in colouring and its graceful shape by far the handsomest Odonate larva I have found in Australia. The beautiful green of the body and the bright colouring of the caudal gill-plates distinguish it from the other ugly and muddy larvæ of the pools. The following is a detailed description of a typical full-grown nymph (Plate xxxii., fig.2) :—

Total length (to tip of lateral gill-plates) 26-27 mm.

Head rather wide (4 mm.), transparent green. *Ocelli* reniform, the front one largest; outlined in black or dark brown, and forming three sides of a square the base of which is absent. *Antennæ* slender, 2·5 mm., almost colourless, transparent; a darker patch on the basal joint. *Eyes* brown above, shading from a very pale transparent brown in front to a very dark brown behind, next the orbits; underneath an opaque white. *Orbits* and *occiput* transparent greenish. *Labial mask* pale green, length when extended 6·3 mm. (Plate xxxii., figs.3, 4).

Thorax: *Prothorax* well developed, transparent green with two brownish humeral rays reaching to the bases of the wing-cases. *Meso-* and *metathorax* green, covered dorsally by the wing-cases. Sides pale green. *Wing-cases* brownish, arranged longitudinally down the thorax (see Plate) and reaching along the abdomen down to about the middle of the fourth segment; length 5·2-5·3 mm. *Legs* pale dirty brownish, transparent, with darker spots near the joints and along the femora and tibiæ. In some specimens the legs are practically colourless and transparent.

Abdomen transparent green shaded prettily with darker olive-green; on each side of segments 2-6, near the base, is a small blackish spot; at the anal end of each segment, on either side of the dorsal carina, is a larger but less distinct blackish spot. Dorsal carina pale, transparent and clearly marked, being enclosed by dark olive-green markings on each segment as shown in the figure, forming a pale, somewhat diamond-shaped space in the centre of segments 2-7; there is also a darker parallel patch of olive-green on either side of all the segments. Underside pale fleshy-green.

Caudal gill-plates three, one medial (dorsal) and two lateral [see Plate xxxii., fig.5 (medial), fig.6 (lateral)]. Length, medial, 6·8 mm., lateral 7 mm. In the position of rest (Plate xxxii., fig.7) these gill-plates stand in three vertical planes, the two lateral ones with their main longitudinal tracheæ almost horizontal and making an angle of from 45° to 60° with one another. The medial gill-plate stands up between them at an angle of about 75° to the horizontal. In shape they are irregular, elongate, suboval; the medial one being slightly shorter and somewhat broader than the lateral ones. The main longitudinal trachea runs the whole length of each gill-plate, dividing it into two unequal portions; in the medial, the narrow portion is uppermost; in the lateral, it is underneath. This main trachea carries on either side from 40-50 branches or secondary tracheæ, these being slightly more numerous in the medial than in the lateral plates. A few of these are themselves bifurcate or possibly even trifurcate. These secondary tracheæ are all practically at right angles to the main trachea, this being characteristic of all the *Lestes* nymphs I have examined. In other Agrionid genera such as *Ischnura* and *Pseudagrion* the secondary tracheæ run oblique to the main one. Colour, a bright transparent brown; main tracheæ dark brown. Generally the plate is crossed by three irregular broad bands of suffused rich dark brown, as shown in the figures. Edges minutely and densely serrate, the serration not being visible to the naked eye. Altogether these plates are most beautiful objects for examination under a magnification of from 10 to 20 diameters.

The above description applies to a well coloured larva-nymph, and is probably the commonest type. However, the colouration varies greatly, some specimens being almost without markings of any sort and of a complete beautiful pale transparent green. Others are but slightly marked, and others again are even darker than the one described. As for the gill-plates, these may be pale transparent brownish or greenish (this very rarely) with no bands; or they may be slightly suffused with pale brown bands; or frequently the bands are so broad and dense as to be almost black and cover nearly the whole surface. In one or two specimens I have found them a bright salmon-pink colour. This variation in colour does not seem to be due to locality, all forms described having been taken in one small water-hole.

The larva-nymph is distinguished from that of allied species as follows:—That of *L. analis*, so far as I have been able to get any, has unshaded gill-plates always; it is slightly larger than *L. leda*, and the abdomen is seldom conspicuously marked as in the latter. That of *L. cingulatus* is of a dull transparent brownish colour, and every segment of the abdomen carries on either side of it, near the anal end, a small hook bent backwards. It also has unshaded gill-plates with fewer secondary tracheæ than in *L. leda*, and they are *never* bifurcated.

Emergence of Imago.—For a week or more before emergence the larva-nymph will cease feeding and turn gradually from green to a dull brown, or sometimes to a rosy or even a blackish hue. It will at times make violent rushes round the aquarium, and often seizes upon some stalk and climbs vigorously up it, only to rush as vigorously back again as soon as it has poked its head out of water. This will go on until there arrives a warm sunny day, when the nymph will at last ascend with a definite purpose. One of the nymphs which I had isolated in a small glass jar provided with grass-stalks fortunately emerged on a day when I was able to spend the whole time watching it (Aug. 13th, 1904). The morning was warmer than usual, and about 8 a.m , just as the sun's rays were beginning to slant in on the jar, the larva-nymph became violently agitated and wriggled vigorously about. Soon afterwards it seized upon a grass-stalk and climbed slowly up it. Having got its head above water, it stopped to rest about 5 minutes. Then it slowly ascended until it was two or three inches out of the water. About this time I left for breakfast, and on my return I found it had climbed up about two feet on to some mosquito curtains, and was now full in the sun's rays. Fixing its legs firmly into the meshes of the net, it now began a series of internal struggles. In particular, it seemed to have the power of extending its thorax by violent pulsations. Into the extended thoracic cavity it next withdrew its head and legs, with the result that, a few minutes after, it split open along the dorsal ridge down to the wing-cases. Next, this opening was enlarged by a transverse split across the shoulders. As soon as this opening was sufficiently wide the insect withdrew its head and forelegs from the shell, leaving its thorax partly protruding also. A great deal of struggling followed, and then the other legs were freed, together with the thorax and wings. After this exertion the insect rested about ten minutes. Then suddenly, with a violent bending motion, it worked itself to and fro, wriggling its abdomen bit by bit out of the tightly fitting nymphal shell. Four or five segments were thus liberated, and then the insect hung backwards helpless for about another ten minutes. During this time the legs appeared to have gained some muscular strength and hardness, for the insect soon afterwards began waving them wildly about, and finally fixed them on the mosquito netting. Now, using the leverage, the insect easily extricated the remaining segments of its abdomen, and climbing up the netting got clear of the nymphal case. The dragonfly was now full in the sun's rays, and a few minutes' rest was sufficient to stir it to further action. Development of the wings, which so far had appeared like a set of short flabby greenish bags, began to take place immediately. By observing this process through a strong lens I was enabled to note exactly how it went on. There was very little time for observation, for so rapidly did the wings develop that in ten minutes' time they had reached their full size. Under the lens, I could see the regular pulsations of the thorax, and the quick growth of the wings as the fluids were forced out into their baggy folds. The development was remarkable, and of sufficient interest to be given in detail.

The wings at first lay in a series of folds, or rather rucks, parallel to, and I suppose corresponding with, the main nervures of the completely developed wing. These rucks gradually smoothed out into more or less regular curves. Distension occurred first in the parts before the nodus, so that the basal portion of the wing was fairly well formed, while the rest still remained flabby and shapeless. A large transverse ruck at the nodus itself took a great deal longer to smooth itself out. Development of that portion of the wing lying between the nodus and pterostigma followed later, and began along the postcostal margin from the base outwards. This part of the development was marvellously rapid, so that, almost before I could realize it, the wing had reached its full length, and practically also its perfect shape, except for a small region near the pterostigma. Here were two large indentations at the side of the wing, separating a portion which was destined to become the pterostigma itself. Turning my attention to this, I noticed a series of small indentations along the costa, each one representing a future postnodal. These soon disappeared, leaving only the two large indentations mentioned before. The latter gradually stretched themselves out, becoming less and less concave, and as they did so the isolated portion between them began to harden and to appear as a distinct and regular plate; this being due to the closing up and uniting of the numerous tracheæ surrounding it. It appeared that these tracheæ or fluid-tubes combined naturally in pairs simply by the stretching of the wing, and that as soon as a pair approached one another and lay exactly parallel, a membranous hardening took place around them and they closed up into a strong and distinct nervure.

It thus appears that the nodus and the pterostigma are the two points at which the development of the wing was *arrested*, so to speak. This appears to be due to the excessive number of tracheæ at these points, the quicker development of the adjacent parts causing the large indentations which were so noticeable. But when the arrested development became completed, it would of course be natural to expect a great strengthening and extra stability of those very parts. This we find to be the case, the nodus and stigma being in a very true sense the supports or points about which—next to the base itself—the wing is built.

Immediately after full expansion the wings appear flabby and weak, and are of a pale greenish colour, the pterostigma being slightly paler. In the course of an hour or so the greenish tint almost entirely disappears, the wings becoming brilliantly hyaline and the pterostigma deepening into a pale brown. A day or two afterwards the wings are perfectly stiff and transparent, the pterostigma being opaque and dark brown. The insect is capable of weak flight an hour or two after the complete development of the wings.

Besides development of the wings, there is a gradual development of the abdomen, by elongation. The wings at their full length are about 2-3 mm. longer than the undeveloped abdomen. Later on the abdomen gradually becomes narrowed and elongated, until it reaches some 5 mm. beyond the wings. The development is somewhat slow, occupying about half-an-hour.

The newly developed imago is a very colourless insect, the head parts being greenish and transparent, with a bluish tinge above, underside almost colourless. Thorax and abdomen colourless below, pale greyish-blue above, the abdomen having rings of dark purplish-red at the base of each segment. The only conspicuous markings are a black spot near each wing-join; these afterwards extend to form the dark lateral rays of the thorax. Some time elapses before the true colouration of the insect becomes apparent. For the first few days the brilliant blue colours of the mature insect do not appear, but are replaced by a bright orange-pink, somewhat similar to the colouration seen in *Lestes analis*. I kept one specimen alive for nearly a week, and by that time only the slightest bluish tinge was beginning to show itself. However, it is probable that in a state of nature, and especially with abundant food, the blue colour would assert itself much earlier.

Imago: The following is a description of the mature insect :—♂. Total length 37-40 mm.; abdomen 30-31 mm.; wings, fore 21 mm., hind 20 mm.

Wings: *Neuration* black; *pterostigma* almost black, oblong, 1·5 mm. *Nodal Indicator*

2	9-10
2	8-10

Head: *Eyes* violet-blue above, whitish below; *ocelli* black, in a triangle; *antennæ* black, basal joint somewhat swollen. *Postclypeus* jet-black; *anteclypeus* bright blue. *Labrum* bronzy-black, slightly bluish at sides; *labium* whitish, bordered with black along the outer edge; *mandibles* pale dirty brownish.

Thorax: *Prothorax* black above, paler beneath. *Meso-* and *metathorax* deep bronzy-black, with a narrow light blue dorsal ridge and three broad bright blue bands on either side, the first humeral, the other two lateral, and separated from the first by a still broader band of the ground colour; these second and third bands are irregular and practically contiguous. *Underside* pale dirty brownish, with a slanting oblong black spot on either side. *Legs* black, slightly paler underneath; coxæ and trochanters pale brownish, especially those of the forelegs; tibiæ with several black bristly hairs.

Abdomen: Slender, 1-2 slightly enlarged, 7-10 slightly increasing in width; rest cylindrical. Colour: 1-2 dark bronze, with a somewhat irregular light blue dorsal mark, broadest at the end of 1, and very narrow on 2; on either side a bright blue band; 3-7, basal part bright blue, rest deep bronzy-black; the amount of blue decreasing from about one-third in 3 to one-fifth in 7; 8-9, deep bronzy-black, sutures crossed by a narrow transverse line of blue; 10, bright blue, sometimes slightly clouded anally. Underside pale greyish-white.

Appendages: *Superior* black, forcipate, 1 mm., carrying a sharp black spine on the inner edge; very slightly hairy. *Inferior* very short, brownish, 0·4 mm., separated, tips blunt; curving upwards when viewed laterally. (Plate xxxiii., figs. D_1 and D_2).

♀. Total length 36 mm.; abdomen 29 mm.; wings, fore 22mm., hind 21 mm. *Nodal Indicator*

2	9-11
2	9-10

It differs from the male as follows:—All parts of the head and thorax which are blue in the male are dull greyish-green in the female. Abdomen thicker than in male, cylindrical. Colour: 1, bronzy-black, with a blue anal mark as in the male; 2-6, basal quarter bright-blue, rest bronzy-black; 7, bronzy-black, with a narrow basal blue band; 8-10, deep bronzy-black.

Appendages wide apart, rather short, 0·3 mm., subcylindrical, tips rounded, separated by the downy projection of segment 10; colour dull bronze (Plate xxxiii , figs. E_1 and E_2).

(For colour-scheme of imago, see Plate xxxiii., figs. A, B, C).

EXPLANATION OF PLATES.

Plate xxxii.

Fig. 1.—*Lestes leda*, ova.
Fig. 2.— ,, larva-nymph, full grown.
Fig. 3.— ,, ,, labial mask, extended.
Fig. 4.— ,, ,, ,, ,, extremity.
Fig. 5.— ,, ,, caudal gill-plate (medial).
Fig. 6.— ,, ,, caudal gill-plate (lateral).
Fig. 7.— ,, ,, diagram showing position of gill-plates.

Plate xxxiii.

Fig. A.—*Lestes leda*, imago, ♂.
Fig. B.— ,, ,, ♀, abdomen.
Fig. C.— ,, ,, ♂, head and thorax, lateral view.
Fig D_1.— ,, ,, ♂, appendages, dorsal view.
Fig. D_2.— ,, ,, ,, lateral view.
Fig. E_1.— ,, ,, ♀, appendages, dorsal view.
Fig. E_2.— ,, ,, ,, lateral view.

NOTES AND EXHIBITS.

Dr. Chapman showed experiments upon the curdling of milk by the action of pancreatic juice. This juice had been obtained from a dog with a canula in the pancreatic duct by means of intravenous injection of secretin. The enterokinase solution had been prepared by maceration of the superficial mucosa of the dog's duodenum in chloroform water. Some cubic centimetres of juice were activated by 3 drops of enterokinase solution and incubated for 6 hours.

A series of test tubes, kept in a water-bath at 37° C, was arranged as follows:—(1) 5 c.c. milk + 3 drops of pancreatic juice. (2) 5 c.c. milk + 2 drops of enterokinase solution. (3) 5 c.c. milk + 3 drops of pancreatic juice + 2 drops of enterokinase solution. (4) 5 c.c. milk + 3 drops of "activated" pancreatic juice. (5) 5 c.c. milk + 3 drops of pancreatic juice. (6) 5 c.c. milk + 3 drops of pancreatic juice. These tubes had been in the water-bath for 3 hours. None showed any clotting of the milk. To tube (1), 2 drops of enterokinase were added. Clotting occurred in 15 minutes. To tube (3), 5 c.c. of milk were added. Clotting was observed in 2 minutes. To tube (4), 5 c.c. of milk were added. Clotting was noted in 2 minutes. To tube (5), 3 drops of activated juice were added. Clotting was remarked in 2 minutes. To tube (6), 5 c.c. of milk were added. No clotting occurred.

Mr. G. A. Waterhouse exhibited specimens of all the known Australian species of *Ogyris* [LEPIDOPTERA: *Lycænidæ*]. Commenting on the habits of their larvæ, he remarked that so far all had been found to feed on various species of *Loranthus*, feeding by night only and hiding during daylight under pieces of bark, in holes in the trees, under stones on the ground, or even in ants' nests. Most of the species are attended by ants, which seem to be very useful to them. About 7 o'clock one evening he watched larvæ of *O. ianthis* making their way from a piece of *Loranthus* to their hiding place. These larvæ did not seem to have any idea of direction, for they frequently attempted to go quite away from their hiding place, but were prevented by the ants blocking their further passage in that direction.

Mr. D. G. Stead exhibited a mature intra-uterine fœtus of the Little Saw-Shark *Pristiophorus cirratus* (Latham), and, for comparison, the head of a half-grown example of the same species; and he pointed out that an examination of the rostral lamina or "saw," in the mature fœtus of *Pristiophorus cirratus*, revealed the highly interesting fact that it was armed on each side, at regular intervals, with long spines only; there being none of the small intermediate spines which are so characteristic of the "saw" in the adult or in the half-grown specimen exhibited. In the possession of this character, the fœtus suggested the large predaceous Saw-fishes of the genus *Pristis*. It was interesting to note also that these teeth were not fixed rigidly at right angles to the "saw" as in the adult, but were movable, directed backward, and lay pressed close against each side, thus protecting both fœtus and parent during parturition. Another fact that was worthy of mention was that the subrostral tentacles were about twice as long in the fœtus exhibited as they are in the mature fish.

Mr. Stead also exhibited the right chela of a large Mangrove Crab, *Scylla serrata* (Forskäl), the dactylus of which was very curiously malformed. In addition to being considerably dwarfed, there was a large vertical outgrowth from its upper border, resembling closely an open "nipper," even the teeth being present.

With reference to the fibre exhibited by Mr. R. T. Baker at the May meeting and commented upon by Mr. A. G. Hamilton at the June meeting, Mr. Maiden expressed the opinion that it was probably the product of a marine plant, *Posidonia australis* Hook.f.(Naiadeæ). "The bases of the stems covered with the filamentous remains of old leaf-sheaths" is a character of the genus, those of *P. australis* being covered with longer and finer filaments than in *P. oceanica*, the European species. Mr. Maiden exhibited specimens of *P. australis* showing the fibre *in situ*, and he drew attention to the possible importance the finding of the Posidonia fibre may have from a geological point of view.

Posidonia grows at the present day on the coasts of Tasmania and southern Australia as far as New South Wales; the fibres are firmly attached to the plant, and it remains in doubt whether or not they were washed on shore where they were found. But in the absence of any available geological evidence favouring the idea of raised beaches, it would be premature to conclude that the finding of the fibre indicates the former existence of a sea whose depth did not exceed the maximum depth in which Posidonia is found growing now.

Mr. Maiden also exhibited fruits of Davidson's Plum (*Davidsonia pruriens* F.v.M.), an edible fruit, the size of an Orleans plum when fully ripe, and belonging to the *Saxifrageæ*; it is a native of Queensland, and this appeared to be the first time it had ripened fruit in the Botanic Gardens, Sydney. Likewise a number of New South Wales plants usually called "leafless," which exhibit leaves under certain circumstances, including *Viminaria denudata*, *Bossiæa scolopendria*, *Comesperma defoliatum*, *Tetratheca juncea*, and *Exocarpus cupressiformis*.

Dr. Petrie showed, under the microscope, preparations of the stinging hairs of the Giant Nettle-Tree (*Laportea gigas*).

Mr. H. Leighton Kesteven read the following Note:—"Some three or four years ago I collected material for a review of the New South Wales *Rissoidæ* [MOLLUSCA]. Thanks to the courtesy of workers in the other States, I was able to obtain the opinions of nearly all the Australian conchologists, past and present. As I do not see any immediate prospect of completing the review, and as any information on this troublesome group is of value, I place on record the following fragments. *Rissoa petterdi* Brazier, recorded without definite locality from New South Wales, occurs in Port Jackson. Mr. May compared my specimens with the type, and was able to confirm my identification. *Rissoa bicolor*

Petterd, another southern species, which was dredged off the coast by the 'Thetis,' also occurs inside the harbour. Miss Lodder's collection contained specimens of *R. beddomei* Tate(= *R. flamia* Beddome) identified by Beddome, and *R. sophiæ* Brazier, identified by Brazier. These on comparison with *R flammea* Frauenf., and *inter se* prove to differ only slightly in colour. The first three names are therefore synonyms of the last. The names *R. australe* Frauenfeld, *R. ochroleuca* Brazier, *R. mixta* Tate, and *R. apicilirata* Tate & May, all apply to the one species. In arriving at this conclusion I had the type of *R. ochroleuca* and authentic specimens of *R. apicilirata* to compare with Frauenfeld's species. The salient feature of the species provided Tate & May with their name. Tate's name *mixta* was proposed to replace the preoccupied name *ochroleuca.* Specimens which I have seen, identified by Tate & May as *R. mixta,* were of an apparently undescribed species; this suggests that these authors were not acquainted with the true *ochroleuca.* The confusion arose from the fact that Frauenfeld described a very rare variety of the species devoid of longitudinal ribs. The name *mixta* might well be retained for the common variety. The material on which these notes are founded has been placed, together with the rest of my *Rissoidæ,* in the Australian Museum."

Mr. Froggatt showed some leaves of *Eugenia* sp., beautifully coated with the tests of "snow-flies," an undetermined species of *Aleyrodes* [HOMOPTERA : *Aleurodidæ*]. Also, in illustration of his papers, specimens of the parasitic wasps of the genus *Megalyra,* and of the proposed new species of *Argas.*

WEDNESDAY, AUGUST 29TH, 1906.

The Ordinary Monthly Meeting of the Society was held in the Linnean Hall, Ithaca Road, Elizabeth Bay, on Wednesday evening, August 29th, 1906.

Mr. T. Steel, F.C.S., F.L.S., President, in the Chair.

A letter from Mrs. James Norton, thanking the Members for their appreciation of Dr. Norton's long and helpful association with the Society, and for their expression of sympathy, was read by the Secretary.

The Donations and Exchanges received since the previous Monthly Meeting, amounting to 4 Vols., 67 Parts or Nos., 31 Bulletins, 5 Reports, 18 Pamphlets, 5 Maps, and 2 Miscellanea, received from 60 Societies, &c., and 3 individuals, were laid upon the table.

NOTES AND EXHIBITS.

The President exhibited living specimens, sent by Mr. H. W. Davey from Portland, Victoria, of *Ooperipatus oviparus*, and the following land planarians :—*Geoplana McMahoni*, *G. sanguinea*, and *G. Sugdeni*.

Mr. D. G. Stead exhibited specimens of the following species of Syngnathid Pipe-Fishes :—*Syngnathus tigris* Castlenau, from Hawkesbury River; *Urocampus carinirostris* Castlenau, from Smith's Lake and Lake Illawarra; *Stigmatophora argus* Richardson, from Port Jackson and Hawkesbury River; *Stigmatophora nigra* Kaup, from Tuggerah Lake; and *Gasterotokeus biaculeatus* Bloch, from Tuggerah Lake and Bateman's Bay. Mr. Stead also offered some remarks upon the breeding habits of the Sea-Horses and Pipe-Fishes in general.

Mr. Fred Turner exhibited and offered a number of observations on a very fine collection of Australian grasses, being a portion of the herbarium of the late Hon. Dr. James Norton, M.L.C., who was for so many years associated with the Society. Dr. Norton had completed a botanical survey of the area lying within one mile radius of his late country residence, Euchora, Springwood, Blue Mountains. In the deep gullies on this area are a number of cellular as well as vascular Cryptogams. The rarest plants in the locality are *Triraphis microdon* Benth., amongst Phanerogams; and *Botrychium ternatum* Swartz, amongst Cryptogams.

Mr. North sent for exhibition a skin of an adult male of the so-called *Cracticus leucopterus* of Gould, procured on the 24th July, 1906, by Mr. Tom Carter, of Broome Hill, Western Australia, together with the following note :—" In the 'Catalogue of Birds in the British Museum '* Dr. H. Gadow regards *C. leucopterus* as specifically distinct from *C. destructor* Temm., and gives its habitat as North-eastern and Western Australia. In Vol.ii. of the Australian Museum Special Catalogue, No.i., 'Nests and Eggs of Birds found breeding in Australia and Tasmania,' now passing through the press, I pointed out that the distinguishing characters given by Dr. Gadow to *C. leucopterus* were equally applicable to very old males of *C. destructor*, but for want of adult specimens from Western Australia I was unable to state whether *C. leucopterus* should be regarded as a distinct species. In Dr. R. B. Sharpe's 'Handlist of Birds '† full specific rank is accorded to *C. leucopterus*. As Dr. Gadow stated of the latter, there is no difference in size between the specimens from Queensland and those from Perth. I was not surprised to find that the eastern and western birds are alike. The specimen received from Mr. Carter is precisely similar in colour, the extent of white on the wing, and measurements to another adult male of *C. destructor* exhibited, and obtained by Mr. R. Grant at Cambe-

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* Vol.viii. p.98 (1883).
† Vol.iv. p.277 (1903).

warra, N.S.W. *C. leucopterus* Gould, should therefore rank as a synonym of *C. destructor* Temm."

Mr. North also drew attention to the early breeding of several species of birds in the neighbourhood of Sydney, probably owing to the unusually fine and dry weather for months past. The prolific autumn breeders, *Meliornis novæ-hollandiæ* and *M. sericea*, had continued nesting throughout the usual break in June and July between the early autumn and winter breeders. *Origma rubricata* had been found breeding near Manly by Mr. A. F. B. Hull in June, and by Mr. L. Harrison in July. At Middle Harbour Mr. North saw fully fledged young of *Ptilotis leucotis* on the 15th August, being fed by their parents, and at Chatswood obtained the nest and fledglings of *Melithreptus brevirostris*. At Roseville fledglings of *Melithreptus lunulatus* left the nest on the 17th instant. Of ordinary breeders at this time of the year, nests with eggs or young have been noted, during August, of *Glycyphila fulvifrons*, *Meliornis novæ-hollandiæ*, *M. sericea*, *Geobasileus chrysorrhous*, and *Acanthiza pusilla*. For eight consecutive years at Middle Harbour Mr. North had noted the nests of *Origma rubricata* built in two cave-like shelters, and attached to the same flakes of rock, one of the nests at present nearing completion, the other containing three fresh eggs. Owing to the rapid growth of the suburbs along the Milson's Point railway line, and consequent destruction of trees and undergrowth, this district is being rapidly spoilt as a collecting ground. This is more pronounced at Roseville and Lindfield in the vicinity of the railway, many of the places where nests were photographed *in situ* a few years ago, and figured in the above Catalogue, now being covered with houses.

Mr. Fletcher exhibited, on behalf of Miss M. Lodder, of Launceston, some small fishes 1-2 inches long, which Mr. Masters had been good enough to examine, and had found them to be the young of a species of *Galaxias*. They were obtained at West Strahan, Tasmania, in the early part of the year, in an unusually dry season; and the point of interest about them was that they were dug up in damp soil remote from any water. Similar specimens had been previously brought to light in digging drains, post-holes, &c.; and acting on this information, and with the help of some boys who knew of these occurrences, Miss Lodder had no difficulty in finding patches of ground where the fishes could be turned up with a spade. The explanation of the matter seemed to be that the fishes were æstivating in damp soil representing the bed of a water-hole or swamp which had dried up.

Mr. Stead remarked that other species of *Galaxias* were known to have a similar habit, though he could not, from memory, say just then where a record of the fact was to be found.

Mr. Fletcher also showed some examples of last year's male amenta of the Bunya Bunya (*Araucaria Bidwilli* Hook.), which were larger than those exhibited at the Meeting in September 1904. Some of these were from a tree in the Society's garden which produced male amenta for the first time in 1904 (two), and twelve in 1905. Some of the specimens shown were 18 centims. in length, but only one of them attained the dimensions [20 centims.] given for the species by Mr. A. C. Seward and Miss Ford in their recent paper "On the Araucariæ, Recent and Extinct."*

* Phil. Trans. Series B., Vol.198, p.324, 1906.

NOTES ON THE NATIVE FLORA OF NEW SOUTH WALES.

By R. H. Cambage.

Part v. Bowral to the Wombeyan Caves.

(Plates xxxiv.-xxxv.)

The notes used in the preparation of this paper were taken at the end of September, 1905, during a visit made to the Caves in company with Messrs. J. H. Maiden, F.L.S., and E. C. Andrews, B.A. I have to acknowledge assistance from the former in identifying plants, and from both in collecting specimens. Mr. Maiden also placed his notebook at my disposal to augment my own if necessary.

The Wombeyan Caves are situated 42 miles by road in a general westerly direction from Bowral, which is on the Great Southern Railway Line. The country around Bowral ranges from about 2200 to 2800 feet above sea-level, with an annual rainfall of 39 inches; and may be regarded as part of the table-land which extends across in the direction of Goulburn and Braidwood. The road towards Wombeyan rises slightly for some 15-20 miles, but near the 25-mile post a steep but most picturesque descent is commenced into the valley of the Wollondilly River, which is reached by a winding road in seven miles. The ascent on the western side of the river is made in another seven miles, after which there remains a descent of three miles to the Caves.

The geological formation of the valley in which Bowral is situated consists chiefly of Wianamatta Shale enriched from surrounding basaltic hills; while towards Mittagong stands the well known syenite hill which bears the local name of The Gib, (abbreviation of Gibraltar) and from which the rock known to the builder as trachyte is quarried. The Hawkesbury Sandstone of the Triassic period shows intermittently towards the Wollondilly for a distance of 22 miles, and its terminal point is of interest, as, in this locality, it marks the south-western edge of the great Permo-Carboniferous coal basin which extends approximately from the Hunter to the Clyde River. After passing the 22-mile post, an area of porphyritic and granitic rocks is entered, and this continues to within a few hundred yards of the Caves, where the formation changes to Silurian limestone.

The plants met with are for the most part those which belong to the coastal area, but with some notable exceptions. The effects of climate and aspect are particularly noticeable along the country passed over. Although Bowral is only about 30 miles from the coast, it is some distance back from the edge of the plateau, and therefore to some extent deprived of coastal influence by the cliffs of the Illawarra Range which rise almost perpendicularly to a height of nearly 2000 feet. On the western side of Bowral, towards Wombeyan, there is more exposure to western influence, the result being that the cold south-westerly winds have free access to this area, including the valley of the Wollondilly, and we look in vain for the dense vegetation of the coast or of those sheltered valleys in the Blue Mountains which are protected from the chilling and drying influence of the westerly gales.

Rainfall is also an important factor in the regulation of plant life, and its effects may be seen along the country extending from the coast to Bowral and Wombeyan. According to the records at the Sydney Observatory, the quantity of rain which falls on the coast at Kiama and Wollongong is greater than that at Bowral, from which point it again diminishes towards Taralga just beyond the Caves. The records are as follows:—Kiama 54·37 inches (average for 19 years), Wollongong 43·09 (31 years), Robertson 67·95 (14 years), Bowral 39·11 (20 years), Taralga 29·47 (19 years), and Goulburn 25·91 (48 years).

The relation between the rainfall and the vegetation over the area in question is most instructive. In Illawarra we find dense brush which spreads to the plateau at Robertson, but which, except for a stray plant, is absent at Bowral. The good basaltic soil at Robertson only partly explains the presence of this luxurious vegetation, which is further accounted for by the more eastern aspect of the latter place together with its excessive rainfall.

These three important factors, viz., geological formation, rainfall and aspect, afford an interesting study in regard to their effect upon the vegetation.

The Eucalypts to be found on the sedimentary and basalt-capped area around Bowral and before the 22-mile post near Bullio is reached are :—*E. Macarthuri* Deane & Maiden (Woollybutt), *E. amygdalina* Labill. (Peppermint), *E. coriacea* A. Cunn. (White or Scribbly Gum), *E. viminalis* Labill. (White Gum), *E. regnans* F.v.M. (*E. fastigata* Deane & Maiden),*E. tereticornis* Sm. (Forest Red Gum), *E. eugenioides* Sieb.(Stringybark), *E. numerosa* Maiden (Ribbony Gum or Peppermint), *E. stellulata* Sieb. (Black Sally), *E. piperita* Sm.(Sydney Peppermint), *E. Sieberiana* F.v.M (Mountain Ash), *E. punctata* DC.(Grey Gum), *E. quadrangulata* Deane & Maiden (Box), *E. Smithii* R. T. Baker, *E. hæmastoma* Sm. (White or Brittle Gum), *E. maculosa* R. T. Baker (*E. Gunnii* var. *maculosa* Maiden; White or Spotted Gum), *E. rubida* Deane & Maiden (*E. Gunnii* var. *rubida* Maiden, a White Gum), *E. dives* Schauer (Peppermint, at about 10 miles from Bowral), *E. acervula* Miq.(*E. Gunnii* var. *acervula* Deane & Maiden; *E. paludosa* R. T. Baker), *E. Bosistoana* F.v.M.(called both Yellow Box and Gum), *E. capitellata* Sm.(Stringybark).

One of the most conspicuous Eucalypts around Bowral is *E. Macarthuri* (Plate xxxiv.), often called Woollybutt from the rough semifibrous nature of the bark; and with its dense spreading foliage it makes a beautiful shade tree, being one of the most ornamental of our Eucalypts. It is found on the flats near the watercourses, and its partiality in this district for the particular geological formation known as Wianamatta Shale is of interest, though its chief desideratum appears to be a deep soil near streams. As illustrating, however, the dominating influence of climate, this species, though common on the shale at an altitude of 2200 feet, is, so far as I know, entirely absent from the same formation between Parramatta and Penrith, which averages something over 100 feet above sea-level. It is also absent from the basaltic hills around Bowral.

This species has a limited range in New South Wales so far as is known at present, being almost confined to the plateau between Goulburn and Mittagong. Its most northern point known to me is The Oaks, near Picton, where a few trees are growing on the Wianamatta Shale at an elevation of about 1000 feet above sea-level. These particular trees have less of the woolly bark than is usually found on the species, and for the most part are covered with a fairly smooth gum-tree bark, though hard and flaky near the base, with a very little fibre. The variability in the extent of the fibrous bark on many trees of the genus provides an interesting study.

In January, 1902, some trees were noticed by me from the train in Tasmania between Deloraine and Chudleigh Junction which were suggestive of the Bowral species, specimens being afterwards collected by Mr. Maiden and recorded as *E. Macarthuri.** That it should occur at such widely separated spots at once provides an extensive field for speculation as to the method of its distribution and the age of the species. The subject, however, involves many questions which cannot be disposed of without years of observation and close study, assisted by the geologist and physiographer as well as students of other natural science subjects.

E. Macarthuri is of interest from an economic point, as, according to Mr. H. G. Smith, F.C.S., the leaves contain a large percentage of geraniol. "The oil obtained from this species has no resemblance to ordinary Eucalyptus oil, and belongs to none of the well defined groups of these oils."†

Another interesting tree around Bowral is *E. regnans* F.v.M. (*E. fastigata* Deane & Maiden), the giant gum of Gippsland or at

* Papers and Proc. Royal Society of Tasmania, 1902, p.83.
† Journ. and Proc. Royal Society of N. S. Wales, 1900, p.143.

least a smaller form of that species. The Victorian tree has usually smooth bark to within some 10 feet of the ground, but in New South Wales the fibrous bark extends right up the trunk and usually on the large branches; and this variation in the height of the fibrous bark constitutes the principal difference from a botanist's point of view. *E. fastigata,* however, is never so tall as the typical *E. regnans* of Victoria, nor can I say whether the change from smooth to fibrous bark takes place gradually over the northern part of that State or whether there are no intermediate forms. Usually in this State the tree is known as Messmate or Blackbutt, although quite distinct from the Blackbutt of commerce, *E. pilularis* Sm. The species is of interest in the Bowral district owing to its partiality for igneous formation. Mr. R. T. Baker, F.L.S., has observed that it is sure to be found where the rock is trachyte. It is also growing along a basalt range west of the railway and extending northerly from Mt. Oxley, but nowhere was it found on either the Wianamatta Shale or the typical Hawkesbury Sandstone. (For previous remarks on this species see these Proceedings, 1902, p.588).

E. numerosa Maiden, has for many years been regarded as identical with *E. radiata* Sieb., but Mr. Maiden explains* that, from specimens he examined, the latter is simply a form of *E. amygdalina* Labill., and the tree which has been so long recognised as *E. radiata* was undescribed.

E. numerosa has been sometimes looked upon as only a variety of *E. amygdalina*, but a study of these trees in the field seems to prove them specifically distinct. (For previous remarks see these Proceedings, 1902, p.574). A constant point of distinction in the forest appears to be in the bark; that of *E. numerosa* is rarely what would be classed as truly fibrous, being more of a rough scaly nature, with the scales so short as to give the trunk a mottled appearance, while the upper part of the trunk and the branches are smooth. When growing near watercourses it is sometimes classed as a white gum owing to the increased amount of

* These Proceedings, 1904, p.751.

smooth bark on the trunk. The trunk and large branches of *E. amygdalina* are covered with grey fibrous bark. The two species could be easily separated in the forest between Bowral and Wombeyan during September, by the absence of flowers on *E. amygdalina* and the profusion of blossoms on *E. numerosa*. In the Bowral district the geological formation renders great assistance in identifying these two species, for while the former is common on the basalt hill from Mt. Oxley northward, it is absent from the syenite and the sedimentary formations, though this does not apply to all districts, and it occurs on the sandstone between the 20- and 21-mile posts on the Caves road. On the other hand, *E. amygdalina* is common on the syenite, the sandstone and the shale, but does not occur on the basalt.

E. stellulata is growing just to the south of Bowral on the road to Moss Vale.

The two stringybarks which are found on the sedimentary area along the Caves road are *E. eugenioides* Sieb., and *E. capitellata* Sm., the former being on both the Hawkesbury Sandstone and the Wianamatta Shale, while the latter shows a distinct partiality for the sandstone, particularly in the Sydney district. Neither species, however, is restricted to any particular formation.

E. quadrangulata, the Brush Box of the South Coast, is represented by a few trees about 5 miles out, the country generally being too high and exposed for the species. The long straight stems of these box-trees may be seen towering above the brush or jungle at various places in Illawarra, viz.:—Bulli Pass, Mount Kembla, Barrengarry Mountain near Kangaroo Valley, and also on the igneous formation around Milton. After coming up from the south to Bulli, where it is about a mile from the ocean, it recedes from the coast and continues past Hill Top, from which place it was described, to The Oaks and westward to Burragorang where it is growing on porphyritic formation. The most western locality known for the species is around Yerranderie near The Peaks, while its northern limit is considered to be the Upper Hunter. It seems to practically avoid the Hawkesbury Sandstone formation, which accounts for its absence from the Sydney district.

In the forest *E. quadrangulata* much resembles *E. Rudderi* Maiden, of the North Coast, partly from its growing in corresponding situations, and also because the tall straight boles and branches of each are covered with similar grey box-bark; but the juvenile foliage and timber afford a ready means of distinction to the field botanist.

E. piperita and *E. amygdalina* are associated on the sandstone and syenite, but the former was not found on the shale; and although it continues from Bowral right down to Port Jackson, it does so by following the sandstone areas, avoiding the Wianamatta Shale. *E. piperita* is one of those plants which by its presence almost invariably announces the fact that the rock in the vicinity is sandstone, its occurrence on the syenite being an exception. Owing to climatic influence *E. amygdalina* does not follow far towards Sydney, it being a distinctly cold country species, and thrives at elevations above that at which *E. piperita* usually grows.

E. viminalis is common on the basaltic hills around Bowral, which is a characteristic feature in the various States where it grows, but it is not confined to igneous formation, though it is somewhat rare on sandstone.

E. coriacea, the Snow Gum of Kiandra and Kosciusko, in its passage from Tasmania to New England, reaches Bowral on the eastern margin of its habitat; and north of Goulburn is seldom found below an altitude of 2000 feet, while it grows at elevations exceeding that of all other Eucalypts.

In order to localise the plants, the following lists are so divided that the first refers to the conspicuous members of the flora, other than Eucalypts, on the sedimentary formation which extends about half-way, viz., 22 miles. The second list mentions the plants observed during a walk across the syenite hill, locally known as The Gib, and is given for the purpose of comparison. The third list comprises the flora noticed on the second part of the road, viz., from the 22-mile post near Bullio to the Caves, and which includes the porphyritic and granitic country. The fourth gives the names of plants observed on the limestone around the Caves, while the fifth enumerates the species seen growing beside the Taralga road for a distance of seven miles.

Bowral to the 22-mile post.

Various trees and shrubs noticed near the road between Bowral and the 22-mile post were :—*Clematis glycinoides* DC., *Hibbertia Billardieri* F.v.M., *Ionidium filiforme* F.v.M., *Billardiera scandens* Sm., *Tetratheca thymifolia* Sm., *Comesperma ericinum* DC., *Elæocarpus cyaneus* Ait., *Geranium dissectum* Linn., *Philotheca australis* Rudge var. *Reichenbachiana*, *Pomaderris apetala* Labill., *P. ferruginea* Sieb., *Oxylobium trilobatum* F.v.M., *Mirbelia grandiflora* Ait., *Daviesia latifolia* R.Br., *D. corymbosa* Sm., *D. ulicina* Sm., *Pultenæa flexilis* Sm., *P. daphnoides* Wendl., *Dillwynia floribunda* Sm. var. *spinescens*, *Bossiæa microphylla* Sm., *Hovea linearis* R.Br., *Indigofera australis* Willd., *Glycine clandestina* Wendl., *Hardenbergia* (*Kennedya*) *monophylla* Benth., *Acacia juniperina* Willd., *A. penninervis* Sieb., *A. rubida* A. Cunn., *A. suaveolens* Lindl., *A. buxifolia* A. Cunn., *A. melanoxylon* R.Br., *A. longifolia* Willd., *A. decurrens* Willd., *A.* sp., *Rubus parvifolius* L., *Leptospermum scoparium* Forst., *L. stellatum* Cav., *L. flavescens* Sm., *Melaleuca linariifolia* Sm., *Angophora intermedia* DC., *A. lanceolata* Cav., *Backhousia myrtifolia* Hk. & Harv., *Lythrum Salicaria* L., *Epilobium glabellum* Forst., *Trachymene linearis* Spreng., *Siebera Billardieri* Benth., *Panax sambucifolius* Sieb., *Loranthus celastroides* Sieb., on *Eucalyptus viminalis*, *Sambucus* sp., *Pomax umbellata* Sol., *Olearia ramulosa* Labill., *Cassinia aculeata* R.Br., *C. longifolia* R.Br., *Helichrysum rutidolepis* DC., *H. semipapposum* DC., *Erechtites mixta* DC.(?), *Senecio australis* A. Rich., var. *macrodontus*, *Goodenia bellidifolia* Sm., *G. ovata* Sm., *Scævola hispida* Cav., *Dampiera Brownii* F.v.M., *D. stricta* R.Br., *Styphelia* sp., *Lissanthe strigosa* R.Br., *Leucopogon lanceolatus* R.Br., *L. setiger* R.Br., *Epacris microphylla* R.Br., *Prunella vulgaris* DC., *Hedycarya Cunninghamii* Tul., *Petrophila pul-*

chella R.Br., *Isopogon anemonifolius* R.Br., *Conospermum taxifolium* Sm., *Persoonia ferruginea* Sm., *P. salicina* Pers., *P. lanceolata* Andr., *P. linearis* Andr., *P.* sp., *Grevillea Baueri* R.Br., *Hakea pugioniformis* Cav., *H. dactyloides* Cav., *Lomatia silaifolia* R.Br., *L. longifolia* R.Br.(near Berrima), *Banksia spinulosa* Sm., *B. marginata* Cav., *B. serrata* L., *Pimelea linifolia* Sm., *Poranthera corymbosa* Brong., *Casuarina suberosa* Ott. & Dietr.(Forest Oak), *C. paludosa* Sieb., *Leptomeria acida* R.Br., *Exocarpus cupressiformis* Labill.(Native Cherry), *E. stricta* R.Br., *Dipodium punctatum* R.Br., *Patersonia* sp., *Hæmodorum planifolium* R.Br., *Smilax australis* R.Br., *Eustrephus latifolius* R.Br., *Stypandra glauca* R.Br., *Xerotes flexifolia* R.Br., *Xanthorrhœa hastilis* R.Br. (Grass Tree), *Gleichenia dicarpa* R.Br., *Blechnum* sp.

Philotheca australis was found at about 10 miles from Bowral, plentifully distributed over several acres, and just opening into flower early in October. An area of sandy soil in the locality was very prolific in flowering plants.

Mirbelia grandiflora was noticed on this sandy area, its bright yellow flowers making this prostrate plant a charming addition to the flora.

Dillwynia floribunda var. *spinescens* was a gorgeous object between the 11- and 12-mile posts, and impressed us as one of the most beautiful plants seen.

Acacia buxifolia was also flowering near the 11-mile post; it presents the general facies of *A. decora* Reichb., of the western districts. Some good examples of stem-fasciation were noticed among the branchlets.

Angophora lanceolata, the smooth-barked Apple or so-called Red Gum, was fairly plentiful at intervals on the Hawkesbury Sandstone, but *A. intermedia*, the common Apple Tree, was seen only at one spot, on shale formation, about 15 miles from Bowral, not more than two trees being noticed. Although *A. intermedia* often grows at altitudes exceeding 2000 feet, especially on New England, it thrives best below this level.

Hedycarya Cunninghamii may be seen in slightly sheltered spots on the eastern side of Mt. Oxley. The species is more at home in the brushes along the coastal strip.

Having in view the great difference which often exists between the flora on igneous and sedimentary formations, and which is borne out at Bowral by a comparison of plants on the basaltic and sandstone areas, it was with considerable interest that an examination was made of the syenite hill referred to as The Gib. This was done on the 10th February, 1906, in company with Mr. J. E. Carne, F.G.S., when, contrary to expectations, it was found that much of the flora was similar to that of the sandstone areas around; and while some of that found on the basalt was absent, there was to some extent a mingling of the two floras, and this hill seemed to form a sort of neutral ground for the otherwise exclusive plants. *Eucalyptus viminalis* and *E. regnans* (*E. fastigata*) of the basaltic areas were both found here in company with *E. Sieberiana* and *E. piperita*, which are both typical of the sedimentary formation.

In a paper "On the Geology of Mittagong," Messrs. T. Griffith Taylor and D. Mawson, B.E.,* refer to The Gib as representing the denuded plug of an old volcano. "It consists of syenite allied to Bostonite (Harker, p.117) consisting chiefly of orthoclase felspar. It covers an area of 450 acres, and is surrounded by tilted sandstone on the northern side, while the east slope is overlaid with later basalts."

When examined in February last the whole place was recovering from the effects of a severe bush fire, so that the following list of plants cannot be regarded as nearly complete, but will suffice to give a fair estimate of the vegetation. The plants noticed were :—*Clematis glycinoides* DC., *Hibbertia Billardieri* F.v.M., *H. volubilis* Andr., *Bursaria spinosa* Cav., *Stellaria pungens* Brong., *Pelargonium australe* Willd., var. *erodioides* Benth., *Pomaderris apetala* Labill., *Oxylobium trilobatum* F.v.M.(a typical sedimentary plant), *Daviesia ulicina* Sm., *Hardenbergia monophylla* Benth., *Acacia penninervis* Sieb.(Black Wattle), *A. decurrens* Willd., *Rubus parvifolius* L., *Eucalyptus regnans* (*E. fastigata*), *E. viminalis*, *E. Sieberiana*, *E. piperita*, *E. amygdalina*, *E.*

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* Journ. and Proc. Roy. Soc. N. S. Wales, 1903, pp.315-317.

eugenioides, *E. tereticornis*, *Panax sambucifolius* Sieb., *Brachycome linearifolia* DC., *Helichrysum lucidum* Henck. (*H. bracteatum* Willd.), *H. scorpioides* Labill., *H. semipapposum* DC., *H. leucopsidium* DC., *Wahlenbergia gracilis* DC. (Blue Bell), *Leucopogon lanceolatus* R.Br., *Plantago varia* R.Br., *Persoonia linearis* Andr. (Geebung), *Lomatia silaifolia* R.Br., *Casuarina suberosa* Ott. & Dietr., *Exocarpus cupressiformis* Labill., *Dianella cœrulea* Sims, *Eustrephus latifolius* R.Br., *Stypandra glauca* R.Br., *Themeda Forskalii* Hack.(*Anthistiria ciliata* Linn., Kangaroo Grass), *Stipa* sp., *Adiantum* sp., *Pteris* sp., *Blechnum cartilagineum* Swartz.

From Bullio to Wombeyan Caves.

After passing the 22-mile post near Bullio, the Triassic formation is left behind, and an area of porphyritic and granitic country continues practically the whole way. Much of this area, at least down the river towards Burragorang, was formerly covered by Permo-Carboniferous and Triassic strata which have been removed by denudation, thus exposing the rounded igneous hills which form the present surface. The margin of this igneous area is defined in many places by a line of stupendous sandstone cliffs quite a thousand feet high; that on the eastern side, which divides the waters of the Wollondilly from those of the Nattai, presents in places an impenetrable barrier, and with its towering height and extensive grey rugged front, impresses the observer in all its natural grandeur, especially when illuminated with the rays of the western sun. Through the hard granite and porphyry rocks the Wollondilly is incising its channel, and already, according to figures kindly supplied by Mr. E. C. Andrews, has succeeded in entrenching itself to a depth of 2100 feet from the top of Bullio Trig. Station to its present level. The high bluff overlooking the river (Plate xxxv.) is fully 1500 feet above the stream, so that the grandeur of the valley is at once apparent. The river at the ford is about 620-630 feet above sea-level.

A sample of the porphyritic rock taken from the vicinity of the 35-mile post has been kindly identified by Mr. G. W. Card, A.R.S.M., as a typical quartz-porphyry, and he adds that a somewhat unusual feature is the presence of hypersthene in some quantity.

I am indebted to Mr. J. C. H. Mingaye, F.C.S., for the following analysis in which the high percentage of silicon may be noted :—

ROCK No. 6693 IN GEOLOGICAL SURVEY COLLECTION.

	Weight Percentage.		Weight Percentage.
SiO_2	66·06	Cl	0·01
Al_2O_3	15·25	$S(FeS_2)$	0·06
Fe_2O_3	1·10	Cr_2O_3	None
FeO	3·69	NiO, CoO	0·02
MgO	2·27	MnO	0·02
CaO	4·86	BaO	0·06
Na_2O	2·16	SrO	Trace (spectroscopic)
K_2O	2·77	Li_2O	None
H_2O(100°C)	0·30	V_2O_3	0·03
H_2O(100°C+)	0·94	Copper	Trace
CO_2	0·07	Lead	Trace
TiO_2	0·70		
ZrO_2	0·03		100·51
P_2O_5	0·11		
SO_3	None	Specific Gravity	2·726
Gold—A few grains per ton.		Silver—4dwt. 8gr. per ton.	

Analysis 2479/1906. J. C. H. MINGAYE.

It is of interest that this hard porphyritic rock should contain an appreciable quantity of silver, as it is in this same igneous area at Yerranderie near Burragorang that rich silver lodes are being worked.

The gravel along the banks of the Nepean near Penrith, which provides Sydney with some of its very best road metal, is derived from the waterworn fragments of rocks in this and a somewhat similar geological area on Cox's River.

With this change in geological formation as well as in aspect, a considerably different flora from that of the sedimentary plateau is found, as expected. Sheep are seen grazing over the rocky areas, which at once suggests western conditions, and soon the interest of the botanist is intensified by the sight of plants which more properly belong to the western slopes beyond the

Great Dividing Range. Some of these, which are able to withstand a fairly cold elevation, have simply continued over the range and down the valley of the Wollondilly to the locality under discussion. But several are western plants which invariably avoid the cold heights, and their presence in this valley requires an explanation which presents difficulties.

The following list of Eucalypts will give a general idea of the gradual divergence of the flora from coastal to western forms. Between the 22-mile post and the Caves the Eucalypts noticed were :—*E. eugenioides*, *E. viminalis*, *E. vitrea* R. T. Baker, *E. melliodora* A. Cunn.(Yellow Box), *E. Bosistoana*, *E. Bridgesiana* R. T. Baker (Apple Tree or Woollybutt, and one of the trees regarded by Baron von Mueller as *E. Stuartiana* F.v.M., the latter name being still retained by Mr. Maiden), *E. tereticornis*, and *E. albens* Miq., the common White Box of the western slopes.

The above were all noted between the 22- and 27-mile posts, and with the exception of *E. Bosistoana*, continued intermittently right across the Wollondilly valley. *E. viminalis* was left on the highland, but reappeared on the opposite side when the elevated country was again reached. *E. albens* on the other hand found the hill tops on either side of the valley too cold, and ceased at about the 34-mile post or eight miles from the Caves.

At intervals on the porphyritic area a Stringybark was noticed which was thought to be a form of *E. eugenioides*, but which, from specimens I collected, has been recognised by Mr. Baker as *E. Wilkinsoniana* R. T. Baker.

After passing out of the Wollondilly cañon near the 39-mile post, where the height of the gap is about 2,400 feet above sea-level, the Eucalypts passed on the descent to the Caves were :—*E. melliodora*, *E. tereticornis*, *E. Bridgesiana*, *E. eugenioides*, *E. macrorrhyncha* F.v.M. (Red Stringybark), *E. viminalis*, *E. dives*, *E. capitellata*, and *E. stellulata* Sieb.(Black Sally), the latter only occurring on the flat just above the Cave house.

The presence of *E. macrorrhyncha* is suggestive of western rather than coastal conditions. It is the common stringybark of the ridges on the western slopes, and occurs practically along the whole length of the Great Dividing Range, and though coming at times on to the eastern watershed it is confined to the higher parts.

Other than Eucalypts the various plants noticed between Bullio and the Caves were :—*Clematis glycinoides*, *Ranunculus lappaceus* Sm. (Buttercup), *Hibbertia linearis* R.Br., *Hymenanthera dentata* R.Br., *Pittosporum undulatum* Vent., *Bursaria spinosa*, *Plagianthus pulchellus* A. Gray, *Sterculia diversifolia* G.Don (Currajong), *Erodium cygnorum* Nees, *Nephelium leiocarpum* F.v.M., *Dodonæa viscosa* L., *Oxylobium trilobatum*, *Jacksonia scoparia* R.Br. (Coast Dogwood), *Indigofera australis*, *Glycine clandestina*, *Hardenbergia monophylla*, *Cassia australis* Sims, *Acacia linifolia* Willd., *A.amœna* Wendl., *A.penninervis*, *A.implexa* Benth., *A.melanoxylon*, *A.discolor* Wendl., *Quintinia Sieberi* DC., *Melaleuca styphelioides* Sm. (a Tea-tree on the banks of the River), *Backhousia myrtifolia*, *Sambucus xanthocarpa* F.v.M., *Asperula oligantha* F.v.M., *Olearia viscidula* Benth., *Calotis microcephala*, Benth., *Craspedia Richea* Cass., *Cassinia longifolia* R.Br., *Helipterum anthemoides* DC., *Erechtites arguta* var. *dissecta*, *Senecio macranthus* A. Rich., *Microseris Forsteri* Hook., *Wahlenbergia gracilis* (Blue Bell), *Lissanthe strigosa*, *Notelæa linearis* Benth., *N. longifolia* Vent., *Marsdenia rostrata* R.Br., *Gomphocarpus fruticosus* R.Br. (African Cotton, introduced), *Solanum aviculare* Forst., *Tecoma australis* R.Br. (Bignonia), *Myoporum deserti* A. Cunn., (a Western Dogwood), *Plectranthus parviflorus* Willd., *Persoonia linearis*, *Grevillea obtusiflora* R.Br., *Lomatia longifolia*, *Banksia marginata*, *Pimelea spathulata* Labill., *P. linifolia* Sm., *Carumbium populifolium* Reinw.(Native Poplar), *Trema cannabina* Lour., *Ficus rubiginosa* Desf., *F. aspera* Forst., *Urtica incisa* Poir., *Laportea gigas* Wedd. (Stinging Tree), *Casuarina stricta* Ait. (*C. quadrivalvis* Labill., Sheoak), *C. Cunninghamiana* Miq. (River Oak), *Exocarpus cupressiformis* (Native Cherry), *Dendrobium speciosum* Sm. (Rock Lily), *Caladenia carnea* R.Br., *Bulbine bulbosa* Haw., *Xerotes longifolia* R.Br., *Stipa verticillata* Nees, *Adiantum Aethiopicum* L. (a Maiden Hair fern), *Cheilanthes tenuifolia* Sw., *Pteris falcata* R.Br.

On the limestone formation immediately around the Caves the flora is decidedly sparse, and in many instances the sombre-looking grey rocks are more conspicuous than the surrounding vegetation. From a casual examination near the Caves and up the creek, the following list has been prepared. The plants noted were :—*Clematis glycinoides*, *Hibbertia volubilis*, *Cardamine tenuifolia* Hook., *Hymenanthera dentata*, *Bursaria spinosa*, *Plagianthus pulchellus*, *Sterculia diversifolia*, *Erodium cygnorum*, *Pomaderris apetala*, *Cryptandra amara* Sm., *Discaria australis* Hook., *Dodonæa viscosa* L. var. *attenuata*, *Hardenbergia monophylla*, *Acacia* sp. (No.1349), *Leptospermum flavescens* Sm. (with remarkably small fruits), *Asperula oligantha*, *Craspedia Richea*, *Cassinia quinquefaria* R.Br., *Senecio macranthus*, *Lissanthe strigosa*, *Notelæa ligustrina* Vent. (?), *Logania floribunda* R.Br., *Prostanthera lasianthos* Labill. (sometimes called White Christmas Bush), *Petrophila pulchella* R.Br., *Grevillea obtusiflora*, *Banksia marginata*, *Pimelea linifolia*, *Ficus rubiginosa* (at entrance to Fig Tree Cave), *Casuarina Cunninghamiana*, *Pterostylis curta* R.Br., *Caladenia carnea*, *Xerotes longifolia*, *Imperata arundinacea* Cyr., *Themeda Forskalii (Anthistiria ciliata)*, *Alsophila australis* R.Br. (Tree Fern).

On the limestone just east of the Caves a species of Acacia was found growing as a shrub some 5 or 6 feet high, but in the absence of flowers it has not yet been identified. Its 1-nerved, linear-lanceolate phyllodia vary from about 1 to 2 inches long, often with a gland towards the base. Branchlets angular. Pods 2-2½ inches long and ¼ inch broad. The species, which shows affinities to *A. amœna*, will be further investigated.

The Eucalypts on the limestone in the vicinity of the Caves are *E. Bridgesiana* and *E. melliodora* with *E. stellulata* on the flats, but in going along the Taralga road for a distance of seven miles the following in addition were passed :—*E. viminalis*, *E. dives*, *E. macrorrhyncha*, *E. maculosa*, *E. capitellata*, *E. Sieberiana*, *E. amygdalina* (not flowering), *E. numerosa* (flowering), *E. rubida*, and the rough-barked form of *E. regnans (E. fastigata)*. *E. punctata* (Grey Gum), was noted about a mile up the Caves Creek.

Towards the summit of the range, some 4-5 miles from the Caves, *Eucalyptus rubida* appears. The trees are of considerable size with large undulate leaves, the juvenile foliage being less orbicular than in the type. The same form has been noticed at intervals extending northerly to Oberon and at other places in high altitudes, and appears to be the result of growing at a fairly high elevation (3000 ft. to 4000 ft.) with a suitable soil and a fair amount of moisture. Both this species and *E. viminalis* attain considerable dimensions at high altitudes when the conditions of soil and moisture are suitable, nor is the feature restricted to these two species.

The Great Dividing Range is crossed on the Taralga road at about 5-6 miles from the Caves, and is approximately 3200 feet above sea-level. The geological formation along this road is at first limestone and then granitic, with an altered sedimentary rock beyond the top of the mountain. The junction line between the igneous and limestone soils is so distinct that in places, *e.g.*, in the road cutting, the greyish brown of the former is most distinctly separated from the red soil of the latter, the transition occupying a space of only a few inches. In less than a mile from the Caves, along the Taralga road, the granitic rocks are in places so decomposed that they are nothing more than sand, having the general appearance of the sandy soil derived from the Triassic sandstones around Sydney and on the Blue Mountains, and it is therefore interesting to find that the vegetation on this area is practically the same as much of that on the sandstone formations referred to. It will be noted in the following list of plants along this stretch of road, that many species are more suggestive of sandstone than of igneous rocks, and the explanation lies in the fact above related. The point also appeals to the geologist, inasmuch as our Triassic sandstone is largely composed of the quartz derived from some igneous rock of prior geological age.

Plants along the Taralga Road.

Among the various plants distributed over a distance of seven miles along the Taralga road were:—*Clematis glycinoides*, *Hib-*

bertia linearis, *Bursaria spinosa*, *Tetratheca thymifolia*, *Stellaria pungens*, *Sterculia diversifolia*, *Elæocarpus cyaneus*, *Oxylobium trilobatum*, *Gompholobium* sp. (no flowers), *Daviesia ulicina*, *Dillwynia ericifolia*, Sm. (a very common yellow-flowering Sydney plant), *Bossiæa buxifolia* A. Cunn., *Hovea linearis*, *Indigofera australis*, *Hardenbergia monophylla*, *Acacia vomeriformis* A. Cunn., var., *A. decurrens*, *A. penninervis*, *A. discolor*, *A. melanoxylon*, *A. juniperina*, *A. longifolia*, *A. dealbata* Link (Silver Wattle; in full flower on 1st October), *Leptospermum lanigerum* Sm., *Pomax umbellata*, *Olearia ramulosa* Labill., *Brachycome scapiformis* DC., *Goodenia hederacea* Sm., *Dampiera Brownii*, *Astroloma humifusum* R.Br., *Melichrus urceolatus* R.Br., *Brachyloma daphnoides* Benth., *Lissanthe strigosa*, *Leucopogon virgatus*, R.Br., *L. lanceolatus*, *L. microphyllus* R.Br., *Monotoca scoparia* R.Br., *Veronica Derwentia* Andr., *Euphrasia Brownii* F.v.M., *Hedycarya Cunninghamii* (in small gully), *Cassytha melantha* R.Br., *Persoonia linearis*, *P. ferruginea*, *Grevillea laurifolia* Sieb., *Hakea dactyloides*, *Lomatia longifolia*, *L. silaifolia*, *Banksia marginata*, *B. spinulosa*, *Pimelea linifolia*, *Amperea spartioides* Brong., *Urtica incisa*, *Casuarina suberosa*, *Choretrum spicatum* F.v.M., *Exocarpus cupressiformis*, *E. stricta*, *Patersonia sericea* R.Br., *P. glabrata* R.Br., *Stypandra glauca*, *Xerotes longifolia*, *X. flexifolia*, *Gahnia* sp., *Poa cæspitosa* Forst., *Pteris* sp., *Blechnum cartilagineum*.

A few trees of *Callitris calcarata* R.Br.(Black Pine) are growing about two miles southerly from the Caves. I am indebted to Mr. T. M. Chalker, Caretaker of the Caves, for specimens. The species was noticed some years ago down the Wollondilly towards Burragorang, though it is more commonly found on the ridges along the western slopes. Its most easterly locality south of the Hunter known to me is Cessnock, south-easterly from Singleton.

The absence of plants of the Natural Order Rutaceæ between Bullio and the Caves was very marked, not even a Boronia being noticed by the roadside. Another Order but sparsely represented was Epacrideæ, though curiously, one species of this Order, *Lissanthe strigosa*, was extremely common on the porphyritic area. Dr. James Cox,* in describing a trip to the Caves over forty years ago, refers to "the great variety of *Epacris*," along the roadside, but his remarks apply to the sandstone area which is the common habitat of the genus.

Near the point where the Taralga road crosses the creek above the Caves several trees of *Casuarina Cunninghamiana*, the River Oak, were found growing on the limestone quite 140 feet above the stream. This is unusual, as the species is generally confined to the bed and banks of watercourses. Evidently the roots had reached moisture among the rocks.

One of the most charming plants noticed in the valley of the Wollondilly was *Senecio macranthus*, which, late in September, was in full flower. Clusters of plants, in places several feet across, were, to quote from Mr. Maiden's notebook, "blazes of gold."

An interesting feature of the vegetation in the Wollondilly valley is the presence of small isolated patches of trees, many of which are usually found in coastal brushes, but which are here confined to sheltered nooks in the steep gullies. Amongst the number are *Laportea gigas*, the well known Stinging Tree, *Pittosporum undulatum*, *Nephelium leiocarpum*, *Carumbium populifolium*, *Trema cannabina*, *Ficus rubiginosa* and *F. aspera*. Some of these will grow in the open, though for the most part they prefer shelter. Perhaps *Ficus rubiginosa* braves the elements better than any, and may be seen at times even on the western watershed, an instance once noticed being on the hills near Attunga, beyond Tamworth. But the tree which is more suggestive of shelter and moisture than any other of those mentioned is *Laportea gigas*, and it is also a sure indication of rich soil. In some districts on the South Coast, before the brush was cleared, there was no better guide to good land than that afforded by the presence of the Stinging Tree. Near the Caves road it is stunted, and only occurs in recesses which are sheltered from westerly winds. At one spot where these trees are growing the absence of wind was remarked, although it was known that a cold westerly gale was blowing on the hill tops around. The survival

* Trans. Phil. Soc. New South Wales, 1862-65, p.198.

of this species in the locality in spite of some adverse conditions, affords a splendid example of the influence of shelter, warmth and moisture.

Of the western plants which were found near the Wollondilly, the most interesting were *Eucalyptus albens*, *Casuarina stricta*, and *Myoporum deserti*. Associated with these was *Eucalyptus melliodora*, and the same four species may be seen at Mt. McDonald, near the Lachlan River, and other western spots.

As *E. melliodora*, the Yellow Box, is one of the most amenable to climate of the genus, ranging from the heat of the Lower Lachlan up to elevations of 3000 feet above sea-level in latitudes south of Bathurst, and up to about 4000 feet on New England, its occurrence on both sides of the Main Divide is not remarkable as in places where it crosses, the highest points are less than 3000 feet.

The case of *Myoporum deserti* is somewhat different, and although it has been recorded from all the States on the mainland, it is usually confined to the western watershed in New South Wales. It is well known, however, that many western plants cross the lower parts of the Liverpool Range and follow down the valley of the Hunter River to the vicinity of Singleton, *M. deserti* being one of these. Mr. R. T. Baker* has recorded numerous western forms on the upper part of the Goulburn River, a tributary of the Hunter, but the numbers become less as the valley is descended, and eastern influence is encountered. The wide distribution of *M. deserti* is somewhat suggestive of antiquity, though its seeds are of such form as to assist dispersal by birds.

Casuarina stricta (Sheoak) belongs to the interior and southern parts of Australia, coming up along the eastern coast of New South Wales as far north as Newport, near Sydney, where it is confined chiefly to within a few miles of the ocean. It is another of the western trees which is found in the Hunter valley as far down as Singleton. In these Proceedings, 1905, p.376, I suggested

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* 'On the Botany of Rylstone and the Goulburn River Districts.' Part i. Proc. Linn. Soc. New South Wales, 1896, p.427.

a possible explanation of the distribution of this species along the coast-line of this State, its antiquity being claimed as a necessary condition. Dr. James Cox beyond doubt refers to this species growing on the ascent from the Wollondilly towards Wombeyan Caves where he writes*:—"Here also is to be seen a peculiar species of *Casuarina* (Native Oak). The sexes of the trees are separated—the female bears a fine cone-looking seed vessel, but the male flower resembles the common acorn."

Another most interesting western tree found near the Wollondilly is *Eucalyptus albens.* This species follows, in a general northerly and southerly direction, a strip of country on the western slopes of the Main Dividing Range, where it is usually known as White or Grey Box. Whether it is worthy of specific rank or should be considered a variety of *E. hemiphloia* F.v.M., is to some extent a matter of opinion, for undoubtedly certain herbarium specimens of small-fruited *albens* and large-fruited *hemiphloia* present great difficulties in separation, though in the forest, with the habit of the tree to assist, the identification is usually a simple matter. *E. albens* is practically restricted to a westerly influence, while *E. hemiphloia* belongs to the coast, but where the former has been found on the Wollondilly it retains its western characteristics.

South of the latitude of Sydney it is rarely found at an elevation of 2000 feet above sea-level, so that owing to climatic reasons it cannot cross the Main Range on to the eastern watershed, as in no part is the divide so low as 2000 feet. In the north, however, the conditions are altered by the increased warmth of northern latitudes, and the species crosses the lower parts of the Liverpool Range to the Upper Hunter, and on northern New England may be found at altitudes up to 3000 feet.

The geological influence on plant growth is of importance in the present instance, as the White Box seems confined, near the Wollondilly, to the igneous rock formation previously referred to, and it continues down the river, accompanied by *E. melliodora*, until the porphyritic rocks disappear under the Permo-Carbon-

* Trans. Phil. Soc. New South Wales, 1862-1865, p.198.

iferous strata at Upper Burragorang, which point is the nearest to Sydney known to me where *E. albens* occurs.

Dispersal of seeds by birds is one of the methods first suggested in considering problems of plant distribution, but the presence of so many western forms on this area seems rather to indicate some regulated, or systematic, rather than accidental dispersal. The occurrence of *E. albens* near the Wollondilly could be very simply explained if it could be shown that the species flourished prior to the latest uplifts in Tertiary time, in which case it may have extended right across the country now elevated, and connected with the western areas where it is still growing, some forty miles away. As it cannot withstand the cold, the effect of the uplift would probably have been to destroy the species in the elevated region, unless the movement was slow enough to permit it to become acclimatised while the alteration of levels was in progress.

That Eucalypts and Casuarinas existed in late Tertiary time is beyond dispute, both genera having been found fossil in rocks of that period. It is probable that *C. stricta* flourished in Australia prior to the latest earth movements along the eastern portion of the Continent, but there is no evidence available to prove an equally early existence for *Eucalyptus albens*. For the present, therefore, the distribution of these various species remains an interesting subject for investigation.

The complete list of Eucalypts noticed over the area described in this paper is as follows :—*E. stellulata, E. coriacea, E. Macarthuri, E. regnans (E. fastigata), E. tereticornis, E. amygdalina, E. dives, E. numerosa, E. Sieberiana, E. hæmastoma, E. maculosa, E. rubida, E. viminalis, E. acervula (E. paludosa), E. quadrangulata, E. piperita, E. vitrea, E. eugenioides, E. capitellata, E Bridgesiana, E. melliodora, E. albens, E. Bosistoana, E. Smithii, E. macrorrhyncha, E. punctata.*

EXPLANATION OF PLATES.

Plate xxxiv.

Eucalyptus Macarthuri Deane and Maiden (Woollybutt); Bowral.

Plate xxxv.

Wollondilly River, Wombeyan Caves Road, looking South; *Casuarina Cunninghamiana* Miq. (River-Oak) along the water's edge.

THE MOLLUSCA OF MAST HEAD REEF, CAPRICORN GROUP, QUEENSLAND.

Part I.

By C. Hedley, F.L.S.

(Plates xxxvi.-xxxviii.)

Our revered founder, Sir W. Macleay, pointed to the Great Barrier Reef as a region especially worthy of the investigation of this Society and as a field of superlative importance to zoological students. Example being better than precept, he led the way by devoting wealth and energy to its exploration.

The results of his researches in the 'Chevert' on the marine fauna of tropical Queensland are published in the earlier volumes of these Proceedings.

The explorations of the 'Coquille,' 'Fly,' 'Rattlesnake,' 'Chevert' 'Alert' and 'Challenger,' and of Messrs. Saville Kent, Haddon and Semon, have made Torres Strait classic ground to the naturalist. South from Torres Strait to Sydney, in a distance of two thousand miles, no particular area has been systematically collected. Consequently we have no knowledge of how far the fauna of either extremity spreads, or where their constituents meet or overlap. Indeed, a vague impression exists that Torres Strait is hardly "Australian," and that the "Australian" fauna immediately succeeds it on the south. Thus the "Zoological Record" (Article Mollusca) includes Torres Strait in one Province and Queensland in another.

Perhaps the first and most important deduction to be drawn from the collection now under review is that the Torres Strait fauna flows unbroken down the whole length of the Great Barrier Reef. Indeed, meaning by Torres Strait an expanse of a thousand square miles of twelve fathom water, more Torresian species are here noted from Mast Head than have been observed in any single area of like dimensions in Torres Strait itself. For this marine fauna I have already proposed* the title SOLANDERIAN.

Prompted by a wish to better define the distribution of the East Australian marine fauna, I suggested to several friends the advantage of examining the southern extremity of the Great Barrier Reef. Ease of access induced us to select Mast Head Reef as the point of investigation.

The writer was joined by Dr. R. Pulleine, Messrs. F. E. Grant, A. Liddell, H. C. Skeet, H. L. Kesteven and A. R. McCulloch. Leaving Sydney, 15th October, 1904, we reached Gladstone, Queensland, on the 19th. There we engaged a cutter of 15 tons burden, and after a rough trip landed on Mast Head on the 23rd. We pitched tents ashore and spent the week collecting on the reef, and dredging in its immediate vicinity. On October 31st we struck camp, packed and returned to Gladstone. Sydney was reached on November 7th. A popular account of our trip appeared in the 'Sydney Mail' of 7th December, 1904.

The Bunker and Capricorn Archipelagoes were visited by Prof. Jukes on H.M.S. 'Fly' in 1843, and I am not aware that any naturalist has worked there since. Jukes gave a description† of One Tree, Heron and Wreck Islands (not to be confused with Wreck Reef about 200 miles to the north-east). On the former he noted *Hippopus* and *Tridacna*. Our party failed to find the *Hippopus* on Mast Head. Probably the 'Fly' collectors obtained the *Scapha pulchra* Sowerby, which Gray has recorded‡ from Heron Island. Another rare Volute, *V. canaliculata* McCoy, has been reported under the name of *V. harfordi* from Wreck Island.§ As this reef is the nearest to a trunk railway, and therefore easiest to reach from the large cities of Australia, it will probably be revisited by scientific folk. For their use I preface

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* These Proceedings, xxviii. 1904, p.880.

† Jukes, Voy. 'Fly,' 1847, i. pp.4-12.

‡ Gray, Proc. Zool. Soc. 1855, p.56.

§ Cox, Proc. Zool. Soc. 1869, p.358.

my account of the mollusca by a description of our collecting station.

Mast Head Reef lies just outside the Tropic of Capricorn; it is the most western, and therefore nearest to the mainland, of a chain of reefs extending for 54 miles from North Reef to Lady Elliott Island. A continuation of the axis along which these reefs are arranged would pass through Beaksea Spit. Strictly speaking, this group is not a part of the Great Barrier, which terminates in a coral maze, Swain Reefs, north of the Capricorns. Between Swain Reefs and the Capricorns lies the broad and deep Curtis Channel. But for zoological purposes these pseudatolls may conveniently be regarded as a continuation of the Great Barrier.

The sketch map on the next page explains the position of the reef cluster.

At low tide Mast Head is exposed as an oblong reef about four miles from east to west and one and a half from north to south, its crest ten or twelve feet above the sea. It shrinks at high-water to a small but densely vegetated sandbank about 100 acres in extent, placed near the western end of the reef. The islet is level, raised but a few feet above the sea, and has no lagoonlet. Concentric undulations show the successive increase of beach built on beach. At the western end a clump of uprooted Casuarinas indicates where a gale had inflicted temporary loss.

On the south side a stratum of coral-sand-rock is now suffering denudation. Jukes has given* an excellent description and explanation of this rock. Though considerable literature has gathered on the subject, this account by Jukes seems not to have atttracted the attention it deserves. As my own observations had independently brought me to the same conclusion, I will restate the case. This rock appears to originate as follows:— Water percolating through a drift of coral sand dissolves lime and carries it down to lower levels. Where the water stops lime is deposited, cements the sand grains and forms an obstruction for

* Jukes, Voy. 'Fly,' i. 1847, pp.7-9.


QUEENSLAND
Gladstone
Port Curtis
Cape Capricorn
Tropic of Capricorn
Bustard Head
Mast Head
North-West
CAPRICORN GROUP
Heron
Wreck
One-Tree
Hundred fathom line
BUNKER GROUP

the arrest of subsequent influx. A continuation of the process builds the rock upwards. Like a stalactite, the coral-sand-rock derives its substance from a superincumbent mass of lime. I suggest that the coral-sand-rock can only form beneath a thick cover of sand, and that slow growth of the bank will provide for the increase of the rock. Briefly, the coral-sand-rock is the petrified core of beach or dune.

The islet was chiefly made of coarse sand. It may be laid down as a rule that, *the further from the reef edge an islet is built, the finer are the materials of which it is composed.*

A pit we sunk in search of water passed through foraminiferal sand with lumps of coral; it was bone-dry at a depth of eight feet. There was no surface water at the date of our visit.

For the most part the islet is fringed with Casuarina trees, whose weeping boughs overhang the water at high tide. Behind the shelter of these pioneers grow bushes of *Tournefortia*, *Sophora* and *Pandanus*, with grass and herbage of *Abutilon*, *Wedelia*, *Ipomaea*, &c. Further in the bushes become trees, and the grass and herbage disappear. The centre of the islet is overgrown by a dense *Pisonia* forest, forty or fifty feet in height, whose foliage completely screens the ground from the sunlight and strews it with fallen leaves. Among these were concealed two snails, a *Bifidaria* and a *Tornatellina*. The contrast between the cool shade within and the heat and glare of the beach is very sudden.

This islet is a refuge and breeding ground for sea-fowl. Some frigate birds were shot on the wing. The reef herons were hatching in the *Sophora* boughs. The noddy terns crowded the trees with nests. Fearless in their ignorance of man, they permitted us to approach them on their nests, but would not submit to be handled. The sooty petrels hurrying seawards before dawn, where our party slept across their track, would climb over our bodies as if we were logs of wood. By day and night the bush resounded with the hoarse cries of the sea-birds. The turtles were so plentiful that we never walked around the beach without seeing one. On a moonlight night I have passed twenty ashore in as many minutes. Though we did not find their eggs the disturbed surface of the sand showed oviposition. From the ventral surface of the neck of one we killed for food, Mr. Kesteven collected a species of *Branchellion.*

The crest of the encircling reef is bared at about a quarter ebb, at which state of the tide it assumes the aspect of an atoll with a shallow lagoon enclosed by a rim of boulders. These dead coral blocks on the summit of the reef, locally called "nigger-heads," stand out against the sky like tombstones in a cemetery. They are composed of an enormous astrean coral, a species which does not occur between tide-marks, but doubtless is washed up by heavy gales from the submarine base of the reef. Once perched, these blocks do not travel. A mass of a cubic yard or so, which two men might overturn, sheltered a host of mollusca, tunicates, sponges and such-like cryptozoic fauna; these were tenants who anticipated a long lease of their abode. But the nigger-heads suffer great and rapid erosion, being worn into cavities like those of a melting mass of ice. Purple rock oysters are common on these blocks, and I noticed that all the aged oysters projected like spurs from the surface to which they were attached by the ventral margin. Originally they were fixed by the umbonal end, and as the first point of attachment wore away, they clung by the newer part of the valve. From the appearance of these oysters I deduce that in four or five years these nigger-heads have lost by erosion and solution a crust two inches thick. The presence of "pinnacles" on Mast Head has already been noted by Prof. A. Agassiz.* He is inclined to regard all such as remnants left from the erosion of a larger, more elevated mass. All nigger-heads which I have examined on the Queensland coast appear to me to be erratics. Had the surf planed down an elevated mass, I question if the last phase of degradation would assume this form.

As the ebb tide retreats, smaller blocks and broken branches of dead coral are seen strewn along the summit of the reef. Species

* Bull. Mus. Comp. Zool. xxviii. 1898, p.105. See also Saville Kent, 'Great Barrier Reef,' 1893, pl. XXX.B; and 'Naturalist in Australia,' 1897, p.143.

of *Turbinaria* have come to rest in the position of least resistance, the stem upwards, the basin down. The more fragile madrepores are only present as broken fragments. No living coral is seen at all on the reef crest, which is one long unbroken sepulchre of actinozoan life.

On the north side the nigger-heads were about twelve feet above low spring tide level. The outside of the reef descends this depth in places as a flight of shallow irregular pools and terraces, which reminded Mr. Grant and myself of the terraces of sinter which accumulate below a hot spring. When the lagoon has almost run dry, the shallow heated water is likely to hold an unusually large amount of lime in solution and to thus deposit it. The outer slopes of the reef are not encumbered by much coral, either dead or alive. On the leeward side they are grassed with green seaweed.

The crest of the reef acts as a dam-head to impound the waters of the lagoon from half-ebb to half-flood. No continuous barrier, however, stops the outflow of the water, which is merely choked and obstructed by the dead coral mass strewn along the crest. While the tide is down, the lagoon water trickles and dribbles away on all sides; here and there it finds a byewash through which it streams more freely.

So far as we could explore it, the lagoon floor is carpeted throughout with living coral. The coral takes the form of tables or dwarf hedges composed of interlacing masses of *Madrepora*, *Pocillopora*, *Porites*, *Turbinaria* and *Seriatopora*, in which odd *Fungia* may be entangled. These project from a level layer of foraminiferal sand to a height of one or two feet. One may walk continuously along the summit of a coral hedge for a hundred yards. From another such it may be parted by a sandy lane. The flattened tops of these corals are usually dead, and just project above water when, at quarter-flood, the lagoon is at its lowest. In places drifting sand had filled in the lanes and smothered the coral hedge. The lagoon impressed me as fast filling up.

Mast Head Reef, though sharing many features of the Coral Atolls of the Central Pacific, yet differs widely in detail, a difference due to the circumstances under which each arose. Typically the Central Pacific Reefs spring from abyssal depths, will have, have, or had a deep central lagoon, according to the stage in evolution attained. Their dry land is always greatest on the windward side and is built close to the reef edge.

Mast Head is a tabular mass set on a platform of about 20 fathoms, common to the archipelago. Its lagoon is almost obliterated; the depth at low water being expressed in inches instead of fathoms. The dry land is massed on the leeward side and heaped far within the margin of the reef.

In the Central Pacific the dry land of the atolls seems to have originated in the spasmodic action of hurricanes, which tear masses off the reef edge and stack them above high-water mark in "hurricane beaches." Between the hurricanes little change occurs. There the tides are small.

In contrast be it noted that Mast Head lies beyond the hurricane zone, but is subject to the action of enormous tides of a range of 14-15 feet. These tides race over the reef at a rate of two knots an hour, are the chief agents of island building, and operate with more regularity but less violence than the hurricanes.

The British marine mollusca were grouped by Forbes and Hanley into those of the Littoral, Laminarian and Coralline zones. An analogous but not parallel division of the Queensland marine mollusca may separate them into inhabitants of the mainland beaches, of the mangrove swamps, and of the coral reefs.* The latter fauna, with which we are now concerned, is again segregated into the mollusca of the surf-swept beaches, of the rocky zone from low-water to the mud-line, and of the flat expanse of soft white mortar-like mud beyond the rocks.

The swift currents that rush through the Capricorn Islands remove the mud. The two upper zones were here only available

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* Tenison Woods, these Proceedings, v. 1881, p.107.

for study, and the lower produced almost all the new or remarkable shells noticed in the following pages. The sea-floor over which we dredged in a uniform depth of 17-20 fathoms, consisted of masses of living coral; budding reefs in fact, with intervening spaces of coarse sand and gravel, and here and there dense beds of kelp.

Various plant societies are termed in botanical language, "formations," thus a heather formation, a pine formation or a mangrove formation. We cannot adopt this nomenclature and express the mollusca associated with coral reefs as a "coral formation," because that term is already appropriated by geologists for a different meaning. Let us call it a madreporic assembly.

The first panoramic view of the coral-haunting mollusca was presented to science by the collection made by Hugh Cuming in the Paumotus. The following passages suggest the impression that the madreporic assembly characterises a geographic province, instead of being, as is really the case, a consequence of the special environment of clear and warm water.

"In the animal kingdom" Jukes* "was struck with the difference in the general aspect and character of the shells and echinodermata collected about Cape York and those got near Erroob." . . . "It was evident that in crossing Torres Strait we were passing from the Australian centre of life, so to speak, into that of the Indian Archipelago, or more strictly perhaps, of the Moluccas."

Mr. E. A. Smith wrote† of the marine mollusca of the Maldive coral reefs:—"It is curious to observe that a larger proportion of them have been previously noted from . . . the Pacific, than from the Indian Ocean."

An account of the crustacea (*ante* pp.2-53, Pls. i.-iv.) by Messrs. Grant and McCulloch has already been issued. Representatives of other groups have been handed to various specialists, and it is hoped that further reports on them may appear. We were

* Jukes, Voy. 'Fly, i. 1847, p.298.

† Smith, Fauna Maldive, Laccadive Archipelagoes, ii. 1905, p.589.

interested in finding a species of *Bonellia* in abundance in the lagoon. Though already reported from Sydney Harbour* and Cambridge Gulf, W.A.,† this genus has not yet been recorded from Queensland. The sporadic occurrence of *Bonellia*, *Pocillopora*, and similar tropical forms near Sydney, is probably due to the warm southerly current. Swept down by this, the Australian Gulf Stream, these northern forms incessantly attempt to colonise our coast, but perish.

In the space of a week no collectors, however diligent or expert, would expect to exhaust their station. The subsequent catalogue is not likely to enumerate more than half, if indeed as much, of the total molluscan fauna. The collection studied is presented to the Australian Museum.

Little is known of the minimum temperature corals can endure. The attention of visitors to this archipelago in spring or winter is especially invited to this subject. We had hoped to regularly record sea surface temperatures, but the distance to which the water retreated from our camp at low tide impeded our observations. The lowest reading registered was 65° Fahrenheit.

For the following observations I am indebted to Mr. Skeet :—

Outside the reef, October 23rd, 7 a.m., the sea surface temperature was 74° Fahrenheit.

In the lagoon, October 24th, 6.30 a.m., water 70°; 7 p m., air 73°, water 75°. Oct. 25th, 9 a.m., air 74°, water (high tide) 67°. 3.15 p.m., air 75°, water 78°; 9 p.m., air 68°, water 69½°. Oct. 26th, 7.15 a.m., water (half-flood) 65°; 8 p.m., air 70°, water 72°. Oct. 27th, 7.45 a.m., air 75°, water (half-ebb) 69°; noon, air 85°; water 76°. Oct. 28th, noon, air 85°, water (high tide) 77°. Oct. 30th, noon, air 85°, water 75°.

In conclusion I would express my thanks to my companions, who, whatever their interests or occupations, were always on the look out for shells for me. I am especially indebted to Miss L. Parkes, who kindly undertook the wearisome task of sifting the

* Haswell, these Proceedings, x. 1886, p.331.

† Saville Kent, Proc. Roy. Soc. Q'land, vi. 1889, p.230.

small shells from the dredgings, a labour which occupied 650 hours.

To economise space the species are not noticed in detail. All identified, and many remain undetermined, are enumerated; those new to Australia and those new only to Queensland are marked as such. Fuller treatment is reserved for the new species or those of exceptional interest.

A future part will deal with the Gasteropoda.

Brachiopoda.

† *Crania suessi* Reeve.
† *Cryptopora brazieri* Crane
Megerlia sanguinolenta Gmelin.

Cephalopoda.

* *Sepia esculenta* Hoyle.
* *cultrata* Steenstrup.
† *pfefferi* Hoyle.

Scaphopoda.

Cadulus prionotus Watson.

Polyplacophora.

Callistochiton antiquus Reeve.
Cryptoplax burrowi Smith.

Pelecypoda.

Limopsis multistriata Forskal.
Arca foliata Forskal.
fusca Bruguière.
navicularis Bruguière.
clathrata Reeve.
* *Glycymeris cardiiformis* Angas.
* *capricornea* Hedley.
* *queenslandica* Hedley.
* *Philobrya scabra* Hedley.
* *recapitula* Hedley.

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* New to Australia.
† New to Queensland.

† *Philippiella rubra* Hedley.
Vulsella vulsella Linn.
Ostrea cucullata Born.
* *cerata* Sowerby.
Pecten leopardus Reeve.
pallium Linn.
Chlamys senatorius Gmelin.
Plicatula australis Lamarck.
Lima lima Linn.
bullata Born.
angulata Sowerby.
alata Hedley.
fasciata Linn.
Brachyodontes curvatus Dunker.
Modiola philippinarum Hanley.
australis Gray.
Lithophaga teres Philippi.
cinnamomea Lamarck.
laevigata Quoy and Gaimard.
* *straminea* Dunker.
† *Modiolaria splendida* Dunker.
† *cuneata* Gould.
cumingiana Dunker.
† *miranda* Smith.
* *perstriata* Hedley.
Septifer bilocularis Linn.
* *Julia exquisita* Gould.
† *Pholàdomya arenosa* Hedley.
† *Thraciopsis speciosa* Angas.
† *Thracia modesta* Angas.
Myochama anomioides Stutchbury.
Myodora trigona Reeve.
* *pulleinei* Hedley.

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* New to Australia.
† New to Queensland.

Cœlodon elongatus Carpenter.
* *Verticordia torrida* Hedley.
Cuspidaria brazieri Smith.
* *Crassatellites janus* Hedley.
* *Cuna flava* Hedley.
† *delta* Tate and May.
Carditella torresi Smith.
Cardita variegata Bruguière.
† *incrassata* Sowerby.
* *Condylocardia porrecta* Hedley.
* *trifoliata* Hedley.
† *ovata* Hedley.
Chama pulchella Reeve.
jukesii Reeve.
* *Codakia oblonga* Hedley.
bella Conrad.
interrupta Lamarck.
exasperata Reeve
† *Diplodonta adamsi* Angas.
† *Cryptodon globosum* Forskal.
Kellia cycladiformis Deshayes.
Cyamiomactra mactroides Tate and May.
Cardium lyratum Sowerby.
transcendens Melv. and Standen.
fragum Linn.
bechei Reeve.
† *hemicardium* Linn.
reevianum Dunker.
* *skeeti* Hedley.
Tridacna elongata Lamarck.
Dosinia histrio Gmelin.
* *amphidesmoides* Reeve.
* *Gafrarium navigatum* Hedley.

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* New to Australia.
† New to Queensland.

* *Gafrarium angasi* Smith.
* *scriptum* Linn.
Cytherea chemnitzii Hanley.
reticulata Linn.
lamellaris Schumacher.
Lioconcha castrensis Linn.
ornata Dillwyn.
* *Granicorium indutum* Hedley.
* *Macrocallista roseotincta* Smith.
Chione toreuma Gould.
subnodulosa Hanley.
marica Linn.
† *scabra* Hanley.
* *recognita* Smith.
Pitaria inflata Sowerby.
Petricola lapicida Chemnitz.
Tellina virgulata Hanley.
virgata Linn.
tenuilirata Sowerby.
* *dispar* Conrad.
diluta Smith.
* *fabrefacta* Pilsbry.
* *pulcherrima* Sowerby.
* *gargadia* Linn.
* *Arcopagia scobinata* Linn.
† *robusta* Hanley.
* *Semele exarata* Adams and Reeve.
* *Abra truncata* Hedley.
† *Sanguinolaria tenuis* Deshayes.
Psammobia rasilis Melvill and Standen.
† *puella* Deshayes.
† *gari* Linn.
Asaphis deflorata Linn.

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* New to Australia.
† New to Queensland.

† *Mactra jacksonensis* Smith.
maculata Gmelin.
Lutraria oblonga Gmelin.
Atactodea striata Gmelin.
† *Ervilia bisculpta* Gould.
Corbula scaphoides Hinds.
crassa Hinds.
monilis Hinds.
† *Saxicava arctica* Linn.
Gastrochaena lamellosa Deshayes.

BRACHIOPODA.

Crania suessi Reeve.

Crania suessi Reeve, Conch. Icon. Crania, 1862, pl.i. fig.2.

A few worn valves from 17-20 fathoms are referred to this species with some hesitation. It has not been taken since the types were dredged off Sydney, half a century ago.

Cryptopora brazieri Crane.

Atretia brazieri Crane, Proc. Zool. Soc. 1886, p.183.

(Plate xxxvi., figs.1-2.)

This brachiopod had hitherto been confined to the coast of New South Wales. It is quite common at 17-20 fathoms around Mast Head, where its favourite perch is the polyzoan, *Selenaria maculata* Busk.

Megerlia sanguinolenta Gmelin.

Anomia sanguinolenta Gmelin, Syst. Nat. xiii. 1790, p.3347.

Megerlia sanguinea Davidson, Trans. Linn. Soc.(2) iv. Zool. 1887, p.108, pl.xx. figs.1-8.

In the dredgings from 17-20 fathoms this species occurred in profusion.

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† New to Queensland.

CEPHALOPODA.

Sepia esculenta Hoyle.

Sepia esculenta Hoyle, Chall. Rep. xvi. 1886, p.129, pl.xviii. figs. 1-5, pl.xviii. figs.1-6.

Several large shells gathered on the beach answer to the description of this Japanese species, which has not previously been seen beyond the Japanese Empire.

Sepia cultrata Steenstrup.

S. cultrata Steenstrup, Hoyle, *op. cit.* p.133, pl.xx.

Numerous shells were strewn among the beach drift. This species had not been noted so far north.

Sepia pfefferi Hoyle.

S. pfefferi Hoyle, *op. cit.* p.145, pl.i. fig.10.

Shells of this species occurred with the foregoing, but the species seemed rare. Hitherto it has only been known from the Arafura Sea.

PELECYPODA.

Glycymeris capricornea, n.sp.

(Plate xxxvi., figs.5-6.)

Shell small, solid, almost equilateral, the posterior side slightly exceeding the anterior, the orbicular outline only modified by the short hinge-line and a straight margin of the dorsal posterior. Colour white, variegated with irregular brown concentric streaks. Sculpture: about thirty-five strong sharp radial ribs which denticulate the margin, are wider apart and larger medially and shrink fainter and closer as they recede to the sides. The crests of the ribs are minutely beaded, and fine crossbars lattice the interstitial grooves. Epidermis disposed in separate, erect, falcate bristles set in a double row down each groove. Beaks full and projecting, approximating. Ligamental area short and narrow. Teeth about twenty-four, composing an arch with rather straight limbs. Interior porcellaneous-white, sometimes stained with chocolate. Interior ventral margin provided with about twenty-six interlocking tubercles. Length 12·5 mm.; height 11 mm.; depth of single valve 4 mm.

Hab.—Several separate and perhaps immature valves dredged in 17-20 fathoms.

Obs.—The bold and even radial ribs sufficiently distinguish this small species from its Australian congeners. Forbes has noted that a new species of *Pectunculus* (possibly this one) was dredged by the 'Rattlesnake' from 15-17 fathoms on a sandy and shelly bottom off Cape Capricorn (Voy. 'Rattlesnake,' ii. p.366).

A single valve 27 mm. long and 23 mm. high was collected for me by Mr. H. L. Kesteven on the beach at Caloundra, Queensland, in September, 1902.

GLYCYMERIS QUEENSLANDICA, n sp.

(Plate xxxvi., figs.3-4.)

Shell rather small, inequilateral, transversely ovate, moderately inflated, anteriorly rounded, posteriorly subacuminate. Young shells are rounder; the posterior angle appears in adolescence and is most marked in aged individuals. Colour buff or pale purple, clouded with white towards the apex. Sculpture inconspicuous, consisting of minute radial riblets much broader than their interstices and minutely beaded by concentric sculpture. When full grown the riblets tend to aggregate into bundles of four or five composing low ribs which correspond to the denticles on the inner ventral margin. The epidermis appears as dense rows of minute bristles set in the grooves between the riblets, and as usual is thickest around the margin, leaving the umbo bald. Teeth, about twenty-three set in a low arch. Except the posterior dorsal margin, the inner edge of the valve is frilled by close, small, interlocking tubercles. Length 25 mm.; height 22 mm.; depth of single valve 7 mm.

This species was plentiful in the neighbourhood of Mast Head Reef at a depth of 17-20 fathoms.

I received from Mr. A. F. Hemsley a perfect specimen which he obtained near Cooktown, Queensland.

GLYCYMERIS CARDIIFORMIS Angas.

Pectunculus cardiiformis Angas, Proc. Zool. Soc. 1879, p.419, pl.xxxv. fig.6.

P. hoylei Melvill & Standen, Journ. Linn. Soc. Zool. xxvii. 1899, p.187, pl.xi. fig.24.

A handsome Glycymeris was dredged in all stages of growth. The largest was alive and contained several pearls; it measured, length 47mm., height 47mm., and depth of conjoined valves 35mm.; the radials were thirty-three. With some hesitation it is referred to the species named by Angas. The grooves are deep and squarely cut, and the ribs more scabrous than his description would imply, but he may have used a worn example. In shape and general appearance the figure of *P. robustus* Sowerby,* answers to our shell.

The species of Angas has not been since recognised. It came from the collection of Sylvanus Hanley. Macgillivray, who, dredged from H.M.S. 'Rattlesnake' in the vicinity of the Capricorns, supplied shells to Hanley.

PHILOBRYA SCABRA, n.sp.

(Plate xxxvii., figs.14-15.)

Valve small, nearly square in outline, solid, considerably inflated, very inequilateral. Colour various, chocolate, chrome-yellow, pink or purple, usually a monochrome but sometimes with an occasional dark spot. Epidermis not prominently developed, presenting a lustrous surface. Sculpture: from beneath the protoconch radiate about eighteen round ribs which strongly denticulate the margin and are divided by flat and broader interspaces. These ribs are largest medially and continue in force to the anterior margin, but on the posterior slope they rapidly degenerate and disappear. Concentrically the furrows are latticed by about

* Sowerby, Proc. Zool. Soc. 1883, p.21, pl.vii. fig.4.

twenty-five crossbars connected across the ribs by a hooded scale. Prodissoconch with a narrow rim, interior tumid with a central depression. No proper hinge-teeth are developed; their functions are probably discharged by about seventeen strong interlocking pits and tubercles, set without regard to the external sculpture around the broad inner margin of the valve. A wide chondrophore lies obliquely between a short anterior and a long posterior row of crenulations. Height 1·5 mm.; length 1·54 mm.; depth of conjoined valves 0·96 mm.

Numerous examples, both dead and alive, were taken in 17-20 fathoms.

P. scabra resembles *P. tatei*, from which, without a full series, I should not have ventured to separate it. A dense enveloping epidermis conceals the shell of *P. tatei* in life, but *P. scabra* is naked. Apart from the epidermis, I rely on the more numerous radials of *P. scabra* to distinguish it. The northern species is besides smaller, less inflated, more square in outline, and its anterior side less developed.

Philobrya recapitula, n.sp.

(Plate xxxvii., figs. 11, 12, 13.)

Shell subquadrate, the anterior side being undeveloped, causing it to be inequilateral, much inflated, solid. Colour white (? bleached). Sculpture: thirty-two concentric furrows traverse about forty-eight radii, of which fifteen are anterior and twelve posterior; on each of the resulting facets is set an elevated bead. The beads are conical, half imbedded on the long axis, the apex directed to the umbo, the base overhanging the furrow. They gradually increase in size to the margin. Prodissoconch large and conspicuous, with two rims set some distance apart; the inner basin is shallow triangular, its centre occupied by a prominent spike. Hinge: the ligament set obliquely between two crenulated areas. Under the anterior crenulation a single massive cardinal and socket, below and behind the posterior crenulation three laterals. Height 3 mm.; length 1·85 mm.; depth of single valve 0·9 mm.

Hab.—A few separate valves from 17-20 fathoms.

Obs.—The occurrence of a Philobrya in the coral fauna was unexpected. *P. recapitula* belongs to a group of radiate, inflated asymmetrical species of which the New Zealand *P. costata* was the first known. The exquisite sculpture will readily distinguish the present species, whose individuality is further marked in the hinge and complicated prodissoconch. The median spike of the latter presents inferences of wide interest. The hollows on the summits of the prodissoconch caps of certain species, for example, *Condylocardia concentrica* Bernard,* and *Philobrya parallelogramma*† may, it is now suggested, be the scars from which similar spikes have been shed. Such a spike appears on the prodissoconch of *Cyclopecten obliquus.*‡

Three stages of embyronic life are recorded in the prodissoconch of *P. recapitula.* The spike may be the stage for which Kesteven has proposed§ the name of veloconch.

Modiolaria perstriata, n.sp.

(Plate xxxvi., figs.9-10.)

Shell small, thin, oblong-elongate, rather inflated, umbo much incurved, situated at the anterior extremity. Colour, cream, with a few scattered brown spots. The unsculptured area characteristic of the genus falls within the anterior third; it is here reduced to a narrow ray the width of three grooves and ridges. Sculpture: the specimen drawn has, posterior to the smooth ray, 104 sharp raised radial threads parted by deep grooves of equal breadth. The threads increased in size with the growth of the shell and are largest at the posterior dorsal angle. New threads appear by intercalation. The margin is finely crenulated by the radial sculpture. Anterior to the smooth ray are 18 similar threads and grooves. The radials are crossed and broken by about 40

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* Journ. de Conch., xliv. pl. vi.

† These Proceedings, Vol. xxx., pl. xxxii., fig.16.

‡ Mem. Austr. Mus. iv., p.306, fig. 51.

§ These Proceedings, xxx., p.327.

fine concentric lamellæ. Length 5 mm.; height 3 mm.; depth of single valve 1·85 mm.

Not uncommon as separate valves in 17-20 fathoms.

The numerous delicate radials and the very narrow smooth ray afford recognition marks for the distinction of the species.

Julia exquisita Gould.

Julia exquisita Gould, Smith, Chall. Rep. xiii. 1885, p.269.

Several dead and separate valves were found among the dredgings. One perfect vivid green shell adhered to a strip of green seaweed. This interesting species adds a family to the Australian fauna. Previously it had only been found at Bourbon and Hawaii.

Myodora pulleinei, n.sp.

(Plate xxxvi., fig.7.)

Shell moderately solid, elongate, nearly equilateral, left valve plane, right much compressed. Colour white. Dorsal margins nearly straight, meeting in a hook at the umbo. Posterior end broadly and obliquely truncate, anterior angular. Sculpture: about ten concentric, graduated, broad and high corrugations, which are sharply bent on crossing an imaginary line between the umbo and the postero-dorsal angle. In the left valve the crests of the ridges are acute, in the opposite valve rounded. A high magnification exhibits a secondary sculpture of dense minute grains arranged radially. Length 6 mm.; height 4 mm.

Rare; a few separate valves from 17-20 fathoms.

This species is named in honour of the well-known conchologist, Dr. R. Pulleine, who accompanied our party to Mast Head.

Cœlodon elongatus Carpenter.

Carpenter, Proc. Zool. Soc., 1864, p.600.

(Plate xxxvii., fig.16.)

An unfigured species cannot safely be identified except by those fortunate enough to have access to authentic specimens. The record by the 'Challenger' of *C. elongatus* from Torres Strait suggested that name for a specimen here figured, which is

5 mm. high, 9·5 mm. long; and was dredged in 17-20 fathoms, off Mast Head Island.

VERTICORDIA TORRIDA, n.sp.

(Plate xxxvii., figs.17, 18, 19.)

Shell small, rather inflated, subrhomboidal. Right valve exceeding and clasping the left. Umbo much incurved, on its summit a small smooth sharply defined prodissoconch. Lunule deeply excavate. Dorsal area flattened. Colour uniform clear amber. Sculpture: the whole surface of the valve ornamented with numerous faint radial riblets, separated by flat interspaces; both riblets and interspaces crowded with sharp and very minute grains. Interior highly nacreous, external radial sculpture impressed between the pallial line and the margin. In the right valve a massive cardinal under the umbo and a lateral under the dorsal margin. Height 3 mm.; length 3·25 mm.; diameter of conjoined valves, 1·1 mm.

A few living specimens from 17-20 fathoms.

CRASSATELLITES JANUS, n.sp.

(Plate xxxviii., figs.29, 30, 31, 32.)

Shell small, much compressed, subtrigonal, slightly inequilateral. Colour buff to orange, with two or three interrupted rays of chocolate and grey; the interior brown in the centre. Sculpture: about sixteen concentric folds which become broader, higher and more widely spaced as the shell grows. The inner margin of the valve is smooth. The prodissoconch, worn away in mature specimens, is shown (fig.32) in a shell 0·47 mm. in height. Each prodissoconch rises from a rounded collar in a double-peaked protuberance. Length 4·55 mm.; height 4·0 mm.; depth of single valve 1·5 mm.

Numerous specimens in 17-20 fathoms.

CUNA FLAVA, n.sp.

(Plate xxxviii., fig.28.)

Shell small, solid, subtriangular, compressed. Colour monochrome, usually orange, sometimes pink or purple. Sculpture:

about twenty-two radial ribs parted by narrow though deep grooves, and densely packed with compressed beads which enlarge gradually with the growth of the shell. It is the chief peculiarity of the species that these ribs do not diverge from the umbo, but centre at a point in space considerably beyond the shell. Lunule and impressed dorsal area are unsculptured. About eighteen small interlocking tubercles on the inner ventral margin. Height 1·7 mm.; length 1·65 mm.; depth of conjoined valves 1 mm.

An abundant species in 17-20 fathoms.

Condylocardia porrecta, n.sp.

(Plate xxxviii., fig.24.)

Shell larger than is usual in the genus, solid, rhombic-oblong, inequilateral, anterior end short. Colour white. Sculpture: about fourteen low broad radial ribs, parted by narrow grooves and crossed by delicate growth-lines. Anterior and posterior dorsal areas smooth. Prodissoconch large, with projecting rim, and containing a second inner shield upon the umbo. From within the ribs are visible because more opaque than their interstices; their ends strongly denticulate the inner margins of the valves. Height 1·9 mm.; length 2·5 mm.; depth of conjoined valves 1·3 mm.

A few examples dredged from 17-20 fathoms.

Condylocardia trifoliata, n.sp.

(Plate xxxvii., figs.20, 21, 22, 23.)

Shell solid, inflated, oblique, much higher than long, triangularly ovate, with a flattened anterior area like a lunule. Surface glistening in the light. Colour pale ochre, passing into pearly white on the umbo. There is no radial sculpture; about twenty strong corrugations undulate the middle of the valve, diminish posteriorly, and cease anteriorly. Prodissoconch large, with expanded upturned margin projecting over the main shell. An umbonal boss bears a trefoil scar, and is surrounded by two concentric ridges. Hinge massive; left valve with an anterior and a stronger posterior cardinal, right with one anterior and two posterior cardinals. In the left valve the posterior inner margin is furrowed, and the anterior ridged to clasp corresponding elevations and depressions in the other valve. Muscular impressions distinct. Height 1·4 mm.; length 1·22 mm.; diameter of conjoined valves 0·84 mm.

Several living specimens from 17-20 fathoms. [Since this was written Miss L. Parkes has obtained several separate valves of this species in Middle Harbour, Sydney].

CODAKIA OBLONGA Hedley.

Lucina oblonga Hedley, Mem. Austr. Mus. iii. 1899, p.497, fig.51.

This species was described from Funafuti. A few separate valves were taken in 17-20 fathoms off Mast Head.

CARDIUM SKEETI, n.sp.

(Plate xxxviii., fig.25.)

Shell small, obliquely cordate, inflated, inequilateral, rather thin. Colour: different individuals are various shades of lemon, lilac, pink or purple; in pale specimens with dark concentric streaks on the posterior side. Sculpture: about thirty-eight radials densely crowded with sharp imbricating hooded scales which give a harsh aspect to the shell and extend over the whole surface. These are parted by deep and narrow grooves, latticed by minute densely disposed crossbars, and produced at the margin as interlocking teeth, posteriorly long, acute, anteriorly short and blunt. Length 8 mm.; height 6 mm.; depth of single valve 3 mm.

This is an abundant species in 17-20 fathoms. It is named after Mr. H. C. Skeet, a member of the Expedition.

GAFRARIUM NAVIGATUM, n.sp.

(Plate xxxviii., fig.33.)

Shell small, equilateral, broad cordate, very solid, rather compressed. Umbo sharply pointed. Lunule long and narrow. Colour white, rose, or orange, with a few scattered brown dots.

Sculpture: down the centre of the valve runs a parting line where follow arrow-heads, each limb stretching to the margin in a broad crescentic wave. The general effect is that of waves in the wake of a fast moving vessel, which would in this case be steering from the ventral margin to the umbo. The double crescents number about fifteen, commence as an arcuate ridge, successively broaden and meet at a sharper angle, are parted by shallow furrows of equal breadth whose ends undulate the lateral margins. Over ridge and furrow runs undisturbed a regular fine concentric striation. Muscular impressions normal. Ligament sunk almost to the centre of the hinge-plate. Length 6 mm.; height 5·4 mm.; breadth of single valve 1·6 mm.

Hab.—Several specimens, some alive, from 17-20 fathoms.

Obs.—The remarkable sculpture of this pretty little species readily distinguishes it. Judging from literature, it approaches nearest to *Circe æquivoca* Chemnitz, but differs by being much smaller, more equilateral, and of bolder sculpture. The latter feature recalls waves spreading in the wake of a vessel.

GRANICORIUM, gen.nov.

A genus of the Veneridæ, nearest to *Lioconcha*, which it resembles in shape, solid porcellanous shell and muscular impressions; but from which it differs by the absence of anterior lateral teeth, the want of a groove defining the lunule, and by the habit of plastering the exterior with sand. Type *G. indutum* Hedley.

GRANICORIUM INDUTUM, n.sp.

(Plate xxxviii., figs.26, 27.)

Shell convex, suborbicular, straight on dorsal margin, angled posteriorly and rounded ventrally. Umbo incurved. Lunule deeply excavate. Except the tip of the umbo, the whole of the outside of the valve is densely covered with sand grains, including broken bits of shells, corals, and foraminifera. These grains are so firmly cemented to the valve that it is difficult to remove them. The fragments increase in size towards the margin, and are arranged to slightly overlap each other like tiles on a roof.

Beneath the coat of sand the valve is flesh-coloured, and concentrically sculptured. Interior porcellaneous, sometimes white, sometimes orange-buff. Inner margin smooth, bevelled. Pallial line slightly sinuate. Hinge with three cardinals in each valve, the posterior grooved, no laterals. Length 19 mm.; height 17mm.; depth of single valve 6 mm.

Several separate valves from 17-20 fathoms.

MACROCALLISTA ROSEOTINCTA Smith.

Cytherea (*Callista*) *roseotincta* Smith, Chall. Rep. Zool. xiii. 1885, p.136, pl.i. figs.6-6*b*.

This species is new to Australia; indeed it appears only to have been taken once, in the Philippine Islands. Numerous dead shells were dredged in 17-20 fathoms around Mast Head.

TELLINA FABREFACTA Pilsbry.

Pilsbry, Proc. Acad. Nat. Sci. Philad. 1904, p.555, pl.xli. figs.11-12.

On receiving a paper from Dr. Pilsbry on some new Japanese molluscs, I at once recognised the figure of this as one which commonly occurred in 17-20 fathoms off Mast Head. The identification was confirmed by the author of the species, who was surprised to receive his novelty from so remote a locality.

ABRA TRUNCATA, n.sp.

(Plate xxxviii., fig.34.)

Shell thin, compressed, a long and narrow wedge, the dorsal and anterior margins forming a right angle, posterior and ventral margins rounded. Colour white. Sculpture: concentric elevate lamellæ, wide-spaced and prominent posteriorly, finer and crowded towards the umbo, arrested abruptly on reaching the dorsal area, across which they continue as fine threads. No muscle-scars are perceptible on the glazed interior. The abbreviation of the anterior side has probably contracted the hinge. In the single left valve before me it appears to consist of a medium oblique deeply entering chondrophore and a well developed anterior and posterior lateral. Height 3·6 mm.; length 7 mm.; depth of single valve 1 mm.

A separate valve from 17-20 fathoms.

ERVILIA BISCULPTA Gould.

Smith, Chall. Rep. Zool. xiii. 1885, p.80.

(Plate xxxvi., fig.8.)

This species was dredged in abundance round Mast Head Island. In Australia it has only hitherto been recorded from Sydney, where it is extremely rare. The figure of it* is so unlike our specimens that I offer a drawing of a Queensland example 5·5 mm. long and 3·6 mm. high.

EXPLANATION OF PLATES.

Plate xxxvi.

Figs. 1, 2.—*Cryptopora brazieri* Crane.
Figs. 3, 4.—*Glycymeris queenslandica* Hedley, and enlarged sculpture.
Figs. 5, 6.—*Glycymeris capricornea* Hedley, and enlarged sculpture.
Fig. 7.—*Myodora pulleinei* Hedley.
Fig. 8.—*Ervilia bisculpta* Gould.
Figs. 9, 10.—Different aspects of *Modiolaria perstriata* Hedley.

Plate xxxvii.

Figs. 11, 12, 13.—*Philobrya recapitula* Hedley; exterior of valve, magnified sculpture, and hinge.
Figs. 14, 15.—*Philobrya scabra* Hedley; exterior of valves and hinge.
Fig. 16.—*Cœlodon elongatus* Carpenter.
Figs, 17, 18, 19.—*Verticordia torrida* Hedley; exterior of valve, profile, and hinge.
Figs. 20, 21, 22, 23.—*Condylocardia trifoliata* Hedley; exterior of valve, profile, and hinge.

Plate xxxviii.

Fig. 24.—*Condylocardia porrecta* Hedley.
Fig. 25.—*Cardium skeeti* Hedley.
Figs. 26, 27.—*Granicorium indutum* Hedley; interior and exterior.
Fig, 28.—*Cuna flava* Hedley.
Figs. 29, 30, 31, 32.—*Crassatellites janus* Hedley; adult, interior and exterior; young, side-view and profile.
Fig. 33.—*Gafrarium navigatum* Hedley.
Fig. 34.—*Abra truncata* Hedley.

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* Angas, Proc. Zool. Soc. 1877, pl.xxvi. fig.21.

NEW AUSTRALIAN SPECIES OF THE FAMILY *LIBELLULIDÆ.*

[NEUROPTERA : *Odonata.*]

BY R. J. TILLYARD, B.A.

(Plate xliv.)

In this paper eleven new species are added to the list of Australian *Libellulidæ*, bringing the total up from 50 to 61. All the new species were taken in the Cairns district of North Queensland during the summer of 1904-5. Of these, three only are new to science. The remainder are species already known in other parts of the world, but so far unobserved in Australia. Of the new species, one, represented by a single female, belongs to the beautiful genus *Rhyothemis*. A second is a *Synthemis*, and closely allied to several common southern Australian forms already described. A third adds a new genus (*Macromia*) to the Australian list. Of the eight remaining species, one is common in South Europe, Africa and East Indies; four others occur in the East Indies, India and Ceylon; two in New Guinea; and one, hitherto known from the male only, in Borneo. Altogether six new genera are added to the Australian list, viz., *Zyxomma*, *Erythemis*, *Macrodiplax*, *Agrionoptera*, *Tetrathemis* and *Macromia*. In two of the new species the males are yet to be discovered.

I am much indebted to M. René Martin of Le Blanc, France, for his kindness in verifying the species sent him.

i.—Subfamily **LIBELLULINÆ.**

1. ZYXOMMA PETIOLATUM Ramb.

This insect belongs to a remarkable genus whose affinities have been the subject of much speculation. Originally included amongst the Libellulinæ, it was later on separated out and formed by Karsch into a separate subfamily, Zyxomminæ. A first examination of the insect would suggest that it belongs to the *Corduliinæ*, since it has the general *facies* of that subfamily. But the eyes, both in shape and in their extreme contiguity, as well as the wing-neuration, demand that it should be placed somewhere at the head of the Libellulinæ, close to *Tholymis* and *Pantala*. This seems to me its proper position; nor is there any need for a new subfamily to contain it, unless we are to split up the Libellulinæ altogether into half-a-dozen or more subfamilies.

Four species of this genus are known, one from West Africa, and three from India and East Indies. *Z. petiolatum* is found in India, Ceylon, and the East Indies. In Australia it is evidently extremely rare. I found it in only one spot, some ten miles out of Cairns, flying swiftly up and down a creek in the guava scrub, at dusk. It often hovers quite motionless in the air for a long time, and when flying, almost skims the surface of the water. I took about half-a-dozen males and two or three females.

The following is a description of this remarkable insect, made from the freshly killed specimens :—♂. Total length, 49 mm.; abdomen, 37 mm.; wings, fore 32 mm., hind 32·5 mm. Wings completely shaded (in the mature insect) with dull yellowish-brown; tips from pterostigma outwards, fuscous; bases of hind wings very slightly saffroned; hindwings slightly *longer* than forewings, anal border rounded. *Pterostigma* 3 mm., brown. *Membranule*, fore, small, brown ; hind, 2·5 mm., rather broad, dull brown on a black nervure. *Nodal Indicator* | 11 7-8 | / | 8 8-9 | last antenodal of forewings, and first two or three postnodals of all wing *not* continuous. Head: *Vertex* small, hairy, tubercled, black; *ocelli* central, brilliant; other two smaller, brown; *antennæ* 2 mm., brown; eyes dark green in the living insect, dark brown in the dried specimen. Front cleft medially, dark brown above with greyish hairs, dull dirty yellowish-grey on sides and below; *clypeus* dull dirty yellowish-grey; *labrum* brown ; *labium* and *mandibles* pale dirty yellowish-grey. Thorax: *Prothorax* pale brown. *Meso-* and *metathorax* dark brown, almost black on shoulders; sides dirty brown shading to dirty greyish-brown below. *Legs* light brown. Abdomen: 1-3 enormously swollen, rest very slender, subcylindrical, slightly thickest in the middle. Colour, black shaded with deep maroon in parts; 10 carries a hairy tuft below the inferior appendage. Appendages: *Superior* 2·5 mm., rather close together, parallel, curving slightly downwards; black, bases brown. *Inferior* 1·7 mm., broadly triangular-lanceolate, pointed upwards; light brown.

♀. Differs very slightly from male, as follows:—Total length, 52 mm.; abdomen, 38mm. Wings: 6-7 postnodals; *pterostigma* nearly 3 mm. Head: *Vertex* and *antennæ* brown; *front* pale brown above. Thorax pale dirty brown. Abdomen: 1-3 enormously swollen, rest not quite as slender as in male. Colour, brown, sutures black. Segment 9 carries a small pointed tubercle underneath; 10 has a large swelling underneath, between and below the appendages. Between 9 and 10, below, is a small ridge carrying a few bristles bent downwards and backwards. Appendages wide apart, pointed, curving outwards, 1·5 mm. Colour brown, shading to dull black at tips.

Hab.—Kamerunga, near Cairns, N.Q.; rare; January.

2. Rhyothemis Alcestis, n.sp.

♀. Unique. Total length 27 mm.; abdomen 17 mm.; wings, fore 27·5 mm., hind 26·5 mm.

Wings: *Pterostigma* short, 1·8 mm., black. *Membranule* narrow, rather long, about 2·5 mm., pale dirty greyish-brown. *Nodal Indicator* $\left\|\begin{matrix} 9 & 10\text{-}11 \\ 6 & 10\text{-}11 \end{matrix}\right|$ Basal half of all wings coloured black, with metallic reflections, as follows: in the forewings the colour-line runs *from the nodus exactly* across the wings to the postcostal margin, ending at a point nearly 4 mm. from the bottom of the wing-triangle, and is *slightly* irregular in shape; in the hindwing the colour-line starts *from the first postnodal* and proceeds, bending slightly *outwards*, to about the middle of the wing; it then takes an irregular semicircular curve inwards, and ends up somewhere about half-way along the postcostal margin. Head: *Vertex* shiny metallic black, small, hairy, tubercled; *eyes* brown; *antennæ* black, 1·7 mm. *Front* hairy, cleft medially, very deep metallic green above, shading to brown next the clypeus.

Clypeus brown; *labrum* dark brown; *labium* and *mandibles* paler brown. Thorax: *Prothorax* narrow, shiny black. *Meso-* and *metathorax* hairy, shining metallic black, with bronze reflections. Abdomen short, subcylindrical; seen from above, almost the same width from end to end; seen sideways, tapering gradually from 3 to end. Colour dull black. Segment 10 carries a small hairy projection between the appendages. Appendages short, 0·7mm, wide apart, pointed, subconical, black (Plate xliv., fig.1).

Hab.—Kuranda, near Cairns, N.Q. A single female was captured by Mr. F. P. Dodd of Kuranda, in December, 1904, about 12 miles up the river Barron above that township.

This unique specimen is closely related to *R. bipartita* from Borneo. The latter has the wings less coloured with black. It also comes somewhat near to *R. resplendens* (♀), from which it may be at once distinguished by its greater size and by the black colouration of the wings being continuous, whereas in *resplendens* (♀) it is broken by an oval hyaline spot 4-5 mm. long. It would be interesting to obtain the male, which might be either a black insect like the female, or a brilliantly coloured insect like *resplendens*(♂).

3. Crocothemis erythræa Brullé.

This species is very widely distributed, being found commonly over the South of Europe, the Continent of Africa, Ceylon, and the East Indies. A single pair was taken by me on Carrington Marsh, near Atherton, N.Q., flying like *O. villosovittatum*, around the edges of the marsh, and often settling high upon the branches of overhanging trees, with wings depressed. *C. servilia* Drury, already recorded from Australia, is a larger insect, with wings totally shaded with yellow. *C. nigrifrons* Kirby, is the only other Australian species of the genus, and is blue, with black head and thorax.

4. Erythemis rufa Ramb.

At first sight this insect is almost exactly like *C. erythræa*. There is a difference, however, in the neuration of the discoidal area of the forewings. In *Crocothemis* there are three ranks of cells in the discoidal area all the way; in *Erythemis* there are three cells, followed by two ranks afterwards (Plate xliv. figs. 2-3).

One male and two females of this insect were taken by me on the Carrington Marsh, near Atherton, N.Q., in company with the preceding species. Its flight and habits are also similar. One female also from Cairns, N.Q. (E. Allen).

This insect is already recorded from New Guinea.

5. Macrodiplax lycoris Selys.

An insect of similar size and shape to the last two, but easily distinguished by the broad irregular jet black dorsal band on the red abdomen, the portions of which on each segment from 2-8 are clepsydrate in form, and on 9 form a large segment of a circle.

Kirby gives Madagascar(?) as the habitat of this insect. Selys obtained his specimens from New Guinea. I believe the female is unknown. The male flies swiftly over creeks and rivers, often wandering into the bush, like *Pantala flavescens*. It is rare and local, and only occurs singly. About half-a-dozen males were taken by me at Kuranda and Cairns, N.Q.

6. Diplacodes trivialis Ramb.

This common insect is exceedingly abundant in India, Ceylon, and the East Indies. It has never been recorded before for Australia. In the summer it is very rare in the Cairns district. I took several males and two females at Redlynch, near Cairns, N.Q., flying around the edges of billabongs of still water. In the winter it is exceedingly common. I have received great numbers of it, together with *Brachydiplax australis*, a somewhat similar insect, from Mr. E. Allen of Cairns.

The male and female are both, for many weeks after emergence, of a dull brown colour, with black markings. Later on, when quite matured, the thorax and abdomen of the male, and more rarely of the female also, become covered with a bluish bloom, except on the last segment or two, which are jet black. So different does the insect then appear from the described brown type, that I was led to give it a new name; and it was not until I received an abundant supply from Mr. E. Allen that I was able to connect the two forms by intermediate specimens. At Cairns this species appears at the end of July, and in August the brown form swarms. At the end of that month the males begin to assume the bluish bloom, and throughout September they are still common. From then up to December the species rapidly decreases in number, and in January-February only a few tattered individuals are left. The old females which are left over to the end of the season are, like the males, almost entirely covered with bluish bloom.

7. Diplacodes nebulosa Fabr.

This pretty little species is common in the East Indies. It may be easily recognised by its diminutive size, and by the fuscous tips to all four wings. In Australia, I took seven males flying over the Carrington Marsh, near Atherton, N.Q., in January, 1905. It flies about ten yards out from the edge of the swamp and keeps very close to the surface of the water. It can only be captured by wading. The motion of the wings is so quick that it is exceedingly difficult to see this insect when flying, though its actual progress is slow and very zigzag. It is fond of sitting on the very tips of grass and reed-stems sticking out of the water, with its wings depressed. I do not know the female.

8. Agrionoptera insignis Ramb.(?).

During the months of February-April, 1905, Mr. E. Allen of Cairns, forwarded me a number of exceedingly beautiful dragonflies referable to the genus *Agrionoptera.* I forwarded a number of these to M. René Martin, who is of opinion that they are "probably *insignis.*" *A. insignis* is a Javan insect. No species of this genus has ever been recorded for Australia. As there appears to be a possibility that this is a new species, and as no description of *A. insignis* is accessible to Australian collectors, I propose to give a careful description of my species and thus put it permanently on record; when it is to be hoped that any collector possessing specimens of *A. insignis* will at once compare his insects with this published description.

♂. Total length 34-35 mm., abdomen 24 mm.; wings, fore 28-29 mm., hind 26 mm.

Wings long, narrow, especially at bases; neuration black; bases generally slightly saffroned, sometimes not at all. Basilar space free; one cross-nervure in submedian space; triangles of all wings free. *Pterostigma* 2·5 mm., black. *Membranule* minute, nearly black. *Nodal Indicator*

14	10-11
10-11	10-11

Head: *Occipital triangle* very small, black; *eyes* dark brown; *vertex* tubercled, hairy, brilliant deep steely metallic blue; *antennæ* 2 mm., black; *ocelli*, central one large, all three transparent, pinkish; *front* hairy above, very square, brilliant steely metallic blue, sides yellow; *clypeus* yellow, anteclypeus somewhat recessed under postclypeal ridge; *labrum* dirty brown, shiny; *labium* broad, square and large, pale yellow, crossed from top to bottom by a broad black band; *genæ* and *mandibles* black or very dark brown, a yellowish spot on each side.

Thorax: *Prothorax* black, bordered with yellow in front and behind, and with a small dorsal central yellow spot. *Meso-* and *metathorax* metallic greenish-black above, including two narrow parallel dorsal yellow stripes about 1·5 mm. long, separated by a narrow black line along the dorsal ridge; in front of these is a small square yellow spot, and behind them near the wing-joins a pair of small triangular yellow spots close together. Sides bright yellow irregularly marked with metallic greenish-black bands as follows :—A continuation of the metallic groundcolour above starts from near the front wing-joins, and, isolating two yellow spots of which the lower is twice as large as the upper, is continued as a narrow irregular band across to the mesocoxa, where it becomes much enlarged, isolating a yellow spot at the base of the coxa. A similar but smaller band starts from the hind wing-joins and, isolating a triangular yellow spot, proceeds across to the metacoxa, subdividing into a pair of narrow irregular bands, the lower of which spreads out into a big smoky black patch on the underside. A shorter curved black mark connects the base of the abdomen with the middle of the last-mentioned band. On the underside, below the black patch, is a transverse black ray separating off a triangular yellow space above and a yellow band below it. *Scutella* bright yellow. *Legs* black; coxæ dirty brown, two thirds of underside of fore femora bright yellow.

Abdomen slender, 1-3 swollen, 4-10 narrow. Colour: 1-2 reddish marked by transverse rays of black which coalesce somewhat above so as to make the dorsal surface of 1 nearly all black; suture between 2 and 3 lined by a black band; 3-7 bright red (in some specimens testaceous); a very fine transverse black line one-third of the way from the base of 3; at the end of each segment an irregular broad transverse black band spreading out underneath so that the underside is almost entirely black; 8-10 deep jet black; 9-10 enlarged, slightly clubbed.

Appendages: *Superior* 1·5 mm., black; narrow sublanceolate, slightly curved, pointed; apart at bases. *Inferior* almost as long as superior, triangular, black. A few pale hairs on all the appendages (Plate xliv., figs.4-5).

♀. Generally slightly longer than male, and differing from it as follows:—Bases of wings more saffroned, generally for a space of 6-7 mm. Thorax generally somewhat paler than in male and *more* conspicuously marked; scutella *pale* yellow. Abdomen with the red colouring replaced by orange or fulvous; segment 2 pale yellow. Appendages short, 1 mm.; parallel, pointed, subcylindrical, black; well separated by the rounded hairy projection of segment 10. Seen sideways 8-9 appear somewhat wider than the other segments, and 9 projects underneath into a small black spine with a few fine hairs projecting from it.

Hab.—Cairns, N.Q. (E. Allen); February-April; local.

This beautiful insect has the same general shape and appearance as *Lathrecista festa*, a species which also occurs, though rarely, at Cairns. It is, however, far more brilliantly coloured than *L. festa*, and considerably smaller.

9. Tetrathemis flavescens Kirby.

Kirby has described the male of this rare insect, from Borneo. The female has never been described. In January, 1905, I took one male and several females at Kuranda; the male was unfortunately destroyed by ants, but I still have the females. The following is the description :—♀. Total length 22-24 mm.; abdomen 14-15 mm.; wings, fore 22·5 mm., hind 21 mm. Wings tinged with yellow from triangle to nodus and slightly beyond; *pterostigma* rather short and thick, 1·6 mm., black. *Membranule* nil. Triangle of hindwings placed beyond the arculus. *Nodal Indicator* ‖ 8 6-7 / 7-8 5-6. Head somewhat hairy, dull olive-brown, paler on clypeus; *labium* straw-colour. Thorax: *Prothorax* brownish. *Meso-* and *metathorax* dull olive-brown above; sides glaucous, paler yellowish-brown, crossed by two fairly broad parallel brown bands. Abdomen cylindrical, short, 1-2 very slightly enlarged. Colour: 1 brownish; 2 brownish, with a transverse basal black band; 3, central portion black, a narrow transverse yellowish-brown band at either end, sutures black; 4, basal two-fifths yellowish-brown, rest black; 5, basal one-fifth black, central two-fifths yellowish-brown, rest black; 6 black, crossed by a narrow irregular central transverse band of yellowish-brown; 7 dull yellow, a transverse black band at either end; 8 black, a small yellowish spot low down on each side; 9-10 black; 10 projecting below outwards beyond the appendages into a black spine carrying some longish hairs; there is also, above this, a tubercle under the appendages. Appendages very short, 0·6 mm., subconical, points not very sharp but ending with a short stiff hair; separated at bases, very dark brown (Plate xliv., fig.6).

The above description is taken from the dried specimen. If I remember aright, the dull browns of the dead insect were a dull olive-green in the living insect.

This curious dragonfly flies rather high up around small trees and bushes on the banks of densely wooded jungle creeks. It seldom descends low enough to be caught. It is very fond of sitting on leaves or twigs of trees with wings much depressed. If disturbed, it indulges in a bewildering up-and-down flight, finally rising high up into the trees.

It can be distinguished at once from *Nannophlebia Lorquini*, an insect of somewhat similar size and habits, by the position of the triangle of the forewings. In the latter genus this triangle is normal, *i.e.*, it arises just about the arculus, and not quite beyond it as in *Tetrathemis*.

ii.—Subfamily **CORDULIINÆ.**

10. Synthemis nigra, n.sp. (*S. guttata* var. *punctata* Martin).

♂. Total length 50 mm.; abdomen 38 mm.; wings, fore 34 mm., hind 33 mm.

W i n g s rather slack; neuration black, costa yellowish outwards for some distance; *a distinct white round spot* at the base of the costal nervure of all the wings. Basilar space with two or three cross-nervules; anal margin of hind wings obtusely angulated. *Pterostigma* 2·5 mm., narrow, black. *Membranule*, fore nil; hind 1·5 mm., thick, dark brown. *Nodal Indicator* $\left\|\begin{matrix}14 & 8\\ 10 & 10\end{matrix}\right|$

H e a d: *Vertex* hairy, black; *eyes* brilliant dark green in the living insect; *ocelli* and *antennæ* black. *Front* hairy, cleft medially, minutely punctate, black, with two large pale patches separated by the median cleft Each patch is composed of two conjunct spots; the inner being rounded, chalky white; the outer triangular, dull greyish. *Clypeus*: postclypeus black, anteclypeus brownish with a central white triangular spot; *labrum* black; *labium* very pale yellowish-brown; *mandibles* brown.

T h o r a x: *Prothorax* black. *Meso-* and *metathorax* black with metallic green reflections; dorsal suture rather deep, marked with a pale grey line; just behind the suture are two slanting white spots, close together. On either side a greyish band; below this, close to the underside, another shorter band; mesoscutum round, white; metascutum greyish; underside dirty greyish. *Legs* black, coxæ, trochanters and part of fore femora dirty brown.

A b d o m e n thin, much pinched at 3; 3-5 widening, 6-10 cylindrical. Colour deep black; 3 has a pair of small oval greyish spots, basal, close up to suture; 10 slightly swollen below, hairy. Underside deep black, 1 with a transverse grey band; genital appendages of 2 surrounded with grey.

Appendages: *Superior* 1·5 mm., wide apart at bases; narrow sublanceolate, curved downward and inclined so as to meet at tips, which are blunt and rounded; hairy, granulate, deep black. *Inferior* nearly as long as superior, thick, truncate, hairy, black.

The specimen described was a somewhat immature one. Probably in the mature insect the whites and greys become yellowish.

♀. Differs from male as follows:—A larger insect; forewing 37 mm. Wings deeply suffused all over with rich orange-brown; no spots at bases of costal nervures. *Nodal Indicator* | 14 9-10 / 10 11 | Those parts of head and thorax which are white or grey in male are bright yellow in the female. Abdomen thicker than in male, subcylindrical, 2-8 tapering; 3-4 with a suspicion of a brown basal spot on either side of dorsal ridge; 2-5 with a pair of indistinct central brown spots; 10 projecting below, very hairy. Appendages thin, short, cylindrical, 1 mm.; wide apart at bases, parallel, hairy.

Hab.—Kuranda, N.Q.; January, 1905; rare (1 ♂, 2 ♀).

Taken along the railway line in the dense bush on the side of the ranges. It has an easy flight and is not difficult to capture. Male very similar at first sight to *Syncordulia atrifrons*, but easily distinguished by the basilar space being reticulate.

M. René Martin has regarded this species merely as a variety of *S. guttata*, a common southern species. A careful comparison of *S. nigra* and *S. guttata*, however, will show that the differences between the two are as great as, if not greater than, the differences between any two of the three species *guttata, brevistyla* and *virgula*. Perhaps they none of them deserve higher rank than that of subspecies; but while the other species stand, I am convinced that this must also take rank as a separate species.

The following comparison will show the points of difference between *nigra* and *guttata*:—

S. guttata.	*S. nigra.*
Neuration close.	Neuration much more open.
A clear yellow line along the dorsal ridge.	Only the slightest touch of yellow along the dorsal ridge.

S. guttata.	*S. nigra.*
Frontal spots of male 1 mm. apart.	Frontal spots of male close together.
No white spots at bases of wings in male.	Four distinct white spots at bases of wings in male.
A broad straw-coloured transverse band across the mesonotum.	No band at all across the mesonotum.
Abdomen much spotted with yellow.	Abdomen almost entirely black.

Besides these differences, *S. guttata* is a smaller insect (especially the ♀); though on the other hand the pterostigma in *guttata* is slightly larger than in *nigra* (especially in ♂).

In some ways *S. nigra* shows closer affinity with *S. brevistyla* than with *S. guttata*, notably in having the four spots at the bases of the wings, and in lacking the transverse mesonotal band.

The four closely allied species, viz., *virgula*, *brevistyla*, *guttata* and *nigra*, may now be easily distinguished by the following key:—

A. Superior appendages of ♂ short.

B. { A pair of dorsal humeral yellow stripes on thorax.......... *virgula.*
  { No dorsal humeral stripes on thorax........................... *C.*

C. { Four distinct spots at the bases of the wings in ♂....... *D.*
  { No spots at the bases of the wings in ♂.................... *guttata.*

D. { Abdomen much spotted, a large yellow spot on 7..... *brevistyla.*
  { Abdomen almost entirely black.............................. *nigra.*

11. Macromia Tillyardi Martin.

Three females of this magnificent insect were taken by me at Kuranda, N.Q., in January, 1905. As M. René Martin is about to issue his work on the Corduliinæ, it seems fitting that the record and description of so fine a species should appear in his new work. I have therefore sent him my description of the insect together with the type-specimen. It will be sufficient in this paper to give a short description only, so that the insect may be recognised by Australian collectors:—

This is by far the largest of the Australian Corduliinæ.

♂. Unknown.

♀. Total length 68 mm.; abdomen 50 mm.; wings, fore 50 mm., hind 46·5 mm. Wings: *Pterostigma* 3 mm., blackish. *Membranule*, fore, 3mm. broad; hind, 5mm., narrower, semidiaphanous, greyish-white. *Nodal Indicator* 12-14 6-7 / 8-9 7-10. Head metallic steel-coloured, with a pair of frontal yellow spots, and yellow postclypeus. Thorax deep brown with steely blue reflections; dorsal ridge yellow, a pair of broad straight subhumeral yellow bands, below them a broader yellow band, parallel, passing transversely across the notum between the wing-joins. Abdomen flat, flabby, and apparently ill-nourished in all three specimens. Colour black with bright yellow bands as follows— a broad yellow band encircling 2; 3 nearly all yellow; 4 similar to 3 but with less yellow; 5-6 a narrow irregular central yellow band; 7, basal half yellow; 8, an irregular transverse basal yellow band; 9-10 black. Appendages 1·5 mm., wide apart, flattish, narrow subtriangular, sharply pointed, black (Plate xliv., figs. 7-8).

It flies swiftly in the dense bush and occasionally along the densely wooded creeks and rivers. Very difficult to capture.

EXPLANATION OF PLATE XLIV.

Fig. 1.—*Rhyothemis Alcestis* n.sp. (♀); appendages.

Fig. 2.—*Crocothemis erythræa* Brullé; triangle and part of discoidal area of forewing.

Fig. 3.—*Erythemis rufa* Ramb. ,, ,, ,,

Fig. 4.—(?)*Agrionoptera insignis* Ramb. (♂); appendages, dorsal view.

Fig. 5.— ,, ,, ,, ,, ,, lateral view.

Fig. 6.—*Tetrathemis flavescens* Kirby (♀); appendages.

Fig. 7.—*Macromia Tillyardi* Martin, n.sp. (♀); appendages, dorsal view.

Fig. 8.— ,, ,, ,, ,, ,, lateral view.

NOTE ON CEREBRAL LOCALIZATION IN THE BANDICOOT (*PERAMELES*).

By H. G. Chapman, M.D., B.S., Demonstrator of Physiology in the University of Sydney.

(*From the Physiological Laboratory of the University of Sydney.*)

Historical.—The positions of the cortical motor centres in the brains of marsupials have been described in the Opossum (*Didelphys virginiana*) by Ziehen,* and by R. Cunningham;† and in the Native Cat (*Dasyurus viverrinus*) by Flashman.‡

Scope.—In this investigation the motor areas have been observed in *Perameles nasuta* and *P. obesula.* The centres described have been found regularly in each animal and on both sides of the brain. Other movements have been seen in single individuals, but as these latter movements have not been found constantly they are not mentioned here but will be the object of further inquiry. Experiments by ablation of the cortical centres with observation of the subsequent behaviour of the animal and consequent degeneration in the brain have not as yet been completed and will be reserved for future communication.

Methods.—After preliminary administration of ether, tracheotomy was performed, a tube was inserted into the trachea, and anæsthesia was maintained by causing the animal to breathe through a Woulff's bottle containing ether. The skin was incised to expose the calvarium, and the bone chipped away after an aperture had been made with a small trephine. Almost the

* Centralb. f. Physiol., 1897, Bd. xi. s.457.

† Journ. of Physiol., 1897-1898, xxii. p.264.

‡ Reports from Pathological Laboratory of the Lunacy Department, New South Wales, Vol. i., Pt. ii., 1906.

whole vault was removed. The dura mater was cut away, all hæmorrhage checked by ligature, and the brain kept warm by sponges moistened in hot salt solution. The positions of the vessels and sulci of the exposed portions of the brain were measured with callipers, and the whole was drawn to scale on ruled paper. Anæsthesia was then diminished and the brain surface stimulated by weak faradaic currents through fine platinum electrodes embedded in paraffin. The movements occasioned by stimulation were defined upon one side of the brain, and the corresponding area was then sought for on the opposite side of the brain. These positions were measured with callipers and marked in the drawings. When all the areas had been recorded they were individually mapped out again and the results checked. In this way unnecessary stimulation was avoided, and it was possible to obtain movements by the use of faradaic currents only just perceptible to the tongue.

Results.—The movements obtained by stimulation of the appropriate cortex (fig. 1) have been:—(1) Retraction of the head with rotation of the face towards the opposite side (A. fig 1). (2) Rotation of the opposite fore-limb with backward movement of the shoulder(B.). (3) Extension of the opposite hindlimb and contraction of the muscles of the back(C.). (4)Abduction and adduction of the tail(D.). (5) Closure of the opposite eyelid(E.). All the movements obtained were crossed. Other limb-movements were noted by stimulation in the vicinity of those mentioned above, but were not constantly found.

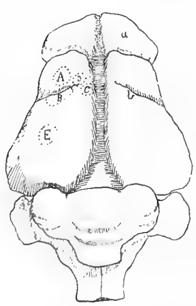

Fig. 1.—Dorsal surface of brain of *Perameles obesula* showing cortical motor areas—a. olfactory lobe. b. sulcus orbitalis. A, B, C, D, E, cortical areas, see text references. Natural size.

These results were obtained in all of five animals examined in August and September, 1905.

In conclusion I would express my thanks to Professor Anderson Stuart, in whose laboratory this investigation was carried on.

WEDNESDAY, SEPTEMBER 26TH, 1906.

The Ordinary Monthly Meeting of the Society was held in the Linnean Hall, Ithaca Road, Elizabeth Bay, on Wednesday evening, September 26th, 1906.

Mr. Thomas Steel, F.C.S., F.L.S., President, in the Chair.

Miss MARGARET FLOCKTON, Gladesville, was elected an Associate Member; and Dr. R. J. MILLARD, Board of Health, Sydney, and Mr. LEONARD RODWAY, Hobart, were elected Ordinary Members.

The President announced that the Council had elected Mr. R. H. Cambage and Professor J. T. Wilson, M.B., Ch.M., to fill two extraordinary vacancies in the Council caused by the decease of the Hon. Dr. Norton, and Dr. J. P. Hill's removal to London.

The Donations and Exchanges received since the previous Monthly Meeting, amounting to 5 Vols, 60 Parts or Nos., 15 Bulletins, 3 Reports, 19 Pamphlets, and 2 Maps, received from 39 Societies, &c., and 5 Individuals, were laid upon the table.

NOTES AND EXHIBITS.

The President exhibited a specimen of the volcanic dust from Mount Vesuvius which fell over Naples during the recent eruptions, also of volcanic ash from Pompeii, and of the dust from the eruption of Mount Pélée, Martinique, in 1902.

The President mentioned that there is at present on view in the bedstead department of Messrs. Anthony Hordern & Sons, a most interesting and instructive working model showing the great ocean currents of the world. All the principal land masses and islands are modelled to scale and surrounded by water. The currents are produced by jets of air issuing from numerous little brass tubes, and the motion of the water is made visible by means of lycopodium sprinkled on its surface. The model was constructed from the designs of Prof. A. W. Clayden, of Exeter, England, and was purchased from the makers—Messrs. G. Philip & Son—by Mr. S. Hordern. A similar model was acquired some years ago by the Japanese Government.

Mr. D. G. Stead exhibited examples of the following species of fishes, which, he stated, were new to the fauna of New South Wales:—*Dasyatis sephen* (Forskal), from Clarence River; *Dasyatis uarnak* (Forskal), from Clarence River; *Epinephelus tauvina* (Forskal), from Macleay River; *Genyoroge sebæ* (Cuvier and Valenciennes), from Broken Bay; *Emmelichthys nitidus* Richardson, from Port Jackson; *Auxis thazard* (Lacépède), from Port Jackson; *Gasterochisma melampus* Richardson, from Shoalhaven; *Bramichthys woodwardi* Waite, from Port Jackson; and *Sphæroides pleurostictus* (Günther), from Clarence River. In addition, he recorded for the first time the occurrence of the well-known Albacore, *Germo germo* (Lacépède) on the coast; an adult specimen 43½ inches in length was taken during 1903 at Port Macquarie, and portions of it had been handed to him for determination. Mr. Stead also pointed out that *Dasyatis sephen* above recorded is probably the most dangerous of all our sting-rays, as it has a most powerful, muscular tail, and is able to to strike further in any given direction with its long and sharp, barbed spine, than any other species.

Mr. Froggatt exhibited the larvæ, pupæ, cocoons and living specimens of *Axionicus insignis* Pasc., taken from the stem of a damaged Kurragong tree at Junee, N.S.W. Though the beetle is very common upon the bark of this tree, this is the first that the life-history had been recorded. The eggs appear to be laid in a damaged spot on the bark; and the larvæ burrow and feed in the undersurface of the bark and the upper surface of the wood beneath. This causes a great exudation of gum, and it is probably to protect themselves from the gum that the larvæ construct such solid cocoons in which to pupate.

Mr. Maiden exhibited another sample of the fibre of the marine plant, *Posidonia autralis,* forwarded to him by Mr. W. Gill, Conservator of Forests, Adelaide (20-viii.-06), with the following note :—"It has been found in several places on our coast and seems abundant in the sea; so much so that it often clogs the machinery of the dredge working at the Outer Harbour (near Port Adelaide). It seems likely to be of value as a fibre-yielder and has aroused some interest, but no definite information has yet been obtained. Our Surveyor-General inquires from me about it."

Mr. W. M. Carne sent, for exhibition, portions of fresh branches of a four-year-old Aleppo Pine (*Pinus Halepensis* Miller) now flowering at Richmond, which afforded an interesting example of heterogamy, or an arrangement of the sexual organs different from that which habitually obtains. The upper branches of the tree were bearing normal isolated cones, but in all the examples from the lower branches which were exhibited, the female sporophylls (cones) were growing at the summits of the male sporophylls (amenta). [Similar cases in other Conifers are mentioned in Maxwell T. Masters' "Vegetable Teratology," p.191].

Dr. Petrie offered some remarks on the occurrence of strychnine in the bark and wood of one of the Queensland species of Strychnos (*S. psilosperma* F.v.M.).

Mr. Fletcher stated that he had received a letter from Miss Lodder dissenting from the explanation of the occurrence of small fishes (*Galaxias* sp.) in damp earth at Strahan, Tasmania, put forward at last Meeting. In Miss Lodder's opinion the fishes were not simply æstivating in ground which represented the bed of a water hole or swamp which had dried up, as they were found in a grass (tussocky) paddock, probably swampy in the rainy season. Mr. T. S. Hall, M.A., Melbourne University, had also kindly written, calling attention to his note on a similar fish from the same locality. ["A Burrowing Fish (*Galaxias* sp.)." Victorian Naturalist, xviii. 65, Aug. 1901].

Mr. Fletcher also exhibited flowers of a common Epacrid, *Melichrus rotatus* R.Br., which had been gathered fresh and placed in closed tubes for several days, to show the relatively extraordinary amount of honey or nectar which is produced. This is presumably secreted by the "five large scales [of the corolla] densely covered with prominent glands, alternating with the stamens inside." The suggestion was offered that the appearance of the nectar, which is at first clear and colourless but becomes yellowish-brown as the flowers age, rather than its taste, was probably what Robert Brown particularly had in mind when he chose the generic name [μελιχροος (-ους) rather than μελιχρός].* The descriptions of the textbooks make no mention of any character to which the colour or taste of honey is attributed. The use of the honey as a lure or trap, and its function, if any, in facilitating cross-pollination remain in doubt at present, as so far (from daylight observations) the plants had always been found to be singularly free from visitors likely to act as pollinators, even ants being conspicuously absent. The plant flowers from July to October, and among noteworthy points were the scarcity of fruit in the early and middle portions of the flowering period; the early stage at which the anthers are found to be empty in open flowers, and the difficulty of finding out what becomes of the pollen; and the more or less complete submergence of the pistil in the nectar as the flowers fade and shrivel.

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* Subsequently, on referring to Mr. F. M. Bailey's "Queensland Flora" (iii. 927), it was found that the author gives "Flower-glands honey-coloured" as the meaning of *Melichrus*. The glands and the honey, at first, are alike colourless in the fresh condition. As Robert Brown had the opportunity of examining fresh flowers, the appearance of the honey rather than that of the glands (with the remains of the honey) as these are seen in dried herbarium specimens, may possibly have attracted most attention.

THE NEW ZEALAND SOUND (AND LAKE) BASINS AND THE CANYONS OF EASTERN AUSTRALIA IN THEIR BEARING ON THE THEORY OF THE PENEPLAIN.

By E. C. Andrews, B.A.

(Plates xxxix.-xli.)

INTRODUCTION.

The following brief note was suggested by a perusal of three recent geographical articles* by Professors W. M. Davis, W. S. Tangier Smith and R. S. Tarr, and is mainly an extract from a larger note just going to press. In the latter—copiously illustrated with maps, photographs, sketches, and sections—an attempt is made to prove that the various high plateaus of New South Wales are the result of incomplete reductions to base-level (sea-level) by stream agency during periods of comparatively stable equilibrium. It may here be stated that several of the physiographic processes discussed in this note are not unknown to science, as the works of Playfair, W. M. Davis, G. K. Gilbert, Penck, Tarr, and others so ably prove. The claim to originality consists in taking certain, heretofore, *isolated* facts and pointing out the logical consequences of accepting them. Their co-dependence becomes at once strikingly manifest, and successive steps in a whole routine of perceptions admit of clear and ready statement. Thus a corollary from the proposition that stream channel grades in bed-rock are the result of *mighty* floods only is that we must wait until the next immense ice-flood before expecting to see the old glaciated contours altered; similarly, the grand

* W. M. Davis, (c) pp.207-239; W. S. Tangier Smith, pp.155-178; R. S. Tarr, pp.351-370.

contours of shore lines and river mouths are explained by terrific streams of *rare* occurrence, the action of *prevailing* currents carried on during the long years of inter-storm occurrences being almost negligible in this great work.

For the readier understanding of the present note a brief summary of the late-geographical history of Eastern New South Wales (also E. Australia) and South-Western New Zealand, as understood by the author, is here furnished.

i. Eastern New South Wales (also Eastern Australia).

(*a*) Eastern New South Wales—as also doubtless the eastern strip of Australia generally—has formed a geographical unit since Cretaceous time.

(*b*) Upper Cretaceous time appears to have been marked by the development of a great plain of erosion. Monadnocks, however, attest to the existence of a still earlier plain of erosion.

(*c*) An epeirogenic movement interrupted the final touches which were being bestowed on the peneplain and carried the plain to a considerable height above sea-level.

(*d*) Valleys retreated headwards into the central plateau, but, prior to their mature development, a gentle subsidence of the central areas of former elevations supervened and the torrent tracks were replaced by lakelets. In these were deposited many plant remains to which various ages* such as Eocene, Miocene—and even Pliocene in certain cases—have been assigned by eminent palæontologists and palæobotanists.

(*e*) Subsidence still progressing, great fissure† eruptions of basalt again and again inundated the sunken area and buried the "leads."

(*f*) A period of comparatively stable equilibrium ensued and a gigantic plain of erosion was carved out of basalts, Tertiary "leads" and the associated geologic complex alike. From its

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* Baron von Ettingshausen; Sir Frederick McCoy; Baron von Mueller; Reginald A. F. Murray, pp.86-92.

† T. W. E. David, (b) pp.108-109; E. C. Andrews, (g) pp.16-17.

characteristic appearance in the less reduced central areas, the author has named this now elevated plain the "Upland Valley Level."* Its age is probably Miocene or even Pliocene in part.

(*g*) A gentle elevation of the "Upland Valley" Level closed this stage, and a series of broad, shallow, and well-matured valleys† were developed in the "Upland Valley" Level (Plate xli.).

(*h*) Then came the great elevation of Eastern Australia. The movement was differential and varied in the central areas from 2000 to 6000 feet. Large flexings and faults accompanied the movement, as at Lapstone Hill,‡ Kurrajong,‡ near Armidale,§ Guy Fawkes,§ Tingha,§ Kosciusko and Kiandra.§ The movement was of an excessively slow nature, since the streams were simply revived and not turned out of their courses even when hard structures were warped athwart|| their direction of flow. [In warped areas also, as in New England, the cañons are seen retreating *along* their old matured valleys (Pl.xli.).] The movement is youthful, since the eastern cañons resulting from such uplift have not yet reached the central plateau, but head along their old well-matured tracks in gigantic waterfalls (Pl.xl.). On the western slope the stream channels, however, as a result of comparative aridity and terrific storms of rare occurrence, have approximated already to the graded stage.

(*i*) In historical time a movement of subsidence, amounting to several hundreds of feet, affected the whole eastern coast of Australia.

(*j*) A vibration of elevation¶ marked the latest of these Eastern Australian movements.

(*k*) A period of stable equilibrium has succeeded to the very recent elevation.

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* For this term I am indebted to the work of Prof. A. C. Lawson mentioned in the list of authors supplied at the end of this note.

† Rarely do these valleys exceed 300 feet in depth.

‡ T. W. E. David, (a) pp.359-370.

§ E. C. Andrews, in preparation.

|| E. C. Andrews, (c) pp. 812.

¶ E. C. Andrews, (c) pp..815-824.

ii. South-Western New Zealand.

(*a*) An incomplete plain of erosion was induced, by subaërial agencies, in the igneous, sedimentary and crystalline schistose complex. Huge "relict" mountains point to the existence of a former higher plain.

(*b*) An enormous differential movement closed this cycle of erosion. Great faultings and flexings appear to have accompanied the elevation. At Preservation Inlet a plateau some 1500 feet high is seen, while apparently the same elevated plain is nearly 6000 feet in height* a little farther north.

(*c*) Streams acted on this warped mass so as to produce a series of graded valleys.

(*d*) Glacial conditions supervening, the old graded water channels were lowered so as to become adjusted to the new and heavier burdens imposed upon them. In this way spurs were removed, valley walls were straightened, hanging valleys were produced, and huge basins were excavated in the valley floors almost 2000 feet† below sea-level.

THESIS.

Streams, of whatsoever material composed, and in plateaus however high, attempt an early and decided approximation to main base-level. At a certain stage of erosion a grade occurs along which the strongest floods only obtaining in the particular area under consideration can effect even slight corrasion of the channel bases. Henceforth lateral corrasion gains the ascendancy over vertical work.

This stream slope may be called the *transitional* grade.

In areas of homogeneous material the *transitional* grades, for streams of varying strength, could be worked out from the

* E. C. Andrews, (h) figs. 1, 2 and 3. See also J. M. Bell.

† As will be shown in this brief note, these sound and lake basins could have been predicted on the assumption of an ice-flood by analogy with the observed work of ordinary streams and sea-waves in respectively excavating basins and cutting platforms below base-level.

transitional grade known for any one member: this by use of the formula—(Transportation) varies as (Velocity)^6.

Stream grades are determined by the mightiest floods *only*, the normal stream being mainly functional in smoothing over the irregularities marking the approximation of floods to base-level. Extreme types of these activities are to be found in ordinary roadside flood-streams, the Amazon River in flood, the ice-floods of the recent great Glacial Period, and the storm sea-wave.

Thus several distinct plateaus excavated in a geological complex, and arranged in vertical succession, without faulting, represent as many cycles of erosion forming plains *at or near base-level*, later elevations giving the present heights to the upland levels.

Flood and drought-stream grades.

Let us consider the action of streams on a raised plain. Such a plain may be, structurally, homogeneous, a series of horizontal strata varying in texture, or a geologic complex.

(a) *Action of streams on a homogeneous mass upon uplift.*

The quickening of stream velocity by the uplift allows of the early incising of the raised surface. Every stream seeks to maintain a grade along which to accomplish efficient work, yet, at the same time to approximate as *closely as possible* to base-level. The establishment of a grade along which the stream can only just cope with its load leads to main stream action being directed towards lateral cutting. These truths follow immediately from gravitative considerations. The stronger the stream, the flatter the grade along which appreciable work, as corrasion, can be accomplished. *Mighty* floods are enabled to excavate deep holes below local and even *main* base-level, thereby demonstrating their ability to accomplish important work along *much* flattened grades. The depths of these holes excavated below the temporary or main base-levels are measures of the strength—*i.e.*, volume (depth) and velocity of the flood. This leads to the important consideration *that present channel grades are not measures of the strength of normal stream action, but that of the mightiest floods.* Normal stream activities are mainly functional in restoring a uniform grade by aggradation *of flood holes.* The apprehension of this fact is absolutely vital to the proper understanding of land forms. One very strong flood will do incalculably more work than a decade of ordinary weather. Thus the author has seen, along an eastern torrent track in New England, a storm which yielded some 10 or 12 inches of rain within an hour. Hundreds of boulders, many tons in weight, were dashed against each other in the creek bed until they had covered one another with small holes from half-an-inch to an inch in depth. Smaller blocks were carried along with such force as to produce loud shrieks as they struck each other. Large basins were ploughed out to such depths along the torrent bed that the later work of the stream has been *entirely confined to their aggradation.*

A very powerful stream, therefore, quickly accomplishes its vertical work, and even develops holes below local base-level to depths roughly commensurate with its own height above base-level at that particular spot; a very weak stream, on the other hand, does its vertical cutting much more slowly. After a certain stage of downcutting has been reached, *each* possesses a grade the lowering of which progresses almost infinitely slowly, and lateral cutting henceforth assumes the ascendancy. This slope, for any stream, at which vertical cutting becomes very inefficient, *i.e.*, along which the heaviest floods alone obtaining over the area can cope with their loads so as to produce any corrasion of their beds, may be called the *transitional grade.* For weak and strong streams alike all such transitional grades are fairly close approximations to base-level, as will be proven anon; nevertheless they differ widely among themselves. For a very powerful stream, the transitional grade of an insignificant brook would be excessively steep, and, if acted upon by such stronger body of water, would be quickly made flatter before lateral corrasion, in its case, gained the upper hand.

To select a simple illustration:—The normal stream of the giant Amazon River is *excessively* powerful compared with the mightiest floods of our Eastern New South Wales streams, and would, if turned into their valleys, quickly corrade their short channel bases almost completely to sea-level; nevertheless as its own channel grade is the result of mighty floods, the normal stream of even such a river as the Amazon merely purls among its flood boulders.

If by experiment the grade of a certain stream channel entering this transitional stage should be ascertained, then the grades of streams of equal volume, but of varying velocities, at this transition stage could be very simply calculated, since power of transportation varies as the sixth power of the velocity.

In this connection we may consider the flood grades of several stream types, two characteristically developed in Australasia, and two being common facts of experience the world over :—(1) The ordinary roadside gutter flood-stream. (2) The storm-wave. (3) The flood-glaciers of New Zealand. (4) The New South Wales streams.

(1) *Ordinary roadside streams.*

Miniature examples of eroded lake basins, etc., occur along all disused roads where the wheelruts have determined new stream courses, and the channel occupies the whole valley. Here, after a heavy storm, at the bases of miniature *steeps* or marked rut convergences, basins will be found with reversed grades lower down stream, flat-bottomed valleys exist having precipitous and straight-bordering walls, and plunging waterfalls, with deep holes at their bases, are common. In areas of weakness, also, such as heaps of mine "slimes," the tiny cañons thus formed are all quickly carried, approximately, to base-level* before lateral corrasion causes noticeable widening of such cañons. If now we consider the base *only* of an ordinary river valley it will be found that both it and the roadside gutter have much in common. The river flood channel has its straight-bordering banks, its rapids, and its depressions below temporary base-level. In the one case the river occupies but a tiny fraction of its valley, while in the other case the stream, in the earlier stages at least, occupies the whole of its valley. This fact throws a flood of light upon

* *i.e.*, the level of the "bed-rock" supporting the "slimes."

glaciation, which then, in turn, being admissible into the discussion, casts a strong light upon the theory of the peneplain. To this we will return shortly.

(2) *The storm wave.*

The wave of translation may be considered as a stream whose efficiency, as a rock-corrader, depends on its velocity and volume. The difference between the wave and the ordinary stream is that the one corrades by descending to base-level, the other acts from base-level to a depth below that plane determined by its gravitative thrust. In this way the depths below sea-level of the wave-cut platforms are the counterparts of the depths of flood-holes in ordinary rivers, and, as will be shown directly, also of fiord-basins excavated by ice-floods. Naturally these various gravitative thrust types differ quantitatively, since the ice-floods were frequently 100 times as high as the stream- or wave-flood.

Ordinary streams generally work normally to the coastal curve, while wave grading progresses in a direction parallel to that line. Each attains a linear development at the outset, but the one by advancing, the other by meandering, form wide areas of corrasion. But, in all, it is the mightiest floods only which determine the channel grades

Therefore the wave-cut slope which marks the encroachment of the sea upon the land is a *flood grade.* Here the flood wave is determined by the heaviest storms. The function of the normal current, tide and wave is simply to equalise the shore slope by aggradation of irregularities of contour (made during heavy floods). The shingle masses are the weapons of the storm wave. In periods of calm the bathers know the apparent stability of position for the boulders where the sand only moves gently amongst their bases. In heavy storms, however, their shrieks may be heard as they attack the cliff or retreat along the shore. That is, these grades have been cut by storm waves, and as such they are *too flat to allow of further corrasion by normal activities.* It will be well now to see how applicable all this is to ice flood grades, and from these in turn to learn somewhat of the earlier stages of peneplain formation.

(3) *The glacial floods of New Zealand.*

To establish the fact that the lake and sound basin contours of South-Western New Zealand are practically the expression of ice-flood attack along preglacial channels and not the result of recent subsidence, will be to justify the introduction of a brief account of their origin into this discussion, for it will then be seen that they represent the early attack of streams on lofty plateaus, such attack—even in the enormously elevated land blocks of New Zealand —having given rise at the outset to deep cañons, with floors at times developed *thousands of feet below sea-level, and that also before such time as lateral corrasion had found opportunity to appreciably widen the cañons themselves.* This would materially help us in our efforts to understand the origin of the peneplain, since it would demonstrate the futility of expecting peneplains to be formed, in homogeneous masses, at heights differing at all materially from the main base-level. In the following brief explanatory notes the details of movement as exhibited by glaciers need not concern us. Professor T. C. Chamberlin* appears to have satisfactorily shown that glacial motion "involves only the *momentary liquefaction of minute portions of the mass*, while the ice, as a whole, remains rigid, as its crystalline nature requires. Instead of assigning a slow viscous fluidity, like that of asphalt, to the *whole* mass, which seems inconsistent with its crystalline character, it assigns a free fluidity to a succession of particles that form only a minute fraction of the whole at any instant." It will, however, be sufficient for our purpose to note that the general aspect of glacial motion is analogous to that of a viscous mass.

The difficulties apparently attending the conception of a stream origin for the lake and sound basins of New Zealand appear to be :—

(1) The apparent impossibility of excavating rock basins, thousands of feet in depth below main base-level, by stream-action.

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* T. C. Chamberlin p.11.

(2) The apparent lack of corrasive power displayed by even such great glaciers as those of present day Greenland.

With regard to the first-named difficulty, viz., the great size of the sound and lake basins, it appears to be merely a question of the size and velocity of the agent employed. In the case of the ordinary river, long holes over 50 feet deep are ploughed out below temporary base-level during high floods. The enormous flood sea-wave also can apparently carve out a rock platform to depths exceeding 100 feet below sea-level. A strongly converging ice-stream, say 5,000 to 6,000 feet in depth such as once occupied Milford Sound, should be able, also, at such points of cañon convergence, to corrade to great depths below base-level. For the efficiency of a glacier, as regards vertical corrasion, is not necessarily limited by the level of the temporary base on to which it descends any more than the flood streams of roadside gutters, ordinary rivers, or the ocean are. As a matter of fact one would naturally expect the flood glacier to exert an influence comparable at least with its own depth. Thus if the river flood (say 50 feet in depth) could produce a hollow in its bed some 50 feet deep, and the storm wave, less than 100 feet in height, carve a rock platform deeply below sea-level; so also we should expect the glacier 5,000 to 6,000 feet in depth to not *necessarily* lose its corrasive power at points of marked cañon convergence, until it had produced a basin comparable in depth with its own height above base-level. And it is just at such points that we find deep sound and lake basins. Thus at Milford Sound, to take one out of many illustrations the old glacier had a short and steep run to base-level, and the main fiord cañon has but little larger area in cross-section than that of either of its two converging feeders, viz., the Arthur and Cleddau Cañons. The floors of the cañons themselves are but slightly raised above base-level, but the sound formed by their sharp convergence is a rock basin with a floor nearly 2,000 feet below base-level. Lower down, at the junction with Harrison Cove Cañon, the depth is even more accentuated. Moreover, the Sound walls are enormously high; so that the ice-flood was prevented from spreading and was forced to fiercely scour its narrow channel. At the fiord or Sound mouth, where the gravitative thrusts due to convergence and rapid fall had been greatly expended, the depth of the rock basin is quite insignificant as compared with the depths occurring near the convergence of Harrison Cove, the Cleddau and Arthur Cañons. Again, the sides of the Sound are undercut; spurs have been removed; lateral valley mouths have been removed so as to leave the streams "hung" up (or perched) hundreds, or even thousands, of feet above the main waterway; and the cliffs of the Sound facing the cañon convergences are undercut to an amazing extent. Now all this may be seen, on a small scale, along a disused road, where the ruts are occupied entirely by storm waters. Here, at rut convergences, and at local steeps, deep basins with reversed grades lower down stream are well seen, and, moreover, such basins have steep bordering spurless walls.

No topographer, in fact no casual student of geography who has lived in a nonglaciated area, could, moreover, mistake these New Zealand cañons for stream-developed valleys. The enormous undercut walls, the planation of spurs, the great rock basins with reversed grades, the wealth of cirques, the hanging valleys, all point indisputably to one fact, viz., that *whatever* agent imposed these plateau forms on the landscape, such agent had occupied *all, or at least the greater portions, of the cañons.** For the forms, gigantic as they are, show the one form; the slopes are orderly and continuous, and are such as one observes along a stream valley if attention be directed *only to that portion occupied by a great flood.* Magnify the river flood channel to Brobdingnagian proportions and we have a New Zealand cañon with its associated lakes or Sounds. Nor can we seek to explain the peculiar depths of the Sounds by calling in postglacial subsidence, and thus minimise the effects of gravitative thrusts in acting to points deeply below base-level. The tale of moderate subsidence is certainly told, for postglacial time, all round New Zealand and East Australia,

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* For magnificent illustrations of these contours, see figs. 1, 2 and 3 in W. M. Davis ( ).

but to nothing the amount demanded by the Sound depths. It is hardly conceivable that the Sounds area should have been the one spot to have sunk so deeply after the *release* of so great a load as it was burdened with, the surrounding and but slightly sunken areas being practically, at the same time, devoid of ice-load!

In the second place it has been claimed that *mighty* present-day glaciers, such as those of Greenland, are not actively corrading their beds, but lie, instead, inactive in fiords and valleys; and that therefore even larger glaciers cannot be expected to have seriously modified their channel forms. But this present inactivity must occur of necessity, as has been already shown in part by the author,* since the fiord bases, in common with other stream-channel grades, represent the action of the *mightiest* floods only, and as such their slopes are altogether too slight to admit of corrasion by the present *drought-stricken* ice-streams. Here again is evident the necessity for a clear conception of the idea that floods accomplish the rock corrasion and determine the channel grades. Very heavy floods in ordinary rivers are not infrequent, and therefore their efficiency is easily appreciated. Were they, however, as in the case of the Great Ice Deluges, to be of rare occurrence only, then controversy would, in turn, rage round the origin of fishing holes in the river, the huge boulders in the channel, the comparative freedom from débris in a channel narrow, as also other peculiarities of contour along the flood-channel. The drought-stream itself would be studied and its utter incompetency observed to do aught than *babble* around or *override* the flood débris, and hence the conclusion might be arrived at that the theory of rock erosion by water action was a delusion. The great masses of flood débris would be examined and referred to a period of former "intense water action" when huge floods had acted so as to suspend and even transport large fragments over each other, yet smoothly without much friction. Some observers would, from an observed absence of much débris in certain steep narrows, actually deny even the presence of a flood at those spots.

* E. C. Andrews (h).

The undercuttings of banks and spurs would be incomprehensible except as products of weathering and landslips. The shriekings and crashings of the boulders under the influence of a flood along a torrent track would be altogether denied, since it would be carefully noted that even the Amazon—the greatest of river streams, as the Arctic and Antarctic glaciers are amongst ice-streams—under the normal conditions perceptible only to them, fails to rouse to action its load of flood débris, but loiters and babbles only amongst the pebbles and boulders.

And the one thing needful to clear away the doubt would be an apprehension of the fact that a *drought-stream cannot reduce a grade along which the mightiest floods have acted so as to approximate their channel bases to, if not to actually reach, that transitional grade when they themselves even have parted with most of their efficiency as vertical corraders.*

(4) *Streams of Eastern New South Wales.*

These are weak streams, and nowhere possessed of a greater length than 330 miles.

The Hawkesbury (Wollondilly).—The Upper Hawkesbury or Wollondilly near Wombeyan flows through the dense granites in a profound gorge 2,100 feet in depth (Pl. xxxix.). It is evident at a glance that it is still actively downcutting, having, as yet, found no opportunity for lateral cutting in the acid igneous series through which it flows. Yet here, more than 200 miles from its mouth, and not far removed from its source, it is *625 feet only above main base-level*; while the enormous upland valley, 15 to 20 miles in width, through which it has cut its way is *some 2.700 feet above the same level.* The cañon, the far stretching upland valley, and the still higher and older enveloping plateau, are alike carved, in places, out of fairly homogeneous Palæozoic granites.

The Wollondilly has then *not attained to its transitional grade.*

The Macleay (New England).—The headwaters of this stream wind sluggishly for distances of from 20 to 50 miles in the matured valleys (3,200 feet above sea-level) of the Upland Level.

They suddenly precipitate themselves (Plates xl. and xli.) over enormous ledges into knife-shaped clefts. Generally, after traversing these torrent-tracks for several miles only they have established themselves thus early *some 2,000 to 2,500* (Plate xl.) *feet below the mature valley level*, while 30 or 40 miles down, but still 150 miles from the sea, their channel bases rarely exceed heights of from 500 to 600 feet above base-level. In every case where traversing hard rocks they occupy V-shaped cañons, showing the absolute impotency of lateral corrasion at these points; in other words, the transitional grade has not yet been attained.

The Clarence River (New England).—This is a stronger stream than the Macleay, but of identical age, and has cut its channel still *more closely* to base-level. Along the south arm, and nearly 200 miles from the sea, the height above base-level is about 400 feet. Here enormous basins occur in the channel, showing the effects of floods. Yet in the hard rocks it flows as a *profound defile*, showing that even its weak grade has not nearly reached the transitional stage.

In all these examples incipient plains are being formed near the river mouths, but here for nearly 100 miles inland the grades of the streams are practically nil. Before plain-making can proceed in the hard central areas, the channel grades must be still considerably reduced; that is, at that stage they will be but slightly above sea-level.

iii. Western Slope of New England.

The Namoi near Manilla and the Gwydir at Bingara exhibit similar features to those of the eastern streams. The Gwydir here issues from a remarkable gorge cut in a hard Palæozoic plateau (Upland Valley) from 2,200 to 2,400 feet high. It is 1,700 miles from the sea, but only 1,000 feet above that level. The immense "Black-soil Plains," however, distant some 70 to 80 miles by stream and 700 feet above sea-level, form a *local* base-level.

From a comparison thus of the New Zealand fiords (and cañons) with the flood channels of northern New South Wales rivers, and each of these, in turn, with the marvellous topography of disused roads, the first-named is seen to represent merely a phase of vertical cutting by ice-streams and thus to throw a flood of light on the theory of peneplanation, for if we had no evidence of similar strong stream-action excavating locally for thousands of feet below base-level before commencing serious lateral cutting, we might be inclined to imagine the *transitional* grade as a negligible quantity only in the discussion. On the other hand, unless we had compared these enormous ice-streams with modern rivers and found them producing similar forms to those effected by present day rivers *along their flood channels only*, it might have been supposed that their *containing* fiord and cañon contours were due rather to diastrophism than to stream-erosion, and as such a mention of them would have been irrelevant to the present discussion. Or still again, unless we had ascertained that the gravitative thrusts of ordinary flood streams, as also of storm sea waves, acted to points *considerably* below base-level we might have been prepared to deny the fact of glaciers having any material influence in shaping the contours of their cañons, and this being so, we again could not hope, from glacial studies, to get much light thrown on stream studies as illustrating peneplain formation.

In a word, then, streams of any material will, in homogeneous plateaus, however high, cut their channel bases to points approximating *closely* to base-level before lateral corrasion gains the ascendancy. Even the weak and short New South Wales streams are still actively corrading their channel bases in attempting the establishment of *transitional* grades, yet they have already incised their ways thousands of feet into the old Upland Valleys, and along their V-shaped *torrent tracks even* the channel bases are from 400 to 600 feet only above sea-level. The closer and quicker approximation of certain streams to base-level than others, before entering that transitional stage when vertical cutting tends to approximate to zero, and lateral cutting gains the upper hand, is simply an expression of their greater strength. Thus the New Zealand ice-floods quickly lowered the preglacial stream grades to base-level along their lower portions, with production of huge basins thousands of feet deep below that level on certain *steeps* and at many cañon *convergences*, a *necessity* from gravitative considerations, as can be observed by comparison with the action of ordinary stream floods in determining their channel basins; with that of storm waves as forming rock platforms below sea-level; or as may be ascertained simply by a study of mechanics.

(*b*) Similarly for corrasion in homogeneous unstable structures.

(*c*)* The same reasoning holds also for a geologic complex. The important point to remember in this case is that, since a stream must preserve a slope from head to mouth, a strong belt of rock will check *vertical* corrasion in weak structures higher upstream. During this period the weak structures will suffer wholesale destruction by lateral cutting and more or less complete local planation ensue.† This, however, is merely a local effect, for the existence of the cañon stage in the lower stream rocks is at most a *very youthful* phase of plateau reduction.

CONCLUSION.

Therefore, in mountains or plateaus formed of homogeneous or complex structures, a *plain of erosion* can be formed only *after* the transitional grade has been reached and this will, even for weak streams, *show a very slight fall to base-level.* The Peneplain, or plain of erosion, will therefore be developed practically at base-level.

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* The case of planation in horizontal strata is dealt with in the main paper.

† In this way a stream valley is often observed to be *youthful* near its mouth and *mature* along its upper portions. The terms refer to developmental stages only, not to actual age.

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EXPLANATION OF PLATES.

Plate xxxix.

The Wollondilly (Upper Hawkesbury) Cañon at Wombeyan Crossing.

The excessive youth of the cañon is noticeable. The even sky-line in the background is the 3,200 feet level excavated in a Palæozoic complex. Photo by R. H. Cambage.

Plate xl.

The Wooloomumbi Falls, showing inception of cañons in New England. The Falls are 900 feet high and the wall through which it discharges is 1,500 feet in height. Here a mature valley is giving place to a young cañon.

(This is a Hanging Valley, and almost the only one known to the author in New England. The Chandler (right-hand stream in picture) and Wooloomumbi formerly effected a junction along their mature valleys near their present junction in the cañon base. The Wooloomumbi in sinking its cañon discovered a local hardness, while the Chandler had no difficulties to encounter. They have, however, only just become separated).

Plate xli.

View of Baker's Creek Gorge, Hillgrove, 1,500 feet deep. The sky-line marks the dismantled Upland Valley (Miocene) Level. In this have been excavated the mature valleys and the still later cañons.

A CORRELATION OF CONTOUR, CLIMATE AND COAL: A CONTRIBUTION TO THE PHYSIOGRAPHY OF NEW SOUTH WALES.

By T. Griffith Taylor, B.Sc., B.E., Assistant Demonstrator in Palæontology and Geology, University of Sydney.

(Plates xlv.-xlviii.)

Recent work in connection with the Stereography and Climate of New South Wales, while preparing portion of a textbook of physical geography for this State, has brought into prominence many interdependent physiographical problems.

The following is a dictum which I shall endeavour to substantiate in the sequel : The Hunter River district is an example of *equilibrium* in the distribution of natural resources, in that the large extent and value of the coal-supply are counterbalanced by a rainfall much below the general average for that latitude; and these statements, though apparently unconnected, are correlated, *the relatively low rainfall being indirectly due to the presence of the Permo-Carboniferous Coal Measures.*

If the stereogram* (or relief map) of New South Wales be examined, it is seen (*vide* Plate xlvi.) that the Main Divide is constituted of three well defined land masses separated by *cols on a gigantic scale.* For these the term *Geocol* is suggested (analogous to Geosyncline) to differentiate these important positive land forms from the ordinary col between two hills.

In fig.1. three contours, namely, those of sea-level, 1500 and 3000 feet respectively, are indicated. Their distribution gives

*Such a model measuring 6′×5′ was constructed during 1905 at the University by direction of Professor David, and exhibited before the Society in November, 1905.

rise to the *New England* "*Massif*" (using this term in its broadest sense to indicate a huge land mass), the *Blue Mountain Massif*, and towards the south the *Monaro Massif*. [The isolated Canoblas elevation (see fig. 1) is of little importance in the broad questions discussed.]

Between these elevated areas are situated, first the Cassilis Geocol—with its lowest points at Ardglen and Rylstone—and secondly, the less important Lake George Geocol between the Blue Mountain and Southern land-masses.

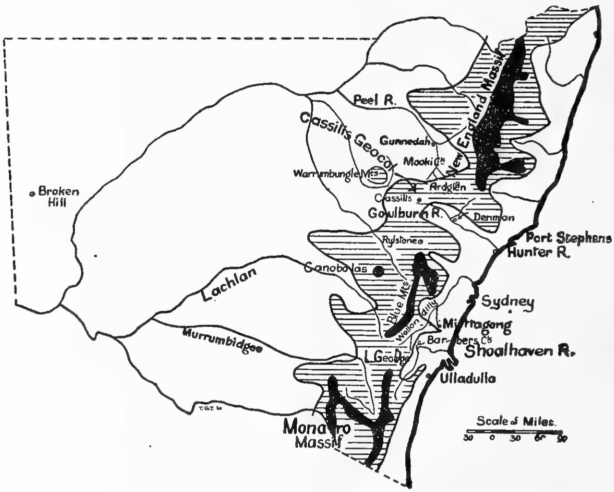

Fig. 1.-Contour diagram of New South Wales. Land elevated above 1500 feet indicated approximately by the *hatched* areas. Over 3000 feet by the *opaque* areas. The three "land massifs" and the Cassilis *Geocol* are shown, together with other localities mentioned in the text.

The plateau-like character of the New England elevation—so strongly insisted on by Mr. E. C. Andrews—is brought out by the large model of New South Wales forming the basis of the figures (Plates xlvii.-xlviii.). One can see that it is of greater physiographical prominence than the Kosciusko massif, though—perhaps owing to the type of hachures employed hitherto on Australian maps—the current opinion is that the New England area is of much less bulk than the higher Southern Mountains.

The question of the origin of the above land-forms next arises. The chief contours have undoubtedly arisen since Carboniferous times. The coal measures were laid down in a huge geosyncline due to earlier folding, possibly in Carboniferous times, since such

TABLE SHOWING THE STRATA INVOLVED.

AGE.	NAME.	THICKNESS.	CHARACTER.	POSITION.
Palæozoic. Permo-Carboniferous	Lower Marine	5000 feet	Shales and sandstones	Constituting portion of the outer margin of the eroded geosyncline.
do.	Greta Series	130	Coal and shales	
do.	Upper Marine	5000	Shales, sandstones, mudstones, etc.	The *peripheral* outcrop of the Coal Measures consists chiefly of these Measures.
do.	Newcastle & Tomago Measures	2500	Coal and shales	
Mesozoic. Triassic	Hawkesbury Series	2500	The upper thousand feet of hard sandstones	A layer protecting the *central* portions of the Coal Measures from denudation.

phenomena seem to have been world-wide at that period. From fig. 2 we see that this syncline, trending N.N.W., extended at least from Ulladulla to Gunnedah (the present northern boundary being somewhat oblique), and thence to the coast near Port Stephens.

Comparing the geosyncline with its beds to a "pile of saucers," we note that the uppermost "saucer" consists of the *hard uniform* Hawkesbury Sandstone, which, though not quite so large as the lower "saucers," most effectually protects the *centre* of the pile from atmospheric wear and tear. The *peripheral portion* of the lower beds is exposed, however, and gives rise to physiographical conditions eminently suited to river-deflection and capture (*vide* fig.2).

The two facts which stand out pre-eminently in the stereogram of the Coal Basin (see Plates xlv.-xlvi) are :—

(1) The extraordinary shifting of the Main Divide by the Hunter-Goulburn Rivers system.

(2) The curious bend of the Shoalhaven River near Marulan and Barber's Creek.

Can these be correlated with the geology of the areas in question?

It is suggestive that the rapid westerly cutting of the Goulburn River should have brought about one structure, while the rapid westerly erosion of the Lower Shoalhaven would seem to have given rise to the other.

The common factor is seen to be (fig.2) the outcrop of the peripheral portions of the Permo-Carboniferous Marine Series (or what is much the same thing—the thinning out of the overlying harder Hawkesbury Sandstones).

It is conceivable, and indeed probable, from study of the current bedding, that the Trias sediments, deposited in the centre of the basin, were derived to a great extent from the ancient southern highlands around Queanbeyan; and that the *ancient* Shoalhaven flowed *north* along the present position of the Wollondilly towards the centre of the Coal Basin.* It is certain that the present Nepean River system antedated the folding of the Blue Mountains, and the same holds good for the Shoalhaven.

There is evidence, far to the south of the classical Lapstone Hill occurrence, that the gradual earth-movements resulting in our

* See the Paper, postea, p.546.

present Blue Mountain Divide did not deflect to any great extent the course of many of the rivers. I refer to the Nattai gorge

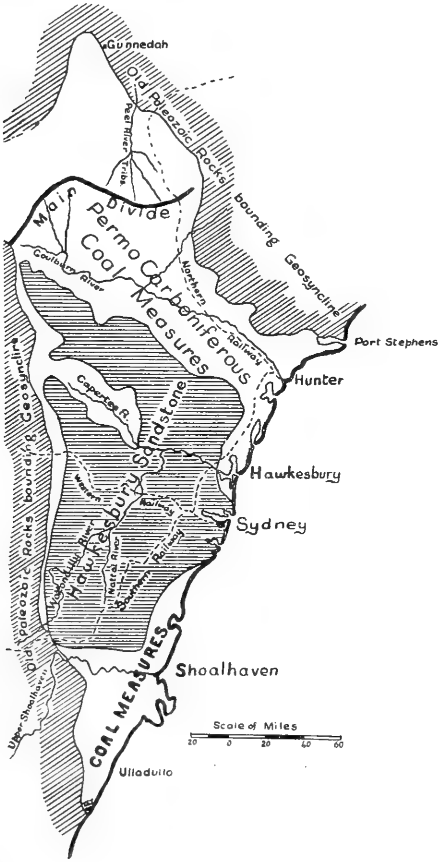

Fig. 2.—Geological sketch map of the Great Permo-Carboniferous Geo-syncline of New South Wales. The *older Palæozoic* rocks are hatched diagonally, the *Coal Measures* are not hatched. The later *Triassic Hawkesbury* Series is hatched with horizontal lines. The figure shows the peripheral exposed portions of the Coal Measures in which the chief phenomena discussed in the paper have occurred.

at Mittagong, where the stream leaves the broad triangular valley in which Mittagong is situated, and abruptly flows into a gloomy gorge with walls several hundred feet above its source. It continues through similar gorges for many miles.*

Consider now the action of a small consequent river while cutting back through the comparatively soft strata at the limits of the hard Triassic sandstones in the south of the Geosyncline. We will suppose its mouth lies north of Jervis Bay. It gradually erodes the rocks, striving to reach its base-level, while its bed has a lower "coefficient of resistance" (to borrow an engineering term) than that of the *ancient* Shoalhaven-Wollondilly River which flowed chiefly through an area of hard Triassic sandstones. There results a typical example of river-capture; the headwaters of the northward-flowing river (Upper Shoalhaven) are deflected into the young pirate stream (Lower Shoalhaven) and we get the present Shoalhaven with its abrupt change of course as mentioned above.

Turning now to the northern exposure of the Coal Measures, we see traces of a similar differentiation in river-erosion exemplified by the Upper Hunter and Goulburn Rivers. The Goulburn is the longer branch above Denman, its development being due to the lesser resistance of the Permo-Carboniferous marine strata. The Upper Hunter flows over older (*Carboniferous Age*) rocks within a comparatively short distance of Denman (the junction town), while, as seen from the model, the Goulburn is steadily eating into the main divide along the centre of the *Permo-Carboniferous* basin.

It is not difficult to predict the formation of an even more definite "geocol" to the west of Cassilis before no very great length of time (geologically speaking) has elapsed. It is possible that the New England massif originally extended towards the south and joined the Blue Mountains massif with but little lowering of the general 3,000 ft. contour. There is little doubt at any rate as to the action of the Hunter and its tributaries in materially *reducing the level of this region and thus leading to the*

* A figure illustrating this feature will be found at the end of a paper by Mr. Mawson and myself, opposite Plate xxv. Journ. Proc. Roy. Soc. N. S. Wales, Vol. xxxvii.

diversities in temperature and rainfall which will be discussed in the remainder of this paper.

It has been stated that the rainfall of New South Wales is due primarily to *horizontal* movements of the atmosphere. This in general holds true, but the *local* distribution of rain in this State is wholly due to its stereography, *i.e*, to the distribution of positive and negative land-forms.

To bring about rain it is necessary to cool air containing water vapour below a definite temperature (known as the saturation point, which is critical for the given proportion of water). This cooling generally arises in one of two ways, (1) by elevation of moist air into cooler and rarer regions; (2) by horizontal motion to cooler regions.

A glance at the *stereothermal* chart (Plate xlv.) shows strikingly the distribution of mean annual temperature. [This has been adapted from a temperature chart of some years back by Mr. H. C. Russell, B.A.] Four facts are noticeable—

(1) The general concavity (of the isotherms) directed towards the Central Australian area of higher temperature, and the broadening of the isotherms towards the Wimmera and Broken Hill districts. (2) The cool loops surrounding the New England and Kosciusko massifs. (3) The interesting looping of the coastal isotherms, indicating, as first pointed out by Professor David, a hot "hinterland" where the temperature is neither lessened by elevation nor materially lowered by proximity to the sea. (4) The *bulging of the isotherm up the Goulburn valley*, indicating (as the loop is *towards* cool elevated regions) heating above the normal. This bulge is directed towards the Cassilis Geocol. A similar interesting bulge up the Peel River valley* (towards colder

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* This bulge up the Peel River valley is probably due to river-erosion, and may be explained as follows:—The crescent-shape of the Liverpool Range is a further confirmation of the theory advanced. It will be noticed (fig. 2) that the southern tributaries of the Peel River (Mooki Creek, etc.) rise in the Liverpool Range. Their course lies for some considerable distance *within the northern portion of the Coal Measure area* near Gunnedah. They have thus been able to cut back rather more rapidly than other less advantageously situated streams in the north-east. The *concave* Liverpool Range thus reproduces on the northern slope a characteristic shifting of the divide similar to that due to the Goulburn River on the southern slope.

regions) to the same geocol, is indicated on the western side of the divide.

This fact—the higher than normal temperature on the Cassilis Geocol, tending to a lowering of the rainfall—is directly traceable to the erosion of the river basin.

A brief description of an actual general rainfall, its distribution and reasons for the latter, will serve to introduce a discussion on the annual rainfall distribution (as affected by contour) in New South Wales.

The general rains of October, 1905, show in a remarkable way the correlation between the three *massifs* and the three areas of maximum rainfall (see Plate xlvi.). The hot moist air from the north was raised by the *more elevated* portions of the divide into cooler regions than at intermediate positions, the result being indicated in the figure.

However, it is with the local rainfall of the Hunter Valley that we are more particularly concerned.

The rainfall data for two type-years, 1900 and 1902, were taken from the official publications, and *isohyetals* (lines of equal rainfall) plotted on the stereogram. The annual rainfall for this State lies near 24½ inches. In 1902 the average was only 14 inches—this being a drought year. In 1900 the average was 27 inches, being considerably over the average.

In Plates xlvii. and xlviii. for 1900-2 we see, as is natural, that the isohyetal lines lie roughly parallel to the coast. The greatest rainfall is experienced in the extreme North-East and in the Kiandra districts. The former maximum is owing to the elevation of moist warm air (flowing south from the tropical seas) by the Macpherson Range and adjacent portions of the New England massif. The precipitation being the greater perhaps since the air has not yet become *still further heated* by its contact with land-masses at somewhat greater temperature than the ocean it has left behind. The Kiandra maximum is largely due to the high level of the Kosciusko area, which reaches cold portions of the atmosphere where somewhat different conditions obtain.

A noticeable point is the way in which the isohyetal lines bulge *up* the river valleys in many instances, *from* the dry regions. (This is the wrong type of isohyetal bulge, from an economic point of view, since it indicates a rainfall *below* the normal for the area in question. It may be termed a *negative loop*). Thus in the stereo-isohyetal chart for 1900 (Plate xlvii.) such bulges may be noticed in the *10-inch line* up the Bogan and Darling, and on the *20-inch line* up the Namoi, Lachlan, etc. In the similar chart for 1902 the phenomena are much more marked (as in the cases of *10 and 15-inch lines* on the Lachlan and Murrumbidgee).

We infer that river-valleys on the western slopes of the Main Divide are relatively dry areas. The explanation is that the "interfluvial" areas being usually elevated, cause the isohyetals for the latter to become bulged *towards* dry areas, forming *positive loops* in these regions (*i.e.*, in the right direction). Thus arises the loop over the Warrumbungle Mountains (*vide* Plate xlvii.) and, *indirectly*, the loops directed up the river valleys previously cited.

Paying particular attention to the stereo-isohyetal maps of the Hunter River district, a very pronounced series of loops, projected towards the east, will be noticed in the charts for 1900 and 1902. These negative loops, *concave towards the western dry areas*, indicate abnormal decrease in rainfall. Normally the 30-inch line of rainfall would extend from X to Y direct (*vide* Plate xlvii.); but, owing to the shifting of the divide by the Goulburn and Hunter Rivers, the isohyetal 30-inch reaches almost to Maitland. This indicates, as stated, a very much lower rainfall than that of the districts north and south of the area. A similar bulge is noted in the Peel River district which may be ascribed to a like reason. In the chart for 1902 (in which year the rainfall was only half that of 1900) the corresponding loops in the 15- and 20-inch rainfall lines are very marked (*vide* R, S, T in Plate xlviii.), though slightly further south.

Finally may be mentioned the *deflection of the anticyclones*, so often noticeable on the weather-charts, by the Blue Mountains.

These huge eddies of air, moving over Australia from Perth to Sydney at a rate of some 400 miles per day, occasionally appear to be arrested by the Blue Mountain massif, perhaps for a day or so. As Professor David graphically puts it, when lecturing on this subject, " the preceding anticyclone having marched on ahead, a tension between the two areas of high pressure may be pictured, resulting in a sort of snap in the isobars. This may give rise to a 'Southerly Burster' from the south towards the abnormal low pressure thus produced," while the increasing pressure on the western slope of the divide causes the detained anticyclone to be deflected somewhat to the north; where it is able to *cross the relatively low levels of the Cassilis Geocol.*

We thus see that even the grand westerly drift of the anticyclones may be vitally affected by the variations in land-surface due to river-erosion.

Before closing this contribution to the physiography of the State, brief mention may be made of another interesting allied question, although it does not fall under the head of a correlation of contour, climate and coal.

Ferrel's Law and the Rivers of the Western Plains.—A highly interesting feature indicated by the stereogram is the constant *tendency of the Murray tributaries to curve towards the left.* This was pointed out when the model was exhibited in November, 1905, and a possible explanation is as follows:—According to Ferrel's law, *all bodies* (including water) *moving in the southern hemisphere have a tendency to curve to the left.* Other writers have brought forward examples of such river-curvature (*cf.* Obi and Yenesei in the Siberian tundras), and it appears to me that in the flat alluvial plains of the Murray-Darling system there obtains an ideal state of affairs in this connection. The Macintyre, Gwydir, Lower Castlereagh, Lachlan and Darling itself seem to show that there has been a greater tendency to erode the left bank than the right, giving rise to a gradual curving to the left. The rivers are several hundred miles in length, and the water necessarily passes across portions of the earth's surface which are rotating at very different speeds. Since the flow is not controlled very greatly by the slope—many square miles being practically flat—and since the influence of hard strata is practically wanting,

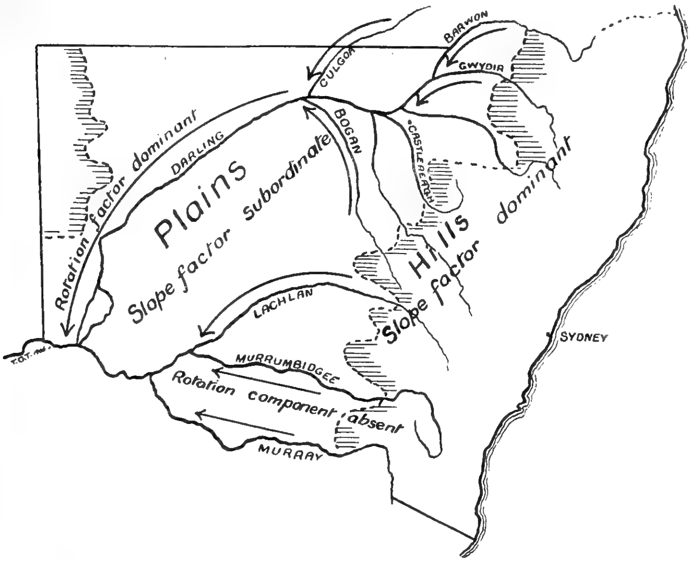

Fig. 3.—Ferrel's law of deflection applied to the rivers of the Western Plains.

one can readily understand that the earth's rotation becomes a prime factor in determining the course of the rivers (*vide* fig. 3).

The two rivers least affected are the Murrumbidgee and the Murray, which is what one would expect, since their course is practically at right angles to the meridians, and so the rotational factor has least influence.

The above hypothesis, though not connected with the Coal Measures of the State, seems of sufficient interest and importance to be introduced here.

In conclusion I would like to thank Dr. W. G. Woolnough, F.G.S., for help in preparing illustrations, and Professor David, F.R.S. To lectures by the latter I owe my knowledge of the fundamental principles involved in this paper, and I desire to

acknowledge the continued help and advice I have received from that gentleman.

Conclusions.

(1) The Cassilis Geocol exercises a profound influence on the climatological conditions of the State.

(2) This Geocol arises from the action of the Goulburn River on the south and the Peel River system on the north in shifting the Divide.

(3) This action having occurred on one and the same geological horizon (*i.e.*, Permo-Carboniferous Coal Measures)—coupled with similar action in the Shoalhaven district—indicates a correlation worthy of note between the Contour, Stratigraphy and Climate of this State.

(4) The rivers of the western plains of New South Wales seem to furnish a striking example of Ferrel's law of *moving bodies as affected by the earth's rotation.*

(5) The use of stereograms should be extended for all purposes of physiographical research.

EXPLANATION OF PLATES XLV.-XLVIII.

Plate xlv.

Mean annual lines of equal temperature (isotherms) plotted on the Stereogram of New South Wales, constituting a Stereo-isothermal Chart. This figure illustrates the bulging over the "Cassilis Geocol" and the hot "hinterland."

Plate xlvi.

Chart showing the connection between the general rain of October, 1905, and the three "land massifs" (rain in points). The position of the Hawkesbury Sandstones (H.S.) and Coal Measures (P. Carbs.) also indicated.

Plate xlvii.

Chart showing connection between land-form and rainfall for 1900 (Stereo-isohyetal Chart). The "negative loop" extending over the Hunter Valley is strongly marked; and positive loops are shown over the Warrumbungle and Monaro Ranges.

Plate xlviii.

A Stereo-isohyetal Chart for 1902, showing negative loops in the river valleys and over the Cassilis Geocol.

Postscript (*added 28th September*, 1906)—As regards the Geocol and its effect on the flora, Mr. J. H. Maiden, F.L.S., Government Botanist, has informed me that the flora of the Hunter-Goulburn Valley exhibits features of interest in this connection. A number of genera of plants, otherwise confined to the western side of the Divide, have apparently migrated over the Geocol, and form an *isolated* plant settlement in the littoral province of New South Wales. Among these may be mentioned such important examples as *Geijera parviflora* (Wilga), *Acacia salicina* and *Casuarina Luehmanni* (Bull-Oak). Hence it would seem to be justifiable to assign an important rôle to the Cassilis Geocol in the geographical distribution of plant-life.

THE STINGING PROPERTY OF THE GIANT NETTLE TREE (*LAPORTEA GIGAS* Wedd.).

By James M. Petrie, D.Sc., F.I.C.

(From the Physiological Laboratory of the University of Sydney).

The Giant Nettle-Tree is native to Australia, and grows plentifully in certain of the coastal districts. It is often found attaining a height of over 100 feet, with green, succulent stem and branches, which are very easily broken. Its leaves, often a foot in diameter, are very juicy, and are covered with numerous strong hairs or bristles which are filled with a powerful stinging fluid. If the leaves be lightly touched with the hand these bristles penetrate and break in the skin, causing pain which, however slight at first gradually increases in severity and sometimes lasts for many days. There are instances where children have been ill for weeks with the pain of the sting, and in certain seasons at least, it truly earns its popular name of the "Mad" Tree.

The poisonous properties of the sap of the leaves form the main subject of this research. From Clifton, 35 miles south of Sydney, a large supply of leaves was obtained. They are soft and succulent when fresh, but exposure to the sun for a day makes them quite dry and brittle, and therefore easily powdered in a mortar.

Reaction of the sap.—When fresh leaves are steeped in water the latter becomes acid, but leaves which have been air-dried yield a perfectly neutral extract. On distilling fresh leaves and air-dried leaves with pure water, the same definite result was obtained, only that, on long-continued boiling, the neutral distillate gradually became acid, a fact which points to dissociation and liberation of a volatile acid. When the dried leaves are distilled with a little sulphuric acid, the distillate obtained is strongly acid; it turns ferric chloride solution red, and silver nitrate paper held in the steam is instantly blackened.

A volatile acid therefore exists in the fresh leaves partly as free acid, and the greater part combined as a non-volatile compound. The free acid quickly evaporates when the leaves dry, and only the neutral compound remains. The presence of formic acid is indicated.

Tested on the growing tree, the juice of leaves and stalks is strongly acid, and when a piece of blue litmus paper is gently pressed on the hairs numerous red points are observed.

Separation and identification of the organic acids.—100 grams of the air-dried leaves were distilled with water and 2 % of phosphoric acid, until the distillate ceased to give an acid reaction. The whole of the acid was obtained only after 24 litres had collected. In the first part of the distillate a thin layer of a fragrant yellow oil was observed on the surface, and a small amount of a white fatty solid formed in the condenser. This very bulky distillate was filtered to remove the oil and fatty substance, and then neutralised with standard alkali; 200 cc. $\frac{N}{10}$ potassium hydroxide were required. The solution was evaporated to dryness and weighed. The equivalent of K added being known, the approximate amount of the total organic acid could be calculated:—

Organic acid = 1·56 % on the air-dried leaves.
0·365 % on the fresh leaves.

The potassium salts were distilled twice with phosphoric acid, and the final distillate of free acid was used for the separation of the constituents.

The Ba salt was first prepared, then converted into sulphate, and the equivalent calculated. This gave an organic acid with molecular weight 62, and showed that acids other than formic were present. During the decomposition of the Ba salt strong vapours of acetic acid were recognised, and a drop of alcohol gave the characteristic ester.

The rest of the acid distillate was next treated for the separation of the acetic series. Lead oxide separates the latter from all other organic acids. The solution, after removal of the lead, is shaken out with ether; the lower members remain in aqueous solution, while those higher than butyric are found in the ethereal solution. Lead formate and acetate are next formed, and after evaporation are separated by alcohol in which the latter is soluble. Each of these salts was then distilled with phosphoric acid, the distillates neutralised with Ba hydroxide and the molecular weights of the acids determined :—

Formic acid—required 46, found 51·7.
Acetic acid „ 60, „ 59·4.

The Ba acetate was tested for purity and found to contain a trace of formate which had lowered the mol. weight. It is clear from these results that the process separates nearly pure acetic acid, but leaves much of the latter associated with formic acid.

The ethereal extract yielded only traces of the higher members of the acetic series.

The two principal acids present are therefore formic and acetic, with traces of the higher homologues.

Estimation of the free acids.—For this purpose a sample of fresh leaves was obtained, and treated within a few hours of pulling to ensure the minimum of loss by drying. Then by cutting each leaf in halves two similar samples were obtained and these were treated separately as in A and B.

(A) *For total volatile organic acids.*—100 grams were distilled in a current of steam with phosphoric acid. The acid distillate neutralised 98·6 cc. $\frac{N}{10}$ sodium hydroxide.

Formic acid.—The exactly neutral solution was boiled with standard silver nitrate, the reduced silver estimated, and from the latter the equivalent of formic acid was found to be 0·047 grams per cent.; the acetic acid was calculated from the difference and gave 0·527 per cent.

(B) *Acids existing as fixed salts.*—100 grams of leaves were dried at 120°C. for three days. The free acids being volatile are thus driven off. The dried leaves weighing 22 grams (loss = 78%)

were distilled as in (A). The distillate neutralised 68·6 cc. of the standard alkali and contained 0·045 grams of formic acid and 0·35 grams of acetic acid.

Summary of above results.—The total acid less the fixed acid gives free acid.

Formic acid existing free in leaves	0·002 %	} 0·047 % total.	
,, as neutral formate	0·045		
Acetic acid free in leaves ...	... 0·177	} 0·527 %.	
,, as neutral acetate	... 0·350		
Free organic acids ...	.. 0·179 %	driven off by heat.	
Org. acids combined as salts ...	0·395	remain in dried leaves.	
Total volatile org. acids	... 0·574 %	in fresh leaves.	

We have seen that two-thirds of the total acid is combined as neutral salts. The next step is to determine the nature of the base. Acids are found in plants combined with alkaloids, glucosides, and metallic bases. The sting of the Giant Nettle-Tree is so virulent and powerful that it has been believed to be due to a poisonous principle in the sap accompanying the "formic acid." A special examination was then made for such poisonous principles; and most of the known methods were used, including extraction with alcohol, benzene, water, &c., with precipitation of the large amount of tannin present by lead acetate or lead oxide, but from these no basic principle was obtained.

By the well known *Stas-Otto* process more favourable results were obtained. In this the dried leaves were first exhausted with water acidulated with tartaric acid, and after boiling for a short time the acid solution was found to become quite neutral. This remarkable reaction was further examined by titrating the acid solution at intervals.

20 cc. required at first 4·9 cc. standard alkali.

After 1 hour, cold, 4·9 cc.

After 1 hour, boiling, 1·8 cc.

After successive intervals of 1 hour 1·1, 0·8, 0·2, neutral.

During the extraction abundant fumes of formic and acetic acids were evolved; the tartaric is therefore able to slowly decompose the salts and displace the volatile acids; the latter being free are then driven off on boiling.

The aqueous solution after evaporation was extracted with alcohol, and this left a large amount of insoluble matter which was reserved. The alcohol was then distilled off, the residue dissolved in water and extracted with immiscible solvents. The latter on evaporation left a small yellow amorphous residue. This was purified and examined. It contained no nitrogen, reduced Fehling's solution, possessed a strong pungent and bitter taste, blistered the tongue, and was soluble in hot water, giving a yellow, acid solution. The latter when neutralised with calcium carbonate became strongly fluorescent. On standing for some time the neutral solution became acid by dissociation. It gave no osazone, proving the absence of glucose. Fumes of formic and acetic acids were evolved on boiling, and when these were completely driven off Fehling's solution was no longer reduced. This result shows the absence of glucosides. The reactions of alkaloids also gave negative results, and the residue was proved to consist mainly of a yellow colouring matter.

Since the absence of organic base is thus definitely proved, it only now remains to be shown whether the acids are fixed with metals. The residue insoluble in alcohol, which was reserved in the previous operation, was purified and examined. It consisted almost entirely of calcium, magnesium, with traces of potassium and sodium, and combined with formic, acetic and sulphuric acids.

Systematic Proximate Analysis of the Leaves.

(A) *Moisture.*—A sample of the fresh leaves was dried in the air at ordinary temperature, and lost 76·65 % of its weight.

(B) On further *drying at 110°C.* in the air oven, 3·11 % was driven off, which is represented by water and volatile acids.

(C) *Ash.*—The dried residue was incinerated in a muffle furnace at incipient redness; the weight of ash obtained was 3·6 %, or 15·42 % on the air-dried leaves. The chief constituents of the ash were then approximately ascertained:—

Portion soluble in water 15 % of the ash. This contains chiefly potassium and a little sodium as chlorides (Cl. = 5·73 %) with a trace of sulphate and silicate; also free alkali equivalent to 3·13 % of potassium carbonate.

Portion soluble in hydrochloric acid 62·4 % of the ash, consisting of Al_2O_3 7·25, CaO 25, MgO 5·9, P_2O_5 2·8, SO_3 1·12, CO_2 20·33 (by difference).

Portion insoluble in acid 22·59 % of the ash, chiefly silica, silicates, etc.

(D) *The organic constituents.*—The air-dried leaves were treated by the method of Dragendorff, by successive extractions with various solvents.

The very finely powdered leaves first gave up to petroleum spirit 2·56 %. This contained 2·4 of fixed oil or wax, a small quantity of a fragrant volatile oil, and traces of resin. The wax is an odourless dark brown solid, which leaves a yellow stain on paper. At 15°C the sp. gr. is 0·935, ref. index 1·5229; and m.p. 43°C. The volatile oil has previously been mentioned as collecting in the receiver during the distillation for organic acids.

The leaves were next extracted with ether, the solvent on evaporation giving 1·41%. This residue consisted of 0·48 of wax similar to that obtained above, neutral and acid resins, and chlorophyll.

Alcohol extracted 4·74 % of tannin and organic acids.

Water removed in solution 17·5 %, of which 6·9 is inorganic matter. From this solution alcohol precipitated 4·5 % of albumen and 1·5 % of mucilage. The filtrate contained no glucose, but a carbohydrate which reduced Fehling's solution only after long boiling, 1·4% expressed as saccharose. The ordinary mucilage of plant tissues is seldom associated with more than 5 % of mineral matter; in this case, however, the ratio is nearly 70 %. The ash consisted chiefly of lime and magnesia as carbonates, doubtless from the decomposition of organic acids.

Sodium hydroxide extracted 0·85 % of albuminoids, pectin, etc., precipitated by alcohol.

SUMMARY OF THE SYSTEMATIC ANALYSIS.

Fresh juicy leaves contain :—

Water removed by drying at ordinary temp., 76·65%

Air-dried residue ... ... 23·35

	On fresh leaves.	On air-dried leaves.
Moisture by air drying	76·65%	
,, and vol. acids at 110° ...	3·11	13·30
Inorganic matter=ash	3·60	15·42
Extracted by solvents	6·12	26·21
Petroleum spirit	0·60	2·56
Ether	0·33	1·41
Alcohol (absolute)	1·10	4·74
Water	4·09	17·50
Cellulose, lignin (by difference) ...	10·52	45·07
	100·00	100·00

The following considerations will show the most probable mode of combination of the formic and acetic acids with the metals as found in the analysis of the ash.

Formates and acetates when heated are converted into carbonates, and therefore exist in the ash as such. The portion soluble in water contains 3·13 % of alkali carbonate, equivalent to K, 0·065% on the fresh leaves. By apportioning the acid having the higher dissociation constant to the strongest base we find that the whole of the combined formic acid requires 0·038 K, leaving the rest of the K, 0·027, in combination with part of the acetic acid, 0·041. The remaining 0·309 of acetic acid is then given to Ca, the metal next in order of avidity. We may now state the results in their final form as follows :—

		On fresh leaves.	On air-dried leaves.
Free acids	Free formic acid	0·002%	Nil.
	Free acetic acid	0·177	Nil.
	Higher members of acetic series	Traces	Nil.
Salts ...	Potassium formate	0·082	0·351
	Potassium acetate	0·067	0·287
	Calcium acetate	0·406	1·739
		0·734%	2·377%.

For comparison with the preceding, the amount of acid present in the common nettle (*Urtica urens*) was determined, under precisely similar conditions.

100 grams of fresh young nettle leaves were distilled with phosphoric acid into standard alkali, and on titration gave an amount equivalent to 0·002 % of formic acid.

Another 100 grams were dried at 120° C. and then distilled as before. The distillate contained no trace of a volatile acid, showing that the latter had been completely volatilised in drying.

The whole of the acid in the common nettle is therefore free uncombined formic acid, and the amount in the specimen tried was 0·002%.

Microscopic Structure of the Hairs.

The whole of the surface of the leaves and stalks is covered with an infinite number of minute hollow hairs. More sparsely

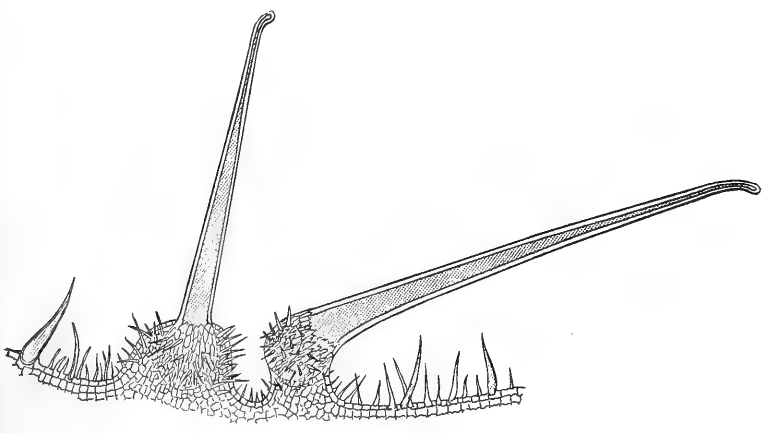

Fig. 1.—Stinging hairs of *Laportea gigas.*

distributed among these are certain very large hairs, which are strong and rigid, and each one is fixed by a bulbous root in a raised mound or basal cushion. The latter is green and cellular, and is likewise covered with the minute hairs.

The hairs are seen to be hollow tubes with circular section, and contain a strong acid. Some are only partly filled and show a distinct meniscus, while others are completely filled to the tip. By carefully watching the action of litmus solution on suitable sections under the microscope the glandular tissue of the basal cushion is found to be strongly acid only round the bulb of the hair, and in the rest of the cushion cells the litmus remains blue for some time. The blue litmus is also observed to quickly become red in the cells of the epidermis.

The root-bulbs of the hairs are also filled with the strong acid, and when gently pressed air bubbles form which move about in the interior. Empty hairs can be filled completely by pressing the root-bulbs and tiny drops of acid made to ooze out from the open ends.

To ascertain the composition of the hairs, some of them were shaved off and heated to redness on platinum. Microscopic examination then showed that they were considerably cracked and broken, yet otherwise unaltered in structure. These burnt hairs were next submitted to the action of boiling strong hydrochloric, nitric and sulphuric acids, and from this ordeal they came out practically unchanged.

The hairs are therefore hollow siliceous tubes, which when fresh seem to be glassy silica, and after heating naturally appear opaque and white. On the other hand, the hairs of the common nettle are always described as having their walls silicified at the end only, and calcified for the rest of the length (1).

Physiological Action.—The sting is undoubtedly due to the free acid existing in a concentrated form in the hairs, and differs from the sting of the common nettle only in degree.

Common nettle plant contains 0·002% formic acid.

Giant nettle-tree contains 0·179 % (0·002 % formic and 0·177 % acetic).

That is, *Laportea gigas* contains 90 times more free acid than *Urtica urens.*

The amount of strong acid injected under the skin by one of the large hairs is quite a sufficient cause for the severe shock which follows the sting. For a long time after, the pain keeps returning whenever the injured part is wet. The Hon. W. Pettigrew records a case (2) where the pain continued to be felt, under these conditions, after the lapse of a month from the sting.

An occasional companion of the dreaded stinging tree is the small plant *Colocasia macrorrhiza*, which the aborigines call "cunjevoi." This large-leaved plant is sometimes found growing round the nettle trees and is used as an antidote and painkiller, by rubbing on the affected part for an hour or more. In a note to Pettigrew's paper mentioned above, I find it stated that the inner bark of the Laportea itself contains an antidote to its sting. An interesting fact, which may possibly be associated with this antidote, is the occurrence of numerous crystals of calcium oxalate in the bark, first observed by H. G. Smith, of the Technological Museum.

The Metabolism of the Plant.

Occurrence of Organic Acids.—They occur (1) free, (2) combined with inorganic bases, with which they frequently form acid-salts, (3) combined with organic bases, as alkaloids, glucosides, or other vegetable principles.

The first six acids of the acetic series have been met with in plants(3). Acetic acid in minute quantities occurs in the sap of a great many plants both free and as esters or salts. Formic acid is of very rare occurrence(4). Its existence was first discovered in the common nettle in 1849, by Professor Gorup-Besanez of Erlangen(5), the acid nature of the fresh sap having been noticed shortly before by Lucas, an apothecary of Arnstadt. It is also present in pine needles, where it is probably the result of the oxidation of terpenes, and in the wood of *Goupia tomentosa*(6). Neutral formic esters exist in the juice of the house-leek, in the fruit of the soap-tree (*Sapindus*) together with butyric acid compounds, and in tamarinds associated with acetic and butyric compounds. It seems quite possible that the tartaric acid in these fruits may have oxidised and formed formic and acetic esters, since these changes can easily be brought about artificially by slow oxidation.

As is well known, free oxalic acid is found in Opuntias, free malic acid in Cacti, etc., and free tartaric and citric acids in fruits.

Formation of Organic Acids.—Liebig and his followers held that organic acids were formed by plants in their *constructive* metabolism, *e.g.*:—$CO_2 + H_2O = HCOOH + O$

$$2CO_2 + H_2O = (COOH)_2 + O$$

Now, although the formation of acids is accompanied by the evolution of oxygen, yet the above explanation of the process does not correspond with the accumulated evidence of recent observations, and Liebig's theory has been discarded.

During the respiration of plants the absorbed oxygen has been found to enter in some obscure manner into combination with the protoplasm, and then follows a long series of katabolic changes. The breaking down of these unstable protoplasmic molecules results most generally in the production of carbonic acid, but in some plants other and more complex organic acids are formed instead of carbonic acid. And so it is now generally held that the production of organic acids by plants is a result of *destructive* metabolism.

Carbohydrates form the chief synthetic products of plants, and these are used both for storage of reserve food-material, and also to supply the energy for the formation of the various products of metabolism. From the carbohydrates organic acids are formed(7), the acids are neutralised by bases taken up from the soil, and these organic salts in certain rare instances are found to predominate, as the reserve food-supply of the plant.

Among the various ways in which carbohydrates can be converted into organic acids the most prominent seems to be by the agency of bacteria(8). Certain of these produce enzymes, and the latter can form carbonic, formic, or acetic acid by oxidation of carbohydrates. Also formates have been produced by the decomposition of bicarbonates at ordinary temperatures(9).

Quite recently, Usher and Priestley of Bristol, have studied the mechanics of carbon assimilation(17), and have definitely proved that the photolysis of carbon dioxide always produces formic aldehyde (in some cases formic acid) and hydrogen peroxide.

These, however, cannot be detected in the living plant, since the aldehyde is instantly polymerised to carbohydrate by the protoplasm, and the peroxide is catalysed by an enzyme, with evolution of oxygen. Leaves in which the protoplasm and enzyme have both been killed, when placed under conditions favourable to assimilation, develop formic aldehyde and hydrogen peroxide, and these accumulate until the latter has destroyed and bleached all the chlorophyll, and the photolytic process is stopped.

In applying this photosynthesis of formaldehyde to the case of the Nettle-Tree, it seems not improbable that under certain altered conditions (as in the absence of the enzyme) the aldehyde may be oxidised by the hydrogen peroxide to formic acid :— $HCHO + H_2O_2 = HCOOH + H_2O$. It is certain, however, that acetic acid is never formed in this way. We are then led of necessity to the unlikely view that the two acids, so closely allied chemically and so intimately associated in the metabolism of the Nettle-Tree, are formed by entirely different processes in the plant.

Liberation of Acids from their Salts.—The fresh leaves were found to contain 80 % of water. This gives us in every 100 parts of sap, 0·224 of formic and acetic acids, and 0·694 of their salts, and is approximately a 1 % solution in the plant.

Now every organism, both plant and animal, by means of its self-regulating function, strives to prevent any variation in the ratio of its hydrogen and hydroxyl ionic concentrations to which its cells are habituated, by forming acid or alkali as required. We must therefore regard the formation of acid as being able to excite and call up an equivalent amount of base in the mineral solution from the soil, until a certain equilibrium is obtained. It is not necessary that this equilibrium point indicate neutrality, it is simply the balance of a number of reversible reactions of production and dissociation.

In the first place, by the principle of mass action, carbonic acid can replace a little acetic acid from its salts :—

$$Ca\bar{A}_2 + CO_2 + H_2O = CaCO_3 + 2H\bar{A}.$$

This may occur with the assimilation in the leaves, and there is distinct evidence of a concentration of acid fluid in the epidermal cells, shown by the instant reddening of blue litmus solution, while in the cells of the deeper tissues the indicator remains unaltered for a considerable time. The extent to which the above reaction will proceed, and therefore the quantity of free acid formed (10) depends on the rate of removal of the active mass of the products from the sphere of action. Now, one of these is insoluble, it is found in the minute cystoliths in the epidermal cells, and we shall next see how the free acids also are removed, and thus the tendency of the reaction to proceed from left to right is maintained.

The sap is a very dilute solution of free acids and their salts. Free acids, having a high diosmotic value, are removed from the sap by diffusion through the primordial utricle of the cells, and this seems to be the special function of the cells in the glandular tissue of the basal cushions of the hairs. In these cells the separation takes place, and the free concentrated acids are secreted into the hairs. The acids are volatile, and constantly evaporate from the open ends of the hairs, and so the second product disappears from the scene of action, and the active mass of the carbon dioxide from the air restores the equilibrium.

We have said that the sap in the leaves of Laportea is a 0·224% solution of free acid, in which one gram molecular weight of acetic acid is contained in 24 litres of water. Now, in this state of dilution, acetic acid is dissociated to the extent of 2%, at the ordinary temperature, and the free ions of both acetic and formic acids are powerful plant poisons. Fassbender (11) states that plants are killed by watering with a 0·05 % solution of acetic acid. It is here that we see the great significance of the neutral acetate and formate, for these when present in the same solution cause the degree of ionisation of the acids to be enormously decreased, and so their activity as acid poisons is correspondingly reduced.

In the common nettle the free acid is probably all contained in the hairs, with perhaps an exceedingly small quantity in the sap. There is therefore no need for neutral formate in the solution, and none is found.

Functions of the Organic Acids.—These may serve for—

(*a*) Osmotic substances.
(*b*) Plastic material.
(*c*) Protection from natural enemies.
(*d*) Liberation of other acids by mass action.
(*e*) Solvents, or neutralising agents.

(*a*) Formic and acetic acids and their salts have a strong affinity for water, and therefore a high osmotic pressure. In consequence, they are especially favourable to the production of great turgidity. Even the thick stem of the Laportea is green and succulent, and when cut or wounded it bleeds very profusely. This occurs in most members of the Urticaceæ, and shows the high exudation pressure. It has been generally found that the sap in all rapidly growing parts of plants has an acid reaction, for the purpose of maintaining and regulating the turgidity of the cells, which are therefore kept succulent during the period of their growth. Astruc (12) finds that a definite relation exists between the formation of acids and the intensity of growth in plants.

(*b*) Under certain conditions formic and acetic acids can be used by plants as food, though they have but a small nutritive value. When a decrease of turgidity closes the stomata on the leaves and causes the assimilation of carbon dioxide to cease, the plants may then draw on their store of organic acids for the manufacture of carbohydrates. This is especially the case in green succulent plants, when organic acids acted upon by light produce carbohydrates, oxygen, and carbon dioxide (13), and the latter is at once assimilated.

Again, many common forms of bacteria are able to decompose formates and acetates directly into hydrogen and carbon dioxide (14); formates yield equal volumes of the two gases. In this way carbon dioxide is made available for assimilation.

Kraus (15) has shown how certain plants store up organic acids as reserve food-supplies from which they can draw as required.

(*c*) By the concentration of the free acids in the stinging hairs the plant is protected from certain natural enemies, such as caterpillars, fungi, &c.

(*d*) In the regulation of the chemical processes of metabolism mass action plays an important part, as when the free formic and acetic acids slowly liberate sulphuric, nitric (16), phosphoric acids, etc., from their salts. These products, being assimilated by the plant for the purpose of its complex proteid synthesis, are continually removed, so that the feeble chemical reactions may be completed.

(*e*) The inorganic constituents of the sap are present in abnormally large quantities in the Nettle-Tree, and especially in the leaves, where the active process of assimilation takes place. Common forest trees like the oak and beech contain an average of 4 to 5 % of ash in the dried leaves, and there is experimental evidence to show that from 2 to 4 % only is absolutely necessary to the plant; therefore all over this amount must be considered as non-essential to the vital activity of the plant.

Now in the Nettle-Tree we find 15·4 % of ash, and the presence of this large amount can be explained by the excess of free acid in the root sap exerting a powerful solvent action on the mineral constituents of the soil. In this way the large amount of soluble calcium salts finds its way to the leaves, and is there partly deposited in an insoluble form in the epidermal cells. The free acid is also able to convert calcium phosphate into the soluble phosphate, in which form we find it in the plant sap.

Silica in the form of alkaline silicate, as shown by the analysis, is carried up in solution from the soil, to provide material for the cell walls of the hairs and the hard outer layer of the epidermis, on which the silica is deposited in minute masses by chemical precipitation, during the exchange by the alkali of silicate for formate and acetate.

In conclusion, after consideration of the various functions in which organic acids take a part, we cannot believe that the function of protection is the only one in this case. But the free formate and acetate ions with the practically non-ionised acids must play a primary part in those profound activities of the protoplast, by which, in seasons of plenty, it is enabled to lay up a large store of food-material, and to change it as required into a form easily assimilated. We see the outward evidence of this in the healthy, vigorous and rapid growth of the Giant Nettle-Tree. Far from upsetting the balance and constituting abnormal conditions (as sometimes happens in animal physiology) we find the production of the excess of organic acid to be intimately linked with the processes of dissociation and decomposition which I have outlined above, and that together they conform to the self-regulating mechanism of the plant metabolism.

I here wish to express my indebtedness to Professor Anderson Stuart, in whose laboratory the greater part of the work has been done.

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A STRIKING EXAMPLE OF RIVER-CAPTURE IN THE COASTAL DISTRICT OF NEW SOUTH WALES.

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(Plates xlii.-xliii.)

Even a casual examination of a map of New South Wales which shows plainly the courses of the coastal rivers will reveal the fact that, throughout the greater part of the length of the sea-board, the upper waters of the rivers have a marked tendency to flow parallel with the coast line. This is the case particularly with the Shoalhaven, Hawkesbury, Macleay, and Clarence systems. The authors were independently struck with the remarkable arrangement of the watercourses in the neighbourhood of Marulan and came to the conclusion, from theoretical considerations, that the present structure pointed to river-capture on a magnificent scale in that area. They therefore made two expeditions and satisfied themselves in the field of the correctness of their theoretical deductions.

Summary of the facts.—The Shoalhaven River rises about 35° 57′ S., 149° 40′ E., about twenty miles south-west of Araluen. It flows in a general north-north-east direction to near 34° 46′ S., 150° 7′ E., at Bungonia. Here it suddenly changes direction and flows generally east-south-easterly and empties into the sea near Nowra. The Wollondilly River rises 34° 26′ S., 149° 36′ E., near Crookwell. At first it flows south-south-easterly, but near Goulburn it sweeps round and then flows north-north-east towards the Hawkesbury. A tributary, Barber's Creek, enters the Shoalhaven on its left bank, just at the great elbow above described, flowing from the north. A tributary, Joaramin Creek, flows northwards into the Wollondilly, entering its right bank. Joaramin Creek and Barber's Creek are almost collinear, and the divide between them is not more than 40 chains wide (fig. 1). The Shoalhaven in this part of its course occupies a narrow V-shaped gorge

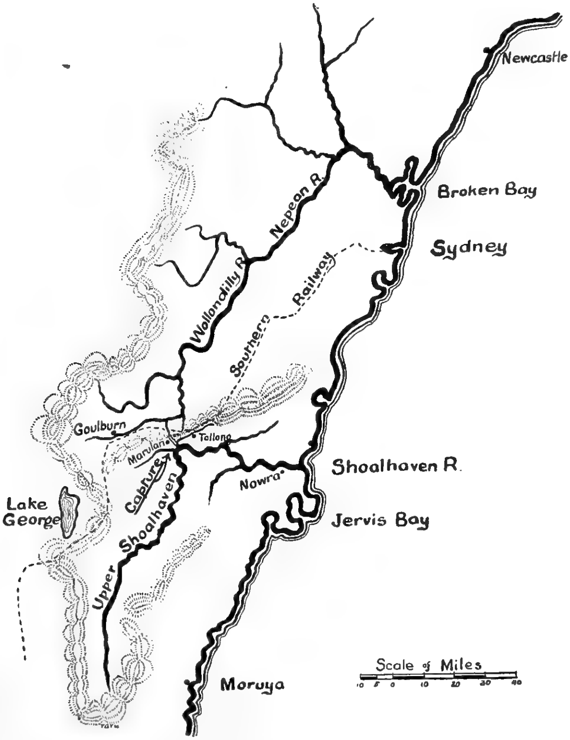

Fig. 1.—Locality map, showing relations between Shoalhaven and Wollondilly Rivers.

1,600 feet deep. The plateau is about 2,000 feet above sea-level, so that the bed of the Shoalhaven is only 400 feet above sea-level, and therefore comparatively little above base-level. The bed of the Wollondilly is on the plateau at an altitude of about 2,000 feet above sea-level. These facts made us suspect that, originally, the head waters of the Shoalhaven formed part of the Wollondilly system, flowing along the plateau of approximately the same level as the latter stream. If this were so, there should be distinct evidence of the former course in the configuration of the country. This is found to be distinctly the case. The maps (fig.1 and Plate xlii.) show that a well defined channel exists, extending from Digger's Creek in a general north-north-westerly direction past Glen Rock Trig. Station and between Marulan and Shepherd Trig. Stations, leading from the valley of the Shoalhaven across the trend of Barber's Creek to Joaramin Creek. There is a gentle fall all the way from the precipitous northern bank of the Shoalhaven to the point of entry into the Wollondilly system. This valley is not by any means the chief evidence available. On the very edge of the precipitous bank of Digger's Creek, 1,500 feet above the present stream, there are extensive remains of a very coarse river-gravel. The boulders in this run up to two feet in diameter (Plate xliii., fig.1). They include fragments of granite, quartzite, slate, black jasper, quartz porphyry and other rocks *which do not occur anywhere in the valleys of the streams now draining from north to south* in this neighbourhood. The boulders are perfectly rounded and mostly show evidence of long transport. They are quite similar to the rocks lying away to the south, and therefore within the scope of action of the ancestor of the Shoalhaven. It is inconceivable that this gravel should have accumulated upon the very edge of the precipice where it now occurs, and, in fact, forms part of that precipice. *The deep gully of Digger's Creek and that of the main river must be of later date than the river-gravel.*

We have followed this gravel more or less continuously for a distance of over three miles as shown on the map (Plate xlii.). In places it is covered by a thick capping of sandy alluvial washed down from the surrounding hills. Towards the north-western end of the channel this later alluvial completely hides all trace of the gravel; but there can be no other outlet for the stream that brought the gravel, except that indicated, namely, the gap between Marulan and Shepherd Trig. Stations. The surrounding hills, consisting of Trias-Jura, Permo-Carboniferous and Silurian rocks, rise to considerable heights above the level of the gravel.

The view from Ballanya Trig. Station is a very instructive one. The country for miles around is of the nature of a peneplain standing at 2,000 to 2,200 feet above sea-level. About ten or fifteen miles away, to the N.W., W., and S.W., there appear extensive areas of country rising to a height of 400 or 500 feet higher than the general level of the surrounding country. These have an almost absolutely level sky-line and very strongly suggest the existence of an older peneplain.

The course of the old river channel is fairly well defined from its commencement at Digger's Creek to its junction with Joara-

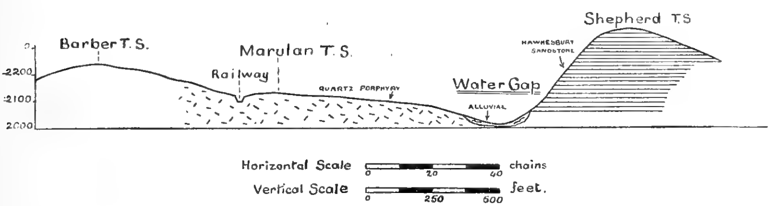

Fig. 2.—Profile section along the lowest portion of the Shoalhaven-Wollondilly Divide.

min Creek. The gap between Marulan and Shepherd Trigs. has all the appearance of an old water gap (fig. 2).

An examination of the bed of the present Wollondilly between Carrick and Goulburn throws considerable light upon the structure of the old valley. The rocks composing the present gravels are of the same types as those above described. The valley is distinctly terraced; the present flood plain being from 20 to 25 feet above the water-level. An older flood plain exists at a level of some 50 feet from the river bed. It consists of sandy alluvial and rather fine gravel, very strikingly similar to the gravels at the highest levels met with near Glenrock. In many of the cuttings on the railway line, which, between Marulan and Goulburn, skirts the northern side of the Wollondilly Valley, this high-level gravel can be seen covered by sandy wash, of recent date, brought down from the neighbouring hills. This wash completely obscures all surface indications of the underlying gravels.

In the case of the captured river, the coarsest gravels are met with on the bank of Digger's Creek. For nearly two miles along the course of the old valley large boulders appear at intervals, mostly, however, redistributed in the modern stream beds. Some of these are shown in the photograph (Plate xliii., fig. 2). The creek in which these occur heads not more than half-a-mile from the place figured, and in this distance has scarcely any appreciable fall. No solid rocks of any kind exist in its upper valley competent to form such boulders. Another patch of coarse boulders is met with just south of the railway line. In the neighbourhood of Glenrock the character of the gravels is distinctly different, being finer and more quartzose; but answers exactly to that of the high-level gravels of the present Wollondilly. There can be little doubt that these represent the high-level gravels of the former river. Gravels of this type are met with at the Woolshed Flat, just north of the railway line, and extend about a quarter of a mile north of the line, nearly to the road. In the small railway cutting just west of the Barber's Creek viaduct, these upper gravels are seen resting directly upon decomposed granite.

From the Woolshed Flat to the gap between Shepherd and Marulan Trigs., no pebbles are met with; the country consists of a sensibly level stretch of fine sandy alluvial, representing, in our opinion, the recent wash from the hills, overlying the old river gravels. On the north-western side of the ridge, that is in the watershed of Joaramin Creek, the surface appears to consist entirely of this sandy wash.

Another very interesting comparison is afforded by the redistribution of the "Argyle Apple" (*Eucalyptus pulverulenta* Sims). This very local eucalypt is characterized by the light blue colour of the leaves on its terminal branches. It is met with, so far as our experience goes, chiefly, if not entirely, on the gravels of the Wollondilly. It rarely, if ever, transgresses the limits of this formation, and is not found on the sandstone, quartzite, granite, &c., upon which the gravels rest. All along the course of the old gravels, from Digger's Creek at least, as far as the railway line, this tree is very conspicuous. This fact may serve as additional evidence of the relationship of the area under consideration to the Wollondilly system.

Physiographical History of the District.—At some period, geologically comparatively recent, this area underwent extensive base-levelling. A number of geological formations occur, probably unequalled for variety in any other district of equal size in the State. These include Silurian slates, jaspers, quartzites, and limestones, Permo-Carboniferous marine and fresh-water beds, Triassic sandstones and conglomerates, together with pre-Permo-Carboniferous granites and quartz-porphyries, and Cainozoic basalts and tuffs (?). These formations were reduced to the character of a peneplain. An elevation of 400 to 500 feet then took place which revived the streams. During a long period of stable equilibrium the rivers again cut down almost to base-level. The chief streams flowed parallel to one another in a general S.S.W. to N.N.E. direction, through a low-lying plain. A grand elevation of 2000 feet now followed, raising the low-level plain into a plateau. River-action again became very active, and deep cañons were begun. Short, steep, coastal streams by reason of their rapid flow incised their channels and formed narrow, V-shaped cañons, cut down almost to sea-level. The heads of these valleys worked backwards rapidly. One such stream occupied the position of the present Lower Shoalhaven. Working back westerly, it was at last able to tap the waters of the old N. and S. river and capture the upper part of its valley, thus producing the present stream-distribution. This last phase is of very recent date, as is shown by the fact that the present valley of the Shoalhaven is a beautifully typical young river valley, its cross section being an absolute V. The capture has not been so recent but that the valley has been gouged out to a depth of 1600 feet since it took place (fig.3).

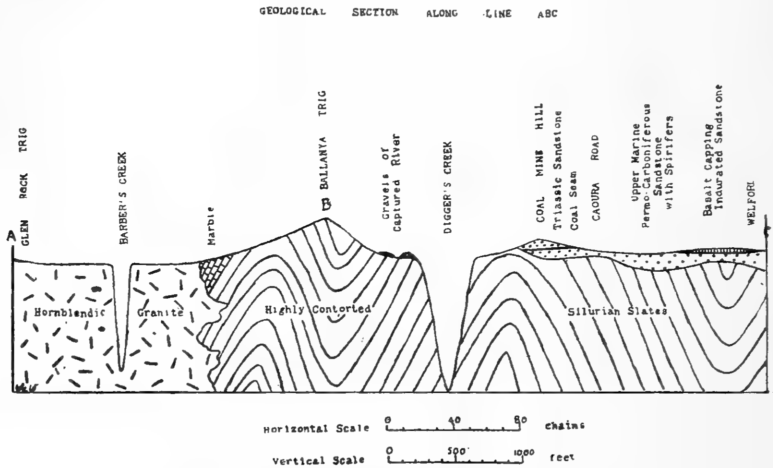

Fig. 3.—Geological section along the line A, B, C on the map (Plate xlii.). The representation is slightly diagrammatic. The curves for Silurian slates indicate only that these rocks are intensely contorted and do not represent the actual folds. The Silurian marble is conformable with the slates; its extent in the direction of the line of section is small. Thicknesses of Permo-Carboniferous and Triassic rocks and of basalt are diagrammatic.

A similar process of piracy of Wollondilly water by the Shoalhaven system is imminent a little further north. In the neighbourhood of Bundanoon the Bundanoon Creek occupies a gorge very similar in depth to that of the Shoalhaven at Tallong. Into the head of this valley the creek plunges over a magnificent series of waterfalls. The railway runs along the razor-backed divide between Bundanoon Creek on the east and Paddy's River (a tributary of the Wollondilly) on the west. Paddy's River flows along through a very broad U-shaped valley at an elevation not much under 2000 feet above sea-level. In places the head of Paddy's River is not more than ten chains from some of the headwaters of Bundanoon Creek. With this structure, the capture of another section of the Wollondilly is certain to take place in the very near future, geologically speaking.

An interesting example of capture on a smaller scale is suggested by the head waters of Barber's Creek, just to the east of Twin Trig. Station. The head of Barber's Creek flows in a northerly direction, then suddenly turns almost at right angles and flows westerly. On the northern side of the divide, continuing the northerly trend of the head waters of Barber's Creek, is a marshy tract of country which serves as the head waters of a small creek flowing into the Wollondilly system. An objection to this idea that capture has recently occurred here is that the divide between the two systems, though only half a mile wide, is fairly high, and is composed of solid Hawkesbury Sandstones. This may possibly be accounted for by supposing a slight buckling of the crust at this point. Of this buckling we have, however, no very positive proof. The water gap of the old river between Shepherd and Marulan Trigs. lies on the same ridge. Its level is 25 feet below the gravels at Digger's Creek, but is nearly 30 feet above those on the railway line near Woolshed Flat. We believe that this fact indicates that a slight warping has taken place along the course of the old river-channel. It is possible that this warping may have assisted in the diversion of the water of the old river, but capture of the type above described, and so imminent near Bundanoon, is quite competent to account for all the peculiarities in river-structure in the Tallong area. In our opinion, if warping has taken place, it is more recent than the river-capture, and it is to the latter force that we must ascribe the chief features in the very remarkable topography of this interesting region.

EXPLANATION OF PLATES.

Plate xlii.

Map of the captured river. The extent of the gravels described in the text is indicated by dots. Large dots show positions where the coarse gravels occur *in situ*; small dots the areas where they are more or less hidden by recent wash from the hills.

Plate xliii.

Fig. 1.—Photograph of the coarse gravels of the captured river at the point where they occur on the very edge of the precipitous bank of Digger's (Ottowa) Creek. Eleven yards to the right of the centre of the picture there is a steep drop of about 1100 feet.

Fig. 2.—Photograph of the coarse gravels of the captured river near the intersection of the latter with Barber's Creek. The modern creek in the picture has somewhat redistributed the gravels, but has nowhere in its watershed rock outcrops competent to have originally produced them.

SUPPLEMENT TO THE "REVISION OF THE CICINDELIDÆ OF AUSTRALIA."

By Thomas G. Sloane.

After I had finished my 'Revision of the Cicindelidæ of Australia' I had the opportunity of meeting Mr. Henry Hacker, a visitor to Sydney, who brought with him a number of Cicindelids which he had captured last summer in the vicinity of Coën, 150 miles north of Cooktown, Queensland. My thanks are specially due to Mr. Hacker for the opportunity of examining his Coën collection, and for the gift of specimens of the new forms therein contained. I identify the species found by Mr. Hacker at Coën as under :—

Distypsidera gruti Pascoe.
D. parva Macleay.
D. hackeri, n.sp.
Cicindela iosceles Hope.
C. doddi Sloane, and var. *semiviridis*, n.var.
C. leai Sloane, and var. *nigella*, n.var.
C. semicincta Brullé.
Tricondyla aptera Oliv.

Mr. Hacker informed me that all the species of Cicindela mentioned above were taken on the ground, along tracks and similar places in open forest country.

Mr. C. French has also sent to me, for description, a specimen of a new and remarkable species of *Megacephala*.

Megacephala marginicollis, n.sp.

♂. Metallic-green; elytra near suture on basal half and pronotum on disc atrous, inflexed margins of elytra piceous; under surface piceous, subviridescent on pro-episterna, mesepisterna and first ventral segment; head viridescent beneath eyes and behind base of maxillæ; ventral segments 3-5 with narrow brown posterior margins, fifth segment with narrow lateral testaceous border, sixth segment piceous with border testaceous (widely on sides towards base, very narrowly on apex); femora piceous, tibiæ, tarsi, palpi and joints 5-11 of antennæ testaceous, four anterior trochanters brown, coxæ testaceous, joints 1-4 of antennæ piceous (joints 1-3 brownish in parts); clypeus black; mandibles piceous.

Head hardly wider across eyes than prothorax (4·1 mm.). Labial palpi with basal stalk long, projecting beyond lobes of mentum. Prothorax subcordate (3·7 × 4 mm.), wider across apex (3·4 mm.) than across base (3·1 mm.), convex, sharply and deeply declivous to depressed basal area; sides lightly arcuate on anterior half, obliquely narrowed to base; anterior margin sinuate, very shortly bordered on each side near anterior angles; anterior sulcus deeply impressed on each side, shallow across disc; posterior sulcus deeply impressed; lateral border entire, narrow, reflexed, reaching base. Elytra convex, oval (9·5 × 5·7 mm.), widest about middle, lightly rounded on sides, narrowed to base; humeral angles not marked, base hardly ampliate on each side of peduncle; disc not declivous to peduncle; surface smooth, impunctate on posterior two-thirds, basal third punctate (without rugosity) in longitudinal rows; punctures smaller and less closely placed towards sides. Prosternum before coxæ roundly convex, this rounded convexity defined before and behind by a well marked transverse sulcus. Metasternum as in *M. greyana* Sl.—short between intermediate coxæ; episterna short, flat, subcordate. Ventral segments impunctate, longitudinally striolate laterally, sixth triangularly excised at apex as in *M. australis* Chaud. Posterior trochanters not reaching to posterior margin of third ventral segment; posterior femora extending to apex of abdomen. Four anterior trochanters bearing a fine seta. Length 15·5, breadth 5·7 mm.

Hab.—Northern Territory: Katharine River (Coll. French; unique).

A very distinct species, differentiated at once from all the described Australian species by having the lateral border of the prothorax entire and attaining the base; the bicolorous legs and antennæ are very conspicuous and sufficiently peculiar to differentiate it from all other species; a black clypeus is only found in one other species, viz., *M. frenchi* Sl. Its place in the genus is beside *M. howitti* Cast., (with which I am unable to compare it) but the following are some decided differences :—*M. howitti*, elytra 9·5 × 6·8 mm. (from a specimen (♀) in Mr. French's possession), prothorax with lateral carina *nonexistent*, apical ventral segment scarcely sinuate at apex in male.* From *M. greyana* Sl., to which it has some affinity, it differs conspicuously by colour, prothorax with disc far more sharply raised above basal area, lateral margin entire; elytra with shoulders not at all ampliate, not rugose near base; apical notch of abdomen in male much deeper, etc. The specimen before me has the elytra a little parted near the apex, and evidently not soldered together, but I cannot detect any underwings, and the great reduction of the shoulders of the elytra indicates that they are not likely to exist. This is the only Australian species in which I have found a seta present on the four anterior trochanters.

DISTYPSIDERA HACKERI, n.sp.

Elongate, convex; each elytron with a juxta-sutural basal spot, a humeral vitta, two decidedly separated median spots, and an apical spot white.

Upper surface blue-black, becoming more metallic towards sides; each elytron with two basal white marks separated by the deep humeral depression (inner mark small and round, outer at humeral angle and giving off an oblique vitta extending backwards about one-third the length of the elytra), a rather narrow elongate triangular juxta-marginal white mark just before the middle of the length, a subcircular white mark near the suture just before the posterior third of the length, and an apical wide oblique white mark extending from beginning of apical curve nearly to suture, the apical border black. Under surface chalybeate. Labrum black on each side with a wide central vitta white. Antennæ dark with a subtestaceous mark on upper side of basal joint. Colour of legs variable; male coxæ, trochanters

* These Proceedings, 1900, p.643.

and anterior sides of femora more or less testaceous; female darker. Head wide (4·3 mm. across eyes), not differing from *D. gruti* Pascoe. Prothorax broader than long (2·7 × 3·1 mm.), not presenting any noticeable differences from *D. gruti.* Elytra twice as long as wide (4·7 × 9·2 mm.); sculpture not differing from *D. gruti.* Length 17-20, breadth 4·7-6·0 mm.

Hab.—Q.: Coën (Hacker).

D. hackeri, the largest species of the genus, closely resembles *D. gruti* Pascoe in all particulars of form and sculpture, but differs conspicuously by the pattern of the elytra. In *D. gruti* there is no apical white mark, and the central fascia, though sometimes broken into two spots (*vide* Pl. xxix., fig. 66), has in that case these two spots almost equidistant from the base and apex; but in *D. hackeri* the two spots are not only more distant from one another, but the inner is situated behind the level of the posterior margin of the outer one. *D. hackeri* shows a resemblance to *D. undulata* by the white apical marks of the elytra, but differs by having the interocular depression much deeper, the sculpture of the elytra less coarse, particularly the punctuation near the sides behind the shoulders, and the elytra without a zigzag median fascia. Mr. Hacker presented me with three specimens.

Cicindela doddi Sl., var. semiviridis.

♂. Upper surface of head and prothorax bright green; elytra bronzy-black with three whitish lateral marks on each, the dark part shagreened and closely beset with very shallow rounded depressions of a bluish tint, a row of nine subfoveolate cyaneous punctures near suture, and a row of about five similar punctures extending backwards from humeral depression; labrum white with extreme edge infuscate; under surface metallic-blue. Prosternal episterna with a few white setæ near coxæ, mesosternum on each side, metasternum on each side and on episterna near posterior margin, and posterior coxæ albo-pubescent. Head much wider than prothorax (2·1 mm. across eyes), rugulose, deeply channelled between eyes. Labrum with teeth and setæ as in *C. doddi.*

Prothorax a little broader than long (1·4 × 1·5 mm.), decidedly rounded on sides and convex on disc between the shallow but well marked frontal sulci. Length 7·7, breadth 2·4 mm.

Hab.—Q.: Coën (Hacker).

Differs from *C. doddi* (typical form) by head and prothorax bright green, not bronzy; elytra with the three lateral whitish marks larger, the intermediate mark particularly more conspicuous; head larger; prothorax in male more convex on disc and more strongly rounded on sides (particularly the prosternal episterna) between the transverse frontal sulci, these deeper. Mr. Hacker obtained a considerable number of this form in one locality which showed no differences amongst themselves; but I have considered it as a variety of *C. doddi*. Two specimens (♂) were given to me by Mr. Hacker.

CICINDELA LEAI, var.(?) NIGELLA.

Subcylindrical, elytra strongly and closely punctate, glabrous. Upper surface black, with sometimes bronzy metallic tints, brighter on head, obscure on pronotum, and still more obscure and rarely seen on elytron; each elytron with two conspicuous lateral white spots, the anterior just behind middle, the posterior wide and extending from outer apical angle along margin nearly to suture, labrum white with edge and a central basal area infuscate, under surface cyaneous. Prosternal episterna (near coxæ), mesosternal episterna, metasternum (on sides), metasternal episterna (generally) and posterior coxæ (at outer sides) albopubescent.

Head glabrous (1·9 mm. across eyes), channelled and striolate between eyes, occiput rugulose. Labrum 7-dentate; setæ marginal. Prothorax as long as broad (1 3 × 1·3 mm.), pronotum transversely rugulose, anterior and posterior sulci well marked but shallow, sides hardly at all rounded between them. Elytra much wider than prothorax (4 × 2·2 mm.), very convex, parallel on sides, puncturation close and coarse, finer towards apex than base, apical margin serrate, a very small spine at apex of suture. Length 6·0-7·75, breadth 1·8-2 2 mm.

Hab.—Q.: Coën (Hacker).

I look upon it as a well-marked variety of *C. leai* Sl., though most collectors will probably regard it as a distinct species. From the typical form of *C. leai* it is differentiated by its black colour, prothorax less rotundate between the pronotal sulci, which are shallower (although the measurements of the prothorax are the same in both forms, the prothorax of the typical form is more bulged on the sides and more convex on the disc, which causes the transverse sulci to be more deeply marked). The labrum appears more rounded on the sides and to have the dentate part of the margin shorter and more rounded. Several specimens were given to me by Mr. Hacker.

Tricondyla aptera Olivier.

The discovery of *T. aptera* on the mainland of Australia gives us a solitary representative of Dr. W. Horn's division Cicindelidæ-Alacosternalæ, although this species cannot be looked upon as more than an immigrant from Papua. It is an important addition to the many Papuan Coleoptera which have invaded the Cape York Peninsula. Mr. Hacker's specimens (two) were taken running very actively on the trunk of a fallen tree.

Corrigenda.

In the "Revision of the Cicindelidæ of Australia," (*antea* p.309) fig.113, Pl. xxx., shows the posterior trochanter of *Cicindela semicincta* Brullé, bearing a tactile seta. This is an error. I have never seen a Cicindelid with any seta on the posterior trochanters (*cf.* p.313, last line).

Page 345—Seventh line, *for* male *read* female.

,, Eighth line, *for* female *read* male.

DESCRIPTIONS OF NEW SPECIES OF *LOMAPTERA* (COLEOPTERA: *SCARABÆIDÆ*, SUBFAMILY *CETONIDES*).

By Arthur M. Lea, F.E.S.

Lomaptera Hackeri, n.sp.

Black, or deep blackish-purple; with, or without a faint greenish gloss; each elytron with a large patch of deep red, the two patches almost conjoined close to the suture, along which they extend to about the middle; oblique on their outer edges. Undersurface of head with dense yellowish hairs; prosternum in parts and front coxæ with greyish hair; legs in places with short blackish setæ; abdomen with a few scattered bristles; elsewhere glabrous.

Head with dense punctures in front, becoming much finer and sparser on vertex. *Prothorax* transversely strigose on sides, then with punctures; the disc itself almost impunctate. *Scutellum* entirely concealed. *Elytra* transversely or obliquely strigose, except on shoulders and close to scutellar lobe, where there are a few minute punctures only. Sides of *undersurface* and the femora transversely or obliquely strigose. *Pygidium* pointed and densely strigose. *Tibiæ* curved, and with deep scattered punctures. Length ♂ 20, ♀ 23 mm.

Hab.—Queensland: Coen district (Henry Hacker).

Mr. Hacker took numerous specimens of this fine insect in the Coen district of North Queensland, a district which appears to be singularly rich in showy beetles, especially Cetonidæ and Longicornes, and which he was the first entomologist to explore.

In build and punctures the species is much like *cinnamomea*, but the colour is very different from that, or in fact from any previously described Australian species. The outer line of the subconjoined elytral markings is much like a v, but the markings are sometimes very indistinct or altogether absent. The pygidium is more densely strigose than elsewhere and from some directions appears to be covered with small overlapping plates.

The female is more robust and has the pygidium more produced than in the male, and the abdomen is convex instead of concave along the middle.

Lomaptera macrosticta, n.sp.

♂. Flavous, base of head and a large oval spot, common to prothorax and elytra, green with a coppery gloss; parts of undersurface and of legs coppery-green, or with a coppery-green gloss; tips of tarsal joints infuscate. Undersurface of head, prosternum, sides of meso- and of metasternum, and of abdomen, front coxæ and femora, and inner margin of hind tibiæ, with yellowish hair.

Head with dense punctures in front, becoming sparser but no smaller on vertex. *Prothorax* with sparse and minute punctures on disc, becoming denser and larger towards, and more or less confluent or substrigose on, sides. *Scutellum* entirely concealed. *Elytra* densely strigose, except near shoulders and about scutellar lobe, where there are fairly large punctures (except at the base itself). *Pygidium* widely rounded and densely strigose. *Femora* obliquely strigose. Length 23 mm.

Hab.—Queensland: Coen district (Henry Hacker).

Allied to *L. Duboulayi** but smaller, more compact and less coarsely sculptured, the green portion of the prothorax covering a smaller area in proportion and of the elytra covering less than one-third of the surface, instead of the entire surface except the margins. On the prothorax the large spot is truncated almost

* There is nothing in the Latin diagnosis of *L. marginata* Kraatz, to distinguish it from the widely distributed *Duboulayi*.

at the apex, its sides to the base (where it is widest) are slightly sinuous and it occupies about two-thirds of the surface; on the elytra it extends rather more than one-third of their length from the base along the suture, and covers considerably less area than on the prothorax. To the naked eye it appears almost perfectly oval, except that the small end is truncated. In a specimen in Mr. Hacker's collection the greenish marking is interrupted at the base of the elytra. On the specimen before me there is a small indistinct spot on each side near the front of the prothorax, and, when viewed obliquely, the flavous portions are seen to have a very decided coppery-green gloss.

WEDNESDAY, OCTOBER 31st, 1906.

The Ordinary Monthly Meeting of the Society was held in the Linnean Hall, Ithaca Road, Elizabeth Bay, on Wednesday evening, October 31st, 1906.

Mr. Henry Deane, M.A., F.L.S., &c., Vice-President, in the Chair.

Mr. Charles Anderson, M.A., B.Sc., Australian Museum, Sydney, was elected an Ordinary Member of the Society.

The Chairman announced that the Council was prepared to receive applications for two Linnean Macleay Fellowships from qualified Candidates. Applications should be in the hands of the Secretary on or before 30th November, 1906. In the meantime intending Candidates were recommended to put themselves in communication with the Secretary, who would afford all necessary information.

The Donations and Exchanges received since the previous Monthly Meeting, amounting to 9 Vols., 62 Parts or Nos., 15 Bulletins, 1 Report, and 4 Pamphlets, received from 45 Societies, &c., and 1 Individual, were laid upon the table.

NOTES AND EXHIBITS.

Dr. J. B. Cleland of Perth, W.A., sent for exhibition a very interesting and varied assortment of botanical specimens gathered in the neighbourhood of that city, and showing abnormalities due to fasciation, to the attacks of Brachyscelidæ or other insects, or fungi. An offer to supply additional material to workers interested in this field of study was received with the specimens.

Mr. D. G. Stead exhibited an example of *Cheilodactylus spectabilis* Hutton, and stated that two specimens were now in the collection of the Department of Fisheries, from coastal waters of New South Wales, thus forming an addition to the known fish-fauna. He also exhibited an immature example of a species of *Trachinotus* ("Dart") captured at Terrigal by Miss Gibbins; and some intra-uterine embryos of the little "Gummy" Shark, *Mustelus antarcticus* Günther, taken from a specimen captured in Port Jackson. Mr. Stead also recorded the occurrence in the waters of Port Hacking, at the beginning of October, of large numbers of the cilio-flagellate infusorian, *Ceratium furca* Ehrenberg.

Mr. Froggatt exhibited a large series of the remarkable galls of a Coccid from Tennant's Creek, Central Australia, collected by Mr. I. F. Field. The gall had been described, from Queensland, under the name of *Brachyscelis pomiformis* in the Society's Proceedings for 1892. An examination of the series exhibited showed that the enclosed insects could not be placed in the genus *Apiomorpha* (= *Brachyscelis*) or any other known genus, as the structure of the female coccid was very different from that of every other known form.

On behalf of Professor Haswell, a collection of deep sea animals was exhibited by Mr. Hedley. They were obtained by a cast of the trawl on October 27th in 800 fathoms, 35 miles east of Sydney Heads. Among fishes, the following genera had been determined by Mr. McCulloch :—*Scorpæna*, *Hoplichthys*, *Cœlorhynchus*, *Macrurus*, *Optonurus* and *Trachichthys*. The crab, *Latreillopsis petterdi*, lately described by Mr. F. E. Grant in these Proceedings, from a specimen 9 millimetres in length, is now shown to exceed 80 mm. These were associated with the rare urchins, *Phormosoma* and *Porocidaris elegans*, the latter in great abundance. Except during the operations of the 'Challenger,' no deeper cast had been made in Australian waters than that which yielded this abundant harvest.

Mr. Maiden sent for exhibition a living plant of *Myrmecodia Beccarii* Hook.f., from Cardwell, Queensland, collected by Mr. P. MacMahon. It belongs to a genus of Epiphytic Rubiaceæ "which have been long known from their singular habit of forming often spinous tubers of great size, the interior of which is galleried by ants of various species, and of which insects these are the native homes" (Hooker f.). It is figured in Bot. Mag. t. 6883.

Mr. Maiden also exhibited for the President, Mr. T. Steel, an interesting Boronia from French's Forest, near Sydney, collected by Mr. E. A. Holden. The habit of the plant is that of *B. serrulata* Sm., but the colour of the flower is paler; while as regards the ovarium, style, stigma and stamens, it is more closely allied to *B. floribunda* Sieb. The leaves are sometimes trifoliate, the leaflets are narrower and less serrulate, all characters which seem to tend to show that it is a hybrid between the two species named. It would seem, mainly because of habit, that *B. serrulata* was the mother. The common Boronias in the immediate neighbourhood of the plant were *B. serrulata* and *B. floribunda*. The specimens are in the National Herbarium, Sydney.

Mr. Fletcher said that Mr. Stead had been good enough to examine specimens of the Tasmanian fishes found in damp earth by Miss Lodder, and to report that, with some reservation, they might perhaps be referred to *Galaxias truttaceus* Cuv. & Val.; also that the following considerations, on the whole, seemed to favour the view that the fishes were merely æstivating—the specimens were enveloped in a thick film of mucus; there was nothing remarkable about the structure of the branchiæ, nor did there appear to be any special apparatus for enabling the fishes to breathe for lengthened periods out of water; the eyes were fully developed, and likewise the ventral fins (though small).

CONTRIBUTION TO OUR KNOWLEDGE OF THE ACTION OF RENNIN.

By A. H. Moseley, M.B., Junior Demonstrator of Physiology in the University of Sydney, and H. G. Chapman, M.D., B.S., Demonstrator of Physiology in the University of Sydney.

(From the Physiological Laboratory of the University of Sydney.)

In the course of some experiments upon the clotting of milk, it was noted, that when milk which was bought in Sydney and which showed an acid reaction to litmus was neutralised with alkali, rennin ceased to produce its customary clot. Further, it was found that the addition of quantities of alkali insufficient to produce neutrality of reaction to litmus inhibited the clotting of the milk with rennin. This investigation was undertaken to ascertain the cause of this phenomenon and to study the circumstances which modified its occurrence.

Methods.—For all experiments a sample of rennet which possessed considerable potency and which had been in the laboratory for some years was utilised. The milk which was bought in Sydney varied in acidity with different samples. The acidity was determined after the addition of 1 c.c. phenol-phthalein to 25 c.c. milk by titration, with $\frac{N}{10}$NaOH until a pink colour appeared.* All measurements were made from burettes, so that strict quantitative conditions were observed. Water-baths were arranged to keep a constant temperature of 40°C. The test-tubes were examined frequently at definite intervals of time to determine clotting. That time at which the test-tube could be

* Winter Blyth, "Foods, their Composition and Analysis." London, 1903, p.230.

[Printed off November 16th, 1906.]

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CONTRIBUTION TO OUR KNOWLEDGE OF THE ACTION OF RENNIN.

By A. H. Moseley, M.B., Junior Demonstrator of Physiology in the University of Sydney, and H. G. Chapman, M.D., B.S., Demonstrator of Physiology in the University of Sydney.

(From the Physiological Laboratory of the University of Sydney).

In the course of some experiments upon the clotting of milk, it was noted, that when milk which was bought in Sydney and which showed an acid reaction to litmus was neutralised with alkali, rennin ceased to produce its customary clot. Further, it was found that the addition of quantities of alkali insufficient to produce neutrality of reaction to litmus inhibited the clotting of the milk with rennin. This investigation was undertaken to ascertain the cause of this phenomenon and to study the circumstances which modified its occurrence.

Methods.—For all experiments a sample of rennet which possessed considerable potency and which had been in the laboratory for some years was utilised. The milk which was bought in Sydney varied in acidity with different samples. The acidity was determined after the addition of 1 c.c. phenol-phthalein to 25 c.c. milk by titration with $\frac{N}{10}$NaOH until a pink colour appeared.* All measurements were made from burettes, so that strict quantitative conditions were observed. Water-baths were arranged to keep a constant temperature of 40°C. The test-tubes were examined frequently at definite intervals of time to determine clotting. That time at which the test-tube could be

* Winter Blyth, "Foods, their Composition and Analysis." London, 1903, p.230.

inverted without disturbance of the contents was considered as the time of clotting. Since frequent movement of the test-tubes tended to prevent the formation of a solid clot when the time of clotting was prolonged, those experiments in which solid clots were not formed have been rejected. All these experiments have been repeated, some of them many times.

The effect of alkali upon clotting.—Most of the experimental work was performed with soda, the other alkalies being used only as controls. When varying quantities of soda were added to milk, results were obtained of which those recorded in Table i. were typical.

Table i.

Acidity of milk, 16·8°.

Tube.	Milk.	$\frac{N}{10}$NaOH.	Water.	Rennet.	Result.
1	5 c.c.	—	1 c c.	0·15 c.c.	Clotting in 37 min.
2	,,	0·1 c.c.	0·9 c.c.	,,	,, 62 ,,
3	,,	0·2 c.c.	0·8 c.c.	,,	,, 137 ,,
4	,,	0·3 c.c.	0·7 c-c.	,,	,, 398 ,,
5	,,	0·4 c.c.	0·6 c.c.	,,	No clotting.
6	,,	0·5 c.c.	0·5 c.c.	,,	,,
7	,,	0·6 c.c.	0·4 c.c,	,,	,,
8	,,	0·7 c.c.	0·3 c.c.	,,	,,

From Table i. it will be seen that while 0·8 cc. $\frac{N}{10}$NaOH at least was required to neutralise the milk, the addition of 0·4 cc. $\frac{N}{10}$NaOH sufficed to prevent clotting. Less quantities than 0·4 cc. $\frac{N}{10}$NaOH also markedly delayed the onset of the change. This milk therefore, though acid to litmus and phenolphthalein, does not clot with rennin even after many hours.

If the amount of rennet was increased, analogous results which are tabulated in Table ii. were obtained.

It is seen that while the greater quantity of rennet hastened the time of clotting when the amount of soda was small, the addition of 0·4 c.c. $\frac{N}{10}$NaOH to 5 c.c. milk prevented clotting. The quantity of soda that was sufficient to prevent clotting in samples of milk of different degrees* of acidity was very constant. Thus, though the acidity of different samples of milk varied from 12°-20°, the same quantity of soda (0·4 c.c. $\frac{N}{10}$ NaOH to 5 c.c. milk) prevented

TABLE ii.

Acidity of milk, 16·8°.

Tube.	Milk.	$\frac{N}{10}$ NaHO.	Water.	Rennet.	Result.
1	5 c.c.	—	1 c.c.	1 c.c.	Clotting in 13 min.
2	,,	0·1 c.c.	0·9 c.c.	,,	,, 29 ,,
3	,,	0·2 c.c.	0·8 c.c.	,,	,, 38 ,,
4	,,	0·3 c.c.	0·7 c.c.	,,	,, 82 ,,
5	,,	0·4 c.c.	0·6 c.c.	,,	No clotting.
6	,,	0·5 c.c.	0·5 c.c.	,,	,,
7	,,	0·6 c.c.	0·4 c.c.	,,	,,
8	,,	0·7 c.c.	0·3 c.c.	,,	,,

clotting. This is dependent upon the quantity of mono-hydrogen and di-hydrogen phosphate present in the milk. Further, as will be shewn in a later paper, the measure of the acidity of milk is not the measure of the lactic acid present, and the acidity of milk is not that of the lactic acid formed by fermentation from lactose. If the quantity of soda was kept constant in a series of tubes in which the amount of rennet was varied, the time of

TABLE iii.

100 c.c. milk received 2·8 c.c. $\frac{N}{10}$ NaOH.

Acidity of milk then 12°. Each tube contains 5 c.c. milk.

Tube.	Rennet.	Time of Clotting.
1	0·1 c.c.	33 min.
2	0·2 c.c.	22 min.
3	0·3 c.c.	19 min.

clotting diminished as the rennet was present in larger quantity, provided always that clotting occurred at all. Such a series is recorded in Table iii.

* It is customary to denote the number of cubic centimetres of decinormal soda required to neutralise 100 c.c. milk as so many degrees of acidity.

If potash was substituted for soda, analogous results such as those recorded in Table iv. were obtained. The addition of 0·5 c.c. $\frac{N}{10}$KOH was sufficient to prevent clotting, though 0·7 c.c.

TABLE iv.

Acidity of milk, 14·6°.
5 c.c. milk in each tube. 0·15 c.c. rennet in each tube.

Tube.	$\frac{N}{10}$KOH.	Result.
1	—	Clotting in 27 min.
2	0·1	,, 30 ,,
3	0·2	,, 67 ,,
4	0·3	,, 128 ,,
5	0·4	,, 150 ,,
6	0·5	No clotting.
7	0·6	,,
8	0·7	,,

$\frac{N}{10}$KOH, at least, was required to neutralise the milk. The alkalies, soda and potash, in solution ionise freely, so that a large number of hydroxyl ions are present in the solution. With the carbonates, dissociation is less and the number of hydroxyl ions is relatively much lower. Schields* has shown that in decinormal

TABLE v.

Acidity of milk, 15°.
5 c.c. milk in each tube. 0·15 c.c. rennet in each tube.

Tube.	$\frac{N}{10}Na_2CO_3$	Result.
1	—	Clotting in 27 min.
2	0·1 c.c.	,, 28 ,,
3	0·2 c.c.	,, 66 ,,
4	0·3 c.c.	,, 82 ,,
5	0·4 c.c.	,, 223 ,,
6	0·5 c.c.	No clotting.
7	0·6 c.c.	,,
8	0·7 c.c.	,,

sodium carbonate solution only about 3 % of the concentration of hydroxyl ions in decinormal hydrate are found. Ammonia,

* Schields, Zeitsch. f. physik. Chem., Bd.xii.

also, is only slightly dissociated in solution (about $\frac{1}{88}$ of sodium hydrate). Series of experiments with sodium carbonate and ammonia are tabulated in Tables v. and vi. With sodium carbonate, while 0·75 c.c. $\frac{N}{10}NaOH$ was required to render 5 c.c. milk neutral, the addition of 0·5 c.c. $\frac{N}{10}Na_2CO_3$ prevented clotting. With ammonia, 0·6 c.c. $\frac{N}{10}NH_3$ was required to prevent clotting,

TABLE vi.

Acidity of milk, 14·6°.
5 c.c. milk in each tube. 0·15 c.c. rennet in each tube.

Tubes.	$\frac{N}{10}NH_3$	Result.
1	—	Clotting in 27 min.
2	0·1 c.c.	,, 34 ,,
3	0·2 c.c.	,, 68 ,,
4	0·3 c.c.	,, 134 ,,
5	0·4 c.c.	,, 138 ,,
6	0·5 c.c.	,, 210 ,,
7	0·6 c.c.	No clotting
8	0·7 c.c.	,,

while a little more than 0·7 c.c. $\frac{N}{10}NH_3$ was necessary to produce neutrality of reaction.

The effect of alkali and soluble lime salt.—It is well known that removal of the soluble calcium salts from milk prevents the formation of a clot by rennin, though this removal does not interfere with the conversion of caseinogen into casein; and, further, the addition of small amounts of soluble lime salts hastens the clotting by rennin. If a soluble lime salt was added at the same time as the soda, clotting occurred rapidly. In the series recorded in Table vii., 1 c.c. $\frac{N}{5}CaCl_2$ was added to a series otherwise similar to that recorded in Table i. From Table vii., it is seen that the speed of clotting was rapid whatever amount of soda was present. While the addition of calcium chloride at the same time as soda sufficed to produce clotting, yet the addition of calcium chloride after soda, rennet, and milk had been in contact many minutes was without effect in causing clotting.

TABLE vii.

Acidity of milk, 17°.

5 c.c. milk in each tube. 0·15 c.c. rennet in each tube.

Tube.	$\frac{N}{10}$NaOH.	$\frac{N}{5}CaCl_2$	Result.
1	—	1 c.c.	Clotting in 6 min.
2	0·1 c.c.	,,	,, 6 ,,
3	0·2 c.c.	,,	,, 6·5 ,,
4	0·3 c.c.	,,	,, 15 ,,
5	0·4 c.c.	,,	,, 17 ,,
6	0·5 c.c.	,,	,, 28 ,,
7	0·6 c.c.	,,	,, 32 ,,
8*	—	,,	No clotting.

Some experiments of this nature are recorded in Table viii. Calcium lactate was found to behave similarly to calcium chloride.

TABLE viii.

Acidity of milk, 15°.

5 c.c. milk in each tube.

Tubes.	$\frac{N}{10}$NaOH	Rennet.		Result.
1	0·7 c.c.	0·2 c.c.	after 98 min., added 0·3 c.c. $\frac{N}{5}CaCl_2$	No clotting.
2	0·5 c.c.	0·15 c.c.	after 300min., added 0·1 c.c. $\frac{N}{5}CaCl_2$	,, ,,
3	0·7 c.c.	0·15 c.c.	after 300min., added 0·1 c.c. $\frac{N}{5}CaCl_2$	,, ,,
4	0·5 c.c.	1 c.c.	after 226min., added 0·1 c.c. $\frac{N}{5}CaCl_2$	,, ,,
5	0·7 c.c.	1 c.c.	after 226min., added 0·1 c.c. $\frac{N}{5}CaCl_2$	,, ,,

The effect of sodium lactate.—If the acidity of milk be due to lactic acid, as is usually stated, the addition of insufficient soda to neutralise the acid would lead to the formation of sodium lactate. When varied amounts of $\frac{N}{10}$ sodium lactate were added to milk, results similar to those in Table ix. were obtained. With increasing quantities of $\frac{N}{10}$ sodium lactate from 0·1 c.c. to 0·7 c.c. to each 5 c.c. milk, little or no alteration in the time of clotting was observed.

*No rennet.

TABLE ix.

Acidity of milk, 18·8°.

5 c.c. milk in each tube. 0·15 c.c. rennet in each tube.

Tubes.	$\frac{N}{10}$ Sodium lactate.	Result.
1	—	Clotting in 27 min.
2	0·1 c.c.	,, 28 ,,
3	0·2 c.c.	,, 28 ,,
4	0·3 c.c.	,, 28 ,,
5	0·4 c.c.	,, 28 ,,
6	0·5 c.c.	,, 28 ,,
7	0·6 c.c.	,, 28 ,,
8	0·7 c.c.	,, 29 ,,

The effect of other sodium salts.—The action of two other salts of sodium, di-sodium hydrogen phosphate and sodium chloride, was examined. Both these salts delayed somewhat the clotting, as shown by Tables x. and xi. The addition of increasing

TABLE x.

Acidity of milk, 18·8°.

5 c.c. milk in each tube. 0·15 c.c. rennet in each tube.

Tubes.	$\frac{N}{3}$NaCl	Result.
1	0·1 c.c.	Clotting in 39 min.
2	0·4 c c.	,, ,, 51 ,,
3	0·8 c.c.	,, ,, 54 ,,
4	—	,, ,. 38 ,,

quantities of $\frac{N}{3}$NaCl from 0·1 c.c. to 0·8 c.c. to 5 c.c. milk slowed somewhat coagulation. With sodium phosphate the addition of quantities from 0·1 c.c. to 0·7 c.c. $\frac{N}{10}Na_2HPO_4$ delayed the speed of clotting.

Causation of the prevention of clotting.—In the first place it was desirable to ascertain whether the rennet had been destroyed or whether its action upon the milk had been inhibited. It has been shown by numerous investigators, Maly,* Lörcher,† Hammarsten,‡ Ringer,§ Langley,|| and Boas,¶ that small quantities of free caustic soda rapidly destroy rennin. This destruction is

TABLE xi.

Acidity of milk, 18·8°.

5 c.c. milk in each tube. 0·15 c.c. rennet in each tube.

Tubes.	$\frac{N}{10}Na_2HPO_4$	Result.
1	—	Clotting in 31 min.
2	0·1 c.c.	,, 43 ,,
3	0·2 c.c.	,, 59 ,,
4	0·3 c.c.	,, 59 ,,
5	0·4 c.c.	,, 59 ,,
6	0·5 c.c.	,, 70 ,,
7	0·6 c.c.	,, 74 ,,
8	0·7 c.c.	,, 76 ,,

produced by the hydroxyl ions which result from the dissociation of the soda. If there were present in the milk to which caustic soda had been added free hydroxyl ions, destruction of rennin would occur. If the rennin had been destroyed, it would not be possible to produce clotting of this milk after the conditions of the milk had again been made favourable to clotting. On the other hand, if rennin were still present, the establishment of a favourable environment should produce clotting. It was found that the addition of neither hydrochloric acid, nor hydrochloric acid and calcium chloride, nor fresh milk, hydrochloric acid and calcium chloride, produced clotting after the milk and soda had been in contact for four hours. If, however, the quantity of $\frac{N}{10}NaOH$ was not great, the addition of these substances sometimes produced clotting. Some typical experiments are recorded in Table xii.

* Quoted in article 'Estomac,' Richet, Dict. Physiol., Paris, 1902, t.v., p.688.

† Arch. f. d. g. Physiol., Bd.lxix., s.141, 1898.

‡ Maly's Jahrb., 1874.

§ Journ. Physiol., Vol.xi., 1890.

|| Journ. Physiol., Vol.iii., p.287, 1880-2.

¶ Zeitschr. f. klin. Med., Bd.xiv., s.249, 1888.

When, however, in addition to hydrochloric acid, rennet was added, clotting occurred in a few minutes. Experiments in this category are tabulated in Table xiii.

TABLE xii.

Acidity of milk, 16·8°.

5 c.c. milk in each tube. 0·15 c.c. rennet in each tube.

Tube.	$\frac{N}{10}$NaOH.	Time in contact without clotting.	Remarks.
1	0·4 c.c.	270 min.	added 0·3 c.c. $\frac{N}{10}$HCl. No clotting.
2	0·5 c.c.	270 ,,	added 0·4 c.c. $\frac{N}{10}$HCl. ,, ,,
3	0·6 c.c.	270 ,,	added 0·4 c.c. $\frac{N}{10}$HCl. ,, ,,
4	0·5 c.c.	270 ,,	added 0·4 c.c. $\frac{N}{10}$HCl. + 1 c.c. $\frac{N}{5}CaCl_2$. No clotting.
5	0·5 c.c.	250 ,,	added 0·4 c.c. $\frac{N}{10}$HCl. + 1 c.c. $\frac{N}{5}CaCl_2$. No clotting.
6	0·6 c.c.	250 ,,	added 0·6 c.c. $\frac{N}{10}$HCl. + 1 c.c. $\frac{N}{5}CaCl_2$ + 0·5 c.c. fresh milk. No clotting.

The conclusion to be drawn from these data is that the presence of small quantities of soda insufficient to neutralise the milk leads to the destruction of the added rennet.

TABLE xiii.

5 c.c. milk in each tube.

Tube	$\frac{N}{10}$NaOH	Time in contact without clotting.	Remarks.
1	0·4 c.c.	270 min.	added 0·3 c.c. $\frac{N}{10}$HCl + 0·15 c.c. rennet. Clot in 5 min.
2	0·7 c.c.	270 ,,	added 0·6 c.c. $\frac{N}{10}$HCl + 0·15 c.c. rennet. Clot in 86 min.
3	0·6 c.c.	300 ,,	added 0·5 c.c. $\frac{N}{10}$HCl + 1 c.c. $\frac{N}{5}CaCl_2$ + 0·15 c.c. rennet. Clot in 4 min.
4	0·6 c.c.	270 ,,	added 0·5 c.c. $\frac{N}{10}$HCl + 1 c.c. $\frac{N}{5}CaCl_2$ + 0·15 c.c. rennet. Clot in 18 min.
5	0·6 c.c.	250 ,,	added 0·6 c.c. $\frac{N}{10}$HCl + 1 c.c. $\frac{N}{5}CaCl_2$ + 5 c.c. milk + 0·15 c.c. rennet. Clot in 26 min.

In considering the cause of this destruction, the results that have been obtained in the presence of other sodium salts must be remembered. Since sodium lactate had little or no action upon clotting, it would appear that sodium hydrate did not react with lactic acid and form sodium lactate. Again, since sodium chloride and di-sodium hydrogen phosphate had likewise no rapid deleterious action upon rennet, the sodium ion must be excluded as the cause of the destruction of rennet. Since the relative concentrations of sodium and calcium ions present did not need to be altered to produce clotting (see Table xiii.) it would appear that the increased mass of sodium was not responsible for the failure of the formation of a clot. Destruction of the rennet with no conversion of caseinogen into casein is, therefore, to be regarded as the principal factor in the prevention of clotting by the soda.

In the further elucidation of this question certain general considerations are of value. Milk contains salts of phosphoric acid, both in suspension and solution, and when fresh both hydrogen and hydroxyl ions are present. Within certain limits the addition of free acid or alkali will occasion little alteration in the concentrations of hydrogen or hydroxyl ions. Instead there will be a slow conversion of mono-hydrogen to di-hydrogen phosphate or *vice versâ* with the object of eliminating any excess of hydrogen or hydroxyl ions. The addition of acid or alkali to milk will thus not lead to a marked alteration in the acid or alkaline nature of the fluid, but to an alteration in the type of the phosphates present in the milk.

When milk stands for some hours after milking, acid is produced by the lactic acid bacilli in the milk. This lactic acid interacts with the di-sodium phosphate and other mono-hydrogen phosphate in the milk forming as a result lactate and di-hydrogen phosphate.

$$HC_3H_5O_3 + Na_2HPO_4 = NaC_3H_5O_3 + NaH_2PO_4$$

As is well known, the lactic acid bacilli do not multiply in culture media unless means are adopted to neutralise the lactic acid as it is formed. This neutrality is usually assured by the addition of chalk or zinc white. In milk, as we see, a somewhat similar result is attained by a different mechanism. Free acid will not be present until the phosphate has been entirely converted to the di-hydrogen form. Experimentally this has been confirmed by examination of milk for free acid. Only a small quantity of free acid corresponding to 1 c.c. or 2 c.c. $\frac{N}{10}$NaOH was present when 100 c.c. of milk required 14 c.c. to 18 c.c. $\frac{N}{10}$NaOH for neutralisation.

As the milk becomes acid, the phosphate will be present partly as soluble sodium di-hydrogen phosphate and partly as soluble sodium di-hydrogen phosphate and partly as slightly soluble calcium hydrogen phosphate. Much calcium hydrogen phosphate is present in suspension, not in solution. When this suspended calcium hydrogen phosphate was removed by filtering acid milk through porcelain, the clear transparent filtrate required only a small amount of $\frac{N}{10}$NaOH to render it alkaline. Thus a sample of milk, 100 c.c. of which required 16 c.c. $\frac{N}{10}$NaOH was filtered through porcelain, and 100 c.c. of the filtrate required 4 c.c. $\frac{N}{10}$NaOH to turn phenolphthalein pink. In this sample the free lactic acid in 100 c.c. milk was equivalent to only 0·8 c.c. $\frac{N}{10}$NaOH. The addition of quantities of $\frac{N}{10}$NaOH to 5 c.c. milk as described in the experiments in Table i., would thus lead to free hydroxyl ions in the milk in concentration sufficient to destroy the rennet before the necessary conversion of caseinogen into casein.

In conclusion we would render our thanks to Professor Anderson Stuart, in whose laboratory these experiments were carried out.

THE MINERALS AND GENESIS OF THE VEINS AND SCHLIEREN TRAVERSING THE ÆGIRINE-SYENITE IN THE BOWRAL QUARRIES.

By D. Mawson, B.E., B.Sc., Lecturer in Mineralogy and Petrology at the University of Adelaide.

(Plates xlix.-li.)

Contents.

i. The Parent Intrusive Mass of Ægirine-Syenite.

The syenite quarries of Bowral* have been somewhat largely described in a previous communication† by T. G. Taylor and the author; on that occasion, however, detailed attention was not given to the small pegmatite and related veins so numerous and well exposed by quarrying operations.

The intrusive body, due to surface denudation, stands out as an imposing mass, the "Gibraltar Rock," rising nearly 1000 ft. above the neighbouring flat country, and is over half a mile in width and about one and a half miles long. The intruded sedimentary beds are Triassic shales and sandstones above, passing evenly downwards into the Permo-Carboniferous productive coal measures at a depth of less than 1000 ft. below.

In dealing with the syenite, we had correlated it with *bostonite* after a petrological examination of the light-coloured variety prevailing in the easternmost quarries. Since then, more detailed work has revealed that originally the whole mass of the Gibraltar syenite was fairly uniform in character, and that the "leucocratic" variety owes its light colour to extreme carbonation of the ferriferous minerals by the powerful action of highly carbonated solutions, containing in addition fluorine, which circulated in the vicinity of Loveridge's main quarry at the close of the pneumatolitic stage. A little further to the south and east of this locality, near the margin of the intrusion, the mephitic action has been extreme and the felspars are completely kaolinised. This is an example of deep-seated kaolinisation not infrequently met with and difficult of explanation by normal agencies of decomposition.

In specimens of the less-altered rock obtained from the quarries, the former sites of iron silicates are seen to be occupied by a heterogeneous mass of decomposition products, chiefly carbonates.

---

* Bowral is situated about 70 miles in a south-west direction from Sydney.

† "The Geology of Mittagong," Journ. Proc. Roy. Soc. N. S. Wales, Vol. xxxvii, p. 306.

After a careful study of a number of sections representing stages from the completely carbonated rock to the freshest obtainable, I am able to state that the original iron silicates were ægirine and ægirine-augite. Exceptionally, traces of blue amphibole were observed, but evidently derived by uralitisation from the ægirine.

The felspar is a clear orthoclase and has evidently preceded the ægirine in crystallising out. In fact the ferriferous silicates, in the main, occupy what were minute drusy cavities, fairly evenly scattered, left after the complete crystallisation of the felspar; the latter has taken effect in such a way as to form compact areas between the residual drusy spaces. These compact felspar areas, though presenting idiomorphic boundaries towards the cavities, have internally a moiré appearance.

In distinction to this type of solidification, producing solid felspar aggregates and free areas between occupied by the ferriferous residuum of the magma, is the typical *paisanite** from the summit of Mt. Jellore, eight miles to the north-east, in which spongy felspar crystallisations have resulted, with interspaces occupied by a poikilitic arrangement of later crystallising amphibole.

The Bowral syenite is unique in forming so huge an intrusive mass and still remaining so even-textured and fine-grained; it is completely crystalline and shows no attempt at flow structure.

The general characters of the rock are more those of an aplite than of a typical syenite, but, on account of its field relations, must be considered with the latter.

Originally containing a considerable proportion of ægirine and related pyroxene, it can no longer be regarded a *bostonite*, and naturally is to be considered with the class of ægirine-syenites described by Rosenbusch.† Comparison of the analyses‡ with that of the ægirine-syenite from Salem Neck§ makes the analogy more apparent.

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* *Loc. cit.*, compare figs.1 and 2 of Plate xxvi.
† "Elemente der Gesteinslehre," 1901 Ed., p.118.
‡ "Geology of Mittagong," Analyses ii. and iii., p.341.
§ "Elemente der Gesteinslehre," Anal.15, p.114.

ii. Classified Descriptions of the Veins.

(a) *Bitumen veins.*—In the neighbourhood of Loveridge's main quarry, traversing the carbonated syenite usually in an almost vertical direction, are occasional black lines hardly broader than a thread of cotton. Ready fracture of the rock along them discloses considerable lateral extension. The main strings are always plane and straight. In some instances several parallel were noted crowded into a breadth of only a few centimetres. Blindly ending branches often diverge for short distances. The dark filling is pitch-like in appearance, and will burn on platinum foil with a smoky flame leaving only a trace of ash. This forms a very interesting occurrence of a hydrocarbon evidently distilled from the Permo-Carboniferous coal measures below and condensed in fissures of escape.

Examined microscopically, the bitumen is often seen to line either side of the crack, whilst the central filling may be of chalcedony. The rock traversed is completely carbonated, no iron silicates or iron oxides showing; in one instance bitumen itself was observed partly occupying the site of a former alkali-iron silicate.

(b) *Simple pegmatite veins.*—(1) Those of small dimensions, width about 1 cm., also typified by absence or paucity of amphibole.

(*a*) Veins almost exclusively occupied by sanidine crystals. These are irregular in direction, usually more or less horizontal, extend only short distances, and preserve a subparallelism of the sides. Where they are narrow, glassy felspar crystals interlace across the whole width, leaving, however, much unoccupied space between the individuals. In the case of wider fissures, drusy walls have been noted. Alkali-iron minerals are absent or only very sparingly represented. The probable explanation of this type of vein formation seems to be that of contraction fissures of limited extent, into which material capable of developing sanidine crystals has sweated from the sides.

(β) A more typically developed vein of this class is that enriched by a fair proportion of alkali-iron silicates(Pl.xlix., fig.1). These are most numerous crossing the dark-coloured syenite of the westernmost quarries. Though the sides are by no means plane, they preserve a well-marked parallelism, definitely indicating contraction fissures in which evidence of lateral movement of the sides is absent. The vein-filling is uniformly coarse and abruptly differentiated from the fine-grained ægirine-syenite traversed. Large crystals of sanidine reticulate from one side to the other, though seldom extend completely across; the interspaces are largely occupied by ægirine and acmite-like pyroxene with less frequent arfvedsonite and grains of leucoxenised ilmenite. Uralitisation and carbonation are seldom observable; decomposition of the pyroxene, when evidenced, generally having attacked the ægirine-augite centres which are occasionally found as a brownish-green chlorite-like substance. Interspaces are numerous, lined by secondary chalcedony and fibrous quartz, often with a central filling of granular quartz.

It is supposed that this type of vein had a similar origin to that preceding. Iron molecules were likely derived from a similar source as the ingredients of the sanidine; the late crystallisation of the alkali-iron silicates can no doubt be ascribed to their superior solubility. There is, however, just a possibility that the iron minerals were introduced from a distant source at the close of the sanidine crystallisation period; against this is to be urged the absence of any corrosion or zoning phenomena in the sanidines, indicative of such a change in physical conditions.

(2) Those of larger dimensions both as regards width and lateral extension. Examples examined and classed under this heading averaged 3 cms. wide. In these amphibole is abundant.

(*a*) Veins that have suffered but little from attack by secondary circulating active vapours (Pl.l., figs.1 and 2).

These have a fresh appearance, clear idiomorphic sanidines contrasting strongly with the black ferriferous minerals. The best examples were got in a quarry about 200 yards west of Loveridge's main workings.

On close inspection, these veins often show vestiges of a border zone like that strongly developed in class (c). The texture is very similar to that of the preceding subtype; a reticulating network of idiomorphic sanidine crystals represents the product of first deposition, arfvedsonite and a little ægirine occupy the interspaces especially abundant towards the centre, conspicuous on account of their contrasting colour. Quartz, perofskite, zircon and ilmenite are also represented in the original crystallisation but are very variable in amount, never more than accessories, and often quite wanting.

A second period of mineral deposition is evidenced, more or less, in all cases examined. Original cavities, drusy with perfectly developed arfvedsonite tables, have been lined by chalcedony and filled, chiefly, by granular quartz; such areas occupied by siliceous fillings are distributed most conspicuously down the centre of the vein, testimony of the passage of mineralising solutions.

The silica of this second deposition is considered not to have been derived from a like source as that producing the primary crop of minerals. It has its origin beginning with decomposition of original minerals by secondary active solutions; silica depositions in the trunk channels being a consequence of carbonation, uralitisation, etc., elsewhere. As the classification implies, this feature is here but slightly marked when comparison is made with the next succeeding subclass described.

(β) Veins which have been subjected to powerful secondary attack by active solutions. Incidentally, much oxide of iron has been set free, pervading the formation with a general clove-brown tint.

In their earlier stages, these are identical with those described immediately preceding; much that has been said therefore need not be further repeated.

The very interesting phenomenon of their metamorphosis, in this case best expressed by the term metachemisation, is the main subject for description. The invasion of active solutions has been chiefly into those veins of largest dimensions, having greatest residual central space (after primary crystallisation) and probably at the same time most extensive laterally, allowing access of material from distant sources and obtaining continued serviceability as trunk channels for circulation.

The metamorphosing solutions may have been characterised by two stages; firstly, those producing uralitisation of the pyroxene and affecting the sanidine by corrosion and deposition of foreign dust-like matter along the cleavage traces; secondly, powerfully carbonating solutions reducing especially the alkali-iron minerals to simple compounds. It is entirely more probable, however, that as both effects are commonly seen represented in the same slide and often apparently in process together, that they have been wrought not by different vapours and solutions, but only by different phases of action, either singly or in conjunction, of one active menstruum

The ultimate results of metachemisation have been to produce a secondary arfvedsonite-riebeckite amphibole from the primary ægirine (uralitisation); to convert the amphibole both primary and secondary to heterogeneous paramorphs chiefly composed of siderite, calcite, silica and a small quantity of fluorspar, and in addition, where carbon dioxide has not been present in sufficient quantity, some brown oxide of iron; powerful corrosion of the sanidines, often only dusty paramorphs remaining; choking of former passages and miarolitic and drusy cavities by deposition of chalcedony and quartz, usually stained by oxide of iron and enclosing other less abundant secondary minerals, as fluorspar, calcite, &c.

It is necessary to postulate final escape for the active circulating waters in order to explain the complete disappearance of alkalies set free from the silicates affected.

The carbon dioxide forming alkaline carbonates so potent in attack on the silicates has, without a doubt, originated from the effects of intrusion into the thick coal measures below.

(c) *Those exhibiting well marked flow structure;* at the same time a strongly developed prismatic border zone is persistently present.

(1) This type is typical of the class and shows well defined border zones on either side, about 0·5 cm. wide, composed of stout sanidine crystals arranged normally to the sides of the fissure; the main body of the vein, within, has a finer-grained texture than that of the preceding classes, but is yet much coarser than the parent syenite traversed. The sanidines of the core towards its margins, in proximity to the prismatic zones, are conspicuously arranged in flow structure; towards the interior, it assumes a pilotaxitic arrangement in which ægirine and arfvedsonite are subordinate, the latter noticeably more abundant towards the centre (Pl.xlix., fig.2). The flow structure argues introduction in a viscous state with felspars previously formed or contemporaneously crystallising out. Corrosion and corrasion of the inner extremities of the sanidines forming the prismatic border zone is sufficient evidence that they are not crystallisations from the central filling but formed at an earlier period, either sweating from the sides or proceeding from less viscous solutions.

Uralitisation and carbonation are both to be noted, though not sufficiently extensive to materially affect its characters.

(2) In the carbonated syenite of Loveridge's main quarry, parallel-sided veins about 2 cms. wide were noted, of a uniform colour slightly darker than the rock traversed. At first glance they appear to be of an entirely new class. Carefully examined, they show close analogy to that just described. A much corraded prismatic border zone and a central filling with flow structure towards the margin. Like the body of the rock in the neighbourhood, however, it has been bleached by extreme carbonation and its salient characters thereby somewhat obliterated.

Abundant siderite and leucoxene are all that remain of the ferriferous minerals; secondary chalcedony and silica compose about twenty per cent. of the material, their preponderance suggesting a primary origin which, however, cannot be reconciled with their petrographical relations. In places where sanidine crystals are embedded in chalcedony, they frequently show a narrow marginal zone of what appears to be a slightly more acid felspar extinguishing alike with the original individual.

In a few cases, slight parting along the walls suggested that contraction consequent perhaps on cooling had taken place in the vein subsequent to the consolidation of invading magma.

iii. Descriptions of the Minerals.

Ægirine is found as stumpy crystals with splendent black faces, in association with arfvedsonite.

A typically developed crystal measured 0·75 cms. in the c to c' direction, with a cross-section of 0·44 cms. from a to a', and 0·31 cms. from b to b'. The prism zone is always well formed, and several accordant readings were made $b \wedge m = 42° \ 38'$. No satisfaction was obtained by measurements on several irregular vestiges of pyramid faces closing the crystal. Internally these large crystals are often quite uniform in character, though in some of the veins they are invariably zoned.

Result of analysis.—Colour of the powder yellowish-grey. Specific gravity determined on pure material, employing similar methods to those adopted in the case of the amphibole—3·70 at 26°C.

SiO_2	49·49	K_2O	0·18
TiO_2	0·89	Li_2O	nil
Al_2O_3...	trace	ZrO_2	1·80
Fe_2O_3	27·76	$H_2O+(110°C)$ ...	0·95
FeO	4·71	$H_2O-(110°C)$ ...	0·35
MnO	0·60	$Fl. Cl. SO_3. P_2O_5. V_2O_5. Cr_2O_3$	nil
CaO	3·28		
MgO	0·30		
Na_2O...	10·10		100·41

Notes on the analysis.—Only one complete analysis was attempted owing to scarcity of the pure mineral. The material was carefully selected from the débris of the rock by hand-picking. Each of the fragments was separately crushed, and the streak noted as a means of deciding on its final inclusion amongst the chosen material.

A petrographical study revealed the fact that, no matter how carefully the material for analysis be chosen, it would likely not represent a distinct species on account of many of the crystals being composed of several kernels, one within the other, of slightly varying composition, as evidenced by progressive differences in physical properties.

Discordance amongst the several analyses quoted by Dana in respect of the relative proportions of monoxide to sesquioxide bases was sufficient inducement to cause me to make several extra determinations of ferrous iron; these were done on small chips readily obtained from some of the larger crystals showing in the rock. As a result the FeO constituent was found to vary considerably, up to almost 8%, and in one case completely absent; in this last assay the chip had the appearance of being specially select, and the operations were conducted with the greatest care. The absence of ferrous iron indicates a theoretically pure ægirine; returns of small quantities of ferrous iron betoken intermediate stages between ægirine and other pyroxenes, and substantiate conclusions evinced by the microscopically zoned characters.

The only other constituent deserving special mention is the ZrO_2 which appears to be definitely combined with the silicate as a Lavenite-like molecule. Inclusions of zircon in the ægirine were rare, and, taken together with the fact that the three separate determinations proved its presence in fairly constant amount, lend support to the above decision.

Discussion of the formula.—In an attempt to develop a formula in agreement with the analysis, zirconia was regarded as an acid radicle from analogy with the cases of the closely related minerals Lavenite and Wohlerite. Likewise, as in titaniferous augites, the titania was taken as an acid radicle.

The rôle of the water was not so evident, though it was expected to rank with the alkalies, as is to be inferred in the cases of several of the analyses quoted by Dana.

The impossibility of meeting the demands of the analysis with any concise formula is most certain evidence that, as was suspected after the petrological examination, the pyroxene material selected was not of uniform composition.

The theoretical empirical formula $Na\overset{III}{Fe}(SiO_3)_2$ given by Dana is no doubt correct for the pure mineral, though only roughly approximated to by any of the analyses quoted. In all cases a considerable amount of ferrous iron is returned, as also are varying quantities of the other protoxide bases. No strict analogy was found amongst any of them when stated in groupings of like vicarious constituents.

Petrological features.—A slide prepared from the remaining part of a crystal, portion of which, on analysis, had returned no ferrous iron, showed it to be of a bright grass-green colour by transmitted light; pleochroism along a horizontal axis, slightly yellower than that along a(near c); extinction with $c = 3°$. The mineral is therefore rather a bright green variety of ægirine.

The crystals are often much zoned, especially in the smaller veins; a single individual may show a succession of stages intermediate between ægirine-augite and ægirine(see text fig.1).

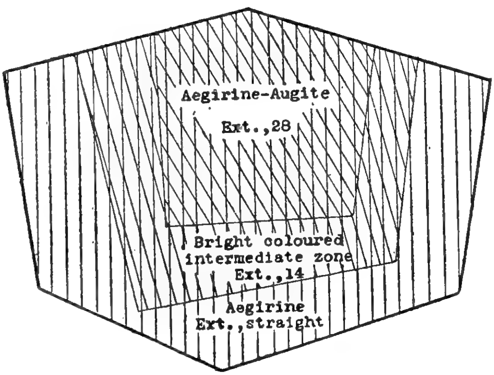

Fig.1.—Zoned pyroxene; ægirine-augite within to ægirine externally.

Such progressive change in optical properties from the kernel outwards is evidently occasioned by a systematic development of its molecular constituents, whereby protoxide bases, most abundant in its earlier stages of growth, were later on replaced in increasing amount by sesquioxides; also that the earlier crystallisations were marked by greater abundance of lime, magnesia and like molecules in place of iron.

The ægirine strongly withstands decomposition, often quite fresh in situations where sanidine and arfvedsonite have entirely succumbed. When zoned, selective decomposition is generally to be noticed, one band only being attached, often to its complete destruction, whilst other parts of the crystal remain perfectly fresh. The various zones have also, to a certain extent, methods of decomposition peculiar to themselves. The outer zone of ægirine almost universally passes through a stage of uralitisation, before conversion to what may be more accurately termed decomposition products.

Uralitisation produces an arfvedsonite-riebeckite type of amphibole, accompanied usually by a small amount of colourless mineral, in basal sections, seen arranged in fine strings along the cleavage directions; this latter substance is largely chalcedony (Pl. li., fig. 1). In its turn the amphibole suffers decomposition just as does the primary mineral to be later described.

The volume changes experienced by the conversion of ægirine to arfvedsonite would in the case of the theoretically pure minerals be of the following nature:—

$$\underset{\text{(ægirine)}}{5(Na_2O.Fe_2O_3.4SiO_2)} = \underset{\text{(arfvedsonite)}}{(5Na_2O.8FeO.Fe_2O_3.16SiO_2)} + 4SiO_2 + 4O$$

and assuming specific gravities as determined for the particular minerals* described in this paper—

$$\frac{\text{Vol. of Arfved.}}{\text{Vol. of Æg.}} = \frac{\text{Molec. wt. of Arfved.}}{\text{Sp. Gr. of Arfved.}} \times \frac{\text{Sp. Gr. of Æg.}}{\text{Molec. wt. of Æg.}} = \frac{1933 \cdot 9}{3 \cdot 35} \times \frac{2 \cdot 7}{2239 \cdot 5}$$

and the volume of arfvedsonite works out to be 95·38 % of the original ægirine. In other words, a loss in volume of 4·62 %. As already noted, a little silica was observed deposited along the cleavage lines; the greater part, however, must be removed during the process, as if all were retained, it is found on calculation that an increase in volume of 10 % above that afforded by the ægirine would be necessary to accommodate it.

In cases where the ægirine was observed to pass rapidly into carbonates, a narrow greenish-grey, semi-opaque belt separates

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* Taken in conjunction with theoretical molecular weights, of course only approximate results can ensue.

the carbonates from the unaltered mineral; under high power this belt was found to consist chiefly of very fine granular deep blue amphibole.

Direct carbonation, or what appeared to be such, was noted only in one or two rare instances.

In zoned crystals, a strongly coloured portion with extinction angle about 12° and intermediate in composition withstands decomposition most effectively, often remaining as the sole remnant of the former composite individual.

The ægirine-augite kernels, when decomposed, are more usually found altered chiefly to a yellowish-brown chlorite-like substance with a small admixture of carbonates. The text figure (fig.2)

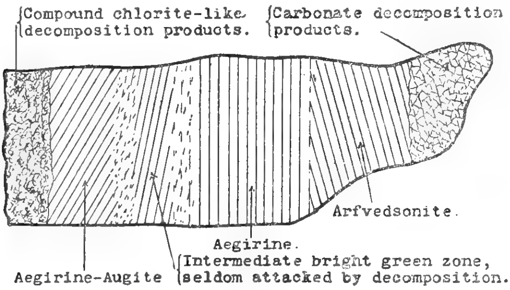

Fig.2.—Illustrating a common form of decomposition in the case of zoned pyroxenes.

represents an actual case noted in one of the smaller veins, and is very instructive as showing all the various peculiarities above described.

Arfvedsonite.—The arfvedsonite is found in association with well developed ægirine crystals and plentiful glassy sanidines; zirconium and titanium minerals are present as accessories; chalcedony and quartz, the products of a second cycle of deposition, are usually abundant (Pl.li., fig.2). In some of the veins the chalcedony is brownish in colour, due to the presence of ferric iron, and is then indicative of certain changes having taken place in the accompanying minerals. In such locations much of the arfvedsonite is secondary, derived from the uralitisation of the ægirine, and should be avoided when pure material is required.

The crystals are jet black with splendent lustre best exhibited on cleavage faces. I have followed the crystallographic orientation adopted by Rosenbusch.*

The characteristic form is tabular on the *b* face, which is always pre-eminently developed. The *m* form completes the prism zone, *a* faces not being observed. Terminal faces are often present, the usual forms (see fig. 3) being {001}, {$\bar{1}$11}, {021}; rarely other faces appear, giving, however, only poor reflections.

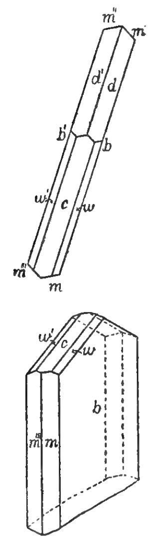

Fig. 3.—Orthographic and clinographic projection of an arfvedsonite crystal as commonly developed.

Two of these forms {$\bar{2}$·5·1} {$\bar{2}$·10·1} appear to be noted here for the first time.

The largest crystal met with had a length of 8 cms., breadth 3 cms. and thickness 2·5 mms. More usually the better developed individuals averaged 2 cms. long and from 1 mm. to 5 mms. thick. Long narrow crystals were frequently bent. The signal from the *b* faces was often much confused, due chiefly to warping. The angles varied slightly from one crystal to another; for example, the (110 ∧ 1$\bar{1}$0) with particularly sharp signals varied through 3′. This is no doubt morphotrophy due to replacement amongst the vicarious constituents.

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* I have to thank Professor Rosenbusch for kindly enlightening me in the matter of recent literature, leading to his interpretation of the crystallographic orientation of the amphiboles and pyroxenes. Following Tschermak, he regards the crystallographic orientation of the amphiboles, in the light of a rotation about the vertical axis of 180° from that originally introduced by Nordenskiold and contained in Dana, 1899 ed.

For further proof that this is the correct view to take, see "A Comparative Study of Etch-Figures. The Amphiboles and the Pyroxenes," R. A. Daly, Proc. Amer. Acad. of Arts and Sciences, Vol. xxxiv., No. 15, 1899, tp. 422.

For comparison, the crystal indices calculated by the old mehod, are quoted as follows:—

$$\grave{a} : \overset{\perp}{b} : \overset{|}{c} = \cdot55600 : 1 : \cdot29222.$$
$$\beta = 73°.$$

The following measurements were made with a Fuess universal reflecting goniometer.

Faces.		Measured Angles.	Calculated Angles.
1. $m \wedge m'''$	$110 \wedge 1\bar{1}0$	56° 0′	
2. $c \wedge m$	$001 \wedge 110$	77° 54′	
3. $d \wedge b$	$\bar{1}11 \wedge 010$	74° 15′	
4. $d \wedge m'$	$\bar{1}11 \wedge \bar{1}10$	67° 55′	
5. $d \wedge c$	$\bar{1}11 \wedge 001$	33° 8′	33° 7′
6. $b \wedge$ D	$010 \wedge 111$	Approx. 77°	75° 51′
7. $b \wedge w$	$010 \wedge 021$	60° 23′	60° 25′
8. $b \wedge u$	$010 \wedge \bar{1}31$	50° 35′	50° 40′
9. $b \wedge g$	$010 \wedge \bar{2}51$	Approx. 45° 20′	45° 55′
10. $b \wedge y$	$010 \wedge 2\cdot10\cdot1$	,, 26° 45′	26° 54′
11. $c \wedge g$	$001 \wedge \bar{2}\cdot5\cdot1$		60° 54′

Numbers 1, 2, 3, and 4 are measurements of the first order, and were used for calculating the crystal indices; the figures quoted are the mean angles for about 15 crystals measured. The face *D* yielded in place of the signal only a faint blur of light, the reading being indefinite, though the presence of the face was certain. Faces *g* and *y* yielded only faint signals.

Calculated crystal indices :—$\breve{a} : \overset{|}{b} : \overset{|}{c}$ = ·54736 : 1 : ·28404

$\beta = 76° \ 16' = 001 \wedge 100.$

Twinning not observed. Cleavage {110} perfect, {010} less perfect. Brittle. Fracture, splintery. Hardness, quite 6. Specific gravity determined by the pycnometer method on an idiomorphic crystal after boiling in distilled water under a suction pump, 3·35 at 26°C. Colour of powder, slate-blue. Highly opaque until the slice approaches 0·06 mm. in thickness. Colour by transmitted light, on sections 0·03 mm. thick, varies from olive-green on (010) to sky-blue tints on (100), and yellowish-grey on (001). Pleochroism on sections 0·03 mm. thick.—

$\mathfrak{a}$ (near *c*) = yellowish-blue.
$\mathfrak{b}$ = bluish-grey.
$\mathfrak{c}$ (near *a*) = faintly brownish-yellow.

Absorption strong,— $\mathfrak{a} > \mathfrak{b} > \mathfrak{c}$

Refractive index not measurable directly by the refractometer; mean value determined with oils about 1·66. Birefringence, very weak and positive.

Dispersion very great. Optic orientation with sodium light, extinction angle on b, $\mathfrak{a} \wedge c = 6°$ in front. No complete extinction in sunlight, due to marked dispersion of the optic axes.

Fusibility does not exceed 2, the fused mineral forming a black magnetic globule. Very little affected by considerable digestion on the water bath with concentrated HCl or H_2SO_4.

Result of Analysis.—Specific Gravity 3·35.

		Molec. Ratio.		
SiO_2	48·90	0·815	0·823÷0·052=15·83	
TiO_2	0·65	0·008		
Al_2O_3...	trace		0·054	=1·04
Fe_2O_3	8·70	0·054		
FeO	26·76	0·372		
MnO	1·09	0·015	0·416	=8·00
CaO	1·35	0·024		
MgO	0·20	0·005		
Na_2O	8·53	0·138		
K_2O	1·60	0·017	0·267	=5·13
Li_2O	0·60	0·020		
H_2O + (110°C.) ...	1·67	0·092		
H_2O − (110°C.) ...	0·29			
Fl	0·18			
ZrO_2	trace			
Cl.SO_3.P_2O_5.Cr_2O_3. V_2O_5.CO_2 ...	nil			
	100·52			
Less O equivalent of Fl	0·08			
	100·44			

Notes on the Analyses.—Several methods for separating the pure mineral were tried, until finally it was found necessary to hand-pick the crushed veinstuff, each crystal fragment then being separately tested by observing its streak when crushed in an agate mortar; in this way, the arfvedsonite was distinguished from all other associated dark minerals, and by rejecting any material in which inclusions were made apparent during the operation of crushing, a very pure sample was obtained.

Several preliminary analyses of different samples showed, by their eccentricities, the material first selected to be slightly contaminated. This led to a more stringent selection from the best obtainable veinstuff for the final analysis quoted above.

The results of the several preliminary partial analyses were of special value in helping to draw up a formula for the mineral, and so will enter into the following discussion.

Silica: Besides that quoted in the analysis, the two following were very accordant, 49·05 %, 50·00 %. *Titania* almost quite constant. *Alumina*: In one case a few centigrammes of the sesquioxides precipitated by ammonium hydrate appeared to be alumina when calculated by difference; more often though, the ferric oxide, calculated from the total iron as determined on the reduced solution which had already served for ferrous iron determinations, was more than sufficient to account for the whole sesquioxide precipitate. *Ferrous and ferric iron* were determined quite a number of times. The earlier determinations varied considerably; later on, with purer material, the following results were obtained on different samples: FeO = 25·39 %, 27 72 %, 26·51 %. In order to determine this proportion as accurately as possible, a single crystal, after powdering, was digested with fairly concentrated H_2SO_4 for five minutes, which, it was expected, would help to free it from foreign matter, and yet not appreciably affect the silicate itself. The washed and dried mineral gave 26·50 % FeO which, calculating from the total iron determined in the same sample, leaves 8·25 % Fe_2O_3. The ratio of ferrous to ferric iron thus appears to be $FeO:Fe_2O_3$::26·50:8·25. *Manganous oxide*: Two estimations gave 1·09 %, 1·30 %. *Lime*: 2·30 %, 1·70 %, 1·48 %, rather variable. *Magnesia* appeared as a minute trace in one only of the analyses. *Soda and Potash*: The importance of an accurate determination of the alkalies merited an unusually careful estimation, the results of blank tests on the reagents being duly regarded. *Lithia*: Two estimations gave 0·60 %, 0·70 %. *Fluorine* though undetected by a careful qualitative test, was proved to be present in notable quantities in several different samples. The estimates were carefully checked by conversion into sulphate and reweighing; two determinations gave 1·40 % and 0·80 %. Finally, specially fresh material was selected and subjected to a preliminary treatment with strong sulphuric acid to decompose any fluorspar which might be present as impurity; on analysis only 0·18 % fluorine was then returned. *Water* above 110°C was very constant. Due care was taken to eliminate any possibility of contamination with fluorine by the introduction of a granulated fused lithage plug before the calcium chloride weighing tube.

Development of a formula.—Grouping the vicarious constituents into like sets offers no special case for consideration, it being evident that titania replaces silica and that the combined water is to be taken with the alkalies. Fluorine might be correctly referred to a combination with the monoxide bases, but as this is somewhat uncertain, the fluorine contents will be overlooked in deducing a formula, its small bulk having very little appreciable effect on the results.

Referring to the molecular ratios calculated from the analysis, a fairly simple empirical formula can be deduced, namely

$$\overset{\text{I}}{R}_5\overset{\text{II}}{R}_4\overset{\text{III}}{R}(SiO_3)_8$$

in which $\overset{\text{I}}{R}$ is chiefly Na, $\overset{\text{II}}{R}$ mainly Fe, and $\overset{\text{III}}{R}$ practically all Fe.

For a theoretically pure arfvedsonite this formula would read

$$5Na_2O.\ 8FeO.\ Fe_2O_3.\ 16SiO_2$$

or stated as a semiconstitutional formula

$$4Na_2SiO_3.\ 8FeSiO_3.\ 2Na\overset{\text{III}}{Fe}(SiO_3)_2$$

$$\text{or } 2(NaFe)_2\ (SiO_3)_3.\ Na\overset{\text{III}}{Fe}(SiO_3)_2$$

Comparison with former Analyses.—The physical properties of the mineral here described appear to answer exactly to those of arfvedsonite; notwithstanding the slight discrepancies in analyses by comparison with that from Kangerdluarsuk, there can be no doubt as to its species. The crystals analysed from Bowral were most of them perfectly formed, and, being smaller than the Greenland material, should give the best results on analysis. Extreme variation in the sesquioxide constituents in the two analyses quoted in Dana* makes it plain that this latter material was not homogeneous.

Decomposition products.—The decomposition products vary with the conditions operating. Carbonation is most in evidence though in some situations, where carbon dioxide supply has been inefficient for complete carbonation, oxidation is prominent. Illustrative examples were noted in one of the slides in which several small arfvedsonite fragments appeared included in sanidine crystals; in one case, where the sanidine envelope was specially perfect, the amphibole remained fresh; where the sanidine proved a less perfect shield, oxidation was prominent; elsewhere the soda-iron silicates were completely carbonated. For illustrations showing an early and a late stage in primary arfvedsonite decomposition, see Pl.li., figs.3 and 4.

Very commonly, especially in veins of class (*b*), subclass 2, type β, carbonation and oxidation are both evidenced, the product being an iron oxide-stained siderite.

Examined critically under a high power, the first stage in the breaking down of the amphibole appears to be the separation of magnetite in dust-like particles, and an irresolvable base which is capable of taking a stain after treatment with hydrochloric acid; it seems likely that this latter substance is a sodium silicate. The attack has, in all probability, been made by solutions of the alkali carbonates, and the effect has been, first, the separation of magnetite, sodium silicate, and iron carbonate followed closely by complete carbonation, when practically all the soda and silica were removed from the original site, the latter largely precipitated later in trunk channels. In some cases, even after the whole individual has suffered alteration, stainable matter remains in small quantity amongst the débris. Chalcedony is likewise found to a small extent scattered sporadically amongst the carbonates,

* Recent literature on the alkali-iron amphiboles quoted by Murgoci is not available here in Adelaide for further reference.

normally only very little silica remains. A little calcite is always present and invariably small amounts of fluorspar, rendered readily perceptible by its violet tinge. The main body of the paramorph is siderite often in well-shaped rhombohedrons, more usually massive with a rough arrangement in the direction of the amphibole cleavage

The small quantities of fluorine present in the scattered grains of fluorspar so generally associated with the amphibole decomposition products may have been introduced with the carbon dioxide at the time of carbonation, or may have had a primary origin locked up in the amphibole until liberated by decomposition; the detection of fluorine by analysis in the unaltered mineral is proof that this latter explanation is correct, at least in part.

Special features.—Slight variations from the typical arfvedsonite are common. The border-zone often shades off into a deeper blue variety which, though more opaque, has not the same intensity of absorption-variation.

This seems to be a parallel case with the zoned arrangement more general amongst the ægirine individuals, and indicating a gradual change in chemical composition. Several cases were noted where the amphibole was observed of this deeper colour in proximity to minute penetrating fissures filled by secondary silica depositions; in such cases, the chemical character of the amphibole accessible for attack seems to have suffered change by contact with vapours or solutions circulating after crystallisation —a slow replacement of some of its molecules in the solid, as is known to be readily possible in the light of modern chemical knowledge.

The central lighter portions are evidently more prone to decomposition, as it is there, always, that carbonation commences (see Pl. li., fig. 4); when far advanced, the resistant blue border alone remains enveloping a mass of carbonates.

The amphibole derived from the uralitisation of the ægirine shows considerable variation; occasionally lighter-coloured with marked absorption, closely resembling in its optical properties Griqualand crocidolite; at other times it appears dense indigo-blue with only moderate absorption-variation. Modifications may even appear in the uralite of a single individual.

An interesting case was noted in a section prepared from one of the smaller pegmatite veins where, in a primary amphibole, a deep blue border zone appeared sharply differentiated from a lighter-coloured central area (see fig. 4). The exact orientation of the section was not ascertainable, though evidently in the prism zone near the *b* face. The border zone, with pleochroism bluer in the **b** direction, corresponds more nearly to riebeckite, and the lighter-coloured central area to arfvedsonite. The deeper blue colour is very likely significant of relatively increased ferric iron molecules.

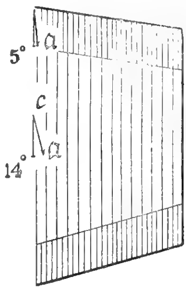

Fig. 4.—Arfvedsonite with a border-zone of riebeckite.

Felspar—The felspars are large well-formed idiomorphic orthoclase crystals which, from their clear and glassy characters, are true sanidines. They are beautifully tabular on the *b* face, show a strongly marked cleavage parallel to the *a* face, and almost universally exhibit carlsbad twinning.

In the hand-specimen, they are seen to be an early product of crystallisation, other minerals appearing, for the most part, pilotaxitically arranged in the interspaces between the sanidine tablets. A microscopic examination shows occasional enclosures of both arfvedsonite and ægirine fragments always, however, very small. At other times, there is evidence that the latest stages of felspar-growth have been concurrent with the earlier development of the larger arfvedsonite individuals. There is a tendency for decomposition to take place along the cleavage planes, and when sufficiently far advanced, by the deposition of opaque dust-like matter often of a reddish hue due to iron oxide stain; twinned individuals present a herring-bone appearance. Concurrently with the deposition of decomposition products along the cleavage traces, corrosion of the border has been noted.

In cases of extreme attack, as met with in class (*b*), subclass 2, type β, semi-opaque rusty-brown areas shading into secondary chalcedonic depositions alone remain. A comparative petrological examination of the various types of veins shows that the conditions active in uralitising the ægirine and decomposing the arfvedsonite have likewise radically affected the sanidine.

In several of the veins, in association with much secondarily deposited silica, the sanidines, first slightly corroded, have received a peripheral addition in the form of a very narrow film of apparently clear glassy felspar; the width of the bands is only about 0·02 mm., too narrow for obtaining an interference figure or to apply microchemical tests. It shows twinning, and is probably a soda felspar.

Accessory Minerals.—**Quartz** developed in small idiomorphic dirhombohedral pyramids subordinate to the arfvedsonite and ægirine, and evidently the last crystallisation of the primary cycle. Frequently it shows evidence of corrosive and penetrative attack in common with all the original minerals. Primary quartz was noted only in class (*b*), subclass 2 veins, and then not in every slide.

Perofskite (?)—Very tiny idiomorphic crystals of a light honey-yellow mineral are rather numerous in the larger types of class (*b*) veins. Their outlines are always quite sharp, usually in very perfect isometric octahedrons, and are found embedded in any of the minerals succeeding the sanidine in period of crystallisation. They are little affected by alteration, though leucoxene-like products are sometimes to be noted developing from without, inwards.

In all cases the mineral is isotropic, not showing any of the optical anomalies usual with perofskite; it may, therefore, be one of several somewhat similar minerals as pyrochlore or dysanalyte.

Ilmenite in large crystals is occasionally noted, and then usually far advanced in leucoxenisation. Small crystals of ilmeniferous magnetite are abundant in the parent mass.

Zircon—Only very exceptionally are crystals answering to zircon met with. These are developed as microscopic laths with high double refraction and straight extinction.

Apatite is wanting in the vein-products, though in the syenite it is often exceptionally well developed as idiomorphic hexagonal prisms.

Small colourless to faintly greenish crystal fragments with optical properties very close to acmite were occasionally noted, and are probably a variety of pyroxene inclined towards lavenite. In one case, where a comparison was possible, the crystallisation period was determined as preceding that of the ægirine.

Secondary Minerals.—**Bitumen,** as described under veins of type (*a*), is found filling microscopic fissures and neighbouring minute cavities. It is no doubt a condensation from vapours originating with the distillation of the coal beds at a depth below.

Examined microscopically, it appears black by reflected light and also by transmitted light except in the thinnest sections, when it is red-brown, resembling hæmatite. It is non-pleochroic and isotropic.

Chalcedony lining cellular spaces in a zonal arrangement of parallel fibrous bands; also as spherulitic radial aggregates, especially so in the larger veins.

Quartz, in comparatively large crystals, often forms the central filling of original cavities; frequently they remain drusy. Much of the quartz exhibits shadowy extinction and is sometimes built up of roughly arranged sectors; after a detailed examination, it was decided that this is a case of optically anomalous quartz and not tridymite as might have been suspected.

In several instances, parallel fibrous material resembling chalcedony was proved by its positive character to be quartz.

Especially where metachemisation has been extreme, a large bulk of the vein is occupied by a mixture of *radial fibrous chalcedony* and *quartz;* in such cases the secondary products always appear red-brown in colour, due to much distributed *iron-oxide.* This iron oxide is derived in part from the decomposition of secondary ferrous silicates, vestiges of which, as minute acicular crystals of a light bluish-green colour, yet remain. In other parts, patches of chlorite are developed. An interesting radial-fibrous mineral is developed amongst the decomposition products of the large veins; the aggregates are very tiny and spherical, light yellow to reddish-yellow, and have a high double refraction.

Carbonation of the ferriferous silicates has led to the development of much *siderite* accompanied by small quantities of *calcite.* The siderite forms perfectly idiomorphic rhombs and is attacked by dilute hydrochloric acid only after warming, thereby readily distinguishing it from calcite. Where decomposition has been effected in the presence of insufficient carbon dioxide, the carbonates are deeply stained by *hydrated iron and manganese oxides.* Amongst the materials of some of these carbonate paramorphs, and in rare instances scattered through the more indefinite siliceous products of the metachemisation cycle, are minute stainable areas thought to probably imply the presence of **Analcite** or some nearly related mineral.

Fluor is found constantly in tiny violet grains amongst the carbonates developed from the arfvedsonite, and in large isometric forms occupying positions amongst the secondary siliceous fillings.

Titanite—Some of the sections contain very numerous fragments of a highly refracting and doubly refracting mineral, chiefly appearing in the wedge-shaped form typical of this mineral. The individuals are very tiny. They have been noted to occur in connection with highly altered felspar, commonly in chalcedony fillings, and in one instance forming a fringe around a perofskite crystal embedded in chalcedony.

Leucoxene in pseudomorphic areas after ilmenite.

iv. Summary and Conclusions.

The veins occupy one-time fissures, some of which were very local, extending only a few inches; others were continuous by the development of connections between a series of these minor openings; in the latter case circulation was established with distant sources.

Veins occupied by bitumen distilled from the coal measures below, form instructive cases and afford a key to other phenomena; they are evidence of distant transportation and incorporation of exotic material.

The more local pegmatite veins could only have originated by sweating from the sides. In the larger and more continuous channels the residual gaseous and more liquid contents of the solidifying rock have collected largely in the same fashion, and, while possessing a considerable freedom of circulation, have crystallised out as a coarse-grained product.

Another class of veins is distinguished as possessing indications of viscous flow whilst in a semi-crystallised state; these latter are finer-grained than the preceding, though noticeably coarser than the syenite alongside. The explanation afforded is that this type has probably been derived from material more in the nature of a solution of small quantities of water and gases in magma, and had commenced crystallising before equilibrium had been arrived at, during viscous flow along developing passages. The coarser-grained veins not showing flow-structure are held to be excellent examples of water- and gas-solutions of the magma.*

Examples intermediate between the latter two classes described are common in the rock mass, and tend to bear out the conclusions regarding pegmatites arrived at by Van Hise,† "there are all gradations between heated waters containing mineral material in solution and magma containing water in solution."

In these Bowral veins the coarser types described under class (*b*) are true pegmatites in every sense of the term; class (*c*) types with their finer grain and flow-structure are more nearly related to the aplites.

Van Hise‡ brings forward solid arguments proving that pegmatites may pass by insensible gradations to simple quartz reefs.

* C. R. Van Hise, "A Treatise on Metamorphism," Mon.47, United States Geol. Survey, p.732.

† *Op. cit.*, p.723.

‡ *Op. cit.*, p.724.

Modern treatises on ore deposits* describe classes of lodes, quite apart from the well-known stanniferous pegmatites and like formations, closely connected with volcanic intrusions and evidently of related origin with pegmatites.

The best known cases in Australia are those described by E. C. Andrews† genetically connected with the great granitic intrusions of the New England District of New South Wales.

Here in South Australia, where pegmatisation is evidenced on an excessive scale, there is no end to examples illustrating its connection with ore-bearing reefs, both oxide and sulphide. Such usually contain complex ores, and in addition the ore-bodies are generally very irregularly distributed; mining development, consequently, seldom leads to profitable results.

The aplites are, therefore, at one extreme of a series of related rock forms differing progressively in abundance of mineralisers (water chiefly) contained in the original magma or solution. It is contended that the origin of aplite is to be ascribed to rupturing of the recently solidified cooling magma, due perhaps chiefly to contraction forces,‡ followed by consequent inflow of yet liquid material, partly by sweating from the sides, but largely augmented by outwellings from the interior extension of the fissures where they approach the unconsolidated magma. Infillings originating in this latter manner would likely show flow-structure and be of the nature of dykes within the parent mass; at their source, passing from the condition of *schlieren*, they would blend as one with their surroundings. Hydrous conditions being more in force at the margins of intrusive masses, such locations would be characterised by the occurrence of pegmatites in contraction fissures, whilst aplites would be more abundant interiorly.

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* See especially Dr. R. Beck's, "The Nature of Ore Deposits," Trans. by W. H. Weed, 1905.

† Records Geol. Survey N. S. Wales, 1905, Vol. viii., Pt. 1, p. 22.

‡ Plain-sided, uniform-textured aplite veins showing little deviation in direction, and continuing for long distances, most likely occupy fault fissures developed during solidification.

The discovery of a small quantity of fluorine in the arfvedsonite is of special interest in view of recent conjectures by petrologists, suspicion being raised that perhaps traces of fluorine may be an invariable constituent of amphibole.

Another case has been brought to light of the occurrence of alkali-amphibole and related pyroxene in pegmatite veins in association with fluorite, titanium minerals and zircon. In the author's opinion, too much stress may be placed on deductions drawn from this fact as to the effect of mineralisers, other than water, on the resulting crystallisations. It is, however, incontrovertible that the presence of water and to a less extent, perhaps, that of fluorine, are necessary for the formation of amphibole in preference to pyroxene. This has been demonstrated by many writers.*

The occurrence of ægirine in excess of arfvedsonite in the more local veins described in this paper, and the abundance of the latter in the wider and more continuous veins, especially in the central part in positions where hydrous action is demonstrated to have had supreme effect, afford additional confirmation of the correctness of this conclusion.

The frequently noted intergrowths† of pyroxene and amphibole would on this determinant alone be difficult of explanation, unless it is assumed that a hydrous magma had been replaced subsequently by anhydrous conditions or vice versâ.

In these veins examples are common where a considerable range in composition is experienced from the kernel outwards, both in the case of pyroxene and amphibole. In some, the variant was found to consist only in the state of oxidation of the iron contents, and may indicate the introduction of periods of greater and less intensity of oxidation or even reduction.

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* Note especially "On the Genesis of Riebeckite and Riebeckite Rocks," by G. M. Murgoci, Amer. Journ. Sci. Aug. 1905, p. 133.

† Primary intergrowths of pyroxene and amphibole, which could be definitely determined as such, were not met with in any of these veins.

The unique feature amongst the minerals is the abundance of a secondary amphibole usually resembling the primary arfvedsonite, but occasionally near crocidolite and riebeckite; this appears to be the first record of uralitisation (typically shown) of ægirine to form alkali-amphibole.* The reverse process, an extraordinary proceeding not elsewhere noted in the case of any of the pyroxenes, has been described by Brögger as taking place in the pegmatite dykes of Christiania.

The uralitisation succeeded consolidation, and proceeded under hydrothermal conditions very active in corroding the felspars and to some extent the quartz; as the secondary minerals contain scattered grains of fluorspar and are largely carbonates, it is inferred that the metachemisation was effected by circulating solutions rendered highly active by containing a small amount of fluorine and large quantities of alkali carbonates.

Pegmatites of the ægirine-syenite following have not, so far as I am aware, been previously described, and might well be called *Bowralite* — a coarse-textured holocrystalline type composed essentially of idiomorphic sanidine, subordinate alkali-amphibole typically arfvedsonite, and some ægirine. See the hand-specimen photograph, Plate I., fig. 2.

Conclusion.

The work herein contained was begun at the Sydney University, and I am indebted to Professor T. W. E. David, F.R.S., etc., and H. S. Jevons, M.A., for suggestions on the petrological side; and to Professor A. Liversidge, F.R.S., etc., and J. S. Schofield, A.R.S.M., for assistance in analysis. Much of the analytical work had to be repeated, later, here in Adelaide, and for its consummation my best thanks are due to Professor Rennie, D.Sc., for unstinted liberality in the matter of apparatus and conveniences, often attended with personal discomfort to himself.

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* Cross and others have described cases of secondary ægirite on amphibole and vice versâ, but such probably do not actually indicate uralitisation.

EXPLANATION OF PLATES.

Plate xlix.

Fig. 1.—One of the smaller pegmatite veins of class (*b*), subclass 1, type *a*. Magnified 2 diameters. The fine-grained texture of the ægirine-syenite traversed is noticeable by comparison. Though warped, the sides are sensibly parallel.

Fig. 2.—A vein, showing flow-structure and a well-marked border-zone, of class (*c*), type 1. Reduced to $\frac{2}{3}$-natural size. This variety has characters relating it to both the pegmatites and the aplites. The accompanying key-plate brings out more prominently its dominant features.

Plate l.

Fig. 1.—Larger-sized pegmatite vein of class (*b*), subclass 2, type *a*. Magnified $\frac{4}{5}$ diameters. The abundance of dark-coloured amphibole occupying the centre of the vein filling is well shown.

Fig. 2.—A typical specimen of the ægirine-syenite pegmatite. Natural size. The dominant constituents, twinned idiomorphic sanidines and the darker subordinate arfvedsonite are readily distinguishable. It is proposed to adopt the locality name *Bowralite* to denote this rock type.

Plate li.

Fig. 1.—Uralitisation of ægirine to arfvedsonite-like amphibole. Magnified 13 diameters. The several light-coloured crystals are ægirine; the amphibole, developing, is the large dark area. Note the clear gaps in the amphibole; these are chiefly chalcedony.

Fig. 2.—Idiomorphic arfvedsonite crystals subordinate to the large sanidine individuals (parts of three of which show on the right), and embedded in secondary silica, largely chalcedony. Before the introduction of this silica, the cavity evidently had a drusy lining of arfvedsonite and sanidine. Magnified 14 diameters.

Fig. 3.—A late stage in the decomposition of idiomorphic arfvedsonite. The clear gaps are mainly carbonates. Magnified 12 diameters.

Fig. 4.—Illustrating the decomposition of amphibole. An earlier stage than that represented in fig. 3. There are fewer clear spaces in the section indicating carbonates and the like, and dark lines where partial carbonation and oxidation are in progress are more abundant. The general darker appearance of the marginal parts is original, and is frequently observed in the primary mineral where metachemisation is evidenced, as explained in the text. Magnified 13 diameters.

THE FIXATION OF NITROGEN BY *RHIZOBIUM LEGUMINOSARUM.*

By R. Greig-Smith, D Sc., Macleay Bacteriologist to the Society.

In the course of the research upon the formation of slime by *Rhizobium leguminosarum*, it was noted that some races formed more slime than others upon media to which no asparagin or other nitrogenous substance had been added, and, being curious to know whether there could possibly be a fixation of nitrogen, I examined two races which gave the most promise of a positive result. At the time, an experiment connected with the fixation of nitrogen by *Azotobacter chroococcum* was about to be made, and an extension was added to include the Robinia and Lupin "d" (acidophile) races of the nodule-former. The results are given in the following table.

The Formation of Slime and Fixation of Nitrogen by Races of Rhizobium alone and in Combination.*

	Infected twice.		Infected once.	
	Slime, grms.	Nitrogen gained, mgrms.	Slime, grms.	Nitrogen gained, mgrms.
Robinia alone..	7	0	3	2
,, with *B. levaniformans*	10	1	7	2
B. radiobacter ...	11	0	5	2
Azotobacter	5	5	3	0
Lupin "d" alone	12	4	4	1
,, with *B. levaniformans*	15	4	14	3
B. radiobacter ...	15	4	10	3
Azotobacter	7	5	8	3

* The medium contained dextrose 2 %, sodium phosphate 0·2 %, and agar 2 %. No nitrogenous constituent was added. The method of procedure in this and the following experiments consisted in pouring 20 c.c. portions into the ordinary 9 cm. Petri-dishes and smearing the plates with cultures of the bacteria. The first set were infected twice, the slime being scraped off at the end of the seventh day; the plates were reinfected and incubated at 22° for a further period of 23 days when the experiment was finished. The nitrogen was estimated in the whole test, *i.e.*, agar + slime, by the Kjeldahl-Gunning

The main point brought out by the experiment is that concurrently with the formation of slime there is a fixation of atmospheric nitrogen by *Rhizobium*. We already know that *Azotobacter* can gain nitrogen, and indeed Stoklasa says that it is the most powerful agent in this respect that the soil possesses. This experiment shows that the combination of *Azotobacter* and *Rhizobium* appears to be still more powerful. *Bac. levaniformans* cannot fix nitrogen, and although it does not form slime from dextrose, yet it undoubtedly assists other bacteria to do so. *Bact. radiobacter* is another bacterium of much the same nature. It is

THE FORMATION OF SLIME AND FIXATION OF NITROGEN BY RACES OF RHIZOBIUM ALONE AND IN COMBINATION WITH BAC. LEVANIFORMANS.

Race.	*Rhizobium* alone.		*Rhizobium* and *Bac. levaniformans.*	
	Slime, grms.	Nitrogen gained, mgrms.	Slime, grms.	Nitrogen gained, mgrms.
Macrozamia	3	0	5	2
Robinia	6	0	11	2
French Bean	2	1	1	1
Tare	3	0	5	0
Pea (March)	2	0	5	1
,, (October)	2	0	3	1
Lupin (Král)	0	0	(1)	0
Bean ,, ...	0	0	(1)	0
Pea ,, ...	0	0	(1)	0
Lupin "a"	5	0	8	2
,, "c"	4	0	12	1
,, "d"	11	2	22	4

most difficult to maintain it in pure culture; it soon dies out, although in mixed culture it keeps well. Both of these bacteria have assisted the Lupin race to form slime, and probably also to

process, using tenth-normal alkali and methyl-orange for the final titration. Due allowance was made for the nitrogen in the original medium + infecting material by means of check tests which also controlled the error of reagents and apparatus. The milligram of nitrogen per 100 c.c. of medium has been taken as the unit. This is equivalent to 0·15 c.c. of tenth-normal alkali in the 20 c.c. test. Quantities less than 0·15 c.c. are expressed as 0, 0·15 to 0·25 c.c. as 1, 0·25 to 0·4 c.c as 2 and so on. The quantities are small, but the method is sufficiently delicate, the check tests agreeing in three cases out of four, the fourth differing by 0·05 c.c.

fix the atmospheric nitrogen. The quantity of slime is no criterion of the activity of *Azotobacter*, for in this experiment it was autodigested after formation.

Other races of *Rhizobium* were tested to see if similar gains could be detected, the medium being the same as before and the experiment occupying three weeks.

The medium had the same composition as in the previous experiment, viz., dextrose, sodium phosphate, etc. The Král races do not form slime from such a combination of nutrients, and it is seen that they are also unable to gain nitrogen. There was, however, a considerable reproduction, probably from the nitrogen contained as impurity in the agar, etc. These races show that in the absence of slime there may be an increase of bacterial cells but there is no fixation of free nitrogen

Considering the experiment generally, one sees that a small slime product usually means a small or negligible fixation. One thing, however, has to be remembered, and that is that some of these races exhibit more or less autodigestion of their slime, which though not very evident in seven days, becomes considerable when the experiment extends over a longer time. The general increase in nitrogen-fixation in the presence of *Bac. levaniformans* shows that *Rhizobium* derives some advantage from the presence of this bacterium which by itself cannot elaborate atmospheric nitrogen.* I am inclined to think that if this bacterium can assist in the elaboration, it is possible that the cells of the root-nodule may also assist in a similar manner.

A number of races of *Bac. levaniformans* from widely different sources, such as Mauritius sugar, New South Wales sugar, *Hakea saligna*, Blue Lupin, and a race which had been in the laboratory collection for six years, were all tested in combination with several races of *Rhizobium*. The experiment showed a general gain of nitrogen and an assistance given to *Rhizobium* by the races of *Bac. levaniformans*, all of which had a very uniform action.

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* See p.617.

A medium containing saccharose and citrate of potash in place of dextrose and sodium phosphate was used in the following experiment; each 20 c.c. test received 0·1 c.c. of twice normal sodium carbonate (approximately 10 %). The slimes were removed as in the previous experiment at the end of the first week and finally on the 37th day.*

Race.	*Rhizobium* alone.		*Rhizobium* and *Bac. levaniformans.*	
	Slime, grms.	Nitrogen gained, mgrms.	Slime, grms.	Nitrogen gained, mgrms.
Robinia	8	2	13	2
Lupin "a"	3	1	12	2
,, "c"	10	1	10	1
,, "d"	1	0	7	2

It has been already shown that the acidophile race, Lupin "d," forms very little slime from saccharose in alkaline medium, and this experiment, while confirming the earlier result, shows that there is no fixation with nitrogen. But with the co-operation of *Bac. levaniformans*, which inverts the saccharose, there is a formation of slime and a gain of nitrogen.

Race.	*Rhizobium* alone.		*Rhizobium* and *Bac. levaniformans.*	
	Slime, grms.	Nitrogen gained, mgrms.	Slime, grms.	Nitrogen gained, mgrms.
Tare	5	1	9	2
Lupin (Král)	8	1	3	2
Bean ,,	5	2	2	2
Pea ,,	6	3	2	3
Pea (March)	3	2	6	3
Lupin "a"	4	1	7	2
,, "c"	12	3	10	3
,, "d"	3	1	13	3

* With sodium phosphate in the medium, the slimes are generally acid, and with citrate they are usually alkaline. It is necessary to acidify the agar, etc., of the citrate tests, before driving off the water, preliminary to the moist combustion. When this is not done, a volatile nitrogenous substance is driven off.

The experiment was repeated, with the difference that no sodium carbonate was added to the medium and the time extended over 31 days.

The last two experiments show that saccharose is as capable as dextrose of assisting in the fixation of nitrogen. Furthermore, as the slimes and media were alkaline, the fixation can occur in alkaline as well as in acid media.

The fixation of nitrogen by certain races of *Rhizobium* has been already proved by Mazé,* but many investigators,† myself included, could not confirm his results. Then Moore,‡ and finally Löhnis,§ showed that a gain had taken place. The quantities of nitrogen demonstrated were about the same as I have found. Mazé obtained up to 4 milligrams per cent. of medium in 14 days; Moore of from 2 to 3 mgrms. in three weeks, and Löhnis of from 0 to 1·5 mgrms. in the same time.

From my own experiments, it would appear that rhe failure of investigators to detect a fixation has been caused either by using races which were incapable of forming slime or by testing the races under conditions which precluded slime-formation. The fixation appears to be proportional to the amount of slime formed, and although in my experiments the individual tests do not bring this out clearly, yet if we take averages of all the tests with *Rhizobium* alone and in combination with *Bac. levaniformans*, we obtain numbers which indicate a certain relationship.

The intimate relation between the fixation of nitrogen and the formation of slime is best brought out in the last table because the number of tests which are included in the averages are greater and one irregularity is probably counterbalanced by another. These irregularities may have been caused by (1) experimental errors greatly influencing the small gains of nitrogen; (2) varia-

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* Mazé, Ann. de l'Inst. Past. xii.(1898).

†Beijerinck and v. Delden found no fixation of nitrogen with cultures of *Rhizobium* + *Granulobacter* (*B. levaniformans*?).

‡ Moore, Bulletin Bureau of Plant Industry, No.71(1905).

§ Löhnis, Centrbl. f. Bakt. 2te, Abt. xiv.(1905), 582.

tions in the moisture-content of the slimes; and (3) the autodigestion of the slimes. Autodigestion was very marked with some races, *e.g.*, Pea, Bean, Tare and Lupin(Král), when the experiment occupied more than a week.

Average Gain of Nitrogen per Gram of Slime.

Slime, grms.	None	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	22
Nitrogen gained, mgrams.	0	0·2	1·2	1·3	0·7	1	1·5	1·5	1·7	2	1·5	2	2·5	2·5	3	4	4
No. of Tests in average ...	3	5	5	9	3	6	2	4	3	1	4	2	4	2	1	1	1

Average Weight of Slime per Milligram of Nitrogen Gained.

Nitrogen gained, mgrms	None	1	2	3	4
Slime formed, grms	2·6	5·7	7·1	8·6	16·3
No. of tests in average	16	14	16	7	3

Taken as a whole, the research shows that

(1) Races of *Rhizobium leguminosarum* can fix atmospheric nitrogen in artificial culture;

(2) The fixation is coincident with and proportional to the formation of slime;

(3) Under conditions that preclude the formation of slime, there is no fixation;

(4) Conditions, such as the presence of another bacterium, which assist the formation of slime, also assist fixation;

(5) It is a matter of indifference whether the medium is acid or alkaline.

The simultaneous production of slime and fixation of nitrogen have not been noted by Moore or by Löhnis, but Mazé clearly points out the relation. Translating from a part of his conclusions (p.24) we read—" From the beginning of our experiments, our attention has been strongly drawn to the abundance of slime formed in the cultures . . . we have noticed that there is a direct relation between the quantity of nitrogen fixed and the elaboration of this substance in the cultures; its solubility in water, its property of passing through membranes, its absence in the nodules although the bacteria transferred to artificial media elaborate it in 24 hours, have led us to consider it as a nitrogenous material arising from the fixation of the nitrogen and serving as a bond of union between the bacterium and the host-plant." At another place, he shows a gain of nitrogen by a slime-forming race and a loss by a race which was incapable of producing slime.

Just as my observations upon the structure of *Rhizobium** largely corroborate those of Mazé, inasmuch as he has depicted it as a compound organism of cocco-bacterial type and I have shown it to be a compound micro-organism of coccus type (leuconostoc- or streptococcus-like), so the investigation embodied in this paper upon the fixation of nitrogen confirms and amplifies his observations. The confirmation is the more effective since I have employed synthetic solid media while he used fluid extracts of beans.

All bacterial slimes are nitrogenous, and because the substance is a slime we are justified, from our knowledge of the effect of albuminoids upon gelatine, etc., in thinking that it contains soluble albuminoids. By the action of heat, the slime is converted into a solution of gum, which in the case of that furnished by the nodule-former is gelatinous, and into a precipitate, probably of coagulated albumen, which encloses the bacterial cells. The gum is nitrogenous, and the nitrogenous matter may be associated with the gum in other than a mechanical manner, for repeated precipitation of the gum from aqueous solution fails to eliminate the nitrogen (p.271). There is probably nothing in the nature of the albuminous slime to prevent its passing through the porous cell-walls of the nodular tissue and being utilised as such by the plant. It may, however, be digested by the cell enzymes or even by bacterial autodigestive enzymes before passing from the cell.

* These Proceedings, p.295.

Having been able to prove that the compound bacterium can gain nitrogen from the atmosphere and knowing that the slime is nitrogenous, we can see the method by which the plant is nourished by the bacterium. And still the conclusion which was arrived at in my research upon the slime holds good. The slime is a cell or plant nutrient, but in addition to the gum constituent being peculiarly suited for building up the carbohydrate of the nucleoproteid molecule, as I have pointed out, it has also an albuminous constituent which is capable of making the plant independent of the supply of soil nitrogen in certain circumstances, *e.g.*, in nitrogen-free soils. We are now certain of the kind of help which the bacterium gives the plant. There exists a symbiosis; the plant supplies saline and saccharine matter, the latter of which the bacterium converts into gum and at the same time elaborates atmospheric nitrogen into constituents which are partly contained within the bacterial cell and partly diffused in the gum, which by virtue of their presence appears as a slime. Both the nitrogenous and the carbohydrate constituents of the slime are then elaborated by the plant cells into tissue elements.

THE FIXATION OF NITROGEN BY *AZOTOBACTER CHROOCOCCUM.*

By R. Greig-Smith, D.Sc., Macleay Bacteriologist to the Society.

During the process of isolating *Rhizobium leguminosarum* from a nodule of the Blue Lupin, a slimy colony was picked from a plate and grown upon nutritive media. The culture formed slime very readily, and as it proved to be a mixture of bacteria, the components were separated and examined in order to see to which bacterium the slime-formation was due. The first micro-organism obtained in pure culture was *Azotobacter chroococcum*, and as at that time experiments were being made upon the influence of increasing amounts of asparagin upon the production of slime by *Rhizobium*, the pure and the mixed cultures of *Azotobacter* were also tested.

The following are the yields that were obtained, in seven days, upon plates of medium containing dextrose 2 %, sodium phosphate 0·2 %, and agar 2 %, with increasing quantities of asparagin. The figures represent grams of slime from 100 c.c of medium.

Asparagin %	0·0	0·01	0·02	0·03	0·04	0·05	0·06	0·08	0·10	0·12
Mixed culture.	10	11	15	16	15	20	22	16	17	17
Azotobacter..	2	3	4	8	14	17	19	19	18	17

The quantity of slime formed by *Azotobacter* in the absence of asparagin is much the same as is produced by races of *Rhizobium*, producing a similar optimum amount, as may be seen upon comparing the yield with that of the Pea race on p.281. The slime obtained from the mixed culture is in sharp contrast, and suggests that a fixation of nitrogen had occurred. Such proved to be the case, for duplicate determinations showed a gain of 0·000392 grm. of nitrogen in 20 c.c. of medium, which is equal to 0·01 % of asparagin. The test to which 0·01 % of asparagin had been added showed a total over the blank tests of 0·000742 grms., which is equivalent to 0·02 % of asparagin, or a gain of 0·01 %. A gain of nitrogen by the mixed culture is therefore established.

Meanwhile the other components of the mixed culture had been separated. They were identified as *Bact. radiobacter* and *Bac. levaniformans.* Beijerinck and v. Delden* examined a similar combination of bacteria, but instead of using *Bac. levaniformans* they employed other spore-bearing bacteria, viz., varieties of *Granulobacter* and *Bac. mesentericus vulgatus.* The various races of *Bac. levaniformans* differ so greatly in their growth-characters that, were it not for the characteristic product, gum levan, being so easily detected, one would conclude that species of bacteria were being dealt with instead of races of one bacterium. It is extremely probable that Beijerinck and v. Delden's *Granulobacter* is really *Bac. levaniformans*, the more so as *Granulobacter*, like *Bac. levaniformans*, does not form slime upon glucose-agar by itself, but produces a luxuriant slime in combination with the other bacteria. These authors ascribe the fixation of the nitrogen to *Azotobacter*, and not so much, if at all, to the others, and from their experiments this appears to be the case.

The quantity of slime formed by the pure culture of *Azotobacter* did not appear to confirm this view, and an experiment† was

* Centrbl. f. Bakt. 2te Abt. ix.(1902), 1.

† The medium contained dextrose 2 %, sodium phosphate 0·2 %, and agar 2 %. 20 c.c. of this medium were poured into Petri-dishes, and, after setting, the medium was smeared with cultures of the bacteria. The slimes were scraped off one set at the end of seven days and the plates were reinfected. All the slimes were scraped off the plates at the end of a month after the primary infection, when nitrogen determinations were made by the Kjeldahl-Gunning process. Due allowance was made for the nitrogen in the original media and for the errors of experiment.

made to find out to which of the components of the mixed culture the fixation was due.

THE YIELD OF SLIME AND GAIN OF NITROGEN BY THE BACTERIA ALONE AND IN COMBINATION.

	Twice infected.		Once infected.	
	Slime, grms.	Nitrogen gained, mgrms.	Slime, grms.	Nitrogen gained, mgrms.
B. radiobacter	3	—	4*	—
Azotobacter chroococcum	6	0	1†	2
B. levaniformans	0	0	0	0
B. radiobacter + *Azotobacter*	13	1	12	3
B. radiobacter + *levaniformans*	8	0	7	0
Azotobacter + *levaniformans*	7	2	12	3
B. radiobacter + *Azotobacter* + *levaniformans*	16	3	15	3
	15	3	16	3

The experiment bears out Beijerinck and v. Delden's results, that the fixation of nitrogen by these bacteria is chiefly, if not entirely, due to *Azotobacter chroococcum*; and when considered with the first experiment, it indicates that the combination of bacteria brings about a quicker and more regular fixation.

* A coccus had accidentally gained access to the plate.
† The slime had been autodigested.

SAND MOVEMENT ON THE NEW SOUTH WALES COAST.

By G. H. Halligan, F.G.S.

(Plates lii.-liii.)

The coast of New South Wales is 600 miles long, extending from Point Danger, in South latitute 28° 09′ and East longitude 150° 34½′, to Cape Howe in S. lat. 37° 30′ and E. long. 150° 00′; and as it closely approximates to a straight line, its general direction is about N.N.E. and S.S.W.

There is undoubted evidence of the coastal strip having, within very recent geological time, been submerged, either by a positive movement of the ocean or a negative movement of the land, and it is probable that this movement was to the extent of between 200 and 300 feet.*

This fact makes the movement of sand and shingle on our coast more complicated, and for that reason perhaps more interesting. Subaerial denudation produces inequalities in the land surface, and when the land is afterwards submerged the hollows thus formed give rise to indentations in the coast, and these indentations exist for a considerable time before they are filled up by sand and shingle drifting along the shore.

When a coast is subjected to marine denudation during a period of elevation or of negative movements of the ocean, a much more simple class of coast will appear. The shore-line being largely composed of sediment, the denudation curve will be quickly

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* David, T. W. E., B.A., F.R.S., "Anniversary Address to the Royal Society of New South Wales, May, 1896," Journ. Proc. xxx., 1896, p.57.

formed, as there will be no salient points to erode nor indentations to fill up.

When a coast is in process of rapid subsidence it is characterised by deep indentations, with rocky headlands and with a foreshore steep to. When the subsidence is slow the currents and waves have time to erode the shore and convey the resultant shingle and sand to the quiet bays and inlets, to form flats and beaches. Should the geological formation be coarse sandstone or other easily eroded rock, the beaches are quickly formed, the indentations filled up, and the scenery assumes the character so familiar to the residents near Sydney. When the cliffs and salient points are composed of shale, which, on disintegration, forms a fine mud, we have no sandy beaches, but, except at the head of deep indentations where the mud is deposited to form mangrove flats and marshes, the water is generally deep right up to the shore-line.

When the subsidence is very slow, or when there is no change in the relative level of sea and land, and there is a good supply of shingle and sand, even the deepest indentations are filled up and islands may be joined to the mainland and form salient points on the coast. There are several instances of this on the coast of New South Wales; the most notable being Cape Hawke, Charlotte Head, Sugar Loaf Point, and Treachery Head and Yacaaba Head at the entrance to Port Stephens. The low-lying sandy country to the west of Cape Hawke is undoubtedly of marine origin, and Wallis Lakes are the only remnants of the large sheet of salt water which originally extended to the foothills of the Dividing Range about eight miles away.

The sand-reef between the eastern shore of the lakes and the sea beach probably started as a banner reef from Cape Hawke, and as the littoral drift and the prevailing wind both favoured a southerly movement, the reef eventually joined Charlotte Head, South Woody Peak, and then Sugar Loaf Point and Treachery Head. The Myall and Smith's Lakes are not yet filled up, but as time goes on they assuredly will be.

A similar movement has taken place at Jervis Bay, where the North Head—originally an island—has been joined to the mainland by sand drifting from the north after first filling the Shoalhaven Bight.

Coming nearer home, we have all that stretch of coast between Wabung Head and Tuggerah Lakes entrance formed to its present shape by sand-movement; and Norah Head, which was once an island about eight miles from the shore, now forms a salient point on the coast.

Tuggerah, Minmorah and Macquarie Lakes are but lagoons not yet filled up, though the onshore winds which blow the sand from the beach, the discharges of sediment and débris by the streams, and the growth of saltwater weeds are slowly but surely carrying out their functions. The lakes will become marshes, the marshes swampy land, and then, in due course, good agricultural land for the use of future generations. There does not appear to be any necessity to assume a movement of elevation to account for the land thus formed. Where borings have been taken for bridges, harbour works, etc., over the area mentioned, they invariably show coarse or fine sand of marine origin from about three to twenty feet above high water to the bottom, with a thin capping of humus or carbonaceous soil.

As sand dunes sometimes reach a height of 100 feet or more, and have an average height on this coast of about 20-25 feet, it appears probable that the wind and sea are solely responsible for the elevation of the land referred to.

The form of the coast-line of New South Wales indicates a very slow negative movement of the land, and there is nothing, from a physiographer's standpoint, which necessitates the assumption that a positive movement has taken place within recent geological time.

The principal factors which govern the movement of sand and shingle on the littoral are: (1) ocean and tidal currents; (2) wave-action; and (3) wind. On any coast where the tidal range is large, say from 12 to 20 or more feet, the flood tide is the predominant influence,* and its direction indicates the course which sand and shingle will take on the beach; but when the range is comparatively small and the current due to it weak, the littoral drift or the eddy currents, caused by projecting headlands, will control the movement. If this, in its turn, should also be weak, then the prevailing winds may set up surface currents which will determine the direction and rate of sand-travel. It is possible also that one of the causes mentioned may so interfere with another that the results become very difficult and often impossible to trace.

The accompanying chart of part of the Pacific Ocean (Plate lii.) shows a bifurcation of the drift-current due to the South-East trade winds, about 800 miles off the coast of Queensland. The northern part of this current flows through Torres Straits into the Arafura Sea, and thence to the Indian Ocean; and the southern portion, with which we are immediately concerned, strikes the Australian coast about Moreton Bay. It is here deflected to the southward and follows the east coast of New South Wales as a stream current until it meets the north-easterly current of the South Pacific, when it is again deflected, this time to the east, and then again to the north along the western coast of New Zealand.

In the offing the average speed of this current is about one-half to one knot, so that *per se* it is not a powerful stream. Its surface-speed is increased by a northerly or north-easterly wind; and a southerly gale lasting for more than twenty-four hours will often temporarily reverse the direction for a period depending upon the force of the gale and its duration.

As before stated, the coast of New South Wales is fairly straight, the salient points not projecting into the ocean far enough to cause any serious disturbance of the current. Some of them, however, whilst exposing a concave side to the north, are sufficiently prominent to cause deflections or counter currents

* Haupt, L. M., "Littoral Movements of the New Jersey Coast," Trans. Amer. Soc. Civil Engineers, Vol.xxiii., 1890.

which determine the contour of the shore-line in the vicinity. Text-figures 1 to 4 will show how a projecting headland on this coast may cause a counter current on its northern or southern side, according as its northern side is concave or convex, or

FIG 1

FIG. 2

FIG. 3

FIG. 4

whether the headland is at right angles to the course of the current or meets it at an angle.

The importance of this and its influence on sand-movement will be seen later on.

Plate liii. is a copy of the Admiralty charts from Point Danger to Cape Howe in one sheet, showing the direction of the ocean current, and the deflections and counter currents or eddies caused by each projecting headland.

It must be here stated that, owing mainly to the lack of funds for detailed survey work on the coast, and also perhaps to a want of appreciation of the importance of hydrographic work in a country which must always depend so largely on its harbours and on the maintenance of its mercantile marine for its success, the currents here shown are largely speculative, and I am entirely responsible for the drawing. Some ocean current observations have been taken at Byron Bay, Coff's Harbour, and Trial Bay by the late Captain F. Howard, R.N.; at Norah Head by Mr. E. Kenny; and off Solitary Island, Port Macquarie, Seal Rocks, Newcastle, Wollongong, Port Kembla and Twofold Bay by myself; but as the information obtained was, in each case, confined to one portion of the year, and has not been followed up by further observations, it is almost useless. However, the laws governing the flow of water are so well known that, given a current of know velocity and direction, and a plan showing the salient points of a coast, the existence and direction of the counter currents and eddies may be indicated with a fair degree of accuracy. It should be borne in mind that the current immediately adjacent to the shore on this coast is so sluggish, even when accelerated by favourable winds, that its speed rarely exeeeds $1\frac{1}{2}$ knots within two miles of the beach. It remains to be seen, therefore, if the winds, monsoonal or cyclonic, are of sufficient strength and persistence to cause currents which might affect to any great extent the travel of beach sand and shingle.

Through the kindness of Mr. H. A. Lenehan, F.R.A.S., Acting Government Astronomer, I have been able to analyse the wind records made at the Sydney Observatory during the ten years, 1894-1903, with the following interesting results :—

	All Winds. Hours.				Above 11 Miles per Hour. Gentle Breeze.				Above 20 Miles per Hour. Strong Breeze.				Above 30 Miles per Hour. Moderate Gale.			
Year.	N-E	S-E	S-W	N-W	N-E	S-E	S-W	N-W	N-E	S-E	S-W	N-W	N-E	S-E	S-W	N-W
1894	2475	1915	2277	2016	104	111	101	33	45	60	60	23	1	16	14	10
1895	2495	2005	2549	1717	101	113	87	29	46	68	60	17	1	11	22	5
1896	2490	2006	2538	1722	109	118	91	30	46	69	58	17	1	12	25	6
1897	2675	1967	2203	1833	119	106	87	27	51	54	53	18	2	16	35	7
1898	2412	2186	2169	2048	117	107	77	43	36	61	50	31	1	19	23	11
1899	2735	2082	2151	1806	134	113	79	23	54	64	65	13	1	11	17	2
1900	2610	1888	2371	1868	116	117	90	26	51	60	61	16	2	18	24	8
1901	2554	1844	2281	2035	115	99	100	36	43	51	66	19	1	12	29	8
1902	2764	1902	2205	1788	122	105	88	21	52	50	59	13	1	14	27	4
1903	2667	1870	2402	1773	124	96	96	28	50	42	64	17	1	8	19	7
Totals ...	25877	19665	23146	18606	1161	1085	896	296	474	579	596	184	12	137	235	68
Proportion	1·37	1·05	1·24	1	3·91	3·66	3·02	1	2·58	3·13	3·24	1	1	11·5	19·58	5·66
E. : W. ...	45542		41752		2246		1192		1053		780		149		303	
Proportion	1·09		1		1·88		1		1·35		1		1		2·03	

In the first four columns of the above tables the number of hours in each year the wind blew in each quadrant is shown, and it should be explained that where a wind was recorded as due north, one-half the number of hours it blew were put into the north-west column and the other half into the north-east column; and similarly for the winds recorded due east, south or west.

The remaining sixteen columns show the *number* of winds in each year in each quadrant after eliminating all winds of less velocity than eleven miles per hour (a gentle breeze), twenty miles per hour (a strong breeze), and thirty miles per hour (a moderate gale).

The north-east wind blows during the greatest number of hours, when all winds are taken into consideration; and they still prevail when all winds below eleven miles per hour (gentle breeze) are eliminated.

Above twenty miles per hour (fresh breeze) the south-west winds are greatest in numbers, but they are run very close by the south-easters, the proportion being 596 : 579, while there were only 474 north-easters during the same period.

When all winds below the force of a moderate gale are neglected, we find the south-westerlies strongly in the ascendant, being 19½ times as many as the north-easterlies, 3½ times the north-westerlies, and nearly twice the south-easterlies.

The winds blowing from the eastern half of the compass are to those from the western half as 1·09 : 1, but there are twice as many gales from the western half.

From a report by Sir John Coode to the Secretary for Public Works on the proposed Harbour Works at the Clarence River in 1887, the following observations on "Winds" are extracted:—

"The following results are given by an examination of the records made by the Pilots at the Clarence Heads, and extracted from their log books for my use by Captain Howard, R.N.

"Between March, 1877, and August, 1886, 5965 observations were made and recorded; these show that on 3303 occasions the wind was blowing from some point either in the quadrant between north and east or in that between east and south, and on 2662 occasions from some point either in the quadrant between north and west or in that between west and south. Thus taking all velocities into account, easterly or onshore winds prevailed more frequently than those westerly or offshore in the proportion of 11 to 9.

"If, however, the winds classed as 'light' are omitted, the variation is more marked, the observation being 1500 easterly and only 723 westerly, a proportion of more than 2 to 1.

"The winds from the two westerly quadrants being offshore need not be further discussed, but with regard to those from the easterly quadrants, examination gives the following results:—

	Number.
Total observations from between N. and E.	1484
,, ,, ,, ,, E. ,, S.	1819
Proportion of northerly to southerly, about 9 : 11.	
Moderate and strong winds and gales N. to E.	752
,, ,, ,, ,, ,, ,, E. ,, S.	748
Proportion of northerly to southerly, about 1 to 1.	
Gales only, N. to E.	3
,, ,, E. ,, S.	18
Proportion of northerly to southerly, 1 to 6.	

"It may therefore be stated briefly that, although in the totals, onshore winds from the southern quadrant exceed slightly those from the northern quadrant, yet with regard to the winds of higher velocity taken alone, the proportion is equal; and further, that onshore gales from the southward exceed those from the northward in the proportion of 6 to 1."

Although the information here given is not presented in the same way as that compiled by me from the Sydney Observatory records, the former being the result of personal observation and the latter being automatically recorded by an anemometer, the results are in accord, and some interesting deductions may be made.

At Clarence River the onshore winds from the north-east quadrant are to those from the south-east quadrant as 9 : 11; but at Sydney Observatory the proportion is as 1·3 : 1, and onshore gales from the north-east quadrant are to those from the south-east quadrant at Clarence River as 1 : 6, and at Sydney as 1 : 11½.

These figures will perhaps correct the general impression that the north-easters are more prevalent on the north coast than in Sydney or on the south coast, and also that the southerly winds and gales do not reach our northern ports with the same frequency as at Sydney.

After about 30 years' experience on this coast, I am of opinion that the monsoonal north-east wind extends with undiminished force at least as far south as Jervis Bay. About this point it is pushed upwards by the colder south-west wind from the Antarctic, and is also deflected to the east in the direction of the south-eastern current before referred to. At Twofold Bay the north-easters do not begin to be felt before the end of October or November, and cease about February; whereas on the Richmond River the same winds begin in September and do not cease till March or early April.

The south-west, south, and south-east winds extend well up into Queensland, though the "Southerly Burster" does not often get beyond Port Macquarie.*

The above table will show that the south-westers blew for the greatest number of hours during two years of the period 1894-1903; while the north-easters prevailed during the remaining eight years.

Tidal Current.—The current due to the tide on the New South Wales littoral may be said to be negligible. The direction of the tidal wave is almost at right angles to the coast, and the times of high water of any one tide at Point Danger and Twofold Bay are almost identical. This means that the tidal current is so weak that it is controlled entirely by a very light breeze, and this cannot, in itself, have any influence on the velocity of sand-movement. The rise and fall of the water has, however, a large

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* Hunt, H. A., "An Essay on Southerly Bursters," Journ. Proc. Roy. Soc. N. S. Wales, 1894, xxviii., p.155.

influence indirectly on the travel of beach-material, as it either loosens or compacts the sand as the tide rises or falls, and thus enables the prevailing wind to effect a considerable movement which would be otherwise imperceptible.

In a calm tidal estuary with a sandy shore, the water cannot, of course, percolate the sand, when the tide is rising, at the same rate as the water itself rises. The water in the stream is thus higher than the water in the sand, and the effect is to make the sand "live;" the upward pressure of the water tends to lessen the cohesion of the grains. In this state it is manifest that, should an alongshore current arise, the sand or shingle will be easily moved. With a falling tide the water in the sand does not fall at the same rate as the water in the stream, and the tendency is to increase the cohesion of the grains and thus render them less easily moved than during the flowing tide. The credit of this interesting discovery is due to L. M. Haupt, M. Amer. Soc. C.E., and was published with his paper on "Littoral Movements on the New Jersey Coast" in 1890. Suppose now a strong onshore wind arises and creates waves and a heaping up of the water on the beach. In order to restore equilibrium, this heaped-up water flows away seawards as an undercurrent, known to surf bathers as the undertow or backwash.

The action of the waves is to heap up the sand on the beach, and of the undertow or offshore current to take the sand to the sea, and the resultant movement of the beach depends upon the violence of the wind. A very strong onshore wind will heap up the water on the beach to a considerable extent; the violence of the wind will increase the size of the waves, and thus stir up the sand and shingle, and the undertow will be more effective in conveying it seawards. As a result of long-continued gales, a false beach or "full" is sometimes formed, consisting of the sand thus transported by the undertow, and deposited where the movement of the waves is not sufficient to hold it further in suspension. When the gales subside, this sand is gradually moved shorewards again, but in transit it is shifted up or down the coast even by the slowest of currents.

When the wind blows obliquely to the shore, it either creates a current or accelerates or retards the existing current, in any case tending to move the beach-material in the same direction as the wind blows. But independently of the current, there is a movement due to the obliquity of the breaking wave to the shore. An alongshore wind on a steep coast causes obliquely running waves to break before they have time to swing round and face the shore; but on a sandy beach the waves due to a moderate wind swing round almost parallel to the shore before breaking. With a strong wind, or gale, the velocity is too great to allow of this, and in consequence we have waves breaking more or less obliquely to the shore, the obliquity varying as the velocity of the wind, and with the steepness of the beach. Even with a moderate breeze there may be two sets of waves running, one coming in from the offing, due to distant storms, and the other caused by the alongshore wind. In deep water these two sets of waves pass through each other without any appreciable interference of the transmission by each of its proper impulse in the direct line of its motion. When these two sets of waves are running the combined billow formed by the coincidence of the two crests, breaks before the time proper to the alongshore wave, and therefore before it can swing round to face the shore.* A number of short breakers are thus formed in the direction of the mechanical resultant of the two forces, and the result in moving the sand and shingle on the shore line is considerable.

It will be manifest that the undertow or offshore current will be greatest at the southern end of the beach as the result of a northerly wind, and at the northern end in consequence of a southerly wind; and, as the result of the undertow is to cut down the beach, the effect of a prevailing wind blowing obliquely to the shore will be to deepen the water at the far end of a beach and to allow the sand to accumulate at the near end.

An onshore wind blowing at right angles to the shore-line does not move the sand or shingle alongshore, but it has the effect of

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*Cornish, V., "On Sea-beaches and Sand-banks," Geog. Journ., Vol.xl., 1898.

stirring up the sand and leaving it more fit for transportation by the littoral currents. Currents of considerable velocity may flow over sands without disturbing them, but if these sands are broken up or agitated they will be transported by a current of less velocity.*

It is thus evident that, on this coast, the alongshore wind which happens to be blowing during flood tide—although the flood tide has no current in itself—will have a greater effect in the movement of sand and shingle than a very much stronger wind blowing during ebb tide.

It must also be apparent that, as the S.S.E. littoral current on this coast, though a slow one, is accelerated by northerly winds and retarded by southerly winds, and as the winds from the north-east quadrant are the prevailing winds on this coast, the littoral current will be accelerated more often than it will be retarded or reversed. The winds from the south, although much stronger than those from the north, have to expend so much of their energy in reversing the littoral current that they cannot be termed the dominant wind, so far as the movement of beach-material is concerned. In the matter of the formation of sand dunes, the southerly winds undoubtedly predominate, and there are many instances of this on almost any sandy stretch on this coast. Perhaps the best and most accessible example is near the mouth of Tuggerah Lake. The so-called Tuggerah Lake is really an estuary. The entrance is rarely closed, and while it is open there is a small astronomical tide in the lake. The same remarks apply in the case of Lake Illawarra, Myall Lakes, and other similar formations on the coast.†

The entrance in this case has been forced to the south by the littoral drift, accelerated by the prevailing winds, until a rocky

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* Wheeler, W. H., "The Sea Coast"; also Haupt, L. M., "Littoral Movement on the New Jersey Coast," Trans. Amer. Soc. Civil Engineers, Vol. xxiii., 1900.

† Report by the author on "Tidal Investigation at Lakes Tuggerah and Illawarra," Public Works Department Records, January, 1906.

headland was reached. Unable to move further south, the impounded waters force their way through a narrow channel, which is being continually filled in by sand drifted from the north.

When dry weather prevails for a lengthened period, the sand accumulates until the entrance is completely blocked, and the sheet of water becomes a saltwater lagoon, but when rain at length falls, and the water-level of the lagoon is raised, the sand dam gives way (helped perhaps by the exertions of the fishermen) and another channel is formed, which in its turn is filled up, and so the cycle runs. About a mile to the north of the entrance to Tuggerah Lake the sand spit is about 700 feet wide, and the sand dunes about 30-40 high; and here a remarkable bank of white sand is visible for many miles. A violent gale made a break in the line of sand dunes about 10 years ago, and exposed a surface of sand for the southerly winds to play upon. Since that time the sand has been moving northwards, and now presents a face 35 feet high at its northern end at a distance of 600 feet from the break.

On the southern side of the break very little movement has taken place, although the prevailing N.E. winds have been blowing against it for 10 years. The sand is now encroaching on the lake at the rate of about 60 feet per year. Advantage has been taken of this well known influence of the predominant winds in moving dune sand to construct a roadway across the wind-blown sand at Bondi.* This work was designed and carried out by Mr. W. A. Smith, M. Inst. C.E., of the Public Works Department, and is an object lesson on the results to be obtained by utilising the forces of nature intelligently.

In this case the dominant wind, so far as the material above high water is concerned, is the southerly; but the fact of the beach-sand moving to the south proves that these winds have no effect, so far as the movement of the material below high water

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* Smith, W. A., M. Inst. C.E., "Treatment of Drift Sand, as applied to Bondi Sand Dunes," Sydney University Engineering Soc., Oct. 27th, 1902.

is concerned. In fact, it may be laid down as a rule that, on this coast, the wind *per se* has no effect on the movement of beach-material. It may accelerate or retard the littoral current, and thus influence the formation of sandbanks and shallows, but as a factor in the determination of the position of a river outlet, or in the modification of a lagoon entrance, its effect is negligible.

We may now consider in detail each of the river-entrances on the coast, where the tide is blocked by moving sand; and see how that movement affects the navigable width, sometimes moving it to the north and sometimes to the south.

Commencing at the most northern point of the coast, and travelling south, the first river we meet with is the Tweed. Admiralty Chart No. 1028 shows this entrance to be just south of Danger Point, and two miles north of Danger Reefs. The littoral current is here shown to have a velocity of two knots at four miles offshore, and with strong ripples outside the reefs. The beach trends away to the north-west from Danger Point, and it is evident that Fig. 1 illustrates fairly well the state of the current, and the probable movement of the sand in this locality. Danger Point is not sufficiently concave on its northern side to cause a counter current, but it extends sufficiently far into the ocean to cause a deflection of the current as shown on the plan. When this deflected current meets the Danger Reefs and Cook Island, part of it is again deflected to the north, and forms a counter current along the beach, causing the sand to travel northwards, and thus compelling the Tweed River to discharge its waters on the southern side of Danger Point.

Byron Bay.—The next important headland is Byron Bay, and, being the most easterly point of Australia, it extends well out into the current. Its northern side is concave, so that Fig. 1 represents the current-effect we might expect, and which we find to exist. The counter current along the beach forces Belongil Creek northwards until it meets a rocky patch which prevents further progress. The sand-travel due to this current is sufficient to completely block the entrance to this small creek, and it is only in times of flood that a passage is forced through the sand by the pressure of water at the back.

Richmond River.—Travelling south from Cape Byron we find the coast trending to the south-west, and as there is a large deflection of the littoral current at the Cape, the water near the beach, at all events as far south as Evans' Head, appears to travel to the north. More information on this point is required in the way of current-observations, and until this is available it is difficult to see the trend of the movements at the Richmond River entrance.

The outlet is hard up to North Head, and the course of the river for nearly 20 miles from the entrance is approximately parallel to the beach. This indicates that the travel of the sand is from the south, but exactly what it is due to is at present not quite clear.

For 120 miles south of the Richmond River entrance, the coast is approximately a straight line, and it is on this length that the characteristic curve, due to the sand-travel with the littoral southerly current, becomes very evident. A cursory study of the chart will show the outline of the beach from Evans' Reef to the Wooded Bluff, in lat. 29° 22′, reproduced on nearly every beach for more than 100 miles. There is no headland projecting sufficiently far into the sea to cause a deflection of the main southerly current or an eddy current, until Trial Bay is reached, so that we have a shore-line somewhat of the form of the Greek letter ζ repeated with astonishing regularity.

Clarence River.—It is more than probable that the original outlet of the Clarence River was about five miles further north than at present, but the southerly drift of the sand so choked the entrance and heaped up the flood waters that the stream, following the line of least resistance, at length found the present outlet; and the old one, north of the Wooded Bluff, is now completely hidden by drift sand and dense scrub.

That such change in the position of the outlet was the result of many ages of desperate struggle between the great forces of nature, represented on the one hand by the waters of a large river trying to find a way to the ocean on the natural slope of the country, and on the other by the sand moved across the mouth by the littoral currents accelerated by the prevailing north-easterly winds, is evident by the many channels, and anabranches and swamps into which the river is divided between the south-western end of Woodford Island and the sea. The present entrance is forced as far to the south as possible until the rocky headland of Yamba is reached, and here the old struggle is still going on, and will for all time. Many thousands of pounds have been spent in improving the channel of the river as far up as Grafton, but the sand still pours in from the northern beach in thousands of tons, forming a dangerous bar at the entrance, and a troublesome inner crossing. Some day a northern breakwater will be built, and all the trouble stopped, but it must be carried out sufficiently far to form the characteristic Zeta curve from North Head to its eastern end.

The next headland of importance is Laggers Point, and the current impinging upon it is deflected to the north, and has scooped out sufficient land to form Trial Bay. The original entrance to the Macleay River was forced about five miles to the north by this eddy current until a rocky obstruction was met with, and here the struggle between the drifting sand and the ebbing tide was continued. The sand had the best of the battle all the time, and it was only when the flood water came down in force and swept everything before it that a temporary channel of navigable depth was opened up.

In 1895 a heavier flood than usual opened a new course for itself, or rather it burst out in one of its old channels about one mile north of Half-Tide Rocks. Advantage was taken of the opening thus effected to make a new outlet at the spot, and breakwaters are now being built with the object of rendering the work permanent. If these walls are continued out far enough to form the characteristic Zeta curve with the headlands north and south of them, the looked-for results will be obtained, but obviously not otherwise. The form of the beach between Smoky Cape and

Korogoro Point is perhaps as good an example of this curve as any on the coast. It will be noticed that where the current is deflected to the north, the form of the beach approximates more to a flat, circular curve than to the hooked outline of the letter Zeta, the curvature of course varying as the strength of the current where the material acted upon is the same.

The entrance to the Hastings River has been forced to the south by the southerly current until the rocky headland on which the historic town of Port Macquarie is built was met with. This point does not extend far enough into the sea to cause a return current to the north, and the circumstances are best illustrated by fig.2. Camden Haven entrance is formed in the same way.

At Crowdy Head the shore-line bends away to the west, and the current is impeded at this point and loses a good deal of its force for at least 20 miles to the south.

The current between Crowdy Head and Cape York is very sluggish and uncertain, as the disposition of the Manning River entrances will show. The engineering works carried out at the Harrington entrance will probably prevent any serious impediment to the discharge of the flood-waters in the future, but should a sudden stoppage of the river current unfortunately occur at a time of high flood, a fresh opening to the sea would be formed, and probably Farquhar Inlet be much enlarged.

The current has not yet regained its normal direction and velocity when Cape Hawke is reached, and the sand-movement is not sufficient to close up such a comparatively insignificant stream as the Cooloongolook River.

The probable cause of the formation of the Wallis and Myall Lakes and the coast in the vicinity of Port Stephens has already been referred to in this paper. This part of the coast will be of greatest interest to the hydrographer in the future, when the currents come to be investigated and the movements of beach-material recorded.

Just below Port Stephens the coast takes a sudden bend to the west, and between Morna Point and Newcastle the trend is west-south-west. This causes a deviation of the current, which swirls round Stephens Point at an increased velocity and does not resume its normal direction, parallel to the coast, until within a few miles of Nobby's Head, the entrance to the Hunter River. Nobby's Headland is not sufficiently prominent to cause a deflection of the current to the north, and the movement of the beach-material at the entrance to Port Hunter is to the south. This is abundantly evident from an examination of the sand heaped against the northern breakwater now under construction, and this sand will continue to pile up till the northern breakwater extends far enough to the east to form the base of the Zeta curve before referred to. The southern breakwater is, of course, valuable as a shelter from the south and south-east sea, but it is the northern breakwater alone that will keep the entrance free from drifting sand.

Lake Macquarie and Tuggerah Lake* both have rocky headlands on the southern side of their entrances, and the moving sand spit, with the characteristic Zeta curve on the north, shows without doubt the direction of the alongshore current.

The prominent headland with the descriptive name of Long Point, with its dangerous reef running still further to the east, deflects the current, and causes a strong northerly return current along the beach. The effect is to force the entrance to Narrabeen Lagoon to the northward till a rocky projection is met with; and as the fresh water from Narrabeen Creek is inconsiderable, a sand bar is formed, which completely blocks the entrance to the lagoon. After heavy rains the water rises sufficiently high to burst this sandy dam, and for several weeks the tide ebbs and flows in the lagoon. The northerly movement of the beach-material, however, soon prevails, and the entrance is once more blocked and remains so until the next flood.

THE HAWKESBURY, PORT JACKSON, BOTANY BAY.—The entrances to the Hawkesbury River, Port Jackson and Botany Bay

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* The term *Lake* is here used in deference to popular nomenclature. The so-called Lakes Macquarie, Tuggerah, Illawarra and several others are not lakes at all, but arms of the sea.

present physiographical features of special interest, sufficient to form the subject of another paper. It is enough here to state that there are no indications of sand-movement of more than ordinary interest, until Wollongong is reached in lat. 34° 25½′.

Below Botany the effect of the littoral current, already much lessened by the sudden change in the direction of the shore-line below Port Stephens, becomes less pronounced.

The reaction caused by the impact of the powerful north-east current from the Southern Ocean is beginning to be felt; and as we travel southwards, the outline of the coast indicates more and more clearly the absence of sand-movement. The outline of the beaches becomes a flatter curve, which is a sure indication of a sluggish current. Current-observations made at Port Kembla and Wollongong by the author, show a weak northerly beach-current caused by Port Kembla headland; which extends only as far as the entrance to Tom Thumb Lagoon. Here it is met by the southerly current moving the sand southwards from Wollongong, and the relative strengths of these two currents determines the position of the lagoon-entrance.

Lake Illawarra.—The entrance to Lake Illawarra is forced to the south by moving sand until Windang Island and the adjacent high ground are met with. In times of drought this entrance is entirely blocked, and remains so until the welcome rains so raise the level of the enclosed water as to burst the sand-dam, when the old struggle for mastery is renewed. A very similar state of affairs exists at Coila Lake in lat. 36° 03′, Burra Lake and Wagonga Inlet, and several other places on the South Coast. At Moruya River the entrance is forced to the south in like manner, and other small rivers and creeks, and lagoon-entrances have their channels sometimes on the north, at other times on the south, and, occasionally, as at Womboyn River, in the middle of a sandy beach.

The evidence of sand-movement on the coast certainly becomes less as we travel to the south, and below Montague Island it becomes quite insignificant; and this can only be attributed to the absence of a littoral current of sufficient velocity to transport the beach-material. This is, as already stated, due to a variety of causes; firstly, the original southerly current, never a very powerful one, is diminishing by friction over the shallow sea-bottom; secondly, the prevailing north-easterly winds, which accelerated it in low latitudes, are diminishing in force; thirdly, it is beginning to feel the reaction due to the impact of the powerful north-easterly current from the Southern Ocean, and this becomes more pronounced as we proceed to the south; and fourthly, the trend of the shore being slightly to the west, while the current is being impelled to the east, the effect is to diminish its influence on the littoral until, as we have seen, it is wholly ineffective below, say, Montague Island in lat.36° 15′.

It is to be hoped that our legislators will some day be impressed with the necesssity for a complete current survey of the coast, in the interests of commerce and science. In other countries of the world information of this character is looked upon as absolutely necessary before any scheme of harbour-construction or river-entrance improvement is undertaken; the small amount spent on such surveys enabling engineers to design with safety works of considerable magnitude, while the value to the mariner cannot, perhaps, be over-estimated. New South Wales must in the future, as in the past, depend very largely on her means of communication by sea with the rest of the world for her success, and the more safe this means of communication is made the more rapid will be the advancement of the country. If looked upon in the light of insurance only, the comparatively small expenditure for the complete investigation of the tides and currents on this coast would appear to be amply justified. When we know the forces of nature we have to contend with, we may with confidence enter upon the largest engineering schemes, and be tolerably certain of success; but it is rash and unscientific to attempt to coerce nature instead of controlling her, and this we are always liable to do unless the most complete data are at our command.

EXPLANATION OF PLATES.

Plate lii.

Chart of the Pacific Ocean showing ocean-currents.

Plate liii.

Copy of the Admiralty Charts from Point Danger to Cape Howe, showing the direction of the ocean-current, and the deflections and counter currents or eddies caused by each projecting headland.

THE GEOLOGY OF SAMOA, AND THE ERUPTIONS IN SAVAII.

By H. I. Jensen, B.Sc., Linnean Macleay Fellow of the Society in Geology.

(Plate liv.-lxiv.)

1. Introduction.

In March and April last upon the receipt of news bearing on the gigantic eruptions then in progress in the island of Savaii, Professor David expressed a desire that I should pay a visit to the island to report on these phenomena. Accordingly, the Council of this Society having granted me the necessary leave of absence in order to pursue investigations on the Samoan volcano, I left Sydney on May 29th, and arrived in Samoa on June 10th. My stay there lasted one month. Without entering into unnecessary details I will proceed to give an account of the results of my observations there. First, however, I wish to express my cordial thanks to Mr. R. Williams, the Administrator (Amtmann) of Savaii, the Rev. Père Mennel, Roman Catholic Missionary at Safotu, and Mr. von der Heide, the courageous planter, who, throughout the period of volcanic violence, remained on his estate (Olenono) less than four miles from the crater. These gentlemen, living close to the scene of activity, have generously given me the benefit of the facts and observations they have collected. To Dr. Schultz, Acting Governor of Samoa, Dr. Linke, astronomer and meteorologist at Apia, Dr. Funke, and the Deutscher Handels und Plantagengesellschaft I am indebted for many acts of kindness and courtesy. I have also to thank Capt. Allan, of the s.s. 'Maori,' and Mr. Tattersall, photographer, Apia, for permission to copy the photographs which appear in Plates i. to iv. of this paper.

2. General Geology.

The German Samoan Islands, the chief of which are Upolo, Savaii and Apolima, have been built up from oceanic depths by volcanic action. The same is probably equally true of the other, the American, islands of the group, Tutuila and Manua, which according to the investigations of J. D. Dana* bear a close resemblance to Upolo.

The islands of Savaii, Apolima, Upolo and Tutuila lie on a line of earth fracture which runs W. 20° N., E. 20° S. (see fig. 1). As Dana points out, the fracture appears to have been widest at the western extremity, where, accordingly, the largest extravasation of lava has taken place. Through each of the two largest islands,

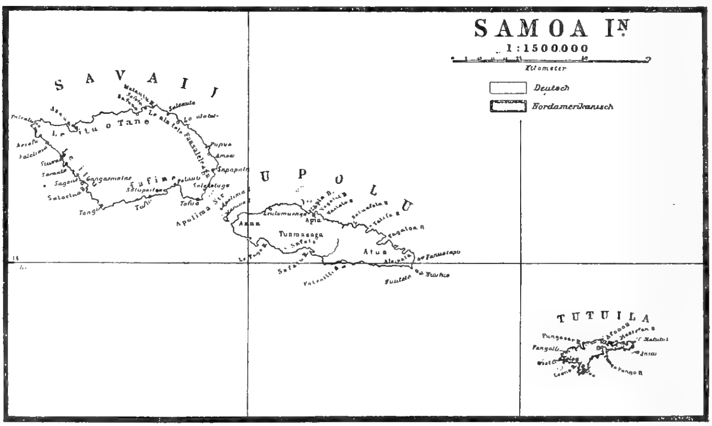


Fig. 1.

Savaii (1,691 sq. kilometers) and Upolo (868 sq kilometers), there runs a mountain range forming a backbone. These ranges consist entirely of basaltic lava and have craters situated on them only a few miles apart so as to appear to be made up of a line of volcanic cones which have fused into a mountain chain. This arrangement points to the probability that the islands have been

* See 'Geology of The U. S. Exploring Expedition.'

formed in the first place by a gigantic fissure eruption, and that on the closing of the fissure and diminution of volcanic energy lava continued to be exuded at a number of points along the original fissure.

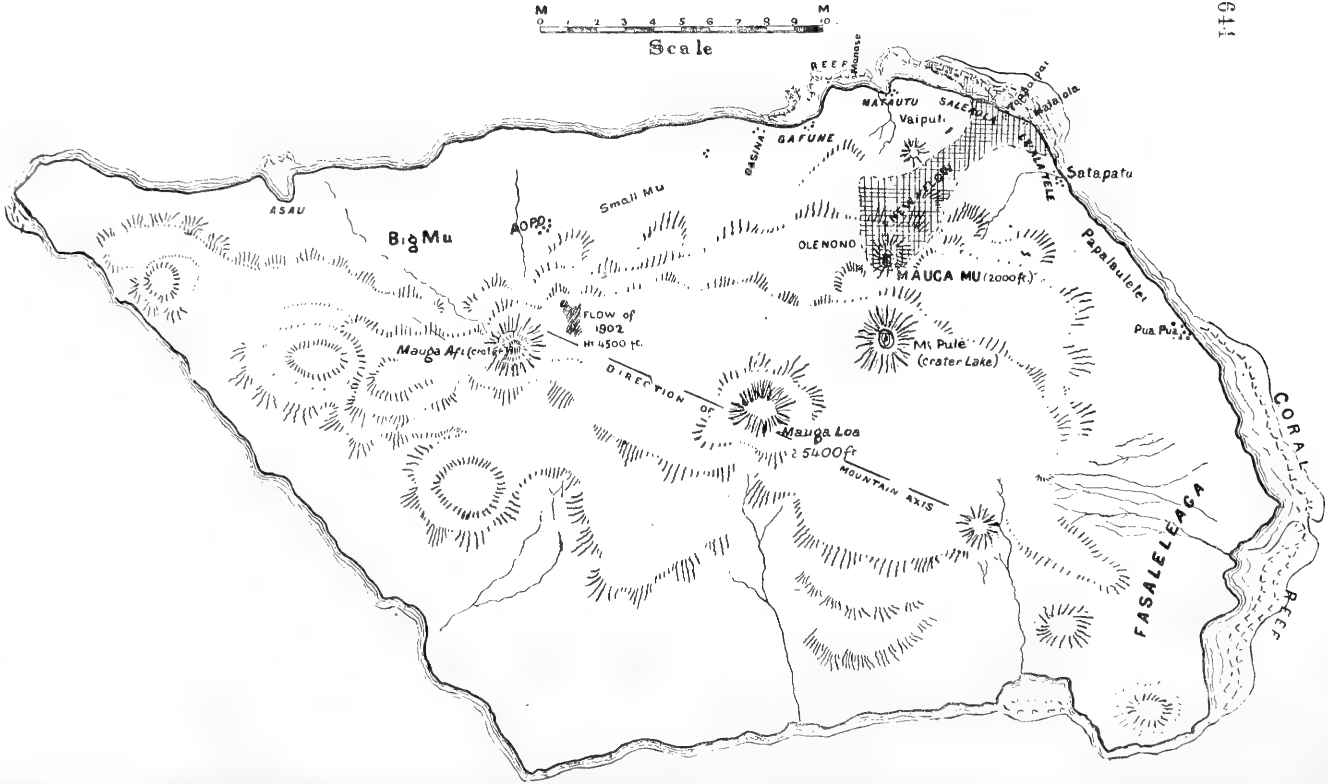
Some of the craters contain beautiful crater lakes like Lanutoo in Upolo, and Mt. Pule in Savaii. Lanutoo crater lake, which I visited, has no outlet, and yet the water in it always keeps the same level. This peculiarity seems to be due to the fact that the walls of the crater are composed of alternating lava streams and porous tuff beds. The lake is supplied by a copious rainfall, and is drained through the porous tuffs of its wall. Other craters have no lakes. These usually consist essentially of porous rock (*e.g.* Tofoa in Upolo).

The height of the range which forms the backbone of Upolo exceeds 2000 feet, and many of the peaks on it surpass 3000 feet in altitude. From the craters, long ridges representing lava flows descend to the sea. Their slope is generally speaking gentle, usually ranging between 5 and 10 degrees. Although the craters of Upolo show no activity, the lava is in many places so fresh that it is probable that several of the craters have been active within the last thousand years. The rock is everywhere the same, consisting of more or less vesicular basalt, usually olivine-bearing and varying in crystallinity from hemicrystalline to glassy.

Savaii is a somewhat dome-shaped island. It is studded with craters, the largest and most important of which lie on the backbone of the island. The highest peaks are probably not much short of 6000 feet high, and 4500 feet is the average height of the middle of the main range, which, however, diminishes in altitude to the east and west. Arched lava streams are seen in all parts. They run from the central mountains to the sea. Only the craters in the interior have given rise to much lava. Other cones with craters exist; but they are of a comparatively small size, and they are situated on cross fissures which radiate from the interior of the island. The lava is very uniform in composition, but varies considerably in texture and appearance.

Fig. 2.

SAVAII


M 0 1 2 3 4 5 6 7 8 9 10 M
Scale
REEF
Manase
MATAUTU
SALEAULA
Vaipuli
GAFUNE
Satapatu
Papalaulelei
Pua Pua
OLENONO
MAUCA MU (2000 ft.)
Mt Pule (crater Lake)
Small Mu
AOPO
Big Mu
ASAU
FLOW of 1902
Ht 4500 ft.
DIRECTION OF MOUNTAIN AXIS
Mauga Loa
5400 ft
FASALELEAGA
CORAL REEF

Most of what is seen on the surface is tachylitic or hemicrystalline. A specimen of coarse-grained dolerite from the western end of the island was shown to me, and is the only macrocrystalline rock I have seen there. Holocrystalline fine-grained basalts may be obtained in deep creek beds and sea cliffs where denudation has had time to work into the core of the flows.

Drainage is naturally in a very youthful stage. The larger streams, which run with great rapidity after rains and are at other times a mere string of waterholes, are cutting deep trenches and gorges.

The surface of all the flows, old and young, is tachylitic and highly vesicular, proving their recent nature. Besides the lava-flow of 1902 and that of 1905-06, there are many flows of very recent appearance which support but scanty vegetation, and have soil only in the cracks and holes on the surface. As the lava decomposes very rapidly under the influence of a moist climate, especially as the surface is so porous, it is probable that these flows are less than 500 years old. Such are the "Big Mu"* between Aopo and Asau, the "Small Mu" between Aopo and Sasina, the Papalaulelei flow (on the north side), and several other flows on the south side of Savaii.

The large and small flows of Aopo and one on the south side of Savaii opposite the big "Mu" probably come from the Mauga Afi† crater or one of its parasitic craters in the west end of the island. The Papalaulelei flow probably came from Mauga Pulé in the eastern end of the island. On all these flows the original crust still exists, showing wrinkled, twisted, ropy, billowy, hummocky and knobbed structures. Deep cracks formed by cooling, partly infilled with soil, and deep holes where trees have been burnt out, holes formed by the falling in of the roof of lava tunnels and smaller depressions (formed by the collapse of the thin glassy lava crust, over caverns formed by the withdrawal of he lava in the molten state after the crust haa formed) exist in

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* "*O le Mu*" means "*the burnt.*"

† "Afi," fire.

all these flows. The curious tapestry-like folds and cavernous bulges and domes described and figured by Dana* abound on these flows as well as on the new lava flow of 1905-06, all of which belong to the *pahoehoe* type.

The island of Upolo is almost wholly surrounded by a coral reef. Savaii on the other hand has for the most part rocky coast, called ironbound coast; and where reefs occur they are close to the land. Savaii is evidently much the more recent. The coral polyps keep up a struggle to build a reef round it, but from time to time new eruptions pour down masses of lava which fill up the space between the reef and the shore, and cover the young reef. The new volcano has in this way turned several miles of coral coast into rocky, ironbound coast. At Papalaulelei, between Lealatele and Fasaleaga, basalt cliffs, one hundred feet and over, form the coast for several miles, and jut into deep water. This piece of coast has most probably been formed in the way indicated above, although I have nowhere seen basalt directly covering a coral rock.

Nowhere in Upolo or Savaii have I seen any marked indication of raised beaches like those of Fiji. In the eastern extremity of the island, from Puapua southwards, over a large area comprising much of the province of Fasaleaga, the land is low-lying, and composed of a calcareous sand of the coral reef type. This may have been formed either of material driven in by wind and wave from the coral reef skirting this piece of coast line, or by a slight uplift of the sea bottom, amounting at most to 6 or 8 feet. From the swampy nature of the country inside the coast, I consider the latter alternative the more probable. A few similar patches of much smaller extent occur in other places, as at Safune It is highly doubtful whether they should be considered indicative of uplift. On the other hand we have no evidence of depression. The coral reefs fringe the coast and are separated from it by shallow water only. Where in Savaii basaltic cliffs face the open sea, they jut into very deep water. If the island were undergoing

* 'Characteristics of Volcanoes,' pp. 117 and 118.

subsidence, we should expect to find the water gradually deepening for a long distance out. For these reasons it is probable that Samoa (and Savaii especially) has been not subject to any oscillations of considerable magnitude in recent time. Minor oscillations (amounting to a few feet) of both positive and negative character may have taken place. Dana, who visited Upolo in 1839, gives reasons for believing that a slight depression has taken place at the western end of Upolo, but his evidence is very meagre, and is explicable on other grounds.

The high and rocky ironbound coast at Papalaulelei suggests a faulted coast. It is, however, quite unnecessary to assume faulting to account for this type. When a lava stream reaches the coral reef it is turned back, and a cool crust forms in front. The surface of the stream gradually rises as new lava wells in underneath. If it should pour over the reef into deep water, the advancing stream will tend to preserve an almost vertical front. It is easy to conceive of the waves working in along the line of the old coral reef, and undermining a basalt flow of this character, producing steep seaward cliffs (see Plate lxi.).

3. Examination and Description of the Volcanic Flows.

Most of my time in Samoa was spent on the island of Savaii on the study of the lava flows, and chiefly on that of 1905-06.

(*a*) *Old Flows.* I had not an opportunity of examining the big "Mu" between Aopo and Asau, but I was informed by several reliable residents of the island that this area supports almost no vegetation, and in many places the lava looks as fresh as if it had been erupted yesterday. In a climate like that of Samoa, the vesicular aud scoriaceous basalts would tend to decay quickly, so that such a fresh lava-plain cannot be more than a few hundred years old. It has been suggested by some that it was formed fourteen generations (about 350 years) ago. Mr. W. von Bülow, an eminent ethnologist resident on the island, tells me that it was probably formed about the year 1800, basing his calculations on information received from the natives. This estimate appears from the description to be the more likely. The other estimate is based on a saying amongst the Samoans, used whenever a man returns from a "melaga" (trip, voyage) and finds trouble in his house:—"When I left all was peaceful and beautiful coral reef coast, and now, when I return, all is confusion and ironbound coast." These words are said to have been first used by a princess on her return from Tonga whither she had gone to marry a king. She belonged to the royal family of Samoa and lived about fourteen generations ago. Probably about that time it was that the lavas came down which created the small "Mu" at Aopo, and the Papalaulelei flow; and perhaps also an older "Mu" underlying the present big "Mu" of Aopo. On all these lava-plains, as already mentioned, we find the original crust almost as fresh as on the day of its formation, with wrinkles, knobbed, ropy and tapestry-like folds, and the general characteristics of the "pahoehoe" type of lava-flow.

In a few places in Samoa there are unwooded patches which have a different nature. On these the soil is deep, ashy, or clayey, and supports ferns, grass, and a few "fala" (Pandanus) trees. Probably, such patches represent volcanic ash deposits.

(*b*) *The New Flow of 1905-06.*—The new flow is situated in the north-eastern part of the island, and comes from the new crater which formed a couple of miles to the north of Mt. Pule (crater lake) on the mountain slopes. The new crater is seven or eight miles from the sea in the shortest direction, but the lava, following a circuitous course, runs an even greater distance before reaching the sea. South and east of the crater are remnants of older craters; and north of it, between it and Matauto, there are a couple of small cones (Mumea and Mauga Ele, near Vaipuli) barely reaching a thousand feet in altitude, which have perfect craters and are composed of lava cinders The new volcano attains an altitude of 2000 feet. The lava rom it covers an area of about 30 square miles, and flowed from the vent in a north-easterly direction. Fig. 3, from a plan constructed by Mr. Williams, the Amtmann of Savaii, shows the area covered by each of the big lava flows since August, 1905. The thickness of the lava varies greatly, depending on proximity to the volcano

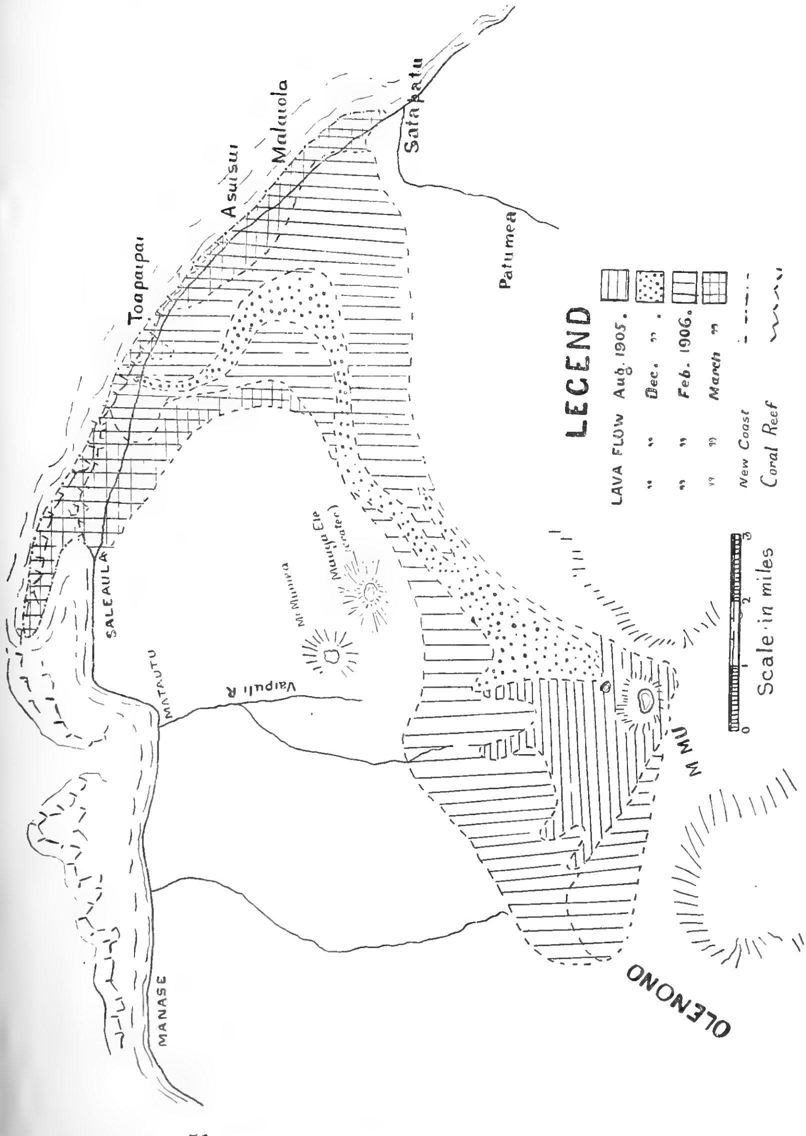

Fig.3.—Plan of the lava flows since August, 1905.

and previous configuration of the country. I was informed by reliable authorities, like Mr. Williams and the Rev. Père Mennel of Safotu, that originally a deep valley reached almost to the present site of the active cone. The earliest flows followed this valley, and in it, for a distance of several miles, there is now a thickness of lava which probably exceeds a thousand feet. What was originally a deep valley, only a few hundred feet high, now forms a huge, bulging, lava ridge about 1500 feet high near the volcano, and sloping gently towards the sea. This inclined lava-plain is continually rising through the intercalation of new lava sheets or sills under the cooled crust. Captain Allan, of the s.s. "Maori," who periodically visits the islands, tells me that he sees an appreciable difference in its altitude each trip.

Most of the lava at present exuded goes to the sea, following definite lava tunnels beneath the cooled crust. The course of these tunnels can be traced by ventholes, through which steam and sulphurous gases rise (see Plate lviii.).

Where the lava flows into the sea we have what seems a miniature volcano (Plates lix.-lx.). On the shore-side an embankment of stones and cinders is formed by explosions, which occurred at the time of my visits in very rapid succession (one every two minutes), and which depend on the principle of geyser-action. Immense masses of steam form, which, as shown in Plates lix.-lx., rise like gigantic columns, and drift off as cumulus clouds, giving continued rains on the area over which they drift. The showers from these clouds often were salty and contained cinders, showing that matter was carried up mechanically by the steam. The roar of the rising columns was continuous, modified only by the geyser-like explosions. In the vicinity waterspouts and tornado-like whirlwinds were frequently formed. At night this spot had a glow overspreading it like the volcano itself; and on each explosion followed a magnificent firework display, probably through red-hot stones being hurled up several hundred yards.

The cause of the explosions seems to be as follows. As the lava pours into deep water, a considerable amount of water is included in and beneath it. When the steam pressure becomes great enough, an explosion takes place.

In March last the lava was entering the sea along a width of several miles, so that a continuous wall of steam lined the coast; and the sea was boiling hot, and in ebullition several hundred yards out. The stench from the dead coral and fishes was very bad at Matauto.

The weight of the lava poured out it is impossible to estimate, even for one who perfectly understands the previous configuration of the country, some of it being compact, some vesicular, and some mere scoria. One can, however, say with certainty that in volume it exceeds a cubic mile, and that three cubic miles may not be too high an estimate. Over a considerable area it probably exceeds 1000 feet in thickness. Over the coastal area from Saleaula to Satapatu, and inland three or four miles, its thickness varies from twenty to several hundred feet. Between Asuisui and Satapatu it has flowed into deep water, and has filled up the sea bottom to such an extent as to make the water greenish and shallow-looking for nearly a mile out from shore. The explosions where the lava runs into the sea have given rise to a lot of black sand on the Savaiian beaches. This consists of lava blown to cinders.

On the crust the lava is almost wholly tachylitic.* Occasionally it contains an olivine, more rarely a plagioclase (probably albite) phenocryst. At Malaiola steam explosions beneath have in several places broken the crust so as to form stony hills; and in many of the wide cracks here formed, several feet wide and 8-10 feet deep, which at the time of my visits emitted steam and sulphurous vapours, the nature of the more deep-seated lava may be seen. The specimens obtained here have large, almond-shaped vesicles forming about one-third the volume of an otherwise compact and almost holocrystalline, close-grained rock.† The lava surface is, generally speaking, satiny and level, of the

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* See Petrological Descriptions, *postea* p.667, Sp. S.2.

† See Petrological Descriptions, *postea* p.666, Sp. S.1.

pahoehoe type, though hummocks, bulges, and cracks due to cooling abound. The tachylitic crust shows ropy, wave-like and tapestry-like structures due to variations in the rate of flow of the plastic lava on the surface, and other causes which have been already explained by Dana.* Curious concentric wrinkles and ripples are often seen; and are in some cases, if not in all, caused where lava flows from the surface into a hole left by the burning out of a tree by a former flow. Such holes abound, especially where the lava has destroyed cocoanut plantations. Cavernous hollows, with lava stalactites and stalagmites, abound in the scoriaceous crust, and the roof often breaks when a pedestrian walks across. Patches of the flow conform to the *Aa* type. A narrow patch of this nature has to be crossed in going from Matauto to Satapatu, on the eastern side of the flow. Other patches of *Aa* exist on the eastern side of the flow, west and south-west of Patumea.

From the basic nature of the lava and the level surface of the main flows, one would at first suppose that the lava was very liquid, and had come down with great rapidity. Such is, however, not always the case. It flows rapidly into and out of the crater, and probably in the main lava-tunnels; but, as soon as it spreads out in a sheet on the surface, it becomes very pasty, and advances very slowly (in most cases not as rapidly as a man can walk). The reason of this sluggishness is that, owing to the low temperature necessary for the liquidity of a basic lava, the crust cools quickly, tends to hold back the molten lava within and behind, and advances with it like an encompassing filament. The lava front advances, and grows by cracking when the interstices are filled with pasty lava which quickly cools. By a repetition of this process of intercalation, the stream spreads and advances. Stones and rubbish taken up in the lava front also hasten the cooling and impede the progress. In many places the lava advances only a few yards per hour at the time of the great flows. At other places it advanced as fast as a man walks. I

* Characteristics of Volcanoes.

heard of only one case where the spectators had to run to escape, and that occurred near the crater.

The present eruption is remarkable for its poorness in tuffs and ashes. Some fragmentary material exists in the active cone itself, and scoriaceous cinders to a depth of several feet cover miles of country south and south-west of it; but this material was thrown out in the early stages of the eruption, when liquid lava was also shot up from the crater to a great height, and fell in splashes, many hundred pounds in weight, as much as half-a-mile from the crater. The liquidity and heat of the lava were such that it did not become cold, and form bombs in the air, but landed with a splash, and spread out on the rocks like cow manure in a field. Most of the scoriaceous cinders erupted at first have since become covered with lava.

The cone has a slope of about 33°, and is built up of alternate beds of red scoriaceous cinders, and scoriaceous lava. It is about one-third of a mile in diameter at the base, and about 330 feet high. The crater appears to be about 200 yards wide at the top, and the inner walls are vertical or slightly overhanging, so that the width of the crater is about the same below. At a depth of about 200 feet in the crater is seen a lake of seething, red-hot lava with occasional white streaks and flashes, showing that it is white-hot at a depth. The lava enters the crater from the south-west, rising diagonally upwards, and flows out by two vents, one in the north and the other in the north-east wall. The north-easterly outflowing stream, of which I had a good view in my ascent, was probably 30 yards wide, and flowed like a river rushing over a cataract. The northern stream is drawn downwards with a vortex motion. The lava in the crater was in continuous violent ebullition and motion Loud rumbles were heard intermittently in the heart of the mountain, accompanied by the emission of immense puffs of vapour. Huge clouds of vapour charged with gases were constantly rising from the crater, and from the vent hole about half-a-mile north-east of the crater.

An obstacle composed of stone greatly impedes the progress of the lava. In portions of the coastal area, as at Toapaipai, where the thickness of the flow is between 10 and 40 feet, the lava has in several instances flowed round buildings of stone, piling itself higher and higher, without crushing in the walls. Such houses are now represented by holes, except where the flow has been sufficiently high to enter by the roof, or sufficiently liquid to overcome its own sluggishness and flow in through the windows. At one place, near Saleaula, where the lava is between 6 and 10 feet thick, a native house was removed before the stream advanced, but the spot where it stood is now a depression surrounded by almost vertical lava walls, and has grass growing on the bottom. This spot was preserved by a ring of stones about eighteen inches high, such as the natives make round their houses. These facts show that, on fairly level ground, when a piece of land is not in the very front of the main lava stream, but is being threatened by the backwash, so to speak, the quick erection of a stone mound may save it from destruction.

The coral reef has acted in the same way as the stones of the native house referred to. The lava, on reaching it, stops flowing seaward, and rises by new masses being thrust under and lifting the cooled surface. It now flows along the coral reef. Mr. Williams informed me that as soon as a lava stream reached the sea it became "quick-flowing and full of life." The increased mobility may be due to mixture with water, or to diminished resistance.

Before the eruption the coral reef extended from Sasina to Asuisui. Lava has filled the space between the reef and the shore from Asuisui to Toapaipai, and has further followed the reef so as to build a long peninsula, several miles in length, enclosing a fine sheet of water, which forms a safe harbour at Saleaula.

Mr. Williams tells me that, in the early stages of the eruption, in August, 1905, no actual lava could be seen, and yet the whole countryside near the volcano rose and flowed like lava, and seemed like a mountain on a "melanga" (journey). When you thrust a stick into the moving mass, you saw only reddish cinders. The explanation of this phenomenon is, of course, that the first lava was thrust in under the cinder and scoria masses first ejected, and the latter were floated and pushed along on the molten matter beneath and behind. It was not till September, 1905, that any actual "live" lava was seen by Mr. Williams, who kept a keen eye on the progress of events. Père Mennel recognised a distinct lava flow on September 3rd, moving towards the north-west; and a second towards the south on October 14th; but these were only short flows.

(c) *The Flow of 1902.*—This lava flow, which I also visited, is situated about 10 miles in a direct line from the more recent crater. It belongs to the *Aa* type, consisting of fragments of all sizes, from cinders the size of peas to blocks many yards in diameter, piled in wild confusion. The lava is vesicular and scoriaceous. The small patches of *Aa* in the 1906 flows occur where the lava has overwhelmed a very humid scrub or jungle, and hence has cooled quickly from beneath. The flow of 1902 is situated a couple of miles north-east of Mauga Afi, and some four miles south-south-east of the town of Aopo. Hence, it is called the Mauga Mu of Aopo. The crater, which is very indefinite and of the pit type, and has built no cone, is 4500 feet above sea-level on the northern slope of the main range. The flow is short, and bifurcates some distance down the side of the mountain. Fog and rain prevented me from making a thorough examination of this locality, and from getting photographs; however, it appears to me that the fragmentary nature of the material met with is only partly due to the causes which usually produce the *Aa*. Probably the volcano of 1902 was formed by the opening of a fissure in the side of the Mauga Afi. The lava has risen slowly, and partially cooled in the vent, after which, increased pressure has blown to fragments the cooling plug. This process was probably repeated frequently, and served to pile up angular fragments and scoria round the fissure. A subsequent small exudation of lava has carried these masses with it down the mountain side. The stream is less than half-a-mile wide, and only a couple of miles long. Sulphurous vapours are still emitted at the crater.

4. History of the Volcanic Activity.

Père Mennel informed me that the *Afi* (fire, eruption) of 1902 was preceded by violent earthquake shocks, which frightened all the people of Aopo and Safune, so that they fled to Safotu, where, indeed, the shocks were also extremely violent. The natives were particularly scared, as neither their parents nor grandparents had ever experienced earthquakes of such violence. The eruption commenced on October 30th and lasted three weeks. Repeated earthquakes and great detonations took place during this time, and huge flames curled into the air. This record shows that the eruption was connected with earth-fissuring, and was of an explosive character. There was no previous crater where it broke out.

The natives had no experience of eruptions, and were greatly frightened. Only the existence of names like the "Mu" (meaning "burnt") and Mauga Afi (fire mountain) evidences that some remote ancestors of the Samoans had witnessed similar events.*

The new volcano, Maugi Afi of Olenono, is also situated on a spot where no crater was known to exist before. The outbreak commenced at 9-10 p.m. on August 4th, 1905, and was accompanied by an earthquake shock, which was strongly felt only

* In the "Samoan Reporter" (which was published half-yearly by the London Missionary Society, and of which only one copy is extant), we find published, in September, 1846,—"On the north-west side of Savaii, about 12 miles west of Safune, passing inland, on emerging from the bush you are astonished at the sudden bursting to view of an extensive field of lava, which you at first think cannot have been thrown up more than a few years. Much of it is still hard and compact, and shows the waves and ripples on its surface as when it cooled. Other parts are partially broken up, and the masses lie in wild confusion. This scenery extends for some miles longitudinally, and in breadth from the summits of the mountains to the sea. The people know very little about the facts of the eruption, but their vague tradition seems to fix it three or four generations back, and ascribes it to the anger of one of their Aitus (demons), and says that the natives, with difficulty, escaped in their canoes. The name they give it is significant, 'O le Mu' (the Burnt)"!

near the point of eruption, but nevertheless registered by the seismograph at Apia. The moon was early in the first quarter.

The Rev. Père Mennel of Safotu has kindly given me information regarding the early history of the volcano. This occupies a position which before was a small stony plain about 1600 feet above sea-level. In the centre of this plain there stood a small stony hill, which might have been piled up by a previous eruption, but there was no evidence of a crater. To the east of the active cone there is a high mountain (about 2000 feet), which is a remnant of a very old crater ring This mountain is connected by a ridge with another mountain, one mile south-west of the cone between it and Olenono. This mountain also consists of old volcanic rock. To the south the ground gradually rises to Mt. Pule (crater lake) on the backbone of Savaii, over 4000 feet high.

In the beginning there were three vents, out of each of which ashes, sand, and stones were hurled. By the ejections three little cones were built up. On September 1st two of them, the most southerly and the most easterly, had united to form one. Later, in the end of September, the third coalesced with them, and a crater formed in the middle. The lava commenced to flow in the same month. The first flow, on September 3rd, was towards the north-west; the second was towards the south. The latter was soon stopped by the high ground. On December 3rd, a long lava stream came down to the sea, running in a north-east direction, and destroyed Toapaipai. The great flows in February and March of the present year were still more destructive. All the lava flows cooled quickly on the surface. A few hours after a stream came down, it was possible to walk on it; and messengers crossed the lava every day between Matauto and Satapatu.

Père Mennel tells me that large pieces of sulphur and common salt were ejected from the volcano in the early stages. At the time of my visits sulphur and crystals of common salt (NaCl) were the most common encrustations met with lining the fissures on the volcano and lava flows.

5. Gases Evolved and General Observations.

The great vapour clouds formed where the lava runs into the sea contain sulphur gases as well as the salt already referred to. The rains from these vapours have a very injurious effect on the cocoanut trees at Matauto and Safune. The immense steam-clouds rising from the crater and from a venthole one-half or three-quarters of a mile north-east of the crater are highly charged with noxious gases. One can easily detect by the smell sulphur dioxide, sulphuretted hydrogen, and hydrochloric acid. The rain which falls south-west of the crater (the prevailing winds being from the north-east) has killed all vegetation for miles around. At Olenono, three or four miles west of the crater, not only have the plantation trees and all the forest been killed by the rain, but the rain-water is in reality dilute sulphurous acid, which rusts galvanised iron rapidly, and curdles condensed milk. Patches of forest near Olenono, which were still green in the middle of June, were quite leafless by the end of the month. It appears that the forest destruction by poisoning has taken place wholly in the months of May, June, and July of the present year. Hence it may be concluded that the evolution of noxious gases must have greatly increased during these months, and that the volcano is becoming more solfataric.

Carbonic acid is probably also evolved, but no definite proof was noticed.

Speaking generally, the activity has been weakening since March last. After the outbreak in August, 1905, until December, 1905, violent explosions are said to have taken place frequently in the crater, hurling stones and lava hundreds of yards into the air, and over a radius exceeding half-a-mile. The lava frequently overflowed at the top of the crater rim. Mr. von der Heide, of Olenono, informs me that since then the lava has been gradually sinking in the crater, and explosive action has practically ceased. Now the lava-level is 200 feet beneath the rim. A steady but gradually diminishing stream has, since March, been flowing to the sea through the lava-tunnel. Probably so much material is now exuded that pressure within is relieved, and extinction is approaching. Should the lava-tunnel plug up, and the same crater continue active, several fine villages would be in danger of destruction.

It is interesting to note that both the new craters (1902 and 1905-6) are situated on the northern slopes of the backbone of Savaii, and broke out in fresh places but only a few miles from old and well-marked craters. Possibly the line of weakness has moved northwards.

Mr. von der Heide described to me a small pillar seen by him in the crater. On my visit I did not see it, but from the description, I take it to be a driplet cone.

The foregoing description of the flows, as well as the petrological investigation of the rocks, bring out a close correspondence between the volcanoes of Savaii and those of Hawaii. The lavas are of the same type, and their modes of eruption, flow, and cooling are similar in the two localities. In the production of long flows sloping gently towards the sea, and, in the quiet way lava is poured steadily to the sea, the new Savaiian volcano resembles Mount Loa in Hawaii.

Simultaneous eruptions in other places.—It is interesting to note that early this year (1906) when the Savaiian volcano displayed its maximum energy, a sympathetic outbreak occurred in the island of Tofua in the Tongan group. The Rev. Walkden Browne, of Tongatabu, who visited the island during the outbreak, gave me a short account of the event. In January the Tofuan volcanoes burst out into eruption and remained active for about two months. There are two cones on the island, which were both active. Many other small craters exist in various parts. The island is about six miles by five, and constitues in fact a single volcano whose summit has been blown off. The rim of the island is 1800 feet high all round, and one ascends rapidly from the sea. The descent to the interior of the island is again steep. In the centre of the island there is a lake whose level is probably 400 feet above the sea. The two cones that were active stand east of the lake. The higher and more easterly only smoked during the eruption, but the smaller cone was in violent eruption, throwing stones over 1000 feet into the air. The height of the smaller cone above sea-level is 900 feet. The accompanying rough sketches (figs. 4 and 5) from information given by Mr.

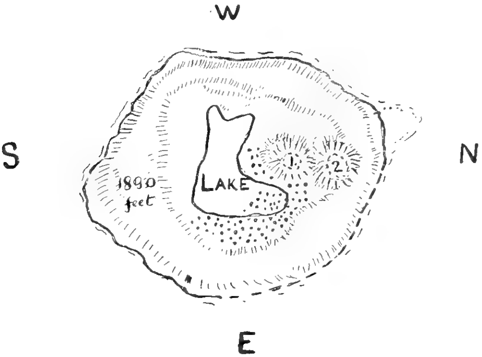

Fig. 4.—Plan of Tofua. The number 1 represents the smaller cone which was in violent eruption; 2 is the higher cone which was only smoking. The dotted area represents a lava flow from the small cone which destroyed a forest surrounding the lake.

Walkden Browne, illustrate the structure of the island, and Plate lxiii. shows the crater lake.

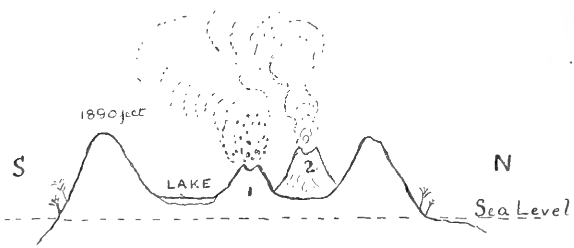

Fig. 5.—Sketch Section of Tofua in the Tongan Islands.

About March 22nd of this year a violent geyser eruption took place in the crater lake of Ruapehu, in the Taupo region of New Zealand. Immense volumes of steam and also hot stones were ejected. The Tongan island of Fonualaei was also in eruption.

The simultaneous outburst at three points on the same line of fissure is significant. It serves to remind of a similar event in

1886. *Four or five days* after the eruption of Tarawera, White Island, in the Bay of Plenty, became unusually active; and *two months later* there was a violent eruption of Niuafau in the Tongan group. Again, in 1902 there was a violent eruption in the Kermadec Islands, a violent eruption as already described in Savaii, and severe earthquakes at Cheviot, New Zealand, and in Samoa.

Admission of sea-water.—There can be no doubt that the explosive violence of the youngest volcano in the world in its early stages was due to the admission of sea-water. The evolution of hydrochloric acid (HCl) and the deposition of common salt (NaCl) in the fissures are clear proof that sea-water had found its way down to the hot lavas.

6. Tongan Geology as bearing on the nature of the outbreak.

An excellent paper on the "Geology of the Tongan Islands" by Mr. J. J. Lister appeared in the Quarterly Journal of the Geological Society (Vol.xlvii., November 2nd, 1891). Not being acquainted with this paper until after my return to Sydney, I made some observations in Vavau, Haapai and Tongatabu which I find, though less complete, agree in all respects with Lister's.

There is, in the Tongan group, a line of volcanic islands, situated to the west of the islands, which are built wholly or partly of coral rock. The volcanic line runs about N. 22° E., and, if produced north and south, passes through Samoa, the Kermadec Islands, White Island, and the Taupo zone in New Zealand. The wholly volcanic islands of the Tongan group lying on this line are Pylstaart, Falcon Island, Tofua, Kao, Latté, Amargura, Toku, Boscawen, Keppel Island and Niuafou.* The coralline islands are partly raised atolls, and partly raised reefs. Elevation has usually been greatest on the eastern side, which is, in most cases, the highest. The island of Eua, which lies S.E. of Tongatabu, is by far the highest in the group, exceeding in places 1000 feet.

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* See Map of the Tongan Islands, Admiralty Charts.

Lister gives an excellent account of the terraced appearance and geology of this island. He found inclusions of tourmaline-bearing rock, and gabbro in the lavas of the island. He also calls attention to the terracing of Vavau. I made an examination of the interesting hill at Vavau, and found four distinct levels represented on the island, (1) the summit of the hill 420 feet, (2) a 280 feet level, (3) the 160-180 feet level, and (4) a 40 feet level, evidencing at least four distinct uplifts. From the top of the hill to sea-level, the hill is composed of coral limestone containing coralline seaweeds (Nullipore, Lithothamnion), foraminifera (Miliolinidæ, Orbitoides, and Rotalidæ) and mollusca. The limestone has a late Tertiary appearance.

The oceanic depths near Tonga and the Kermadec Islands are also of interest. East of these groups the greatest known depths have been obtained, and there is, in fact, a long, very deep trough running parallel to the volcanic line, between which and the trough the shelf, on which the islands stand, is situated. West

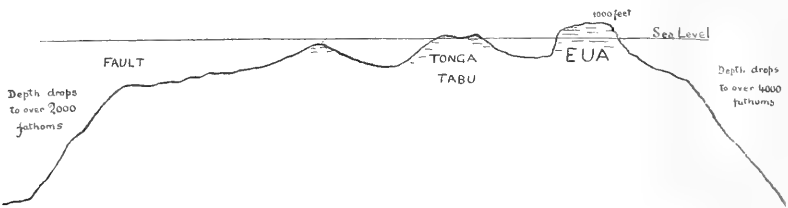

Fig. 6.—Sketch Section W.N.W.-E.S.E. across Tonga.

of the volcanic belt the depth also suddenly increases. Considerable depths are also known between the several groups of islands (see fig. 6).

The foregoing facts show that the volcanic belt from Lake Taupo to Samoa is ranged along a great structural line in the earth's crust, which possibly marks the eastern border of the submerged Fijian continent. The deep trough eastward is probably the depressed deep ocean which usually obtains near the shores of continents, and may represent an old trough fault or otherwise faulted area.* The volcanic line probably represents

* *Cf.* Dana, "Characteristics of Volcanoes," Part 3.

a long fault caused by an overfolding movement from the west-north-west, which is tending to elevate the sea-bottom along its whole length; and the deep water to the west of it is accounted for by a downthrow to the rear of the fault. The breaks in the continuity in the shelf between the volcanic line and the deep trough eastward, may be due to cross faulting of the blätter type, and its after-result cross trough-faulting.* The fact that tourmaline inclusions have been discovered in the Eua lavas, and the existence of a deep trough east of Tonga point to these islands being situated over continental rocks on an old shore-line. The fact that the great deep is separated by a ridge from the fissure-line shows that it is probably a structural feature, and not the effect of volcanism. The simultaneity of eruptions along the line of fissure can be accounted for only on the assumption that crustal movements take place simultaneously along the whole length of the fissure, and the extravasation of lava is probably due to the melting of rock by pressure and friction below.

7. Connection of the Eruption with Lunar Phases, Sunspots and Earth-Magnetism.

It has been noticed by the observers of the volcano in Savaii that most of the important eruptions, or periods of particular violence, have been at New Moon, or early in the first quarter; some occurred at Full Moon, and very few in the last quarter.

Dr. Linke, of the Apia Observatory, informs me that very great magnetic disturbances were recorded by his instruments at the time of the outbreak of the volcano in 1905. Every subsequent violent eruption was likewise accompanied by magnetic disturbances How far these disturbances depend on solar or other extra-terrestrial causes, or on the movement of lava-masses, rich in ferric minerals, within the earth, is a matter of extreme importance in the realm of seismic forecasting; and we may look to Dr. Linke for the solution of the problem, as regards Savaii.

There seem to be good reasons to suppose that great earth-movements or lava-movements under an area will affect local

* *Cf.* "Geology of the New Hebrides," by D. Mawson. These Proceedings, 1905, Part 3.

magnetic conditions. If that be not so, the solution of the problem of seismic forecasting becomes simplified. Inasmuch as sudden outbursts of prominences and faculæ on the sun affect the earth's magnetic conditions very quickly, and magnetic disturbances may lead to earthquakes and eruptions in a region of instability; and, further, as good seismograph records enable us to judge, by the frequency of minor shocks, that earth-movements are tending to take place under an area, it follows that, if we can obtain sufficient knowledge of the sun to anticipate changes in its atmosphere, we can forecast earthquakes. Solar physics is now so well understood that seismic forecasting is within the range of the practical.

The eruption in Savaii, in 1902, took place during sunspot minimum by the opening of a fissure. In my paper entitled "Possible Relations between Sunspots and Volcanic and Seismic Phenomena and Climate,"* I tried to show that earthquake fissures would tend to form in years of sunspot minimum.

The outpouring of lava from the 1902 volcano stopped quickly, probably because of the height of the vent, 4500 feet above sea-level, but pressure within the earth was not wholly relieved. In the paper cited above I also mentioned that volcanoes situated on fissure-lines in regions undergoing folding from rise of the isogeotherms, may have their most violent outbursts in years of sunspot maximum. That the Samoan-New Zealand volcanic line marks such a region, I have shown probable. Hence, it is not surprising to learn that new outbursts took place during the maximum of 1905. Most of the violent eruptions on this line have taken place at the end of sunspot maxima, *e.g.*, Tarawera, White Island and Niaufou, 1886; Falcon Island, 1885; Ruapehu, 1895; and many of the Hawaiian eruptions.

8. Summary and Conclusions.

In the foregoing notes I have attempted to give an account of the area, composition, and appearance of the lava fields of Savaii;

* Journ. Proc. Roy. Soc. N.S. Wales, Vol. xxxviii.

of their age and history, and of the volcanoes which have produced them. I have shown that the Samoan islands lie on a fissure running W.N.W.-E.S.W., almost at right angles to the great fissure running from Samoa to New Zealand. It is probably on account of the situation of these islands on the intersection of two great structural lines, that volcanic extravasation has been so great here. The elevation of coral reefs and atolls in the Tongan group has been shown to be probably due to a great earth-folding and continent-making movement tending to restore the old continent of Fiji; and most likely a continuation of the movement that raised New Zealand in late Tertiary times, leaving Miocene and Pliocene limestones high and dry. Structurally the two regions are alike. A glance at the geological map of New Zealand, and the Admiralty map of the Tongan group, will serve to show that, just as the east of New Zealand is composed mainly of Tertiary sediments overlying older metamorphic and plutonic rocks; and the west coast is mostly covered with Tertiary eruptive rocks, and has a sharp faulted front towards the deep ocean; so Tonga has her raised limestones to the eastward of the line of volcanic activity, and a fault and downthrow behind, that is to the west of this line. I have suggested that the folding has come from the west. Owing to the magnitude and length of the fault it is most likely to be normal, and in the rear of the anticline.

I have tried to show that the phenomena observed at the Savaiian volcano afford us some clue to the direction in which to look for future developments in preparing forecasts of earthquakes and eruptions.

The eruption has been shown to be due to a movement along the great structural line between Samoa and New Zealand which opened the fissure in 1902; the increase of folding, consequent upon the rise of the isogeotherms accompanying the sunspot maximum of 1905, caused the remelting of magmas at a depth, and squeezed them into the fissure, whence they have been escaping from several vents. The ingress of sea-water has had something to do with the eruption, as shown by the HCl evolved, and, it should be mentioned, the rainy season, January to March, was that of greatest activity.

Many points of resemblance between Samoan and Hawaiian lavas have been dealt with.

Part ii.—Petrology of the Samoan Lavas.

Sp. S.1. Hyalopilitic Olivine Basalt. Loc.: New lava flow between Matauto and Satapatu near Malaiola. (Plate lxiv., figs. 1-2).

i. Handspecimen vesicular, consisting of two-thirds compact lava and one-third large almond-shaped vesicles. Olivine is abundant in small but macroscopic crystals of greenish colour.

ii. Microscopic examination.—(1) Texture: (*a*) Crystallinity hypocrystalline; (*b*) grain-size uneven and fine; (*c*) fabric vesicular, porphyritic; hyalopilitic base; and occasionally aggregates of augite, optically continuous, embrace felspar ophitically.

(2) Constituents.—Augite, felspar, and olivine occur in about equal amount, and form over 90 % of the rock. The other constituents, magnetite and ilmenite, form perhaps 5 % and glass 5 %.

(3) The augite is greenish brown in colour, and slightly pleochroic, hence probably *titaniferous.* It occurs in small idiomorphic grains and ophitic aggregates. The felspar is plagioclase, having a maximum extinction of about 27° in cross sections of microlites, and up to 40° in longitudinal sections with symmetrical albite extinction, hence basic bytownite. It occurs in lath-shaped and tabular sections, showing prismatic, acicular, and tabular habit. It is twinned on the Carlsbad and albite plans. Sometimes needles of it penetrate augite. The olivine is in idiomorphic but highly corroded phenocrysts, containing primary magnetite inclusions. The ilmenite occurs in tables, and the titaniferous magnetite in idiomorphic grains. A few flakes of *hematite* are represented, and, as the rock was barely two months old when taken, it is evidently a *primary constituent.* A little glass is present in the groundmass.

(4) Order of consolidation—

Magnetite ————
Olivine ————
Ilmenite ————
Augite ————
Felspar ————
Glass ————

The augite and felspar evidently cooled together most of the time.

(5) Name: Typical Hyalopilitic Olivine Basalt.

(6) Remark.—This specimen consolidated at a depth of 5 or 6 feet under the crust of the lava flow, and was obtained from a broad fissure in the lava flow. The surface rock consisted here, as everywhere else on the flow, of glassy or hypohyaline scoria.

Sp. S.2. Hypohyaline Olivine Basalt, or Tachylite. Loc.: Lava surface, near sea, Malaiola. (Plate lxiv., fig.3).

i. Handspecimen black, glassy-looking, light through great porosity, being almost pumiceous, showing a few small phenocrysts of olivine and fragments of augite.

Microscopically the cells are seen to be round or oval, and separated by more or less thin partitions of glassy lava containing a few small corroded crystals of olivine and microlites of felspar (labradorite). The olivine occludes minute magnetite grains.

Name: Hypophyaline Olivine Basalt or Tachylite.

Sp. S.3. Hyalopilitic and Porphyritic Olivine Basalt. Loc.: Manase near Safotu.

Handspecimen a compact dark grey porphyritic rock, with phenocrysts of yellowish-green olivine in an aphanitic base. Microscopically it is seen to be a hypocrystalline, fine-grained, microcrystalline and uneven-grained basalt, with large olivine phenocrysts in a hyalopilitic base.

The olivine forms about 20 % of the area of the slide. Magnetite forms about 5 %. The rest of the rock is made up of augite, in idiomorphic grains; felspar in microlites and crystallites; and brownish glass. A little chlorite from decomposition of augite and serpentine after olivine are present. The augite is light brownish and titaniferous.

Name: Hyalopilitic and Porphyritic Olivine Basalt.

Sp. S.4. Hyalopilitic and Porphyritic Olivine Basalt. Loc: Patamea; old lava flow. (Plate lxiv., figs.5-6).

Handspecimen grey, porphyritic in olivine phenocrysts studded in an aphanitic base.

Microscopically it is like Sp. S.3. The felspar consists of basic labradorite, and the augite is a slightly titaniferous diopside. The iron ore is titaniferous magnetite, decomposing to leucoxene. The olivine is decomposing at the edges to serpentine, with a structure resembling bastite structure under the high power.

Name: Hyalopilitic and Porphyritic Olivine Basalt.

Sp. S.5. Pilotaxitic Olivine-Enstatite Basalt. Loc.: Vaipuli, near Matauto, Savaii. (Plate lxiv., fig.4).

Handspecimen greyish-black, porphyritic in olivine, and vesicular; the vesicles large and egg-shaped, amounting to less than 10 % of the bulk of the rock.

This rock is holocrystalline, with a very fine-grained pilotaxitic base consisting of augite in small grains, and labradorite felspar in acicular microlites. The phenocrysts comprise olivine, greenish-yellow augite, bronzite, and colourless enstatite.

Name: Pilotaxitic Olivine-Enstatite Basalt.

Sp. S.6. Olivine Basalt. Loc.: Vailima Plantation, near Apia, Upolo.

Handspecimen a compact, miarolitic, greyish-black rock, fine and even-grained in appearance.

Under the microscope it is seen to have a holocrystalline texture, with pilotaxitic fabric. It is porphyritic in olivine under the microscope. The felspar exists in the form of acicular microlites and crystallites, and the augite in minute grains in the base. These three constituents occur in about equal amounts. The magnetite is less in amount.

Name: Olivine Basalt.

Note: At Stevenson's grave, on the top of Vai Mountain, near Apia, a basalt of similar appearance was obtained. It proved to be even more fine-grained, richer in magnetite and wanting in olivine. A little glass is probably present. It would therefore be a Hyalopilitic Basalt, or Augite Andesite

Sp. S.7. Olivine Basalt Porphyrite. Loc.: near Papasee Falls, near Apia.

i. Handspecimen dark grey, porphyritic in olivine and augite.

ii. Microscopic examination.—(1) Texture: Holocrystalline with variable grain-size; average grain-size fine; fabric porphyritic, with pilotaxitic base

(2) Felspar, augite, and olivine form the essential constituents; magnetite is a minor constituent; whilst serpentine, calcite, sericite, and kaoline exist as decomposition products.

(3) The olivine occurs wholly as phenocrysts. Augite occurs as idiomorphic, corroded, phenocrysts, often twinned; and also in idiomorphic grains in the base. The felspar consists of basic bytownite (maximum extinction angle 30°-40° in symmetrical sections), and is represented both as corroded phenocrysts, and as microlites in the base. It is frequently zoned in the phenocrysts, and exhibits Carlsbad, albite, and pericline twinning. Serpentine is abundant, secondary after augite and olivine.

This is a rock of two generations.

Name: Olivine Basalt Porphyrite.

Note: A fine-grained, even-grained, pilotaxitic lava, containing no olivine, was also obtained at the Papasee Falls.

Sp. S.8. Loc.: Tofua, Tonga.

The specimen examined was a pebble obtained from the heap of rock at Nukualofa, brought from Tofua to construct a jetty.

Under the microscope it was found to be a hypohyaline, very fine-grained, hyalopilitic rock, showing flow structure. It consists of a felted mass of acicular felspar microlites and crystallites and brownish glass. Some small tabular felspar crystals also exist There is no olivine. It is, therefore, probably a basic andesite in composition.

General Remarks —Petrologically, the Samoan rocks are very like one another, and the basalts near Auckland, New Zealand. The olivine content varies from nil to nearly 50%. Most of the rocks are hypohyaline, if obtained from a depth beneath the surface of a flow; hyaline or hemicrystalline, highly vesicular or scoriaceous when obtained near the surface. The earlier rocks erupted were probably augite andesites, the later ones being olivine basalts. The new flow is richer in iron ores than any of the old flows.

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EXPLANATION OF PLATES.

Plate liv.—View of the volcano.

Plates lv., lvi., lvii.—Building of lava peninsula.

(Plates liv.-lvii. are from photos by Captain Allan.)

Plate lviii.—View from summit to the sea.

Plate lix.—Lava running into the sea (from the land).

Plate lx.— ,, ,, ,, ,, ,,

Plate lxi.—Papalaulelei flow.

Plate lxii.—Flow, Aa type.

Plate lxiii.—Tofua crater lake.

Plate lxiv.—Microsections of (a) new lava, (b) old lava, from Savaii.

Fig. 1.—Basalt from new lava stream (S.1) taken at Malaiola, between Matauto and Satapatu. Nicolls uncrossed. The porphyritic crystals giving rectilinear and rounded sections are olivines. The augite is interstitial. The felspar occurs as lath-shaped microlites. Note the steam vesicles.

Fig. 2.—Same as Fig. 1. Nicolls crossed.

Fig. 3. -Basalt Scoria from the Mauga Mu (S.2). Nicolls uncrossed. The phenocryst fragment is augite.

Fig. 4.—Basalt from an old lava stream (S.5): Vaipuli, near Matauto; the phenocrysts are corroded olivines. Nicolls crossed.

Fig. 5.—Basalt from an old lava stream (S.4); Patamea, near Satapatu. Nicolls uncrossed. The rectilinear phenocrysts are olivines with rounded glass inclusions.

Fig. 6.—Same as Fig. 5. Nicolls crossed.

Postscript (*added 28th November, 1906*).—Since the foregoing paper was written, further developments have taken place in connection with the volcanic eruption of Savaii. A report in the Sydney "Daily Telegraph," of November 3rd, 1906, dated Apia, October 10, states that the volcano continues active; and that immense quantities of lava still flow seaward, and enter the Pacific, forming quite an extension of the island. "The old lava channels," the report says, "were choked up, and the rising lava almost overflowed the crater's mouth. But before getting quite to the top, an exit was found, and the accumulated mass rushed down the mountain side, overwhelming the village of Satapatu."

In a private letter to me dated 21-ix.-06, Mr. Williams, the Amtmann of Savaii, writes—"On September 4th the flow of lava started to run in Satapatu, and filled up the passage in the sea, and ran along past the priest's house on the beach side. On the 6th it stopped running, and only at one small place on the coast was there any lava flow. I consider the lava flow of 4-ix.-06 as one of the most fierce we have had. It ran into the sea at Satapatu, and filled up the bay, which was 30 fathoms deep. Now, since that time it started again, on Thursday, the 13th, inland, and burnt all the town (Satapatu), taking everything before it. The large Catholic Church is half-full of lava, and every house is gone. It is dead again inland, but is running into the sea. The volcano itself is as strong as ever. Last Thursday week (September 13th) Dr. Linke registered an earthquake of tremendous force some 3000 miles from here.

Dr. Linke, meteorologist and seismologist at the Apia Observatory, writes to me from Apia (Sept. 3rd, 1906), that the Valparaiso earthquake was registered by his seismograph, but the volcano on Savaii was not influenced by the Chilian disturbance.

In a letter in the "Samoanische Zeitung" for August 18th, 1906, Dr. Linke states as follows:—"It appears as if, since the beginning of July – when magnetic disturbances commenced—there is again increased activity."

Second Postscript (*added 23rd January, 1907*).—News from Tonga last month (Dec., 1906) state that the volcano of Tofua is again active. A new crater has formed and there are, in all, three active craters. The eruption is of a very explosive character. Before 1906 Tofua had been quiescent about 40 years. The volcano of Mauna Loa in Hawaii, on the same line, has also become active.

WEDNESDAY, NOVEMBER 28TH, 1906.

The concluding Ordinary Monthly Meeting of the Session was held in the Linnean Hall, Ithaca Road, Elizabeth Bay, on Wednesday evening, November 28th, 1906.

Mr. T. Steel, F.C.S., F.L.S., President, in the Chair.

Mr. Carl F. Laseron, Technological Museum, Sydney, was elected an Ordinary Member of the Society.

The Donations and Exchanges received since the previous Monthly Meeting, amounting to 20 Vols., 71 Parts or Nos., 41 Bulletins, 2 Reports, and 45 Pamphlets, received from 47 Societies, &c., and 1 Individual, were laid upon the table.

NOTES AND EXHIBITS.

Mr. D. G. Stead stated that during the month a magnificent adult example of the "Government Bream," *Genyoroge sebæ* (Cuv & Val.) had been forwarded to Sydney from Coff's Harbour, thus making a second record of the occurrence of this handsome northern species in New South Wales waters. Mr. Stead also exhibited a specimen of the rare Syngnathid Pipefish, *Syngnathus altirostris* Ogilby, captured in the estuary of the Bellinger River by Mr. C. Stace; and a young example (the short-beaked form), measuring 170 mm., of the Skipper Garfish, *Scombresox forsteri* Cuv. & Val.; at the same time stating that, about the middle of the month, these Scombresocids were present in the waters of Port Jackson in immense numbers.

Dr. J. M. Petrie announced that he had identified a new midriatic alkaloid from the leaves of *Solandra lævis* Hook., a Tropical American Solanaceous plant. He had succeeded in hydrolysing it into tropine and atropic acid, thereby proving it to be a member of the atropine group. Its properties closely resembled those of hyoscine, from which it differed in certain fundamental points, notably in the crystalline form of its aurochloride, in giving no colour with phenolphthalein, and in yielding atropic instead of tropic acid on hydrolysis. It possesses the property of powerfully dilating the pupil of the eye. He proposed to name the new alkaloid Solandrine, from its source. A sample of it was exhibited.

Dr. Chapman exhibited a graphic record of the blood pressure of a dog which had received an intravenous injection of 8·2 mg. solandrine separated by Dr. Petrie from *Solandra lævis.* Previously the dog, which weighed 20·6 kilos, had been given 103 mg. pilocarpine nitrate which had produced inhibition of the heart's action with subsequent slow rhythm (27 beats per minute), and secretion of saliva and tears. After the injection of solandrine the rate of the heart beat was increased (in the second minute after injection 100 beats), so that the blood pressure rose rapidly. Stimulation of the peripheral end of the vagus no longer caused any alteration in the heart beat. Respiration became more rapid. Secretion of the saliva and tears ceased. Dilatation of the pupils of the eyes was also evident.

Mr. G. A. Waterhouse exhibited a pupa and perfect insects of *Troides priamus poseidon* [LEPIDOPTERA : Rhopalocera.] The pupæ were found at Cape York and sent to Sydney, being received during the first week in September. The first imago (♀) emerged on the 31st October, the second (♀) on 1st November, and the third (♂) on 6th November. Two pupæ were still alive.

Mr. H. S. Mort showed specimens of a freshwater mollusc, *Vivipara stelomphora* Bgt. var. *malleata* Rve., from Ibusuki, Satsuma, Japan. This species inhabits the warm water near the hot springs, and is called "Tabina" by the Japanese.

Mr. Baker showed herbarium and timber specimens, preserved fungi, and various vegetable products in illustration of his paper. Also a branch of *Eucalyptus Bridgesiana* having normal and abnormal leaves and fruits on the same twigs.

Mr. Maiden exhibited many of the plants referred to in the paper by Mr. Betche and himself; also examples of two species of New South Wales Halorrhagis from the Vienna herbarium, namely, *H. longifolia* Schindler, and *H. scoparia* Fenzl.

Mr. Cheel exhibited fresh specimens of *Daviesia buxifolia* Benth. [N.O. *Leguminosæ*], raised from seed collected at Eden, Twofold Bay, in December, 1903; and he communicated the following Note thereon.—"At present the only published record of the occurrence of this species in the State is that afforded by the 'Flora Australiensis' (ii. 75), namely, "between Wombim river and False Bay, *Mossman*"; but neither the river nor the bay had been located on any available map, and the 'Gazetteer' did not mention them. Mr. J. H. Maiden had suggested that probably what was intended was Womboyn River, just south of Twofold Bay. Specimens of the plant in the National Herbarium have been collected more recently by Mr. J. L. Boorman at Boonoo Boonoo, in November, 1904; and at Acacia Creek, Macpherson Range, by Mr. Dunn, in November, 1906. There are also specimens from Gippsland, Victoria, collected by Mr. R. Millard, M.P., who reports that the plant is called "Hop-bush," and that it is eaten by cattle. Baron von Mueller considered *D. buxifolia* to be a variety of *D. latifolia* R.Br., but Mr. Bentham (l.c.) remarks that "if so, the specimens show it to be a very well-marked and distinct form." The cultivated specimens exhibited, which are identical with the parent plant, lend support to Mr. Bentham's conclusion."

Mr. Cheel also showed specimens, and communicated the subjoined list, of ten species of New South Wales Hepatics, including one previously undescribed, from determinations by Dr. Stephani, kindly forwarded by the Rev. W. W. Watts.

HEPATICEÆ.

* *Anthoceros Brotheri* Steph.; Centennial Park, Sydney (E. Cheel; October, 1900).

* For previous records of these species see these Proceedings, 1901, pp.215 and 633; and 1902, p.494.

Fimbriaria Muelleri Gottsche; Lilly-Pilly Gully, Hurstville; and Rookwood (E. Cheel; August, 1900).

Fossombronia integrifolia Steph., sp. nov., MS., 1906; (Rookwood (E. Cheel; August, 1900) and Parramatta (October, 1900).

Fossombronia intestinalis Tayl.; Centennial Park, near reservoir (E. Cheel; September, 1900).

Frullania monocera Tayl.; Penshurst (on living *Backhousia myrtifolia* Hook.; (E. Cheel; October, 1901).

* *Frullania squarrulosa* Mitt.; Tia Falls, New England (E. Cheel; October, 1900).

* *Marchantia cephaloscypha* Steph.; Fairy Bower, Mount Victoria; and Apsley Falls, New England (E. Cheel; October, 1900).

Marsupidium Knightii Mitt.; Rookwood; very rare (E. Cheel; August, 1900).

* *Mastigobryum Novæ-Zealandiæ* Mitt.; Lawson, Blue Mountains (J. Spencer; September, 1902).

Zoopsis setulosa Leitgeb; Blackheath, Blue Mountains; (A. A. Hamilton; October, 1900).

Mr. H. I. Jensen showed specimens of lava from Samoa and Tonga; shells (*Ostrea crista-galli*, *Spondylus* sp., and *Tridacna elongata*) from a raised beach at Lautoka, Fiji; and a series of lantern slides showing various aspects of the intermittently active volcano in Savaii, the character and extent of the lava-flows and the generation of clouds of steam on their reaching the sea, the destruction of vegetation caused by the flows, and the extension of the land-surface due to the steady pouring of lava into the sea.

Mr. Tillyard showed two proliferous roses from a garden in Macleay Street, every bloom on the plant being more or less like those exhibited.

Professor Klaatsch, of Heidelberg, a visitor, on the invitation of the President, exhibited a series of lantern views illustrating

* For previous records of these species see these Proceedings, 1901, pp.215 and 633: and 1902, p.494.

his recent travels among the Aborigines of the North coast of Australia between Broome, on the North-west, and the Gulf of Carpentaria, and at Melville Island, for the purpose of ethnological and anthropological study. The Aborigines of the northern half of the Continent were more numerous than was generally supposed, and their number might be estimated as between 100,000 and 150,000. Professor Klaatsch concluded his very interesting observations with a fervent appeal, on behalf of the Northern Blacks, for greater consideration in the way of a more adequate provision of reserves and for more effective protection than the Southern Blacks had received in the past. Apart altogether from humanitarian questions, the demand for their more enlightened treatment was justifiable on scientific grounds alone.

Professor Wilson gave expression to the pleasure and interest which Dr. Klaatsch's narrative and conclusions evoked; and he expressed his cordial concurrence with the timely note of warning which had been given, and emphasised its importance.

On the invitation of the President, Mr. Coleman Phillips, a visitor from New Zealand, addressed the Meeting in support of the views upon the subject of rabbit extermination, which he had long advocated, and which he had explained to the Society on a previous occasion (Proceedings for 1901, p.146). The speaker contended that New Zealand had undoubtedly conquered the rabbits by means of " natural enemies and natural diseases."

REVISION OF AUSTRALIAN LEPIDOPTERA, III.

By A. J. Turner, M.D., F.E.S.

The present instalment consists of supplementary notes on families previously treated of.

Fam. SYNTOMIDÆ.

Syntomis xanthura.

Vic.: Sea Lake (Goudie).

Syntomis annulata.

Q.: Gympie, Nanango.

Syntomis pyrocoma.

N.S.W.: Sydney (Lyell).

Syntomis phæochyta,* n.sp.

♂♀. 30-34 mm. Head orange. Antennæ black to apices; in ♂ serrate. Thorax with a few orange scales posteriorly scarcely forming a distinct spot. Abdomen in ♂ with seven, in ♀ with six orange rings; tuft in ♂ orange. Forewings with spots obsolete in ♂; in ♀ very small, ochreous-tinged, semihyaline, sometimes partly obsolete; hindwings with spots small, usually distinctly developed, but either spot may be obsolete.

Easily distinguishable from *S. bicolor* and *S. phepsalotis*, the only species with which it might be confused, by the antennæ not being white-tipped. The spots are always small, but vary in development, the tendency to obsolescence being greater in the ♂.

Type in Coll. Turner.

N.Q.: Kuranda, in January and February; a series received from Mr. F. P. Dodd.

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*φαιοχυτος, dusky-suffused.

ERESSA GEOGRAPHICA.

Q.: Gympie, Stradbroke Island.

ERESSA ANGUSTIPENNA.

Q.: Gympie.

Unrecognised species.

Syntomis lucta Luc., Proc. R. Soc. Queensland, 1901, p.73.

Fam. NOTODONTIDÆ.

SYNTYPISTIS,* n.g.

Head with a crest of dense hairs. Eyes naked. Tongue obsolete. Palpi moderate, ascending, not reaching middle of face; second joint stout, well developed, evenly hairy; terminal joint minute. Antennæ in ♂ with a double row of long pectinations, apical $\frac{1}{4}$ simple. Thorax and abdomen not crested. Posterior tibiæ with two pairs of spurs. Forewings without dorsal scale-tooth; vein 6 from upper angle of cell, 7, 8, 9, 10 stalked, no areole, 7 from 8 + 9 before 10. Hindwings with 3 and 4 separate, 5 from above middle of discocellulars, 6 and 7 stalked, 8 approximated to near end of cell.

Closely allied to *Stauropus* Germar, but in the type of this genus, *S. fagi* Linn., there is only one pair of spurs on posterior tibiæ according to Meyrick (Brit. Lep. p.307). Hampson (Moths Ind. i. p.149) does not allude to the tibial spurs in his definition of *Stauropus*.

In my tabulation† this genus would be distinguished from *Teleclita* by the origin of vein 7 of forewings before 8.

SYNTYPISTIS CHLOROPASTA,‡ n sp.

♂. 42 mm. Head whitish-ochreous; face mixed with brown-fuscous. Palpi pale ochreous, posteriorly brown-fuscous. Antennæ whitish mixed with brownish; pectinations in ♂ very long (10-12). Thorax pale ochreous tinged with green; posteriorly

*συντυπιστις, of similar type.

† These Proceedings, 1903, p. 45.

‡χλωροπαστος, green-besprinkled.

brownish. Abdomen brown. Legs whitish-ochreous, anterior pair suffused with brownish. Forewings elongate-oval, costa straight to middle then strongly arched; apex rounded, termen obliquely rounded; dark brown-fuscous finely irrorated with green scales; a basal green suffusion; cilia dark brown-fuscous barred with whitish. Hindwings with termen rounded; rather pale brown; a small apical patch concolorous with forewing; cilia pale brown barred with whitish.

Stauropus dubiosus Bak., (Nov. Zool. 1904, p. 379, Pl. vi., f. 39) from New Guinea, appears to be a closely allied species.

Type in Coll. Turner.

N.Q.: Kuranda, in June; one specimen received from Mr. F. P. Dodd.

Discophlebia lucasii.

Discophlebia lucasii Rosen., Ann. Mag. Nat. Hist. 1885, p. 421, Pl. xi., f. 4.

♀. 58 mm. Head grey; face grey becoming paler below, with a narrow, dark, transverse line on upper edge. Palpi grey. Antennæ whitish-grey. Thorax grey (somewhat rubbed); tegulæ brownish-ochreous. Abdomen grey mixed with dark fuscous. Forewings ovate-oblong, costa very strongly arched towards base, nearly straight towards apex, apex rectangular, termen rounded, moderately oblique, dorsum gently rounded; grey with a dull purplish tinge; with fine dark fuscous lines; a line from costa near base to fold, giving off short lines along median vein and fold; a line from $\frac{1}{6}$ costa, with a blunt outward projection in middle, thence sinuate to $\frac{1}{3}$ dorsum; a third ferruginous-fuscous line from costa near preceding, outwardly curved, outwardly oblique, slightly wavy, to mid-dorsum; costal $\frac{2}{3}$ of disc suffused with fuscous as far as this line; some brownish suffusion before and after this line in dorsal part of disc; orbicular small, round, pale brownish outlined with ferruginous-fuscous between the two lines; reniform similar, rather larger, oval, oblique, situated near mid-disc; traces of a very fine, acutely dentate, transverse line in disc at $\frac{2}{3}$; cilia grey. Hindwings with termen rounded; dark fuscous; cilia fuscous, apices paler.

N.S.W.: Sydney, in April; one specimen taken by Mr. G. H. Wyld, and now in Coll. Lyell, corresponding closely to Rosenstock's description.

POLYCHOA,* n.g.

Head rough-haired. Eyes naked. Tongue well developed. Palpi curved, ascending, nearly reaching vertex; second joint long, thickened with long hairs towards apex; terminal joint moderate, bent forward, and resting on second joint. Antennæ of ♂ with a double row of pectinations extending to apex. Thorax and abdomen not crested. Posterior tibiæ with two pairs of spurs, the inner spurs much longer. Forewings without dorsal scale-tooth, with tufts of raised scales on upper surface, vein 6 from upper angle of cell, 7 from near end of areole, 8, 9 stalked from areole, 10 connected by a bar with 8 + 9 to form the areole, which is very long. Hindwings with 3 and 4 separate, 5 from middle of discocellulars, 6 and 7 separate, 8 approximated to cell as far as middle, then diverging.

This genus, which appears to me very isolated in our fauna, should follow *Cascera*. The separation of veins 6 and 7 of hindwings is unusual.

POLYCHOA STYPHLOPIS,† n.sp.

♂. 40 mm. Head dark greenish-fuscous irrorated with pale ochreous; lower part of face whitish-ochreous. Palpi dark fuscous irrorated with pale ochreous, anterior part of second joint wholly pale ochreous. Antennæ fuscous; pectinations in ♂ moderately long (6-7). Thorax fuscous, anteriorly greenish-tinged, sparsely irrorated with pale ochreous. Abdomen fuscous. Legs pale ochreous; anterior pair dark green-fuscous irrorated, and tarsi annulated, with pale ochreous. Forewings elongate-oblong, costa gently arched towards base and apex, middle portion straight, apex rectangular, termen rounded beneath; dark green-fuscous finely and sparsely irrorated with bright green and with pale

*πολύχοος, with many mounds, in allusion to forewings.

†στυφλωπις, of stern appearance.

ochreous; a dark fuscous dot formed of raised scales and narrowly edged with whitish beneath mid-costa; two similar dots arranged longitudinally in mid-disc before and after first, and a fourth dot between inner central dot and dorsum; a line of pale ochreous dots from $\frac{2}{3}$ dorsum not reaching costa; an interrupted line of minute white dots from beneath $\frac{7}{8}$ costa to tornus; a fine interrupted dark fuscous subterminal line; cilia fuscous with a basal series of whitish dots. Hindwings with termen rounded; fuscous, towards base whitish-ochreous; cilia fuscous.

Type in Coll. Turner.

N.Q.: Kuranda, in July; one bred specimen received from Mr. F. P. Dodd.

Unrecognised species.

Cerura (?) *melanoglypta* Low., Trans. R. Soc. South Aust. 1905, p.177.

Fam. GEOMETRIDÆ.

Subfam. Hydriomeninæ.

Since my revision of this subfamily* a large amount of fresh material has come into my hands, chiefly from Northern Queensland and Victoria. Including two species which have been previously described, I am able to add 30 to the list of recognised species (which now stands at 163), together with many new localities.

Sauris hirudinata.

N.Q.: Thursday Island, Kuranda.

Sauris protima,† n.sp.

♂♀. 28-32 mm. Head whitish, anteriorly pale green; face fuscous. Palpi very long ($3\frac{1}{2}$); fuscous. Antennæ grey; ciliations in ♂ extremely short. Thorax pale green. Abdomen pale green; lower surface, sides, apices of segments, and tuft whitish. Legs whitish; anterior pair fuscous annulated with whitish. Forewings triangular, costa strongly arched towards apex, apex

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* Proc. Roy. Soc. Vic. 1903, p.218.

†πρότιμος, honoured, preferred.

rounded, termen obliquely rounded; similar in both sexes; whitish with numerous pale olive-green wavy transverse lines; a darker line near base, angulated beneath costa; three parallel antemedian lines at about $\frac{1}{3}$; median band free from lines; six lines beyond this, parallel, somewhat dentate; a fuscous line from costa before middle, crossing median band obliquely to lower angle of cell; the three postmedian lines are fuscous as far as this junction, and from it proceed two fuscous streaks to termen above and below vein 5; two fuscous terminal lines, the second thickened and interrupted ; cilia whitish. Hindwings with termen rounded; in ♂ smaller, inner portion aborted, with a vesicular thickening on base of dorsum; grey-whitish ; cilia whitish.

This species belongs to Hampson's Sect. i. B. (Moths Ind. iii. p.408). I have not been able to identify it with any extra-Australian species.

Type in Coll. Turner.

N.Q. : Kuranda, in October and November; two specimens received from Mr. F. P. Dodd.

SYMMIMETIS,* n.g.

Head with projecting cone of scales. Palpi moderately long, porrect. Tongue well developed. Abdomen with slight median dorsal crests on basal segments. Posterior tibiæ with middle spurs absent; outer end spur about half length of inner. Forewings with 7, 8, 9, 10, 11, stalked; no areole; 11 anastomosing strongly with 12. Hindwings with 3 and 4 short-stalked, 5 from middle of cell, 6 and 7 stalked, 8 anastomosing to near end of cell.

Evidently a development of the *Gymnoscelis* group. It has no relationship to *Cleptocosmia* Warr., the only other Australian genus in which there is no areole. It appears, however, to be related to *Hybridoneura* Warr., (Nov. Zool. 1898, p.24) which has a similar neuration.

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*συμμιμητης, a fellow-imitator.

SYMMIMETIS MUSCOSA,* n.sp.

♀. 20-22mm. Head dull greenish. Palpi $1\frac{3}{4}$; fuscous, greenish-tinged. Antennæ grey. Thorax dull greenish mixed with fuscous. Abdomen ochreous-greenish with fuscous irroration on bases of segments. Legs whitish; anterior pair pale fuscous. Forewings broadly triangular, costa slightly arched near base and apex only, apex rounded, termen bowed, oblique; whitish mixed with fuscous and greenish, and in places suffused with reddish-brown; a line of raised blackish scales on lower border of cell; two finely dentate transverse postmedian lines faintly indicated; beyond middle of disc are short, interrupted, blackish streaks of raised scales on veins; a faintly marked dentate subterminal line preceded by whitish dots; a fuscous terminal line interrupted on veins; cilia greenish, apices grey. Hindwings with termen rounded; colour and markings as forewings. Underside whitish; both wings with fine fuscous antemedian lines, broader and more suffused postmedian lines, and a broad terminal fuscous suffusion.

The type has the general appearance of a *Gymnoscelis*, but the forewings are proportionately broader.

Type in Coll. Turner.

N.Q. : Kuranda, in November; two specimens received from Mr. F. P. Dodd, of which one is in Coll. Lyell.

Gen. GYMNOSCELIS.

This genus is largely represented in Northern Queensland, and as the number of known species is more than doubled, I append a new tabulation. The species appear to be limited in their distribution, and the discovery of several closely related forms with greenish coloration makes me doubt whether *G. erymna* Meyr., of which the type comes from Tonga, is really represented in Australia. At any rate it is unknown to me. *G. subrufata* Warr., is, I am now convinced, distinct from *G. erymna*, and from any species known to me.

1. Fore and hindwings with a whitish spot on middle of termen.. *coquina*.
   Fore and hindwings without a whitish spot on middle of termen.. 2.

* Muscosus, mossy.

2.	Hindwings with termen more or less projecting between veins 3 and 4	3.
	Hindwings with termen evenly rounded	4.
3.	Forewings with postmedian line thickened above middle, postmedian line of hindwings with a median projection	*minima.*
	Forewings with postmedian line not thickened above middle, postmedian line of hindwings without a median projection	*acidna.*
4.	Forewings with postmedian line twice angled	5.
	Forewings with postmedian line not twice angled	7.
5.	Hindwings with an acute median tooth on postmedian line	*homogona.*
	Hindwings with postmedian line nearly straight	6.
6.	Fore and hindwings with median area partly suffused with purple-reddish	*mesophœna.*
	Wings without reddish suffusion	*chlorobapta.*
7.	Underside of wings reddish	*subrufata.*
	Underside of wings not reddish	8.
8.	Forewings with postmedian line acutely angled or toothed at or below middle	9.
	Forewings with postmedian line more or less rounded	10.
9.	Wings bright green	*callichlora.*
	Wings blackish	*celænephes.*
	Wings brownish-fuscous	*lophopus.*
10.	Forewings with postmedian line finely denticulate	*œnictopa.*
	Forewings with postmedian line not denticulate	11.
11.	Wings distinctly greenish	*tanaoptila.*
	Wings without greenish tinge	*delocyma.*

GYMNOSCELIS SUBRUFATA.

Gymnoscelis subrufata Warr., Nov. Zool. 1898, p.24.

Type in Coll. Rothschild.

Q. : Duaringa.

GYMNOSCELIS HOMOGONA,* n.sp.

♀. 16 mm. Head ochreous-whitish; face purplish-fuscous. Palpi 2; dark fuscous mixed with whitish. Antennæ grey-whitish. Thorax and abdomen ochreous-whitish irrorated with

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*ὁμόγονος, related, akin.

fuscous and reddish-brown scales. Forewings triangular, costa straight for $\frac{2}{3}$, then arched, apex rounded, termen bowed, oblique; 11 anastomosing with 12; whitish with fuscous lines and irroration, towards apex slightly greenish-tinged; antemedian line undefined anteriorly, where it passes into fuscous irroration, sharply defined posteriorly, from $\frac{2}{5}$ costa obliquely outwards to end of cell, thence bent inwardly and irregularly dentate to mid-dorsum; postmedian line sharp and distinct, from $\frac{3}{5}$ costa obliquely outwards, with a slight tooth above and a prominent acute tooth below middle of disc, thence inwardly oblique and irregularly waved to $\frac{3}{4}$ dorsum; a faint dentate, whitish subterminal line; an interrupted fuscous terminal line; cilia whitish with an interrupted median fuscous line. Hindwings with termen rounded; colour and markings as forewings, but antemedian line absent; postmedian line with a single acute median tooth.

Type in Coll. Turner.

N.Q.: Kuranda, in July; one specimen received from Mr. F. P. Dodd.

GYMNOSCELIS MESOPHŒNA,* n.sp.

♀. 18-20 mm. Head whitish; face purple-reddish, lower edge whitish. Palpi $1\frac{1}{2}$; whitish barred with fuscous. Antennæ ochreous-whitish. Thorax greenish. Abdomen greenish; some fuscous and reddish-brown irroration on basal segments. Legs ochreous-whitish; anterior pair fuscous with whitish annulations. Forewings elongate-triangular, costa straight to near apex, apex rounded, termen bowed, oblique; 11 anastomosing with 12; green mixed with whitish; a costal streak to antemedian line purple-reddish mixed with whitish and dark fuscous; antemedian line indistinct, dentate, interrupted below middle, from $\frac{1}{3}$ costa to $\frac{1}{3}$ dorsum, dark fuscous preceded and followed by purple-reddish suffusion; a dark fuscous discal dot immediately beyond this line, and sometimes merged with it; postmedian line fuscous, from $\frac{2}{3}$ costa to beyond $\frac{2}{3}$ dorsum, dentate, with more prominent dentations between veins 3 and 4 and 6 and 7; area between

*μεσοφοινος, reddish in the middle.

lines suffused with purple-reddish, except towards dorsum; a terminal pale fuscous suffusion, traversed by a whitish dentate subterminal line; cilia whitish. Hindwings with termen rounded; colour as forewings; some basal fuscous suffusion, antemedian line not traceable; postmedian line nearly straight; a whitish dentate subterminal line preceded by pale fuscous suffusion, except in middle; a fuscous terminal line; cilia whitish. Underside whitish.

Type in Coll. Turner.

N.Q.: Kuranda, in April, June and October; three specimens received from Mr. F. P. Dodd.

GYMNOSCELIS CHLOROBAPTA,* n.sp.

♂. 18 mm. Head whitish with a few reddish-brown scales. Palpi $1\frac{1}{4}$; whitish with some dark fuscous scales. Antennæ whitish, obscurely annulated with fuscous; in ♂ shortly ciliated ($\frac{1}{2}$). Thorax and abdomen whitish, greenish-tinged, with some dark fuscous scales, and a series of dark fuscous dorsal abdominal dots. Legs whitish; anterior pair fuscous annulated with whitish. Forewings elongate-triangular, costa nearly straight, except towards apex, apex rounded, termen bowed, very oblique; 11 free or very shortly anastomosing; whitish tinged with green, with scattered fuscous irroration; a fine dentate fuscous antemedian line from $\frac{1}{3}$ costa to $\frac{1}{3}$ dorsum; postmedian line from $\frac{2}{3}$ costa to $\frac{2}{3}$ dorsum, dentate, with two acute projections, one in middle, the other half-way between this and costa; a longitudinal line connects antemedian with postmedian between projections; a slight subapical fuscous suffusion traversed by a fine whitish dentate subterminal line; an interrupted fuscous terminal line; cilia whitish. Hindwings with termen rounded; colour as forewings; postmedian line very distinct, fuscous, nearly straight. Underside whitish.

Type in Coll. Turner. The neuration differs slightly on the two sides.

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*χλωροβαπτος, tinged with green.

N.Q.: Kuranda, in November; one specimen received from Mr. F. P. Dodd.

GYMNOSCELIS CALLICHLORA,* n.sp.

♀. 19 mm. Head pale green; face whitish. Palpi $1\frac{3}{4}$; whitish irrorated with fuscous. Antennæ whitish. Thorax and abdomen greenish. Legs whitish; anterior pair fuscous annulated with whitish. Forewings triangular, costa nearly straight to near apex, apex rounded, termen bowed, oblique; 11 anastomosing very shortly with 12; pale green; markings fuscous tinged with brownish; a line along costa to $\frac{2}{3}$; a basal line only represented near costa and by a dot on $\frac{1}{4}$ dorsum; an antemedian line represented by a thick bar from $\frac{1}{3}$ costa, narrowing abruptly to a slender dentate line to dorsum before middle; a large quadrangular postmedian blotch from costa not reaching dorsum, its posterior edge formed by a line from $\frac{2}{3}$ costa obliquely outwards to beyond mid-disc, where it forms an acute angle and ends in a fine line to $\frac{3}{4}$ dorsum; a fine whitish dentate subterminal line; an interrupted fuscous terminal line; cilia pale fuscous. Hindwings with termen rounded; colour as forewings, but without lines or blotches, except a dark fuscous postmedian line with a projecting tooth between veins 3 and 4. Underside whitish.

Type in Coll. Turner.

N.Q.: Kuranda, in May; one specimen received from Mr. F. P. Dodd.

GYMNOSCELIS CELÆNEPHES,† n.sp.

♀. 20 mm. Head whitish with some fuscous scales. Palpi $1\frac{3}{4}$; fuscous mixed with whitish. Antennæ pale fuscous. Thorax dark fuscous; tegulæ mixed with whitish; patagia with a transverse whitish bar near base. Abdomen dark fuscous with some whitish and greenish scales. Legs pale fuscous; anterior pair darker. Forewings triangular, costa scarcely arched except at base and near apex, apex rounded, termen bowed, oblique; 11

*καλλιχλωρος, beautifully green,

†κελαινεφής, darkly clouded.

anastomosing with 12; rather dark fuscous; lines whitish; an irregularly dentate antemedian line, preceded by darker fuscous at $\frac{1}{3}$; a faintly marked median line; postmedian sharply defined anteriorly, posteriorly diffused, from $\frac{2}{3}$ costa, rather concave to below mid-disc, where it forms an acute angle, and ends on $\frac{2}{3}$ dorsum; a fine dentate subterminal line; cilia fuscous barred with whitish opposite veins. Hindwings with termen rounded, wavy; dark fuscous with some blackish dots on veins; double antemedian and postmedian whitish lines from costa; a whitish subterminal spot between veins 3 and 4; cilia as forewings. Underside fuscous.

Type in Coll. Turner.

N Q.: Kuranda, in November; one specimen received from Mr. F. P. Dodd.

GYMNOSCELIS ÆNICTOPA,* n.sp.

♂♀. 19-20 mm. Head pale brownish with some reddish-purple scales in ♂; a dark fuscous line between antennæ; face in ♂ reddish-purple. Palpi $1\frac{1}{3}$; brownish mixed with dark fuscous. Antennæ brown-whitish with obscure darker annulations; ciliations in ♂ very short ($\frac{1}{3}$). Thorax pale brownish with some reddish-purple scales. Abdomen pale brownish with some dark fuscous suffusion on 2nd and 3rd, and in ♂ on penultimate segments Legs brown-whitish with fuscous irroration; anterior pair mostly fuscous. Forewings elongate-triangular, costa nearly straight, except towards base and apex, apex rounded, termen bowed, oblique; 11 anastomosing with 12; brownish with fuscous suffusion, in some parts tending towards reddish-purple; lines indistinct, fuscous; a fuscous costal dot near base; a fine wavy line from $\frac{1}{4}$ costa to $\frac{1}{3}$ dorsum succeeded by a parallel line at $\frac{2}{5}$, the included area more or less infuscated; a finely denticulate line from $\frac{2}{3}$ costa to $\frac{2}{3}$ dorsum succeeded by a pale, and again by a fine fuscous line; a dentate, pale subterminal line; a fuscous suffusion at tornus; an interrupted fuscous terminal line; cilia

*αἰνικτωπος, obscure-looking.

fuscous interrupted with brownish opposite veins. Hindwings with termen rounded; colour and markings as forewings, but basal lines obsolete, tornal suffusion absent, and with a fuscous suffusion in disc not reaching dorsum.

Type in Coll. Turner.

N.Q.: Kuranda, in October and November; three specimens received from Mr. F. P. Dodd.

GYMNOSCELIS TANAOPTILA,* n.sp.

♂. 21 mm. Head whitish, face fuscous. Palpi $1\frac{1}{2}$, fuscous with some whitish scales. Antennæ whitish, obscurely annulated with fuscous; in ♂ minutely ciliated ($\frac{1}{3}$). Thorax fuscous, anterior edge and a transverse median line whitish. Abdomen whitish mixed with fuscous; tuft whitish. Legs whitish mixed with fuscous; anterior pair mostly fuscous; [posterior pair broken]. Forewings elongate-triangular, costa straight except at extremities, apex rounded, termen bowed, strongly oblique; 11 anastomosing with 12; whitish tinged with greenish; markings fuscous; an interrupted line along costa to $\frac{2}{5}$; a slender line from $\frac{2}{5}$ costa, very acutely angled beneath costa, thence obliquely inwards to mid-dorsum; a postmedian line from costa at $\frac{2}{3}$ outwardly curved, not dentate nor angled, sinuate beneath to before tornus; a whitish dentate subterminal line bounded anteriorly by a fuscous suffusion; a fuscous terminal line; cilia whitish with some fuscous scales. Hindwings with termen rounded; colour as forewings, but with more fuscous irroration; transverse brownish-fuscous suffused lines at $\frac{1}{3}$, $\frac{2}{3}$, and subterminal; the last somewhat dentate; terminal line and cilia as forewings.

Type in Coll. Turner. As the hindlegs are unfortunately missing this might be a *Chloroclystis.*

N.Q.: Kuranda, in July; one specimen received from Mr. F. P. Dodd.

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*ταναοπτιλος, slender-winged.

Gen. Chloroclystis.

Section i. *Males with secondary sexual characters on forewings* (Phrissogonus).

Chloroclystis testulata.

Vic.: Birchip.

Chloroclystis insigillata.

N.Q.: Kuranda—Vic.: Birchip.

Chloroclystis laticostata.

Q.: Cunnamulla, Southport.

Chloroclystis pyrrholopha,* n.sp.

♂. 14 mm. Head and thorax green-whitish. Palpi $1\frac{2}{3}$; second joint thickened at apex; whitish. Antennæ whitish; minutely ciliated. Abdomen pale greenish; a fuscous spot on 3rd segment. Legs whitish; anterior pair with some fuscous scales. Forewings triangular, costa strongly arched at base, thence straight to near apex, apex round-pointed, termen bowed, oblique; whitish mixed with pale greenish; a strong, triangular, anteriorly projecting crest on costa near base; base of costa, crest, and a broad bar from costa before middle obliquely outwards to half-way across disc, reddish; cilia whitish. Hindwings with termen dentate at tornus and opposite veins 3, 4, and 6; green-whitish; some reddish-fuscous suffusion on mid-disc; cilia whitish.

♀. 15-17 mm. Head and antennæ whitish; face and palpi fuscous-brown. Thorax green-whitish with some ferruginous scales. Abdomen green-whitish with a ferruginous basal band. Legs whitish suffused with fuscous; anterior pair darker. Forewings triangular, costa straight, except near base and apex, apex rounded, termen bowed, oblique; whitish mixed with pale greenish; a fuscous streak along costa to $\frac{2}{5}$; a transverse, slightly outwardly-curved fuscous line at $\frac{2}{5}$, indications of a similar line at $\frac{2}{3}$; the median and postmedian areas suffused with reddish or

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*πυρρολοφος, with reddish crest.

ferruginous except near costa and termen; a fuscous terminal line; cilia whitish mixed with fuscous. Hindmargin rounded, slightly sinuate; a fuscous basal band mixed with reddish; a twice-dentate fuscous postmedian line preceded by some reddish suffusion; an irregular dentate reddish subterminal line; terminal line and cilia as forewings.

These dissimilar sexes are probably associated. The differences are analogous to those in *C. approximata* (*C. pyretodes* Meyr.)

Type in Coll. Turner.

N.Q.: Kuranda, in September, November, and May; three specimens received from Mr. F. P. Dodd.

CHLOROCLYSTIS EPILOPHA,* n.sp.

♂♀. 14 mm. Head whitish with a few fuscous scales. Palpi $1\frac{2}{3}$; second joint thickened at apex; dark fuscous. Antennæ whitish; in ♂ somewhat serrate, minutely ciliated. Thorax and abdomen whitish, more or less suffused with fuscous. Legs whitish; anterior pair fuscous. Forewings triangular, costa arched at base, then straight to near apex, apex rounded, termen bowed, moderately oblique; whitish more or less suffused with fuscous, and sparsely irrorated with dark fuscous scales; a suffused dark fuscous spot on base of costa; succeeded at about $\frac{1}{3}$ by a double ridge of grey-whitish hairs curved upwards and backwards towards disc; a dark fuscous spot on mid-costa, and another more suffused on costa before apex; a dark fuscous subterminal spot above middle; tornal area and termen faintly reddish-tinged; an interrupted fuscous terminal line; cilia whitish, bases tinged with reddish. Hindwings with termen rounded, slightly wavy; as forewings but without defined markings.

♀. 15-16 mm. Forewings more elongate, without crest, and with numerous fine, wavy, transverse, pale fuscous lines.

Type in Coll. Lyell. I have five examples in my own collection.

N.Q.: Kuranda, in October, November and April; six specimens received from Mr. F. P. Dodd.

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* ἐπιλοφος, crested.

Section ii. *Males with secondary sexual characters on hindwings.*

CHLOROCLYSTIS PAUXILLULA,* n.sp.

♂♀. 15-16 mm. Head and thorax fuscous. Palpi 1½; ochreous-whitish mixed with fuscous. Antennæ fuscous; in ♂ minutely ciliated (¼). Abdomen fuscous; in ♂ ochreous-tinged and with some reddish-brown scales on sides near base. Legs fuscous; posterior pair whitish; posterior tibiæ with outer proximal spur extremely short, outer distal spur less than ½ inner. Forewings elongate-triangular; costa gently arched, more strongly towards apex, termen bowed, oblique; fuscous with indistinct wavy darker transverse lines; antemedian and postmedian lines traceable; an indistinct dentate pale subterminal line; cilia fuscous. Hindwings with termen prominent at apex and middle, rather excavated before and beyond middle; colour and markings as forewings. Underside whitish; hindwings in ♂ densely covered in basal half with fuscous hair-like scales.

An inconspicuous species resembling *C. ablechra*, but without transverse blackish lines. The ♂ should be easily recognised by the underside of the hindwings.

Type in Coll. Turner.

N.Q.: Kuranda, in September, October, November, and April; four specimens received from Mr. F. P. Dodd.

Section iii. *Males without secondary sexual characters on wings.* (Chloroclystis).

CHLOROCLYSTIS FILATA.

Vic.: Beaconsfield.

CHLOROCLYSTIS ALPNISTA,† n.sp.

♀. 19 mm. Head greenish-white; lower half of face blackish. Palpi blackish, extreme apices whitish. Antennæ whitish with fuscous annulations. Thorax whitish mixed with fuscous and greenish. Abdomen brown, apical third greenish-white with

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*Pauxillulus, tiny.

†ἄλπνιστος, most lovely.

blackish irroration, basal segment whitish. Legs whitish; posterior tibiæ with inner distal spur long, outer $\frac{1}{2}$, inner proximal spur short, outer $\frac{2}{3}$. Forewings triangular, costa moderately arched, apex rounded, termen bowed, oblique; fuscous-brown; basal area pale green with blackish irroration on costa, and a fine limiting blackish line, slightly crenate, outwardly curved, from $\frac{1}{4}$ costa to $\frac{1}{4}$ dorsum; a few blackish scales on veins in disc; a fine double pale greenish line from $\frac{2}{3}$ costa to $\frac{2}{3}$ dorsum, curved outwards in disc; a fine whitish dentate subterminal line, preceded by a large blackish costal spot and a similar spot above mid-disc; a fine pale fuscous terminal line interrupted on veins; cilia fuscous-brown, paler opposite veins, apices fuscous-whitish. Hindwings with termen rounded; colour as forewings, but basal patch very small, no blackish spots, a white anal blotch irrorated with greenish and blackish, terminal line blackish. Underside fuscous with obscure whitish postmedian fasciæ.

In my table falls with *cissocosma* and *mniochroa*, from which it is distinguished by the wings being mainly brownish, the blackish subapical spots on forewing, and the blackish palpi, &c.

Type in Coll. Lyell.

N.Q.: Kuranda, in June; one specimen received from Mr. F. P. Dodd.

CHLOROCLYSTIS BRYODES,* n.sp.

♂. 16 mm. ♀. 19 mm. Head whitish. Palpi $1\frac{3}{4}$; ochreous-whitish. Antennæ grey-whitish; ciliations in ♂ very short ($\frac{1}{5}$). Thorax pale green. Abdomen whitish, tinged with green, with some dark fuscous scales on basal segments. Legs whitish; anterior pair fuscous annulated with whitish; posterior tibiæ with outer proximal spur $\frac{1}{5}$, outer distal spur $\frac{1}{3}$. Forewings elongate-triangular, costa nearly straight except near apex, apex rounded, termen bowed, strongly oblique; green with whitish transverse lines; costa more or less strigulated with dark fuscous in basal $\frac{2}{3}$; a fuscous dot on costa near base; antemedian from $\frac{1}{3}$ costa to $\frac{1}{4}$ dorsum, outwardly curved, broadly suffused towards

*βρυωδης, mossy.

costa, more or less obsolete towards dorsum; a double median whitish line; postmedian dark fuscous, from $\frac{2}{3}$ costa, outwardly oblique, straight and conspicuous to mid-disc where it is angled, beneath angle it is fine and scarcely traceable; followed immediately by a double white line; a dentate whitish subterminal line; a grey terminal line interrupted by whitish on veins; cilia whitish. Hindwings with termen rounded; colour as forewings; a sharply angled postmedian line represented by a series of elongate dark fuscous dots.

Distinguished from *C. guttifera* by the green colouring, and from *C. cissocosma* by the form of the postmedian line of forewing.

Type in Coll. Turner.

N.Q.: Kuranda, in September, November, and March; four specimens received from Mr. F. P. Dodd.

Chloroclystis leptomita,* n.sp.

♂♀. 22-30 mm. Head whitish-ochreous, with a reddish spot opposite base of each antenna; face edged above and beneath with reddish. Palpi in ♂ $1\frac{1}{2}$, in ♀ 2; whitish-ochreous mixed with fuscous and reddish. Antennæ whitish-ochreous annulated with pale fuscous in ♂ with rather long cilia ($1\frac{1}{4}$) arranged in tufts. Thorax whitish-ochreous with some reddish scales. Abdomen whitish-ochreous with reddish irroration, which forms a transverse bar near base; crests dark fuscous. Legs fuscous mixed with whitish; posterior pair mostly whitish. Forewings triangular, costa moderately arched, apex rounded, termen bowed, oblique; whitish-ochreous with numerous fine reddish lines, some of which are dotted with fuscous on veins; a dark fuscous median discal dot; an irregular oblique reddish-fuscous suffusion containing some lustrous scales from apex to before mid-dorsum, giving off a branch to termen above middle, sometimes with a fuscous blotch at bifurcation, cilia whitish-ochreous with a few obscure fuscous bars. Hindwings with termen rounded; colour and

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*λεπτόμιτος, with slender threads.

markings as forewings, but fuscous suffusion transverse and subbasal.

In my tabulation this falls with *C. filata*, from which it may be distinguished by the oblique fuscous suffusion across forewings. It is a rather variable species.

Type in Coll. Lyell.

N.Q.: Kuranda, in March and May; several specimens received from Mr. F. P. Dodd, of which three are in my own collection.

MICRODES SQUAMULATA.

Vic.: Birchip.

EUCHOECA RUBROPUNCTARIA.

N.S.W.: Ben Lomond—Vic.: Birchip.

EUCHOECA IOPHRICA,* n.sp.

♀. 24 mm. Head reddish-violet; fillet white; lower part of face ochreous. Palpi slender, short (1); ochreous. Antennæ pale ochreous, upper surface on basal half white. Thorax and abdomen pale ochreous irrorated with reddish-violet. Legs whitish-ochreous. Forewings triangular, costa almost straight except near base and apex, apex round-pointed, termen slightly bowed, oblique; whitish-ochreous, with numerous, transverse, wavy, fine, reddish-violet lines; a deeper violet terminal line thickened into small spots between veins; cilia whitish-ochreous. Hindwings with termen gently rounded; colour and markings as forewings.

The forewing has the areole small, and veins 7, 8, 9, 10, 11 stalked from areole. In this it agrees with *atrostrigata*, Warr., and I am inclined to think both species will ultimately be removed from the genus *Euchoeca*.

Type in Coll. Turner.

N.Q.: Kuranda, in October and November; two specimens received from Mr. F. P. Dodd.

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* *ἰοφρικος*, violet-rippled.

ASTHENA THALASSIAS.

Q : Stanthorpe—N.S.W.: Ben Lomond.

ASTHENA XYLOCYMA.

Vic.: Beaconsfield.

ASTHENA ANTHODES.

Vic.: Beaconsfield.

ASTHENA EUTHECTA.

The ♂ differs from the ♀ in the apex of the forewing being scarcely acute and not produced, costal edge of forewing more distinctly rosy (this colour is just traceable in ♀) and postmedian line being interrupted by a rather conspicuous dark fuscous spot.

Q.: Brisbane, in August; one ♂ example taken on a lamp.

ASTHENA BALIOLOMA,* n.sp.

♂♀. 23-26 mm. Head and face fuscous; fillet whitish. Antennæ pale grey. Thorax green. Abdomen green, sides, tuft, and apices of segments whitish. Legs fuscous; posterior pair whitish. Forewings triangular, costa straight except near base and apex, apex round-pointed, termen bowed, slightly oblique; green with numerous wavy parallel transverse paler lines; a dark fuscous discal dot beneath $\frac{2}{5}$ costa; a-brown-whitish streak along costa; a fine fuscous terminal line interrupted by brown-whitish dots on veins; cilia whitish. Hindwings with termen bowed, scarcely angled on vein 4: colour, marginal line and dots, and cilia as forewings.

Readily distinguished from *A. pulchraria* by the spotted termen. The forewings are less acute, and hindwings more rounded than in that species, and the thorax is wholly green.

Type in Coll. Lyell.

Vic.: Gisborne, in November, January, and March; three specimens received from Mr. G. Lyell. From the same source I have received five slightly larger but wasted specimens from Mt. Erica, which I believe to be the same species.

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* βαλιολωμος, with spotted fringe.

Scordylia leucophragma.

Vic.: Lorne, Beaconsfield.

Scordylia decipiens.

N.S.W.: Katoomba.

Scordylia niphosticha,* n.sp.

♀. 25 mm. Head, palpi, antennæ, thorax, and abdomen reddish-brown. Legs brown-whitish, irrorated with fuscous; anterior pair darker. Forewings triangular, costa moderately arched, apex round-pointed, termen bowed, oblique; deep reddish-brown: lines snow-white; a narrow straight basal line at $\frac{1}{6}$; a slightly outwardly curved line from beneath $\frac{1}{3}$ costa to mid-dorsum, dilated in middle; a pale mark on $\frac{2}{3}$ costa, from beneath which is a thickened sigmoid line to before tornus; an elongate-oval longitudinal snow-white subapical spot; from which proceeds a line of fuscous spots to tornus; cilia fuscous-brown, apices paler. Hindwings with termen strongly rounded; pale brownish grey; a faint antemedian fuscous discal dot; a faint white line from $\frac{3}{4}$ costa to tornus, angulated in disc; cilia concolorous.

Closely allied to *S. leucophragma*, but the lines are differently formed, the median line being curved, and the postmedian without the strong median projection.

Type in Coll. Lyell.

Vic.: Beaconsfield, in March; one specimen.

Scordylia pteridophila,† n.sp.

♂♀ 17-20 mm. Head, palpi, thorax, and abdomen reddish-brown; the last with some whitish scales. Antennæ brownish-grey obscurely annulated with fuscous; in ♂ with very short ciliations ($\frac{1}{5}$). Legs brownish-ochreous; anterior tibiæ and tarsi suffused with fuscous. Forewings triangular, costa rather strongly arched, apex rounded, termen bowed, oblique; lines

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* *νιφοστιχος*, with snow-white lines.

†*πτεριδοφιλος*, fern-loving.

whitish; a suffused indistinct line near base, edged anteriorly with fuscous; a nearly straight line from $\frac{1}{3}$ costa to $\frac{2}{5}$ dorsum, edged posteriorly with fuscous; a suffused line from $\frac{2}{3}$ costa to $\frac{4}{5}$ dorsum, angled in disc, anteriorly sharply edged with fuscous, posteriorly indistinct; a whitish subapical dot, connected with apex by a faintly marked dark streak; cilia grey. Hindwings with termen strongly rounded; pale brownish-grey; cilia pale grey.

Also allied to the two preceding species.

Type in Coll. Lyell.

Vic.: Beaconsfield, in March; two specimens received from Mr. G. Lyell.

Gen. EUCYMATOGE.

Section ii. *Hindwings with vein 5 approximated to 6. Thorax not crested.*

EUCYMATOGE MULTIFILATA.

Collix multifilata Warr., Nov. Zool. 1896, p.385.

♂. 23-25 mm. ♀. 34 mm. Head pale fuscous; face darker in centre. Palpi long, porrect (♂ 2, ♀ 3-$3\frac{1}{2}$); pale reddish, towards base mixed with dark fuscous. Antennæ pale fuscous; in ♂ thickened by lamellæ ($\frac{3}{4}$), and very shortly ciliated ($\frac{1}{4}$). Thorax pale reddish mixed with pale fuscous. Abdomen pale reddish; with leaden-fuscous dorsal and lateral lines, the former double towards base; beneath whitish-ochreous. Legs fuscous, annulated with whitish-ochreous; posterior pair whitish-ochreous. Forewings triangular, costa gently arched, apex round-pointed, termen bowed, oblique; pale reddish with numerous wavy fuscous transverse lines, which are largely confluent in central part of disc; a conspicuous round blackish discal dot; a double fuscous terminal line interrupted on veins; cilia fuscous. Hindwings with termen rounded, dentate; colour and markings as forewings. Underside pale fuscous, with suffused darker discal dots, postmedian, and subterminal lines.

Distinguished from *E. ghosha*, to which it is allied, by the ♂ antennæ, and reddish colouring.

N.Q.: Cooktown, Kuranda, in November and March; four specimens received from Mr. F. P. Dodd.

EUCYMATOGE AORISTA,* n.sp.

♂♀. 27-34 mm. Head fuscous or ochreous-fuscous. Palpi short ($1\frac{1}{4}$); fuscous. Antennæ pale fuscous; in ♂ with very short ciliations ($\frac{1}{6}$). Thorax fuscous or ochreous-fuscous. Abdomen fuscous mixed with whitish and sometimes with reddish-ochreous. Legs whitish irrorated with fuscous; anterior pair mostly fuscous. Forewings triangular, costa nearly straight, except towards base and apex, apex round-pointed, termen bowed, oblique, crenulate; fuscous or ochreous-fuscous; lines obscurely darker; an inwardly oblique line near base; antemedian line from $\frac{1}{3}$ costa to $\frac{1}{3}$ dorsum; postmedian from $\frac{4}{5}$ costa to $\frac{3}{4}$ dorsum, with a small acute posterior tooth in middle, but this cannot always be traced; discal dot small or obsolete; traces of a fine pale subterminal line; an interrupted fuscous terminal line; cilia fuscous mixed with ochreous-whitish. Hindwings with termen rounded, dentate; colour and markings as forewings. Underside fuscous-whitish, with faintly marked fuscous discal dot and postmedian line.

An obscurely marked and variable species. The ♀ has sometimes, in addition, white blotches on costa of forewings at $\frac{1}{3}$ and $\frac{3}{4}$, and white dots on postmedian and subterminal lines of both wings. The ill-defined markings and absence of a subterminal line on underside are good points of difference from *E. ghosha*. The costa of forewings is straighter than in that species.

Type in Coll. Turner.

N.Q.: Cairns and Kuranda; ten specimens.

Section iii. *Hindwings with discocellulars angled; vein 5 from nearer 4 than 6.*

EUCYMATOGE FULVIDA,† n.sp.

♀. 34 mm. Head dark fuscous. Palpi short ($1\frac{1}{4}$); dark fuscous. Antennæ fuscous. Thorax pale brownish; anterior

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*ἀοριστος, indefinite, ill-defined.

† Fulvidus, tawny.

margin and a posterior spot fuscous. Abdomen dark fuscous; first two segments and a series of four minute median dots pale brownish. Legs fuscous with pale annulations; posterior pair wholly pale. Forewings triangular, costa nearly straight except close to base and apex, apex round-pointed, termen bowed, oblique, crenulate; pale brownish; costa and termen rather broadly fuscous; antemedian and postmedian lines fuscous, dentate, extremely fine and scarcely traceable; discal dot dark fuscous, consisting of a conspicuous tuft of raised scales; a series of minute white dots representing subterminal line; a fuscous terminal line interrupted on veins by pale brownish dots; cilia fuscous. Hindwings with termen scarcely rounded, markedly dentate; fuscous; indications of a darker, straight postmedian line, beyond which is a zone of brownish irroration; subterminal and terminal lines and cilia as forewings.

The discal scale-tuft recalls *Mesoptila* Meyr., which, however, has the areole simple.

Type in Coll. Turner.

Q.: Brisbane, in July; one specimen taken on a lamp.

Polyclysta hypogrammata.

N.Q.: Kuranda.

Protaulaca scythropa.

N.Q: Kuranda.

Gen. Hydriomena.

Section i. *Hindwings with vein 5 approximated at base to 6.*

Hydriomena conifasciata.

N.S.W.: Sydney—Tas.: Strahan.

Hydriomena subrectaria.

Q.: Cunnamulla—N.S.W.: Sydney—Vic.: Birchip.

Hydriomena vacuaria.

Vic: Kewell, Mt. Hotham.

Hydriomena lamprotis.

Vic.: Lorne.

Hydriomena polycarpa.

Vic.: Mt. Erica, Mt. Hotham.

Hydriomena oxygona.

Vic.: Mt. Erica, Mt. Hotham.

Hydriomena stereozona.

Vic.: Mt. Hotham.

Hydriomena insulsata.

Tas.: Hobart.

Hydriomena trygodes.

Vic.: Beaconsfield.

Hydriomena cryeropa.

Vic.: Birchip, Sea Lake. The locality Kewell must be deleted as based on an error, though the species may not improbably occur there.

Hydriomena plagiocausta.

Vic.: Beaconsfield.

Hydriomena severata.

Vic.: Beaconsfield.

Hydriomena plesia.

Vic.: Black Rock.

Hydriomena loxocyma.

♂. 18 mm. Antennæ slightly serrate, with short ciliations (½). This obscure little species appears to be somewhat variable, and the doubly sigmoid character of the postmedian line is not always traceable.

Vic.: Brentwood, Sea Lake.

Hydriomena ptochopis,* n.sp.

Hydriomena ptochopis Meyr., MS.

♀. 24 mm. Head whitish. Palpi 2; whitish with some reddish-fuscous scales. Antennæ whitish. Thorax whitish. Abdomen whitish; third and fourth segments with paired fuscous dots

*πτωχωπις, shabby.

edged posteriorly with white. Forewings elongate-triangular, costa almost straight, apex round-pointed, termen slightly bowed, strongly oblique, wavy; whitish, with numerous straight, strongly oblique, fuscous, transverse lines; a strong line at $\frac{1}{6}$ followed by two fine lines; a strong antemedian line from $\frac{1}{4}$ dorsum, obsolete towards costa; a dark fuscous discal dot beneath mid-costa; a strong postmedian line from $\frac{4}{5}$ costa to $\frac{2}{3}$ dorsum. ill-defined on costa; preceded by a fine line, and followed by several fine lines; a short oblique fuscous subapical streak; a fine fuscous terminal line; cilia whitish with a pale fuscous line before middle. Hindwings with termen nearly straight to near apex, there rounded; whitish; posterior half marked by numerous, fine, indistinct, fuscous, transverse lines; terminal line and cilia as forewings.

In Meyrick's tabulation this falls with *H. subrectaria*, for which it cannot be mistaken.

Type in Coll Drake.

Vic.: Beaconsfield; one specimen.

Hydriomena opipara,* n.sp.

♀. 38 mm. Head and palpi fuscous mixed with whitish; palpi $2\frac{1}{2}$. Antennæ fuscous. Thorax and abdomen whitish irrorated with fuscous. Legs fuscous irrorated, and tarsi annulated, with fuscous. Forewings triangular, costa gently arched, apex rounded, termen bowed, oblique; whitish with fuscous lines and irroration; median band mostly fuscous; three or four wavy fuscous lines in basal $\frac{1}{4}$; antemedian line slightly outwardly curved, dentate, from $\frac{1}{3}$ costa to $\frac{2}{5}$ dorsum; postmedian line wavy, slightly indented above middle, with a moderate median projection with two rounded heads, from $\frac{2}{3}$ costa to $\frac{4}{5}$ dorsum; a blackish median discal dot, and several wavy transverse dark fuscous lines in median band; postmedian line followed by a wavy whitish line, indistinctly double; this by several fuscous lines; terminal area tinged with reddish-ochreous; an interrupted blackish terminal line; cilia grey-whitish with a median fuscous line, bases tinged

* Opiparus, splendid.

with purple-reddish. Hindwings with termen rounded; ochreous-yellow; a fuscous discal dot at $\frac{1}{3}$; a basal dorsal fuscous suffusion and several fuscous lines from dorsum, not passing mid-disc; two fuscous subterminal lines and an interrupted dark fuscous terminal line; cilia fuscous, apices grey-whitish. Underside ochreous, discal dots distinct, followed in forewings by a large median fuscous blotch, in both wings by several fine wavy fuscous lines; both wings with a fuscous subterminal band interrupted in middle.

In Meyrick's tabulation this falls with *doliopis*, but may be distinguished by the dentate antemedian line and dark median band of forewings. It is also much larger.

Type in Coll. Drake.

Vic.: Mt. Hotham, in January; one specimen taken by Dr. W. E. Drake.

HYDRIOMENA CYDALIMA*, n.sp.

♀. 26-28 mm. Head reddish-brown mixed with fuscous. Palpi $1\frac{1}{2}$; fuscous. Antennæ fuscous. Thorax brown. Abdomen brown, bases of segments paler, sides and apices of segments whitish. Legs fuscous irrorated, and tarsi annulated, with whitish-ochreous. Forewings triangular, costa gently arched, apex round-pointed, termen bowed, oblique; pale ochreous with numerous, transverse, scarcely waved, reddish-brown lines; median band limited by fine fuscous lines; anterior from $\frac{1}{3}$ costa to $\frac{1}{3}$ dorsum, nearly straight; posterior from $\frac{3}{4}$ costa to $\frac{2}{3}$ dorsum, with a slight obtuse subcostal projection, and a shallow median projection edged posteriorly by a fine white line; a narrow white median fascia broader on costa, containing a brownish subcostal dot near anterior border, sometimes obscured by fuscous irroration; a fine whitish subterminal line; a dark fuscous terminal line, narrowed on veins; cilia fuscous, bases ochreous, apices reddish-violet with fuscous bars. Hindwings with termen rounded, crenulate; orange-ochreous; base irrorated with fuscous; several fine fuscous lines from dorsum not

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* κυδαλιμος, glorious.

passing mid-disc; a cloudy fuscous subterminal line; a blackish terminal line; cilia ochreous, towards tornus fuscous. Underside pale ochreous with fuscous markings; forewings with discal dot, antemedian and postmedian series of lines; hindwings with several fine lines; both wings with fuscous terminal band becoming incomplete at tornus.

The white median band of forewings is probably variable as in *leucozona*, but it is not snow-white as in that species, and the antemedian and postmedian lines are differently formed.

Type in Coll. Drake.

Vic.: Beaconsfield and Lorne, in March; a very perfect type, and a wasted example in Coll. Lyell.

HYDRIOMENA EUPHILETA,* n.sp.

♂. 28-30 mm. Head and palpi fuscous mixed with whitish-ochreous; palpi rather short ($1\frac{1}{4}$). Antennæ fuscous; ciliations in ♂ $\frac{1}{4}$. Thorax fuscous. Abdomen fuscous mixed with whitish. Legs fuscous mixed, and tarsi annulated, with whitish-ochreous. Forewings triangular, costa gently arched, apex round-pointed, termen bowed, oblique; ochreous-whitish irrorated with fuscous and reddish-brown; median band uniformly fuscous; several fuscous basal lines; anterior edge of median band scarcely rounded, slightly dentate; posterior edge with an obtuse median projection; indications of a whitish subterminal line; an interrupted fuscous terminal line; cilia pale fuscous. Hindwings with termen rounded, wavy; pale ochreous; a fine median fuscous line between which and base is a general fuscous irroration containing several lines; two subterminal lines scarcely distinguishable except towards dorsum; terminal line and cilia as forewings. Underside similar to upper but forewings fuscous from base to postmedian line.

♀ differs as follows:—32-33 mm. Basal area of forewings fuscous, median band edged with fine white lines, the anterior sometimes absent, the posterior sometimes double.

Type in Coll. Lyell.

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* εὐφίλητος, well-beloved.

Vic.: Lorne, in March; seven specimens (5 ♂, 2 ♀), all somewhat rubbed, received from Mr. G. Lyell.

Section iii. *Hindwings with vein 5 from below middle of discocellulars, which are angled.*

HYDRIOMENA SUBOCHRARIA.

Q. : Brisbane, Nanango, Bunya Mountains.

HYDRIOMENA UNCINATA.

Q. : Stradbroke Island.

HYDRIOMENA APOTOMA,* n.sp.

♀. 34 mm. Head and thorax purplish-grey; face with rounded projection. Palpi rather short ($1\frac{1}{2}$); dark fuscous. Antennæ ochreous-whitish. Abdomen grey. Legs whitish irrorated with dark fuscous. Forewings triangular, costa gently arched, apex acute, slightly produced, termen slightly sinuate, oblique; grey tinged with reddish-purple; with numerous wavy darker transverse lines; a basal patch and median band faintly indicated; before and beyond median band the veins are marked by minute dark fuscous dots; a minute, dark fuscous median discal dot; a fine interrupted dark fuscous terminal line; cilia purple-grey, apices whitish. Hindwings with termen slightly wavy, straight; vein 5 from below middle of discocellulars, which are angled; pale purplish-grey; a dark fuscous discal dot; several fine fuscous lines towards termen, and a terminal line; cilia as forewings.

Superficially rather like *H. trygodes*, but it belongs to my Section ii.b†, being nearest to *H. uncinata;* it may be readily known by the peculiarly shaped hindwings.

Type in Coll. Drake. There is a co-type in my own collection.

Vic. : Beaconsfield (900 feet) near Melbourne, in June and July; four specimens taken by Dr. W. E. Drake. Evidently a winter species.

MELITULIAS GLANDULATA.

Tas. : Swansea.

*ἀποτομος, cut off; in allusion to the hindwings.
† Proc. R. Soc. Vic. n.s. xvi. 1903, p. 266.

MELITULIAS DISCOPHORA.

Vic. : Mt. Erica.

Gen. HYPYCNOPA.

Hypycnopa, Low., Trans. Roy. Soc. S. Aust., 1903, p.183.

Face with short cone of scales. Antennæ in ♂ bipectinate nearly to apex. Palpi moderate, porrect, rough-scaled. Thorax not hairy beneath. Posterior tibiæ with all spurs present. Forewings with areole double. Hindwings with vein 5 approximated at base to 6, 6 and 7 stalked, 8 anastomosing with cell to beyond middle; ♂ with a modified patch of yellow scales on upperside of forewings.

I have not seen the ♀. The genus is a development of *Xanthorrhoe*, bearing the same relationship to that genus that *Melitulias* does to *Hydriomena*. Whether it should be considered a good genus is open to question. The modified patch on the hindwings is much less defined than in the three species of *Melitulias*.

HYPYCNOPA DELOTIS.

Hypycnopa delotis, Low., Trans. Roy. Soc. S. Aust. 1903, p.184.

♂. 26 mm. Head and thorax blackish with white irroration. Face and palpi blackish. Antennæ grey with some blackish scales; in ♂ with long pectinations (8-10), apical $\frac{1}{8}$ simple. Abdomen grey mixed with white, a blackish dorsal transverse bar on each segment. Legs fuscous irrorated and annulated with whitish. Forewings triangular, costa very gently arched, apex tolerably pointed, termen bowed, oblique; grey-whitish with fuscous irroration and blackish transverse lines; a fine but distinct line near base; a broader very distinct antemedian line, slightly outwardly curved from $\frac{1}{3}$ costa to $\frac{1}{3}$ dorsum; preceded by several very fine indistinct lines; an irregular postmedian line from $\frac{2}{3}$ costa to beyond mid-dorsum, with a slight outward projection beneath costa, followed by a minute acute hook, and by an obtuse median projection; traces of a very fine median line between the two preceding; three more or less distinct wavy lines beyond postmedian; a blackish terminal line interrupted on veins; cilia grey-whitish mixed with fuscous. Hindwings with termen slightly rounded; colour as forewings, with several fine dark transverse lines beyond middle; terminal line and cilia as forewings; in ♂ a large patch of yellowish modified scales beneath costa, rather ill-defined and with a few normal scales on veins traversing it. Underside grey-whitish; in hindwings with a fuscous discal dot, postmedian, and two subterminal lines.

Vic.: Birchip, in April; one specimen received from Mr. D. Goudie.

DIPLOCTENA NEPHODES.

Vic.: Mt. Erica.

Gen. XANTHORHOE.

Section i. *Hindwings with vein 5 approximated at base to 6.*

XANTHORHOE PAUPER.

Vic.: Gisborne, Beaconsfield.

XANTHORHOE SUBIDARIA.

Vic.: Lorne, Birchip.

XANTHORHOE SUBIDARIA, var. URBANA.

Q.: Nanango.

The forms of this species deserve further study. I have taken *urbana* in Brisbane in large numbers and both sexes without admixture with the typical form. The ♂ *urbana* is whiter than the ♀ except in median band of forewings. Whether this and the typical *subidaria* are seasonal forms or distinct species I have not been able to decide. It is probable that one or more of the names given as synonyms of *subidaria* may really apply to the variety.

XANTHORHOE BRUJATA.

N.Q.: Kuranda.

XANTHORHOE BRACHYCTENA,* n.sp

♂. 22-25 mm. Head fuscous. Palpi moderate (2); fuscous, lower surface towards base white. Antennæ fuscous; in ♂ with fine, short pectinations (2) extending nearly to apex. Thorax

*βραχυκτενος, with short pectinations.

with a small bifid posterior crest; fuscous mixed with whitish. Abdomen fuscous mixed with whitish, with a double series of dorsal fuscous dots, and a transverse whitish line at base. Legs fuscous irrorated, and tarsi annulated, with whitish. Forewings rather elongate-triangular, costa nearly straight except towards apex, apex tolerably acute, termen bowed, oblique, somewhat wavy; whitish, slightly ochreous-tinged, with dark fuscous lines and irroration; a fuscous basal patch containing darker lines; a fuscous median band, sometimes paler in centre, containing several darker lines; its anterior edge from $\frac{2}{5}$ costa to $\frac{2}{5}$ dorsum, slightly outwardly curved; posterior edge from $\frac{4}{5}$ costa to $\frac{2}{3}$ dorsum, with a moderate, fairly acute median projection, followed by a fine whitish line; space before and after median band sometimes pale with dark dots on veins, sometimes infuscated; a fine white, dentate subterminal line; a blackish terminal line; cilia whitish mixed with fuscous, with a fuscous median line. Hindwings with termen slightly rounded, wavy; 5 approximated at base to 6; pale fuscous with darker lines, distinct only near dorsum; terminal line and cilia as forewings. Underside fuscous with darker discal dots.

This species belongs to my Section i., and is apparently similar to *X. xerodes*, but readily distinguished by the shorter antennal pectinations.

Type in Coll. Drake.

Vic.: Black Rock, near Melbourne, in November and March; three specimens.

Gen. NOTOREAS.

Pasithea Meyr., Trans. N.Z. Inst. 1883, p.84, *præocc.*
Notoreas Meyr., Trans. N.Z. Inst. 1885, p.184.

Face roughly haired. Palpi moderate, porrect, with long, dense, rough hairs. Antennæ in ♂ bipectinated. Thorax and coxæ densely hairy beneath. Forewings with areole double. Hindwings with 6 and 7 stalked, 8 anastomosing with cell to beyond middle.

Distinguished from *Dasyuris* by the pectinated antennæ of the ♂. The following species is an interesting discovery, as hitherto the genus has been known only from New Zealand.

NOTOREAS AETHALOPA,* n.sp.

♂. 18 mm. Head, palpi, thorax, and abdomen dark fuscous sparsely irrorated with white. Antennæ dark fuscous with fine white annulations; pectinations in ♂ very long (10-12). Legs dark fuscous sparsely irrorated with white. Forewings triangular, costa straight except at base and apex, apex round-pointed, termen long, bowed, oblique; dark fuscous sparsely irrorated with white scales; a median ochreous spot near base; some blackish suffusion beyond this; antemedian line blackish from $\frac{2}{5}$ costa, mostly obsolete, but edged posteriorly with ochreous; median area pale fuscous with white irroration; posteriorly bounded by a fine blackish, slightly dentate line from $\frac{2}{3}$ costa, obtusely angled in disc to $\frac{3}{4}$ dorsum, anteriorly broadly edged with ochreous; in median area is a blackish discal dot, and a small blackish spot on dorsum; cilia with basal half fuscous, apical half pale fuscous barred with white. Hindwings with termen rounded; uniform dark fuscous with a few white scales; lines blackish, suffused; cilia as forewings. Underside blackish with rather dense white irroration except on antemedian, postmedian, and subterminal lines.

Evidently protectively coloured, the yellow scales being reduced to a minimum above, and absent beneath.

Type in Coll. Lyell.

Tas.: Zeehan, in November; one specimen taken by Mr. W. K. Findlay.

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* αἰθαλωπος, smoky.

CONTRIBUTION TO A KNOWLEDGE OF THE FLORA OF AUSTRALIA.

Part V.

By R. T. Baker, F.L.S., Curator and Economic Botanist, Technological Museum, Sydney.

(Plates lxv.-lxvii.).

RUTACEÆ.

Citrus Planchoni *F.v.M.*, ("Native Lime.")—This species is plentiful at Tandowanna, Goondiwindi, Q. (C. W. Chapman).

C. australasica *F.v.M.*, ("Finger Lime.")—Occurs at Goonoo Goonoo Station, Inverell, N.S.W. (C. W. Chapman).

LEGUMINOSÆ.

Jacksonia scoparia *R.Br.*—This usually considered coast species occurs at Shuttleton (W. Bäuerlen). The western shrubs have not their flowers in one-sided racemes as obtains in eastern specimens.

Clianthus Dampieri *A. Cunn.*—This species occurs as far east as Girilambone (W. Robertson).

Swainsona galegifolia *R.Br.*—Around Inverell and district, and the interior to Warialda (C. W. Chapman).

Lespedeza cuneata *G. Don.*—Occurs at Putty, and flowers in June and February (A. C. Barwick).

Hardenbergia alba *R. T. Baker.*—This species was described by me in these Proceedings for 1900 (p.659). Since then I have received the following interesting note in regard to it from Mrs. Helena Forde:—"In 1866, about 9 miles or so above the township of Menindie (on the left bank of the River Darling going up from Wentworth to Fort Bourke), there was a deep creek leading from the river into the interior (or 'back country') called, as far as I can remember, 'Pammamara Creek,' which in time of flood overflowed the low-lying lands and formed a large lake of nearly 27 miles circumference. When we visited this so-called *lake*, after a protracted drought, it had almost dried up, but we distinctly saw the flood-marks on the stems of the trees as high as 11 feet from the ground. A plentiful growth of grass existed all over the immense dry bed of the 'lake,' an excellent grass for fodder, as we saw it being carted in by the squatters and made into stacks to feed the starving stock. It was in this locality I found the one specimen growing of *Kennedya alba*, which, as I told you, had a few seed pods on, and also some very poor spikelets of flowers, which I forwarded to Dr. Woolls, but the seeds I retained, and they afterwards germinated in my father's garden near Double Bay, Sydney. 'Pammamara' Creek was a very interesting spot to us, as close by our camp was the tree marked by A. W. Howitt when he came out to search for poor Burke in 1861 (I think), and I copied his mark in my day book."

Petalostyles labicheoides *R.Br.*—Occurs at Shuttleton, now its most eastern record, where it was collected by W. Bäuerlen.

Acacia fuliginea, sp.nov. (Plate lxv.).

A close, compact shrub from 12 to 16 feet high, occasionally attaining 20 feet, with divaricate, pubescent branchlets, generally affected with a black fungus, probably a species of *Meliola*. Phyllodia viscid, ovate or obliquely ovate, oblong or falcate-oblong, obtuse, gland wanting, 2 to 3 or even 4 cm. long, and varying up to 1 cm. wide, rigid but scarcely coriaceous, with several nerves, and intermediate reticulations. Peduncles hoary, solitary or in pairs on the end of the newly-formed branchlets, bearing a globular head of about *40 flowers*, mostly 5-merous. Sepals very narrow, spathulate, ciliate; bracts numerous, clustered round the base of the buds. Petals glabrous, adnate for the lower half of their length. Pod very slender and narrow, glabrous, straight or slightly curved, 3 to 5 cm. long, and 2 to 3 mm. wide. Seeds oblong, longitudinal; panicle short, scarcely dilated, and shortly filiform.

Hab.—Bylong (R. T. Baker); Coombermelon, Rylstone (E. Dawson).

This Acacia, as far as known, has a restricted geographical distribution, having been collected only in the County of Roxburgh, where it forms in the distance black bands at the base of the ranges. It can scarcely be called an attractive Acacia owing to it sooty appearance, due to the presence of a Fungus (*supra*), and the viscid character of the phyllodes.

A viscidula A. Cunn., also occurs in the same locality, but the differences between the two trees are too pronounced to need to be particularised here.

The shape of the phyllodes, together with the venation, resembles somewhat those of *A. dictyophleba* F.v.M. Although collected by me as far back as 1893, I hesitated to describe it, thinking perhaps it might be a form of Bentham's *A. ixiophylla* (Lond. Journ. Bot. i. 564). When visiting Kew Herbarium in 1904, I compared my material with Hooker's specimens, and concluded that it was distinct from his on the following features :—(a) It has twice as many flowers in the head. (b) The phyllodes have quite a different shape and are larger in size. (c) The inflorescence is not in racemes. (e) The pods are much longer and narrower. In Bentham's classification this species belongs to the series of Plurinerves and subseries Nervosæ, the phyllodes being viscid, with several prominent nerves and reticulations between them. Of the sixteen species placed by him in this section, it is more particularly associated with *A. viscidula* A. Cunn., *A. ixiophylla* Benth., and *A. dictyophleba* F.v.M., these species being very viscid, with numerous nerves or veins. The differences between it and *A. ixiophylla* have already been detailed (*supra*). *A. viscidula* has narrow-linear longer leaves and a pubescent pod, and a different inflorescence; whilst *A. dictyophleba* has larger phyllodes and altogether a longer pod. In botanical sequence it might be placed between *A. viscidula* and *A. ixiophylla*.

A. IXIOPHYLLA *Benth.* (Syn. *A. glutinosa* F.v.M., B. Fl. ii. p.387).—This species appears not to have been previously figured, but as it is a full congener to the above species, *A. fuliginea*, it is now figured for comparison with that species, and to aid future systematists of the genus who may not have an opportunity of examining herbarium or field material (Plate lxvi.).

A. DAWSONI *R. T. Baker.*—This species, previously recorded only from Rylstone, has been found by Mr. D. Kennedy to occur at Abercrombie, 100 miles south of its original record.

RHIZOPHOREÆ.

* BRUGUIERA RHEEDII *Blume.*—Occurs in swamps at Ballina, where it has been collected by Dr. W. H. Tomlins.

MYRTACEÆ.

MELALEUCA ERUBESCENS *Otto.*—Occurs at Shuttleton, Nymagee, having been collected by W. Bäuerlen. This is its most western locality.

EUCALYPTUS RUDDERI *J. H. Maiden* ("Red Box.")—Collected at Blue Gum Gully, Thirlmere, by C. F. Laseron. The timber is red-coloured, hard and durable.

Oil.—The crude oil of this species is of a reddish-brown colour. It has the characteristic odour of the "box" oils and a secondary odour of aromadendral. No phellandrene could be detected; the species therefore, belongs to that group of "boxes" of which *E. hemiphloia* and *E. Woollsiana* are pronounced types. Only a very small amount of eucalyptol could be detected, and it is doubtful whether more than 5 per cent. of that constituent is present. Pinene is practically absent, and only 2 per cent. of the oil distilled below 171°C. (temperature corrected); between that temperature and 178°C., 35 per cent. distilled, and 32 per cent. more between 178°-189°C. The yield of oil was 0·309 per cent. from fresh leaves with terminal branchlets. The specific gravity of the crude oil is 0·9042 at 15°C., the rotation 8·5° to the left in

* New for New South Wales.

100 mm. tube, and the refractive index at 20°C. was 1·4898. The crude oil is entirely soluble in 1 volume 80 per cent. alcohol (by weight). Aromadendral is present, and the lævo-rotation of the oil appears to be entirely due to that aldehyde, because the oil distilling below 178°C. only had 1·7° rotation to the left in 100 mm. tube, whilst the oil distilling between 178° and 205°C. was lævo-rotatory 6·8°, and both lævo-rotatory phellandrene and pinene were absent. According to our present knowledge the oil of this species has little commercial value (Henry G. Smith).

E. Fletcheri *R. T. Baker.*—Has been collected at Putty by A. C. Barwick.

E. Macarthuri *H. Deane* et *J. H. Maiden.*—Occurs on Laggon and Crookwell Creeks (J. J. Hook).

UMBELLIFERÆ.

*Scandix Pecten-Veneris *Hook.*—This European Umbel, "Shepherd's Needle," has been collected at the Macleay River by Dr. W. H. Tomlins.

COMPOSITÆ.

Olearia axillaris *F.v.M.*—Usually regarded as a coastal species, is now to be recorded for Mount Hope (W. Bäuerlen).

SAPOTACEÆ.

*Achras chartacea *F.v.M.*—Occurs at Tumbulgum (Tweed River), Ballina (Richmond River), having been collected by W. Bäuerlen.

ASCLEPIADEÆ.

Tylophora barbata *R.Br.*—The distribution of this species may now be extended from Port Jackson north to Putty (A. C. Barwick). Mr. Barwick's specimens are pale on the underside, a feature not mentioned in the "Flora Australiensis" (iv. p.335).

BORAGINEÆ.

Ehretia membranifolia *R.Br.*—This species, previously recorded from the North Coast District (C. M. Moore), has been collected at New Angledool by Mr. A. C. Paddison.

* New for New South Wales.

POLYGONACEÆ.

Muehlenbeckia adpressa *Meissn.*—Shrubby form, 6 feet high, Tenterfield (W. Bäuerlen).

LAURINEÆ.

Litsea dealbata *Nees.*—Has been collected at Putty by Mr. A. C. Barwick.

*Litsea zeylanica *Nees.*—Occurs from the Tweed to the Richmond Rivers (W. Bäuerlen).

PROTEACEÆ.

Persoonia Caleyi *R. Br.*—Has been collected at Fagan's Creek, near Braidwood, by W. Bäuerlen. Previously recorded from Jervis Bay.

P. oblongata *A. Cunn.*—Mr. A. C. Barwick has found this "Geebung" at Putty. The plant differs, however, in a few points from the description in B.Fl. and Moore's Handbook Fl. N. S.W. The pedicel is over an inch long and the ovary has silky hairs in all the specimens sent. In flower in June.

Hicksbeachia pinnatifolia.—Mr. F. A. Murray, of Lismore, informs me that the nuts of this tree are edible and as much esteemed as those of *Macadamia ternifolia.*

*Hakea Ivoryi *Bail.*—This species, described by F. M. Bailey in Q.Fl., Vol.iv., p.1346, has been collected by Mr. R. Ridge, Tuncoona, near Bourke.

EUPHORBIACEÆ.

Euphorbia Drummondii *Boiss.*—This plant is often reported as poisonous to stock, but Mr. C. H. Smith, of Womboo, Moama, tells a different tale, for he states that *E. Drummondii* has grown plentifully there this (1903) summer owing to the December rains. Stock eat it with relish and thrive well on it, but it creeps so closely to the ground that old big stock can hardly crop it. From this it appears to be a valuable summer fodder.

Homoranthus virgatus *A. Cunn.*—Occurs at West Kempsey, having been collected by Dr. W. H. Tomlins.

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* New for New South Wales.

URTICACEÆ.

*BOEHMERIA PLATYPHYLLA *Don.*—This plant, recorded by F. M. Bailey from Goambo Creek, Tambourine Mountain, Queensland, has been found to occur at Tumbulgum by W. Bäuerlen.

CASUARINEÆ.

CASUARINA LUEHMANNI *R. T. Baker.*—Putty (A. C. Barwick). This locality is worthy of mention, as it is the connecting link between the Scone and interior records.

CONIFERÆ.

CALLITRIS VERRUCOSA *R.Br.*—Collected at Boorabbin, Western Australia, by Dr. A. Morrison. This species, which is found near Lake Cudgellico, N. S.W., has thus a geographical range extending right across the Continent into Western Australia.

C. MUELLERI *Benth.*—This species has been collected at Mt. Baker, near Curricudgry Ranges, by J. E. Carne, F.G.S., Assist. Gov. Geologist.

C. MORRISONI, sp.nov.(Plate lxvii.).

A tree 20 to 30 feet high occurring on rocky places (Oldfield). Branchlets glaucous, erect, terete, internodes exceptionally short, in fact shorter than those of any other species. Leaf scales blunt, adpressed, decurrent portion being quite short and flattened. Male amenta terminal, mostly single, short, with few whorls of stamens. Female cones unknown. Fruit cones globular, axillary, solitary or in clusters, about 8 lines in diameter when opened, smooth or wrinkled when aged, ash-grey in colour, in early fruit tapering towards the pedicel or branchlets as in *C. Drummondii* Benth. & Hooker, but rather intruded at the base in the mature stage. Valves 6, thick, at first valvate, then channelled, the larger one with parallel edges, the smaller ones triangular.

Seeds usually two-winged, the central column three-sided; about 2 lines long.

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* New for New South Wales.

Hab.—Killerberrin (Dr. A. Morrison); South West Australia (F. S. Roe); Murchison River, W.A. (Oldfield).

A specimen of this species was sent to me some time ago by Dr. A. Morrison, then Government Botanist of Western Australia, who stated that it was collected by Mr. F. H. Vachell at Killerberrin in July, 1903. On comparing it with known species of *Callitris*, it was apparent that it was undescribed, but a trip to Europe in 1904 barred my publishing a description. When visiting Kew Herbarium in that year I found that similar material had been collected in South West Australia by F. S. Roe; and in looking over the Melbourne Herbarium upon my return, I found that Oldfield had also collected specimens of this Conifer on the Murchison River, Western Australia.

The exceedingly short internodes differentiate it from any described species of *Callitris*; whilst in the terete, glaucous branchlets it approaches more closely *C. robusta* R.Br., and *C. gracilis* R. T. Baker, but differs from the first of these in the absence of tubercles on the cones, which latter are also smaller than those of *C. gracilis*, from which species it differs also in its erect glaucous branchlets. From *C. rhomboidea* R.Br., it differs altogether in the shape of the fruit cones, and of course it cannot be placed in the series with angular branchlets. The specimen in the Melbourne Herbarium is labelled *C verrucosa* var. by Baron von. Mueller, but there are no features showing a gradation to that species.

In the 'Flora Australiensis' there appears to be no reference to these particular specimens.

The Kew Herbarium specimen is labelled "Inter. S. W. Australia, F. S. Roe, Esq."

C. robusta J.D.H., Hookerian Herb., is identical with that at Melbourne collected by Oldfield.

The systematic description is based on the above-mentioned specimens and other notes.

It has cones which are similar to those of *C. Drummondii*, whilst the branchlets much resemble those of *C. robusta* R.Br.

LILIACEÆ.

Eustrephus latifolius *R.Br.*—West Kempsey, a remarkably small variety of this species has been found at West Kempsey by Dr. W. H. Tomlins.

GRAMINEÆ.

*Setaria verticillata *Beauv.*—This grass has been collected at Caulfield and Malvern by Mr. C. W. Chapman, who states that stock eat it freely. This is its first record from the Eastern States.

Anthistiria membranacea *Lindl.*—This species, previously recorded from the country between the Darling and Cooper's Creek, has been found now to occur as far north and east as Walgett (S. W. Humphries).

FUNGI.

I am indebted to Messrs. G. Massie of Kew and C. G. Lloyd of Cincinnati for the identification of the greater number of these species.

*Pames stypticus *Bail.*—Wentworth Falls; on old stumps (Mr. T. Steel). †

Polystictus stereinus *Berk. & Cook.*—Wentworth Falls; on trunks (T. Steel).

*Hydnum coralloides *Scop.*—Wentworth Falls; on rotten wood (T. Steel). ‡

Clavaria botrytes *Pers.*—Wentworth Falls; on the ground (T. Steel).

*C. cinerea *Bull.*—Wentworth Falls; on the ground (T. Steel).†

*C. lurida *Kalch.*—Wentworth Falls; on the ground (T. Steel).†

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* New for New South Wales.

† Previously recorded only from Victoria.

‡ Previously recorded only from Queensland.

*C. RUGOSA *Bull.*—Wentworth Falls; in moist places (T. Steel).‡

*TREMELLA FRONDOSA *Fries.*—Wentworth Falls; on old trunks (T. Steel).§

*CLATHRUS TRISCAPUS *Fries.*—Wentworth Falls; on the ground (T. Steel).‡

CALOSTOMA FUSCA *Moss.*—Wentworth Falls; on the ground (T. Steel).

*GEASTER FIMBRIATUS *Fries.*—Wentworth Falls; on the ground (T. Steel).

LYCOPERDON PYRIFORME *Schæff.*—Wentworth Falls; on the ground (T. Steel).

*SCLERODERMA AURANTIACUM *Bull.*—Wentworth Falls; on the ground (R. V. Edwards).||

*POLYSACCUM PISOCARPIUM *Fries.*—Coogee; on the ground (R. V. Edwards).

PEZIZA RHYTIDEA *Berk.*—Wentworth Falls; on the ground (T. Steel).

*DALDINIA VERNICOSA.—Name of loc. and coll. lost.

COLUS HIRUDINOSUS *C. & S.*—Bynga; on the ground (W. N. Bruce).

*CALVATIA VIOLASCENS *Cooke & Mass.*—Belmore; on the ground (R. T. Baker).||

*CLITOAYBE TUBA *Fries.*—Wentworth Falls; on dead wood (T. Steel).||

*LEPTONIA LAMPRODA *Fries.*—Wentworth Falls (T. Steel).||

*MYCENA SANGUINOLENTA *Alb. & Schau.*—Wentworth Falls (T. Steel).||

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* New for New South Wales.
‡ Previously recorded only from Queensland.
§ Previously recorded only from Tasmania.
|| Not previously recorded from Australia.

Podaxon aegyptiacus *Mont.*—Forty miles south of Bourke (R. H. Cambage).

*Qnocybe flocculosa *Berk.*—Wentworth Falls; on the ground (T. Steel).||

EXPLANATION OF PLATES.

Plate lxv.

Acacia fuliginea.

Fig. 1.—Branchlet in flower.
†Fig. 2.—Bud.
†Fig. 3.—Flower.
Fig. 4.—Pod.
Fig. 5.—Seed.

Plate lxvi.

Acacia ixiophylla.

Fig. 1.—Spray in flower.
Fig. 2.—Twig with pods.
Fig. 3.—Narrow-leaved form in flower.
†Fig. 4.—Flower.
†Fig. 5.—Seed.

Plate lxvii.

Callitris Morrisoni.

Specimen of twig with cones.

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* New for New South Wales.
|| Not previously recorded from Australia.
†Enlarged.

NEW AUSTRALIAN SPECIES OF THE FAMILY *AESCHNIDÆ.*

[Neuroptera : *Odonata.*]

By R. J. Tillyard, B.A.

(Plate lxviii.).

i. Subfamily CORDULEGASTERINÆ.

No species of this subfamily has previously been recorded from Australia. In December, 1903, Mr. G. A. Waterhouse took, while collecting in the Blue Mountains, two dragonflies One of these is in the possession of Mr. W. W. Froggatt; the other was sent home to England for identification, but has not since been heard of. Some time ago I noticed the dragonfly in Mr. Froggatt's collection, and requested him to allow me to send it to M. René Martin of France, as I believed it was a new species. M. Martin was much struck with the beauty and peculiarity of the insect, and forwarded it to Dr. Ris of Belgium, who pronounced it to be *Petalia Apollo* ♀, a rare insect, so far only known to occur in Chili; he was also strongly of opinion that there had been some mistake as to locality until I convinced him of the truth of the capture. If we have in Queensland a dragonfly (*Ceriagrion glabrum*) whose only other known locality is Central Africa, it need hardly occasion surprise that we should also have on the Blue Mountains a dragonfly that until now had only been known to inhabit the Andes.

As the insect is a most remarkable and beautiful one, I append a short description :—

Petalia Apollo Selys.

♀. Total length 59 mm.; abdomen 44 mm.; wings, fore 39 mm., hind 37 mm.

W i n g s pointed, forewings rather narrow, reticulation rather open; basilar space free, hypertrigonal space with one cross-nervure. *Triangles* short, broad, once crossed; a large open cell at the base of the wings. Subcostal and median nervures blotched from base to arculus with deep reddish-black; on the same nervures, half-way to the nodus, is a semicircular spot of deep ruby colour surrounded by black; in the hindwings this spot touches the costa. On the forewings only, half-way between this spot and the nodus, is a similar but smaller spot. On all the wings there are also four larger spots of the same colour, somewhat irregular in shape, and placed as follows:—one enveloping the nodus and first postnodal, a second half-way between the nodus and pterostigma, a third under the pterostigma itself, and a fourth, rather oval in shape, at the tip of the wing. *Pterostigma* narrow, 3·6 mm., bright ruby-red. *Nodal Indicator*

13-14	9-11
9-10	10

H e a d : *Eyes* touching for about 2 mm., a ridge of stiff hairs at back of orbits *Epicranium* hairy; seen from above, the front is slightly curved, projecting outwards and slightly upwards like a flat shelf; the vertex and ocellar area tucked away between it and the eyes. Colour very dark brown, a paler line along the frontal ridge. *Antennæ* short, black, basal joint thickened. *Postclypeus* broader than front, dark brown, a transverse band of orange-brown; *anteclypeus* narrow dark brown; *labrum* dark brown with a transverse narrow band of orange-brown; *labium* and *mandibles* dark brown. T h o r a x : *Prothorax* brown. *Meso-* and *metathorax* short, downy, dark chocolate-brown; a pair of humeral orange bands, almost straight, pointed slightly outwards in front; on either side two broader lateral orange bands wide apart, the upper one followed closely by a round orange spot close to mesocoxa. *Legs* rather short and thick, black with brown femora. A b d o m e n : Moderately stout; 1-2 and 8-9 slightly swollen; 2-7 with medial, transverse, supplementary carinæ; latter and sutures black; markings of abdomen faded and indistinct in the only specimen I have seen; ground-colour brown; 9 carrying 2 filaments, 1·5 mm. long; 10 rather narrow, rounded below, carrying a blunt tubercle, sparingly hairy, followed by another tubercle underneath. A p p e n d a g e s : Straight, cylindrical, 1·2 mm. long, wide apart, parallel, tips blunt; colour black.

Hab.—Chili; Blue Mountains (Katoomba), Australia; two specimens only, captured by Mr. G. A. Waterhouse, December, 1903.

The somewhat isolated group of genera, *Petalia*, *Hypopetalia*, and *Phyllopetalia*, are, except this one record, confined exclusively to Chili.

ii. Subfamily AESCHNINÆ.

Fifteen species of this subfamily are already recorded from Australia. Four more are now added, three of which are new to science, one of them forming the type of a new genus.

1. Anax guttatus Burm.

This large and handsome species is common throughout the East Indies, New Guinea and the Seychelles. It has not, however, been recorded before from Australia. I found it flying over the Carrington Marsh, Atherton, in January, 1905; later on I noticed one or two specimens near Cairns, and one only at Townsville. It is a most difficult insect to capture, for it flies well out from the banks, darting in and out of the reeds at terrific speed. I took half-a-dozen males in three days, but never saw a female. There is only one way to capture them, and that is to wade out into the marsh and hide in some favourite clump of reeds, netting them as they career past. One failure in striking is fatal, as the insect will at once mount high into the air and disappear from sight. The flight is like that of *Hemianax papuensis*, only more vigorous and dashing; the dark green thorax, followed by the brilliant sky-blue of the upper part of the abdomen, makes this insect truly a magnificent object as it dashes at lightning speed up and down the marshes.

2. Planaeschna costalis, n.sp.

♀. Unique. Total length 92 mm.; abdomen 69 mm.; wings, fore 69 mm., hind 68·5 mm.

Wings with a deep russet-brown colouration covering the lower half of the costal space up to nodus and all of it beyond, also all the subcostal and median spaces, except the basilar area. *Pterostigma* long, 7 mm., rose-red, strongly braced. *Membranule*, fore 2 mm., very wide; hind 9 mm., wide and curved at base, then becoming very narrow; colour dull whitish. *Nodal Indicator* 29-31 25-27 / 23-25 26-27. Head: *Vertex* tubercled, hairy, brown; *antennæ* 3·5 mm., brown, basal joint thickened; *eyes* meeting for a distance of 5 mm., dark brown. *Front* large, hairy, pale brownish, projecting forwards and pointed in the form of an anvil (compare *Telephlebia Godeffroyi*). *Clypeus:* postclypeus vertical, high; anteclypeus compressed, narrow, pale yellowish-brown. *Labrum* wide, massive, pale yellowish-brown; *labium* cinnamon-brown, mandibles brown. Thorax: *Prothorax* small, pale yellowish-brown. *Meso-* and *metathorax* short, broad, dark brown; dorsal ridge high and strongly marked, rising to an obtuse-angled point; on each side a pale whitish humeral ray; below, a parallel equal ray of the same colour; both rays slightly irregular. *Legs* dark brown, tibiæ with strong bristles. Abdomen cylindrical, 1-2 slightly swollen, 8-10 somewhat enlarged below; colour dark chocolate-brown, markings, if any, obliterated; 10 enlarged beneath into a projection ending in a semicircular 8-denticulate plate, reaching just beyond the appendages. Underside dark brown. Spur of ovipositor huge, reaching to end of abdomen (see Plate lxviii., figs. 2*a*-2*b*). Appendages nearly as long as 10, narrow, subcylindrical, pointed, wide apart, separated by the upper projection of 10; dark brown.

Hab.—New South Wales (circa 1870).

The unique specimen described above is in the Australian Museum, Sydney. It is an old and discoloured specimen, and must have been put away for many long years, nobody knowing what a prize it was. It carries a label marked N. S.W., but this indeed would be insufficient evidence on which to base its claim to be an Australian insect, were it not for the fact that it belongs to a group of subgenera which are known to be exclusively Australian, viz., *Austroaeschna*, *Acanthaeschna*, and *Planaeschna*. As to which of these genera it in reality belongs, it is impossible to say because the male is unknown. The markings on the thorax being straight bands, it should probably be placed in *Planaeschna*. However, considering its huge size and the markings on the wings, it should perhaps be made the type of a new genus allied to this group. The expanse of wings in this insect is 144 mm., or close on 6 inches, making it one of the largest known dragonflies and only second, amongst Australian Odonata, to *Petalura gigantea*, which reaches 6½ inches in expanse.

3. Planaeschna(?) forcipata, n.sp.

♂. Total length 67 mm.; abdomen 52 mm.; wings, fore 45 mm., hind 44 mm.

Wings: Neuration black; anal triangle of hindwings 3-celled. *Pterostigma* 2·5 mm., black. *Membranule*, fore very small; hind, 1·5 mm., brown. *Nodal Indicator* ‖ 22 16-18 / 15-16 16-17 | Head: *Vertex* small, hairy, black; central ocellus brilliant, other two black, smaller; *antennæ* 2 mm., black. *Eyes* dark green in the living insect; *occipital triangle* black. *Front* high, dark brown, almost black in centre. *Clypeus* rich brown; *labrum* black; *labium* and *mandibles* deep brown. Thorax: *Prothorax* very small. *Meso-* and *metathorax* black or very dark brown marked with five bright green stripes on either side, as follows—the first humeral, short, straight, a small sharp point in front on the outer side; the second subhumeral, longer, curved; the third lateral, broader, reaching from the fore wing-joins towards the mesocoxa; the fourth narrow, crossed by a black line at about two-thirds of its length; the fifth sublateral, close to abdomen, very broad, subtriangular in shape. Interalar ridge marked with green; scuta and scutella green surrounded with black; wing-joins black spotted with green. Underside dull brownish. *Legs* black. Abdomen rather thin, 1-2 swollen, 3 much pinched, 4-9 gradually widening, 10 much larger than 9, cut off square anally. Colour: 1, deep rich brown; all the rest jet black spotted with a beautiful rich green as follows—2 with four dorsal rays in the form of a cross, not meeting in the centre; a transverse anal ring broadening on the sides, and a basal spot on either side reaching to the spurs, which are blunt, green above and black beneath: 3-7 with a pair of rounded anal spots: 6-7 have also a pair of narrow slanting pointed marks: 8-10 black: 10 with a pair of small black tubercles, sharply pointed, above the bases of the superior appendages; 10 also much tubercled and swollen below inferior appendage. Appendages: *Superior* 3 mm., depressed, forcipate, black; wide apart at bases. *Inferior* 2·2 mm., truncate, broad at base, very thick, black, concave and marginate above. (See Plate lxviii., figs. 1*a*-1*b*).

Hab.—Kuranda, N.Q.; January, 1905; rare; three males only. It flies very swiftly up and down densely wooded mountain creeks, often hovering, perfectly still, over some favourite pool, or resting on a twig or jutting piece of rock in places where the rocky banks of the jungle creeks are overhanging or vertical. It is very difficult to capture.

As the appendages differ from the typical *Planaeschna* form, notably in the shortness of the superior and the comparative length of the inferior, this insect should probably form the type of a new genus.

5. Caliaeschna conspersa, n.sp.

♂. Total length 58-61 mm.; abdomen 43-45 mm.; wings, fore 36-39 mm., hind 35-38 mm.

Wings: Neuration black; triangles three-celled in fore and two-celled in hindwings, preceded by 4-5 nervules in submedian space. Anal triangle of hindwings fairly broad, right-angled, 3-celled, bases of wings touched with deep brown. *Pterostigma* 2 mm., covering about two cellules, dark brown (fulvous in immature specimens). *Membranule*, fore small; hind 2 mm., rather narrow, pure white. *Nodal Indicator*

15-16	10-11
10	9-10

sixth antenodal thickened. Head: *Vertex* a very small dark brown tubercle; *antennæ* short, black; *eyes* brown, meeting along their whole length; *occipital triangle* very small, cream-coloured. *Front* very high and large, with a well-marked semicircular ridge above, running from one side to the other, and carrying a short row of hairs on top; that part of the front in advance of the ridge is strongly granulate, flattened at the sides, but raised in the middle into a low triangular pyramid somewhat rounded off at the top; colour dark brown, slightly paler in front of ridge; a triangular cream-coloured spot on the pyramid in front; behind the ridge, low down on either side, is a large cream-coloured oval spot. *Postclypeus* large, pale cream-coloured, with a pair of squarish dark brown spots next anteclypeus, separated above from the front by a very dark brown transverse band in the suture; this band expands slightly downwards in the centre, shading the postclypeus; *anteclypeus* small, dark brown. *Labrum* cream-coloured, shaded at sides with dark brown, and surrounded by the same colour; *labium* and *mandibles* dark brown, a round cream-coloured spot on the genæ. Thorax: *Prothorax* very small, dark brown. *Meso-* and *metathorax* rich dark chocolate-brown spotted with pea-green (yellow in immature specimens) as follows—a pair of oval humeral spots, pointed in front; followed behind by a pair of small spots slightly elongated transversely; just below these, outwards, a pair of small narrow elongated spots. Dorsal ridge elevated into an obtuse spine at the centre. On each side are three small spots forming a triangle, and in front of them a large round cream-coloured spot; above this a small round subhumeral point; near the fore wing-join, two spots, the upper one narrow, the lower subtriangular; low down near the hind wing-join a rounded spot, followed in front by another oval spot; and in front of the latter a large cream-coloured spot low down on the metapleurum. Underside dirty brown. *Legs* black, femora brown. Abdomen: 1-2 swollen, 3 pinched, 4-10 subcylindrical, broadening out from 5-7. Genital appendages of 2 very conspicuous, the segment projecting anally downwards so as to form an acute-angled protuberance. Colour of abdomen deep rich chocolate-brown spotted with pale pea-green (pale yellow in immature specimens) as follows—1 with a small round dorsal spot, and a pair of larger lateral spots: 2 with a narrow triangular basal dorsal spot flanked below on either side by a fine short transverse line; a pair of anal spots separated by the dorsal ridge; between them, on the ridge, a short line; low down on either side, two spots, one basal and touching the base of the spur, the other anal, rather pointed in front, spurs brown: 3-8 with a pair of central dorsal spots separated by the dorsal ridge, narrow transversely; a pair of larger roundish anal spots slightly more separated; on either side, low down, a basal spot and a smaller central spot. These spots vary in size from 3-8, the central dorsal spots increasing to 7 and the anal ones flattening down to mere lines in 7-8, the sublateral spots approaching more closely together from 3-8; 9-10 shaded anally with pale green on either side of dorsal ridge. Appendages: *Superior* nearly 4 mm., wide apart at bases, converging and sometimes touching near tips; narrow sublanceolate, tips blunt and rounded, inner margin with a row of long soft hairs; black. *Inferior* narrow triangular, just over half as long as superior; tips slightly upcurved; concave above, marginate; colour semitransparent brown, margins darker. (See Plate lxviii., figs. 3*a*-3*b*).

♀. Generally slightly larger than ♂, differing from it as follows. Abdomen stouter than in ♂; 10 very short above, rounded below anally and projecting between appendages. Ovipositor furnished with two jointed filaments, basal joints thickened. Behind these, on 10, is a small tubercle carrying several minute teeth or spines. Appendages 1 mm., wide apart, parallel, subcylindrical, rather blunt, black.

Hab.—N. S. W.: Illawarra district, National Park, Mittagong, etc.; local; March-May.

In March it flies high up about the bushes and trees around the mountain creeks; later on in the season it may also be seen flying swiftly, low over the water, especially towards evening. A difficult insect to capture.

The genus *Caliaeschna*, to which this new species belongs, contains but few species; and, with this exception, is confined to India, Afghanistan, and Asia Minor. It is therefore a somewhat remarkable discovery to find an isolated species of the genus so far removed from its centre, and with so local a distribution. The genus can be distinguished from the other Australian Aeschnine genera, *Planaeschna*, *Austroaeschna* and *Acanthaeschna*, by the fact that in these genera the basilar space of all the wings is free, while in *Caliaeschna* it is reticulated.

In conclusion, it may be remarked that the five species of the family *Aeschnidæ* now added to the Australian list form about as miscellaneous and as remarkable a set of insects as it would be possible to find. An East Indian species, a Chilian species, and of the new ones, one belonging to an Indian genus and the other two probably the types of new genera—this serves to show us the composite character of the Australian Odonate fauna, and encourages us to believe that nowhere else in the world will careful study and collecting of the group yield so many surprises and treasures.

EXPLANATION OF PLATE LXVIII.

Fig. 1*a*.—*Planaeschna forcipata* (♂); appendages, dorsal view.
Fig. 1*b*.— ,, ,, ; ,, lateral view.
Fig. 2*a*.—*Planaeschna costalis* (♀); appendages, dorsal view.
Fig. 2*b*.— ,, ,, ; ,, lateral view.
Fig. 3*a*.—*Caliaeschna conspersa* (♂); appendages, dorsal view.
Fig. 3*b*.— ,, ,, ; ,, lateral view.

NOTES FROM THE BOTANIC GARDENS, SYDNEY.

No. 12.

By J. H. Maiden and E. Betche.

(Plate lxix.).

RUTACEÆ.

Boronia Deanei, n.sp.

Gregarious* in swamps between Clarence and Wolgan, Blue Mountains (H. Deane; October, 1906).

An erect strong-smelling shrub, about $2\frac{1}{2}$ to 3 feet high, perfectly glabrous in all its parts. Leaves simple, nearly erect, and rather crowded, semi-terete, mostly $\frac{1}{5}$ to $\frac{1}{4}$ of an inch long, obtuse, smooth on the flat inner face, somewhat warty from the prominent oil-glands on the rounded back. Flowers terminal, solitary *on a very short and thick, almost turbinate peduncle,* or in threes, or occasionally one or two in the axils of the next pair of leaves, the pair of bracts on the base of the peduncle entirely leaf-like. Calyx-lobes triangular, acute. Petals imbricate in bud, red, at the most thrice as long as the sepals, not much spreading in the specimens seen, so that the flower has a not fully opened appearance. Sepaline stamens slightly longer than the petaline ones; filaments quite glabrous, but the upper part of all covered with irregular acute excrescences; anthers not apiculate. Disk thick and somewhat warty. Style short, with a small capitate stigma. Ripe fruits and seeds not seen.

A very good species, sharply distinguished from all described Boronias. In position it comes next to *B. parviflora* Sm., but the habit and the leaves are totally different. The colour of the flowers varies from white to deep pink.

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* There are acres of it, to the exclusion of almost any other plant.

BORONIA REPANDA, n.sp.

(*B. ledifolia* J. Gay, var. *repanda* F.v.M. Herb., these Proceedings, 1904, p.735).

We are of opinion that this plant should properly be looked upon as a distinct species. it being, we think, sufficiently and consistently distinct from *B. ledifolia*, its closest congener so far as our knowledge goes at present. It seems to be sufficiently described *loc. cit.*

PORTULACEÆ.

PORTULACA BICOLOR F.v.M., var. ROSEA, n.var.

Howell (J. L. Boorman; January, 1906).

A small tuberous-rooted perennial (or annual) growing on moist shallow deposits of soil on rocks amongst mosses and other dwarf plants. In habit it is entirely like the yellow-flowered *P. bicolor*, with the same characteristic two-coloured leaves, but the colour of the flowers in the new variety is rose-pink, and the number of petals 5 or 6, mostly 6.

SAPINDACEÆ.

*CUPANIA FOVEOLATA F.v.M. (CUPANIOPSIS FOVEOLATA Radlk.).†

Acacia Creek, Macpherson Range (W. Dunn; April, 1905, in flower: December, 1905, in fruit).

Recorded in Mueller's "Census of Australian Plants" from Queensland only, and consequently omitted from Moore & Betche's "Handbook of the Flora of New South Wales;" but we find that Mueller's omission from New South Wales was a clerical error. Mueller himself quotes in his 'Fragmenta' (Vol.ix., p.95) the McLeay (Macleay) and Bellinger Rivers, both in New South Wales, as habitats of the tree, besides Queensland localities. The foveolæ (domatia; see A. G. Hamilton's paper in these Proceedings for 1896) on the underside of the leaves, from which

* New for New South Wales.

† It is our intention to adopt Radlkofer's names in our forthcoming Census of New South Wales Plants, but we desire to deal with the Family in its entirety.

Mueller derived the specific name, are, in our Queensland specimens, neat holes in almost every axil of the secondary veins; in the Acacia Creek specimens they are reduced to a few swellings with a minute aperture. The fruits attain fully 1 inch in diameter, and hang down in large bunches; the seeds are blackish-brown, and nearly covered by the orange-coloured arillus.

The following description has been sent to us by Prof. L. Radlkofer for publication :—

"TOECHIMA* DASYRRHACHE, n.sp., Radlkofer."

Frutex vel arbor parva: rami subteretes, sulcati, apice thyrsique sufferrugineo-pubescentes, cortice fusco in sulcis albide lenticelloso-punctato cellulis secretoriis seriatis resinigeris instructo; folia abrupte pinnata, juniorum petiolus rhachisque dense fulve hirsuto-tomentosus; foliola 6-8, alterna vel subopposita, minora, ovali- vel oblongo-lanceolata, obtusiuscule acuminata, basi subacuta, petiolulata, integerrima subchartacea, paucinervia. nervis utrinque 4-5 e patulo procurvis, supra glabra, subtus ad nervos pilis laxe adspersa, obscure plurifoveolata; thyrsi axillaris, foliis breviores, interdum basi ramulo aucti cincinnis sessilibus paucifloris; calyx hirsutus; discus annularis, regularis, glaber.

Frutex vel arbor 8-15-pedalis. Rami thyrsigeri 3-4 mm. crassi. Folia 12-18 cm. longa; foliola 5-8·5 cm. longa, 2-2·8 cm. lata, supra fuscescentia, interdum livescentia, subtus sordide viridia, laxe reticulato-venosa, punctis elevatis (stomatibus obliteratis) notata, cellulis secretoriis parvis sat raris instructa, epidermide non mucigera; petioli 2-4·5 cm., petioluli 5 mm. longi. Thyrsi 6-12 cm. longi; bracteæ bracteolaeque parvæ, subulatæ, hirtellæ; pedicelli 3-4 mm. longi, puberuli, ad medium articulati. Calyx 1·5 mm. altus, 5-lobus, lobis triangularibus. Petala 5, 2 mm. longa, late obovata, extus glabra, intus puberula, 2-squamata; squamæ petala ipsa aequantes, dorso superne cristato-appendiculatæ, dense villosæ. Stamina 8, 4 mm. longa, filiformia, villosula; antheræ obovoideæ, basi excisæ, papillosæ. Germen trigono-obovoideum,

* Would hitherto have been included under *Cupania*.

3-loculare, adpresse pubescens, 2 mm. longum, stylo aequilongo filiformi curvato apice obscure lobulato; gemmulæ in localis solitariæ. Fructus—(non visus).

In Australiæ colonia New South Wales (W. Bäuerlen, n.571; Tintenbar, m. Oct. 1891, flor.; communicavit J. H. Maiden)."

LEGUMINOSÆ (MIMOSÆ).

ACACIA ACCOLA,* n.sp.

Wallangarra (Jennings), on the Queensland border, on granite hills; in fruit, December, 1903, in flower, July, 1904 (J. H. Maiden and J. L. Boorman); Mt. Dangar, Gungal (J. L. Boorman; September, 1904); Stanthorpe, Q. (J. L. Boorman; November, 1904).

An erect, glabrous, tall, busby shrub about 6-8 feet high, with compressed angular young branches. Phyllodia linear, slightly curved or occasionally nearly straight, generally 3 to nearly 5 inches long, and about 1 line broad, obtuse but usually with a hooked point, 1-veined, the lateral veins concealed in the tissue; marginal glands 1 or 2, below the middle of the phyllodia or 1 above the middle, mostly very prominent, rarely absent. Inflorescence a slender raceme, about 1½ to 2 inches long with about 9 or 10 flower-heads on slender short peduncles, each flower-head containing 10-20 flowers. Calyx (in the fully opened flower) 5-lobed, with spathulate lobes thickened at the top. Petals free, rather narrow, twice as long as the calyx, quite glabrous as well as the ovary. Pods of waxy lustre, linear, flat, slightly curved, generally about 3 to 4 inches long and ½ inch broad, but occasionally attaining nearly 6 inches in length, not or only rarely contracted between the seeds, with slightly thickened margins. Seeds longitudinally placed along the centre of the pod, the funicle thickened under the seed but not folded.

It is most nearly allied to *A. neriifolia* A. Cunn., from which it differs in its narrower phyllodes, less numerous flowers in the heads

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* In allusion to its occurrence on the New South Wales-Queensland border.

with quite glabrous ovarium and petals, and in its larger and different pod with a conspicuous waxy lustre.

Acacia leptoclada A. Cunn.

Howell, N. S.W.(J. L. Boorman; January, 1906).

The pods and seeds of this handsome Acacia were unknown at the time Bentham published the second volume of the "Flora Australiensis," in 1864; and were apparently still unknown when Mr. Bailey published his "Queensland Flora" in 1900. We are now able to complete the description of the species. A tall weak shrub, 6 to 12 feet high, with pendulous branches.* Pods broad-linear more or less curved, 2 to 2½ inches long and rather above ¼ inch broad, with nerve-like margins, the valves densely covered with grey hairs. Seeds ovate-oblong, thick and black, the funicle thickened under the seed into an almost cup-shaped mass.

UMBELLIFERÆ.

Actinotus Forsythii Maiden and Betche.

Katoomba, Blue Mountains (W. Forsyth; February, 1906, in flower; April, 1906, in fruit).

This rare *Actinotus* was described in these Proceedings for 1902(p.60). We give some additional notes from the flowers examined in a fresh state. Involucral bracts alternately 3-veined and 1-veined, all densely covered with silky hairs inside, outside less densely hairy, the 3-veined ones reddish-brown in the upper half. shading into white towards the base, the 1-veined ones reddish-brown only along the midvein.

COMPOSITÆ.

Brachycome pachyptera Turcz.

Paroo River district, about 20 miles south of Wanaaring (E. Betche; September, 1900).

A much-branched annual with ascending leafy stems 6 to 9 inches high. Leaves all, even the uppermost ones, divided into

* See also *antea*, p. 67.

long narrow lobes. Flower-heads at least 1 inch in diameter with expanded rays, the rays blue.

In Moore and Betche's "Handbook of the Flora of New South Wales" it has been attempted, for the sake of an artificial key, to divide the New South Wales species of *Brachycome* into two groups, one with radical leaves only, and the other with stem-leaves; but practical experience has proved that this key is quite unworkable, there being too much variation between radical leaves and stem-leaves in the genus. *Brachycome pachyptera* has been hitherto regarded as one of the few species with strictly radical leaves; but the Paroo River specimens show that even this species varies in this respect. Max Koch's Mt. Lyndhurst (S.A.) specimens have also stem-leaves instead of radical leaves.

Generally speaking, we can say that the eastern forms of *B. pachyptera* have strictly radical leaves and leafless scapes; the rosette of leaves dissolves into stem-leaves only in the far west of New South Wales, beyond the Darling.

ASCLEPIADACEÆ.

Marsdenia rostrata R.Br. var. Dunnii, n.var.

Acacia Creek, Macpherson Range (Mrs. J. L. Dunew; December, 1905).

Leaves somewhat smaller and on shorter petioles than in the typical *M. rostrata*, sparingly pubescent on both sides, the young shoots densely pubescent with very short hairs. Umbels on shorter peduncles, more numerous and more crowded than in the type. The variety is chiefly distinguished from the type by the arrangement of the hairs in the corolla-tube. The lobes are hairy as in the type, but the tube is lined with five thickened longitudinal ridges alternating with the lobes and densely ciliate in the upper part; or, from another point of view, the thick tube is provided with five longitudinal grooves opposite the lobes and edged with hairs in the upper part. These grooves lead down to the gynostegium and represent, no doubt, a special adaptation to insect fertilization. The tube is proportionately rather longer than in the type and the gynostegium rather more slender, but otherwise there is no difference in the flower. Fruits not seen.

We are rather in doubt whether this form should not rather rank as a species, but the arrangement of the hairs in the corolla seems to be merely a more perfect adaptation to insect fertilization. All other species of *Marsdenia* described in Bentham's "Flora Australiensis" are more sharply distinguished from each other than the variety *Dunnii* is from the typical *M. rostrata*.

GOODENIACEÆ.

VELLEYA MONTANA Hook. f.

Between Clarence and Wolgan (J. H. Maiden; November, 1906).

A rare southern plant found occasionally in bleak situations in the Blue Mountains. We recorded the first Blue Mountain locality in 1903 (Medlow), and we are now able to add a second.

LAURACEÆ.

ENDIANDRA DISCOLOR Benth.

Matcham's Brush and Hogan's Brush near Gosford (A. Murphy; June, 1906, fruiting specimens).

Most southern locality. Not previously recorded south of the Hastings River. Mr. Murphy writes that it is common in the district and is probably the tallest tree in the bush. It attains a stem-diameter of 6 feet, though the average thickness of the trees cut by the timber-getter is 2-3 feet in diameter. The local name is "Teakwood," and it is considered good, fairly hard timber.

*LITSEA ZEYLANICA Nees.

Cape Byron (E. Betche; March, 1896); Mt. Lindsay, Macpherson Range (W. Forsyth; September, 1900); Acacia Creek, Macpherson Range (J. L. Boorman; February, 1905)—all in New South Wales.

A very common Queensland plant, but not hitherto found in New South Wales. The three localities given here are all within 10 miles of the border of the two States.

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* New for New South Wales.

VERBENACEÆ.

LIPPIA NODIFLORA Rich.

Kurnell, Botany Bay; abundant (J. L. Boorman).

Most southern locality. This common tropical and subtropical seacoast plant is also common on the northern coast of this State (as far south as Tuggerah Lakes), but has not been recorded previously so far south as Botany Bay.

THYMELACEÆ.

*PHALERIA NEUMANNII F.v.M.

Acacia Creek, Macpherson Range (W. Dunn; November, 1905).

Previously recorded from Queensland only. It is apparently a very rare tree in New South Wales. The Forest Guard of the district, Mr. W. Dunn, writes that he knows of only about a dozen trees in his district, at an altitude of over 2000 feet. The tree from which our specimens were obtained is 20 feet high, with a circumference of 14 inches, 2 feet from the ground. The tree is very ornamental and the flowers very fragrant.

URTICACEÆ.

FICUS STENOCARPA Warb. in Just's Bot. Jahresbericht (Repert. nov. spec. regni veget. Sept. 1905, p.75).

(Syn. *F. aspera* Benth., non Forst.).

Toowoomba scrub, Queensland, Warburg No.18478.

This is our common "Rough-leaved Fig," described in Bentham's "Flora Australiensis" as *Ficus aspera* Forst.; and called by Mueller in his Census *F. scabra* Forst. Prof. Warburg points out in his paper that Forster's type-specimens of *Ficus aspera* are totally different from the Australian plants determined as such by Bentham. Forster's original diagnosis is so short that it is impossible to identify the plant with certainty without the type, but Prof. Warburg had the type before him, from Sprengel's Herbarium in the Berlin Museum, and is consequently in a position to judge.

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* New for New South Wales.

The following information is given by Prof. Warburg in a footnote :—

"As Forster's type-specimen of *F. aspera* from the Sprengel Herbarium is in the Berlin Herbarium before me, it would be well to supplement Forster's exceedingly short original diagnosis, especially as Seemann's description is made from Fiji specimens. *F. aspera* Forst., is a species growing in Tanna (New Hebrides), with fruits the size of the ordinary fig. The specimens before me are 15 mm. in diameter, the leaves are thin, 18 cm. long, glabrous, scarcely rough above, not dentate; the receptacles are nearly globular, densely, nearly felt-like, covered with greyish-yellow hairs, they have stalks 4 mm. long and 2 mm. thick, the ostiolum protrudes like a hunch, but the bracts of which do not stand like a crown outside on the receptacle, but one sees only a few points protruding from the narrow opening; the perigon-leaves of the gall-flowers are provided with a few cilia, mostly elongated and more or less obtuse, the ♂ flowers are monandrous, the perigon leaves hardly hood-shaped, female flowers not seen. The species belongs to the section Sycidium."

Prof. Warburg's paper on the Australian species of Ficus collected by himself, and in 1902 by Dr. Diels and Dr. Pritzel, contains descriptions of eight new species, but the other seven species—*F. cylindrica* Warb., *Cairnsii* Warb., *Pritzelii* Warb., *Dielsii* Warb., *subinflata* Warb., *trichostyla* Warb., *sitistyla* Warb. —are all Queensland plants, not extending south to New South Wales, as far as we know.

GRAMINEÆ.

* SPOROBOLUS BENTHAMI F. M. Bailey.

Lake Cudgellico (J. L. Boorman; May, 1906).

Previously recorded from Queensland, "about the Diamantina and Georgina Rivers." In New South Wales it grows in dense masses in "billabongs" or depressions subject to submersion in rainy seasons.

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* New for New South Wales.

* CYNODON CILIARIS Benth.

Yandama, North-western New South Wales (A. W. Mullen; April, 1906).

Previously only recorded from the Central Australian district of South Australia. The spikes, which are normally in pairs, are occasionally in threes in the New South Wales specimens.

CYNODON CONVERGENS F.v.M.

Bentham gives, in the "Flora Australiensis," two localities for this grass, *i.e.*, Upper Victoria River (F.v.M.) and Cabramatta (Woolls), but Mueller omits it from New South Wales in his "Census." It is difficult to say whether this omission is a clerical error, or whether he regarded the grass as introduced in the Cabramatta locality (now called Rossmore), about 20 miles south of Sydney. Dr. Woolls himself did not regard it as an introduced plant, as is proved by his inclusion of it in his list of "Plants Indigenous to the Neighbourhood of Sydney"; therefore, we think it should be added to the "Census of the Flora of New South Wales." Such a jump in the habitat of a plant from Cabramatta to the Upper Victoria River is peculiar, but not without precedent, and the grass is in appearance so much like the common *Cynodon Dactylon*, that it may have been overlooked till now in the intervening country, especially as the Australian flora is still so very imperfectly explored in detail.

* CHLORIS DIVARICATA R. Br.

Yandama, North-western New South Wales (A. W. Mullen; April, 1906).

Recorded in Mueller's "Census" from North Australia and Queensland. Mr. Max Koch, who did good work in the botanical exploration of South Australia, discovered it in 1900 at Mt. Lyndhurst in that State, and now we are able to record it from New South Wales.

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* New for New South Wales.

Eragrostis concinna Steud.

Paroo River flats, on white sandy soil (A. W. Mullen; April, 1906).

A Central Australian grass, previously recorded from South Australia, Queensland and North Australia. The grain is not described in the "Flora Australiensis"; it is small, narrow-ovate, pale coloured and quite smooth.

Rottboellia truncata, n sp.(Plate lxix.).

Yandama, North-western New South Wales (A. W. Mullen; April, 1906).

A glabrous annual about 9 inches high, with erect somewhat geniculate flattened stems, branched chiefly at the base. Leaves 2 to above 4 inches long, about $1\frac{1}{2}$ lines broad, tapering to a point, the sheath long, rather loose, striate as the blade, and with a short ciliate ligula. Spikelets mostly in threes, rarely in pairs, the lowest group occasionally in fours. all sessile on the alternate sides of a flat and very brittle rhachis, closely appressed so as to form a false spike enclosed when young in the leaf-sheath. Length of the false spike about 3 inches or more, but the articulate rhachis is so fragile that it breaks up into articles, and a whole spike can rarely be seen in dry specimens. When the number of spikelets in the group is 4, one is sessile on the base and the others on the alternate sides of a flattened rhachis prolonged beyond the insertion of the last spikelet, so that no spikelet is terminal, the whole resembling the false spike in miniature, with single spikelets instead of groups of spikelets. The arrangement of the spikelets is the same in the triplets, and, when in pairs, one spikelet is sessile and the other on a flattened pedicel, as in typical *Rottboellia.* Outer glume of the sessile spikelet broad-linear, flat, truncate, about 1 line long, of rather thin texture, pale-coloured, but striate with 4 to 6 green ribs not reaching quite to the truncate apex, giving it a callous appearance Second glume at least $\frac{1}{3}$ longer than the outer one, but of similar shape, the truncate apex rather narrower and somewhat jagged, the texture firmer and the green ribs fewer. Third glume nearly twice as long as the second glume, acuminate, concave on the back with raised sides, empty, but with a similarly shaped shorter palea. Fourth glume ovate, tapering to a fine point as long as the palea of the third glume, somewhat hardened, veinless but minutely rugose, with a bisexual flower and a similar but smaller and thinner palea. The glumes of the second, third and fourth spikelets are similar, except that the third glume is mostly longer; all spikelets have a single bisexual flower, without any sterile flowers, as far as we could see from the material at our disposal. Styles and stamens 2. Grain not seen.

The grass differs in so many more or less important points from *Rottboellia* in the sense in which Bentham defined the genus, that we place it only with great hesitation in that genus.

EXPLANATION OF PLATE LXIX.

Rottboellia truncata.

Fig. A.—Plant; natural size.
Fig. B., Fig. C., Fig. D. } Articles of the rhachis, with groups of spikelets.
Fig. E., Fig. F. } Leaf-sheath with ligule.
Fig. 1.—First or outer glume of the spikelet.
Fig. 2.—Second glume.
Fig. 3.—Third glume.
Fig. 4.—Fourth or flowering glume.
Fig. 5., Fig. 6. } Flowering glume with the palea.
Fig. 7.—Pistil.
Fig. 8.—Spikelet.
Fig. 9.—Palea with pistil.

DONATIONS AND EXCHANGES.

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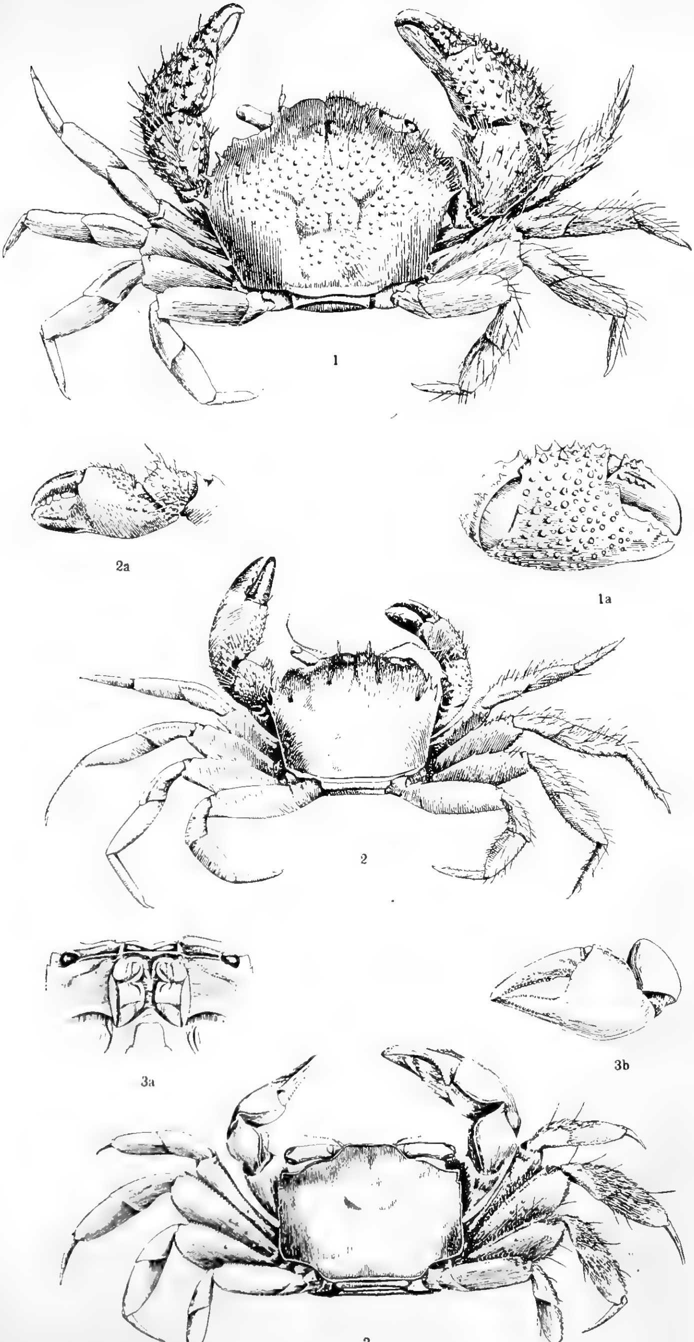

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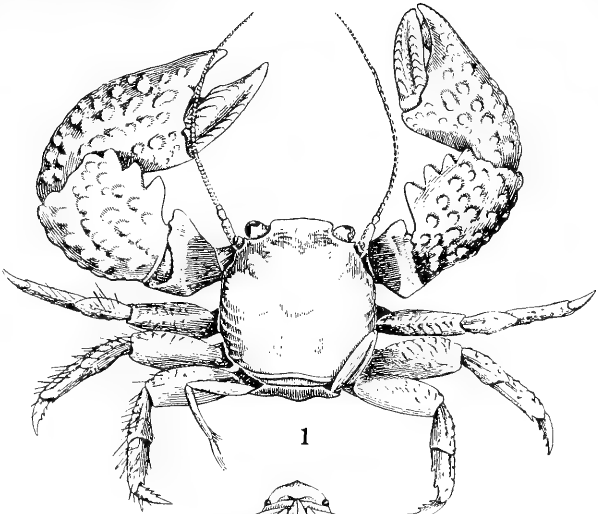

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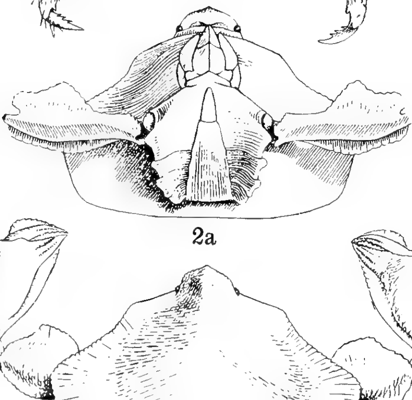

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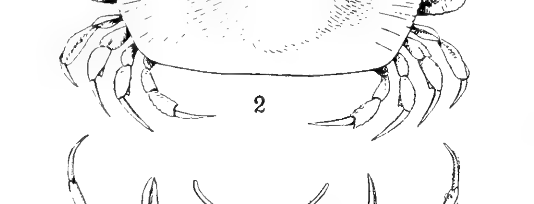

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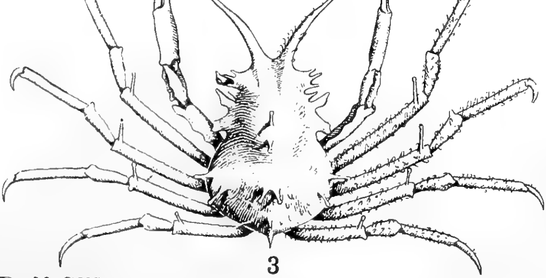

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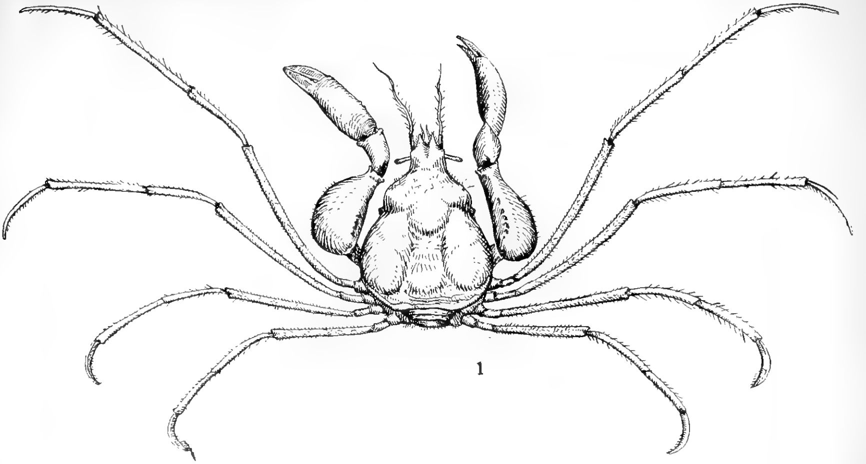

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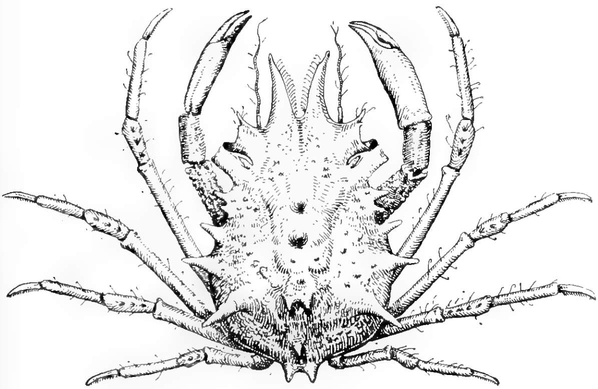

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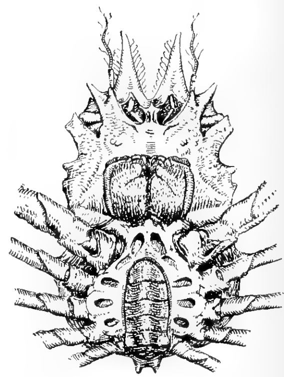

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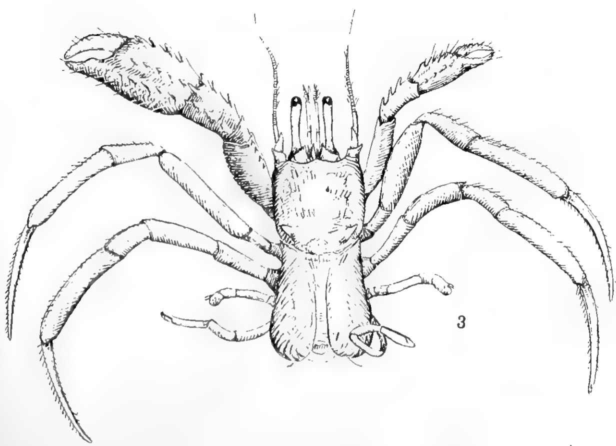

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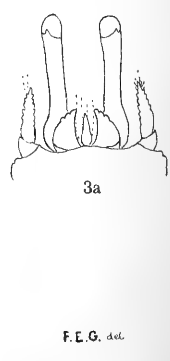

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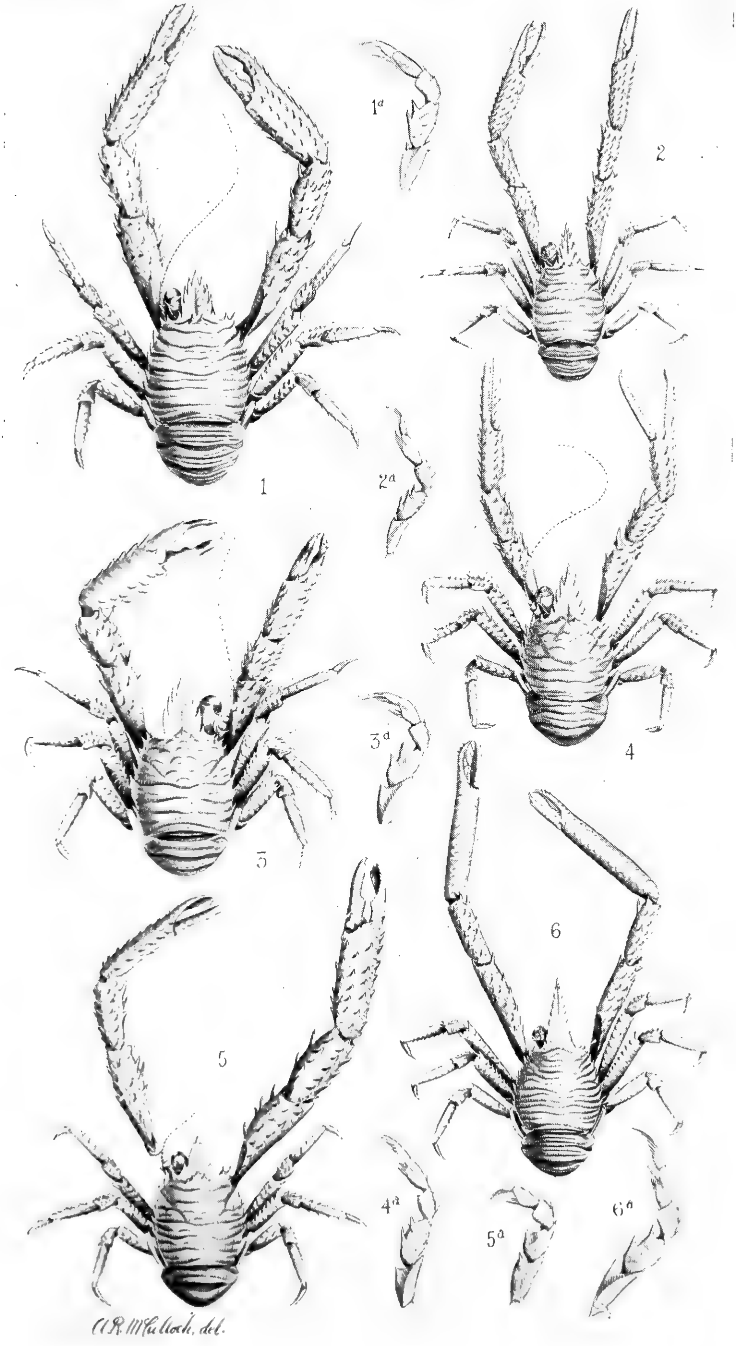

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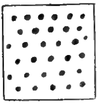
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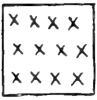
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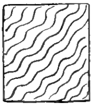
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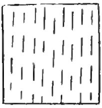
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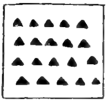
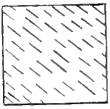
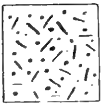
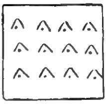
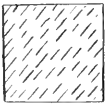
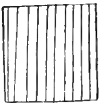

Hornblendic Schists, including Glaucophane Schist.

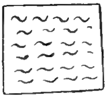

Undetermined Lavas and Tuffs, chiefly Rhyolite.

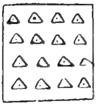

Trachyrhyolite.


Diorite and Porphyrite.


Undetermined Palæzoic.

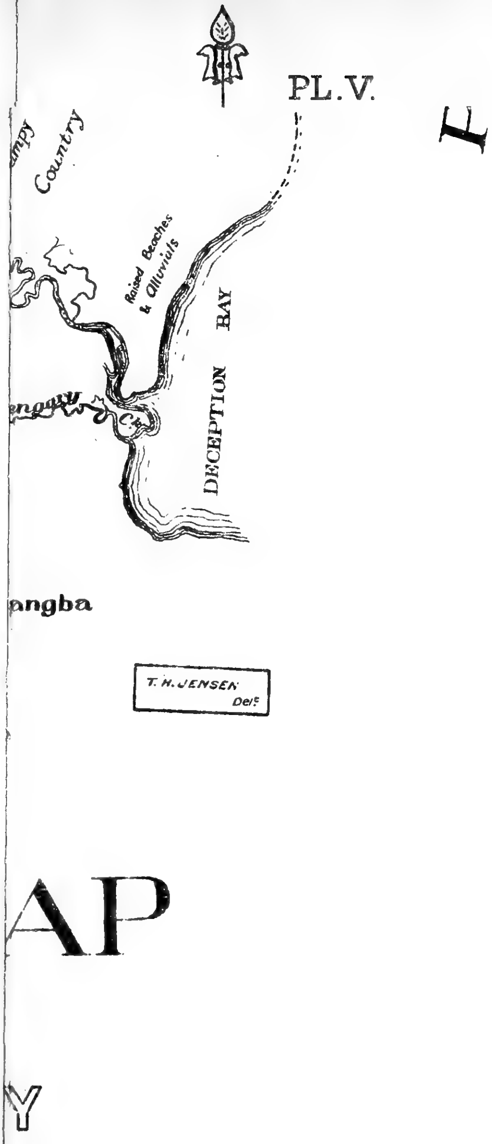

Basalt.

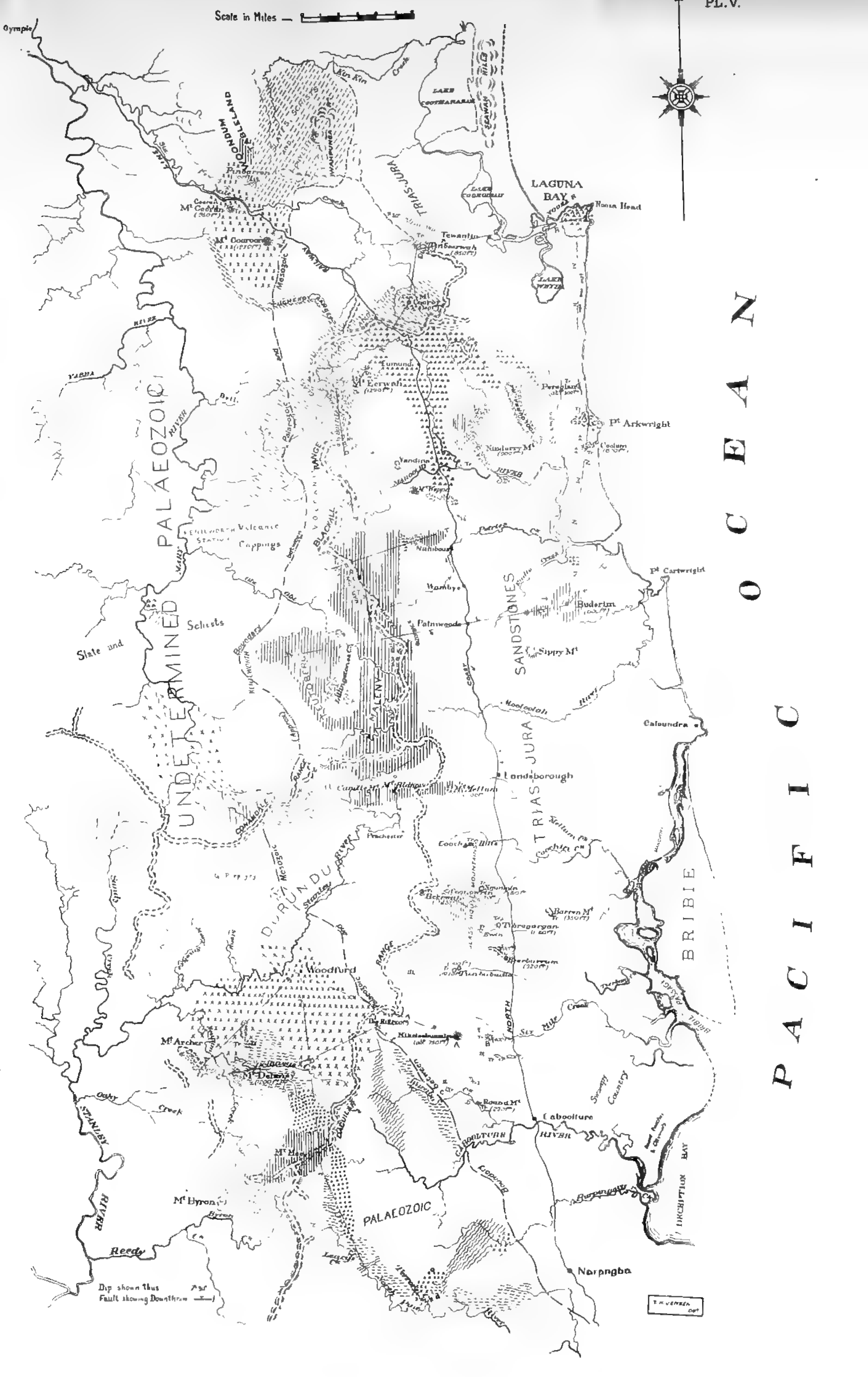

Phyllites, Mica Schist, and Granulites.


Andesite, Rhyolite Tuffs, and Breccias.

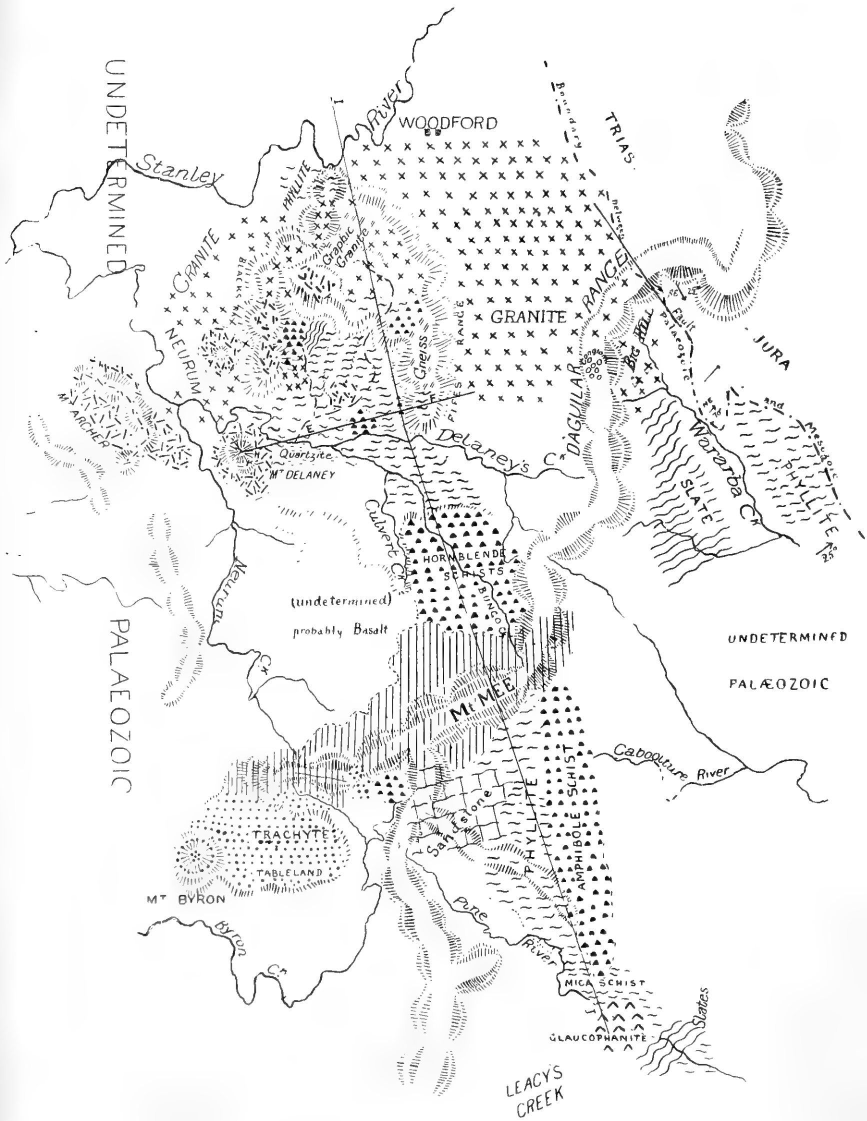
KEY PLATE TO GEOLOGICAL FORMATIONS IN THE MAP.

PL. V.


Country
Raised Beaches & Alluvials
DECEPTION BAY
angba
T. H. JENSEN Del.
AP
Y



GEOLOGICAL MAP
OF THE VOLCANIC AREAS
MORETON AND WIDE BAY DISTRICTS



GEOLOGICAL PLAN OF MT. MEE AND SURROUNDINGS.

Fig. 1—MOUNT ARCHER, WITH PORTION OF THE WOODFORD PENEPLAIN.

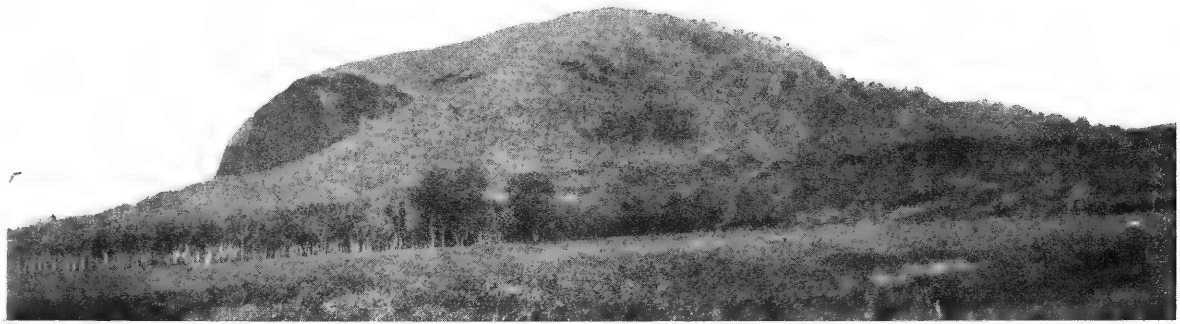


Fig. 2.—COO[illegible]IUM MOUNTAIN FROM THE N.N.E.

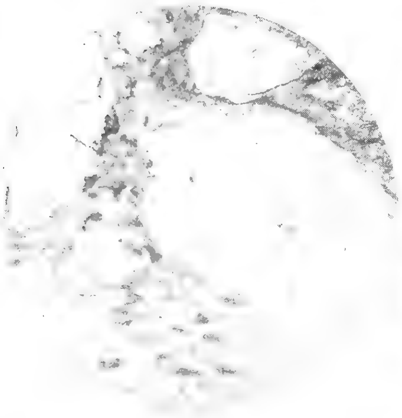
Fig. 1.
VIEW OF BLACKALL RANGE FROM COOLUM MOUNTAIN.

Fig. 2.
NIADHERRY MOUNTAIN FROM THE SOUTH-WEST.

SANDSTONE BLOCK INCLUDED IN VOLCANIC BRECCIA, NEAR YANDINA.

POINT ARKWRIGHT, SHOWING THE DIP OF SANDSTONES.

1



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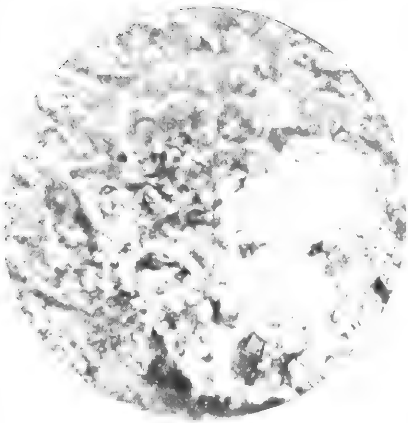

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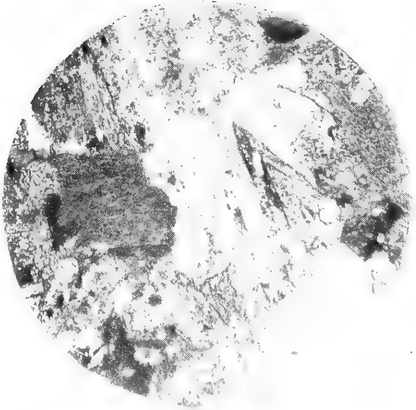

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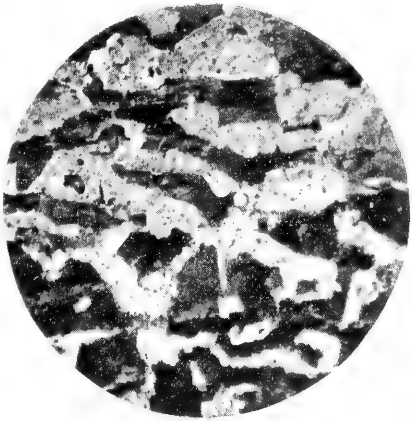

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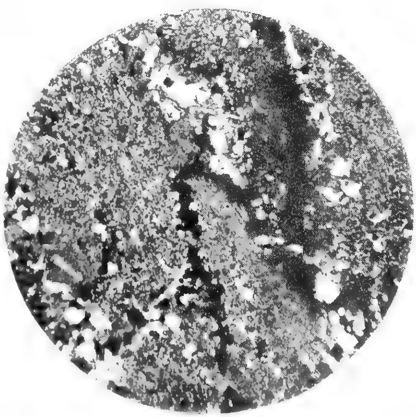

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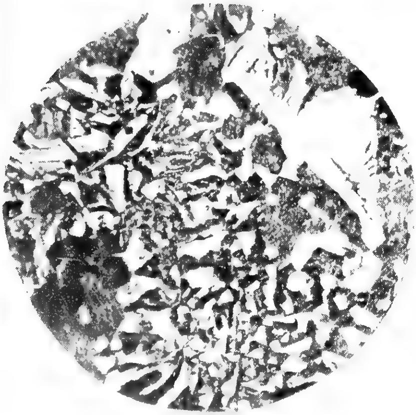

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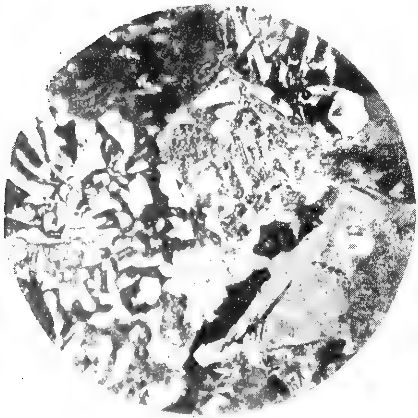

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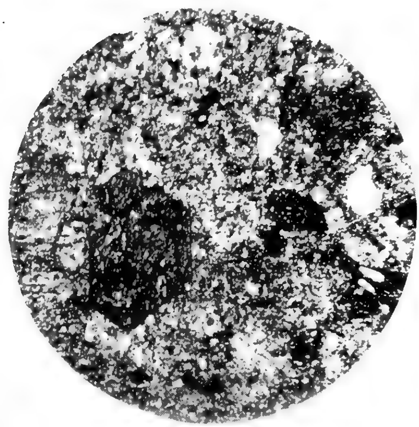

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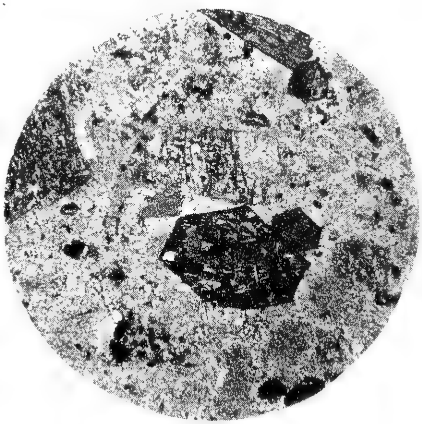

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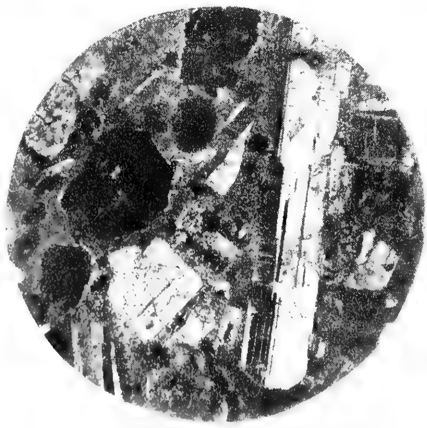

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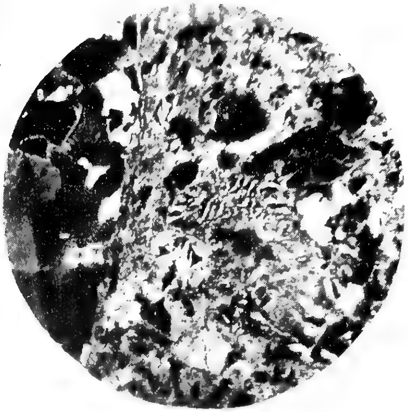

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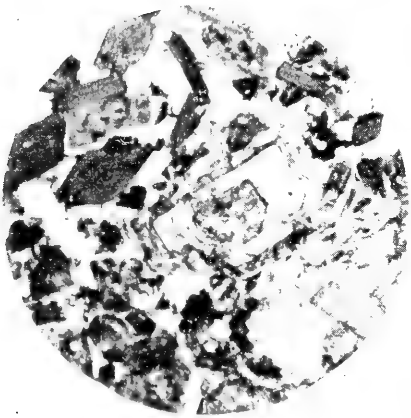

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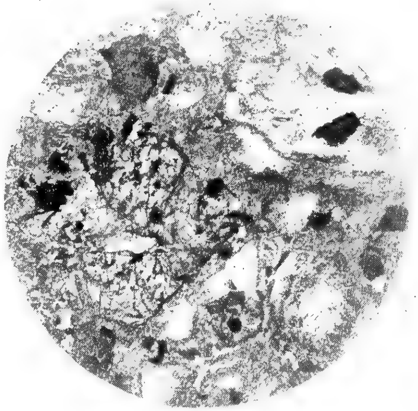

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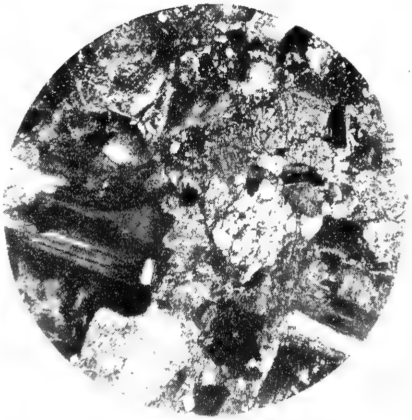

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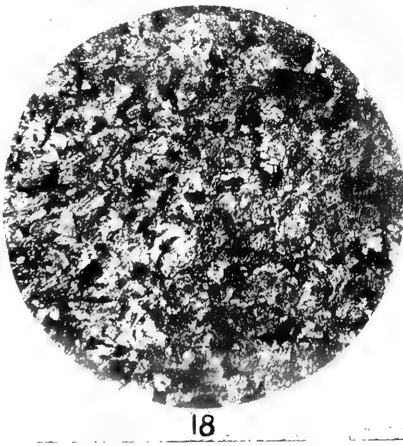

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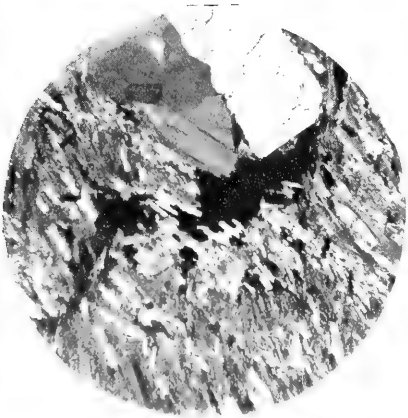

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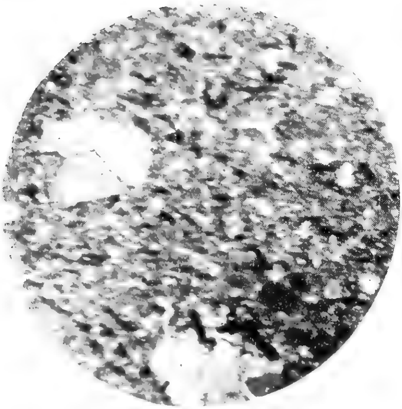

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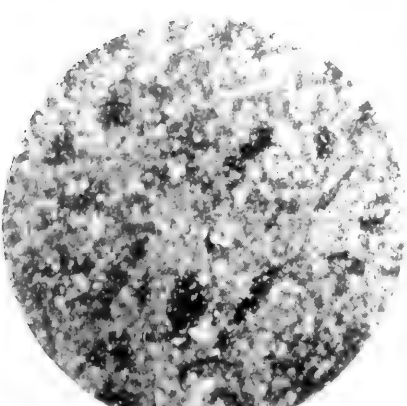

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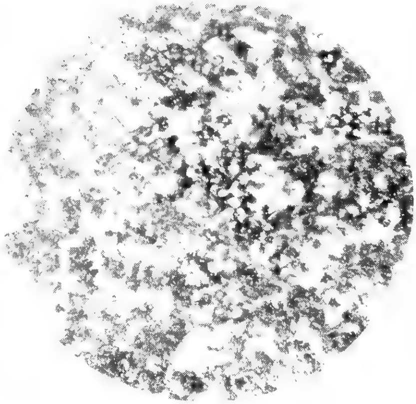

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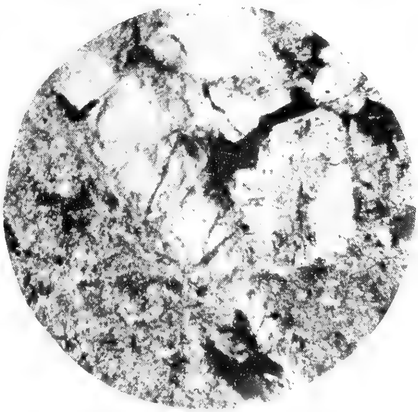

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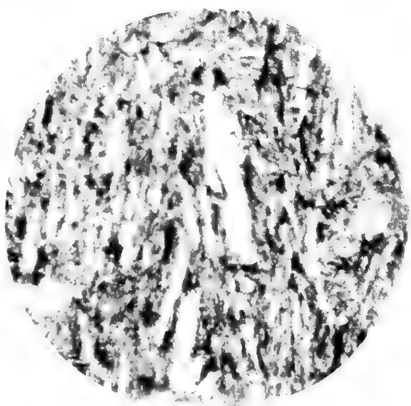

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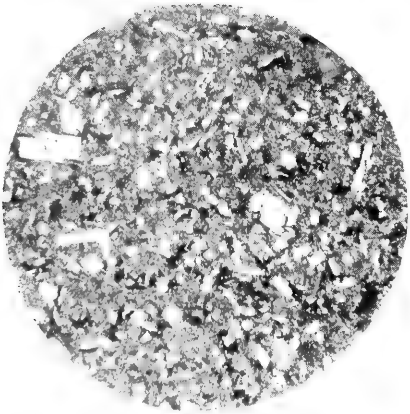

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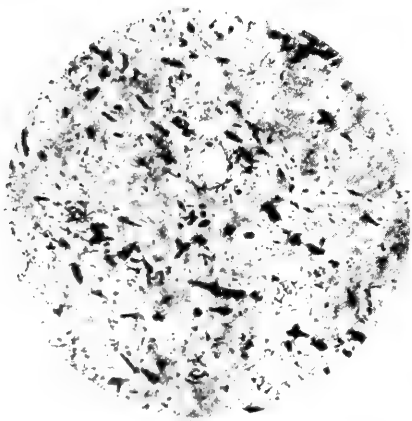

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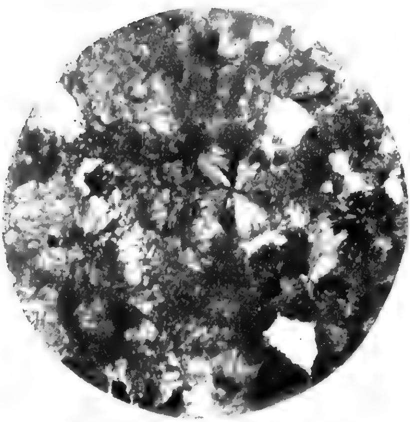

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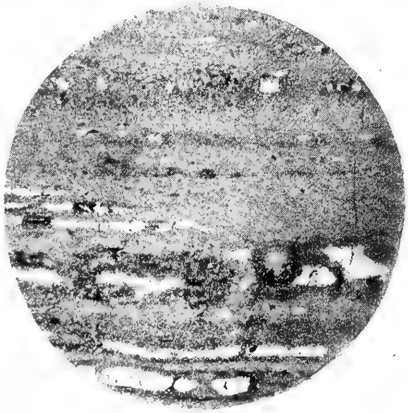

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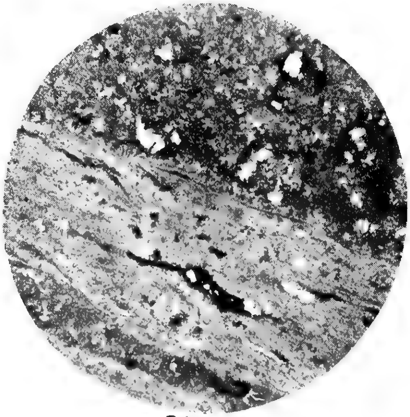

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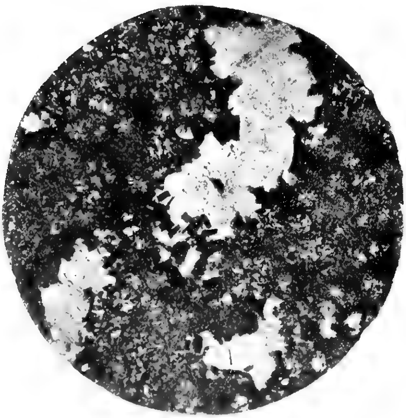

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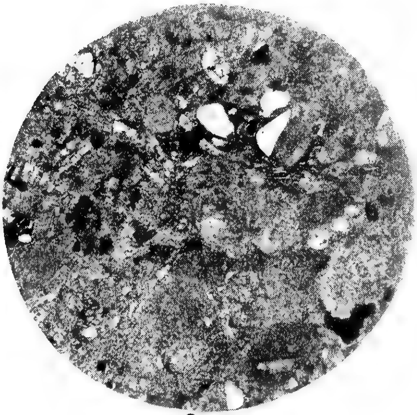

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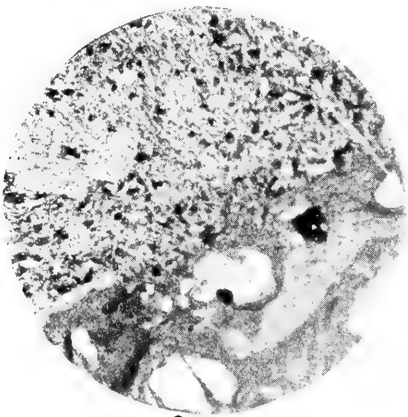

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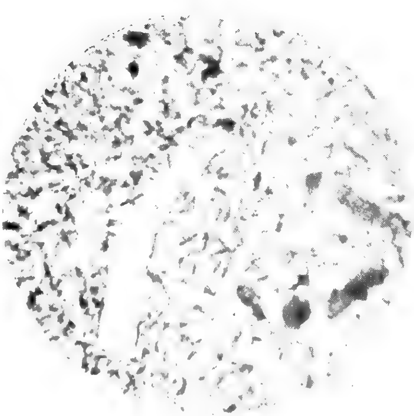

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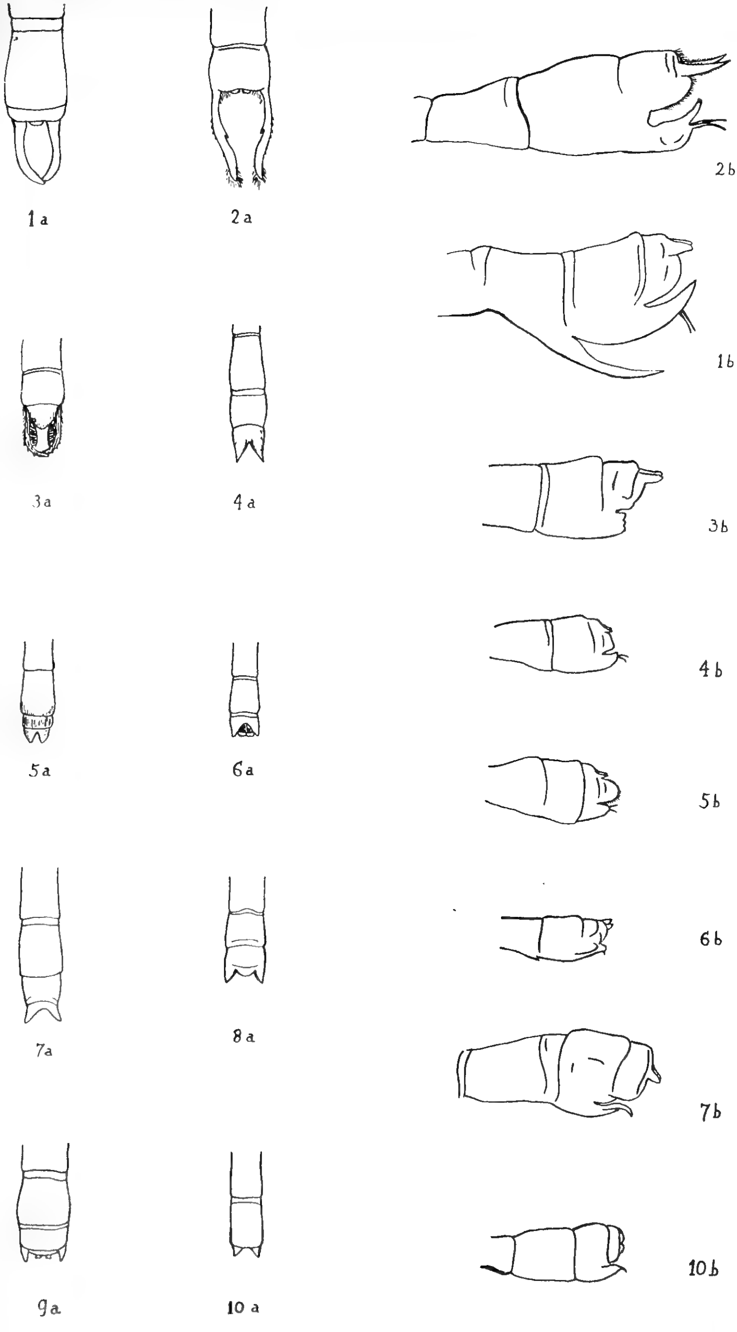

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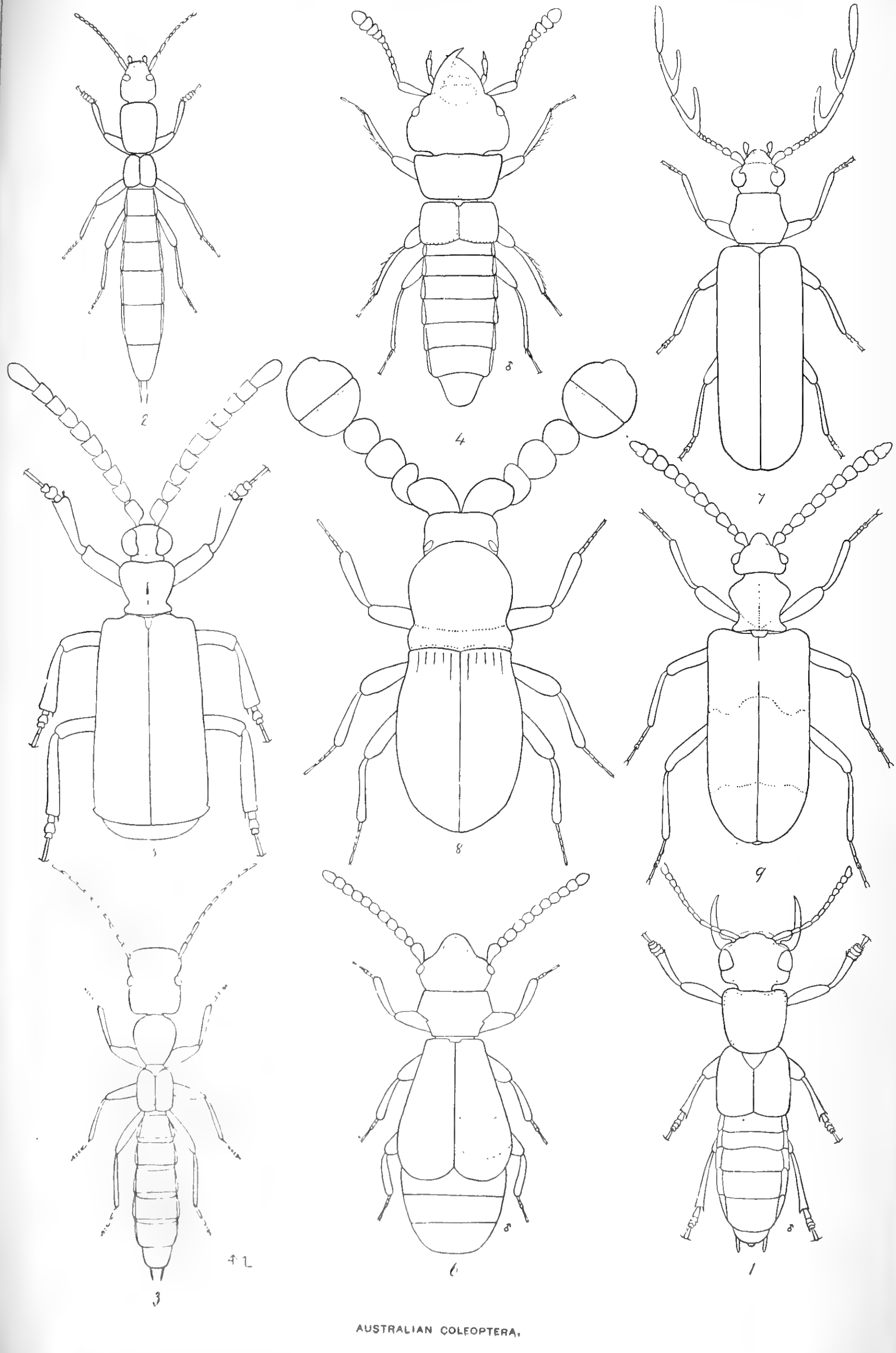
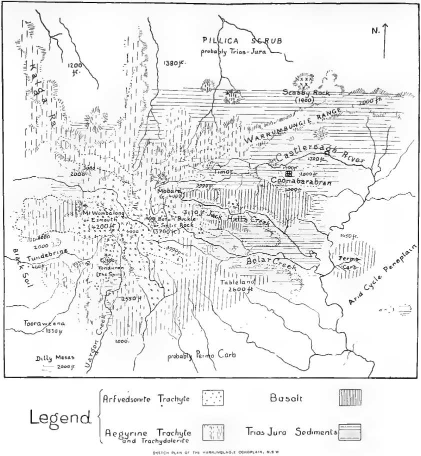
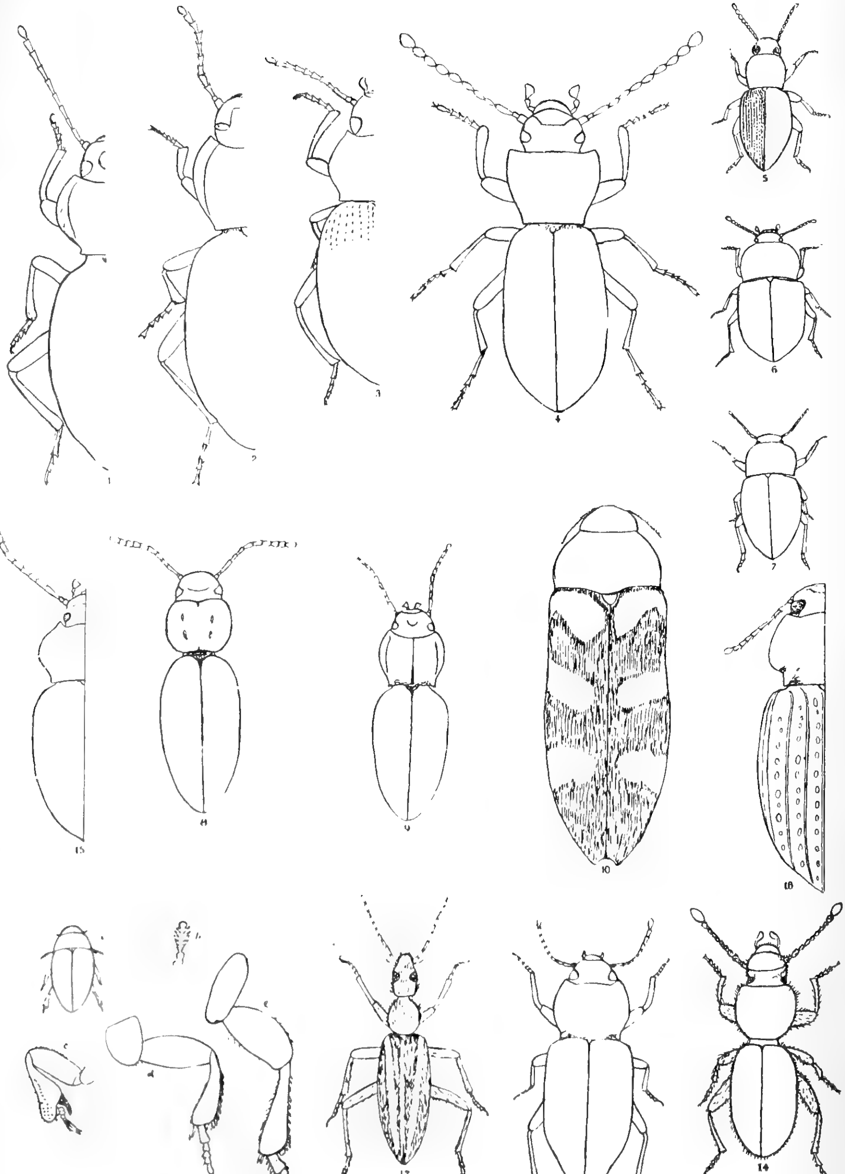


AUSTRALIAN COLEOPTERA.



SKETCH PLAN OF THE WARRUMBUNGLE CONOPLAIN, N.S.W



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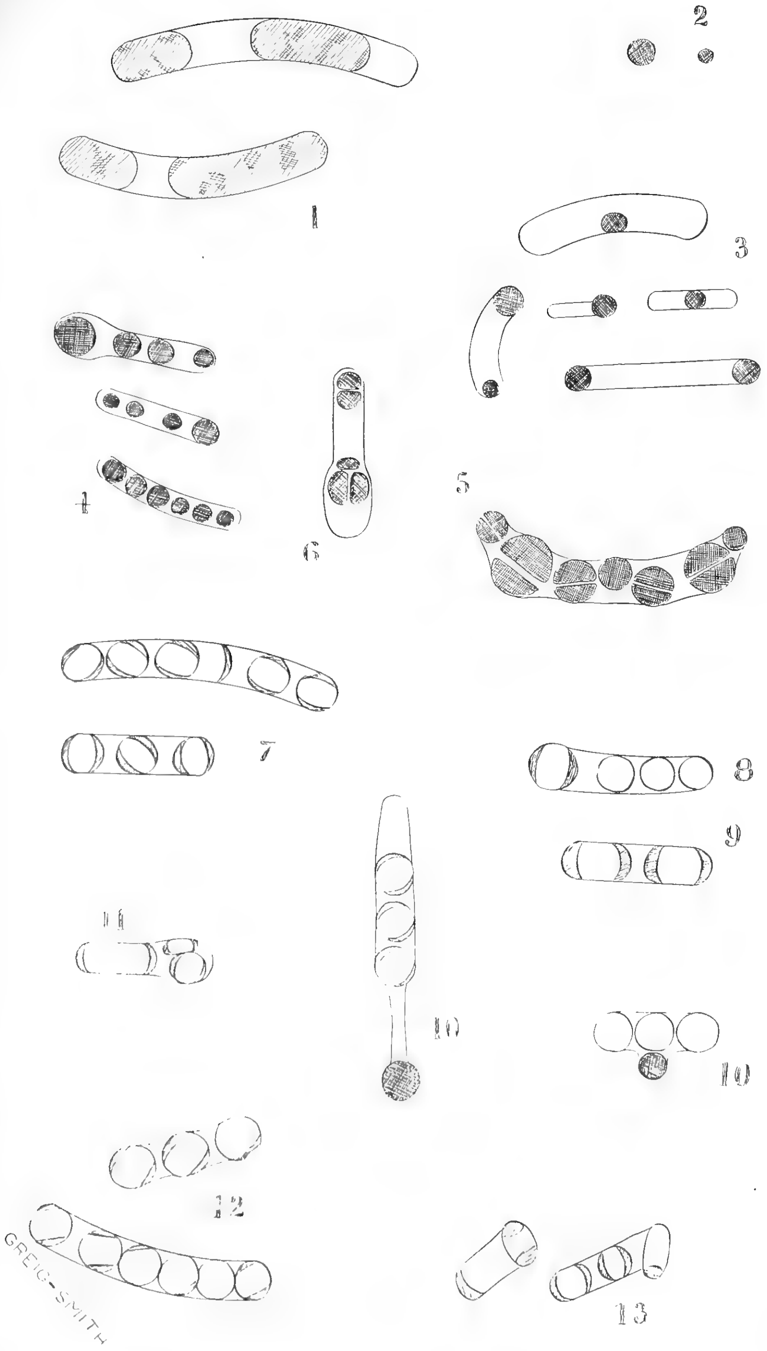
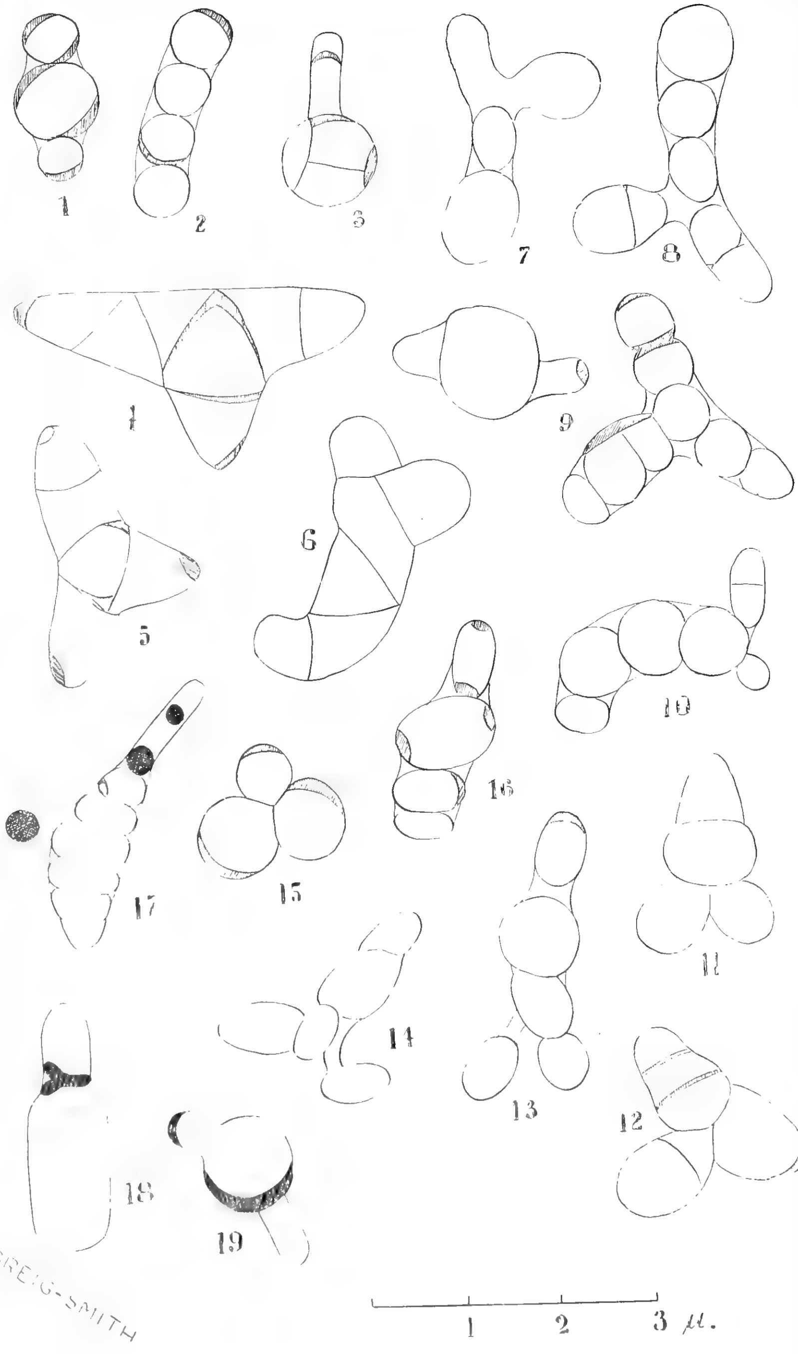


RHIZOBIUM LEGUMINOSARUM

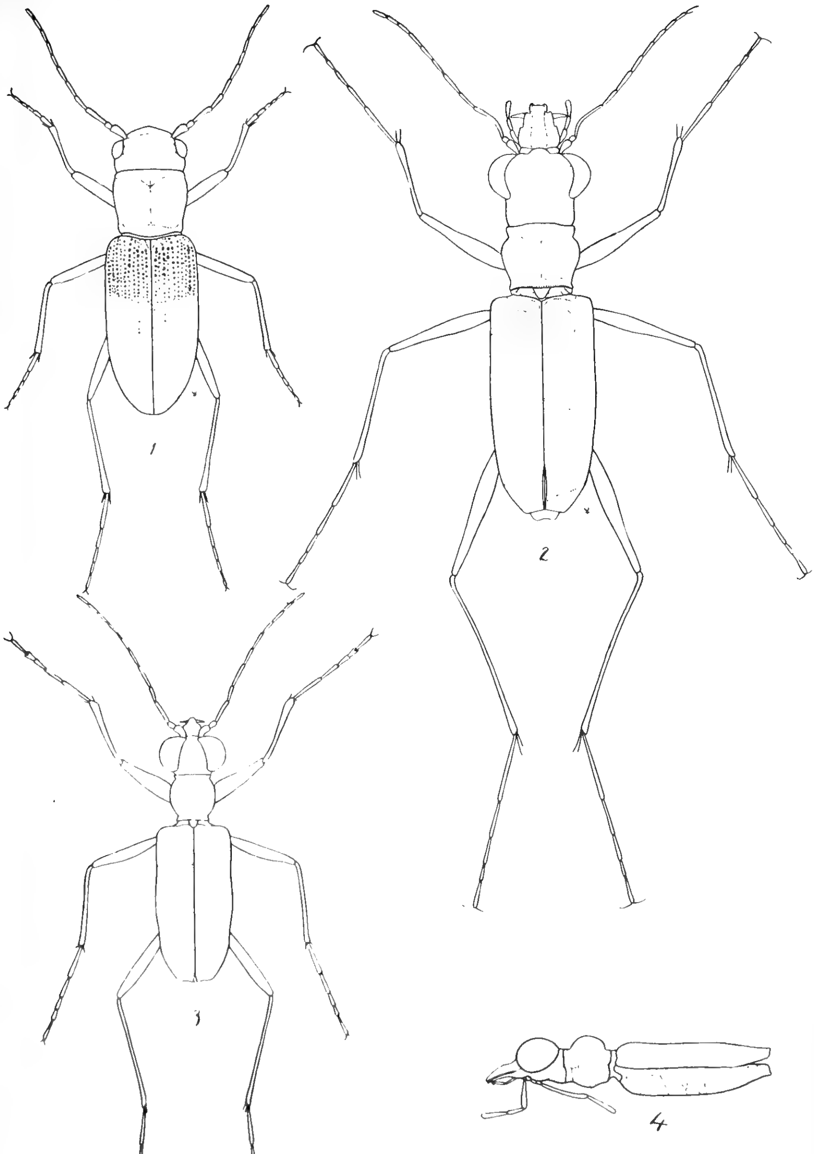


RHIZOBIUM LEGUMINOSARUM.

R.T.B. del ad nat.

EUCALYPTUS CARNEA R.T.Baker

R.T.B. del. ad nat. EUCALYPTUS THOZETIANA F.v.M. H.J.A. Baron, lith.



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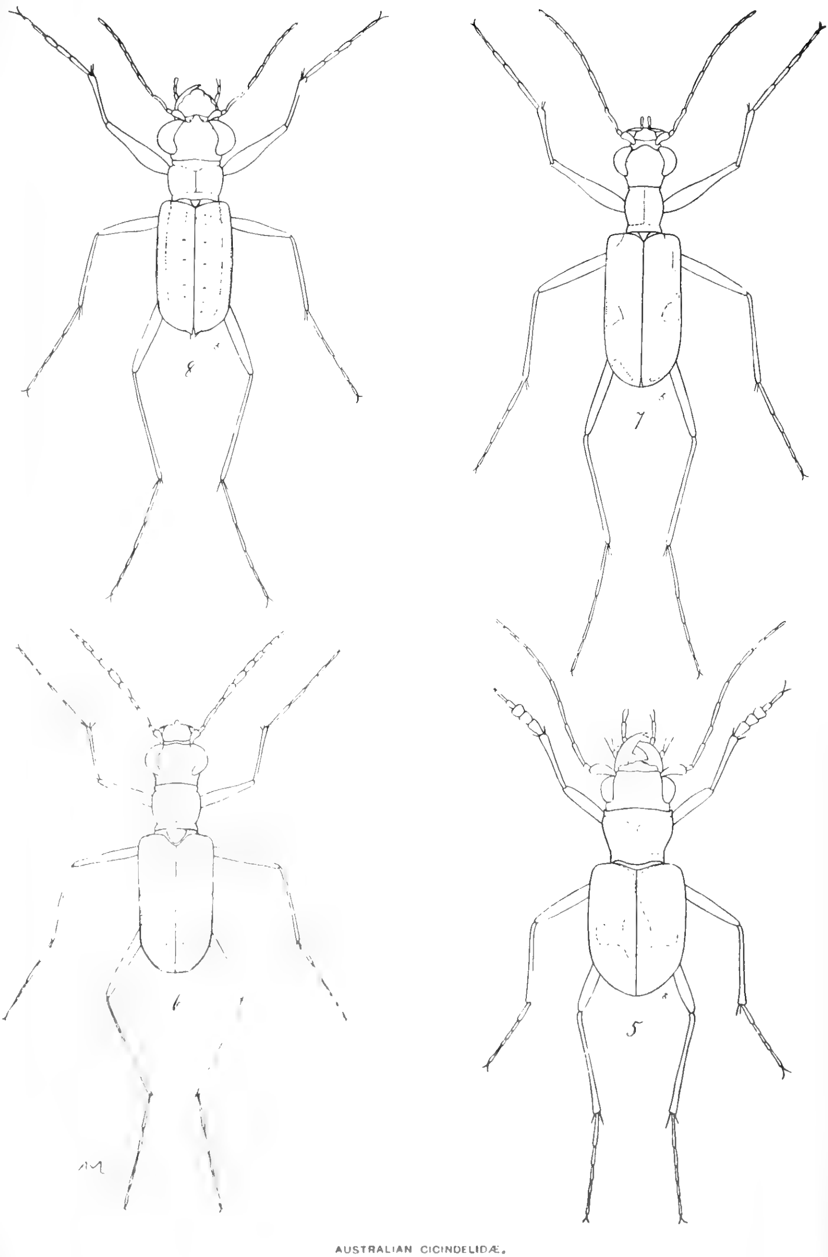

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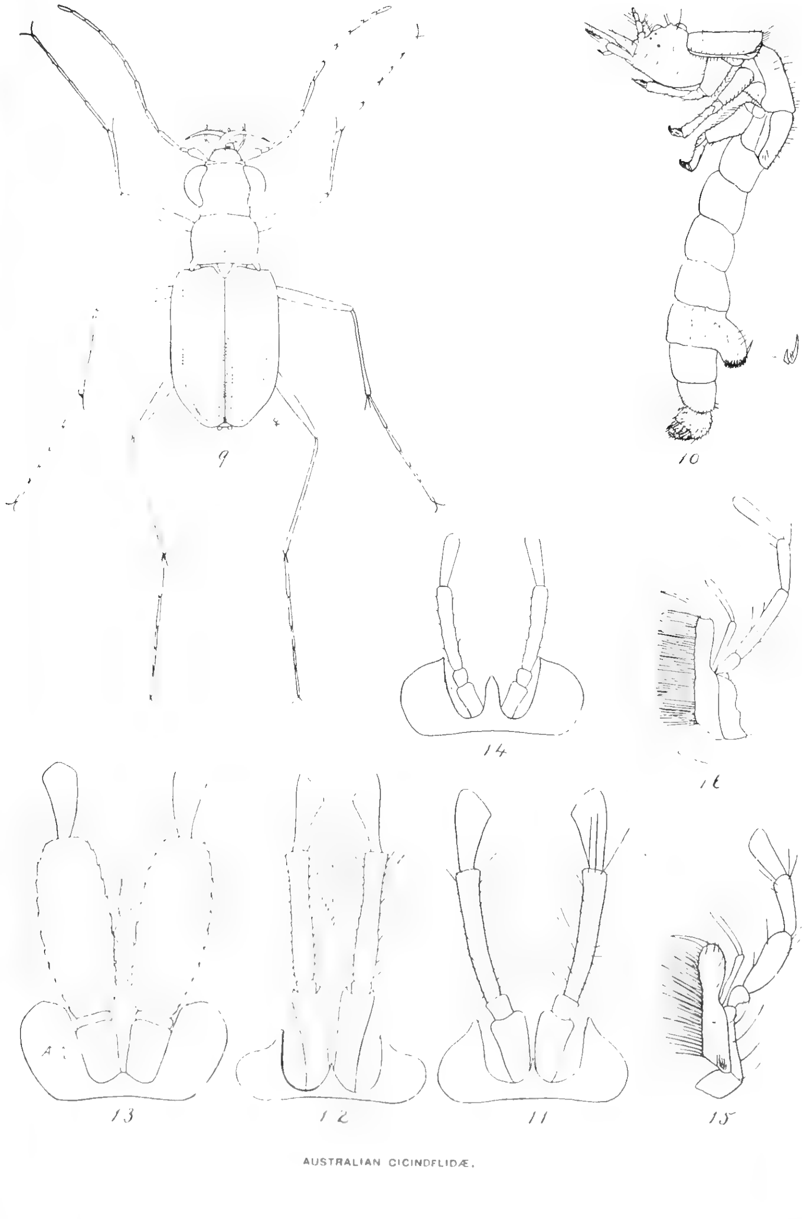

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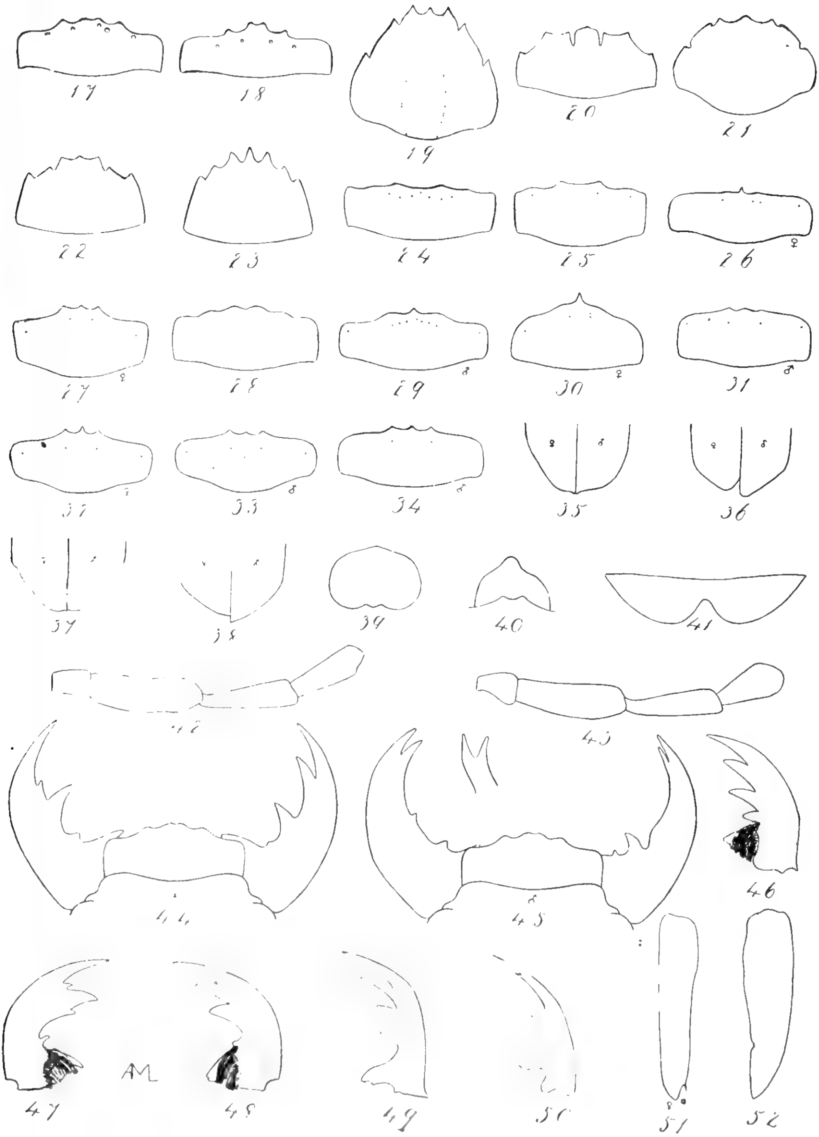

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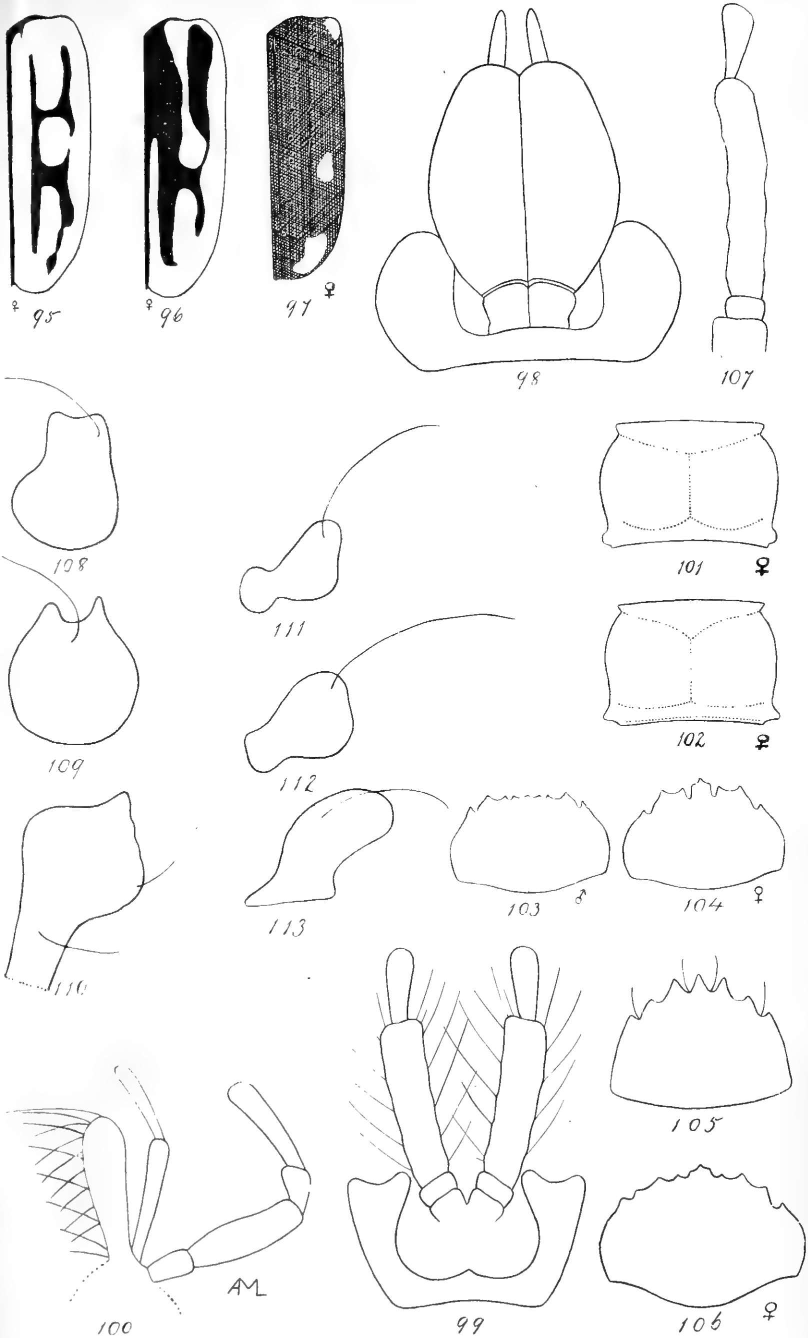
AUSTRALIAN CICINDELIDÆ



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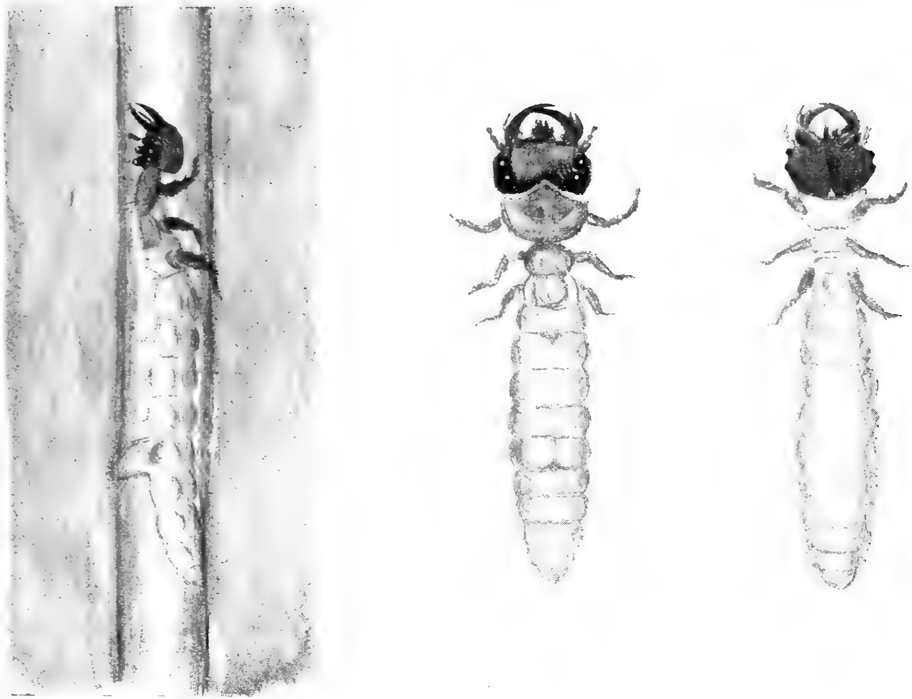
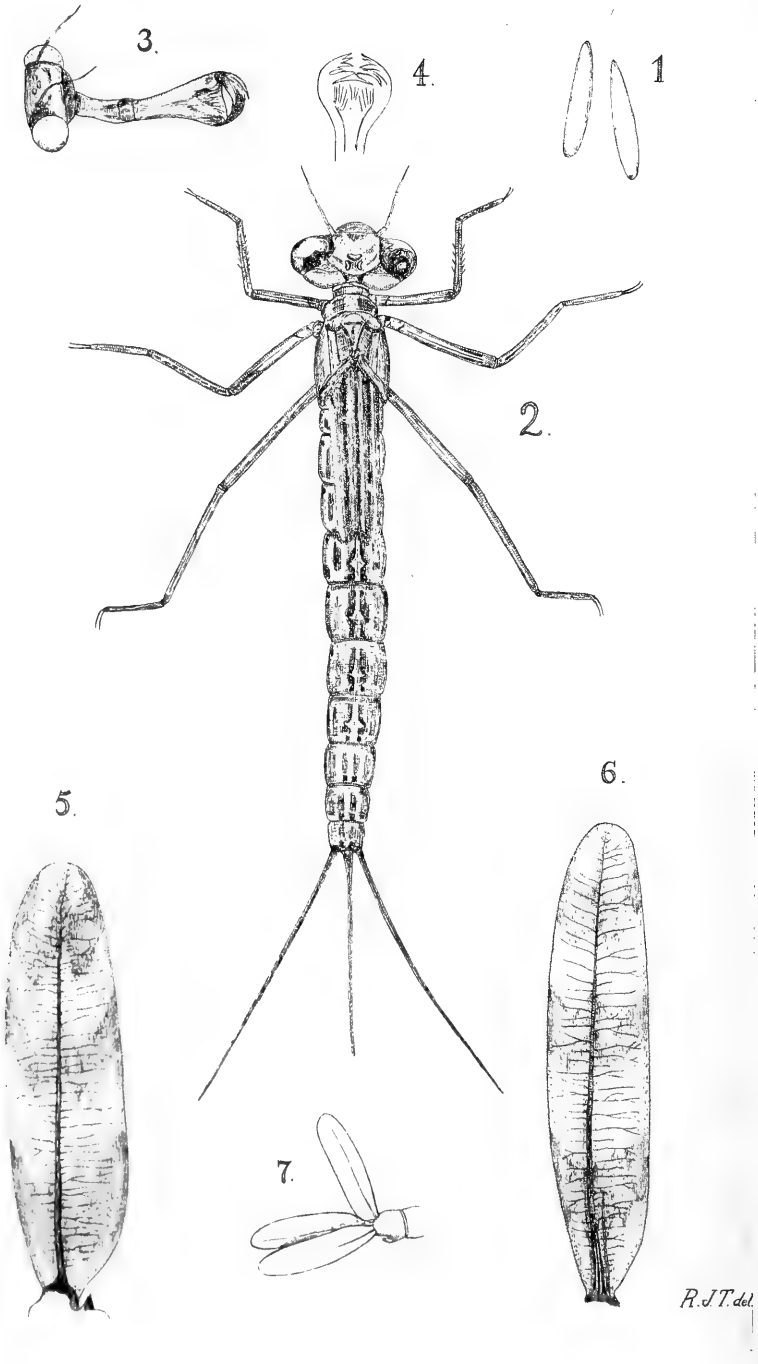
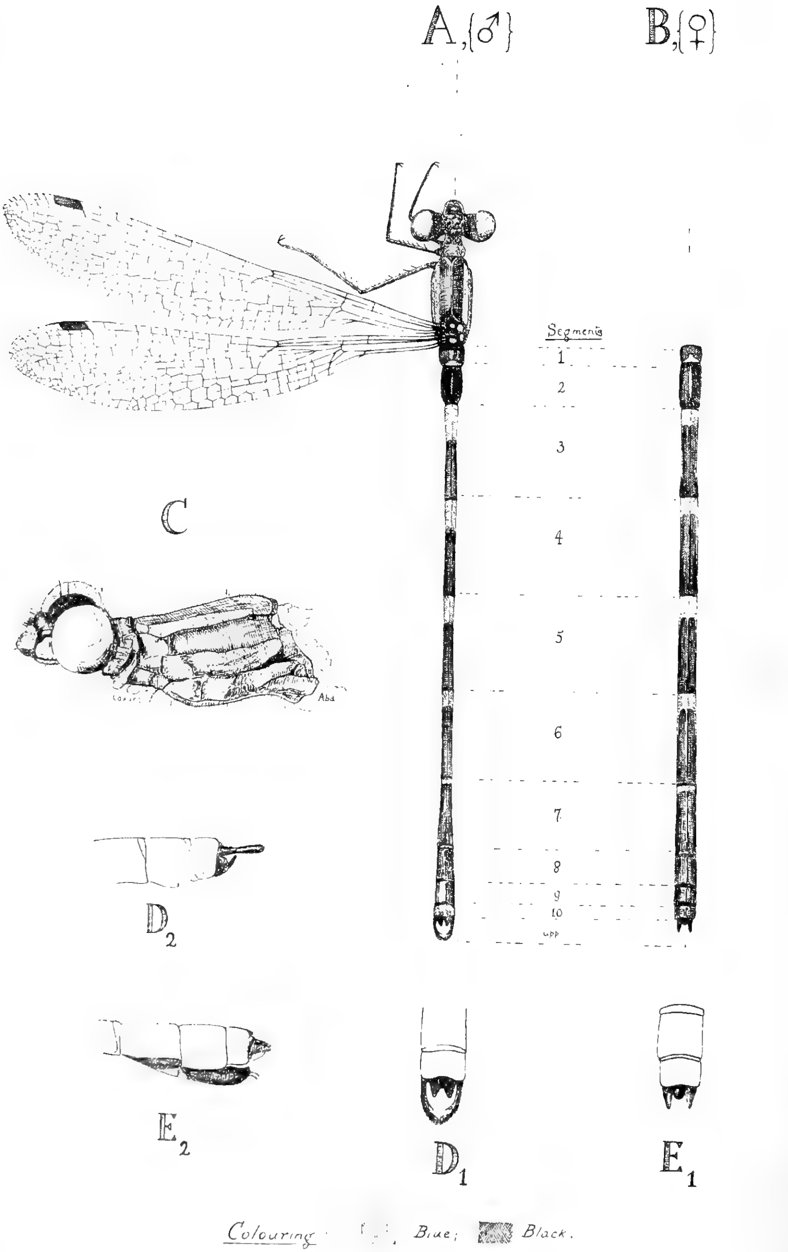


H.J.H. del.

LARVA OF *MEGACEPHALA AUSTRALIS* CHAUD.



LESTES LEDA SELYS.

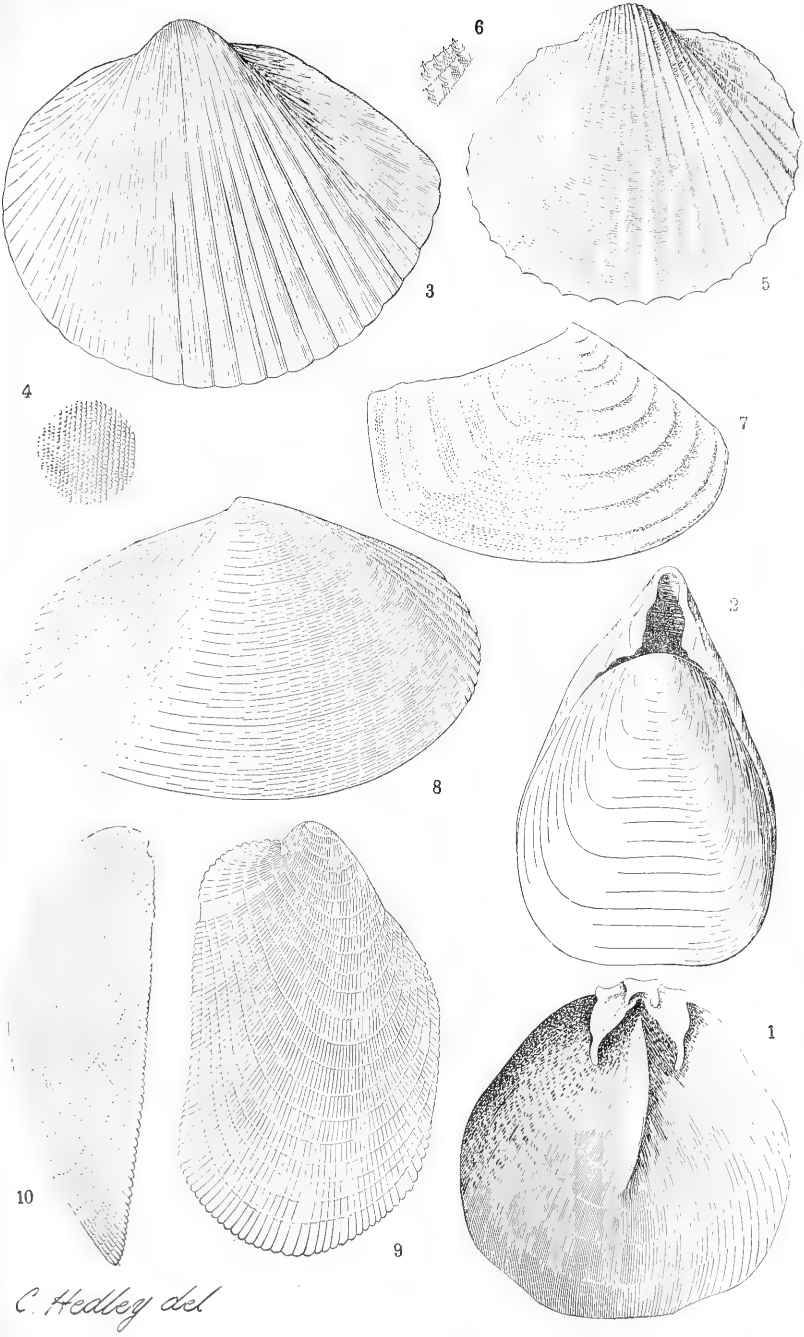


R.J.T. del.

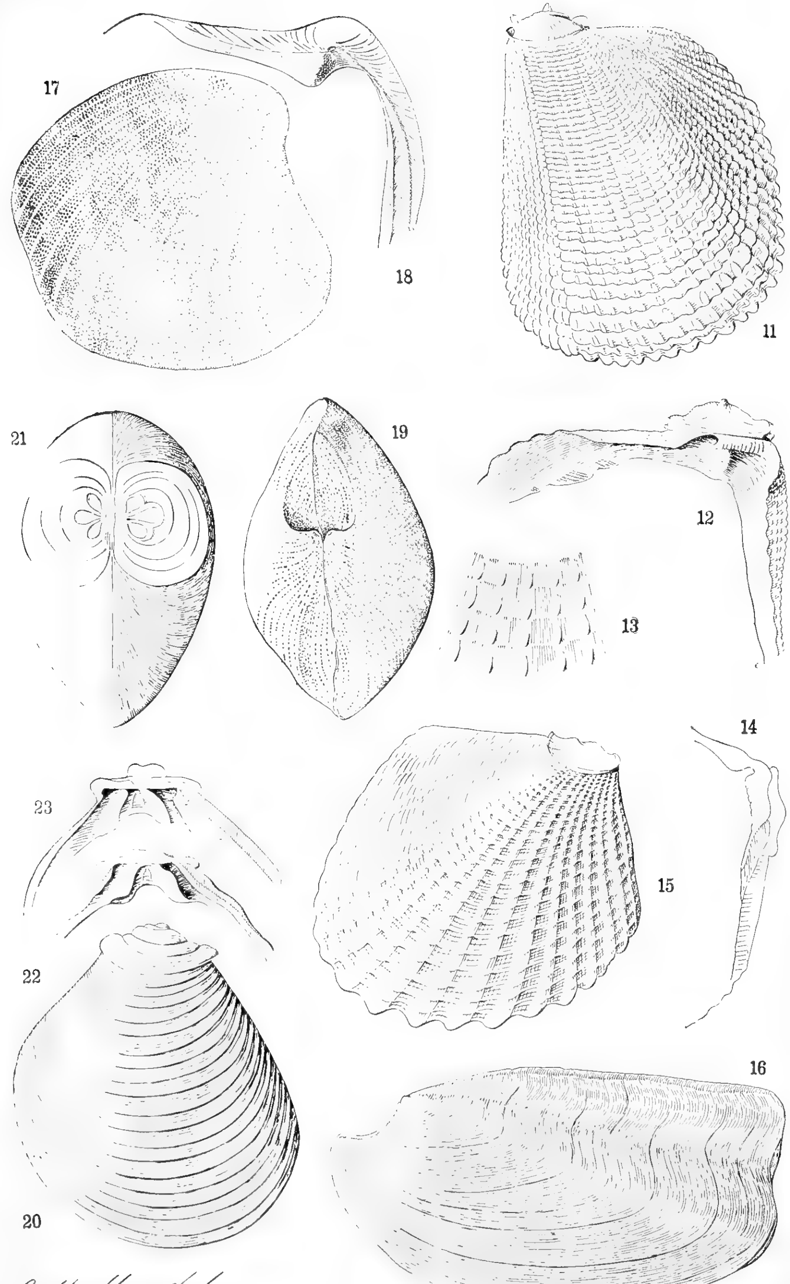
LESTES LEDA SELYS.

EUCALYPTUS MACARTHURI DEANE & MAIDEN.

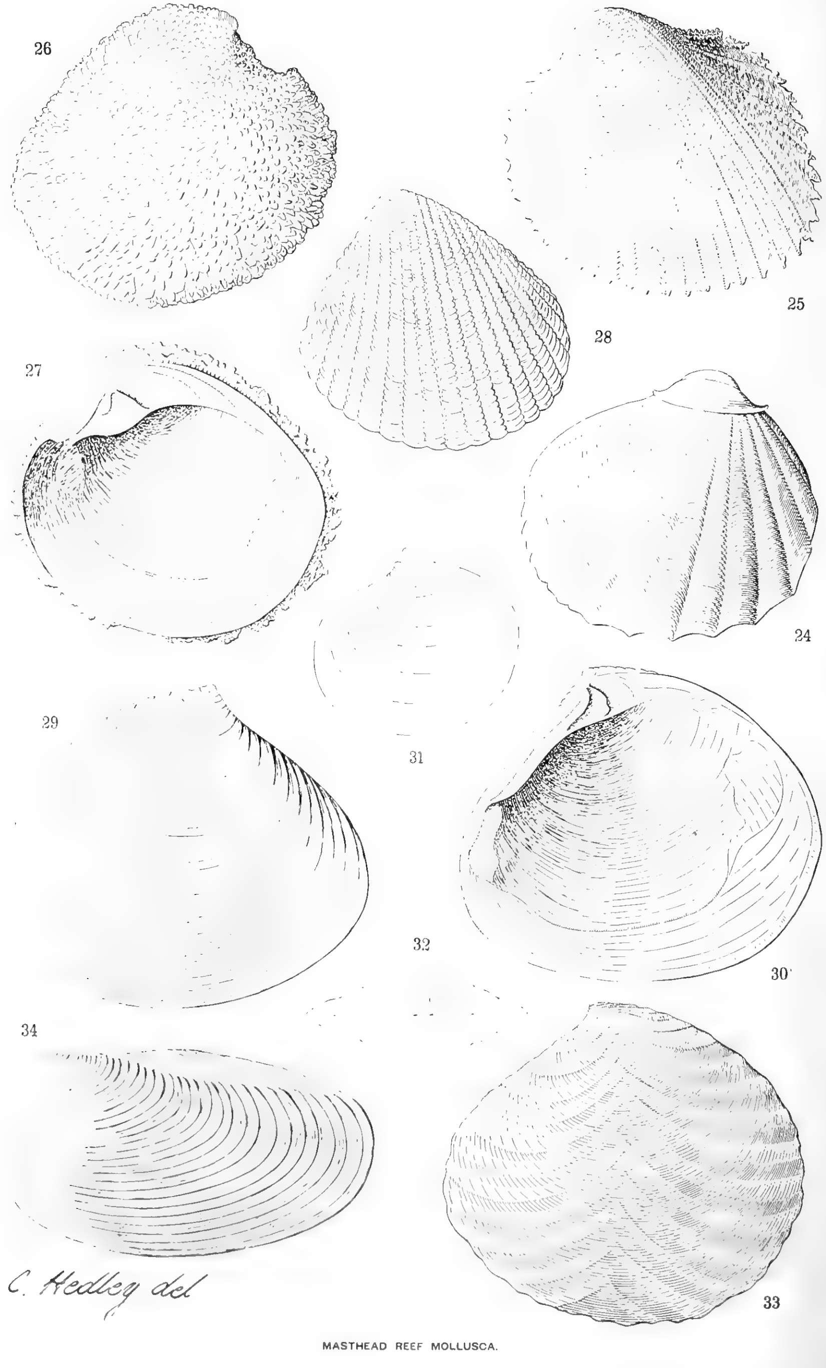
WOLLONDILLY RIVER, WOMBEYAN CAVES ROAD, LOOKING SOUTH.



MASTHEAD REEF MOLLUSCA



MASTHEAD REEF MOLLUSCA.



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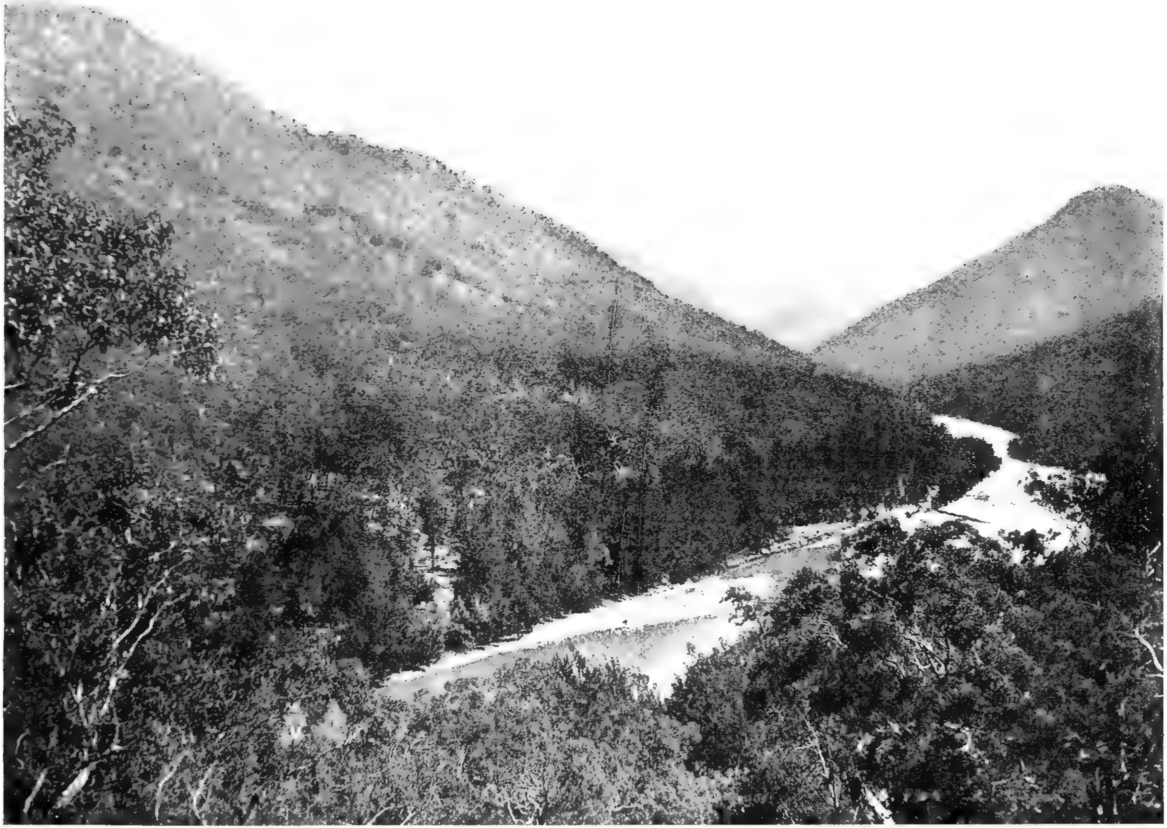
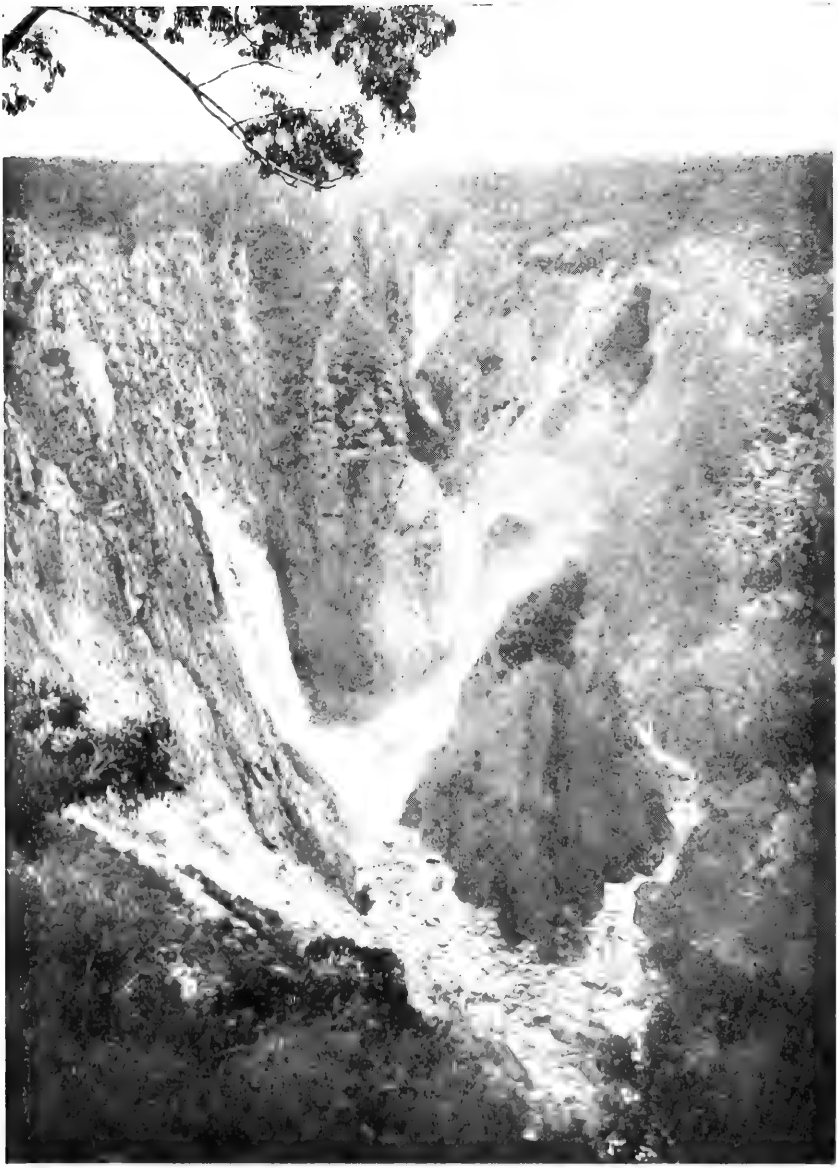


THE WOLLONDILLY (UPPER HAWKESBURY) CANYON AT WOMBEYAN CROSSING.



THE WOOLOOMUMBI FALLS SHOWING INCEPTION OF CANYONS.

BAKER'S CREEK GORGE, HILLGROVE, N.S.W.

PL. XLII

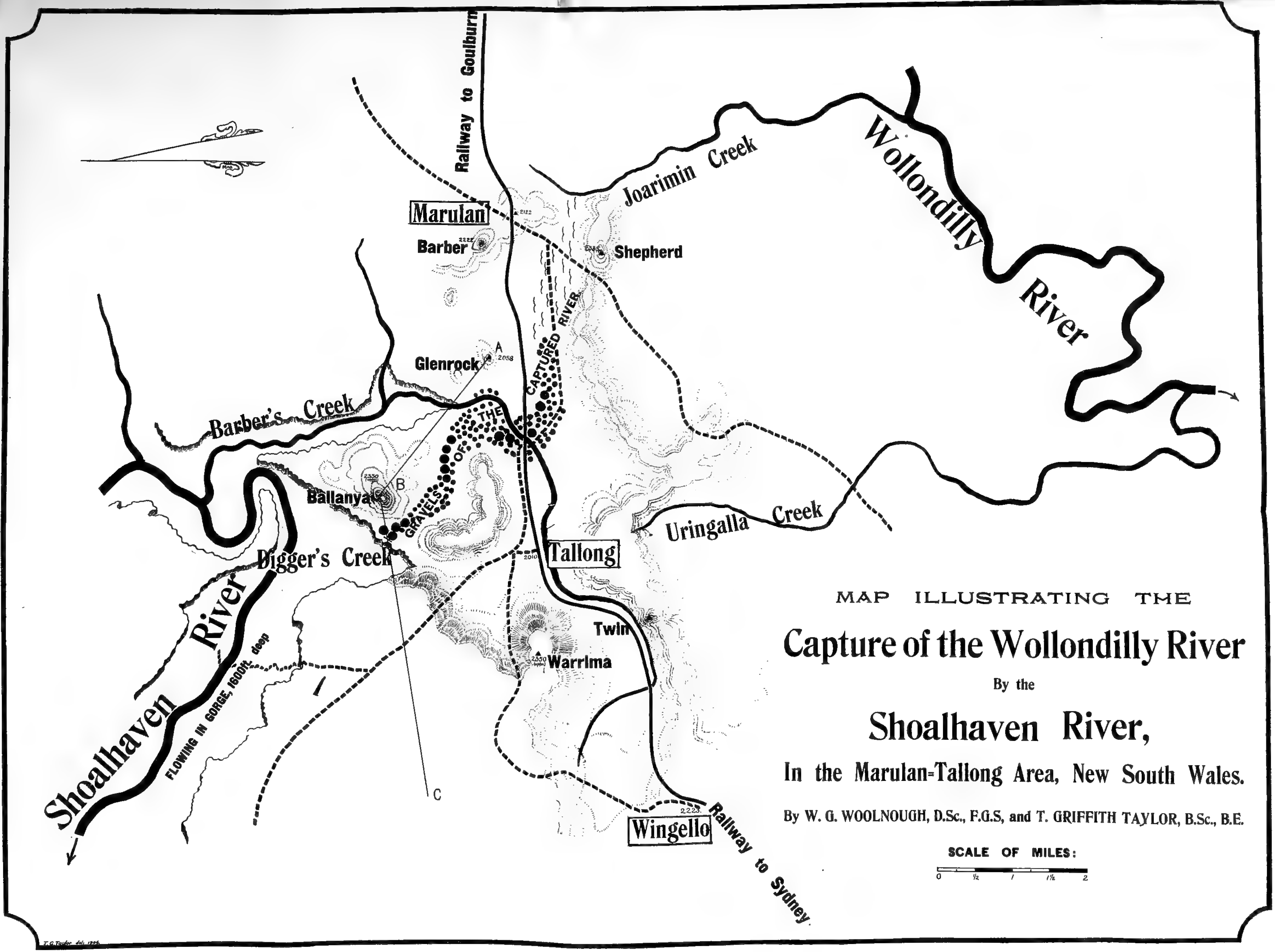
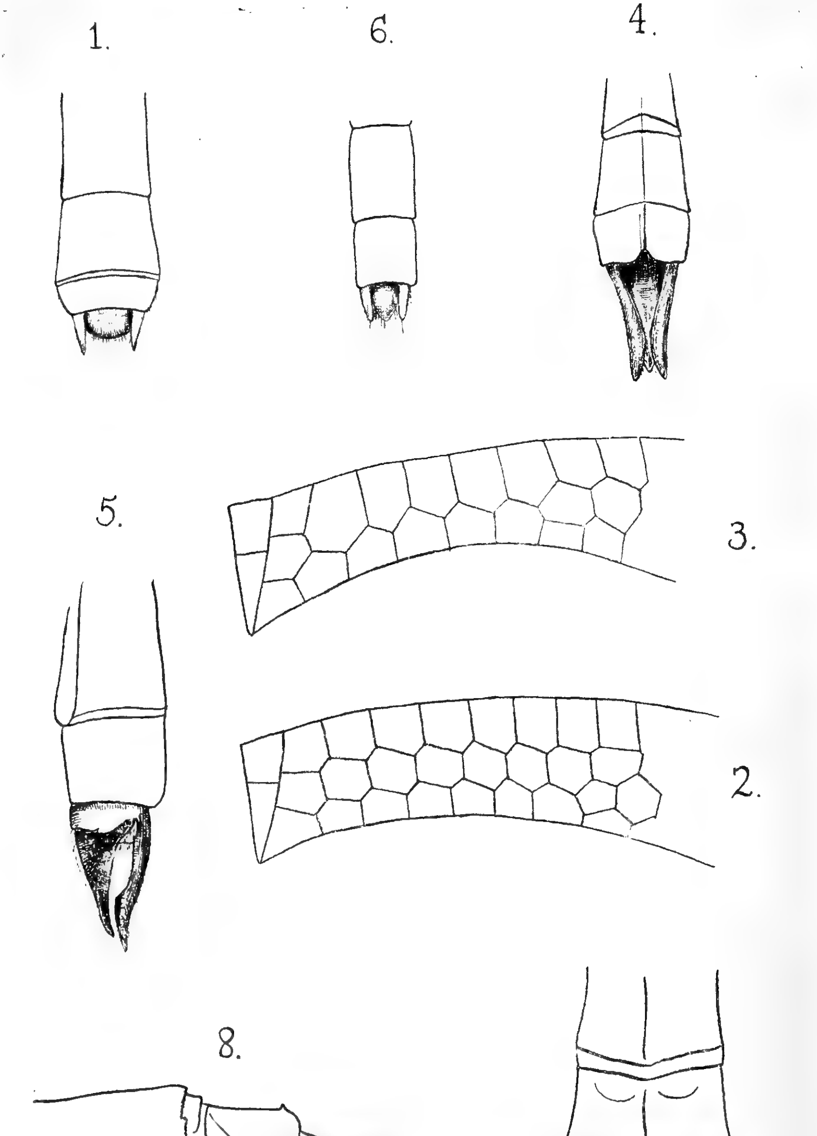
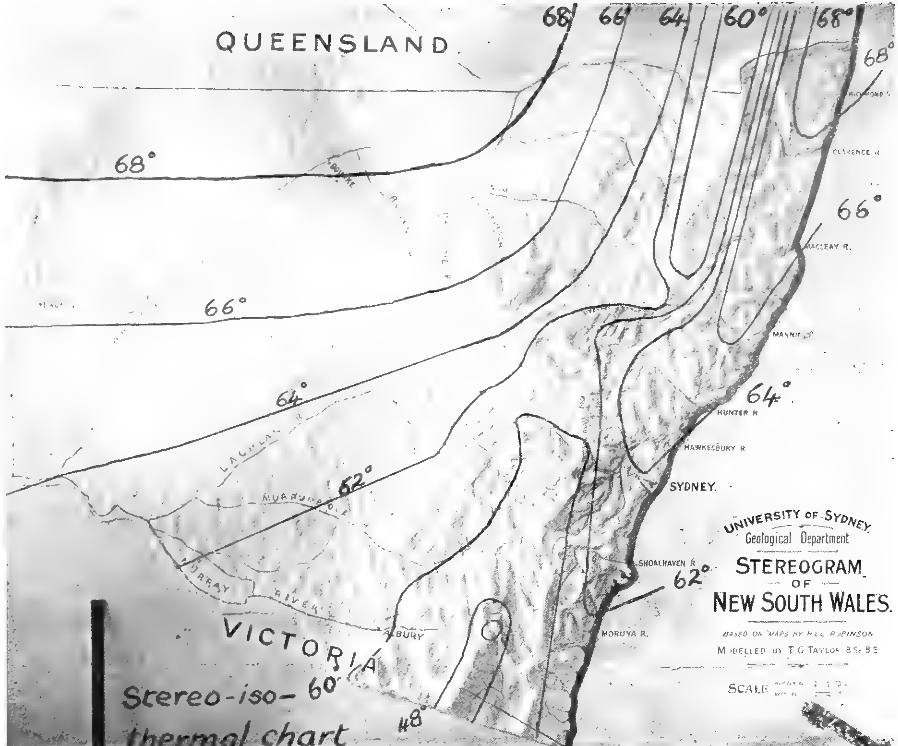

MAP ILLUSTRATING THE
Capture of the Wollondilly River
By the
Shoalhaven River,
In the Marulan-Tallong Area, New South Wales.
By W. G. WOOLNOUGH, D.Sc., F.G.S, and T. GRIFFITH TAYLOR, B.Sc., B.E.
SCALE OF MILES:
0 ½ 1 1½ 2
Railway to Goulburn
Railway to Sydney
Marulan
Tallong
Wingello
Barber
Shepherd
Glenrock
Ballanya
Warrima
Twin
Joarimin Creek
Wollondilly River
Uringalla Creek
Barber's Creek
Digger's Creek
Shoalhaven River
FLOWING IN GORGE, 1600ft. deep
GRAVELS OF THE CAPTURED RIVER
A
B
C
2122
2058
2350
2010
2223

FIG. 1. COARSE GRAVELS OF THE CAPTURED RIVER NEAR DIGGER'S CREEK.

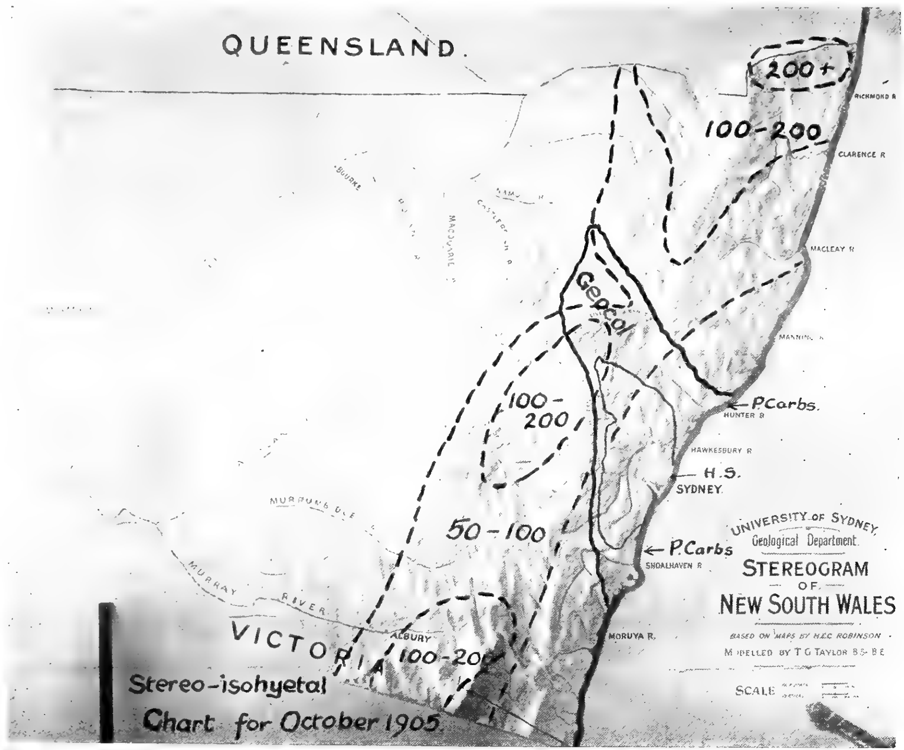
FIG. 2. COARSE GRAVELS NEAR BARBER'S CREEK.



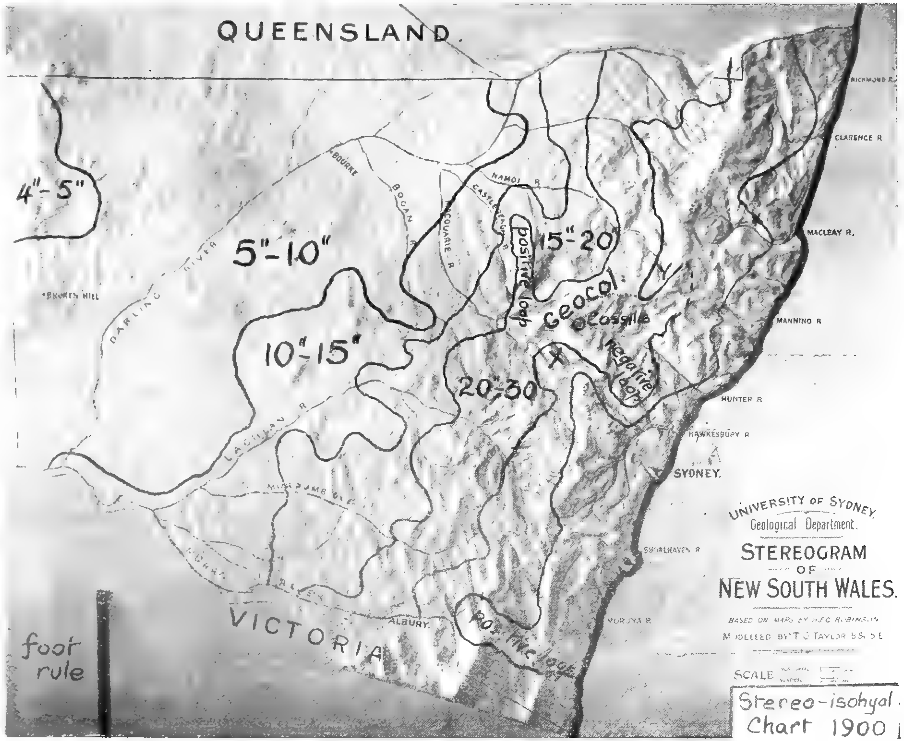
AUSTRALIAN LIBELLULIDÆ.



STEREO-ISOTHERMAL CHART.



STEREO-ISOHYETAL CHART FOR OCTOBER, 1905.



STEREO-ISOHYETAL CHART FOR 1900.

STEREO-ISOHYETAL CHART FOR 1902

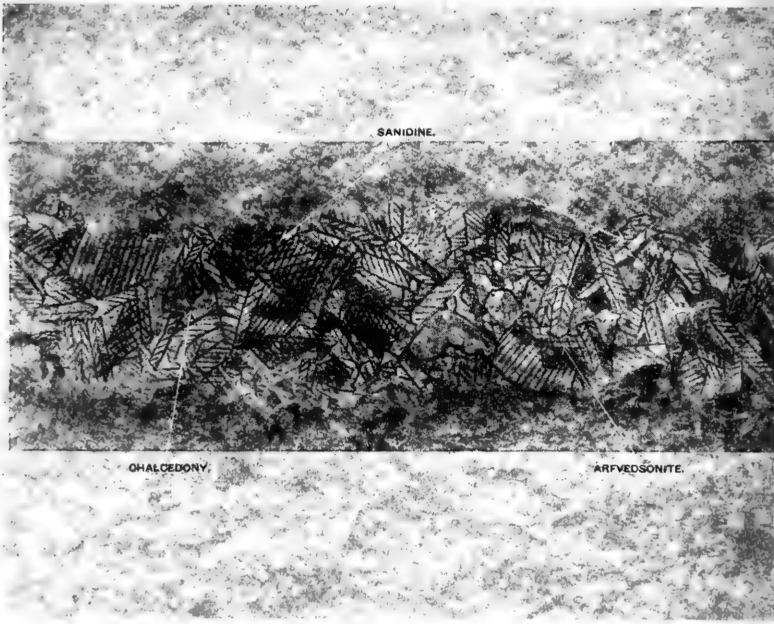


FIG. 1. SMALLER PEGMATITE VEIN (X 2 DIAMS.)

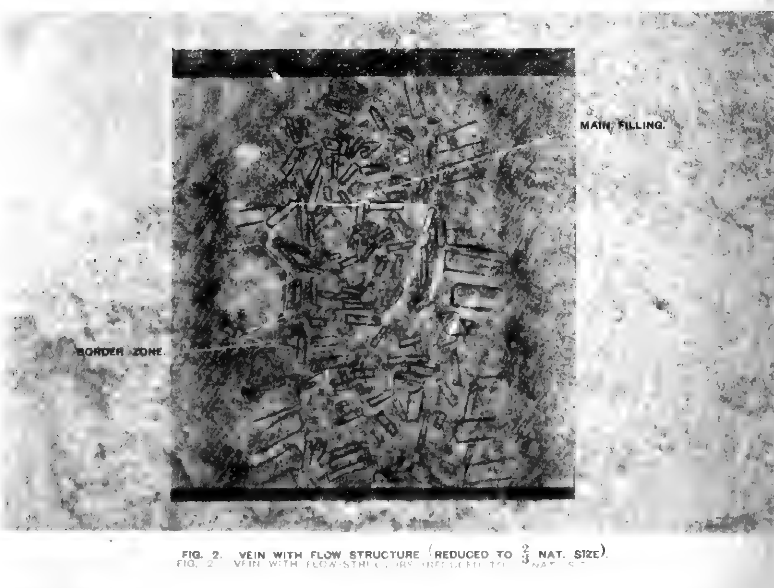


FIG. 2. VEIN WITH FLOW STRUCTURE (REDUCED TO $\frac{2}{3}$ NAT. SIZE).

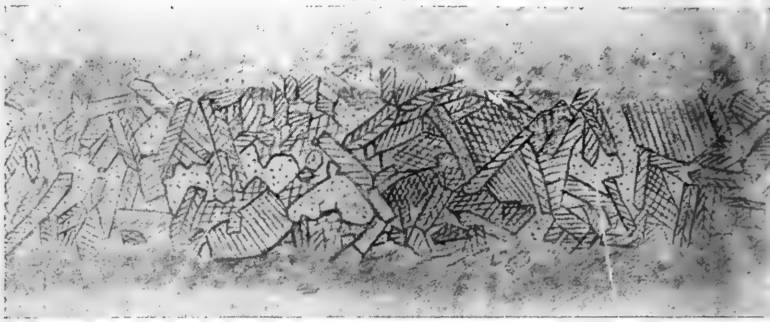


FIG. 1. SMALLER PEGMATITE VEIN (X 2 DIAMS.)

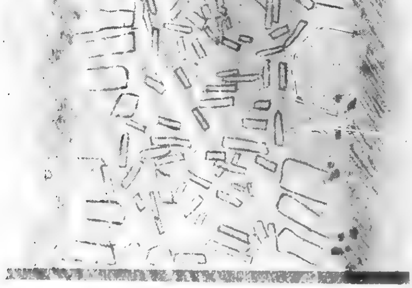


FIG. 2. VEIN WITH FLOW STRUCTURE (REDUCED TO 2/3 NAT SIZE)

FIG 1. SMALLER PEGMATITE VEIN (X 2 DIAMS.)

FIG. 2. VEIN WITH FLOW-STRUCTURE (REDUCED TO $\frac{2}{3}$ NAT. SIZE).

FIG. 1. LARGER-SIZED PEGMATITE VEIN (x $\frac{4}{3}$ DIAMS.).

FIG. 2. AEGIRINE-SYENITE PEGMATITE (BOWRALITE); NAT. SIZE.

Fig. 1.

URALITISATION OF THE ÆGIRINE

Fig. 2.

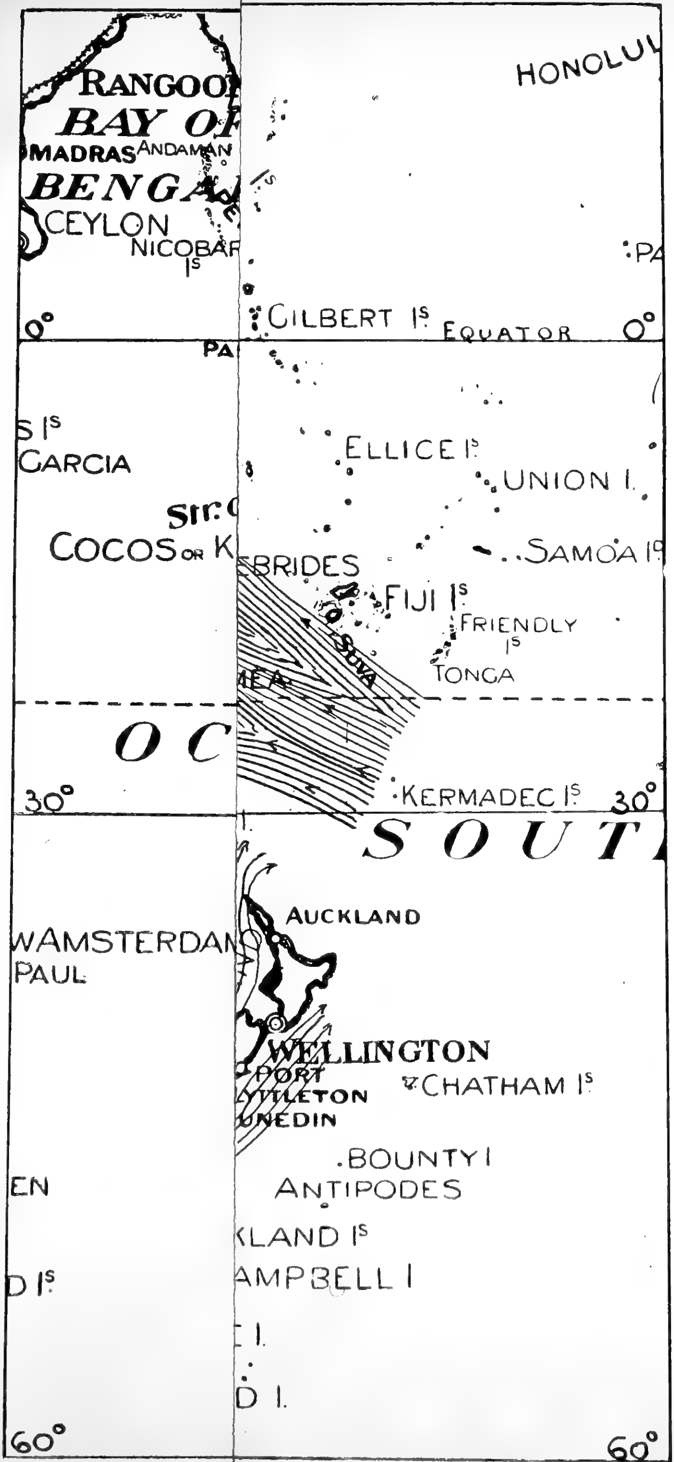
ARFVEDSONITE IN CHALCEDONY.

Fig. 3.

ADVANCED DECOMPOSITION OF ARFVEDSONITE.

Fig. 4.

EARLY STAGES IN DECOMPOSITION OF ARFVEDSONITE.


RANGOO
BAY OF
MADRAS
ANDAMAN
BENGA
CEYLON
NICOBAR Is
0°
HONOLUL
PA
GILBERT Is
EQUATOR
0°
PA
S Is
GARCIA
Str. C
COCOS OR K
EBRIDES
ELLICE Is
UNION I.
SAMOA Is
FIJI Is
SUVA
FRIENDLY Is
TONGA
OC
30°
KERMADEC Is
30°
SOUT
AUCKLAND
WAMSTERDAM
PAUL
WELLINGTON
PORT LYTTLETON
UNEDIN
CHATHAM Is
BOUNTY I
ANTIPODES
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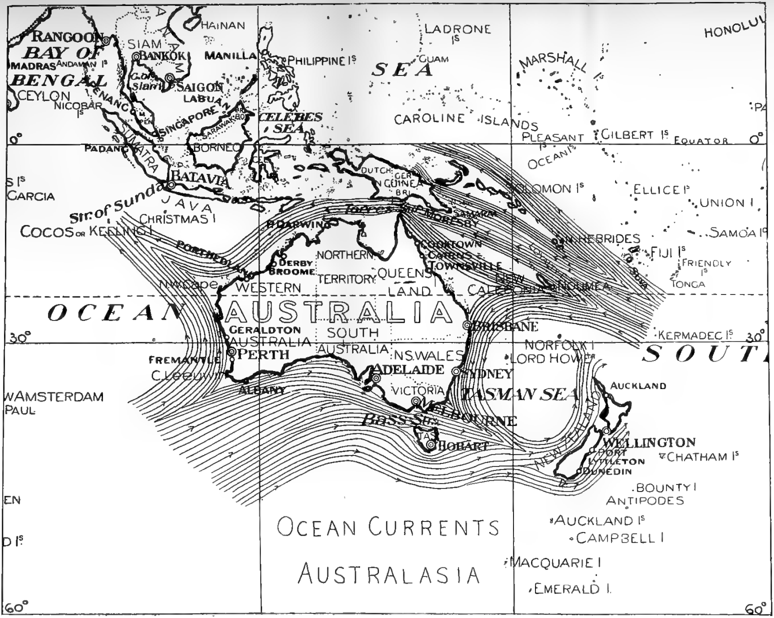
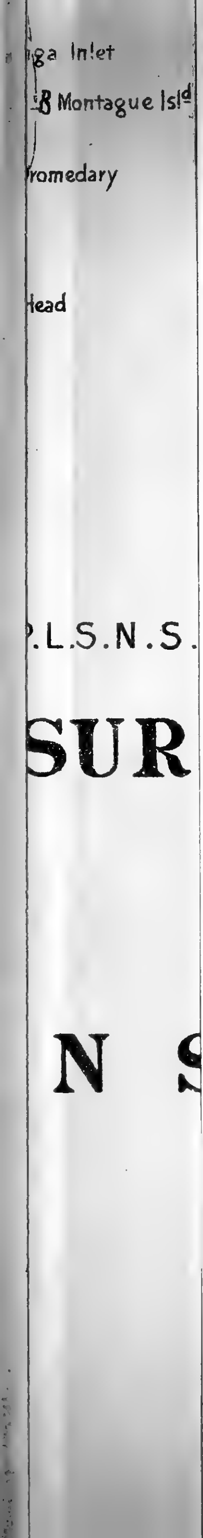
KLAND Is
D Is
AMPBELL I
D I.
60°
60°



OCEAN CURRENTS AUSTRALASIA


ga Inlet
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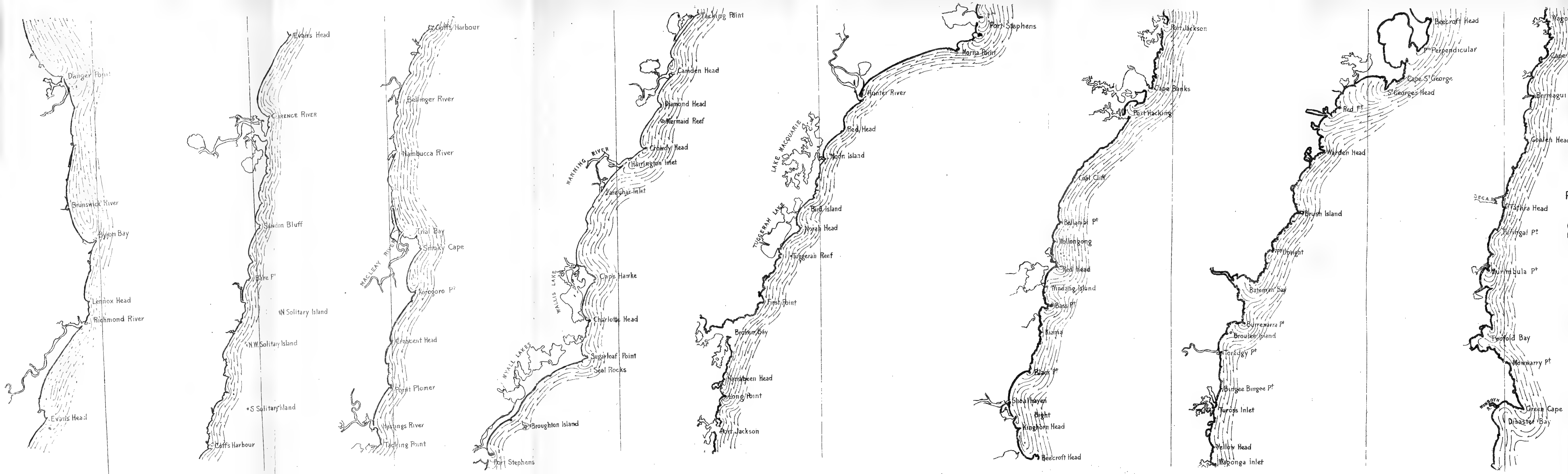
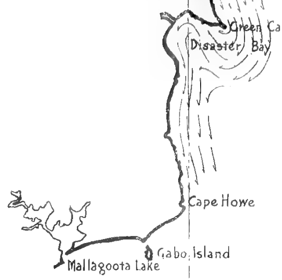
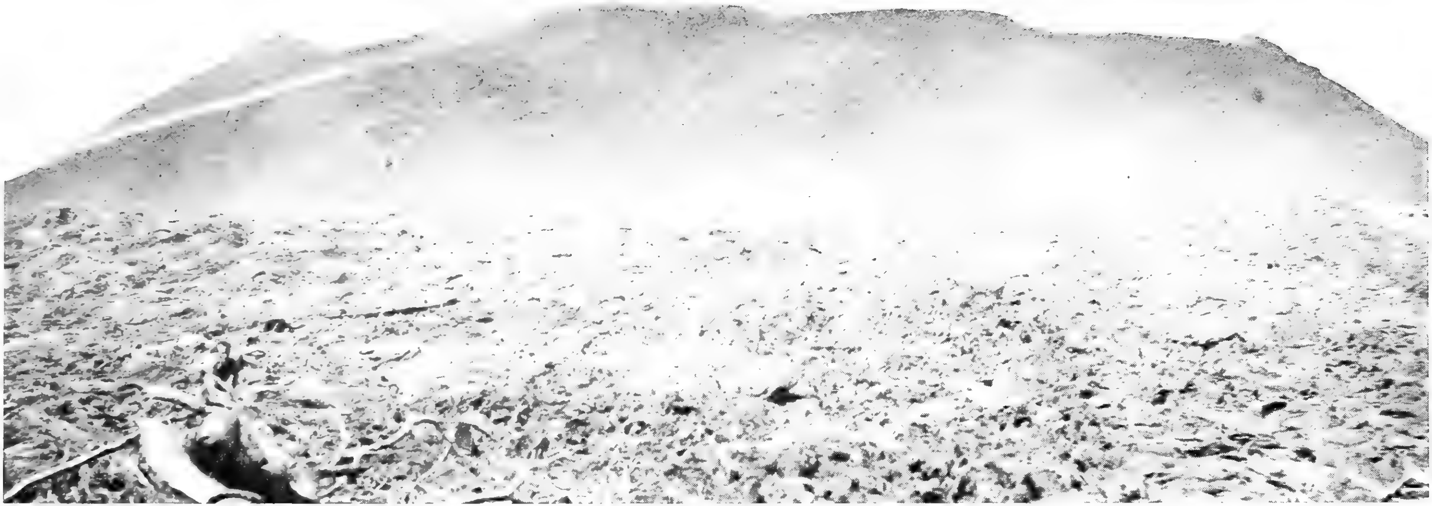


P.L.S.N.S.W. 1906. PL.LIII.

SURFACE CURRENTS ON THE N S WALES COAST





Capt. Allan, Photo.

OLENONO (MATAVANU) VOLCANO (SAVAII)

Capt. Allan, Photo.

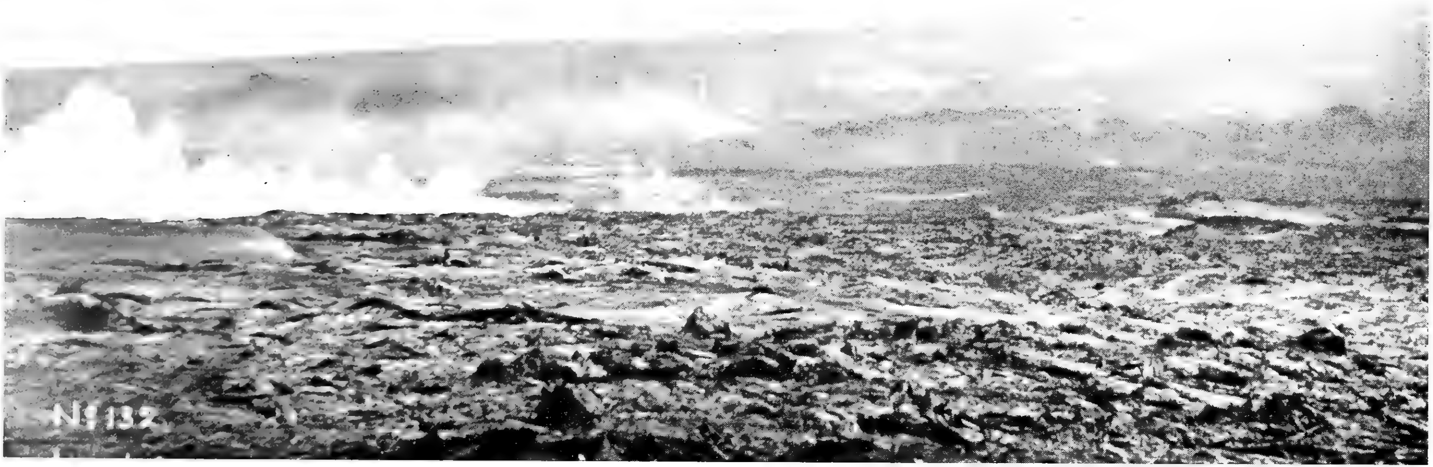
BUILDING OF LAVA PENINSULA.

Capt. Allan, Photo.

BUILDING OF LAVA PENINSULA (A FEW WEEKS LATER THAN PL. LV.)

Capt. Allan, Photo.

BUILDING OF LAVA PENINSULA (A FEW WEEKS LATER THAN PL. LVI.)



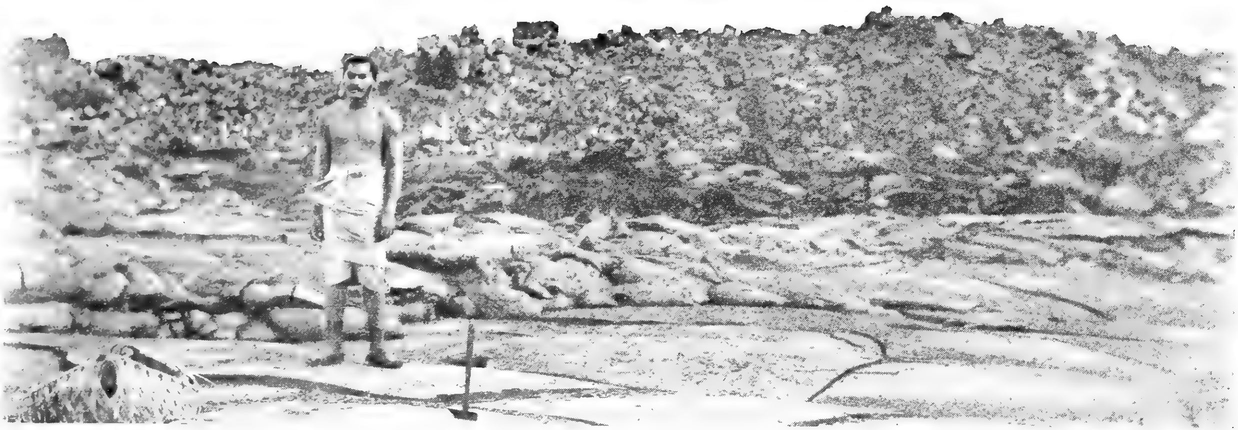
Capt. Allan, Photo.

VIEW FROM SUMMIT OF VOLCANO (LOOKING TOWARDS THE SEA).

LAVA RUNNING INTO THE SEA (VIEWED FROM THE COOLED LAVA CRUST).

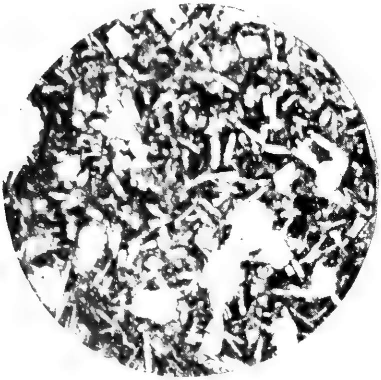
LAVA RUNNING INTO THE SEA (VIEWED FROM THE COOLED LAVA CRUST).

AN OLD LAVA FLOW AT PAPALAULELEI.



LAVA FLOW OF THE Aa TYPE.

TOFUA CRATER LAKE (TONGA).



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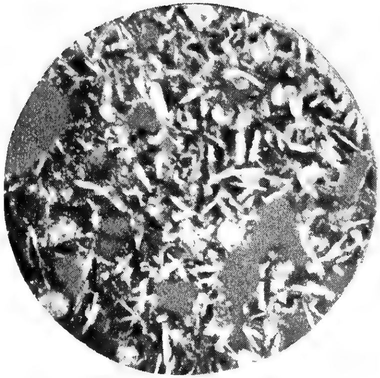

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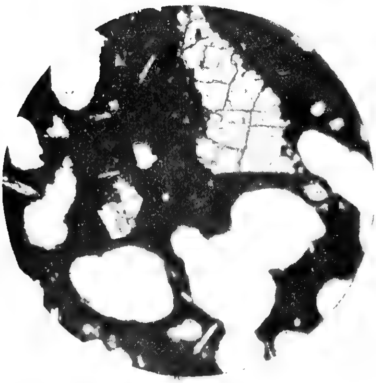

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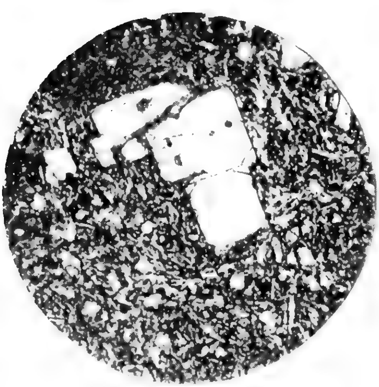


5

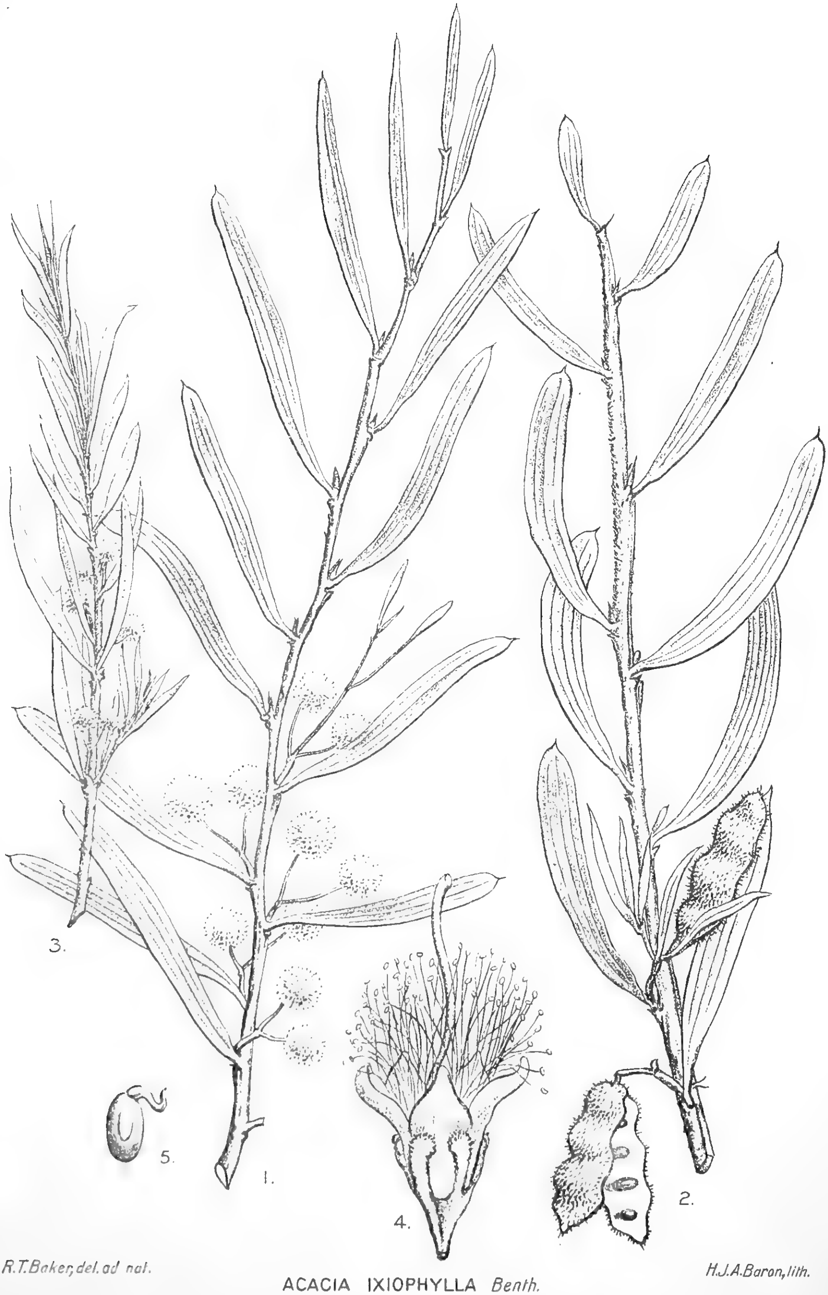
6

LAVA FROM NEW AND OLD FLOWS (SAVAII).

R.T. Baker, del. ad nat.

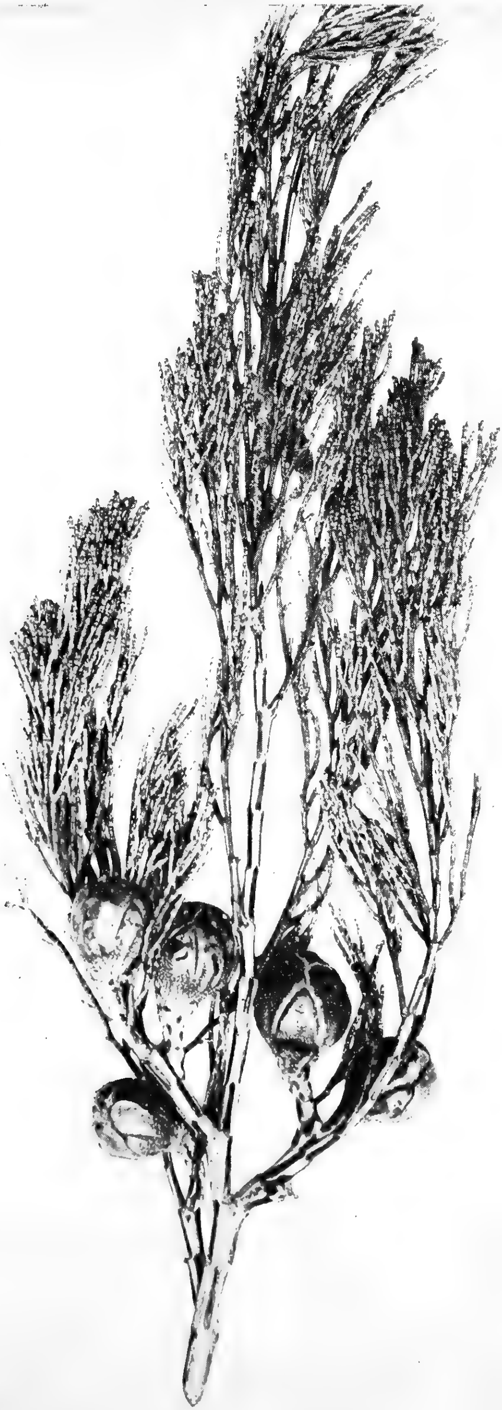
H.J.A. Baron, lith.

ACACIA FULIGINEA R.T. Baker.

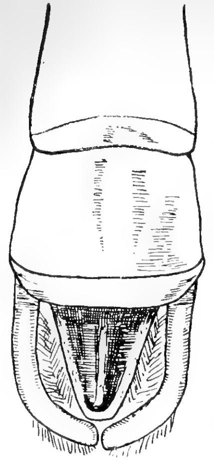


R. T. Baker, del. ad nat. H. J. A. Baron, lith.

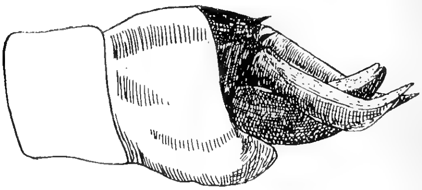
ACACIA IXIOPHYLLA *Benth.*



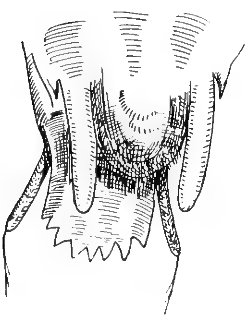
CALLITRIS MORRISONI R. T. BAKER.



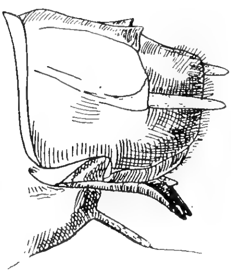
1 a



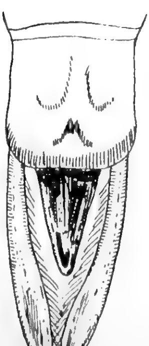
1 b



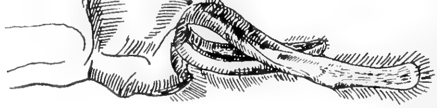
2 a



2 b



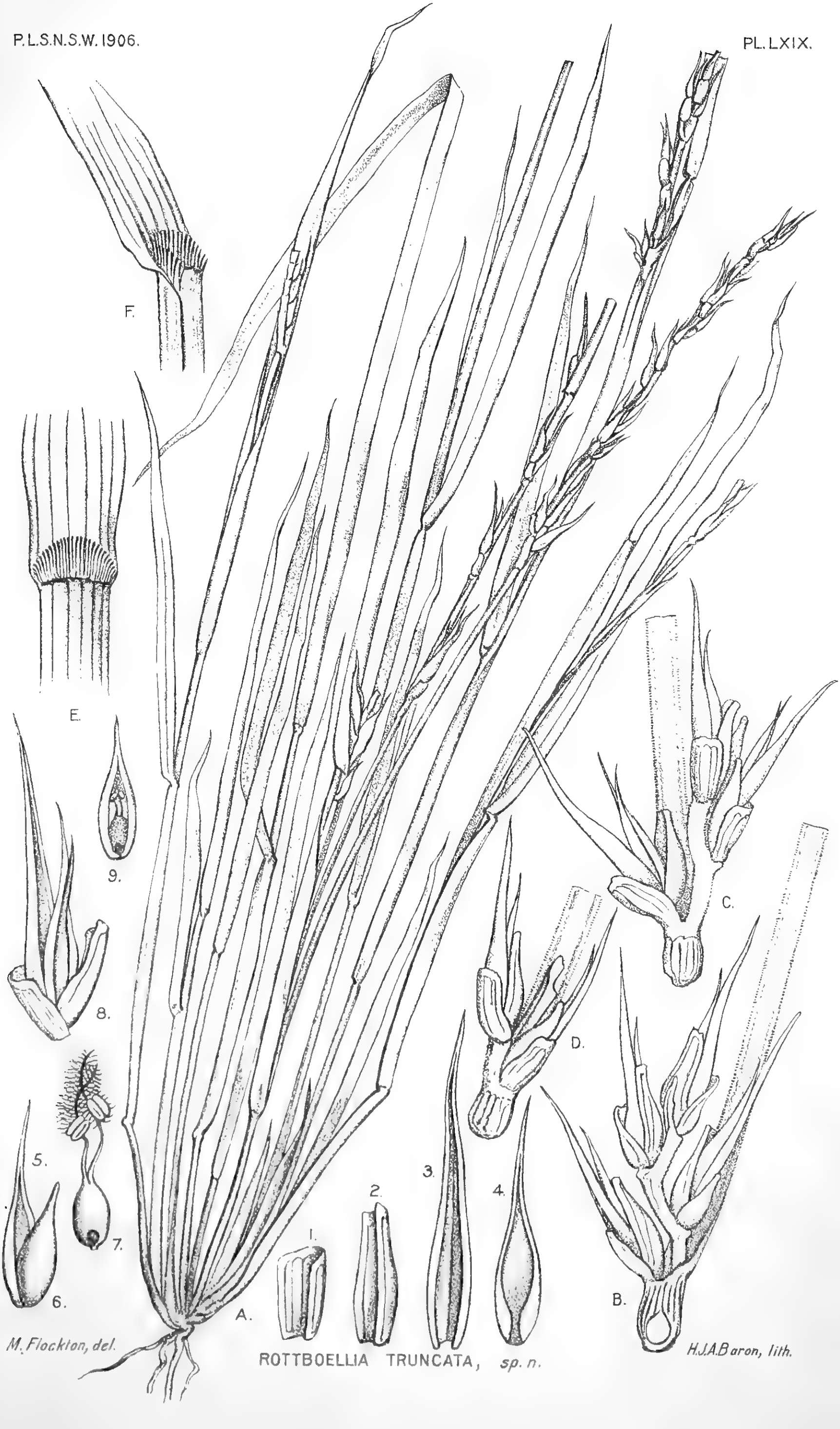
3 a



3 b

R. J. T. del.

AUSTRALIAN DRAGONFLIES (*ÆSCHNIDÆ*).



M. Flockton, del. ROTTBOELLIA TRUNCATA, *sp. n.* *H. J. A. Baron, lith.*